

# Community-Based Restoration of Desert Wetlands: The Case of the Colorado River Delta<sup>1</sup>

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## Abstract

Wetland areas have been drastically reduced through the Pacific Flyway and the Sonoran Desert, with severe consequences for avian populations. In the Colorado River delta, wetlands have been reduced by 80 percent due to water management practices in the Colorado River basin. However, excess flows and agricultural drainage water has restored some areas, providing habitat for several sensitive species such as the Yuma Clapper Rail (*Rallus longirostris yumanensis*). This has sparked community interest to explore different scenarios for the restoration of bird habitat. Three community-based restoration projects are currently underway in the delta, focusing on the restoration of marshlands, riparian stands, and mesquite bosque. The goal of these projects is to reestablish the ecological functions of the Colorado River delta, through an efficient use of available water for the conservation of biodiversity and the preservation of social and cultural values in the region.

*Key words:* birds, Colorado River, Hardy River, water management, wetland restoration.

## Introduction

Wetland restoration has become a critical requirement to achieve conservation and recovery goals of many bird species. This need has become more evident as we have realized that wetland dependent birds have suffered population declines over the last century

(Rosenberg et al. 1991, Davis and Ogden 1994, DeGraff and Rappole 1995). Causes for these declines are related to the dramatic rate at which wetlands have been destroyed in North America (Dahl 1990, National Research Council 1995), diminishing the area and quality of breeding grounds, wintering areas, and migratory stopover habitat (Weller 1999). In western North America, the patterns are shocking: wetland loss in the California Central Valley is estimated at 95 percent (Zedler 1988), and loss along the U.S. Pacific coast has been 50 percent (Helmert 1992).

This trend has been particularly critical in the Sonoran Desert, where the struggle for water between human uses and the environment has dried up most of the riparian forests and wetlands (Brown 1985). The Lower Colorado River basin is a clear example where the Colorado delta has lost over 80 percent of its wetland area over the last 80 years (Valdés-Casillas et al. 1998).

Worldwide, loss of wetlands is often related to water management practices (Lemly et al. 2000), and this certainly is the case in the Lower Colorado Basin (Lemly 1994, Morrison et al. 1996), where water diversions for human activities have negatively impacted the delta region (Glenn et al. 1996). Nevertheless, agricultural runoff, sporadic flood flows, and their interaction with the tidal regime from the Upper Gulf of California have restored and maintained part of these wetlands, showing that environmentally sound water management could help restore and conserve some avian habitats in the delta (Glenn et al. 2001, Zamora-Arroyo et al. 2001).

The interest in restoring wetlands in the Colorado River delta and allotting water for the environment has been increasing on both sides of the border (Valdés-Casillas et al. 1998, Pitt 2001). Opportunities for restoration have been identified (Briggs and Cornelius 1998, Luecke et al. 1999) and these ideas have been discussed in public forums incorporating environmental considerations into the political, social, and economic framework (Varady et al. 2001). An important result is a binational consensus among stakeholders, agencies, environmental groups, and academia on the importance of developing and implementing a binational conservation/restoration program, based on

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robust scientific information, which would consider water requirements for wildlife conservation.

The long-term success of restoration and conservation efforts is linked strongly to the support of local communities (Little 1994). In this sense, wetlands of the Colorado River delta provide one of the greatest opportunities for restoration in the Sonoran Desert. As local communities are strongly connected to wetland resources, they are committed for the long-term conservation and recovery of these resources, and they have joined efforts to form a local association to achieve these goals (Valdés-Casillas et al. 1999, Carrillo-Guerrero 2002).

In this paper we discuss the opportunities for restoration in the Colorado River delta, initial restoration projects, and the critical role that local communities can play in the long-term success of such efforts.

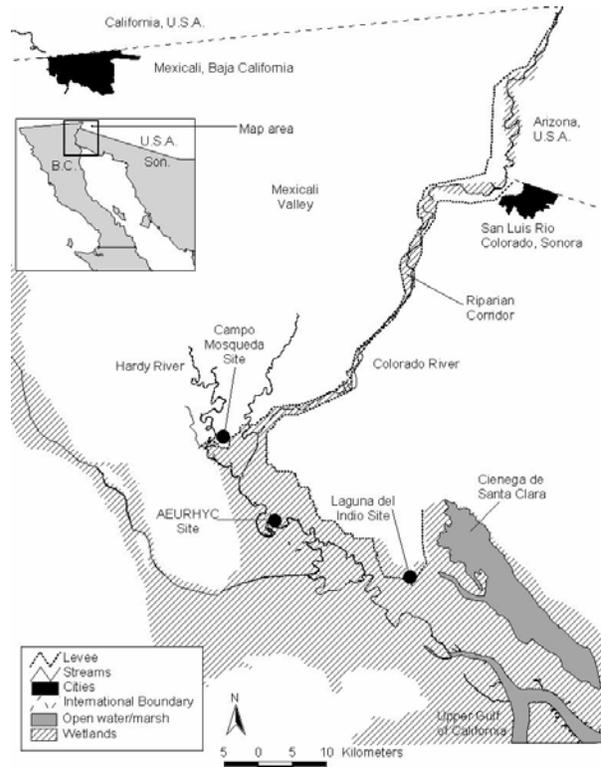
### The Colorado River Delta

The Colorado River delta is located in the western edge of the Sonoran Desert, at the common border of the Mexican states of Baja California and Sonora, surrounded by the driest biomes of the ecoregion (fig. 1). The delta ecosystem covers 169,000 ha, providing critical linkage among deserts, freshwater/riparian areas, brackish marshes, tidal flats, and the Upper Gulf of California.

Prior to the dam era, the cottonwood (*Populus fremontii*) – willow (*Salix gooddingii*) forest was very common in the Colorado River delta, extending over tens of thousands of hectares throughout the Mexicali Valley (Sykes 1937). Thick mesquite (*Prosopis* spp.) bosque dominated the upland terraces, in association with arrowweed (*Pluchea sericea*) and quail bush (*Atriplex lentiformis*) (Mearns 1907). Oxbows, backwaters, and seepage were common, and provided for vast extensions of marshlands (Sykes 1937).

Eighty years later, only 1,500 ha of cottonwood-willow remain, regenerated after excess flows reached the delta, and maintained with “administrative losses” from the irrigation systems (Glenn et al. 2001). The extent of mesquite bosque has been largely diminished, as upland areas have been cleared for agriculture development (Valdés-Casillas et al. 1998). Marshlands have been reduced as well, but significant areas have been maintained with agricultural drainage and brackish water. The Ciénega de Santa Clara, the largest marsh in the Sonoran Desert and a protected natural area, extends over 6,000 ha (Glenn et al. 1992; fig. 1). The Ciénega is maintained by brackish agricultural drainage from the Wellton-Mohawk Valley in Arizona, but

there are still plans to divert this water for human consumption (Glenn et al. 2001).



**Figure 1**— Wetland areas and restoration projects in the Colorado River delta, México. Black dots indicate the location of the restoration sites.

Despite these changes, many species still thrive in the region and the Colorado River delta remains one of the best opportunities for binational collaboration for biodiversity conservation along the border. The importance of the delta for the conservation of birds has been recognized both nationally and internationally. In México, a portion of the delta wetlands is part of the Upper Gulf of California and Colorado River Delta Biosphere Reserve (SEMARNAP 1995). The delta also is an Important Bird Area in México (AICA), and a priority site for the conservation of biodiversity as decreed by the National Commission on Biodiversity (CONABIO; Cervantes et al. 1999). The Colorado River delta also is recognized as a wetland of international importance by the Ramsar Convention (Ramsar Convention Bureau 1998), and is part of the Western Hemisphere Shorebird Reserve Network (WHSRN 1998).

Between 1993 and 2002, 353 bird species have been detected in the Colorado River delta in México (Patten et al. 2001, Hinojosa-Huerta et al. in press). The delta provides habitat for 24 protected Mexican species, for migratory and wintering waterbirds along the Pacific Flyway, and for neotropical migrant landbirds (Mellink and Ferreira-Bartrina 2000; García-Hernández et al.

2001; Hinojosa-Huerta et al. 2001a, 2001b; Diario Oficial de la Federación 2002). Nearly 200,000 shorebirds and 60,000 ducks and geese use the delta wetlands as wintering grounds or for stopover habitat during migration (Morrison et al. 1992, Mellink et al. 1997), and at least 110 species of neotropical migratory landbirds visit the delta during their migratory movements (Patten et al. 2001).

### Restoration Needs in the Colorado Delta

The root causes of ecological decline in the Colorado River delta are the fundamental changes in water and sediment movement brought on by river impoundment and water diversions all along the Colorado River. These have significantly impacted the local avifauna. Ten species of breeding birds and fourteen species that use this area as stopover or wintering ground have required a status of legal protection under Mexican laws (Endangered, Threatened, or Special Protection; Diario Oficial de la Federación 2002; *table 1*).

Populations of many species have declined regionally, and some have been extirpated locally, including populations of five breeding and two wintering species (Hinojosa-Huerta et al. in press; *table 1*). Most affected have been riparian-obligate breeders, waterfowl, and marshbirds. There is major concern for the endemic subspecies of Yuma Clapper Rail (*Rallus longirostris yumanensis*) and Large-billed Savannah Sparrow (*Passerculus sandwichensis rostratus*; Mellink and Ferreira-Bartrina 2000, Hinojosa-Huerta et al. 2001a).

To significantly improve the delta's wetland, riparian, and inter-tidal areas, the management of the Colorado River must meet the ecological needs of these ecosystems. This means allowing the occasional large spring flow to pass through the delta to re-work sediments and create conditions ideal for natural regeneration, and to guarantee smaller, yet consistent flows that keep the wetland and riparian ecosystems moist during the hot, dry months of the summer.

Pulse floods and almost continuous instream flows during the last 5 years have brought significant revegetation of native riparian plants along the Colorado River in México (Zamora-Arroyo et al. 2001). These events, along with others such as the regeneration of marshlands in the Ciénega de Santa Clara, have shown that water management practices can be implemented to restore and protect biodiversity and sensitive species in the region (Glenn et al. 2001, Hinojosa-Huerta et al. 2001a).

Calculations based on vegetation analysis suggest that even 1 percent of the natural flow of the Colorado

River could provide the means for conserving and enhancing riparian and wetland areas in the delta.

The required water is a continuous flow managed to maximize the number of days with discharge larger than 2 m<sup>3</sup>/s (4 X 10<sup>7</sup> m<sup>3</sup>/year). This should be complemented with pulse floods every 4-5 years at 80-120 m<sup>3</sup>/s (3 X 10<sup>8</sup> m<sup>3</sup>/year) to foster recruitment of native plants, wash salts, and rework sediments in the floodplain (Glenn et al. 2001, Zamora-Arroyo et al. 2001). However, achieving even these relatively modest flows will be challenging.

Numerous steps involving social, political, and ecological considerations will have to be taken before the United States and Mexican governments, delta residents, and other stakeholders can agree on what the overarching goal of restoration is, and which strategies would be most effective in accomplishing the restoration goals.

One of the major milestones towards these goals has been the incorporation of local communities in the process, in particular through the representation of the Ecological Association of Users of the Hardy and Colorado Rivers (AEURHYC). The organization was formed in 1998 by different sectors of the local communities of the Río Hardy to work together toward the restoration of the Colorado River delta. The association includes fishermen, farmers, the Cucupá tribe, aquaculturists, and the tourist sector. In particular, they call for 1) a reconsideration of water treaties, which will include considering the environment as another user of river water, 2) the designation of all delta wetlands under a protection status, and 3) the implementation of restoration projects (AEURHYC 2001).

Community support for wetland conservation also extends to farmers and landowners located close to the riparian areas. These farmers have shown their interest in maintaining native riparian vegetation, allotting water for the environment, protecting the Colorado River floodplain with a conservation designation, and in participating in active restoration projects by leasing land and water (Carrillo-Guerrero 2002). These community activities show that long-term restoration and conservation projects for wetlands can be implemented successfully in the Colorado River delta.

### Community-Based Restoration Projects

Delta communities have witnessed environmental changes in the wetlands and negative impacts to their livelihoods over the past decades (Valdés-Casillas et al. 1998). Nevertheless, the natural revegetation and the

**Table 1**— Bird species under a protection category in México or of conservation concern in the Colorado River delta. Four codes are given for each species: protection category (SP – Special Protection, TH – Threatened, EN – Endangered, NP – No Protection), breeding status (NB – Non-breeding, BR – Breeding), relative abundance (EX – Extirpated, CA – Casual, RA – Rare, UN – Uncommon, CO – Common), and temporal presence (WI – Winter, SP – Spring, SU – Summer, PE – Perennial). Abundance categories follow Patten et al. (2001).

Species	Protection category	Breeding status	Relative abundance	Temporal presence
Least Grebe ( <i>Tachybaptus dominicus</i> )	SP	NB	CA	SU
Laysan Albatross ( <i>Phoebastria immutabilis</i> )	TH	NB	RA	SP
Black Storm-Petrel ( <i>Oceanodroma melania</i> )	TH	NB	CO	PE
Least Storm-Petrel ( <i>Oceanodroma microsoma</i> )	TH	NB	CO	PE
Reddish Egret ( <i>Egretta rufescens</i> )	SP	BR	RA	SU
Roseate Spoonbill ( <i>Ajaja ajaja</i> ) <sup>1</sup>	NP	NB	EX	WI
Fulvous Whistling-Duck ( <i>Dendrocygna bicolor</i> ) <sup>1</sup>	NP	BR	EX	SU
Brant ( <i>Branta bernicla</i> )	TH	NB	UN	WI
Bald Eagle ( <i>Haliaeetus leucocephalus</i> ) <sup>2</sup>	EN	NB	UN	WI
Sharp-shinned Hawk ( <i>Accipiter striatus</i> )	SP	NB	UN	WI
Cooper's Hawk ( <i>Accipiter cooperi</i> )	SP	NB	UN	WI
Harris' Hawk ( <i>Parabuteo unicinctus</i> )	SP	NB	UN	WI
Red-shouldered Hawk ( <i>Buteo lineatus</i> )	SP	NB	CA	WI
Swainson's Hawk ( <i>Buteo swainsoni</i> )	SP	NB	UN	WI
Ferruginous Hawk ( <i>Buteo regalis</i> )	SP	NB	RA	WI
Peregrine Falcon ( <i>Falco peregrinus</i> )	SP	NB	UN	WI
Prairie Falcon ( <i>Falco mexicanus</i> )	SP	NB	RA	WI
California Black Rail ( <i>Laterallus jamaicensis coturniculus</i> )	EN	BR	RA	PE
Yuma Clapper Rail ( <i>Rallus longirostris yumanensis</i> ) <sup>2,3</sup>	TH	BR	CO	PE
Virginia Rail ( <i>Rallus limicola</i> )	SP	BR	CO	PE
Sandhill Crane ( <i>Grus canadensis</i> ) <sup>1</sup>	NP	NB	EX	WI
Snowy Plover ( <i>Charadrius alexandrinus nivosus</i> ) <sup>2</sup>	TH	BR	UN	SU
Heermann's Gull ( <i>Larus heermanni</i> )	SP	NB	CO	PE
Gull-billed Tern ( <i>Sterna nilotica vanrossemei</i> ) <sup>1</sup>	NP	BR	CO	PE

Table 1 (contd.).

Species	Protection category	Breeding status	Relative abundance	Temporal presence
Elegant Tern ( <i>Sterna elegans</i> )	SP	BR	RA	SU
Least Tern ( <i>Sterna antillarum</i> ) <sup>2</sup>	SP	BR	UN	SU
Yellow-billed Cuckoo ( <i>Coccyzus americanus occidentalis</i> ) <sup>1</sup>	NP	BR	UN	SU
Western Screech-Owl ( <i>Otus kennicottii</i> ) <sup>1</sup>	NP	BR	RA	SU
Short-eared Owl ( <i>Asio flammeus</i> )	SP	NB	RA	WI
Gilded Flicker ( <i>Colaptes chrysoides</i> ) <sup>1</sup>	NP	BR	EX	SU
Southwestern Willow Flycatcher ( <i>Empidonax traillii eximius</i> ) <sup>1,2,4</sup>	NP	BR	EX	SU
Bell's Vireo ( <i>Vireo bellii</i> ) <sup>1</sup>	NP	BR	RA	SU
Lucy's Warbler ( <i>Vermivora luciae</i> ) <sup>1,4</sup>	NP	BR	EX	SU
Summer Tanager ( <i>Piranga rubra</i> ) <sup>1,4</sup>	NP	BR	EX	SU
Large-billed Savannah Sparrow ( <i>Passerculus sandwichensis rostratus</i> ) <sup>3</sup>	SP	BR	CO	SU

<sup>1</sup> Species not under a protection category, but has experienced sharp population declines in the region.

<sup>2</sup> Species also under federal protection in the US.

<sup>3</sup> Species endemic to the Colorado River delta.

<sup>4</sup> Breeding population has been extirpated, but still present as transient.

maintenance of wetland areas with agricultural drainage water have maintained community interest and hope for conserving a functional ecosystem. Community support has sparked interest in starting restoration efforts that could function as models to obtain information for management of the delta ecosystem, and that could explore the possibilities of using agricultural drainage water, irrigation water, private and ejido lands, and marginal fields for environmental purposes.

Three restoration projects are currently operating in the delta, with the participation of local communities, environmental groups, government agencies, universities, and research institutions from the United States and México. Each one of these projects has different specific objectives and is focused on a different type of ecosystem. However, the common goal is to reestablish some of the ecological functions of the Colorado River delta, through a more efficient and environmental use of the available water, which allows for the conservation of biodiversity and the preservation of social and cultural values of the region.

### The Projects

A riparian/mesquite restoration project is being developed by a binational team of environmental and scientific institutions in the northern area of the Río Hardy, in coordination with a local tourist camp (Campo Mosqueda). South from there, the Ecological Association of Users of the Hardy and Colorado Rivers has been working on the restoration of marsh wetlands in the Río Hardy. Finally, restoration activities have continued at the Laguna del Indio, in the eastern part of the delta since 1998.

### Mosqueda Restoration Project

The Campo Mosqueda site is in the Río Hardy wetland system, on the western side of the Colorado River delta, and at the southern portion of the Mexicali Valley (fig. 1). The Río Hardy is a tributary that drains much of the Mexicali Valley agricultural area as it makes a sinuous 26-km journey to the confluence with the Colorado River.

As with much of the Colorado River delta, extensive areas of riparian vegetation and dense forests of mesquite covered the Río Hardy area before dams were constructed. Today, much of the Hardy complex is hydrologically isolated from the Colorado floodplain, with limited remnant patches of wetland and mesquite plant communities persisting due to agricultural return flows.

The objective of the Mosqueda restoration effort is to re-establish 10 ha of wetland, mesquite and riparian habitat types on lands that were formerly used for agriculture. The overall focus and long-term goal of the restoration design is on providing habitat for migratory waterfowl and neotropical migratory birds and on providing opportunities for local residents to develop an ecotourism enterprise. A nursery of native plants also has been established to provide materials for the Mosqueda project as well as for subsequent riparian revegetation efforts.

The Mosqueda restoration effort is establishing three types of plant communities: a 0.5-ha open water zone with intermixed marsh areas dominated by cattails (*Typha domingensis*), bulrush (*Scirpus americanus*), and sedges (*Juncus* spp.); a 0.5-ha hectare riparian woodland dominated by cottonwoods and willows; and a 10-ha mesquite zone dominated by screwbean (*Prosopis pubescens*) and honey mesquite (*Prosopis glandulosa*).

The restoration design includes considerations for the restoration of breeding habitat for at least 10 bird species dependent on woody vegetation and 9 species dependent on aquatic and marsh areas. We expect that the restored plot will also benefit over 50 species of migratory and wintering birds as well as other wildlife.

### **Laguna del Indio**

El Indio wetland is located at the lower end of the Mexicali Irrigation District, in the buffer zone of the Upper Gulf of California and Colorado River Delta Biosphere Reserve, within Ejido Indiviso, Baja California (fig. 1). El Indio is a 100-ha subtropical floodplain dominated by saltcedar, but includes other species of smaller stature, including arrowweed (*Pluchea sericea*), seep willow (*Baccharis salicifolia*), saltbush (*Atriplex* spp.), and iodine bush (*Allenrolfea occidentalis*). In addition, pockets of cattail, bulrush, and other hydrophytes persist in areas where soils remain saturated throughout the year. Salt grass (*Distichlis palmeri* and *D. spicata*) forms significant patches on the salt-affected wetland fringes at the south end of El Indio.

These lagoons are part of an old stream of the Colorado River on the eastern delta; now they are supported by agricultural run-off water from the Mexicali Valley. These wetlands were created when a drain broke in 1993, flooding about 90 hectares as water was retained between a flood control levee and an agricultural drain. The restoration project is focusing on a rectangular portion of El Indio (roughly 1,650 m long and 220 m wide) that occupies about 36 ha.

El Indio is an important area for migratory waterfowl, wading birds, shorebirds, and marshbirds, with more than 100 avian species recorded in these wetlands. They provide important habitat for several endangered or sensitive species, including the Yuma Clapper Rail (Hinojosa-Huerta et al. 2001), and are considered one of the restoration priorities of the Upper Gulf of California and Colorado River Delta Biosphere Reserve.

Reuse of water for environmental purposes in El Indio will provide an important example of how agricultural return flows can be used for the benefit of both the community and the environment. By implementing this effort in an agricultural area, we hope that project results will serve as a model that other delta communities can follow for developing alternative uses for marginal agricultural lands.

Currently, the activities at El Indio are aimed at securing a source of water for these wetlands, and exploring the opportunities of water re-use for environmental purposes and some economic activities, in particular ecotourism and small-scale aquaculture. Key elements of this project include 1) management of agricultural drains to enhance water availability in the lagoon; 2) saltcedar removal in areas that contain significant amounts of native wetland species; and 3) community participation in the restoration design and in the development of local backyard projects that will address both community and environmental issues.

### **Wetland Restoration at the Río Hardy – AEURHYC**

The Ecological Association of Users of the Hardy and Colorado Rivers (AEURHYC) has united several sectors of the community to channel restoration efforts in the delta. One of the main objectives of the association is to efficiently manage the water of the Río Hardy, in order to optimize its environmental benefits and the functions it provides to the communities.

The current appearance of the Hardy wetlands began to be shaped during the 1930's, when several consecutive flooding events created a natural dam or sandbar 35 km upstream from the Gulf of California that blocked the flow of water from the western delta (Glenn et al. 1996). The sandbar maintained a 20,000 ha marsh in the Río Hardy even during the 50-year period when Lake Mead and Lake Powell were filling and there were few or no flows to the region (Glenn et al. 1996).

After the major flooding on the Colorado in 1983, and until 1989, the delta received significant flows, and the Hardy/Colorado Wetlands grew to some 66,400 ha. Since then, the Hardy wetlands have shrunk to approximately 2,000 ha dominated by saltcedar. Aside from the lack of flows, the shrinkage of the Hardy

complex also was due to the destruction of the natural dam by flooding in 1987 and the subsequent drainage of the wetlands (Glenn et al. 1996).

Due to the significant amounts of agricultural return flows that accumulate in the Río Hardy area, this wetland complex still supports considerable native wetland plant communities that provide habitat to a large number of bird species. In particular, the Río Hardy provides habitat for wintering and migratory waterfowl, piscivorous birds, and marshbirds. Migratory landbirds also stopover at the banks of the Hardy, en route north through the Colorado River corridor.

One of the activities of AEURHYC is the construction of a dike in the lower part of the Río Hardy, that would maintain a larger wetland area, increase river depth, and restore habitat for migratory waterbirds and associated wildlife. The general idea of the AEURHYC project is to simulate the functions of the sandbar, evaluate the feasibility and potential environmental benefits of the project, and to generate information on the hydrologic variables of the river in relation to the dike. The 120-m dike will restore approximately 1,500 ha of marsh, extending over 25 river kilometers.

The first phase of the dike was built during July and August 2001, using sandbags as the main material. The primary force was the participation of more than 80 volunteers from different communities on the delta, and the continuous involvement of the Indigenous Cucapá Community. A second phase was finished in August 2002, in which the dike was extended to reach higher terraces and increase the area to be restored.

The Association was in charge of coordination and fundraising to finish the project, most of which were provided by the tourist camps of the Río Hardy. Other sectors of the community provided equipment and materials.

This project will provide short-term benefits in terms of restored habitat for waterbirds and for the activities of tourist camps and fishermen. In the long-term, the Hardy communities hope that this effort could be a spark that starts a large-scale movement to restore and conserve the wetlands of the Hardy and Colorado Rivers.

## Conclusions

The drastic rate at which wetlands have been degraded within the Pacific Flyway and the Sonoran Desert call for an urgent reconsideration of water policies and for restoration actions to recover these ecosystems. This process is critical for the recovery and conservation of many bird species of northwestern México and south-

western United States. The resilience and remnant biological richness of the Colorado River delta provides unique opportunities for conservation and restoration of riparian and wetland areas within this ecoregion. The community-based projects in the Colorado River delta show that diverse habitat types can be recreated or improved through restoration work. These restoration efforts should be expanded as part of an overall conservation strategy for the Colorado River delta. However, it is unlikely that bird populations can be sustained through localized restoration actions only. The ecological integrity of the riparian and wetland ecosystems of the delta needs to be maintained as well. An overall bird conservation strategy for the delta should find alternatives to large-scale destruction of wetlands and riparian forests while creating islands of high-quality habitat at suitable sites through restoration projects. These efforts should be coupled with the support and interest of local communities, which are working toward the long-term recovery and conservation of the desert wetlands of the Colorado River delta.

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