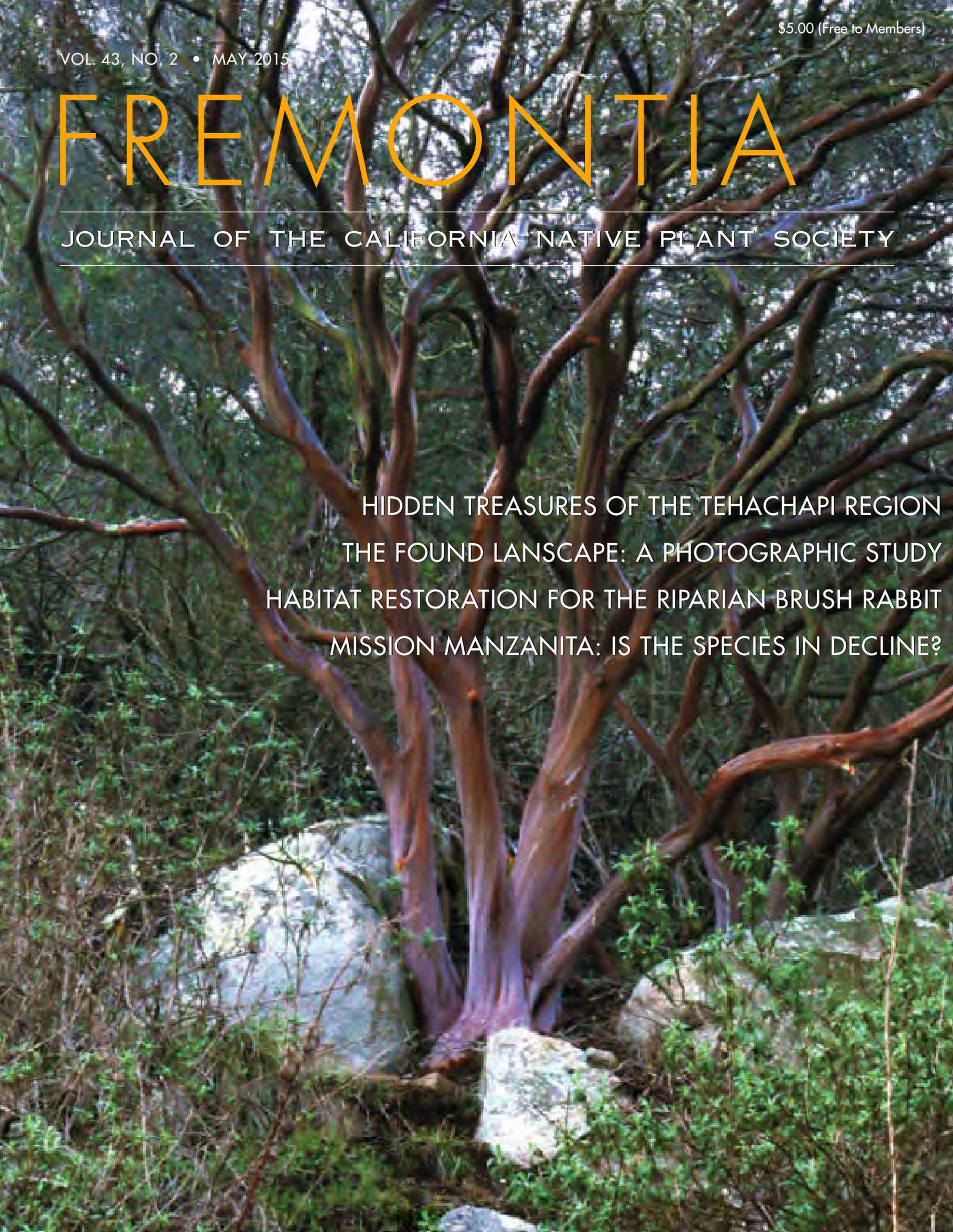


# FREMONTIA

JOURNAL OF THE CALIFORNIA NATIVE PLANT SOCIETY

HIDDEN TREASURES OF THE TEHACHAPI REGION  
THE FOUND LANDSCAPE: A PHOTOGRAPHIC STUDY  
HABITAT RESTORATION FOR THE RIPARIAN BRUSH RABBIT  
MISSION MANZANITA: IS THE SPECIES IN DECLINE?



# FREMONTIA

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PLANT SOCIETY

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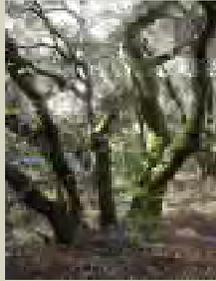
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THE COVER: A 20-foot tall old-growth mission manzanita in Penasquitos Canyon, San Diego. With its signature smooth, reddish-brown bark, the species holds its foliage high above the ground. Story begins on page 21. Photograph by Steve Miller.



# LESSONS LEARNED IN HABITAT RESTORATION FOR THE RIPARIAN BRUSH RABBIT

by Julie Rentner

The ongoing recovery of riparian brush rabbit habitat along the Lower San Joaquin River is a model of integration of wildlife and plant restoration ecology. A highly functioning public-private partnership has been able to rapidly and successfully re-establish a new population of this endangered species across thousands of acres of new habitat in its historic range. This partnership has explicitly looked at the connections between the factors limiting the recovery of this rabbit and the factors limiting the recovery of its habitat, which consists of riparian shrublands dominated by native blackberry and roses. The restored habitat has proven to be resilient to the disturbances it will face into the future, including fires and floods.

The San Joaquin Valley once supported vast and complex wetland habitat types including diverse riparian woodlands. Woodlands ranged from mixed willow-cottonwood stands, to stately valley oak groves laden with dangling grape vines, to vigorous shrublands dominated by native blackberry and roses. These woodlands supported complex wildlife communities including salmon and steelhead trout, neotropical migratory songbirds, antelope, deer, coyote, and bear. Just as many garden flowers develop seasonally through bloom, seed-set, and senescence, and over time require replanting, pruning, and training, wild riparian forest communities also change both seasonally and over the years.

In the past, springtime in the San Joaquin Valley has brought warm, slow flooding as a result of snowmelt from the Sierra Nevada, and rapid greening of the landscape.



Riparian brush rabbits bred in captivity and released into restored and remnant habitat areas are equipped with unique identifiers on ear tags, and radio collars to facilitate location and identification during bi-annual trapping. Photograph courtesy of the Endangered Species Recovery Program at California State University, Stanislaus.

Historically, overbank inundation was the norm. This kept most of the San Joaquin Valley impassible throughout much of the year and supplied perennial species with deep waterings. As summer progressed, channels and sloughs would dry up, and late season vegetation and pioneering species would encroach in channels and banks. This drying phenomenon still occurs today in riparian forest remnants.

The effect of flooding on the phenology of native plants is so distinct that Oregon ash (*Fraxinus velutina*) from the Sacramento River Valley produces leaves on average one month before San Joaquin Valley ecotypes, presumably due to the longer time required for southern

Sierra snowmelt to drain to the valley floor. When drought renders sloughs and channels too dry for aquatic communities, terrestrial wildlife and plants proliferate. Extended wet periods reclaim those areas for aquatic species.

Just like the plants adapted to the drying and wetting dynamics of the San Joaquin River, so did the wildlife. Riparian bird and fish populations adopted a migratory strategy: they simply move into the area only when the season is right. Small mammals adopted a population survival strategy involving high fecundity: they simply reproduce abundantly only when conditions are good.

As humans settled the San Joaquin Valley we built dams, drains,

FIGURE 1: FLOOD REFUGIA OR "BUNNY MOUNDS."



Following a flood in 2006, project planners went back to the drawing boards and designed "bunny mounds" to protect the rabbits from predators in case of future flood events. The mounds were planted with a variety of native shrubs including a skirt of sandbar willow (*Salix exigua*) that serves as green rip-rap, reinforcing the mound base from erosion. Planting densities range from 227 to 845 plants per acre depending on target habitat conditions. Image courtesy of River Partners.

FIGURE 2. HABITAT RESTORATION AREAS IN STANISLAUS COUNTY



Habitat restoration is focused on lands depicted in green at the San Joaquin River National Wildlife Refuge, as well as lands depicted in red and purple at Dos Rios Ranch and the adjacent Hidden Valley Ranch totaling over 5,000 acres at the confluence of the San Joaquin and Tuolumne Rivers.

Source: River Partners, 2014.

levees, and highways. We drained wetland complexes and severely altered the frequency and extent of flooding. We also cleared the riparian forests and shrublands along the river's edge, even resorting to dynamite to remove the massive root balls of ancient valley oaks. What stands in their place today are dairies, orchards, and occasionally a small city perched precariously next to the levee or drain. When the human-made river system of the San Joaquin Valley is overwhelmed, the resulting water damages exceed hundreds of millions of dollars. These constructed places are tenuously reliant upon aging, publicly maintained infrastructure for both flood safety (via dams and levees) and continued agricultural productivity (via reservoirs and canals).

In early January 1997 a warm storm dropped 30 inches of rain at elevations up to 11,000 feet on the southern Sierra Nevada while it was already laden with higher than average snow. Over the course of a few

days, this rain-on-snow event created runoff conditions that quickly overtopped the dams and punched holes in carefully engineered levees as if they were small mounds in a sandbox. Water stretched for miles from the foothills of the Sierras to the Coast Range along the lower San Joaquin River. It inundated vast expanses of farmlands and the straggly remnants of our native riverbank plant communities, drowning out their wildlife populations.

Researchers that had been carefully documenting the extent and abundance of a rare riparian rabbit for several years feared that these floods had finally driven the species to extinction. The riparian brush rabbit (RBR) (*Sylvilagus bachmani riparius*) once inhabited riparian woodlands from Stockton to Fresno, but due to vegetation clearing was now only known from one small population at Caswell Memorial State Park near Modesto. This species and another also found in the same area, the San Joaquin woodrat (SJW) (*Neotoma fuscipes riparia*), were listed as federally endangered in 1998. Thankfully the 1997 floods did not completely destroy the rabbit and woodrat populations, and a few scattered populations have been found since then.

If you've ever heard the phrase, "Never let a good disaster go to waste," this disaster proved a prime example. It was the birth of a successful recovery effort, successful because it linked agency and private sector partners; scientists and farmers; and wildlife recovery and horticultural restoration specialists in an adaptive management framework. Since 1997 this collaborative group, the Riparian Mammals Technical Group (see Table 1) has been working towards the recovery of endangered wildlife species through land acquisition and protection, habitat restoration, research, captive breeding, reintroduction, and integrated flood management. In 2002, the largest contiguous riparian habitat resto-

**TABLE 1. PARTNERS IN THE RECOVERY OF THE RIPARIAN BRUSH RABBIT.**

US Fish and Wildlife Service  
 San Joaquin River National Wildlife Refuge and Central Valley Project Conservation Program and North American Wetland Conservation Act  
 USDA Natural Resources Conservation Service—Wetland Reserve Program  
 US Bureau of Reclamation—Central Valley Project Improvement Act Habitat Restoration Program  
 US Army Corps of Engineers  
 California Department of Fish and Wildlife  
 California Department of Water Resources  
 California Wildlife Conservation Board  
 Central Valley Regional Water Quality Control Board  
 San Francisco Public Utilities Commission  
 CSU Stanislaus Endangered Species Recovery Program  
 Point Blue Conservation Science  
 Stanislaus Audubon Society  
 Tuolumne River Trust  
 American Rivers  
 Natural Resources Defense Council  
 Natural Heritage Institute  
 National Fish and Wildlife Foundation

Source: River Partners, 2014.

ration initiative in California was launched at the San Joaquin River National Wildlife Refuge, and in 2012 and 2013 more than 2,000 acres were purchased and permanently protected at Dos Rios Ranch in Stanislaus County, primarily to support recovery of RBR in coordination with improved flood management.

When the restoration began there were so few remaining stands of valley riparian forest that we lacked both solid reference sites and sufficient suitable plant material needed to propagate native trees and shrubs for this large-scale project. Fremont's cottonwood (*Populus fremontii*), valley oak (*Quercus lobata*), and Goodding's black willow (*Salix gooddingii*) serve as the megaflores for valley riparian forests. However, the vegetative complexity of the understory (shrubs and herbs such as California blackberry (*Rubus ursinus*) and wild rose (*Rosa californica*),

nettles (*Urtica dioica*, *Stachys ajugoides*), sedges (*Carex* spp.), mugwort (*Artemisia douglasiana*), and Great Valley gumplant (*Grindelia camporum*) may be even more important to wildlife recovery than those iconic tree species.

Restoration ecologists from River Partners, the US Fish and Wildlife Service, CSU Stanislaus' Endangered Species Recovery Program, and other agencies and organizations met to discuss habitat needs for the rabbit. In particular the team focused on the logistics of horticultural restoration to support the rabbit while considering the effects of today's dams, levees, canals, and diversions on the natural riverine landscape.

From 2002 to 2006, over 800 acres of habitat restoration was completed at the Refuge, including the cultivation of 22 native plant species in a variety of patterns designed to attract target wildlife. See Table 2



This series of images (CLOCKWISE FROM TOP LEFT) shows a restoration project from planting through three growing seasons. Seasonal variation in vegetation is evident in the bottom right image (springtime) and bottom left image (autumn). Photographs courtesy of River Partners.

for a list of plants used in the restoration project. These restored forests are sometimes affectionately called “Franken-forests” because nowhere along the San Joaquin River today would you find such native floral diversity in one location. We

planted slow-growing valley oaks next to fast-growing cottonwoods and willows to provide forest cover today and for the next 100 years. We planted coyote brush (*Baccharis pilularis*) next to buttonbush (*Cephalanthus occidentalis*) to provide con-

tinuous shrub cover during periods of drought and floods.

After two growing seasons caring for the trees and shrubs, helping them to develop deep root systems through flood irrigation, and performing aggressive weed control



around their bases, we seeded a native understory of creeping wild rye (*Elymus triticoides*), mugwort, and gumplant. These perennial species are abundant on undisturbed floodplains of the San Joaquin River, and grow fast enough to outcompete annual invaders.

In 2006 as an additional 300

acres were being prepared for restoration, a late spring flood event once again broke the levees and tested our restoration. Floodwaters persisted for over four months in some locations, helping to sort out the “Franken-forests” into more-natural mosaicked native plant communities based on each individual plant species’ tolerance to flooding. For example, in localized high-ground areas, flood-sensitive elderberries (*Sambucus nigra* ssp. *caerulea*) persisted and provided cover from predation for the rabbit and other ground-dwelling wildlife. In low-lying areas that were deeply flooded, the elderberries did not survive. In contrast, sandbar willow (*Salix exigua*) and buttonbush thrived and spread in localized wet areas. In dry years since then, we have seen a death of willows and buttonbush in higher elevation areas due to drought stress. Such sorting has made the restoration a mosaic of plant communities that are well-adapted to current on-site conditions.

At first, we were not able to restore vegetation on levees, which are maintained free of vegetation due to regulations of the US Army Corps of Engineers (USACE). In the flood of 2006, snakes, squirrels, foxes, and rabbits fleeing the rising floodwaters were stranded on levees and were easy pickings for the circling hawks and owls. Our restoration collaborative quickly realized that in order to recover a resilient rabbit population, additional work was needed to provide vegetated flood refugia for rabbits and other prey species. Following this 2006 flood event, we went to work fundraising and designing specific flood refugia restoration projects.

The Restoration Plan for the 300 prepared and flooded acres was changed to include excavation of wetland swales to support migratory waterfowl, and piling the excavated material into flood refugia or “bunny mounds” across the landscape (Figure 1). A topographic sur-

vey was performed showing those areas most appropriate for earthmoving. Bunny mounds were then planted with drought and flood tolerant shrubs and herbs, and protected from erosion by a dense planting of sandbar willow around the base—a sort of “green rip-rap.” With collaboration from the USACE and California Department of Water Resources, the previously denuded levee slopes were planted with woody shrubs on drip irrigation. In total, over 30 bunny mounds and 8 miles of levee slopes across more than 3,000 acres of SJR floodplains were vegetated with plants specifically targeting RBR and SJW.

Restoration has continued to proceed in phases over the years as funding and permits allow. One benefit of restoration phasing was that our team was afforded the opportunity to analyze the performance of restoration actions and adapt the plan for the next phase to improve restoration success (our version of “adaptive management”). For example, in 2008 a fire swept across the Refuge, burning over 400 acres of previously restored and remnant riparian forests and shrublands. Our team was able to observe the response of the restored and remnant plant communities, altering the planting plans as a result of these observations.

We also learned over time about other wildlife species using the restoration areas. In 2006 and 2007, Least Bell’s Vireo (once the most abundant riparian songbird in the San Joaquin Valley, now near extinction and federally endangered) nested in our “Franken-forests.” We observed the nesting and replicated those conditions in other locations across the project area.

In total, over \$50 million in fee-title and easement acquisition and habitat restoration funding was garnered from more than a dozen different sources. Over 5,300 acres were protected for riparian forest restoration specifically targeting RBR, SJW, native fish, waterfowl, and neo-

TABLE 2. PLANTS USED IN THE RESTORATION PROJECT.

High-Ground Flood Refugia	Floodplains	Bottomland Forests
<b>Trees</b>		
Arroyo willow	Valley oak	Valley oak
Box elder	Fremont's cottonwood	Fremont's cottonwood
	Goodding's black willow	Goodding's black willow
	Arroyo willow	Arroyo willow
	Box elder	Box elder
		Oregon ash
<b>Shrubs</b>		
Coyote brush	Coyote brush	Buttonbush
Mulefat	Buttonbush	Sandbar willow
California blackberry	California blackberry	California blackberry
California rose	California rose	California rose
Mexican elderberry	Golden currant	Golden currant
Golden currant		
<b>Herbs and Grasses</b>		
Mugwort	Mugwort	Mugwort
Great Valley gumplant	Great Valley gumplant	Great Valley gumplant
Creeping wild rye	Creeping wild rye	Creeping wild rye
Evening primrose	Evening primrose	Evening primrose
Spanish clover	Stinging nettle	Hedge nettle
Basket sedge	Telegraph weed	Stinging nettle
Salt grass	Spanish clover	Dogbane

Source: River Partners, 2014.



tropical migratory songbirds. Phased restoration continues today, and is expected to be completed in 2025. By then this project will have increased the available habitat for RBR by more than 30 times its 1997 extent, and the restored habitat will protect the population from nearing extinction in inevitable future flood events.

Both vegetation and rabbit monitoring have documented our success. Survival of plantings never dropped below 80% after three years of growth, and vegetative cover continued to meet or beat expectations. The restored vegetation was also aggressive enough to outcompete invaders. Over time we have seen natural recruitment of native vegetation, showing that once the plant communities are established, they are



Flooding along the San Joaquin River in March 2011 inundated restored habitat at the San Joaquin River National Wildlife Refuge and agricultural fields at Dos Rios Ranch in Stanislaus County. Photograph courtesy of River Partners.

well adapted to the site. Although encouraging, plant survival and cover is only part of the story for this project to be deemed successful.

Starting in 2003, radio collars were deployed to monitor rabbits that had been bred in captivity and released into the restored areas. Through this monitoring, we found that the RBR preferred using the bunny mounds and other flood refugia to restored floodplains, even during dry years. Radio-collared rabbits also helped us to prioritize land acquisitions. Seasonal rabbit trapping showed us that the restoration was working, yielding higher frequency of trapping each year that the restoration matured.

Rising floodwaters in 2011 provided the real test of restoration suc-

cess. While not a large flood year for most of the state, spring of 2011 brought enough snowmelt to the Lower San Joaquin River to overwhelm the flood control levees again and inundate the Refuge and Caswell Memorial State Park. This time vegetated flood refugia were available across the landscape for rabbits fleeing the rising waters. In fact, so many rabbits found their way to the flood refugia that they caused a dramatic denuding of the carefully restored vegetation during their stay. Concerned wildlife managers boated out with provisions for the stranded bunnies only to find some bunny mounds also hosting coyote, foxes, and weasels (predators of RBR).

Following the 2011 flood, RBR

trapping across the Refuge showed that not only had the bunny mounds preserved a small portion of the RBR population to serve as the founders for a repopulation, but that just two months after floodwaters had receded, RBR were venturing back out onto the floodplain. Today we describe the Refuge as a restored population of RBR. While we still expect flooding to cause periodic damage to the vegetation and the wildlife, we know that the plants and the bunnies are resilient and will now be able to weather such disturbances into the future.

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