

National Wildlife Refuge Management on the United States/Mexico Border

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Abstract—Many conservation strategies have been developed by the U.S. Fish and Wildlife Service in cooperation with others to protect habitat and enhance the recovery of fish and wildlife populations in the San Bernardino Valley, which straddles Arizona, United States, and Sonora, Mexico. Habitats along this international border have been impacted by illegal activities, frustrating recovery of rare species. In addition, potential threats to national security have prompted the United States to aggressively control the country's boundaries, thus creating additional challenges for land managers mandated with protecting the nation's landscapes, natural resources, and associated values. Such challenges are not insurmountable and, with focused coordination, resource management and border security can be achieved and can often compliment one another. With or without the influence of changes along the international border, an effective species recovery strategy must include a coordinated approach that involves assessing the biological requirements of selected species through combinations of inventory, monitoring, and research activities; managing and protecting existing and historic habitats and populations; assessing potential reintroductions of key species into appropriate habitats where feasible; managing exotic plants and animals that threaten the recovery of desired conditions; and providing outreach and education relative to the species, their habitats, and the ecosystems upon which all fish, wildlife, and humans depend.

Introduction and Management Context

The U.S. Fish and Wildlife Service (Service) manages the 2,369-acre San Bernardino National Wildlife Refuge (SBNWR) and the 2,765-acre Leslie Canyon National Wildlife Refuge (LCNWR) located in southeast Arizona's Cochise County adjacent to the international border with Mexico. Both refuges were established under the authority of the Endangered Species Act of 1973 and the Fish and Wildlife Act of 1956 in order to "...conserve fish or wildlife which are listed as endangered species or threatened species...or plants." The refuge landscapes support a documented high diversity of species including at least 493 plants, 332 birds, 67 mammals, 43 reptiles, 13 amphibians, 8 fish, 77 dragonflies and damselflies, 130 butterflies, and over 450 bees.

The primary role of SBNWR and LCNWR is to sustain and recover the native fish of the Río Yaqui Basin (USFWS 1994), which is a large watershed that drains portions of southeastern Arizona and southwestern New Mexico in the United States, and eastern Sonora and western Chihuahua in Mexico. This geographic region is well known for containing enormous biological wealth on both sides of the border (Brown and Kodric-Brown 1996; Sayre and Knight 2009; Van Schoik and others 2006), and cooperative efforts between the

Service and environmentally sensitive landowners in the United States and in Mexico are implementing conservation strategies to protect and restore land and water sources, promote applicable monitoring and research, and reintroduce and maintain self-sustaining fish and wildlife populations (Austin in press; USFWS 1995). Properties are being managed in ways that acknowledge that they are all simply parts of the bigger landscape necessary to perpetuate a healthy mix of plants, fish, and wildlife within the region. Management and restoration efforts are viewed in the context of the entire landscape with a view beyond individual ownership boundaries or the international border. Such a view helps maintain habitat integrity across boundaries, a critical need for wildlife migration and dispersal.

Environmental restoration by government agencies and private landowners is ongoing in this region, and specific goals and objectives of such efforts on both sides of the border in the San Bernardino Valley are focused primarily on maintenance of open space and sustainable restoration of ecological relationships in such a way that the residents of the region may continue a productive rural lifestyle. Wetland restoration throughout the watershed is benefitting populations of all wetland dependent species by increasing the availability of seasonal and permanent water, by increasing the overall quality and quantity of water, and by lessening the potential for erosive scouring of wetlands during extreme flood events. Watershed function of uplands is also being enhanced, positively impacting the entire landscape along with the fish, wildlife, and human populations that they support. An example of these efforts is the ongoing grassland restoration and stream restoration being implemented on Rancho San Bernardino in Sonora. This project is allowing native fish like Mexican stonerollers (*Camptostoma ornatum*) to re-colonize upstream refuge wetlands without the need for active reintroductions.

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Balancing Border Security And Conservation

The San Bernardino Valley is attractive to people for reasons other than its natural biodiversity. SBNWR, LCNWR, and adjacent lands are isolated wildland areas adjacent to the U.S./Mexico border that have become arteries for human trafficking and narcotics smuggling organizations. Such activities are sometimes a hazard to landowners, resource managers, and area visitors because immigrants and smugglers have become increasingly violent and determined to continue their illegal activities. The problem is not just the movement of people and drugs, but includes related illegal activities (Billington and others 2010) such as vandalism, arson, accidental wildfire, property damage, burglary, theft, assault, and even murder conducted by both northbound and southbound people. In response to escalating security concerns, the U.S. Border Patrol (USBP) is aggressively enforcing laws to deter and prevent illegal activities and apprehend smugglers. This effort has promoted national security and has also benefitted the environment by helping reverse the adverse environmental effects of illegal border activities.

Unfortunately, enforcement of illegal activities along the border may also result in incidental property damage and adverse impacts to environmental and cultural resources (Cohn 2007; Christen and Matlack 2009; Duncan and others 2010; Forman and Alexander 1998; Sayre and Knight 2009; Segee and Neely 2006; Shepard and others 2008; Trombulak and Frissell 2000). Aggressive border security measures may affect endangered species and their habitats when it becomes necessary to clear vegetation, which may in turn alter natural water flow, reduce water absorption and infiltration, and impact aquifer recharge capacity. Operation of vehicles off established roadways or across wetlands and flowing streams may discharge petroleum products or other pollutants, increase siltation within perennial and seasonal streams or washes, and accelerate erosion and mobilization of fragile hydric soil types characteristic of the region. Each of these impacts may also negatively influence recovery of endangered plant species by increasing the potential for soil particles to become airborne during dry periods, potentially affecting air quality, vegetation transpiration, and pollination. Terrestrial endangered species may be impacted through crushing or other direct mortality (Glista and others 2009; Lalo 1987; Romin and Bissonette 1996). Aquatic species may be affected by increasing siltation of streams and other wetlands following major precipitation events. These events may result in higher than normal levels of erosion and siltation, which potentially affects oxygen availability, gill function, and reproduction. Illegal activities and their undesirable impacts on the environment are not new; for at least the past 100 years the San Bernardino Valley has been used as a travel route for smugglers and illegal immigrants. However, since about 2001, numbers of illegal immigrants, smugglers, and USBP agents have increased dramatically. Therefore, illegal border activities and the enforcement to control those activities remain threats to resource management and species recovery efforts on SBNWR and LCNWR.

An effective balance can be achieved between the U.S. Department of Homeland Security (DHS) mission of protecting U.S. borders and the U.S. Department of Interior (DOI) mission of protecting natural and cultural resources. SBNWR staff have been active partners with USBP and Immigration and Customs Enforcement (ICE) in planning and implementing national security ever since the refuge was established. More recently, increased cooperation between the Service, USBP, and ICE personnel has additionally enhanced safety, national security, and natural resource protection. Through such cooperative efforts, many of the damaging impacts of illegal activities and

required enforcement have been avoided, minimized, or mitigated. This cooperative effort is exemplified by the work of Service law enforcement officers who function as environmentally sensitive force multipliers serving national security and land management objectives in a cost effective manner. At SBNWR and LCNWR, the Service is assisting with national security efforts and has an effective strategy for monitoring, preventing, and controlling illegal activities by securing refuge boundaries, controlling access, and halting illegal immigration. Service law enforcement officers play an important role in monitoring human access on Refuge lands by using a system of remote seismic sensors and cameras, by patrolling for illegal activities and looking for footprints, by regularly communicating with USBP agents through an improved radio system, and through joint patrol work.

It has become routine for Fish and Wildlife Officers to work with USBP to conduct enforcement activities on and adjacent to Refuge lands and in areas having sensitive natural resources. The Service and USBP have been demonstrably proactive in ensuring that national security and environmental protection are not mutually exclusive objectives, and such cooperation has been very effective, resulting in a decrease of illegal activities occurring on the Refuges. For example, “unofficial” USBP statistics show an average apprehension rate of about two individuals per month on SBNWR for the period October 2011–April 2012; down significantly from 2010, when “unofficial” USBP statistics depicted an average of 142 individuals apprehended each month on SBNWR (USBP, unpublished data).

SBNWR and LCNWR are enclosed by fences, allowing controlled public access that is limited to daytime use only. Most of the south SBNWR boundary is protected by a wildlife permeable vehicle barrier to protect sensitive wetlands, and has been completely effective in preventing vehicle incursions onto the refuge from Mexico since its construction in 2005. Trail cameras and other tactics are used to document and monitor wildlife use of riparian corridors and wetlands, and also identify and document illegal human activities occurring on the refuges. Habitat restoration is being accomplished to benefit wetland, upland, and riparian-dependent species. Refuge pond construction and stream restoration make human travel through mud and water difficult, so wetlands tend to be avoided by those engaged in illegal activities. Grassland restoration is being accomplished through prescribed burning and removal of invasive mesquite trees, providing benefits to resident and migratory wildlife and also removing cover once used by smugglers, increasing visibility across the landscape, and therefore deterring illegal activities. Existing administrative roadways are maintained to increase refuge management efficiency and also to promote effective law enforcement, detection, monitoring, and deterrence of illegal activities. These roadways are being upgraded with base coarse material to provide all weather use and to minimize soil particle movement into the air or into adjacent wetlands. Many roads are remotely monitored by seismically sensitive equipment to help track human activity timing, and by video surveillance cameras to help identify refuge users. Refuge staff and heavy equipment routinely maintain portions of the border road within the Roosevelt Reservation adjacent to SBNWR to ensure passage by USBP agents through areas prone to frequent flooding and sediment deposition.

Many USBP activities have further enhanced Refuge protection and endangered species recovery. For example, USBP operates Mobile Surveillance System equipment in the San Bernardino Valley to help interdict illegal activities, and this equipment is located in off-refuge areas that maximize the deterrence of illegal activities throughout the Valley without negatively impacting refuge lands. Additionally, DHS contractors have surfaced many border roads used by USBP with material that allows all weather vehicle travel and limits dust and sediment transfer into the environment. USBP has allowed grasses to

grow within the 60-foot Roosevelt Reservation rather than attempting to maintain this easement as a corridor that is completely free of vegetation. The original international border fence was not very wildlife permeable, consisting of an eight-strand barbed wire barrier reaching up to 5-feet tall. This barrier altered cross-border movement of wildlife, though some species were capable of moving over or under the barbed wire fence, or of utilizing existing breaks in the fence that allowed easier passage. Construction of vehicle barriers immediately adjacent to the existing barbed wire border fence further reduced wildlife movement. Mule deer (*Odocoileus hemionus*) that often seemed willing to jump the barbed wire fence would not attempt to jump the enhanced obstacle of a barbed wire fence combined with a vehicle barrier. The removal of the barbed wire fence by USBP, other agency personnel, landowners, and volunteers has greatly benefitted cross-border wildlife movement (Sayre and Knight 2009).

Several environmental concerns were favorably addressed by DHS and their contractors by installing vehicle barriers designed so that wildlife movement would not be obstructed; investigating and protecting cultural resources from potential damage; conducting construction during winter to avoid impacts to nesting birds and to avoid periods of heavy, erosive rainfall; and reseeding some disturbed areas to prevent sheet erosion and promote the growth of native grasses. A substantial bridge was constructed by DHS contractors across Black Draw to provide vehicular access along the border within the Roosevelt Reservation while also minimizing negative impacts to the perennial stream and associated species. These examples illustrate that DHS officials are committed to working with SBNWR personnel to minimize disturbance to the refuge, to protect the environment, and to protect endangered species. Not all of the foreseeable environmental impacts related to the congressional mandate of maintaining national security could be minimized or eliminated, so DHS officials collaborated with the Service to identify solutions for potential environmental problems created by the infrastructure, and DHS committed to funding up to a total of \$50 million through January 2018 to support various environmental projects to be split among California, Arizona, New Mexico, and Texas. These projects demonstrate some positive approaches toward reconciling national security and environmental objectives along the international border.

DHS-Funded Environmental Projects

Work on many DHS-funded environmental projects has been initiated on and adjacent to SBNWR (USFWS 2011). A concrete fish barrier in Black Draw near the border is being designed and will be constructed to allow downstream movement of native fish but will prevent upstream migration of non-native fish species. This is the best available option for achieving segregation of native fish from predatory exotic fish occurring downstream in Mexico. A series of shallow wetland units have been constructed, and will help maximize biodiversity and optimize the production of self-sustaining populations of native fish and wildlife. The construction and placement of multiple rock-filled wire cage erosion control gabion structures is being accomplished in key locations throughout the watershed to catch water-borne sediments being transported during precipitation events, improve the landscape's ability to halt and slow the scouring erosive impacts of seasonal flood flows, more effectively catch and hold precipitation runoff to provide water for fish and wildlife, help restore groundwater recharge in the shallow aquifer, allow increased soil stabilization, and ultimately help enhance vegetation corridors for wildlife movement. Construction debris deposited by contractors in several San Bernardino Valley staging areas during vehicle barrier construction has been removed and these areas have been seeded with

native grasses to help control the density and spread of non-native vegetation that could otherwise become invasive and dominate the landscape. Two separate irrigation wells on and adjacent to SBNWR were drilled to ensure adequate water quantity and quality capable of enhancing populations of federally listed species: Yaqui chub (*Gila purpurea*), Yaqui topminnow (*Poeciliopsis sonoriensis*), Yaqui catfish (*Ictalurus pricei*), and San Bernardino springsnails (*Pyrgulopsis bernardina*) located in the area on both public and private lands. The Service and DHS are also working collaboratively with the University of Arizona to monitor Río Yaqui fish species and their habitats on and adjacent to SBNWR to assess their population status and evaluate the potential affects of sediment mobilization into wetlands. Each of these environmental projects, supported financially by DHS, is important to recovery of listed species in the United States and Mexico.

Rare Species Recovery Strategy Inventory, Monitoring, and Research

With or without the influence of changing human activity or land use along the international border, effective recovery of rare species must include coordinated assessments of the biological requirements of selected species through combinations of inventory, monitoring, and research. Refuge staff and collaborators are monitoring species population trends and conducting research to identify management actions that will support species recovery in efficient and cost effective ways. Various refuge monitoring projects are providing information that may be useful in assessing the effects of various border impacts on wildlife populations, and these projects can each function to produce data used by border managers in multiple ways by (1) determining the presence, absence, and relative abundance of species and serving to provide basic inventories and baselines upon which to compare against in the future; (2) documenting use of habitat types by various target species and identifying important wildlife movement corridors between Arizona and Sonora; (3) documenting the dynamics and long-term changes in wildlife use of habitats; (4) determining the impacts of border related activities on habitat use by animal populations; (5) identifying areas of potential conflict between humans and wildlife; and (6) evaluating the impacts that illegal human activities have on plant and animal populations and on animal movement patterns. For example, to learn more about the groundwater aquifer conditions and trends relative to climate change or other influences within the Leslie Creek and San Bernardino Valley watersheds, monitoring wells have been installed to provide a continuous record of water levels on both private and Refuge lands. This data has provided information concerning groundwater and surface water relationships in the watershed, has substantially increased an understanding of the hydrology of Leslie Creek, and shows a declining trend in the level of the aquifer at LCNWR likely related to declining winter precipitation in the Chiricahua Mountains (Broska 2009a).

Monitoring wells in the San Bernardino Valley are documenting that groundwater levels have been raised in some locations (Broska 2009b), and the Río San Bernardino now flows continuously and perennially from north of the U.S. border on SBNWR southward across Rancho San Bernardino to well beyond Mexican Highway 2. To help determine hydrological relationships among individual springs, ponds, and wells on SBNWR and the adjacent privately owned Johnson Historical Museum of the Southwest (Slaughter Ranch), Refuge staff is collecting samples and analyzing water chemistry. This data will benefit management of federally listed species while also providing information for Slaughter Ranch managers and visitors on the safety of consuming the water.

Partners conduct annual monitoring of native fish populations on both sides of the border, and on both private and Refuge lands, to determine and document fish health, fecundity, and population trends. Population monitoring of other federally listed species, such as the Huachuca Water Umbel (*Lilaeopsis schaffneriana* var. *recurva*), the Cochise pincushion cactus (*Coryphantha robbinsorum*), the Chiricahua leopard frog (*Lithobates chiricahuensis*), and the San Bernardino springsnail is accomplished periodically to help document the recovery of these species, to identify threats, and to increase our understanding of ecological associations (Malcom and others 2005; Varela-Romero and Myers 2010).

Long-term monitoring of breeding bird species is being accomplished at both SBNWR and LCNWR to provide data on population and demographic parameters for targeted species. The information collected is providing a better understanding of the productivity, survivorship, and population trends of avian communities on the refuges. Basic long-term reptile and amphibian population monitoring is being conducted on these Refuges to help document species richness, understand ecological trends, investigate population dynamics and the roles of rare species, and to help support resource management decisions. SBNWR and LCNWR serve a large assemblage of wildlife species and provide important landscape features in the form of linear riparian areas. The use of such riparian corridors by large mammals is not well documented (Bennett 1990; Laurance and Laurance 1999). Increasing human activities and development in the San Bernardino Valley might be expected to impact the natural movement and behavior of large mammals, and wildlife movement corridors are expected to become even more important, making our better understanding of these areas crucial to effective management.

Habitat and Population Management and Protection

Managing and protecting existing and historic habitats and wildlife populations is being accomplished by the Service and conservation partners using a variety of effective mechanisms, including the Endangered Species Act Safe Harbor Program, Habitat Conservation Planning for rare species, Service challenge cost share agreements, acquisition of conservation easements, rights-of-ways, memorandums of understanding, and other collaborative approaches. Such cooperation is expected to increase in helping recover native plants, fish, and wildlife as funding become more limiting. These mechanisms provide a framework for establishing creative partnerships with the ultimate goal of reducing conflicts between listed species and planned activities on both public and private lands. For example, the impacts of climate change for the southwestern United States are anticipated to include higher temperatures and lower levels of precipitation. These changes will dramatically impact the ecology of the region. Wildlife migration routes may change, making it important that landscapes and the crucial corridors that interconnect private, state, and federal lands be protected and enhanced, along with the fish and wildlife populations that they support. A coordinated approach to management activities that compliment all the landowners in the San Bernardino Valley must be progressive and recognize the unique needs of each partner.

Species Reintroductions

When managing the recovery of rare plants and animals, it is often important to assess potential reintroductions of key species into ap-

propriate habitats, and this is occurring on and adjacent to SBNWR and LCNWR. The Service has an ongoing program of reintroducing federally listed threatened or endangered fish including the Yaqui chub, Yaqui topminnow, beautiful shiner, and Yaqui catfish into suitable habitats on private and public lands in the Río Yaqui watershed. A major positive step in the recovery of the Chiricahua leopard frog is being accomplished through an effective partnership between the Service, Arizona Game and Fish Department, U.S. Forest Service, and the American Museum of Natural History's Southwestern Research Station near Portal, Arizona. LCNWR is one of the last sites in southeast Arizona where Chiricahua leopard frogs occur naturally in the wild; however, this protected habitat for the frog is rapidly disappearing because increased extreme drought conditions are leaving the Refuge without flow in Leslie Creek. Tadpoles were therefore transported from LCNWR to Southwestern Research Station facilities where they were raised in a controlled environment and their progeny are then being released back into suitable habitat in the Chiricahua Mountains. The endemic San Bernardino springsnail currently exists in multiple isolated metapopulations in both Arizona and Sonora, with such populations further fragmented by the international border. This rare species is being helped through restoration of appropriate wetland habitat on Slaughter Ranch and SBNWR. Once adequate habitat is in place, springsnails from adjacent metapopulations will be restored to areas they once populated without human intervention.

Non-Native Species Management

Introduction of non-native plants and wildlife into environments where they did not occur naturally can have devastating effects on native populations (Bazzaz 1986; Courtenay and Stauffer 1984; D'Antonio and Vitousek 1992; McLaughlin 2002; Rosen and Schwalbe 1996; Rosen and Schwalbe 1998; Scott 1992). This is the case with the Asian tapeworm (*Bothriocephalus acheilognathi*) and bullfrog (*L. catesbeiana*), both of which are now established in the San Bernardino Valley. The Asian tapeworm is adversely affecting recovery of rare cyprinid fish species (Kline and others 2007). Populations of the Chiricahua leopard frog, lowland leopard frog (*L. yavapaiensis*), and Mexican garter snake (*Thamnophis eques*) have all experienced severe decline or have even been eliminated in the area as a result of bullfrog depredation (Rosen and Schwalbe 2002).

Continuing efforts are made by trained Refuge staff and volunteers to control the spread of non-native species from Refuge lands, however, total control will never be achieved given the complexity of the landscape and the widespread establishment and abundance of these species in the area. Fortunately, the vast majority of plant species in the area are natives, leaving the ecosystem relatively free from exotic plant invaders. Nonnative plants that are a current concern to Refuge managers include Russian thistle (*Salsola iberica*), Johnson grass (*Sorghum halapense*), Lehmann's lovegrass (*Eragrostis lehmanniana*), Malta starthistle (*Centaurea melitensis*), giant reed (*Arundo donax*), salt cedar (*Tamarix ramosissima*), and bufflegum (*Pennisetum ciliare*). The existence of all these species requires regular monitoring and control to reduce their spread and their resulting negative impacts to the recovery of rare native species. In some cases, if nonnative species were to establish themselves on the Refuges, restoration work being done would be severely compromised. Given the difficulty and expense of controlling non-native plants and animals once they have established themselves in an environment, efforts must focus on preventing the initial introduction of such species.

Outreach and Education

Under the National Wildlife Refuge System Improvement Act of 1997, national wildlife refuges offer several “priority public uses,” including hunting, fishing, wildlife observation, wildlife photography, environmental education, and interpretation when such activities are compatible with the purpose for which the refuge was established. Arizona’s Cochise County is a major international tourist destination due primarily to the region’s interesting human history and also because of the region’s unique and abundant natural history. SBNWR and LCNWR are two of the few refuges administered by the Service that were created specifically to protect rare native fish. Protection of this border region and restoration of associated fish and wildlife habitats and populations in both the United States and in Mexico by private landowners, conservation organizations, and government agencies including DHS will help ensure that the ecological balance that has been effective for centuries will continue to provide the conditions necessary for all fish, wildlife, and humans dependent upon the Río Yaqui Basin.

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