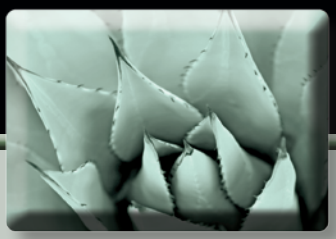
Chapter 3


Rio Grande
Dallas.
Austin
Houston
San Antonio
Gulf of Mexi
California



Chapter 3

Challenge Theme 1. Understanding and Preserving Ecological Resources

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Background

The notable biodiversity within the United States–Mexican border region is driven by the wide variety of natural landscapes in the area and its biologically unique transition zone of habitats for xeric, temperate, and subtropical species. Six diverse ecoregions cover the length of the border (fig. 3–1): California Coastal Sage, Chaparral, and Oak Woodlands; Sonoran Desert; Madrean Archipelago; Chihuahuan Desert; Southern Texas Plains; and Western Gulf Coastal Plain.

The unique geology and many of the distinctive geographic features and climatic conditions that have given rise to the diverse populations of plants and animals found in the Borderlands also attract human populations. The number of people living in the Borderlands has increased dramatically over recent years, from about 7 million in 1980 to almost 12 million in 2003; the population is estimated to be more than 18 million by 2020 (Peach and Williams, 2003). The human population increase and associated change in land use have contributed to habitat fragmentation and habitat loss for native species, thus threatening their survival. Some ways in which humans negatively affect plants and animals in the Borderlands include dewatering of aquatic ecosystems, water pollution, introduction and spread of invasive species, outdoor lighting, military and border enforcement activity, and energy development and transmission.

ecoregions

Base from U.S. Geological Survey
GTOPO30 (Global 30 Arc Second Elevation Data)

0 50 100 150 200 MILES
0 50 100 150 200 KILOMETERS

Ecological regions of North America data from Commission for Environmental Cooperation

EXPLANATION

Ecological Regions

- California Coastal Sage, Chaparral, and Oak Woodlands
- Sonoran Desert
- Madrean Archipelago
- Chihuahuan Desert
- Southern Texas Plains/Interior Plains and Hills with Xerophytic Shrub and Oak Forest
- Western Gulf Coastal Plain

Subareas of the border region

1. Pacific Basins–Salton Trough
2. Colorado River–Gulf of California
3. Mexican Highlands
4. San Basilio–Mimbres
5. Rio Grande West—Elephant Butte Reservoir to Rio Conchos
6. Rio Grande Central—Rio Conchos to Amistad Reservoir
7. Rio Grande East—below Amistad Reservoir to Falcon Reservoir
8. Lower Rio Grande Valley

International boundary

Figure 3–1. Ecological regions along the United States–Mexican border.

Biological Status and Trends

Gilded woodpecker
(*Colaptes chrysoides*)

Nongovernmental organizations, biological resource trustees, and regulatory agencies in the United States and Mexico are trying to manage the loss of local populations of species in addition to the extinction of species in the broader area of the Borderlands. In the U.S. portion of the Borderlands alone, 168 species—81 plant, 19 bird, 14 mammal, 23 fish, 10 reptile, 7 amphibian, and 14 invertebrate—are listed as threatened or endangered by the U.S. Fish and Wildlife Service (2009a). For many of these species, fundamental biological, ecological, and population data are not available. Obtaining these data becomes more difficult for biologists who must contend with the issues of species rarity, private lands, international politics, and the dangers of working in a region where there is criminal trafficking of goods, animals, and people.

Many species of birds, bats, and insects pass through the Borderlands in route to breeding or feeding areas. The lesser long-nosed bat (*Leptonycteris yerbabuenae*) migrates north in the spring from fall and winter roosts in south-central Mexico to spring and summer maternity roosts in the Sonoran Desert of Arizona and California. These bats have a mutualistic relationship with species of agave and the saguaro (fig. 3–2), and their foraging activities and migratory movements are dependent on the presence of these plants along an intact migration corridor. Migratory birds utilize the entire region as stopover habitat during migration (Skagen and others, 2005; Paxton and others, 2007), and many species winter in this region. For example, the Pacific Flyway brant (*Branta bernicla*) winters in the Colorado River delta where expansive marshes and mudflats historically have provided sufficient food resources. Today, only 20 percent of the Colorado River delta's wetlands remain (Glenn and Zamora-Arroyo, 2001). Loss of wetland habitats needed by the Pacific Flyway brant and many other species is largely caused by regulation of the Colorado River by dams, which reduce the river's flow and thus the replenishment of associated nutrient-rich sediments to the delta. Increased salinity and contamination of the Colorado River delta are also implicated in the decline of the vaquita (*Phocoena sinus*), a rare porpoise species endemic to the upper Gulf of California.

Pacific Flyway brant
(*Branta bernicla*)

House finch
(*Carpodacus mexicanus*)

Figure 3–2. A lesser long-nosed bat (*Leptonycteris yerbabuenae*) prepares to collect nectar from a saguaro (*Carnegiea gigantea*) (bottom). These bats have specialized anatomy (top)—elongated rostrums, long brush-tipped tongues, and a reduced number of teeth—that allows them to feed on the nectar and pollen of the saguaro (Fleming and others, 2001).

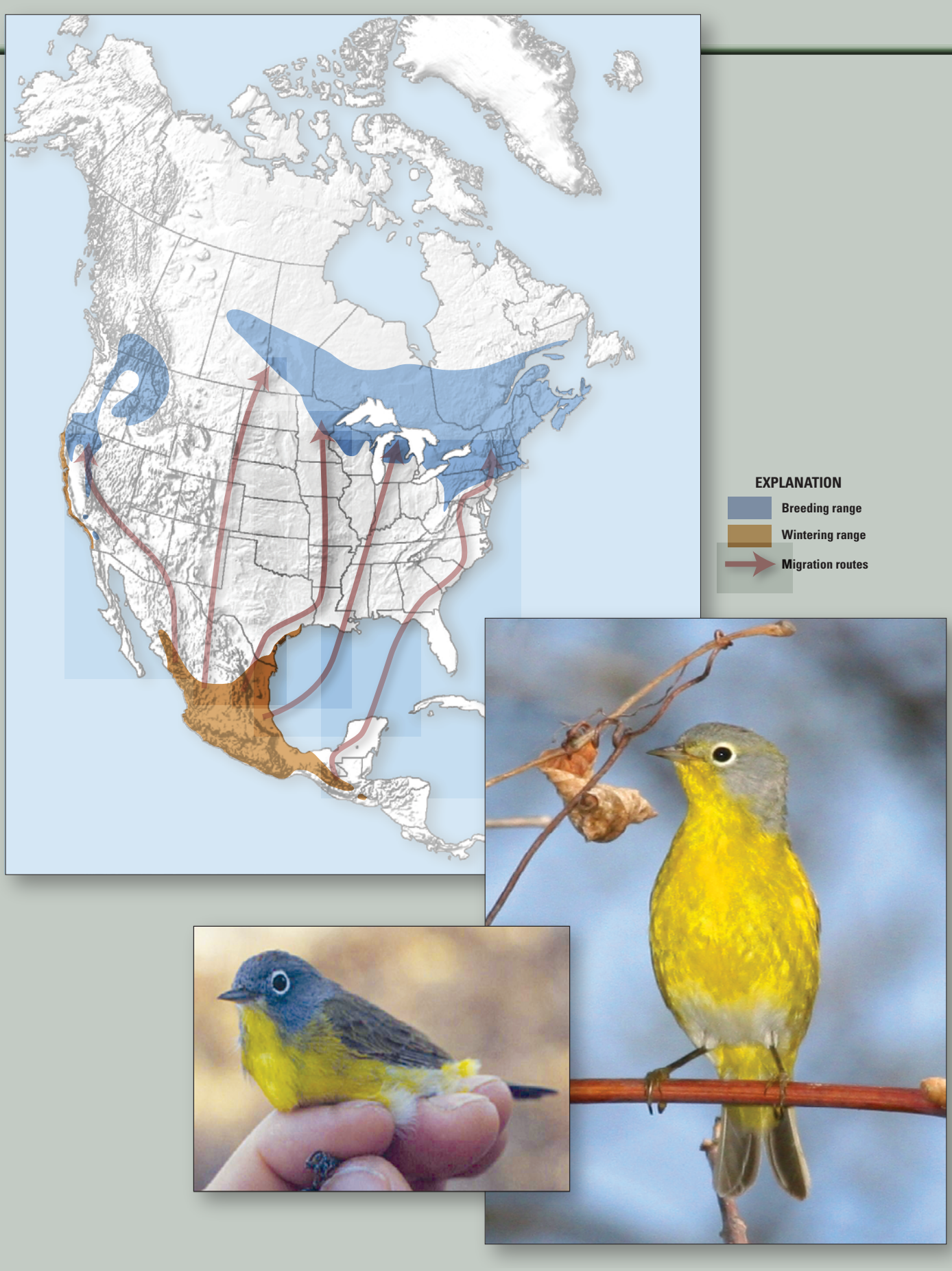
A Migrant Bird's Dilemma

For songbirds that breed in the United States or Canada but winter in the Caribbean or Central or South America, the act of migrating is physically demanding in terms of the energy needed. Because of their small size, many Neotropical migrant warblers are unable to carry sufficient reserves to migrate nonstop and thus must select locations to stop and refuel. Choosing appropriate stopover locations is important to ensure that individuals survive migration and reach their destinations in good condition. Although birds are known to actively choose when and where to stop (Hutto, 1985), little is known about how individuals judge the quality of potential stopover locations.

For example, birds prefer locations with an abundance of food, such as insects, yet the signs or cues that birds use to determine food availability remain largely unknown. One possibility is that birds determine food availability from the types or condition of local trees. The species of tree or changes in the phenology of a tree (for example, flowering, leaf-flush, fruiting, leaf-loss) may present birds that eat insects with an obvious and reliable predictor of insect abundance. Scientists with the USGS Sonoran Desert Research Station in Tucson, Ariz., have tested this possibility by monitoring stopover locations of 28 species of insectivorous Neotropical migrant songbirds at the Cibola National Wildlife Refuge (U.S. Fish and Wildlife Service) along the lower Colorado River and the San Pedro Riparian National Conservation Area (Bureau of Land Management) on the San Pedro River in southern Arizona (McGrath and van Riper, 2005).

In this study (McGrath and van Riper, 2005), USGS researchers were able to show for the first time that the flowering phenology of a common tree species, honey mesquite (*Prosopis glandulosa*), acts as a reliable cue for migrant birds at both local and landscape scales. That the flowering phenology of honey mesquite is a reliable indicator of actual food availability indicates the importance of this cue for migrant bird populations, at least along the San Pedro and Colorado Rivers. It remains unclear how the phenology of honey mesquite or other trees may influence other important migratory corridors that differ geographically, have different migratory peaks, and support different population and species assemblages. Future research should focus on the generality of this pattern and how climate change and invasion by exotic trees may alter settlement cues and thus adversely affect migrant species.

(Facing page) The Nashville warbler (*Vermivora ruficapilla*) (bottom left and right) is a Neotropical migrant bird species. Some of its major migratory pathways travel through the United States–Mexican border region (top; modified from Lowther and Williams, 2011).


EXPLANATION
Breeding range
Wintering range
Migration routes

Carnivorous mammals are at particular risk in the Borderlands. Their wide-ranging movements and sensitivity to habitat fragmentation make them susceptible to decreases in the availability of suitable corridors to sustain the animals' movements. Like a keystone that secures the stability of a structural arch, these keystone mammalian species are critical to the health of an ecosystem and to the maintenance of biodiversity in the Borderlands. Although many native carnivores in the Borderlands had disappeared or declined to near extinction by the early 1900s (Cockrum, 1982), a few species have maintained populations in the wilder parts of northern Mexico, and there is hope they can expand their ranges into protected areas in the United States. Species with ranges that extend north into the Borderlands include the black bear (*Ursus americanus*), the Mexican gray wolf (*Canis lupus baileyi*), the jaguar (*Panthera onca*), and the ocelot (*Leopardus pardalis*). For example, ocelots have a tenuous hold in south Texas (fig. 3–3), and jaguars are infrequently found just north of the Arizona-Sonora border.

Coyote (*Canis latrans*)

Grey wolf (*Canis lupus*)

ocelot

Figure 3–3. The photo of an ocelot adult and kitten (top) was taken by remote camera at the Laguna Atascosa National Wildlife Refuge, Texas, in 2008 and is the first time a mother and baby have been photographed together. The ocelot (*Leopardus pardalis*) (bottom) is an endangered species; fewer than 100 remain in the United States.

Bears and Sky Islands in the Southwest

The current range of the black bear (*Ursus americanus*) in the Borderlands is patchy and extends into southern Texas, New Mexico, Arizona, and Mexico, the southern end of the black bear range where they are endangered. The bears of this region commonly move between what are often called sky islands. The isolated mountain ranges of the Madrean Archipelago (fig. 3–1) form these ecosystem islands that serve as stepping stones for the movement of black bears through this region. The varied topography and extreme elevation gradients in the sky island ranges of the Madrean Archipelago have resulted in a rich flora and fauna (Toledo and Ordonez, 1993). Construction along the United States–Mexican border, such as border fences, can prevent the movements of the black bear across the border, could truncate their range or interrupt a contiguous distribution, and could lead to the retraction of this species' range away from the border.

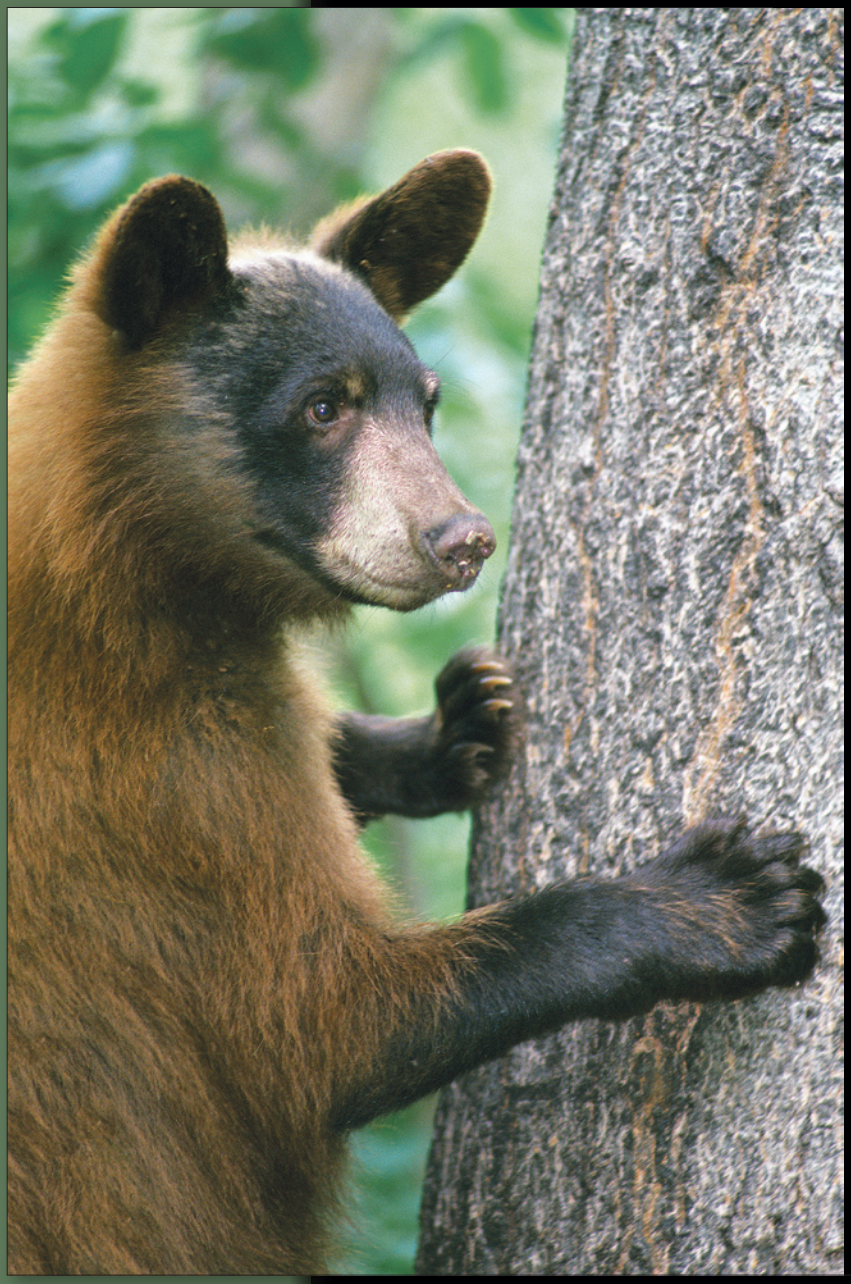
The use of nonintrusive techniques to obtain DNA would allow for a better understanding of the population genetics of the black bear in the Borderlands, which could have a critical role in ensuring the survival of this species in the southern extent of its range. Researchers with the USGS West Glacier Field Station of the Northern Rocky Mountain Science Center in Montana are using recent advances in genetic technology to extract DNA from grizzly bear (*Ursus arctos*) hair and scat without having to capture and handle the bears (Roon and others, 2005); these procedures could be used similarly to study the black bear populations in the Borderlands. Reliable bear population estimates can be determined in a nonintrusive manner, and the DNA collected from the samples can be used to evaluate the degree of genetic variation and relatedness of individuals.

The temperate and tropical species that survive in the arid and often rugged border environment live in habitats not typical to their species, contrasting sharply with the habitats of species populations living farther north or south. Survival of a species in a great range of habitat types may be a key element in that species' long-term survival and continued evolution, particularly when having to adapt to human-induced and natural climate changes. Construction along the border could prevent terrestrial vertebrates from moving across the border, which would likely be detrimental to our ability to preserve the health and continued function of ecosystems along this zone.

(Continued on page 52)

In the Borderlands, the black bear (bottom right) makes its habitat in the sky islands of the Madrean Archipelago, which includes areas such as Saguaro National Park near the Rincon Mountains (top left), the Chiricahua Mountains (top right), and the Santa Catalina Mountains (center).

black bear



Historical Range of Black Bear in North America

Range of Black Bear in North America in 1995

A juvenile black bear (*Ursus americanus*) (left) and a female black bear (right) with maps showing the change in the range of black bears in North America, historically (top center) and in 1995 (bottom center; both modified from Vaughan and Pelton, 1995).

Desert pupfish (*Cyprinodon macularius*)

Many native species that live in and near streams, rivers, and springs are also struggling in the Borderlands. Years of groundwater withdrawals, the operation of dams and reservoirs, diversions of river flows, competition from nonnative species, and habitat loss have all negatively affected many native species associated with aquatic habitats in the Borderlands. The federally endangered desert pupfish (*Cyprinodon macularius*) inhabits desert springs, cienagas, and small streams of the lower Gila and Colorado Rivers in Arizona, California, and Mexico (Center for Biological Diversity, 2011). Threats to the remaining five populations of this species include competition from nonnative fish, dam construction, livestock grazing, stream channelization, and aerial spraying of pesticides. Increases in the populations of nonnative species of fish and the bullfrog (*Lithobates catesbeianus*) correspond with a decline in populations of the narrow-headed garter snake (*Thamnophis rufipunctatus*) of Arizona, New Mexico, and northern Chihuahua (Pierce, 2007). The predicted effects of climate change are likely to worsen the already precarious existence of many of the Borderlands' rare and imperiled amphibians, such as the California red-legged frog (*Rana draytonii*), the Chiricahua leopard frog (*Lithobates chiricahuensis*), and the Tarahumara frog (*Lithobates tarahumarae*), among others.

Native plant species and terrestrial plant communities along the border are exposed to many threats from agriculture, suburban sprawl, wildfire, poaching, grazing, off-road vehicles, and nonnative plants. The invasion of nonnative plants can affect ecosystem structure and function by altering resource availability, soil stability and rates of erosion, accumulation of litter and salts, and natural fire regimes (Freeman and others, 2007). Along the Rio Grande in south Texas, near where the river reaches the Gulf of Mexico, 95 percent of the native thorn forest habitat has been lost with only a few "islands" of native habitat remaining. This part of the Borderlands is ecologically important because it is a crossroads of the climates of the subtropical Gulf Coast, the semiarid Great Plains, and the arid Chihuahuan Desert (U.S. Fish and Wildlife Service, 2009b). On the other end of the Borderlands, Arizona and southern California are combating buffelgrass (*Cenchrus ciliaris*), an invasive species that easily dominates native grasses (fig. 3–4). Buffelgrass spreads quickly, and because it grows densely, it can be a serious fire hazard. Many areas of the Sonoran Desert, once known for beautiful spring flowers, are now carpeted only with buffelgrass.

Climate change in the United States–Mexican border region is predicted to have a profound influence on existing biota (flora and fauna populations), both spatially and temporally. Increased rates of desertification in the Sonoran and Chihuahuan Deserts, both of which cross into the Borderlands, would adversely affect the biota of this area. The Chihuahuan Desert has the highest diversity of plants of any desert region on Earth (Chihuahuan Desert Research Institute, 2012). Even though desert biota are well adapted to extreme fluctuations in daily temperature and seasonal rainfall, their adaptability is not limitless. With desert temperatures in the Borderlands predicted to rise by the end of the century and rainfall to decrease by 2071–2100 (United Nations Environment Programme, 2006), some species may not be able to survive (see chapter 10 for more information). Climate change in the Borderlands would certainly accelerate the reduction in water availability for human and ecological needs. These changes would take place in a region whose population and thus water needs would continue to grow, particularly the San Diego–Tijuana (California–Baja California), Nogales-Nogales (Arizona-Sonora), and El Paso–Ciudad Juárez (Texas-Chihuahua) sister city areas.

Mexican bluewing (*Myscelia ethusa*)

buffelgrass

Figure 3–4. Buffelgrass (*Cenchrus ciliaris*) (facing page) is an invasive species that encroaches on native plant habitat. In Saguaro National Park in Arizona, buffelgrass surrounds a young saguaro cactus at the Javelina picnic area (top left; April 1998). In Sonora, 30 miles north of Hermosillo, buffelgrass has spread from cultivated buffelgrass pastures to rocky hillsides and native desert scrub (bottom left; January 1997).

Salt Cedar and the Forgotten Reach

The 470-kilometer (292-mile) reach of the Rio Grande from El Paso to Presidio, Tex., is recognized as the most dewatered reach of the river and has been referred to by some people as the Forgotten Reach. Annual flows in this reach are about one fifth of flow levels before regulation, and the historic late spring and early summer floods driven by snowmelt from the Rocky Mountains of southern Colorado and northern New Mexico have been all but eliminated (Collier and others, 1996). Because upstream regulation has reduced the occurrence of over-bank floods in the Forgotten Reach, monocultures of salt cedar (also known as tamarisk) have displaced the native gallery of willow (*Salix* spp.) and cottonwood (*Populus* spp.) in the riparian and floodplain habitats. Salt cedar is an exotic species introduced from southern Eurasia more than 100 years ago as an ornamental shrub and a method of controlling bank erosion. Once salt cedar becomes dominant in a given environment, the river channel becomes aggraded as the dense thickets of salt cedar trap sediment (Sudbrock, 1993), resulting in a narrower, simplified channel and thus uniform flow velocities, armored streambeds and bank slopes, and a less diverse fish assemblage and aquatic invertebrate community. Moreover, dense stands of salt cedar inhibit recolonization by native vegetation and can reduce the diversity of birds, rodents, and insects in riparian-floodplain habitats. Contemporary studies of evapotranspiration of riparian plants indicate that salt cedar and native riparian species, such as the cottonwood, transpire about the same amount of water (Shafroth, 2010). However, because salt cedar can grow in places higher above the water table than native riparian species, the total plant transpiration where salt cedar and native species are mixed can be higher (Grubb and others, 2006).

The issues associated with salt cedar and river management are among the topics addressed by the riverine science program at the USGS Fort Collins Science Center (FORT; *http://www.fort.usgs.gov/WaterWrks/*). The program brings together scientists specializing in various aspects of ecosystem science, allowing for multidisciplinary approaches to complex questions. The goal of the FORT riverine science program is to support river management decisionmaking by studying the relations between management actions and riverine ecosystems, for example, the response of invasive species such as salt cedar to altered flow regimes. Other examples of areas of FORT salt cedar research include managing areas overwhelmed by salt cedar through removal and revegetation and planning restoration for areas in the West where salt cedar has been controlled.

Salt cedar (*Tamarix ramosissima*) (background and top right) dominates the channel and floodplain of the Forgotten Reach, the portion of the Rio Grande between El Paso and Presidio, Texas (bottom left). As an invasive species, it competes with native flora for riparian resources.

Curve-billed thrasher (*Toxostoma curvirostre*)

USGS Capabilities

The United States–Mexican border region boasts the highest diversity of desert plants in the world, the largest number of bird species in North America, and some of the most wild and remote places in the United States and Mexico. These unique biological resources are at risk of habitat loss and fragmentation by barriers inhibiting dispersal and migration routes, the dewatering of rivers and streams, and other stressors influenced by global climate change. The U.S. Geological Survey (USGS) has unique capabilities that can help bring the best science to many of the most perplexing and critical issues associated with the ecological resources of the Borderlands.

Scientists with the USGS conduct research that assists resource managers in preventing the loss of species and recovering and protecting aquatic and terrestrial habitat. Scientists at the USGS Southwest Biological Science Center and the Arizona Cooperative Research Unit at the University of Arizona use genetics to detect historical and current wildlife connectivity across the United States–Mexican border. With DNA[1] fingerprinting, they monitor populations of American beaver (*Castor canadensis*), jaguar (*Panthera onca*), and puma (*Puma concolor*). Using remote sensing techniques, hair samples, and scat they identify the presence and ranges of mammal populations that move across the border.

Mexican Jay (*Aphelocoma ultramarina*)

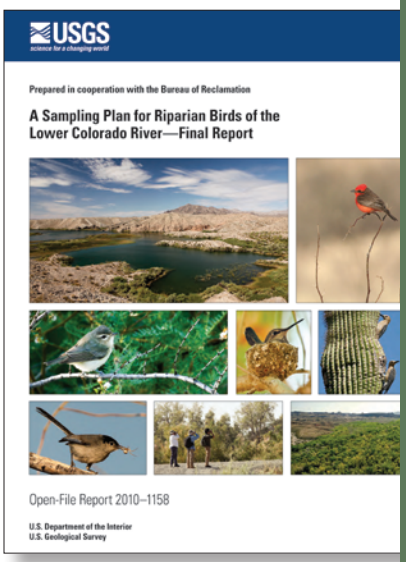
[1] DNA—deoxyribonucleic acid.

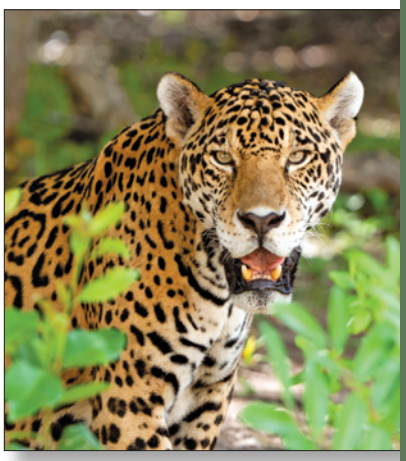
Scientists with the USGS Southwest Biological Science Center's Sonoran Desert Research Station focus on the importance of connectivity between avian breeding and nonbreeding sites. These researchers use advanced telemetry, chemical isotopes, and molecular markers to better understand migratory connectivity (Paxton and Van Riper, 2006). The USGS is recognized internationally for developing state-of-the-art techniques for monitoring the migratory routes of birds; for example, the miniaturization of radio transmitters has greatly increased monitoring capabilities.

A vegetation-association geographic information system (GIS) database for Arizona has been developed by the USGS Arizona Gap Analysis Project to evaluate long-term maintenance of biodiversity (Kunzmann and others, 1998; Thomas and others, 2006). Base vegetation coverage was developed using Thematic Mapper imagery (1990–1992), and vegetation associations were classified using airborne sample points referenced to the global positioning system (GPS) and on-ground plant sampling to correct classification errors. For species such as the nectar-feeding lesser long-nosed bat, the database can identify the occurrence of or changes in host plants along "nectar corridors" from southern Arizona to Mexico.

Under the Weeds of the West initiative, USGS researchers with the Western Ecological Research Center and the Southwest Biological Science Center develop methods to better detect, monitor, and predict the effects of invasive species. For example, their research on salt cedar (*Tamarix ramosissima*) improved the understanding of ecological interactions related to the biological control of this invasive plant and of the overall ecological and political implications of salt cedar invasion in desert wetlands (van Riper and others, 2008).

The Policy Analysis and Science Assistance Branch at the USGS Fort Collins Science Center provides expertise for the management of natural resources through biological, social, economic, and institutional analyses of conservation policy and management practices (Fort Collins Science Center, 2009). The focus of these scientists is to integrate research in biology, sociology, and economics to inform resource managers in a way that will help resolve resource management conflicts. The FORT Center serves an integral role in assisting scientists and resource managers to balance highly complex and sensitive issues in the biologically, sociologically, and economically diverse Borderlands.





Jaguar (*Panthera onca*)

Researchers with the U.S. Geological Survey and National Park Service camping in the Lower Canyons along the Rio Grande

Western coachwhip snake (*Masticophis flagellum testaceus*)

Black-tailed rattlesnake (*Crotalus molossus*)

Scientists with the USGS Texas Water Science Center are collaborating with the National Park Service in Big Bend National Park, the U.S. Fish and Wildlife Service, and the Reserva de la Biosfera Maderas del Carmen [biosphere reserve] and the Área de Protección de Flora y Fauna Cañón de Santa Elena [protected flora and fauna area] in Mexico to evaluate available habitat of the federally endangered Rio Grande silvery minnow (*Hybognathus amarus*). U.S. Geological Survey scientists are field mapping the available habitat of the minnow over a range of river flows critical to spawning and dispersal of various life stages of this species.

The USGS has the scientific expertise to study the biology and ecology of biota, apply and develop ecological indicators, conduct baseline biological inventories, and establish long-term monitoring programs in the Borderlands. The USGS has expertise in the fields of remote sensing, geospatial imagery, and landscape-level analyses, which is highly applicable to solving resource problems along the border. The unique and diverse biological resources along our southern geopolitical boundary provide a positive collaborative opportunity for the United States and Mexico to conduct mutually beneficial research and monitoring of biota in a region that will continue to experience severe ecological stress into the foreseeable future.

A primary focus of the USGS Climate and Land Use Change Program is to evaluate the effects of climate and land-use change on U.S. Department of Interior (DOI) lands and resources. The large number and broad geographic extent of DOI lands in the Borderlands provide a unique opportunity for the USGS to study the effects of climate and land-use change on the ecological resources of this region on a broad scale. Research efforts with application in the Borderlands include (1) addressing the interaction of climate change and other environmental factors with invasive plant infestations in the arid Southwest; (2) predicting the responses, sensitivities, thresholds, resistance, and resilience of western mountain ecosystems to climatic variability and change; and (3) predicting the response of semidesert vegetation to predicted climate change along regional gradients in the arid Southwest.

One example of a USGS project that has broad applications for the Borderlands, particularly on DOI lands, is the effort to determine the causes and consequences of climate change on the distribution and habitat selection of migratory birds (Lloyd and others, 2006). The principal focus of this project is to use localized climatic gradients, or microclimate gradients, as small-scale versions of climate gradients that occur over larger areas. By studying the distribution, habitat selection, and biological interactions of bird species along microclimate gradients, such as mountainsides and hill slopes, USGS scientists can provide important insights into climate influences on species at larger geographic scales that are more difficult to study.

References cited in this chapter are listed in chapter 12.