Riparian Areas of the Great Basin

A Management Guide for Landowners

Wildlife Habitat Council
2005

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Introduction

Though they represent only a small percentage of the land in the western United States and the world over, **riparian areas** provide essential habitat for many wildlife species. In the Great Basin**,** riparian areas represent an oasis of **biodiversity** within a vast sea of arid uplands. However, human land-use practices in the Great Basin have disturbed large tracts of land. As a result of these disturbances, degradation of both riparian and upland areas has become a major concern for natural resources managers and landowners.

The conservation and restoration of Great Basin lands is an urgent environmental issue, particularly in its highly productive and valuable riparian areas. If restoration is not intensive and immediate, the damaged condition of riparian areas will continue to impact both landowners and wildlife. In order to protect riparian wildlife habitat, native plant communities must be restored and watersheds protected. The resultant healthy, native ecosystems will be better able to withstand drought conditions that lead to dry vegetation, decreased availability of water, and increased susceptibility to fires.

The health of riparian areas is tied closely to watershed health, and is affected by ecological forces and human activities in surrounding uplands. Effective riparian conservation takes place at both local watershed and landscape scales. Productive management actions are increasingly the result of cooperative efforts between landowners, state and federal agencies, and other groups within the region that balance economic and ecological considerations.

This document describes the Great Basin riparian areas and their ecological value and outlines the ecology, plants, and wildlife of the area. Threats facing Great Basin riparian areas are presented and conservation strategies and suggestions are provided to assist landowners and resource managers in mitigating ecological threats and improving riparian areas on their properties.

Some of the terminology used in this guide may be unfamiliar to some readers. For this reason, a glossary is included. Glossary terms are bolded when they are used in the text the first time and its definition appears in the sidebar (as seen on this page for riparian areas and biodiversity).

riparian area: aquatic ecosystem (stream or river) and the surrounding terrestrial areas where vegetation may be influenced by elevated water tables or flooding and by the ability of soils to hold water (side channels, floodplains, or wetlands)

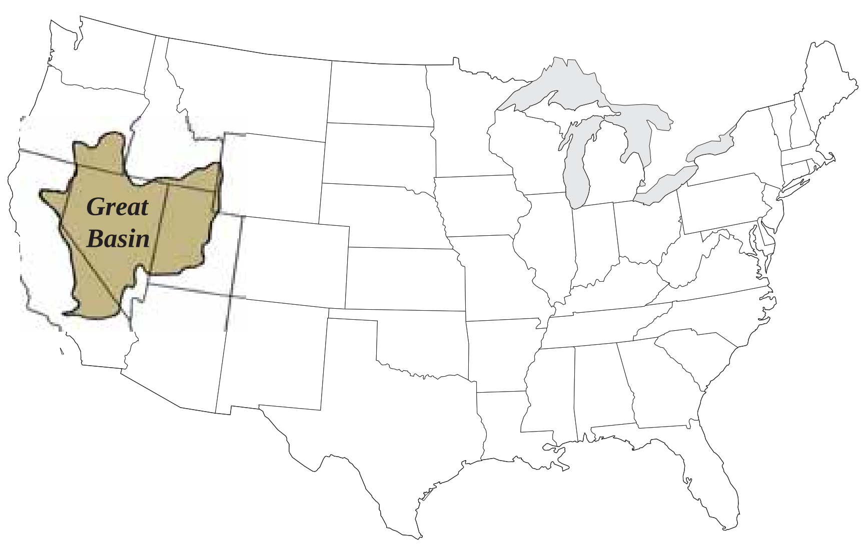
biodiversity: the variability among living organisms on the earth, including the variability within and between species and within and between ecosystems

The Great Basin Riparian Areas

Defining the Great Basin

The Great Basin can be defined within hydrologic, topographic, and climatic parameters. The hydrographic Great Basin includes the entire area of drainage between the Rocky and Sierra Nevada mountain ranges. It is the only region in North America whose waters do not ultimately flow into an ocean. Normally, areas west of the Continental Divide drain into the Pacific, but the flow of water from the Great Basin is blocked by the Sierra Nevada on the west, the uplands of southern Oregon and Idaho to the north, and Nevada's Wasatch Plateau to the south. The topography of the Great Basin consists of a series of approximately 75 alternating, undrained basins and ranges which typically have one steep side and one more gently-sloped side.

The Great Basin is a climatically distinct region. It contains the largest of the four U.S. deserts, encompassing roughly 200,000 square miles of Nevada, western Utah, southeastern Oregon and southern Idaho, and, according to some definitions, small portions of eastern Washington, eastern California, western Colorado, and northern Arizona. It is considered a cold desert, which distinguishes it from the Sonoran, Chihuahuan, and Mojave Deserts. The Great Basin lies mostly above 4,000 ft. elevation, with frequent winter snow and long freezing periods. Precipitation



is low, averaging 4–11 inches per year, with up to 13 inches at higher elevations or farther north. Much of the precipitation falls as snow during the winter and spring. Saline soils are common in the Great Basin as the result of high evaporation and low precipitation.

The climate, hydrology, and highly variable topography of the Great Basin host a wide array of environments, including treeless alpine bogs, montane coniferous forest, sagebrush steppe, and riparian meadows. Although trees and herbaceous plants are present, shrubs dominate the vegetation of the Great Basin. There are three primary vegetation zones, including, from lowest to highest elevation and precipitation levels, salt desert shrub/shadscale, sagebrush, and pinyon-juniper. At the highest elevations, coniferous forest communities are present.

The balance between the three vegetation zones has been disrupted over the last century. The amount of perennial grasses in sagebrush and shadscale zones has decreased due to grazing by domestic livestock and the invasion of exotic species such as cheatgrass. These exotic invaders thrive in disturbed areas, and can take over large tracts of land. They also elevate the risk of fire because they are more flammable than native species since fire has not been a part of their natural history. Also, as a result of grassy fuel removal and active fire suppression, the growth of new trees has not been checked, allowing pinyon-juniper woodlands to encroach on shrub ecosystems and other community types. These types of ecological changes are reducing the amount of habitat available to wildlife and native plants across the Great Basin.

U.S. Fish and Wildlife Service

Sagebrush communities comprise one of the three primary vegetation zones in the Great Basin.

evolution: change in the genetic composition of a population during successive generations, as a result of natural selection acting on the genetic variation among individuals, and resulting in the development of new species

speciation: the evolutionary formation of new biological species, usually by the division of a single species into two or more genetically distinct ones

endemic: a species native to or confined to a particular region

ecoregion: an ecologically unified area that is defined based on the presence of similar natural features, including soils, geologic history, landforms, topography, vegetation types, plant and animal distributions, and climate

species richness: the number of species in an area or habitat

mesic: moderately moist conditions

emergent vegetation: plants rooted underwater that grow above the surface of the water

marsh: a type of wetland that does not accumulate appreciable peat deposits and is dominated by herbaceous vegetation

A great variety of habitats exist in the Great Basin as a result of the unique topography, hydrology, and vegetation communities. These factors have provided important opportunities for **evolution** and **speciation,** producing many unique assemblages of plants and animals. Many species are **endemic** to the Great Basin region, including freshwater shrimp and snails, greasewood, and kangaroo mice. Nevada, for example, is the sixth-ranking state in number of endemic species, with 139 plants, 113 invertebrates, 47 fish, nine mammals, and one amphibian species that are not found elsewhere. Of the 110 North American **ecoregions** as defined by the Nature Conservancy, the Great Basin ranks fifth in total **species richness** and second in diversity. These unique species underscore the need for effective conservation programs.

Defining Riparian Areas

Although shrubby vegetation dominates the Great Basin, **mesic** environments do exist, including wet meadows, terminal wetlands, and riparian areas. Wet meadow areas have more or less continuously waterlogged soil and are dominated by **emergent** herbaceous plants. Because the Great Basin is an isolated drainage basin, rivers and streams do not ultimately flow to the ocean, but into terminal wetlands, which include lakes, **marshes**, and **playas**, many of which are small and **ephemeral**.

Although all three mesic habitat types are important centers for biodiversity, this document focuses specifically on riparian areas. A riparian area can be defined as an aquatic ecosystem (stream or river) and the surrounding terrestrial areas (side channels, floodplains, or wetlands) where vegetation may be influenced by elevated water tables or flooding and by the ability of soils to hold water. Water in riparian areas may be permanent or ephemeral, and streams may flow intermittently or perennially. The edge of a riparian area can often be inferred based on the presence of **obligate** or **facultative** riparian plant species, which require readily available

Nevada Department of Conservation and Natural Resources

Clear Creek, Nevada and its adjacent riparian area. The stream banks have been hevily impaced by cattle grazing.

water and moist soils. It should be noted that some definitions of riparian area only include the terrestrial portion and not the aquatic ecosystem. Nonetheless, the stream and streamside areas are inextricably linked, and restoration and protection efforts must consider both.

Sources of energy in the riparian area include nutrients, seasonal cycles, primary and secondary production, organic matter inputs, and sunlight. Chemical factors that affect streamside areas include water temperature, dissolved oxygen, pH, turbidity, hardness, organic content, nutrients, adsorption, solubility, and alkalinity. Many of these energy sources and chemical factors are moderated directly by the riparian area. Riparian vegetation shades the stream, lowering water temperature, and also provides organic matter to the stream. Riparian vegetation protects the stream from influxes of sediment and pollution from upland areas. These factors are not consistent along the length of a particular stream, and changes in upstream areas affect conditions downstream.

Natural Influences on Stream and Riparian Area Integrity

Stream Channel Structure

The geomorphic features of natural riparian areas are very dynamic. Streams are in constant state of flux, with changing width and depth, bank stability, channel morphology, sinuosity, and gradient over time. A dynamic equilibrium exists between the stream and the environment, with constantly shifting rates of erosion and deposition in the stream channel. These rates depend on factors such as sediment load or stream flow. For example, if the flow rate remains the same but the amount of sediment in the water increases, deposition will occur in the stream channel. If flow increases due to a heavy rainfall, increased channel erosion may occur. Often, many forces interact within the riparian area, creating a more complex stream response. Intermittent flow ranging from nearly dry to flooded conditions leads to variable vegetative cover in various stages of succession.

The structural attributes of the riparian area are influenced by local geology. A hard substrate will result in deeply downcut, narrow stream channels, with a sharp distinction between riparian and upland habitat. In many instances, subsequent uplifting of the surface creates deep canyons, such as the Bryce and Glen Canyons in southeastern Utah. On the other hand, if the substrate is loose, the channel will be more gradually sloping.

Climatic factors, such as precipitation and humidity, influence the depth and erodibility of soils in the riparian area. The Great Basin region has low precipitation and low humidity, which results in a thin soil layer. The thin soil layer means that there are only small quantities of soil that can be eroded and carried by the stream.

playa: a nearly level area at the bottom of an undrained desert basin, sometimes temporarily covered with water during wet periods, underlain by stratified clay, silt, or sand, and commonly by soluble salts

ephemeral: a body of water that only exists in direct response to precipitation and that may dry up during dry seasons

obligate: an organism that is only able to survive in a particular environment or by assuming a particular role

facultative: a species that is capable of functioning under various environmental conditions

groundwater: water beneath the earth's surface that saturates pores and fractures in sand, gravel, and rock formations and that serves as a water source for wells and springs

gaining stream: a stream or reach of stream that receives water from the zone of saturation

losing stream: a stream or reach of stream that contributes water to the zone of saturation

insulated stream: a stream or reach of stream that is separated from the zone of saturation by an impermeable bed

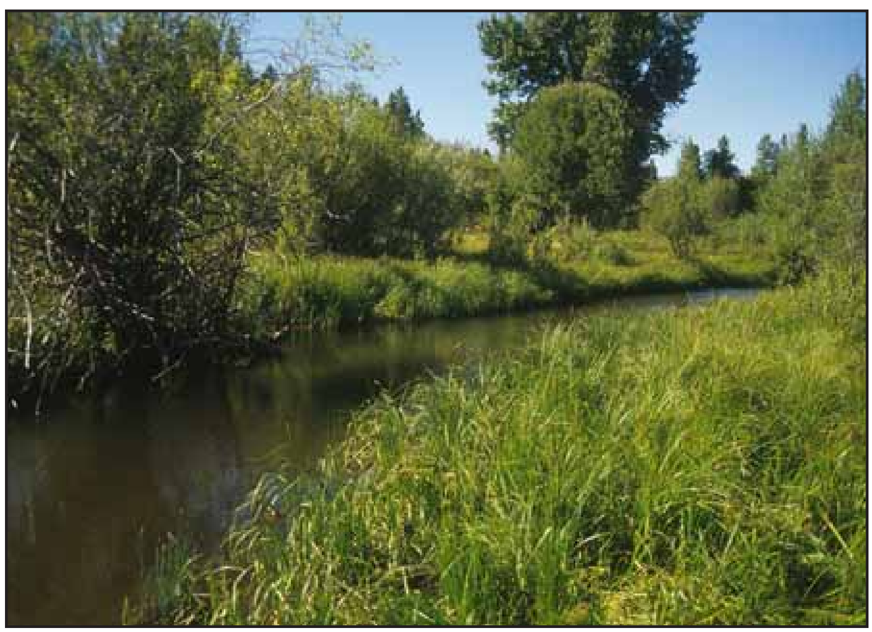
Groundwater, Precipitation, and Stream Flow

Groundwater is an important natural resource that is stored below the earth's surface in the pores of substrate. Groundwater reaches the surface at naturally flowing (artesian) springs, via streams or other bodies of water that intersect with the water table, and through transpiration by plants whose roots extend into the saturated zone. In addition, groundwater can be pumped from the ground at wells.

Stream flow is related to both precipitation and groundwater supply. Streams are either fed by groundwater (**gaining stream**), replenish groundwater (**losing stream**), or are separated from groundwater by an impermeable layer below the stream (**insulated stream**). Streams that are not groundwater-fed receive their water primarily from precipitation/runoff. Because the groundwater supply is fairly constant throughout the year, gaining streams tend to have lower levels of fluctuation in flow. Losing or insulated streams will tend to increase or decrease in flow depending on patterns of precipitation. In arid areas, streams reaching downstream from mountain fronts and on steep hillsides are typically losing streams, making these areas important for recharge (groundwater replenishment).

Groundwater resources must be carefully managed. Large volumes of groundwater are withdrawn for human consumption. Groundwater is the domestic water supply for approximately one-half the population of the United States, either via public supplies or individual wells.

Natural groundwater systems fluctuate over time depending on the rate of recharge. Human land uses often decrease recharge because they decrease the amount of pervious surface. Riparian areas are important sites for groundwater recharge



NRCS

A vegetated riparian buffer offers countless economic and ecological benefits.

because vegetation can trap precipitation and runoff, allowing it to infiltrate slowly over time. If withdrawal from an aquifer is not balanced with respect to recharge, withdrawal may become unsustainable, reducing groundwater flows to the surface and pressure at wells, and thereby reducing the availability of water for riparian areas as well as for human consumption.

Ecological Value of Riparian Areas

Riparian areas are the most diverse and productive habitats within the Great Basin region due to the presence of water in an otherwise arid environment. These areas have high wildlife value, supporting a diverse biological community, and provide an array of **ecological services**. Riparian habitats have been shown to support the highest bird diversity of any western habitat type. Seventy percent of the riparian habitat in the United States has been extensively altered (and only 1% remains in the west). However, more vertebrate species (up to 70%) use these areas at some point in their lifecycle than any other habitat type. The disproportionate use of riparian areas can be attributed to the presence of water, a high ratio of **edge** to **interior habitat**, abundant forage, habitat structural diversity, and a highly productive plant community. Riparian areas crisscross the landscape, providing intact **corridors** for the movement of wildlife and the dispersal of plants. Also, the riparian area helps to regulate and control groundwater resources. Riparian areas have economic value as well. They are used for grazing cattle and for recreation, and they provide a source of water for agriculture, mining, and human consumption.

Vegetation is an especially important component of riparian areas**.** Riparian vegetation acts as a buffer between the stream and adjacent upland areas, filtering pollution and controlling floods. The roots of trees, shrubs, **sedges**, and grasses bind the soil together and help create an erosion-resistant stream bank. Overhanging vegetation shades the stream and prevents the water from overheating. Leaves, stems, seeds, fruits, and other plant parts fall into the stream and provide food for aquatic wildlife. Riparian vegetation is a source of **large wood**, which creates diverse instream conditions, such as pools and roughness, and influences sediment routing. During floods, riparian vegetation reduces the velocity of floodwaters, which allows the water to infiltrate into the soil slowly, depositing the sediments that make the soil richer in the floodplain than in the surrounding uplands. Finally, riparian vegetation helps store water in the riparian area, creating fairly consistent environmental conditions despite variations in precipitation throughout the year.

Unfortunately, much of the biodiversity of riparian areas is being threatened due to loss or degradation of habitat. Furthermore, many of the natural habitats that remain exist in small and disconnected patches. Movement between patches is often difficult or impossible for wildlife.

ecological services: those services provided by the environment, such as water purification and aesthetic importance. The economic value of these services is typically difficult to quantify.

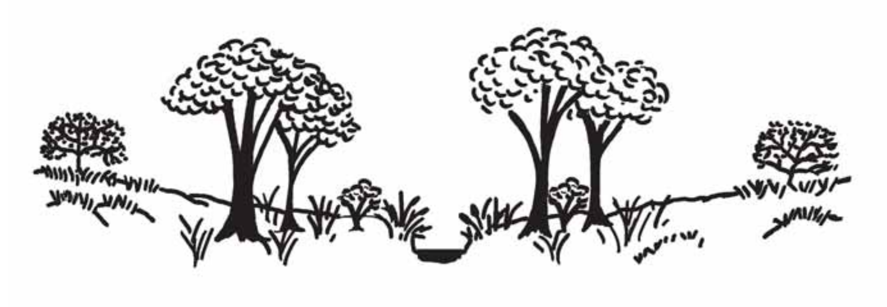
edge habitat: habitat near the border between two different habitat types

interior habitat: an area that is within a relatively uniform patch of habitat

corridor: a more or less intact, linear pathway that can be used for dispersal between areas of habitat

sedge: any of numerous grasslike plants of the family Cyperaceae, having solid stems, leaves in three vertical rows, and spikelets of inconspicuous flowers, with each flower subtended by a scalelike bract

large wood: any large piece of relatively stable woody material having a diameter greater than 4 inches and a length greater than 3 feet that intrudes into the stream channel



Wildlife and Plants of Great Basin Riparian Areas

neotropical migratory bird: any migratory bird species that winters in South America, the West Indies and Central America south of the Mexican Plateau

endangered species: a species that is in danger of extinction throughout all or a significant portion of its range

threatened species: a species that is likely to become endangered in the foreseeable future

Endangered Species Act: legislation passed in 1973 in order to conserve the ecosystems upon which endangered and threatened species depend, and to conserve and recover listed species; administered through the U.S. Fish and Wildlife Service

A variety of wildlife and plant species inhabit Great Basin riparian areas. Some of those species are obligates, confined to the borders of the riparian area. Other species are facultative, either preferring mesic areas if they are available, or only requiring them during certain portions of their life cycle. In addition, riparian areas provide important stopping points for **neotropical migratory birds** passing through desert regions, permanent residents, and those that use the Great Basin for wintering or breeding habitat.

An extensive list of Great Basin riparian species, scientific names, and ranges can be found in Appendix A. Some of these species are considered **endangered** or **threatened**. Federal endangered or threatened status is conferred by the U.S. Fish and Wildlife Service according to the **Endangered Species Act**. State agencies may list a species as endangered, threatened, protected, sensitive, rare, etc. under their own systems. These listings tend to be more extensive than those of the Fish and Wildlife Service, and may carry with them regulatory implications separate from those of the federal listings.

Birds

Riparian areas are extremely important for bird species of the arid and semi arid west, including upland birds, waders, shorebirds, raptors, and passerines. Nearly all species of birds in the Great Basin depend on wetland or riparian habitats during some phase of their lifecycle. According to one estimate, more than one-half of the 134 species that breed regularly in the Great Basin are associated with riparian areas. Riparian areas generally contain a greater density and diversity of bird species as compared to surrounding uplands, and provide important nesting habitat. Riparian vegetation is used for nesting and for food, and streams also provide important food sources, particularly invertebrates.

The majority of bird species found in Great Basin riparian areas are not year-round residents, but rather summer residents, winter residents, or migrants. Neotropical migratory birds that utilize these areas include the Bullock's oriole, yellow warbler, Brewer's blackbird, broad-tailed hummingbird, killdeer, lazuli bunting, red-tailed hawk, red-winged blackbird, savannah sparrow, song sparrow, violet-green

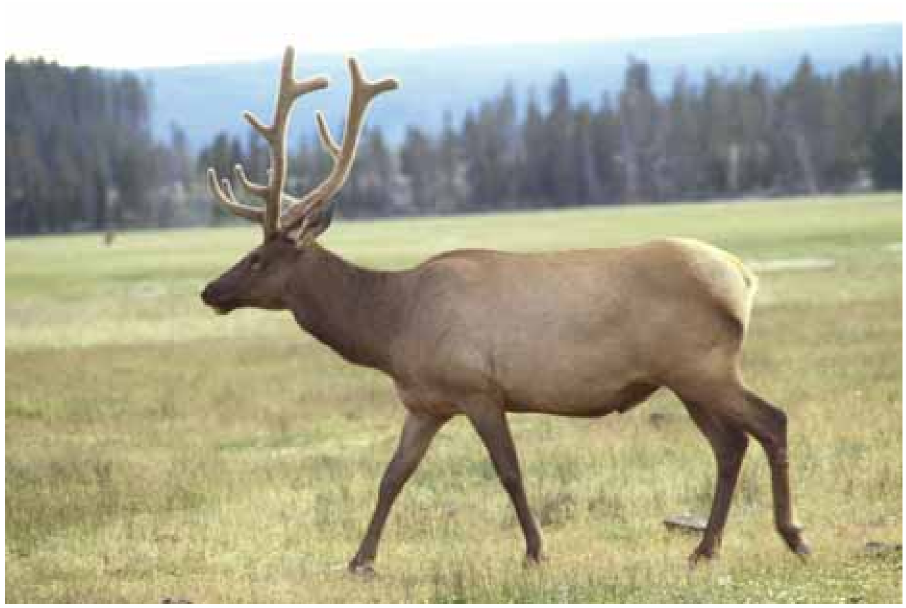
U.S. Fish and Wildlife Service

The yellow-headed blackbird is one of many neotropical migratory birds that utilize riparian areas in the Great Basin.

swallow, warbling vireo, and yellow-headed blackbird. Species of continental importance in the *Partners in Flight North American Landbird Conservation Plan* include the willow flycatcher, calliope hummingbird, red-naped sapsucker, green-tailed towhee, Virginia's warbler, and Lewis's warbler. These birds are profiled in Appendix B.

The destruction of riparian areas is viewed as the most important factor in the decline of western land bird species. However, comprehensively measuring decline of all species is a complex task. There are several measuring systems used, such as the Breeding Bird Survey; however, an accurate count is not always easy to obtain. Furthermore, following degradation, species composition may change, with more sensitive species being replaced by ones that are less susceptible to disturbance, but the total number of species may not be significantly different. Sensitive species, such as the yellow-breasted chat, song sparrow, and common yellowthroat, are useful in measuring degeneration as these species will not be present if the habitat is compromised. Commonly found species in both degraded and intact habitats include American robin, house wren, red-naped sapsucker, warbling vireo, yellow warbler, and Brewer's blackbird.

Bird populations may respond positively to riparian restoration. Bird responses to degradation vary depending on location, habitat type (predominant vegetation), and climatic fluctuations. Periods of drought may further reduce the availability of mesic habitats, exacerbating the effects of environmental degradation on bird populations. More long-term data are needed to effectively address these issues. Furthermore, studies of riparian bird populations must occur throughout the year because so many species are migratory or seasonal residents.



U.S. Fish and Wildlife Service

Elk are among the large mammals that visit riparian areas in the Great Basin.

Mammals

The Great Basin is home to a number of mammal species, ranging from numerous small mammals to large game animals. Mammals forage and find cover in riparian vegetation. Some species are confined to riparian or other wet habitats, while others utilize both riparian and upland areas. Larger game species include mule deer, elk, and white-tailed deer. Smaller and mid-sized mammals include beaver, muskrat, water shrew, porcupine, gray wolf, ermine, river otter, ringtail, western spotted skunk, and various bat species. Beaver are sometimes viewed as a nuisance by agricultural producers because they can cause damage to water systems created for irrigation or domestic use, but they frequently play a vital role in enhancing habitat structural diversity in natural riparian areas. The gray wolf, although controversial, is an important part of the food web, keeping populations of small rodents, coyotes, and rabbits in check and maintaining the vigor of game populations. Bats also play a crucial ecological role by consuming large numbers of insects during their nightly foraging trips.

Reptiles

Reptiles are widely abundant in riparian areas. Reptile species of the Great Basin include the Great Basin/western skink, wandering garter snake, Utah mountain kingsnake, northern alligator lizard, and regal ringneck snake. Reptiles that live in riparian areas often build their nests near the stream. In addition to threats resulting from habitat loss, reptile populations may be threatened by commercial collection.

Amphibians

Perhaps more than any other group, amphibians are dependent on riparian areas because they require slow moving or standing water in which to lay their eggs. Few

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The black toad is native to the Great Basin.

data are available about the effects of riparian habitat loss on amphibian populations in the Great Basin. Native amphibian species include the Great Basin spadefoot, western toad, Pacific chorus frog, western leopard frog, relict leopard frog, Amargosa toad, black toad, spotted frog, boreal toad, and lowland leopard frog.

As a class, amphibians are often described as the most threatened group of animals worldwide. As such, amphibians are useful as indicator species of aquatic health. Exact causes of declines in amphibian populations are under investigation, but they may be related to habitat loss, habitat degradation, or to increasing numbers of non-native species in their ecosystems. Amphibians are unable to tolerate polluted or silty water, and thus tend to disappear quickly from degraded habitats. In addition, native amphibians are preyed upon by two introduced species: bullfrog and rainbow trout. Declines in amphibian populations can be monitored in order to assess changes in stream quality over time.

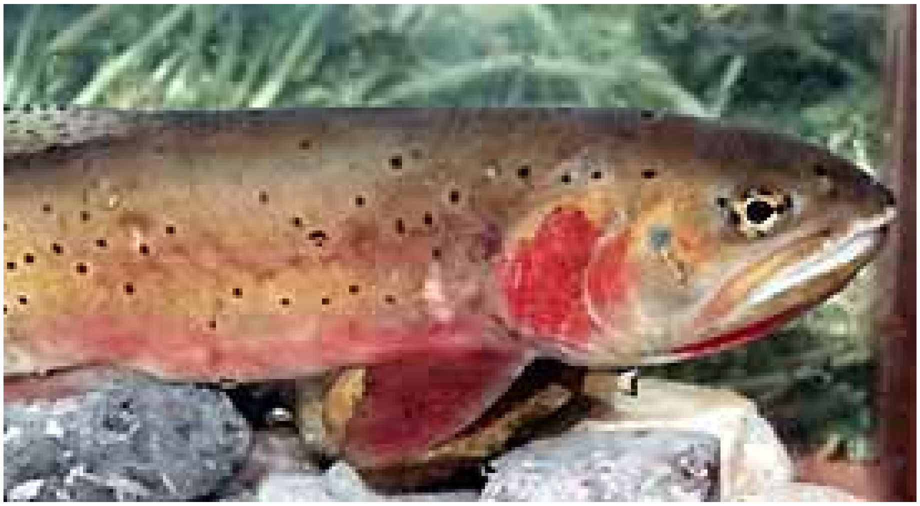
Fish

Many fish species of the Great Basin are unique to the region. For example, 53 of Nevada's 91 native fishes are endemic species or subspecies. This high level of endemism is the result of large water bodies drying since the last ice age, leaving behind isolated remnants of aquatic habitat. Different groups of fish dominate the region's rivers, depending on habitat conditions. The distribution of fish species is influenced by water temperature, stream gradient, **stream order** (generally, higher order indicates greater species diversity), and changes in flow over time (both floods and low flows can impact fish).

Important native fish families that inhabit Great Basin streams are cyprinids (minnows, dace, chubs, and shiners), catostomids (suckers), cyprinodontids (pupfishes), and goodeids (springfishes and poolfishes). The salmonids (salmon, trout, and whitefish)

stream order: a stream classification system according to branching pattern; headwater streams are first order streams, and unite to form second order streams, which unite to form third order streams, and so on

eutrophication: having waters rich in mineral and organic nutrients that promote a proliferation of plant life, especially algae, which reduces the dissolved oxygen content and often causes the local extirpation of other organisms



U.S. Fish and Wildlife Service

Populations of native Bonneville cutthroat trout are impacted by introduced species in the Great Basin.

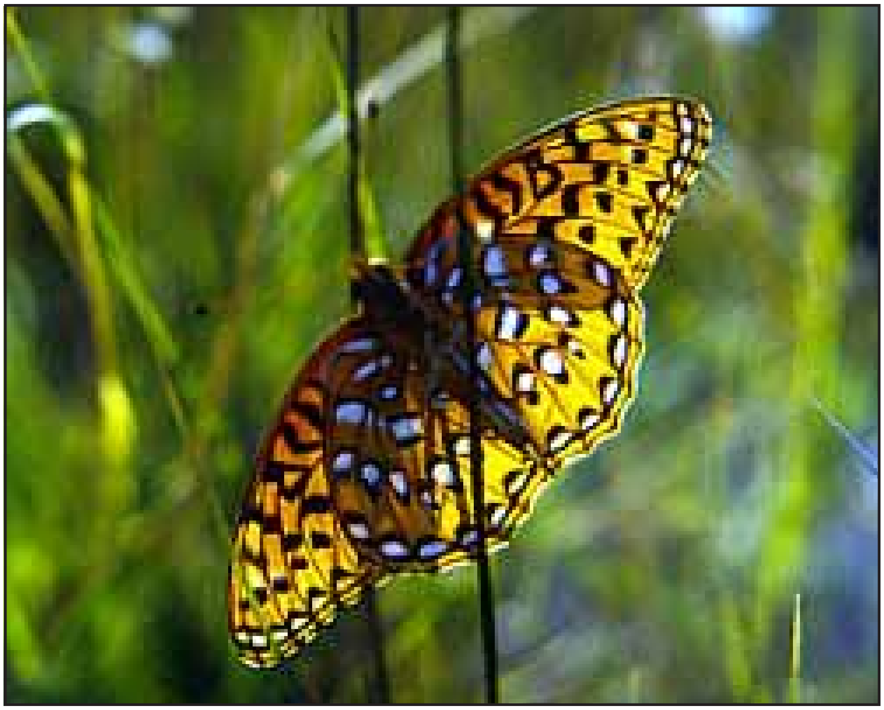
are represented by both native and introduced species. Salmonids are the dominant fish group in North American coldwater streams.

Concern has developed over the status of freshwater fish species in the western United States. Like amphibians, the threats to fish are twofold. The most important contributor to the decline of fish is the degradation of freshwater habitat. Habitats may be altered structurally as a result of damming or erosion. Water level may decrease due to streamflow diversion or unsustainable groundwater use. Water quality declines result from increased sediment and pollution levels

Invertebrates

Invertebrates occupy nearly every type of habitat, and many species have yet to be named or even discovered. Water is an important habitat component for most invertebrates. Many are aquatic (mainly marine but also freshwater), and land-dwelling invertebrate species often have aquatic developmental stages. Members of the phylum Arthropoda make up over 75% of all described species, and the vast majority of known arthropods, over one million species, are insects. One important ecological role of insects is pollination. Butterflies, for example, are notable for their beauty and diversity, but also provide essential pollinator services. Furthermore, many plant-pollinator interactions are very specific. For example, Apache silverspot butterflies require a particular violet species as their larval host, and feed on four specific thistle species during adulthood. Thus, the maintenance of both plant and pollinator populations is important for biodiversity conservation.

Invertebrates are vulnerable to locally degraded environments. Many aquatic invertebrates are sessile or have restricted mobility, which does not allow them to move away from disturbances. Aquatic insects are negatively affected by changes in water temperature after vegetation removal, the presence of heavy metals, and **eutrophication**. Like amphibians, aquatic invertebrates are useful indicators of environmental quality because of their sensitivity to degradation.



Nevada Department of Consesrvation and Natural Resources

The Apache silverspot butterfly is native to the Great Basin.

As a result of natural spatial boundaries between populations, levels of speciation among aquatic invertebrates are often high. Thus, stream conservation in local areas is very important. For example, there are 28 subspecies of aquatic springsnail that inhabit springs and streams in Nevada, Oregon, Utah, and Idaho, often specializing in extreme habitats. The range of many subspecies is restricted to just one small spring, making them very vulnerable.

Plants

Riparian vegetation has a profound effect on conditions within the riparian area. In the Great Basin and other arid regions of the United States, riparian areas are very clearly delineated by the presence of riparian vegetation, which requires an increased availability of soil moisture as compared with upland vegetation. Riparian vegetation types include aquatic, sedges and **rushes**, grasses, forbs, shrubs, understory trees, and overstory trees. Because riparian areas are distributed across elevational gradients, plant community composition may vary. Grasses dominate some riparian areas; willows and other shrubs or trees dominate others; and some contain a variety of vegetation types. Common woody vegetation of riparian areas includes cottonwoods, quaking aspen, birch, and willows. Herbaceous vegetation, grasses, and sedges also provide important habitat components.

There are distinctive habitat regions within riparian systems of the Great Basin. The montane forests rise steeply out of a semi-arid areas of the Great Basin. Geographic isolation on mountain tops here has resulted in a high degree of genetic variation among populations of conifers. Vegetation from valley bottoms to mountain tops includes shrub-steppe, woodlands, pinyon pine, juniper, Douglas-fir, and subalpine

rush: any of various stiff marsh plants of the genus *Juncus*, having pliant hollow or pithy stems and small flowers with scalelike perianths communities. Woodlands represent a transition between more moist coniferous forests of higher elevations and drier grasslands and deserts of the basin. They tend to be more open than forests and contain smaller trees. The dominant woodland trees are drought-tolerant pines and junipers, while conifers are mainly cold-tolerant. Lowland riparian habitats are those associated with the floodplains of major river systems primarily occurring below 1,500 meters elevation. Lush habitat conditions supported by these lowland floodplains stand in stark contrast to the arid landscapes through which they course. With the exception of the Humboldt River, lowland riparian habitats are typically dominated by Fremont cottonwood. Several species of willow are found on river floodplains, including sandbar, arroyo, red, and Goodding's and shining willow. Riparian vegetation is distributed according to different plant species' affinity for water and the extent to which river flow is distributed across its floodplain. Left to their own natural disturbance regimes, habitat structure in lowland riparian areas is substantively similar, though typically wider in extent than montane riparian systems.

Riparian vegetation may be threatened by competition from invasive weeds or by decreased availability of water. As compared with upland species, riparian plants are often heavily used forage by grazing cattle.

Threats to Great Basin Riparian Areas

Loss and degradation of riparian areas is increasing. By 1985, more than 70% of riparian areas in the United States had been compromised. This figure increased to more than 80% by 1993. In large part, the vulnerability of riparian areas results from heavy use in proportion to their area. The mesic conditions that allow abundant vegetation growth and make riparian areas biodiversity hotspots are highly valued by humans. Increasing pressure from human land use is having negative impacts on Great Basin riparian areas, which may include removal of riparian vegetation, decreases in water quality, and changes in channel structure. These land uses include road building, development, chronic over-grazing, agriculture, mining, hydroelectric projects, and timber harvest. Invasive plants, fire, and an overabundance of native grazers also threaten riparian lands.

Development

Urban areas in the Great Basin, such as Reno and Salt Lake City, are expanding rapidly. Industrial parks, subdivisions, and golf courses have taken the place of natural riparian areas across the western United States. Development reduces the amount of pervious surface, leading to decreased infiltration of runoff, thereby reducing groundwater replenishment. Road construction, in particular, impacts riparian areas. The presence of a road within the riparian corridor affects soils, erosion, vegetation, hydrology, water quality, channel morphology, and wildlife.

Under natural conditions, periodic flooding deposits fine layers of sediment over the floodplain, improving soil quality necessary for plant growth. Floods are also important because they scour out pools, clear away fine sediment from the stream channel, and introduce large wood into the stream. However, when areas within the floodplain are developed, stream channels are often engineered to minimize seasonal flood flows. Flood prevention, therefore, may degrade soil quality in the floodplain and negatively affect the stream channel. Straightening, widening, and deepening of river channels during major engineering works usually reduces in-channel and riparian habitat diversity. Furthermore, preventing flooding in a particular area may increase the damage caused by flooding downstream. When a stream overflows its banks, its volume is reduced by water temporarily stored in the floodplain. A larger volume of water will deliver greater erosive power to downstream stream reaches not engineered for flood control. These changes affect downstream flow, levels of winter floodwaters, dry-season flow rates, and riparian area soil moisture.

Rivers are often dammed to create reservoirs, which can negatively affect riparian and stream health. These reservoirs have fluctuating water levels and often are surrounded by poor soils, neither of which is conducive to the establishment of riparian vegetation. Furthermore, water that is moving downstream slows down when it enters the reservoir, and sediments settle out of the water column and onto the reservoir bottom. This reduces the availability of sediment to downstream areas. The volume of water flowing downstream from the reservoir often decreases as well, impacting riparian areas. Another major impact of dams is that they eliminate the natural dynamics of cottonwoods. Typically, a river continually cuts away old cottonwood stands and deposits new sediment where young cottonwoods germinate and start new stands. These young trees have particularly high insect populations which make them very valuable to birds. Downstream of a dam, however, the cottonwoods age without removal and very few new trees are established.

Grazing

Ranching accounts for approximately 70% of the land use in the western U.S. and is the most widespread industry in the Great Basin. The industry is centered on cattle, but sheep, bison, and other species are produced to a lesser extent. Livestock production can be compatible with rangeland ecosystem health when conducted according to sound ecological principles. However, because it is such a large and widespread industry, grazing has huge environmental impacts. Grazing practices influence the vegetation, water quality, channel morphology, and soil structure of riparian areas. These impacts are often severe and have pronounced detrimental effects on animal populations.

Sensitive riparian areas provide drinking water and lush vegetation, and are often attractive to cattle, which prefer them to shrubby upland areas. Heavy browsing, rubbing, and trampling of streamside vegetation can physically damage plants or alter their growth form. Vegetation species composition and community organization can be altered because herbivores can actively select for or against particular plants, some more sensitive to grazing than others. The density and biomass of a particular preferred species may decrease, and as a result, overall species richness may decrease. Constant heavy browsing reduces the number of tree seedlings that reach maturity, resulting in early seral communities in areas where mature trees would normally grow. The loss of riparian vegetation affects soil structure, channel morphology, and water quality. Decreased vegetation cover can raise the temperature of the soil and water, and cause increased evaporation. The loss of soil-stabilizing plants increases the likelihood of erosion and bank failure, which increase the sediment load in the water. Animal waste increases nutrient levels and eutrophication. Cattle trampling compacts the soil, leading to decreased infiltration

NRCS

Ranching is a widespread industry in the Great Basin.

an increased runoff, which further reduces water quality. A loss of vegetation leads to a decrease in **soil litter**, which decreases soil quality over time.

The changes in habitat structure and quality caused by unrestricted grazing can negatively impact riparian wildlife habitats. The removal of vegetation by grazing reduces protective cover. Because cattle remove the lower vegetation layers, grazing can be particularly problematic for bird species nesting on the ground and in lower vegetation layers.

Agriculture

Agricultural practices, such as irrigation and pesticide use, can be particularly detrimental to riparian areas. Agricultural land uses typically have water demands that impact riparian areas. Deep-well irrigation has caused significant problems in Locomotive Springs wildlife management area and others. Water is diverted from rivers and streams for irrigation and return flows are often highly saline. Other problems associated with agricultural areas include pollution from pesticides and herbicides and increased competition between crop species and native plants. Crops in upland areas use more water than native, drought-adapted, shrubby species, such as sagebrush. This depletes the water table, reducing the availability of moisture for natural riparian plants.

Mining

Mining is an economically important industry in the Great Basin, but it can have a negative impact on water resources and thus on riparian areas. For example, gold is sometimes mined below the water table, which necessitates "dewatering" to gain access to the minerals and then reinjecting, reusing, or discharging the groundwater.

soil litter: recently fallen plant material that is partially decomposed and forms the surface layer of some soils

If carefully managed, this water can be recycled through the groundwater system via streams or can be used for agricultural irrigation. It is uncertain how this process impacts the overall hydrology of the area.

Hydroelectric Projects

Hydroelectric development changes the structure of a stream reach and the surrounding riparian area. Diversion of water from a stream reach reduces stream flow, and hydroelectric dams impact fish migration. Smaller fish in particular may suffer mortality when they are drawn into turbines. In addition to changes in the stream channel, development of roads and other infrastructure surrounding hydroelectric plants destroys natural riparian vegetation.

Timber Harvest

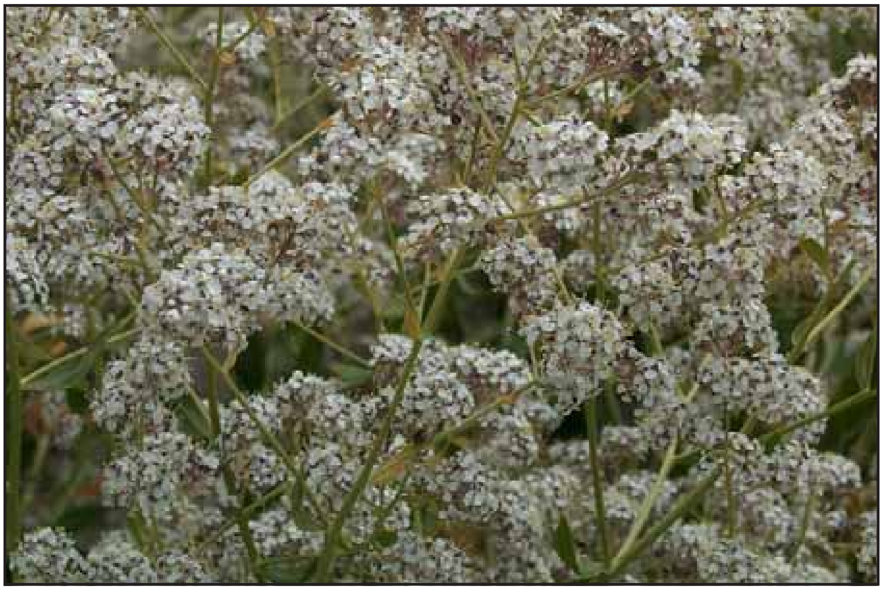
Forestry practices can impact streams during site preparation for tree planting, tree removal, and transportation of products. Prescribed fire during site preparation can change the amount of nutrients entering the stream. Removal of competing vegetation during site preparation and the removal of trees during harvest can lead to increased runoff and faster, more erosive stream flows. Roads and skidtrails used for tree removal may cross riparian areas, causing erosion and sedimentation.

Invasive Plants

Heavily grazed lands and recently burned areas may easily become overrun with invasive plant species. Invasive species are non-native species that may cause harm to the economy, environment, human health, recreation, or public welfare when introduced into an ecosystem. Invasive plants are generally unpalatable to both native and domestic grazers, and are difficult to control and eradicate. Invasive plants are successful in part because they did not evolve in the Great Basin. Therefore, their natural competitors, predators, and diseases are not present to keep them under control. Eradication techniques are expensive and need to be repeated to keep weeds under control. In some areas, entire ranches have been rendered worthless because of weed invasion. Invasive plants also overrun wintering areas that support elk and other wildlife. Exotic annual grasses are not as effective for erosion prevention as native grasses.

Invasive grasses can negatively impact watershed health. Non-native annuals provide less cover than native plants. During rainstorms, a greater number of raindrops hit the soil surface with greater force, loosening soil particles and ultimately forming a seal over the soil surface that restricts infiltration. Healthy vegetation has an important precipitation storage function as well. A fully functioning watershed holds water and then releases it slowly over time through streams, springs, and other bodies of water that are in contact with the water table.

The spread of most invasive species is believed to be the result of human actions. The seeds of invasive species travel via roadways into remote areas, using humans,



California Department of Water Resources

Perennial pepperweed, an annual shrub, is a particularly problematic invasive in riparian areas in the Great Basin.

livestock, and their vehicles as a means of transportation. Invasive weeds and grasses thrive in disturbed areas, producing millions of seeds and out-competing native species. Some invasive species arrived via cattle feed or were brought to the west deliberately as ornamentals. One of the most prevalent invasive grasses of the Great Basin is cheatgrass or downy brome. Riparian areas are particularly affected by perennial pepperweed, also known as whitetop. Other western invasive species include saltcedar or tamarisk, other cheatgrasses, medusahead, rush skeletonweed, knapweeds, Russian thistle, saltlover, and leafy spurge.

Fire

Wildfires in the Great Basin have increased in extent and severity during recent fire seasons. In part, this is due to fire exclusion, which leads to increased natural fuel availability. However, this trend also results from land use practices that include clear-cutting and over-grazing. The rapid spread of invasive weeds contributes to increased fire risk as well. In 1999, over 1.7 million acres of the Great Basin burned, impacting much of the remaining native shrublands.

An accelerated and unpredictable fire cycle can be costly and dangerous. It is estimated that the cost of ecosystem restoration and fire prevention will be less expensive in the long run than fire fighting and rehabilitation efforts. Investing money in rangeland restoration will enhance the ability of these areas to support livestock, resist wildfire, and contribute positively to overall watershed health. Healthy upland areas are more resistant to wildfire, as natural plant communities often contain fire-resistant species. Intact riparian areas may act as firebreaks, but degraded riparian areas are not effective barriers.

Overabundance of Native Grazers

Large populations of elk and mule deer, together with the introduction of free ranging horses, have increased grazing pressure on riparian areas. Overabundance of elk and deer is the result of decreasing numbers of their native predators, such as wolves and cougars, and decreased hunting. Numbers are further magnified as habitat losses force populations into ever-smaller areas. While native grazers do not play as much of a role as livestock, they are still a threat to riparian areas in the Great Basin.

Conservation: The Big Picture

Conservation measures must be enacted if existing riparian areas are to be preserved and degraded riparian areas are to be restored. Because river systems throughout the Great Basin are linked to one another and to the health of upland areas, restoration should be planned and carried out as a cooperative effort between various landowners and interests to be fully effective. A significant percentage of the Great Basin is in public lands, owned by the people of the United States, and therefore there is a great opportunity to better manage these important lands in the future.

Scope

Riparian health is inextricably linked to the health of the landscape as a whole. If uplands in the watershed are mismanaged, actions taken to improve riparian areas will not be fully effective. Traditional approaches to aquatic restoration have focused on fixing small-scale problems in the most degraded areas rather than landscape processes. To be truly effective, watershed-level conservation strategies must be implemented that can then be integrated over large geographic regions.

A watershed analysis can be undertaken to understand the processes and interactions occurring within a watershed, and then applied to describe linkages between land use and biological/physical environments at a large scale. The strength of a watershed analysis is that restoration opportunities are identified in an interdisciplinary, interagency environment. To be effective, restoration experts must understand how site-level problems relate to watershed-level processes.

The basic steps of a watershed analysis are:

- Characterization: Identify dominant physical, biological, and social processes of the watershed that effect ecosystem function or condition.
- Issues and key questions: Identify the key elements of the watershed most relevant to management objectives, social values, or environmental concerns.
- Current conditions: Document current range, distribution, and condition of core topics and important ecosystem elements.
- Reference conditions: Develop a history of landscape conditions to understand what changes are affecting current conditions and to help establish goals and objectives for management plans.
- Synthesis and interpretation: Define temporal linkages between ecosystem processes.

Research Natural Area: an area designated by the U.S. Forest Service that serves as a representative example of a minimally disturbed natural ecosystem for non-manipulative research activities, monitoring, and the protection of biological diversity

- Recommendations: Develop management recommendations based on above information.

On a larger scale, it is important to identify and protect natural areas that are crucial to sustaining long-term the biodiversity of the Great Basin region. Encouragement from private citizens, especially those that own land nearby or adjacent to these areas, can have an impact on their preservation. Large blocks of intact habitat can be found in Black Rock Desert, northwestern NV; Sheep Range, southern NV; Desert National Wildlife Refuge, southern NV; Nevada test site, southern NV; and Great Basin National Park, eastern NV. Important protected areas include Desert National Wildlife Refuge, southern NV; Dugway Proving Grounds, northwestern UT; National Electronic Warfare Center, UT; Hill Air Force Base, Wendover Range, northwestern UT; Arc Dome Wilderness Area, NV; Still Water National Wildlife Refuge, NV; and lakes Pyramid, Walker, Mono and Topaz. **Research Natural Areas** (RNA), which have the dual goal of preserving representative natural ecosystems and providing sites for ecological research, are also important. A good example is Red Butte Canyon near Salt Lake City, which is one of the few remaining undisturbed watersheds in the Great Basin. A number of studies have compared conditions at Red Butte Canyon with those of nearby canyons that have greater levels of human-induced disturbance. Areas like Red Butte Canyon are valuable for determining the effects of disturbance on riparian areas.

Funding Availability

Securing funding is a critical issue for any conservation project. Traditionally, funding has been received, yet focused on fences, personnel, and equipment, providing for livestock grazing, not managing and improving the land. For many states, economically important game species are often the focus of management efforts. Although these efforts benefit other wildlife species incidentally, game management is generally too narrowly focused to effectively conserve entire ecological communities. There is limited funding available for wildlife conservation in particular. Depending on the state, much of this funding comes from the sale of hunting permits and licenses, but the number of hunters has been decreasing in recent years. However, non-hunting recreational use of Great Basin lands is increasing, which may represent a new source of conservation funding. For the private landowner wishing to implement conservation measures, grants are available from federal agencies and other sources (see Appendix D).

Conservation: For the Landowner

Riparian areas, like other natural systems, are extremely complex, and our knowledge of restoration is still evolving. However, it is known that in order to restore these systems, we must understand how they are organized and what influences them. As with any natural system, it is easier to preserve healthy ecosystems than to rebuild degraded ones.

Any management plan should strive to minimize disturbance of the riparian area following project implementation until the stream has had time to stabilize. The riparian area should also be protected during spring and summer seasons when rare or sensitive wildlife are often found to be using the habitat.

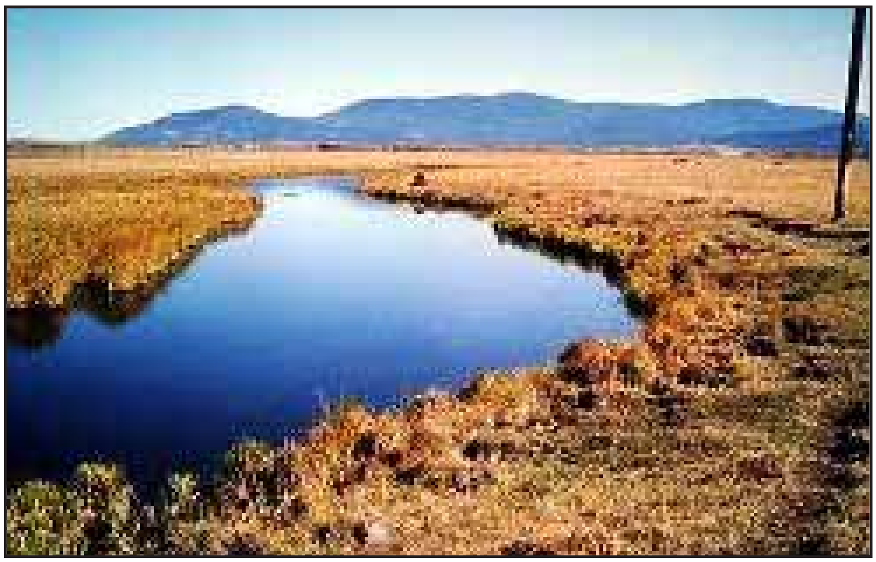
Establishing Restoration Goals

Restoration programs typically attempt to return the land to some previous healthier state. However, determining pre-disturbance environmental conditions in the Great Basin can be challenging because there is little land that has not been altered in some way by human actions. Livestock grazing has occurred in the west since the 1800s and, in many areas, pre-livestock historic conditions are unknown. Pre-grazing conditions may be inferred from pollen samples from soil cores, photographs and historical records (which should be interpreted with caution), serendipitously ungrazed lands, and intentionally ungrazed lands or exclosures, which are often small and were used previously for grazing.

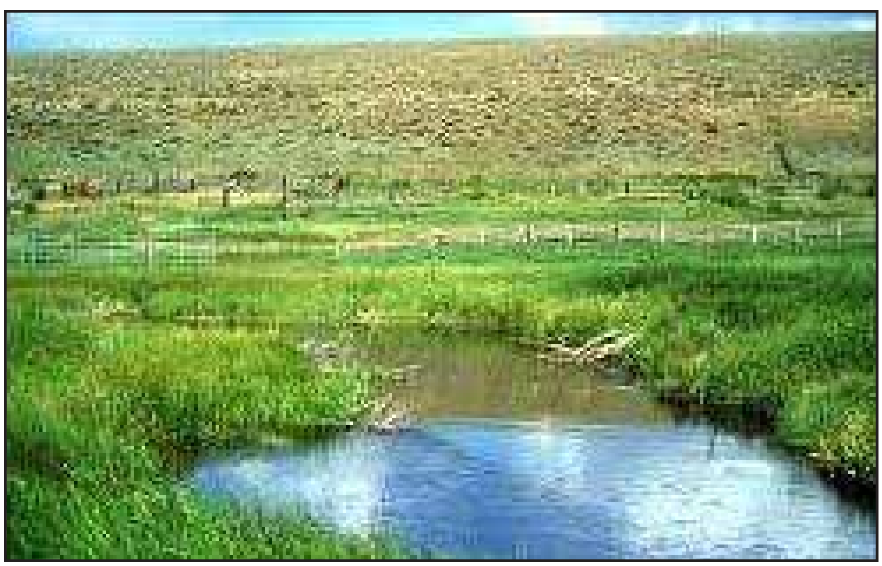
Assessment

The first step in riparian conservation at any scale, on private or government property, is an assessment of current conditions. One system that is very user-friendly for private landowners is the Natural Resources Conservation Service (NRCS) Stream Visual Assessment Protocol (SVAP). This system is effective for determining local stream health. The SVAP is a first tier of assessment; more in-depth protocols may be completed subsequently. Using SVAP, the stream is scored for channel condition, hydrologic alteration, riparian area, bank stability, water appearance, nutrient enrichment, barriers to fish movement, instream fish cover, pools, insect/invertebrate habitat, canopy cover, manure presence, salinity, riffle embeddedness, and macroinvertebrates observed. Additional evaluation or management actions may be recommended during or after the assessment. Individuals interested in obtaining a copy of the SVAP can do so by visiting http://www.nrcs.usda.gov/technical/ECS/aquatic/svapfnl.pdf.

In many areas, rangeland health is closely tied to riparian health because streams pass through areas that are managed for grazing. A method for assessing rangeland health has been developed by the Bureau of Land Management (BLM), Natural Resources Conservation Service (NRCS), United States Geological Survey (USGS), and Agricultural Research Service (ARS). This method, called Process for Assessing Proper Functioning Condition (PFC), is available for use by trained ecologists/land managers, who can be contacted through these organizations. The approach uses 17-20 indicators to qualify three ecosystem attributes, which include



U.S. Fish and Wildlife Service



U.S. Fish and Wildlife Service

Nevada Spring Creek before (top) and after (bottom) habitat restoration efforts. Habitat restoration efforts included planting riparian vegetation, excluding live-stock, and installing instream habitat components.

soil and site stability, hydrologic function, and biotic integrity. Each of these attributes is qualified according to the site's estimated ability to resist a reduction in each capacity and to recover following disturbance or degradation. This qualitative assessment should be used for an initial "moment in time" determination of site health, not as a monitoring tool and can be found at http://www.blm.gov/nstc/library/pdf/1734-6.pdf.

Best Management Practices (BMP's) often guide riparian and other types of habitat restoration. A best management practice is generally accepted as the preferred restoration approach. Typically, a suite of BM's is used to correct a particular problem. BMP's are designed to be implemented as a system, rather than individually. The use of only one BMP's will only address part of the problem and therefore only provide part of the solution. The synergistic nature of riparian systems indicates that a comprehensive management approach will be the most successful. Table 1 offers BMP's solutions for problems caused by agriculture, grazing, timber production, and urban development.

Table 1. Best Management Practices

Land Use	*Impact*	*Best Management Practice*
Agriculture	Sedimentation	Crop residue management
	Nutrient enrichment (eutrophication)	Fertilizer management
	Pesticide inputs	Integrated pest management
	Riparian vegetation clearing	Irrigation management
	Channelization	Riparian buffer creation/ preservation
Grazing	Sedimentation	Grazing management; riparian buffer creation/ preservation
	High-nutrient runoff	Alternative water sources
	Overgrazed vegetation	Fenced riparian buffer strips
	Trampled vegetation	Other structural improvements
Timber Production	Stream crossings	Proper road design
	Vegetation removal	Proper stream crossings and buffer zones
	Increased runoff	Sustainable logging strategies
	Pollution	Riparian buffer creation/ preservation
	Increased runoff	Reduce impervious cover
Urban Development	Vegetation removal	Limit soil disturbance and erosion
	Vegetation trampling	Treat stormwater runoff
	Channelization	Avoid use of riparian areas

Enhance Buffer Capabilities

Establishing a riparian buffer is a central component of any riparian restoration project. However, it is critically important to remember that without other management changes, the newly established vegetation may be destroyed by whatever degraded the buffer zone originally (pollution, erosion, altered hydrology, etc.).

Healthy vegetation is essential to the proper functioning of the riparian area. The riparian area not only provides an important link between the stream and upland areas, but also acts as a barrier between the two. A healthy riparian buffer protects the stream from influxes of pollution and sediment and protects upland areas by managing stream flow during floods. The extent of riparian vegetation along either side of the stream is both dependent on and helps to contain soil moisture. Plants are critical for stream stabilization, and also provide food and shelter for wildlife.

The first step in buffer design, and in creating a holistic riparian management plan, is to assess the current state of the stream, as discussed in the previous section. The second step is to mitigate negative impacts on the existing vegetation. For example, if livestock are overgrazing or trampling the vegetation and causing streambank erosion, livestock exclusion from the area may be necessary. Third, the goals of restoration should be established. For example, a buffer will be most effective for the purpose of preventing sediments and pollutants from entering the stream if it is located along a portion of the stream reach that receives large amounts of runoff. Or, to provide the best wildlife habitat, diverse vegetation types should be planted in clumps, as opposed to long, linear plantings. If the buffer will eventually be reintegrated with grazed areas, plans should include construction of livestock crossing areas and fences where necessary.

Once the stream has been assessed, impacts have been mitigated, and restoration goals set, the buffer can be designed and planted. For the purposes of buffer design, the riparian area can be divided into five zones: the toe zone, the bank zone, the overbank zone, the transitional zone, and the upland zone. The toe zone is the area normally inundated by the average water elevation of the stream. The bank zone is inundated when the stream rises to the bankfull discharge elevation, at the top of the point bar. The overbank zone, or floodplain, is inundated when the stream rises to the overbank elevation during flood events. The transitional zone is occasionally inundated during periods of flooding. The upland zone is rarely, if ever, inundated. It is important to delineate these zones so that particular species can be planted in locations where they will receive the appropriate amount of moisture. A useful way to select zone-appropriate species is to find a reference site with characteristics similar to the site you are trying to restore. See what species grow there and try to replicate the natural site as closely as possible during buffer creation. Remember that water levels probably fluctuate throughout the year, which influences the distribution of vegetation.

To the extent possible, riparian buffers should be designed to approximate the natural ecology of the region and the historical conditions of the particular stream reach to be restored. Although plantings as simple as a grass filter strip will be effective for controlling runoff and preventing some pollutants and sediments from entering the stream, woody species with deeper roots will stabilize the soil most effectively. A diverse assemblage of both woody and herbaceous native plants will provide the greatest wildlife benefit. Emergent wetland species are especially important for managing stream flow. Generally, lower growing species such as sedges, rushes, and grasses should be planted near the water's edge, and larger shrubs and trees should be planted farther from the water. Specifications for various conservation buffer practices can be obtained from NRCS state offices or at http://www.nrcs.usda.gov/feature/buffers/.

It is important to use native species for restoration whenever possible. Native plant species are well suited to the soil and climatic conditions of the region, and provide the best habitat for native wildlife species. The use of locally grown native plants helps to preserve the genetic integrity of native plant communities. A listing of both herbaceous and woody species appropriate for riparian restoration is provided in Tables 2 and 3. If landowners are managing for particular wildlife species, the needs of those species can be specifically addressed.

More information about planting a riparian buffer in the Great Basin region can be obtained from the NRCS Plant Materials Center in Aberdeen, Idaho (http://plant-materials.nrcs.usda.gov/idpmc). Both restoration guidelines as well as species-specific information can be found in their publications, or at the NRCS PLANTS Database (http://plants.usda.gov). Native plant nurseries, a good source of native

NRCS

A vegetated riparian area serves as a buffer between a stream and the surrounding suburbs.

Table 2. Herbaceous Plant Species for Riparian Restoration

Common Name (Scientific Name)	*Soil Conditions**	*Wildlife Value***
Bentgrasses (*Agrostis* spp.)	F	
Sloughgrass (*Bechmannia syzigachne*)	F	GmSW
Water sedge (*Carex aquatilis*)	FSW	CGLMmSW
Nebraska sedge (*Carex nebrascensis*)	FSW	GLMmSW
Beaked sedge (*Carex utriculata*)		GmSW
Tuffed hairgrass (*Deschampsia cespitosa*)	FSW	GmSW
Creeping spikerush (*Eleocharis palustris*)	F	mSW
Mannagrass (*Glyceria striata*)	F	GmSW
Baltic rush (*Juncus balticus*)	DFSW	GMmSW
Soft-leaf or mat muhly (*Muhlenbergia richardsonis*)	DS	GLM
Cusick's bluegrass (*Poa cusickii*)	DS	GLMmW
Nevada bluegrass (*Poa nevadensis*)	DS	GLMmW
Hardstem bulrush (*Scirpus acutus*)	F	GMmSW
Alkali bulrush (*Scirpus maritimus*)	F	GMmSW
Threesquare bulrush (*Scirpus pungens*)	F	MmW
Prairie cordgrass (*Spartina pectinata*)	F	GMmSW
Common cattail (*Typha latifolia*)	F	MmW

Legend

*Soil Conditions:
D - Drought
F - Flooded
S - Sun
s - Shade

**Wildlife Value:
B - Butterflies and Moths
C - Caterpillars
G - Upland Ground Birds
L - Large Mammals
M - Browsing Mammals
m - Small Mammals
S - Songbirds
W - Waterfowl and Shorebirds

seeds and plants, can also provide information and advice. A listing of native plant nurseries by state can be found by contacting the Ladybird Johnson Wildflower Center at http://www.wildflower.org.

Guidelines for Planting Herbaceous Species

Herbaceous species, such as grasses, sedges, and rushes, can be planted in the emergent zone (includes the toe, bank, and overbank zones). They can be established from plugs (seedlings) or from seed. Establishing herbaceous riparian plants from seed is often quite tricky, so planting guidelines for emergent plugs are provided here. However, establishment from seed would be the easiest method in upland areas or if a grassland, rather than emergent, community is being created. A local NRCS field office can provide additional guidance.

U.S. Environmental Protection Agency

Herbaceous species can be established from plugs.

Plugs are most often used when planting emergent species that grow in the portion of the riparian area that is occasionally inundated, but where the soil is at least moist year-round. As a result, these plants are tolerant of low-oxygen soil conditions. When selecting or picking up plugs, make sure that the above ground portion of the plant is tall enough to remain above the water line after planting. Also check that the seedling is not root bound. Try to minimize the amount of time between nursery and planting.

Generally, plugs can be planted from April to October. If planted early, conditions may be slightly cooler than is optimal, but the plugs will have longer to establish prior to the start of the next winter season. If planted too late, frost heaving may dislodge the plugs from the soil and decrease the rate of establishment.

A general guideline is to plant plugs at a spacing of no more than 18 inches. As the plants grow, they will spread both by seed and vegetatively to fill in the gaps. If there are not enough resources to plant the entire area at this concentration, plant in copses, or clumps, rather than spreading the plugs farther apart. If the plants are too far apart they may not fill in properly and will have less value as wildlife cover.

Since emergent plugs are planted in damp soils, it should be easy to dig a hole with a spade. Place the plug in the hole and tamp the soil. In areas where clay dominates the soil, digging may be more difficult. In these situations, a tractor or small bulldozer with a ripper tooth can be used to dig small trenches, which can then be planted at the appropriate spacing.

Typically, fertilizer isn't necessary, but if the soil conditions are very poor, fertilizer may be warranted. Also, having an invasive species control plan in place prior to planting is very important.

Guidelines for Planting Woody Species

Shrubs and smaller trees can be planted in the bank and over bank zones. Larger trees need to be planted outside the bank zone or in the transitional or upland zones, so that they are not uprooted during flood events, but still able to reach the water table.

Woody plants such as willow, cottonwood, or dogwood can be propagated from hardwood cuttings. Hardwood cuttings are easy to plant, inexpensive, and locally

Table 3. Woody Plant Species for Riparian Restoration

Common Name (Scientific Name)	*Soil Conditions**	*Wildlife Value***
Black cottonwood (*Populus trichocarpa*)	SsF	BGLMmSW
Blue elderberry (*Sambucus coerulea*)	FS	GLMmS
Bog birch (*Betula pumila*)	FSW	CGmSW
Boxelder (*Acer negundo*)	DFS	CGMmSW
Chokecherry (*Prunus virginiana*)	DSs	BGLMmS
Common snowberry (*Symphoricarpos albus*)	DSs	GLMmS
Douglas hawthorn (*Crataegus douglasii*)	DFS	GLMmSW
Fremont cottonwood (*Populus fremontii*)	FS	BGLMmS
Golden current (*Ribes aureum*)	Fs	GLMmS
Mockorange (*Philadelphus lewisii*)	Ss	m
Narrowleaf cottonwood (*Populus angustifolia*)	FS	BLM
Paper birch (*Betula papyrifera*)	DS	CGLMmS
Quaking aspen (*Populus tremuloides*)	S	BCGLMmS
Red alder (*Alnus rubra*)	S	GLMS
Red elderberry (*Sambucus racemosa*)	FSsW	GLMmSW
Red-osier dogwood (*Cornus sericea*)	FSsW	BLMmSW
Shrubby cinquefoil (*Pentaphylloides floribunda*)	DFS	GLMmS
Silver buffaloberry (*Sheperdia argentea*)	S	BGS
Sitka alder (*Alnus sinuata*)	SsF	LMmSW
Skunkbush sumac (*Rhus trilobata*)	S	mS
Spring birch (*Betula occidentalis*)	FSW	M
Swamp birch (*Betula nana*)	FSW	CGLMmS
Weeping birch (*Betula pendula*)	Ss	GLMmSW
Willow (*Salix* spp.)	F.Ss	LMm
Thinleaf alder (*Alnus incana tenuifolia*)	SsF	LMmSW

Legend **Wildlife Value:
B - Butterflies and
Moths
*Soil Conditions: C - Caterpillars
D - Drought G - Upland Ground
Birds
F - Flooded L - Large Mammals
S - Sun M - Browsing
Mammals

available. The best time to collect them is just after leaf fall until the buds break in spring. They should be stored in a cool (34-36ºF), moist, dark place until five to seven days before planting time, when they should be placed in water to soak. When soaking, allow buds to swell but remove the cuttings prior to root emergence. Planting should occur after high spring flows have passed but before peak summer temperatures arrive. Smaller cuttings from shrubs and trees should be between one-half and three inches in diameter (pole cuttings), or between three and six inches in diameter (post cuttings). Side branches and the terminal bud should be removed. The cutting must be long enough to extend six to eight inches below the water table, and between one half and two thirds of the cutting should be in the soil after planting. Poles are planted with planting bars, soil augers, and power augers, while posts are planted using posthole diggers, tractor-mounted posthole augers, and backhoe-mounted bars. Willow, cottonwood, or dogwood, as well as alder and birch, can also be obtained as bare root or container stock from a native plant nursery.

After planting either herbaceous or woody plants, it is important to monitor whether or not they establish successfully. Note which types of plantings are most successful and where and how they were planted. Also monitor the growth rate of plants that become established. If additional plantings are necessary in the future, a detailed assessment of the first planting attempt will help streamline the second planting and increase success rate.

Control Invasive Species

Invasive plants are an extremely pressing environmental concern in the Great Basin. Invasive species should be monitored and controlled, as they can spread and decimate both upland and riparian areas with severe ecological and economic effects.

Invasive species often come to dominate local ecosystems, reducing diversity and crowding out native species. When a plant community is dominated by only one or a few species, the diversity of food sources will decrease and native birds, mammals, and other animals can suffer. Furthermore, less diverse communities are more susceptible to environmental stresses, and are less resilient to disturbance than healthy, native ecosystems that contain a wide variety of vegetation.

Generally, non-native invasives possess traits that allow them to spread rapidly. Invasive plants are often prolific seed producers and many develop extensive underground root systems so that they can spread vegetatively. Furthermore, invasive plants are often successful in areas with poor soil quality, and are thus able to outcompete native species that are more “selective.” Primary competitors, predators, and diseases from their native ecosystems do not typically follow invasives to new areas, making their establishment and success all the more likely.

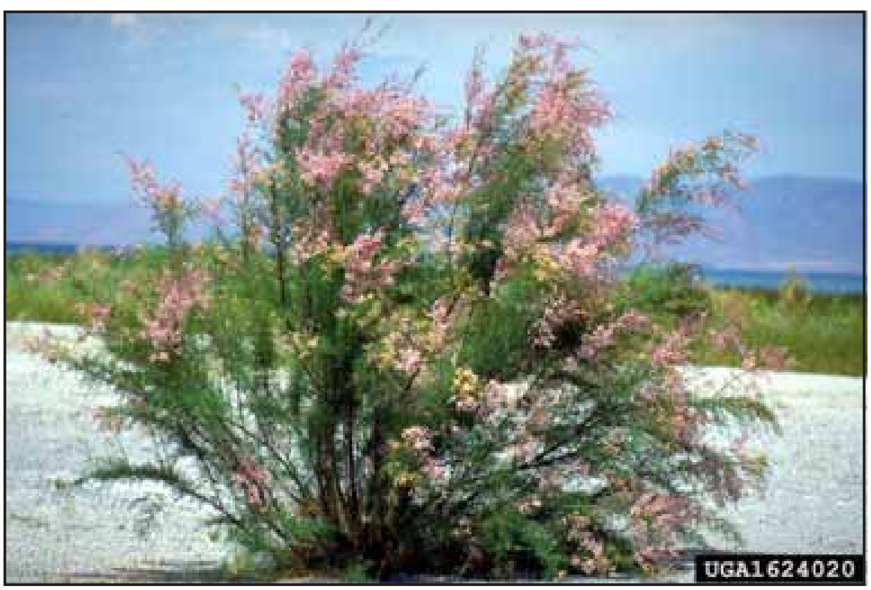
Preventing the spread of invasives is often difficult. Seeds often disperse to new areas via roadways, in seed mixtures, or are carried by birds and mammals that consume them. However, spreading can be minimized by being aware of the identity of invasive plants and avoiding their use.

Eradication of invasive species is often difficult and requires repeated actions and monitoring to achieve success. In many instances, eradication techniques (combined with prevention) can be effective if invasive species at a site are addressed while their populations are still manageable. Working to manage and prevent outbreaks of invasive plants will economically benefit agricultural and ranching operations and help to preserve riparian areas and their native biodiversity.

Weeds that may be problematic in riparian areas include perennial tamarisk (see below), pepperweed, and whitetop. Two good sources of information about invasive plant species and eradication techniques are The Nature Conservancy's Wildland Invasive Species Team *Invasives on the Web* http://tncweeds.ucdavis.edu, and the Plant Conservation Alliance's Alien Plant Working Group, http://www.nps.gov/plants/alien/index.htm.

Case Study: Tamarisk

Tamarisk is one of the most common invaders that are problematic in Great Basin riparian areas. Tamarisk, also known as saltcedar, is the common name for five species of deciduous *Tamarix*: *T. ramosissima*, *T. pentandra*, *T. chinensis*, *T. parviflora*, and *T. gallica*. For management purposes, the five species are generally considered together, but should be distinguished from the evergreen species, *Tamarix aphylla*, which is not nearly as invasive. Tamarisk has invaded nearly one million acres of floodplains, riparian areas, lake margins, and wetlands in the western United States. It is tolerant of a wide variety of environmental conditions once established, and can displace native cottonwoods, willows, and other woody species. Tamarisk consumes more water than native woody species and is able to store salts in its leaves, which leads to highly saline and inhospitable areas around the tamarisk plant



Steve Dewey, Utah State University, www.invasive.org

Tamarisk is one of the most problematic invaders in the Great Basin.

when the deciduous leaves drop. Although tamarisk provides useful nesting habitat for some species of birds, it is generally unpalatable, and has a lower wildlife value than native woody plants. Tamarisk can clog stream channels and alter the extent of the floodplain.

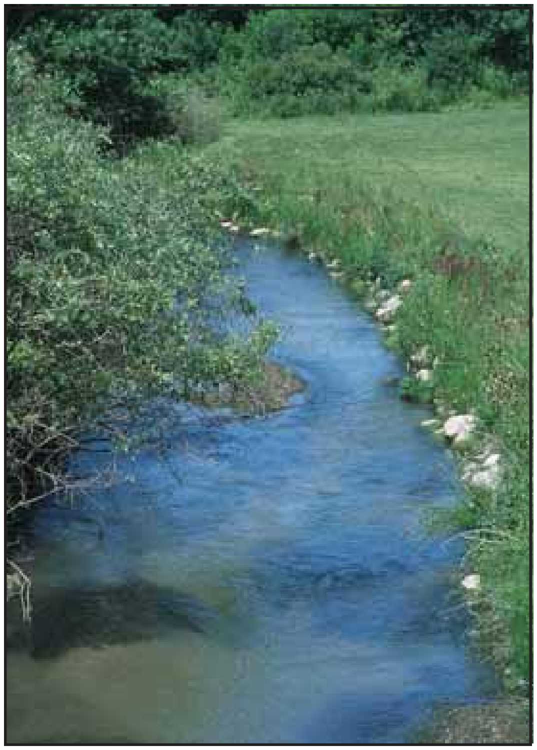
Tamarisk is able to draw water from deep in the soil during establishment, but once established, can survive without groundwater access, making it a facultative **phreatophyte**. This feature gives tamarisk an advantage over willows, which are obligate phreatophytes. In a recent study comparing a native willow species (*Salix gooddingi*) with Chinese tamarisk (*Tamarix chinensis*), tamarisk seedlings displayed a greater resistance to water table decline than willow seedlings. It was also noted, however, that tamarisk will not colonize an area as readily if the existing vegetation is dense. Thus, a healthy riparian area may prevent tamarisk invasion, but if the riparian area is disturbed, tamarisk may invade and then proceed to outcompete willow and other native species during drought conditions.

If tamarisk has already invaded, control methods can be used to halt its spread and remove or kill the existing plants. However, it is likely that tamarisk will reinvade, especially in disturbed areas. Therefore, continued vigilance is necessary for successful tamarisk control. The five basic tamarisk control methods are described in Table 4. Determining which method to use will depend on various factors as noted.

Table 4. Tamarisk Control Methods

Technique	*Applicability*
Foliar herbicide application to intact plants.	Useful if a large area is covered by a monotypic or near monotypic stand of tamarisk. Herbicide use should be avoided near water, or non-persistent chemicals should be used.
Removal of above ground stems either by burning or mechanical means, followed by foliar herbicide application.	Useful if a large area is covered by a monotypic or near monotypic stand of tamarisk. Burning may not be an option in all areas. Herbicide use should be avoided near water, or non-persistent chemicals should be used.
Cutting individual stems near the ground followed by herbicide application on the stumps (cut-stump method).	More time-consuming, but can be useful in moderately-sized areas where tamarisk is interspersed with desirable vegetation.
Herbicide applications on the uncut basal bark.	More time-consuming, but can be useful in areas where tamarisk is interspersed with desirable vegetation.
Digging or pulling individual plants.	Useful if only a few plants are present, or in a very sensitive area where avoidance of herbicide use is essential.

phreatophyte: a deep-rooted plant that obtains water from a permanent groundwater supply or from the water table



NRCS

Riprap placed at the top of the bank in high energy areas can be useful for stablizing streambanks.

Stabilize Streambanks

Ideally, riparian conservation should restore the area to conditions that are as natural as possible. Healthy riparian vegetation has a large impact on stream stability, and working to reestablish riparian plants will solve many stream stabilization issues. However, in many situations, recreating the vegetation community may not be enough and instream engineering solutions may be necessary. If conditions in the channel are very poor (banks are extremely steep, water velocity is too high, heavy scouring occurs), vegetation will not establish easily. Placing instream structures will help to manage flow and create better conditions for vegetation establishment. Instream vegetation will help to manage flow, but is often difficult to establish. When flow conditions improve, instream and riparian vegetation may begin to establish naturally, and plantings have an increased likelihood of success.

Engineering solutions to stabilize streambanks may be required in developed areas. Due to the complex nature of stream dynamics, the outcome of any such engineering project will be difficult to estimate, so structural changes to a stream should only be enacted with the assistance of a professional. Furthermore, while placing instream structures can be very effective, they often require a considerable investment of resources. Therefore, instream improvements should be used in conjunction with other management changes in severely degraded areas. Engineering solutions for stream stabilization are described in Table 5.

Table 5. Engineering Solutions for Stream Stabilization

Type	*Description/Purpose*
Single wing deflector	Guide and concentrate flow and create meandering
Erosion control/bank cribbing	Stabilize and protect eroded banks
K-dam	Provide pools, collect organic matter; waterfalls improve dissolved oxygen levels
Tree snag	Provides habitat for fish
Hollow log imitator	Provides fish spawning habitat
Channel constrictor	Redirect and increase depth of flow
Channel block	Redirect and increase depth of flow

Bio- or soft-engineering techniques, which combine natural materials and live plantings to stabilize streams, are often used. For more information on bioengineering techniques, see Bentrup and Hoag, 1998.

In some areas, beaver introduction may be useful to stabilize streambanks. Beaver dams will slow stream velocity and create conditions that promote the deposition of sediment. State wildlife agencies can help landowners determine if beaver reintroduction would be effective in a particular stream reach.

Water Management

Water is a limited resource in the Great Basin. Agriculture, grazing, hydropower, mining, industrial use, and domestic consumption all serve to divert water from streams. When allocating this limited resource, the riparian environment must be accounted for as a legitimate consumer of water. This investment is returned because a healthier riparian environment will help to replenish groundwater resources by storing water and releasing it during periods of low precipitation.

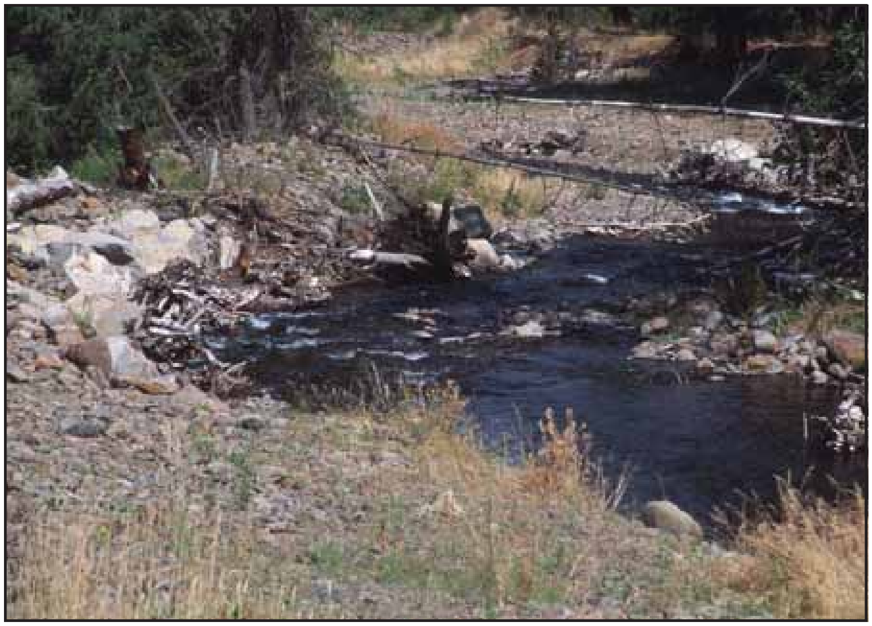
Groundwater and surface water together form an integrated hydrologic system. This system is in dynamic equilibrium: inputs and outputs are directly related. If the recharge capacity of an area remains stable over time, as is often the case, because precipitation levels are relatively constant, increased groundwater withdrawal and surface water use will reduce the amount of water available for ecological systems. Thus, water conservation at a household level is critical. Another solution for groundwater conservation is to increase recharge. Recharge basins can be used for this purpose. On a smaller scale, using permeable surfacing materials can help to prevent some of the decreases in recharge associated with development.

Provide Instream Habitat Components

Providing instream structure can greatly improve a stream's value to various species of fish. Structure alters the movement of water through the stream channel and provides substrates for fish feeding and spawning. Due to the complex nature of stream systems, landowners should seek the assistance of natural resource professionals when attempting to provide instream habitat components. Some examples of instream habitat structures include:

- *Boulder clusters*: create cover, scour holes, and areas of reduced velocity; useful in streams with gravel or rubble bed that are wide and shallow.
- *Weirs or sills*: log, boulder, or quarrystone structures that are placed across the channel and anchored to the stream bank and streambed; create pools, control bed erosion, and collect and retain gravel; may be straight, directed across or diagonally down the stream, or may point upstream or downstream in a U or V shape.
- *Fish passages*: allow fish to migrate up and down streams in areas where obstructions such as waterfalls, dams, sills, culverts, debris accumulations, or beaver dams interfere with their movement.

- *Log/brush/rock shelters*: used along the stream to stabilize banks and create overhanging fish habitat/shading; useful in low-gradient streams where pools are present but overhead cover is needed.
- *Lunker structures*: used along the stream to stabilize banks and create covered compartments for fish shelter; most often used in gravel bed streams that do not carry heavy bed loads; constructed of heavy wooden planks and blocks.



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Large wood and rocks provide in-stream habitat for wildlife. Note the reduced vegetation along the stream bank as a result of over grazing.

Reduce the Impacts of Construction

Urban development can degrade riparian areas. Some impacts are related to roads and other construction near the stream. Paving roads and parking lots increases the amount of runoff that enters streams by decreasing the amount of pervious surface. Often, this runoff carries sediment, chemicals, and other pollutants. Road construction close to the stream may result in structural changes to the riparian area. Conversely, the dynamic nature of the riparian area may result in structural instability of the roadway.

In addition to impacts on stream structure and water quality, roads can influence local ecology. They provide pathways for non-native species invasion and fragment wildlife habitat. Animals may be hindered in their movements through the riparian area or may suffer direct mortality due to vehicle collisions. However, careful road construction can decrease these impacts. The primary objective should be to avoid new road construction in riparian areas, and to close and rehabilitate old roads whenever possible. If this is not an option, a buffer should be preserved between the stream and the road. Some other options include:

- Controlling public access: designate recreational areas and close the road seasonally;

- Relocating or realigning roads to protect sensitive areas;
- Controlling erosion: provide erosion control structures or retaining walls, use outsloping techniques, plant vegetation;
- Controlling landslides;
- Managing runoff with ditches or roadway dips;
- Providing wildlife crossings; and
- Ensuring that bridges or culverts allow fish movement.

Practice Low Impact Recreation

Recreational land use is on the rise. This increase is generally positive because it indicates an interest in the health of natural areas. However, any level of human influence can have negative impacts. With careful management, people can use recreation areas without causing unacceptable stress on natural ecosystems.

Part of the responsibility for maintaining the health of streamside zones in existing recreational areas lies with the public. Low-impact techniques are very important, especially with increased use. Leave No Trace, an organization dedicated to encouraging responsible outdoor recreation, has developed six basic principles to reduce the impacts of recreational land use. They are:
- Plan Ahead and Prepare.
- Travel and Camp on Durable Surfaces.
- Dispose of Waste Properly.
- Leave What You Find.
- Minimize Campfire Impacts.
- Respect Wildlife.
- Be Considerate of Other Visitors.

Additionally, motorists should take caution when driving off roads. It has been shown that off-road vehicles compact soils, crush vegetation and crusts, and increase soil erosion. Each motorist should be responsible for the overall well-being of ecosystems in the west; therefore driving should be limited to already maintained roads.

Hunting and Fishing

Hunting and fishing are American traditions and provide much-needed revenue for conservation efforts. Although targeted management for non-game species is on the rise, conservation of these species has historically been the by-product of game species management. The budgets of state natural resource agencies are heavily dependent on funding received from hunting licenses. Furthermore, organizations that work for the benefit of game species, such as Trout Unlimited, often make important contributions to conservation of nongame species. Individual hunters can work to reduce their impact by practicing low-impact land use as described above, supporting conservation organizations that work to manage game populations, and learning about the species and ecology of local natural areas.

Agricultural Management

The major problems created by agricultural use of riparian areas are erosion and the introduction of contaminants. One way to mitigate both of these impacts is to leave or create a vegetated riparian buffer on both sides of the stream. Source reduction of pollution is important as well. Three strategies of pollution reduction include integrated pest management, nutrient management, and tillage systems.

Integrated Pest Management

An integrated pest management (IPM) plan can be developed to control pests in a way that is most compatible with the environment, using biological, cultural, and other controls in combination with judicious pesticide use. Pests include insects, nematodes, pathogens, vertebrates, and weeds. IPM attempts to control pests primarily by taking advantage of natural forces such as weather, pest diseases, parasites, and predators. IPM takes a proactive, rather than reactive, approach to pest control, and limits pesticide use to situations where other measures are not effective and threats to crops are imminent. An integrated, careful approach to pest management is important because pesticides can have impacts on both the environment and human health.

Nutrient Management

Nutrient inputs to streams from fertilizers applied to agricultural land can be reduced by developing a nutrient management plan. In a cyclic fashion, nutrients are taken up by plants from the soil and replaced in the soil when plants die and decompose. In crop systems, the plant materials are removed, so nutrient levels decrease over time, and thus the addition of nutrients (i.e., fertilizers) is required. Excess amounts of these nutrients cannot be used by the crops or assimilated into the soil, and may end up in streams, causing eutrophication. Nutrient management systems are designed to maximize crop production while minimizing nutrient waste.

The first step in nutrient reduction is soil testing, after which necessary nutrients can be applied in adequate but not excessive amounts. Nutrients added to the soil will be retained better if erosion is decreased and infiltration is increased.

Tillage and Residue Management

One way to reduce sedimentation caused by erosion is to implement no-till/strip-till, mulch-till, or ridge-till systems, which preserve crop residues on the surface of the land throughout the year and minimize disturbance during planting. The amount of crop residue depends on the type of crop and on the tillage method. Retaining crop residues reduces the splash effect of rainfall, increases infiltration, and reduces runoff and windblown loss of soil material and associated contaminants. Residues can also reduce the likelihood of ephemeral gully erosion. Tillage and residue management can also improve the organic structure of the soil. Machinery and labor costs for low-till systems are less than for conventional tillage methods, while

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A tillage system that leaves last year's crop residue on the soil can help reduce erosion.

weed-control is slightly more expensive. On the whole, the budgets for conventional and no-till operations are very similar, and no-till practices improve soil and environmental quality.

Grazing Management

On landscapes used for livestock production, effective grazing management can help maintain the integrity of both upland and riparian ecological communities. A healthy riparian area requires a functioning riparian plant community, which relies on a healthy stream system and adequate moisture. However, riparian areas can also provide an important source of water and forage for livestock. Grazing management practices can be altered to benefit riparian areas while maintaining or improving the value of the land for livestock.

Livestock Exclusion and Fencing

Despite the more complex management required, restricting grazing in riparian areas has been shown to improve the health of the area and increase abundance and diversity of wildlife. As described previously, creating a buffer zone of riparian vegetation between the stream and the grazed area will help to protect the stream and provide habitat for riparian wildlife. A buffer zone can be created by fencing off all or portions of the stream and adjacent riparian area, in addition to a small adjacent upland area. Livestock crossing areas can be developed as necessary. A variety of fence types can be used, which vary in cost, maintenance required, and effectiveness. Different fence designs include electric fences, wood fences, and rock jacks. However, fences may exclude larger wildlife from the riparian area, which may not be a desired outcome. Fence designs have been developed that allow movement of native wildlife species such as pronghorn, mule deer, and mountain sheep, while restricting livestock movement. Varying the number, type, and spacing of wires will make fence safer for wild animals. Financial and technical assistance for fence installation is available through a variety of programs listed in Appendix D.

Rotational Grazing/Alternative Species

Rotational grazing or early or late season grazing may be effective in reducing pressure on both riparian and upland rangeland. A basic description of the various rotational grazing systems is provided in Table 7. Factors that should be considered when selecting a grazing system include water availability, forage type, livestock species, terrain, number and size of pastures available, and the relative location of pastures.

Grazing a different species may benefit riparian areas as well. Bison, for example, will utilize areas of rangeland that cattle will not, and they do not actively select for riparian areas as cattle do. They are hardier than cattle and can survive cold winter temperatures and deep snows. However, bison require more durable, higher fencing than cattle, and they are larger and more difficult to control.

Table 7. Grazing Systems

Grazing System	*Description*
Continuous	Unrestricted livestock access to any part of the range during the entire grazing season.
Rotation	Intensive grazing followed by resting. Livestock are rotated among two or more pastures during grazing season.
Switchback	Livestock are rotated back and forth between two pastures.
Rest-rotation	One pasture rested for an entire grazing year or longer. Others grazed on rotation. Multiple pastures with multiple or single herd.
Deferred Rotation	Grazing discontinued on different parts of range in succeeding years to allow resting and re-growth. Generally involves multiple herds and pastures.
Twice-over Rotation	Variation of deferred rotation, with faster rotation. Uses three to five pastures.
Short-duration Grazing	Grazing for 14 days or less. Large herd, many small pastures (4-8 cells), high stocking density.
High Intensity - Low Frequency	Heavy, short duration grazing of all animals on one pasture at a time. Rotate to another pasture after forage use goal is met. Multiple pastures with single herd.
Merrill	Each of four pastures grazed 12 months and rested four months
Decision Rotation	No specific number of herds or pastures.

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Cattle are grazing on the left side of the fence and will be moved to the right side of the fence after a three-week grazing rotation.

Off-Stream Water Sources

If fencing is used to exclude livestock from riparian areas, alternative water sources must be made available for grazing. A wide variety of artificial water sources can be constructed including horizontal wells, tenajas, sand dams, reservoirs and small ponds, dugouts, adits, and guzzlers. Keep in mind that any artificial water source designed for cattle will also attract wildlife. It is important that the water source be safely and easily accessible for all users. Design elements should be included to prevent stock tanks from becoming traps for bats and other wildlife. Specifically, wires or other structures should be suspended on the water surface and escape ramps should be installed to enable wildlife that fall in the water to exit the tank.

Develop a Monitoring Program

After riparian enhancement projects have been completed, it is desirable to monitor the health of the ecosystem to assess the effects of actions already taken and to determine whether future projects are warranted. Assessments should be completed in terms of structural habitat components and benefit to wildlife. For example, if a riparian buffer was planted, streambank erosion should decrease and water retention capabilities should increase as the buffer vegetation develops. The number and variety of riparian wildlife species should increase as better food and cover resources become available. The assessment might determine that although the buffer vegetation is adequate for erosion prevention in some areas, engineered structures might be useful at areas of the site where erosion continues to be problematic. Wildlife assessment might point to a need for additional food plants used by a particular species.

Candidate Species: a species for which the Fish and Wildlife Service has sufficient information on its biological status to propose it as endangered or threatened under the ESA, but for which development of a proposed listing regulation is precluded by other higher priority listing activiites

Assistance Programs

Many groups that operate locally, regionally, nationally, or globally are involved with conservation efforts in the Great Basin. These organizations, whether they are governmental, private, or non-profit, may be narrowly focused on one or two issues or broadly address a variety of topics. Partnerships between various groups are becoming increasingly common as a way of dealing with environmental issues. One such partnership is Partners in Flight, an umbrella organization that brings together groups that are interested in the conservation of land bird species in the United States. Partners in Flight has united with other bird conservation partnerships under the North American Bird Conservation Initiative (NABCI). The goal of NABCI is to deliver the full spectrum of bird conservation through regionally based, biologically driven, landscape-oriented partnerships. Partnerships work to address conservation on a landscape scale while allowing partner groups to continue working at the local level.

Conservation of riparian and other aquatic habitats is widely recognized as an important issue. Landowners interested in developing riparian conservation projects on their property have a variety of options in seeking assistance. Government programs, mostly administered by the United States Department of Agriculture Natural Resources Conservation Service, provide both technical and financial assistance. Many of these programs were initiated or reauthorized by the 2002 Farm Security and Rural Investment Act (Farm Bill). The United States Fish and Wildlife Service has grant programs for private stewardship of imperiled species (species listed as endangered or threatened, **candidate species**, or those otherwise at risk) and wetlands conservation. For more information, see Appendices C and D.

The Future of Riparian Conservation

Streams and the riparian areas associated with them, although limited in extent, represent some of the most ecologically valuable land in the Great Basin region. The substantial biodiversity therein, which includes many endemic species, is threatened by habitat fragmentation, degradation, and destruction.

The economy of the Great Basin is heavily dependent on the land—grazing, agriculture, and mining are important industries. Outdoor recreation is increasing and brings revenues through usage fees and tourism. Humans depend on the environment for tangible resources, such as groundwater, minerals, or timber, and for intangible ecological services, including purified air and water.

Western biodiversity, already threatened by habitat loss and degradation, depends on the wise use of natural resources. For natural resource conservation actions to be effective and sustainable, they must protect the interests of the diverse group of people that make their home in the Great Basin. Fortunately, everyone can have an effect. Anyone who chooses can make a positive contribution to the conservation and integrity of riparian areas and other natural resources within the Great Basin.

Glossary

Biodiversity: the variability among living organisms on the earth, including the variability within and between species and within and between ecosystems

Candidate species: a species for which the Fish and Wildlife Service has sufficient information on its biological status to propose it as endangered or threatened under the ESA, but for which development of a proposed listing regulation is precluded by other higher priority listing activities

Corridor: a more or less intact, linear pathway that can be used for dispersal between areas of habitat

Ecological services: those services provided by the environment, such as water purification and aesthetic importance. The economic value of these services is typically difficult to quantify

Ecoregion: an ecologically unified area that is defined based on the presence of similar natural features, including soils, geologic history, landforms, topography, vegetation types, plant and animal distributions and climate

Edge habitat: habitat near the border between two different habitat types

Emergent vegetation: plants rooted underwater that grow above the surface of the water

Endangered species: a species that is in danger of extinction throughout all or a significant portion of its range

Endangered Species Act: legislation passed in 1973 in order to conserve the ecosystems upon which endangered and threatened species depend, and to conserve and recover listed species; administered through the U.S. Fish and Wildlife Service

Endemic: a species native to or confined to a particular region

Ephemeral: a body of water that only exists in direct response to precipitation and that may dry up during dry seasons

Eutrophication: having waters rich in mineral and organic nutrients that promote a proliferation of plant life, especially algae, which reduces the dissolved oxygen content and often causes the local extirpation of other organisms

Evolution: change in the genetic composition of a population during successive generations, as a result of natural selection acting on the genetic variation among individuals, and resulting in the development of new species

Facultative: a species that is capable of functioning under various environmental conditions

Gaining stream: a stream or reach of stream that receives water from the zone of saturation

Groundwater: water beneath the earth's surface that saturates pores and fractures in sand, gravel, and rock formations and that serves as a water source for wells and springs

Indicator species: a species or community whose characteristics show the presence of specific environmental conditions

Insulated stream: a stream or reach of stream that is separated from the zone of saturation by an impermeable bed

Interior habitat: an area that is within a relatively uniform patch of habitat

Large wood: any large piece of relatively stable woody material having a diameter greater than four inches and a length greater than three feet that intrudes into the stream channel

Losing stream: a stream or reach of stream that contributes water to the zone of saturation

Marsh: a type of wetland that does not accumulate appreciable peat deposits and is dominated by herbaceous vegetation

Mesic: moderately moist conditions

Neotropical migratory bird: any migratory bird species that winters in South America, the West Indies, and Central America south of the Mexican Plateau

Obligate: an organism that is only able to survive in a particular environment or by assuming a particular role

Phreatophyte: a deep-rooted plant that obtains water from a permanent groundwater supply or from the water table

Playa: a nearly level area at the bottom of an undrained desert basin, sometimes temporarily covered with water during wet periods, underlain by stratified clay, silt, or sand, and commonly by soluble salts

Research Natural Area: an area designated by the U.S. Forest Service that serves as a representative example of a minimally disturbed natural ecosystem for non-manipulative research activities, monitoring and the protection of biological diversity

Riparian area: aquatic ecosystem (stream or river) and the surrounding terrestrial areas where vegetation may be influenced by elevated water tables or flooding and by the ability of soils to hold water (side channels, floodplains, or wetlands)

Rush: any of various stiff marsh plants of the genus *Juncus*, having pliant hollow or pithy stems and small flowers with scalelike perianths

Sedge: any of numerous grasslike plants of the family Cyperaceae, having solid stems, leaves in three vertical rows, and spikelets of inconspicuous flowers, with each flower subtended by a scalelike bract

Soil litter: recently fallen plant material that is partially decomposed and forms the surface layer of some soils

Speciation: the evolutionary formation of new biological species, usually by the division of a single species into two or more genetically distinct ones

Species richness: the number of species in an area or habitat

Stream order: a stream classification system according to branching pattern; headwater streams are first order streams, and unite to form second order streams, which unite to form third order streams, and so on

Threatened species: a species that is likely to become endangered in the foreseeable future

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Appendix A: Riparian Plants and Wildlife of the Great Basin

Common Name (*Scientific Name)*, Distribution in Western U. S.

Amphibians
tiger salamander (*Ambystoma tigrinum*), AZ, CA, CO, ID, NV, OR, UT, WA
western toad (*Bufo boreas*), CA, CO, ID, NV, OR, UT, WA
boreal toad (*Bufo boreas boreas*), NV
black toad (*Bufo exsul*), CA
Amargosa toad (*Bufo nelsoni*), NV
woodhouse toad (*Bufo woodhousei woodhousei*), AZ, CO, NV
Pacific tree frog (*Hyla regilla*), AZ, CA, ID, NV, OR, UT, WA
Pacific chorus frog (*Pseudacris regilla*), AZ, CA, ID, NV, OR, UT, WA
bullfrog (*Rana catesbeiana*), AZ, CA, CO, ID, NV, OR, UT, WA
Columbia spotted frog (*Rana luteiventris*), UT, ID, NV, OR
relict leopard frog (*Rana onca*), AZ, NV, UT
Oregon spotted frog (*Rana pretiosa*), CA, OR, WA
Great Basin spadefoot toad (*Spea intermontana*), AZ, CO, UT

Birds
spotted sandpiper (*Actitis macularia*), AZ, CA, CO, ID, NV, OR, UT, WA
western grebe (*Aechmophorus occidentalis*), AZ, CA, CO, ID, NV, OR, UT, WA
red-winged blackbird (*Agelaius phoeniceus*), AZ, CA, CO, ID, NV, OR, UT, WA
northern pintail (*Anas acuta*), AZ, CA, CO, ID, NV, OR, UT, WA
American wigeon (*Anas americana*), AZ, CA, CO, ID, NV, OR, UT, WA
northern shoveler (*Anas clypeata*), AZ, CA, CO, ID, NV, OR, UT, WA
golden eagle (*Aquila chrysaetos*), AZ, CA, CO, ID, NV, OR, UT, WA
great blue heron (*Ardea herodias*), AZ, CA, CO, ID, NV, OR, UT, WA
short-eared owl (*Asio flammeus*), AZ, CA, CO, ID, NV, OR, UT, WA
canvasback (*Aythya valisineria*), AZ, CA, CO, ID, NV, OR, UT, WA
American bittern (*Botaurus lentiginosus*), AZ, CA, CO, ID, NV, OR, UT, WA
red-tailed hawk (*Buteo jamaicensis*), AZ, CA, CO, ID, NV, OR, UT, WA
western sandpiper (*Calidris mauri*), AZ, CA, CO, ID, NV, OR, UT, WA
least sandpiper (*Calidris minutilla*), AZ, CA, CO, ID, NV, OR, UT, WA
Swainson's thrush (*Catharus ustulatus*), AZ, CA, CO, ID, NV, OR, UT, WA
Vaux's swift (*Chaetura vauxi*), AZ, CA, CO, ID, NV, OR, UT, WA
snowy plover (*Charadrius alexandrinus*), AZ, CA, CO, NV, OR, UT, WA
killdeer (*Charadrius vociferus*), AZ, CA, CO, ID, NV, OR, UT, WA
black tern (*Chlidonias niger*), AZ, CA, CO, ID, NV, OR, UT, WA
northern harrier (*Circus cyaneus*), AZ, CA, CO, ID, NV, OR, UT, WA
marsh wren (*Cistothorus palustris*), AZ, CA, CO, ID, NV, OR, UT, WA
olive-sided flycatcher (*Contopus cooperi*), AZ, CA, CO, ID, NV, OR, UT, WA
trumpeter swan (*Cygnus buccinator*), AZ, CA, CO, ID, NV, OR, UT, WA
yellow warbler (*Dendroica petechia*), AZ, CA, CO, ID, NV, OR, UT, WA
bobolink (*Dolichonyx oryzivorous*), AZ, CA, CO, ID, NV, OR, UT, WA
grey catbird (*Dumetella carolinensis*), AZ, CA, CO, ID, NV, OR, UT, WA
dusky flycatcher (*Empidonax oberholseri*), AZ, CA, CO, ID, NV, OR, UT, WA
willow flycatcher (*Empidonax traillii*), AZ, CA, CO, ID, NV, OR, UT, WA
Brewer's blackbird (*Euphagus cyanocephalus*), AZ, CA, CO, ID, NV, OR, UT, WA
perigrine falcon (*Falco peregrinus*), AZ, CA, CO, ID, NV, OR, UT, WA
common loon (*Gavia immer*), AZ, CA, CO, ID, NV, OR, UT, WA
common yellowthroat (*Geothlypis trichas*), AZ, CA, CO, ID, NV, OR, UT, WA
sandhill crane (*Grus canadensis*), AZ, CA, CO, ID, NV, OR, UT, WA

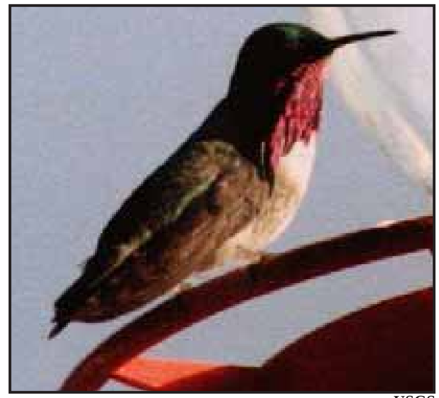
North American porcupine (*Erethizon dorsatuam*), AZ, CA, CO, ID, NV, OR, UT, WA
river otter (*Lontra canadensis*), AZ, CA, CO, ID, NV, OR, UT, WA
least weasel (*Mustela erminea*), AZ, CA, CO, ID, NV, OR, UT, WA
mule deer (*Odocoileus hemionus*), AZ, CA, CO, ID, NV, OR, UT, WA
white-tailed deer (*Odocoileus virginianus*), AZ, CO, ID, OR, WA
muskrat (*Ondatra zibethicus*), AZ, CA, CO, ID, NV, OR, UT, WA
water shrew (*Sorex palustris*), AZ, CA, CO, ID, NV, OR, UT, WA
western spotted skunk (*Spilogale gracilis*), AZ, CA, CO, ID, NV, OR, UT, WA
bats (Order Chiroptera, various species), AZ, CA, CO, ID, NV, OR, UT, WA

Reptiles
ringneck snake (*Diadophis punctatus*), AZ, CA, CO, ID, NV, OR, UT, WA
Great Basin/western skink (*Eumeces skiltonianus utahensis*), NV
Utah mountain kingsnake (*Lampropeltis pyromelana infralabialis*), AZ
terrestrial garter snake (*Thamnophis elegans*), AZ, CA, CO, ID, NV, OR, UT, WA

Plants
boxelder (*Acer negundo*), AZ, CA, CO, ID, NV, OR, UT, WA
bentgrasses (*Agrostis* spp.), AZ, CA, CO, ID, NV, OR, UT, WA
speckled alder (*Alnus incana*), AZ, CA, CO, ID, NV, OR, UT, WA
willow-alder (*Alnus incana tenuifolia*), AZ, CA, CO, ID, NV, OR, UT, WA
sagebrush (*Artemisia* spp.), CO, ID, OR, UT, WA
desert shrub/shadscale (*Atriplex confertifolia*), AZ, CA, CO, ID, OR, UT, WA
spring birch (*Betula occidentalis*), AZ, CA, CO, ID, NV, OR, UT, WA
cheatgrass or downy brome (*Bromus tectorum*), AZ, CA, CO, ID, NV, OR, UT, WA
whitetop (*Cardaria* spp.), AZ, CA, CO, ID, NV, OR, UT, WA
water sedge (*Carex aquatilis*), AZ, CA, CO, ID, NV, OR, UT, WA
Nebraska sedge (*Carex nebrascensis*), AZ, CA, CO, ID, NV, OR, UT, WA
short-beaked / copycat sedge (*Carex simulata*), AZ, CA, CO, ID, NV, OR, UT, WA
knapweeds (*Centaurea spp.)*, AZ, CA, CO, ID, NV, OR, UT, WA
rush skeletonweed or hogbite (*Chondrilla juncea*), CA, ID, OR, WA
red-osier dogwood (*Cornus sericea sericea*), AZ, CA, CO, ID, NV, OR, UT, WA
tufted hairgrass (*Deschampsia cespitosa*), AZ, CA, CO, ID, NV, OR, UT, WA
leafy spurge (*Euphorbia esula*), CA, CO, ID, OR, UT, WA
saltlover (*Halogeton glomeratus*), AZ, CA, CO, ID, OR, UT, WA
baltic rush (*Juncus balticus*), AZ, CA, CO, ID, NV, OR, UT, WA
pepperweed (*Lepidium latifolium*), AZ, CA, CO, ID, NV, OR, UT, WA
soft-leaf or mat muhly (*Muhlenbergia richardsonis*), AZ, CA, CO, ID, NV, OR, UT, WA
Cusick’s bluegrass (*Poa cusickii*), CA, CO, ID, NV, OR, UT, WA
Sandberg bluegrass (*Poa secunda*), AZ, CA, CO, ID, NV, OR, UT, WA
narrowleaf cottonwood (*Populus angustifolia*), AZ, CA, CO, ID, NV, OR, UT
Fremont cottonwood (*Populus fremontii*), AZ, CA, CO, NV, UT
black cottonwood (*Populus nigra*), AZ, CA, CO, ID, NV, UT
quaking aspen (*Populus tremuloides*), AZ, CA, CO, ID, NV, OR, UT, WA
chokecherry (*Prunus virginiana*), AZ, CA, CO, ID, NV, OR, UT, WA
willow (*Salix* spp.), AZ, CA, CO, ID, NV, OR, UT, WA
Russian thistle (*Salsola collina*, *S. paulsenii*, *S. tragus*), AZ. CO, UT
greasewood (*Sarcobatus vermiculatus*), AZ, CA, CO, ID, NV, OR, UT, WA
silver buffaloberry (*Sheperdia argentea*), AZ, CA, CO, ID, NV, OR, UT
medusahead *(Taeniatherum caput-medusae)*, CA, ID, NV, OR, UT, WA
saltcedar or tamarisk (*Tamarix ramosissima*), AZ, CA, CO, NV, UT

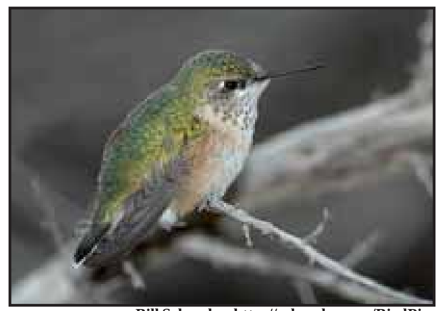
Appendix B: Featured Birds with High Conservation Priority

Calliope hummingbird
(Stellula calliope)



USGS

Male calliope hummingbird



Bill Schmoker http://schmoker.org/BirdPics

Female calliope hummingbird

The smallest of the North American breeding birds, the calliope hummingbird migrates from the northwestern United States and southwestern Canada to south-central Mexico. It occupies habitats ranging from riparian forests to shrub-sapling secondary growth to open montane forests. Adult males are metallic green on their back and crown with a white gorget and the females have a green back and crown, white throat with dark streaks, buff sides, and white-tipped tail corners.

Males arrive on the breeding grounds before the females in late-April to early-May. Males maintain a territory in which multiple females will nest and take sole responsibility for raising the young. Females construct nests usually in pine or other coniferous trees, but sometimes in apple, or alder, usually with the nest tucked under an overhanging branch to reduce exposure to the elements. The nest is often built on the base of an old pinecone and looks like a pinecone when complete. Nests may be used more than once, or new nests built on top of the old. Two eggs are incubated for 15-16 days. Calliopes consume nectar from flowers of many different colors, as well as small insects that may be captured in flight. They also eat sap from wells in trees created by sapsuckers.

Potential threats to this hummingbird include habitat loss, increased use of pesticides, and replacement of native plants by invasive plants. The restricted wintering range of calliope hummingbird makes the species more susceptible to natural disasters, diseases, or land use changes that could wipe out significant portions of the population. The *Partners in Flight North American Landbird Conservation Plan* has put this species on the watch list with the goal to maintain population numbers.

Green-Tailed Towhee
(*Pipilo chlorurus)*

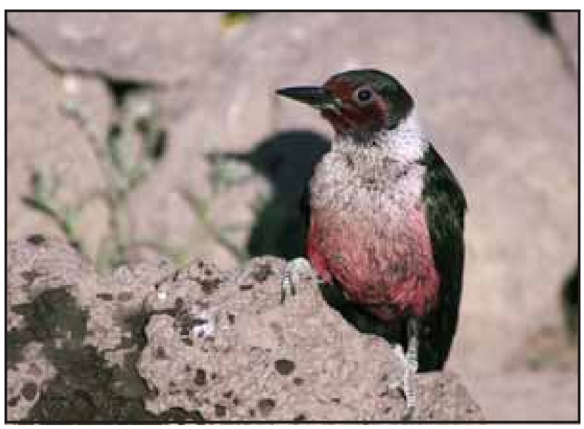
The Green-tailed Towhee is gray underneath with greenish upperparts. Adults have a rufous crown and a white throat-patch. Juvenile birds are brown-and-white streaked; with a yellowish wash on their wings Almost all of the activities of a green-tailed towhee are ground-centered, under the cover of shrubs and bushes. Green-tailed towhees always nest on or close to the ground, usually no farther up in the vegetation than about two feet. Green-tailed towhees primarily eat insects and their larvae, seeds, and occasionally fruit. Ground foraging is not uncommon, and green-tailed towhees will also hawk insects while in flight.

USGS

The green-tailed towhee is the only fully migratory towhee in the United States. It breeds from central Oregon south through the Rocky Mountains to southern California and the Great Basin to southeastern New Mexico, wintering at lower elevations and south to southern Arizona and central and southern Texas, occasionally continuing on to Mexico. The green-tailed towhee prefers to inhabit dry shrublands, primarily scrub oak, mountain mahogany, sagebrush, saltbrush, serviceberry, and pinyon-juniper, in the lowlands and the foothills.

Males arrive on the breeding grounds about a week before the females. The male will defend a territory, usually from a high perch, and monogamous pairs form shortly after the females arrive. The female builds a nest on the ground or in low shrubs made of twigs, grass, weeds, and bark, and lined with grass, rootlets and hair. The female lays three to four eggs and incubates them for about 12 days. Both parents feed the chicks, and fledglings leave the nest at 11 to 14 days of age. The parents continue to feed and tend to them until they can fly alone. The *Partners in Flight North American Landbird Conservation Plan* has listed this as a stewardship species, with the goal of maintaining population numbers.

Lewis's woodpecker (*Melanerpes lewis*)



U. S. Fish and Wildlife Service

Lewis's woodpecker can be found throughout the western United States and into Canada during the breeding season, although its distribution is fairly irregular. It inhabits open woodland and forests that are frequently logged or burned, including oak forest, coniferous forest, riparian woodland, and orchard edges, and occasionally pinyon-juniper habitat up to 9,000 feet. It is closely associated with cottonwoods and old-growth ponderosa pine. Lewis's woodpeckers, primarily those that breed further north, migrate south during the winters to northwestern Mexico.

Lewis's woodpeckers are completely glossy green-black from above, with a pale collar, a bright red face, and a reddish patch on the belly. The juveniles do not have the red face and pale collar, and are instead mottled in coloration, like the more typical woodpeckers.

Like most woodpeckers, the Lewis's woodpecker is monogamous and territorial. All woodpeckers nest in cavities that they typically excavate themselves, but Lewis's woodpeckers tend to use existing natural cavities or abandoned northern flicker cavities. They will excavate their own cavities in softer wood, however. The male builds the nest with help from the female, and both sexes incubate eggs and tend young.

Unlike other woodpeckers, Lewis's woodpeckers capture live food by flycatching in the air or gleaning from tree bark, rather than by drilling. Their diet also includes acorns, commercial nuts, pine seeds, and fruit. Acorns and nuts are cached for use during the non-breeding season in natural cavities. The Lewis's woodpecker defends its stored food aggressively.

Populations of Lewis's woodpeckers have declined approximately 60% during the past forty years. These declines are attributed to the degradation of riparian habitat and the resulting loss of suitable nesting cavities due to fire suppression, drought, and over grazing. *The Partners in Flight North American Landbird Conservation Plan* has put this species on the watch list with the goal to maintain or increase the population numbers.

Red-naped sapsucker
(*Sphyrapicus nuchalis*)

Scott Streit

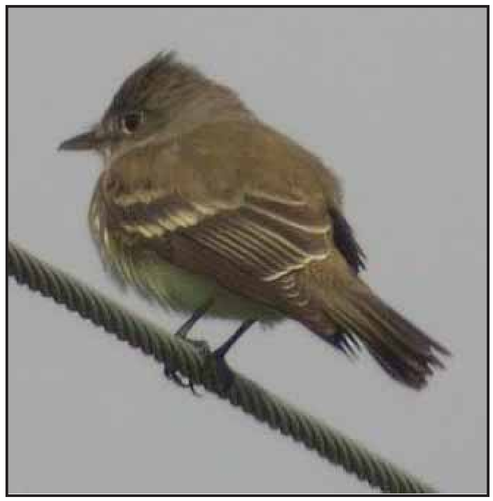
This is a medium-sized woodpecker, smaller than a flicker, and characterized by black-and-white stripes on its face, long white wing patch, barred back, and a white rump. Other markings include a red nape, forehead and throat and a black check crescent separating the throat from a pale yellow belly.

The breeding range of the red-naped sapsucker extends from south-central British Columbia, southwestern Alberta, and western Montana, south to east-central California, southern Nevada, central Arizona, southern New Mexico, and extreme western Texas. They winter in southern California, Oregon, southern Nevada, central Arizona, and central New Mexico, and south to northern Mexico. Found primarily in coniferous and deciduous forests, red-nape sapsuckers prefer areas that include aspen and cottonwood. During migration and in winter, they are found in various forest and open woodland habitats, and in parks, orchards, and gardens.

This species primarily drinks sap and eats the cambium of trees when foraging; however, it will also consume fruits and insects in wood. A primary cavity nester, excavates a nest hole in a snag or a living tree with a dead or rotten interior, and shows a strong preference for aspen, frequently near water. They often return to the same tree, not always the same cavity, year after year. Both sexes incubate four to five eggs for 12-13 days and nestlings fledge at 25-29 days.

The red-naped sapsucker is considered a "double keystone" species for its role excavating nest cavities and drilling sap wells, both of which are subsequently use by other species. Nest cavities are subsequently used by secondary cavity nesters, such as tree swallows, violet-green swallows, mountain bluebirds, chickadees, northern flickers, and house wrens. Threats include land management activities throughout their range, and the suppression of fire to maintain viable habitat. The *Partners in Flight North American Landbird Conservation Plan* has listed this as a stewardship species with the goal to maintain population numbers.

Willow flycatcher
(*Empidonax traillii*)


Fermilab

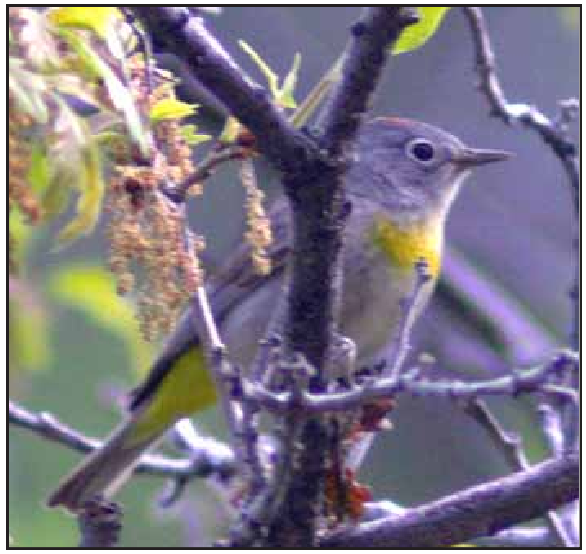
The willow flycatcher is a migratory species that breeds from Maine to British Columbia. Its breeding range extends as far south as southern parts of California and Arizona. Birds migrate over much of the southern United States to wintering sites in south Mexico, Central America, and northern South America. It generally does not breed in the higher elevations of the continental divide and in the drier states to the east. The willow flycatcher is a fairly inconspicuous bird with a flat forehead and a distinct peak on the rear crown. It has wing bars and a broad, straight-sided tail.

The species generally nests in riparian sites that are moist, shrubby areas often with standing or running water. Nests are generally close to the ground at the base of shrubs or small trees near water. Three to four eggs are laid, and the female incubates the eggs for 14 days. Both adults feed the young, and food is primarily insects. Foraging occurs in the air and among various kinds of vegetation.

Brood parasitism by the brown-headed cowbird negatively affects nesting success. This varies both in time and location with some areas being more affected than others. Habitat destruction and degradation plus overgrazing by livestock are the major causes of population decline. Large flood control dams which alter flooding cycles may affect nesting success since it is known that willow flycatchers will not attempt nesting in the absence of flowing water. The *Partners in Flight North*

American Landbird Conservation Plan has put this species on the watch list with the goal to increase population numbers by 50%.

Virginia's Warbler
(Vermivora virginiae)



Edson Leite

This species nests in summer in drought-tolerant pinyon/juniper and oak woodlands in Idaho, Wyoming, Nevada, Utah, Colorado, California, Arizona, New Mexico, and South Dakota. It may also breed in its winter range in the mountainous regions of southwest Mexico as well as Texas.

The adult male is gray with pale underparts, a yellow breast, white eye ring, and a rufous crown, which is often concealed. The female is similar except with a smaller or absent rufous crown.

Virginia's warbler nests in or near coniferous forests usually between 6,000 and 9,000 feet in elevation. They need dry landscapes with dense shrub cover for breeding. Birds leave the wintering grounds to arrive on breeding territory sometime in April or May. The female builds the nest, an open cup, on the ground along a slope, usually in May, and incubates the eggs for roughly 13 days. Both parents feed the young, which fledge between 10 and 14 days. Cowbird parasitism negatively affects nest success. Migration to wintering grounds occurs in July through early October. Virginia's warblers forage on the ground, in and around foliage of trees as well and hawking insects while in flight. They forage at various heights and probe flowers and plants for food in the wintering grounds.

Threats to the Virginia's Warbler include increasing road construction and habitat alteration to improve livestock grazing and the invasion of non-native plants. The *Partners in Flight North American Landbird Conservation Plan* has put this species on the watch list with the goal of maintaining or increasing population numbers.

Appendix C: Conservation Agencies and Organizations

Farm Service Agency: www.fsa.usda.gov / 202-720-7809. FSA works to stabilize farm income, to help farmers conserve land and water resources, to provide credit to new or disadvantaged farmers and ranchers, and to help farm operations recover from the effects of disaster.

National Fish and Wildlife Foundation: www.nfwf.org / 202-857-0166. NFWF is a private, non-profit organization dedicated to the conservation of fish, wildlife, plants, and the habitat on which they depend. It creates partnerships between the public and private sectors and strategically invests in conservation and the sustainable use of natural resources.

Native Seed Network: www.nativeseednetwork.org / 541-753-3099. The Native Seed Network is a collaborative effort to bring information, researchers, and restoration workers together to expand the use of native plants from local sources.

Natural Resources Conservation Service: www.nrcs.usda.gov. NRCS delivers technical conservation assistance to private landowners, local, state, and federal organizations, and policy makers based on sound science; financial and cost-share incentives are available.

Society for Range Management: www.rangelands.org / 303-986-3309. SRM is a non-profit professional society that promotes and publishes information about rangeland ecosystems and their management.

U.S. Fish and Wildlife Service: www.fws.gov. FWS's mission is to conserve, protect and enhance fish, wildlife, and plants and their habitats for the continuing benefit of the American people.

Wildlife Habitat Council: www.wildlifehc.org / 301-588-8994. WHC is a nonprofit group of corporations, conservation organizations, and individuals dedicated to protecting and enhancing wildlife habitat. WHC helps large landowners, particularly corporations, manage their lands in an ecologically sensitive manner for the benefit of wildlife.

The Wildlife Society: www.wildlife.org / 301-897-9770. TWS is an international nonprofit scientific and educational organization serving professionals in all areas of wildlife ecology, conservation, and management.

Appendix D: Assistance Programs

Candidate Conservation Agreements
Formal agreements between the U.S. Fish and Wildlife Service and one or more parties to address the conservation needs of proposed or candidate species, or species likely to become candidates, before they become listed as endangered or threatened. Participants voluntarily commit to implementing specific actions that remove or reduce the threats to these species. Land eligibility: Non-federal private landowners and cooperators. Contact: Local office of U.S. Fish and Wildlife Service.

Challenge Grants
Awards matching federal dollars to projects that address priority actions promoting fish and wildlife conservation and the habitats on which they depend. Land eligibility: Project that promotes conservation of fish, wildlife, and their habitats. Contact: www.nfwf.org/programs/grants_apply.htm.

Conservation of Private Grazing Lands Initiative (CPGL)
Technical assistance initiative offers opportunities for better grazing land management, protecting soil from erosive wind and water, using more energy-efficient ways to produce food and fiber, conserving water, providing habitat for wildlife, sustaining forage and grazing plants, using plants to sequester greenhouse gases and increase soil organic matter, and using grazing lands as a source of biomass energy and raw materials for industrial products. Land eligibility: All privately owned grazing land. Contact: Local office of Natural Resources Conservation Service.

Conservation Reserve Program (CRP)
Provides technical and financial assistance to farmers and ranchers to address soil, water, and related natural resource concerns on their lands in an environmentally beneficial and cost-effective manner. Land eligibility: Highly erodible land, wetlands, and certain other lands with cropping history, also streamside areas in pasture land. Contact: Local office of Natural Resources Conservation Service or U.S. Fish and Wildlife Service.

Conservation Security Program (CSP)
Provides financial and technical assistance to promote the conservation and improvement of soil, water, air, energy, plant and animal life, and other conservation purposes. Land eligibility: Private cropland, grassland, prairie land, improved pasture, range land, and forested land that is an incidental part of an agriculture operation; Tribal lands. Contact: Local office of Natural Resources Conservation Service.

Conservation Technical Assistance Program (CTA)
Provides voluntary conservation technical assistance to land-users, communities, units of state and local government, and other federal agencies in planning and implementing conservation systems. Land eligibility: Highly erodible agricultural land. Contact: Local office of Natural Resources Conservation Service.

Endangered Species Grants, Private Stewardship Program
Provides funds for local, private, and voluntary conservation efforts that protect federally listed threatened or endangered species, proposed species, candidate species or other at-risk species. Land eligibility: Private landowners. Contact: Local office of U.S. Fish and Wildlife Service.

Environmental Quality Incentives Program (EQIP)
Provides a voluntary conservation program for farmers and ranchers that promotes agricultural production and environmental quality as compatible national goals; offers financial and technical assistance to eligible participants to install or implement structural and management practices on eligible agricultural land. Land eligibility: Cropland, range, grazing land, and other agricultural land in need of treatment. Contact: Local office of Natural Resources Conservation Service.

Farm and Ranch Lands Protection Program (FRPP)
Provides matching funds to help purchase development rights to keep productive farm and ranchland in agricultural uses. Partners with state, tribal, or local governments and non-governmental organizations to acquire conservation easements or other interests in land from willing landowners. Land eligibility: Farm or ranchland that is privately owned, part of a pending offer from a state, local, or tribe farmland protection program, highly erodible, market accessible, has adequate infrastructure and support services, and is near surrounding land that can support agricultural production. Contact: Local office of Natural Resources Conservation Service or state or local Land Trust Agencies.

Neotropical Migratory Bird Conservation Act Grants Program
Provides matching federal funds for projects that support the conservation of neotropical migratory birds by perpetuating healthy bird populations, supporting existing conservation initiatives, providing financial resources, and fostering international cooperation. Eligibility: Any U.S., Latin American, or Caribbean individual, corporation, government agency, trust, association, or other private entity may apply. Contact: www.fws.gov/birdhabitat/NMBCA/eng_neo.htm.

North American Wetlands Conservation Fund
Provides funding for the acquisition of land or water property rights, if obtaining the land will ensure that it will be administered for the long term conservation of the lands and the migratory birds, fish, and wildlife dependent on the lands, including restoration, management, or enhancement activities as necessary. Eligibility: Private or public organizations or individuals who have developed partnerships to carry out wetlands conservation projects. Contact: www.fws.gov/birdhabitat/NAWCA/USstandgrants.html.

Partners for Fish and Wildlife Program (PFW)
Up to 100% financial and technical assistance to restore wildlife habitat under minimum 10-year cooperative agreements. Land eligibility: Most degraded fish and/or wildlife habitat. Contact: Local office of U.S. Fish and Wildlife Service.

Resource Conservation and Development (RC&D) Program
Accelerates the conservation, development, and utilization of natural resources, improves the general level of economic activity, and enhance the environment and standard of living in designated RC&D areas. Land eligibility: Locally sponsored areas designated by the Secretary of Agriculture. Contact: Local office of Natural Resources Conservation Service or Conservation District.

Wetlands Reserve Program (WRP)
Provides easement payments and technical and financial support to help landowners restore habitat. Eligibility: Landowners and tribes. Contact: Local office of Natural Resources Conservation Service.

Wildlife Habitat Incentives Program (WHIP)
A voluntary program for people who want to develop and improve wildlife habitat primarily on private land; provides both technical assistance and up to 75% cost-share assistance to establish and improve fish and wildlife habitat. Land eligibility: High priority fish and wildlife habitats. Contact: Local office of Natural Resources Conservation Service.

Wildlife at Work
Technical assistance on developing habitat projects into programs that allow companies to involve employees and the community. Land eligibility: Corporate lands. Contact: Wildlife Habitat Council.