Chapter 3
NEW MEXICO'S BIODIVERSITY

STATE RESOURCES

Physical Description

New Mexico is the 5th largest state in the United States with a total surface area of approximately 121,666 square miles (315,114 km^2). Though primarily a xeric or dry state, New Mexico has approximately 234 square miles (606 km^2) of rivers, streams, lakes, and reservoirs. Elevations range from 2,842 ft (866 m) at Red Bluff Reservoir in the southeastern desert to 13,151 ft (4,008 m) at Wheeler Peak in the northern Sangre de Cristo range (Vigil-Giron 2003). New Mexico spans a variety of regions from the Great Plains, Rocky Mountains, Colorado Plateau, and Madrean Archipelago to the Great Basin, Chihuahuan, and Sonoran Deserts (Mehlman 1996).

Geologic History

New Mexico has a complex geologic history. A shallow sea covered the state during the Paleozoic era. Limestone deposits formed during this time can be seen in the karsts, salt deposits, and soils of the southeastern portion of the state. Near the end of the Paleozoic, the ancestral Rocky Mountains uplifted the central and northern part of the state and a great barrier reef developed to the south. As water evaporated, deposits of salt, potash, and gypsum were left and remain visible today. The repeated advance and retreat of another shallow sea during the Mesozoic era resulted in a tropical swampland rich with vegetation and fauna. Coal deposits found in New Mexico were formed during this era. The Cenozoic era was punctuated by volcanic activity and the formation of today's Rocky Mountains and Colorado Plateau. During the Pleistocene epoch, the land was again covered by lush vegetation and marshes. A cycle of glaciations covered northern New Mexico and etched much of the present day landscape.

Climate

The climate of New Mexico is as diverse as its landforms. Temperature varies significantly with changes in altitude and monitoring stations 4,700 ft apart in elevation can differ by as much as 16° F. New Mexico's highest temperature of record is 122° F (50° C), recorded in 1994. The coldest temperature of record is -50 °F (-46° C), recorded in 1951. Monthly average temperatures range from a high of 93°F (34° C) to a low of 22°F (-6° C). Rainfall varies with latitude and altitude. Most of the rainfall and snowfall occurs in the northern part of the state, where the Pacific weather systems lose much of their moisture in the high elevations of the southern Rocky Mountains. The eastern portion of the state receives precipitation from the Gulf of Mexico. Severe but brief thunderstorms during the summer monsoons of late July, August and early September are the source of most precipitation for the more arid portions of the state.

Flora and Fauna Biodiversity

The size, topography, and physical location of New Mexico combine to make it is one of the more biologically diverse states, with more than 4,500 different species of plants and animals.

Vegetation communities include alpine tundra, coniferous forests, woodlands, grasslands, desert shrublands, and riparian areas. Some of the most diverse flora can be found within the state's many riparian areas, which provide habitat for obligate wetland species as well as facultative upland species. Several life zones converge in southwestern New Mexico, making this area one of the more biologically diverse of the southwestern states (Fig. 3-1).

More than 1100 species of amphibians, reptiles, mammals, birds, invertebrates, and fish are found within the state's geopolitical boundaries (Table 3-1). The bird fauna is diverse, with more than 500 species. Mammal diversity is high compared to other southwestern states, with approximately 184 species known to occur here. New Mexico has approximately 26 species of amphibians and over 100 species of reptiles. Though the total number of species is unknown, invertebrate diversity is high among molluscs, crustaceans, and other arthropods. New Mexico Department of Game and Fish (NMDGF) has management authority for approximately 52% of these species (Table 3-1).

New Mexico's Population and Economy

New Mexico is a mostly rural state with few population centers. The Census Bureau estimates, New Mexico was home to approximately 1,874,614 people and had a population density of 15.4 people/square mile (5.9 people/km^2) in 2003. Albuquerque (Bernalillo County) is the state's largest city, with a population of 448,607 people as of 2000. Las Cruces and the capitol, Santa Fe, are the next largest cities. During the 1990s, the population of New Mexico increased 20%.

The Bureau of Economic Analysis (http://www.bea.gov) estimated New Mexico's per capita personal income at $24,995 in 2003. New Mexico's total state product for 2003 was approximately $57 billion. Construction, retail trade, real estate, health services, and non-educational state and local government industries make up the top 5 industries in New Mexico's economy (Ashcroft 2005). The construction industry output approximately 7.3 billon dollars, while real estate output approximately 6.0 billion dollars in 1998. In rural New Mexico (all but Bernalillo County), the agriculture industry replaces health services in the top 5 industries in terms of output (Ashcroft 2005). The total economic value derived from agriculture within New

Table 3-1. Approximate number of species in New Mexico and the percent of those species that fall under NMDGF management authority (Data: Bison-M, http://fwie.fw.vt.edu/states/nm.htm).

Taxa Group	Number in State	Number of Taxa Group with NMDGF Management Authority	Percent of Taxa Group with NMDGF Management Authority
Amphibians	26	8	31%
Birds	504	441	88%
Crustaceans	35	2	6%
Fish	130	58	45%
Mammals	184	54	29%
Molluscs	182	25	14%
Reptiles	105	17	16%
Total	*1166*	*605*	*52%*

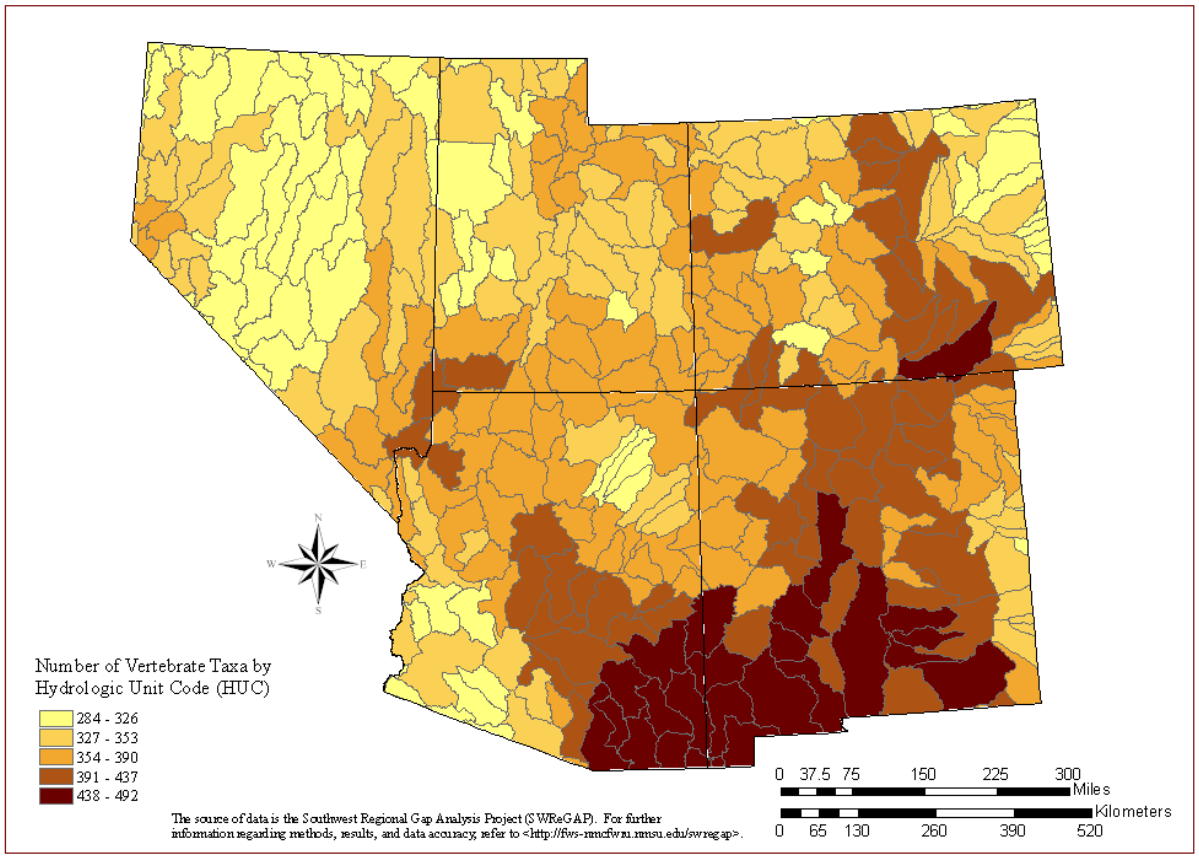

Figure 3-1. Species richness (number of vertebrate taxa) modeled by SWReGAP in Nevada, Arizona, Utah, Colorado, and New Mexico (SWReGAP: http://fws-nmcfwru.nmsu.edu/swregap/).

Mexico was 3.5 billion dollars in 1998. Bernalillo County alone (a non-rural county) produced 40 million dollars in agriculture products in 1998 (Ashcroft 2005). Approximately 5% of New Mexico employment in 1998 was related to agriculture (Ashcroft 2005). Approximately 25% of the state's non-agricultural based jobs are local, state, and federal government based (Vigil-Giron 2003). The educational and health services, retail trade, and professional and business services each employ approximately 12% of the state's non-agricultural based jobs (Vigil-Giron 2003).

New Mexico had approximately 52% rangeland, 7% forest, 2% cropland, 36% non-rural, and 3% other rural uses in 1997 (US Department of Agriculture 2000) (Fig 3-2). The livestock sector is one of the larger agricultural industries in the state, partly due to large federal land acreages and areas of open space (Ashcroft 2005). Agriculture products include hay, sorghum, pecans, onions, potatoes and chiles. Cattle and dairy products top the list of major animal products of New Mexico. The beef industry is one of New Mexico's larger agricultural products that have major economic implications for neighboring states (Ashcroft 2005). The agriculture industry also supports many related or value added industries in New Mexico. As such, agriculture is an important economic, cultural, and social industry to New Mexico (Ashcroft 2005).

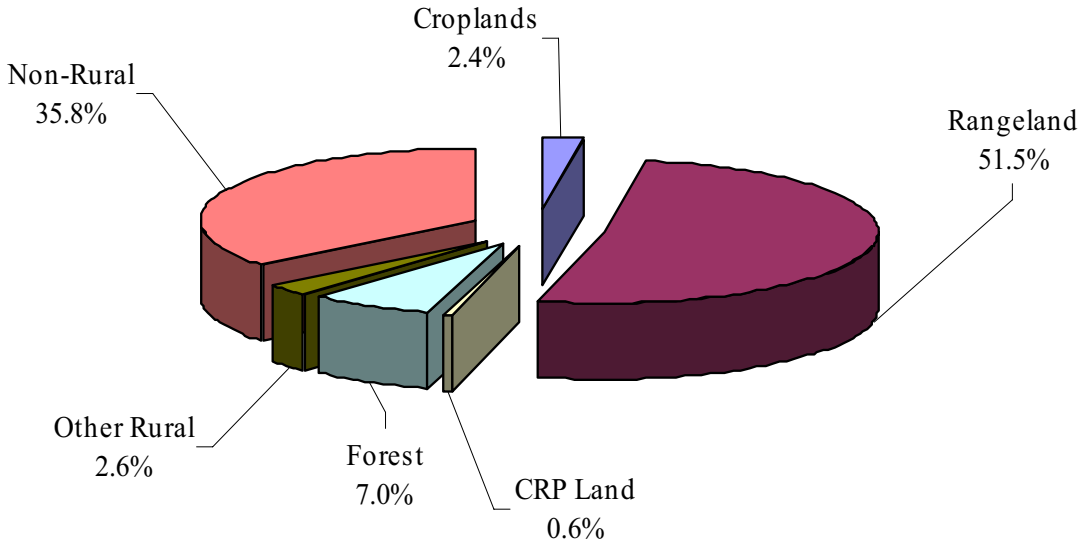

Figure 3-2. Approximate percentages of rangeland, cropland, Conservation Reserve Program land, forest, other rural uses, and non-rural lands in New Mexico. Estimates derived from US Department of Agriculture (2000).

New Mexico also has a long history of mineral extraction and produces uranium ore, manganese ore, potash, salt, perlite, copper ore, beryllium, and tin concentrates. Oil and gas extraction is a major resource-based industry in the state, especially in the southeast and northwest.

Land Stewards

In assessing the current status of New Mexico's biodiversity, it is important to consider land management stewardship and the extent to which areas are, or are not protected or conserved in some fashion. Approximately 34% of New Mexico is federally owned, 12% is state owned, 10% is within Native American (tribal) reservations, and 44% is privately owned (Table 3-2, Fig. 3-3) (Williams 1986, SWReGAP: http://fws-nmcfwru.nmsu.edu/swregap/).

Land management jurisdiction varies across the state. Federally owned lands are primarily under the stewardship of the Bureau of Land Management, US Forest Service, Department of Defense, and National Park Service. The State Land Office, State Parks Division, and State Game Commission manage state owned-lands. There are 22 Indian tribes and reservations in New Mexico (Vigil-Giron 2003). The Navajo Nation owns much of the northwestern part of the state, especially along the Arizona border. The Zuni also own land in the northwestern part of the state along the Arizona border, and the Jicarilla and Mescalero Apache Tribes own land in the north and southeast, respectively. Most of the Pueblos are located along the northern half of the Rio Grande. Several non-governmental organizations (NGOs), such as The Nature Conservancy, Audubon Society, and the Rocky Mountain Elk Foundation, manage parcels within the state. Multiple state and federal policies and management priorities on private lands affect the conservation of New Mexico's biodiversity. About 6% of New Mexico has legal protection from conversion of natural land cover and mandated management plans in operation to maintain

some semblance of a natural state (Table 3-3, Fig. 3-4) (SWReGAP: http://fws-nmcfwru.nmsu.edu/swregap/). The majority of the state (57%) either lacks long-term (10+ years) legal mandates to prevent conversion of natural land cover to anthropogenic land cover types or is not classified. While many private lands fall under this category, these lands are subjected to varied land steward objectives that provide important habitat for many wildlife species.

Table 3-2. Land area (acre) and percent in 12 land steward categories in New Mexico estimated by New Mexico Gap Analysis Project (SWReGAP: http://fws-nmcfwru.nmsu.edu/swregap/).

Steward Category	Land Area (acre)	Percent of Land Area
Bureau of Land Management	13,544,240	17%
Bureau of Reclamation	71,940	< 1%
Forest Service	9,293,923	12%
National Park Service	384,978	< 1%
Fish and Wildlife Service	375,256	< 1%
Department of Defense	2,560,690	3%
Other Federal	110,827	< 1%
State Parks	95,272	< 1%
State Trust Lands	8,858,392	11%
State Wildlife Areas	161,379	< 1%
Tribal	8,008,717	10%
Private	34,167,843	44%

Table 3-3. Land area (acre) and percent of New Mexico in four land status categories estimated by New Mexico Gap Analysis Project (SWReGAP: http://fws-nmcfwru.nmsu.edu/swregap/).

Status	Description	Amount (acre)	Percent
1	An area having permanent protection from conversion of natural land cover and a mandated management plan in operation to maintain a natural state within which disturbance events are allowed to proceed without interference or are mimicked through management.	664,900	1%
2	An area having permanent protection from conversion of natural land cover and a mandated management plan in operation to maintain a primarily natural state, but which may receive use or management practices that degrade the quality of existing natural communities.	4,256,100	5%
3	An area having permanent protection from conversion of natural land cover for the majority of the area, but subject to extractive uses of either a broad, low-intensity type or localized intensity type. It also confers protection to federally listed endangered and threatened species throughout the area.	28,377,500	36%
4	No known mandate to prevent conversion of natural land cover to anthropogenic land cover and allows for intensive use throughout the tract, or existence of such restrictions is unknown.	44,334,700	60%

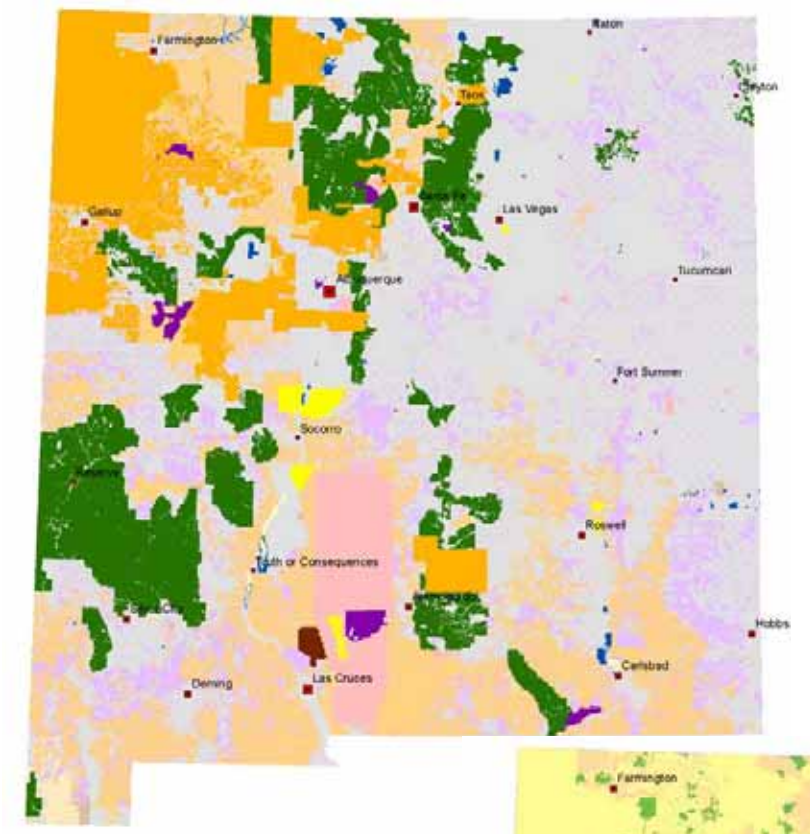

Figure 3-3. (*Left*) New Mexico's land stewardships categorization (SWReGAP: http://fws-nmcfwru.nmsu.edu/swregap/).

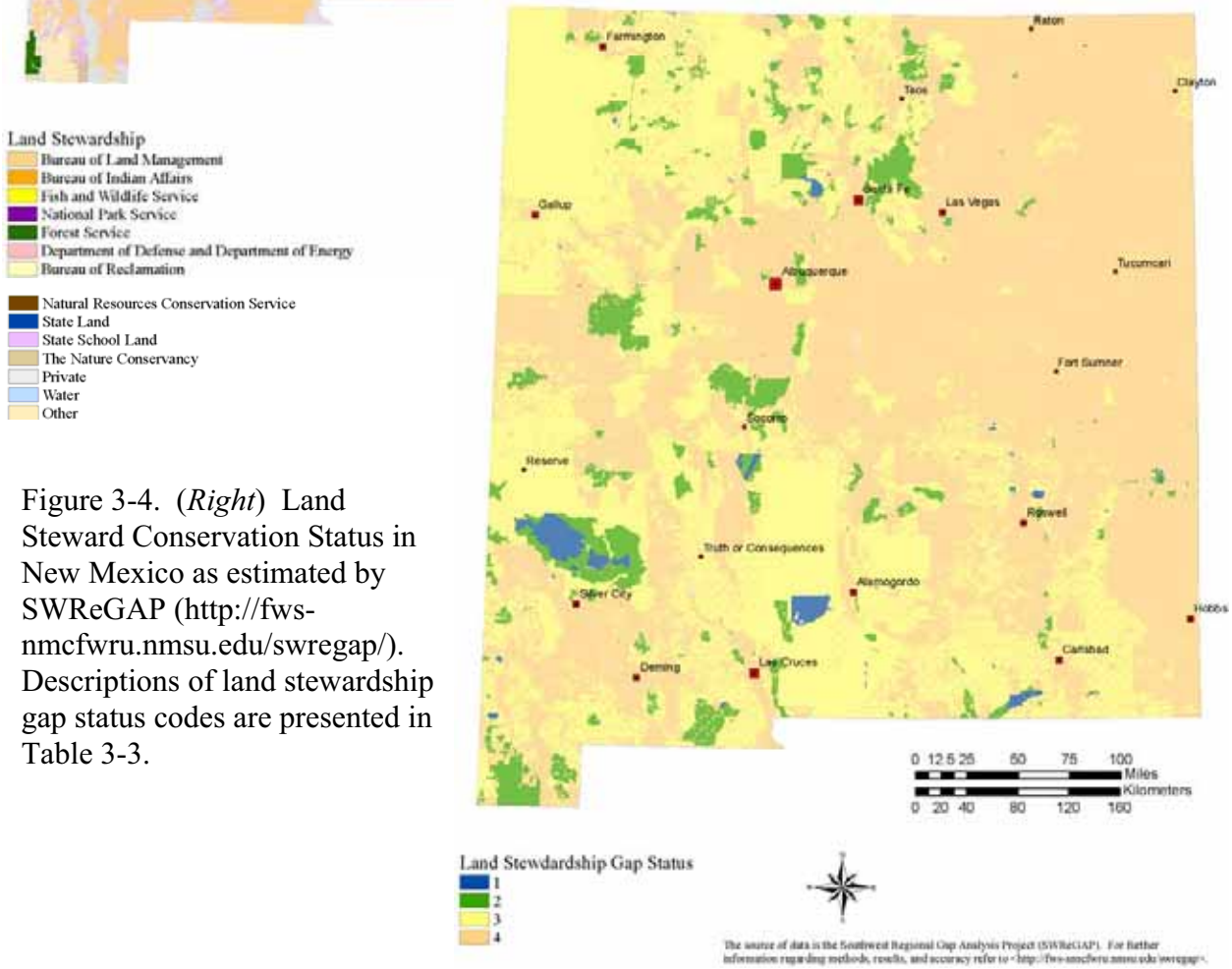

Figure 3-4. (*Right*) Land Steward Conservation Status in New Mexico as estimated by SWReGAP (http://fws-nmcfwru.nmsu.edu/swregap/). Descriptions of land stewardship gap status codes are presented in Table 3-3.

NEW MEXICO'S ECOLOGICAL FRAMEWORKS AND KEY HABITATS

Ecological Frameworks

A desired outcome of the Comprehensive Wildlife Conservation Strategy (CWCS) initiative is the eventual ability to aggregate information from each state plan so as to facilitate a regional and national perspective and cross-jurisdictional coordination. In New Mexico, the diversity of flora and fauna and the nature of problems influencing habitats or species required the use of multiple ecological frameworks. The seven Nature Conservancy (TNC) Ecoregions identified for New Mexico (Fig. 3-5) provide a convenient organizational framework for developing state, regional, and national perspectives with respect to terrestrial habitats. Originally based on Robert Bailey's US Forest Service ecoregions, these boundaries have been extensively modified by TNC's eocregional planning teams (Bailey 1988, 1995, 1998). The Central Shortgrass Prairie Ecoregion (Burget *et al*. 1998), however, encompasses only about 500,000 acres (202,340 ha) in the northeastern part of the state and we found it practical to assimilate it into the neighboring Southern Shortgrass Prairie Ecoregion for planning purposes. Thus, our terrestrial habitats are partitioned into six rather than seven TNC ecoregions.

The diversity of flora and fauna and the nature of problems influencing habitats or species in New Mexico required the use of three ecological frameworks:

- Ecoregions,
- Watersheds, and
- Statewide.

Using watershed drainages as the ecological framework best facilitates regional or national aggregation of New Mexico's aquatic habitat considerations. There are 83 hydrological units (8-digit Hydrological Unit Codes; HUCs) identified in New Mexico. These hydrological units were combined into eight major drainages in New Mexico to serve as our aquatic ecological framework (Fig. 3-6).

Considerations of habitat related problems, Species of Greatest Conservation Need (SGCN), and conservation actions for some habitats in New Mexico are best made on a statewide scale. Thus, key riparian, ephemeral aquatic, and perennial tank habitats are treated within a statewide ecological framework.

Ecoregions

Apache Highlands Ecoregion

The Apache Highlands Ecoregion extends from central to southeastern Arizona into southwestern New Mexico and northern Mexico. This ecoregion contains 30 million ac, 2.6 million ac (1 million ha) of which occur in New Mexico. Woodland and forested habitats types in this ecoregion occur within the greater Madrean Archipelago complex, which are so-named because of the many isolated mountain ranges spread across the ecoregion (Gehlbach 1993). These isolated mountain ranges are separated from one another by plains and valleys of desert and semi-desert grasslands and shrublands. These intervening habitats are thought to limit genetic interchange between the sky island mountain range habitats, creating isolated areas with high evolutionary implications for plant and animal populations (Warshall 1995).

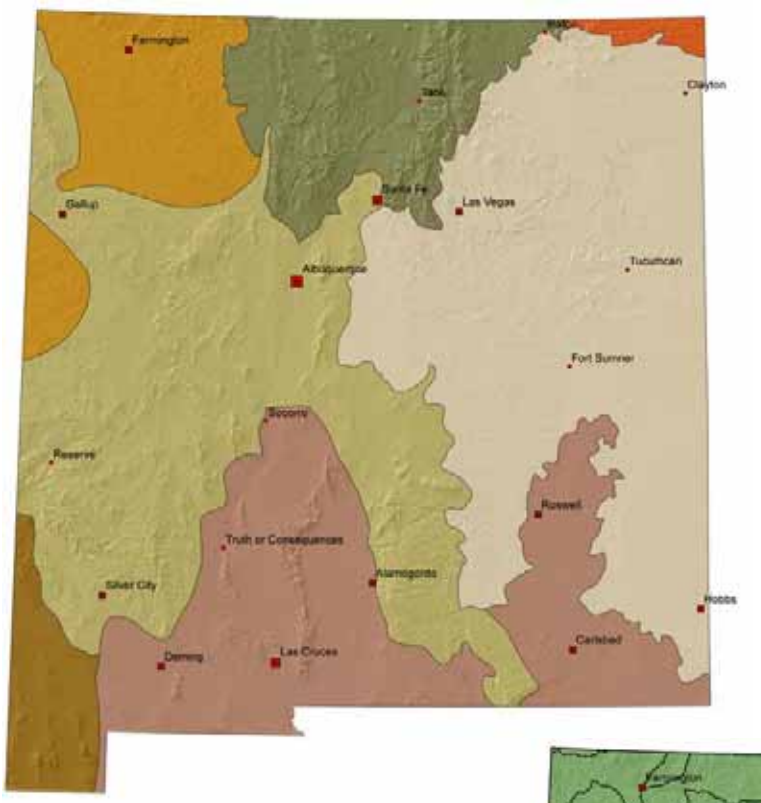

Figure 3-5. (*Left*) The Nature Conservancy (TNC) ecoregions used as the ecological framework for terrestrial habitats in New Mexico.

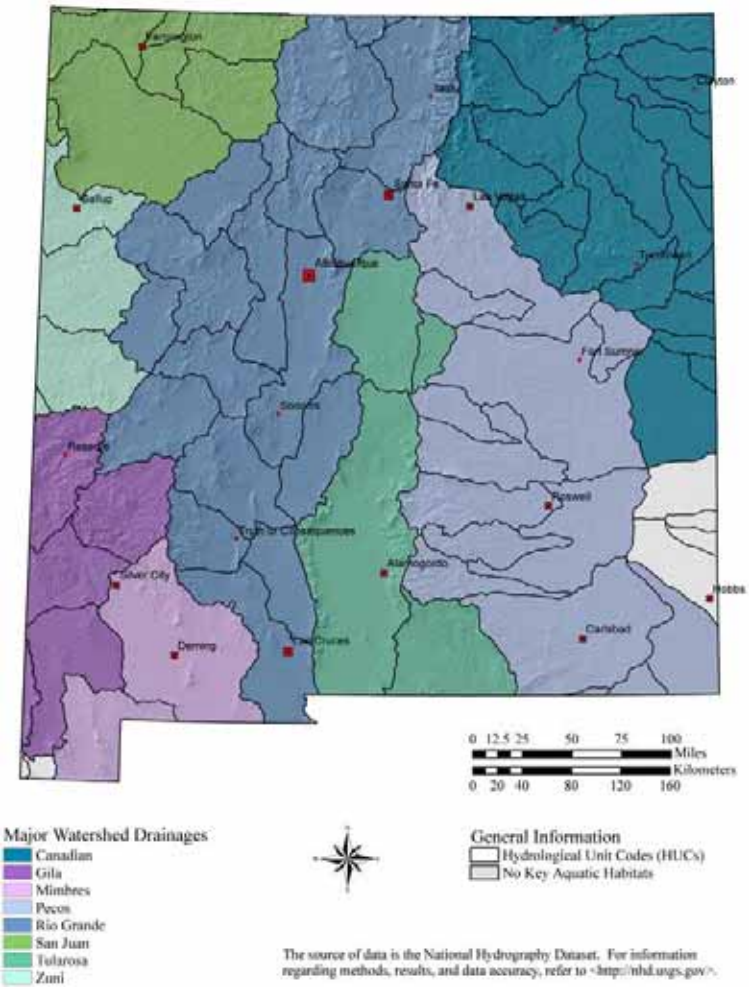

Figure 3-6. (*Right*) Watersheds used for the ecological framework for aquatic habitats in New Mexico.

Elevation in the Apache Highlands Ecoregion ranges from about 2,200 ft (670 m) to 10,717 ft (3,266 m) and averages about 4,340 ft (1,323 m). The diverse plant and animal communities of the Apache Highlands Ecoregion reflect the variation in elevations and the merging of the northern Rocky Mountains in the north and the Sierra Madre Occidental and neotropical regions of Mexico to the south. This high level of diversity and unusual community structure has appropriately been described as a stacking of biotic communities on mountain islands (Marshall 1957).

Arizona-New Mexico Mountains Ecoregion

The Arizona-New Mexico Mountains Ecoregion encompasses the highlands of eastern Arizona and central and western New Mexico, encompassing 29 million ac (12 million ha) of land (Bell *et al.* 1999). New Mexico hosts greater than 23 million ac (9.5 million ha) (78%) of this ecoregion. Mountains in this ecoregion are among the oldest in the southwest. Many are composed of Precambrian igneous rocks and once active volcanoes. This diverse physiographic region has elevations ranging from 4,500 ft (1,371 m) to 12,600 ft (3,840 m) and contains steep foothills, mountains, and plateaus rising above the surrounding desert grasslands and shrublands.

The Arizona-New Mexico Mountains Ecoregion is host to more species of birds and mammals than any other ecoregion in the southwest.

The Arizona-New Mexico Mountains Ecoregion contains a number of mountain ranges and desert plains. The more prevalent habitats include Madrean pine-oak conifer-oak forest and woodland, Rocky Mountain forest and woodland, and Rocky Mountain montane mixed conifer, in the higher elevations and piñon-juniper/juniper savanna, steppe and grasslands, Chihuahuan semi-desert grassland, and Western Great Plains shortgrass prairie in the lower elevations. This ecoregion contains the headwaters for a number of important streams and rivers, including the Little Colorado, Gila, San Francisco, and Mimbres. Riparian habitats in this ecoregion host a variety of flora and fauna. This ecoregion is considered to host more species of birds and mammals than any other ecoregion in the southwest (Bell *et al.* 1999).

Chihuahuan Desert Ecoregion

The Chihuahuan Desert Ecoregion encompasses approximately 174 million ac (70 million ha) from San Luis Potosi, Mexico north to southwestern Texas and southern New Mexico (Bell *et al*. 2004). Approximately 75% of the Ecoregion is in Mexico, with only 2.5% of its total area under formal protection (Dinerstein *et al*. 2000). In New Mexico, the Chihuahuan Desert Ecoregion includes Luna, Dona Ana, Sierra, and Eddy counties, and portions of Socorro, Lincoln, Otero, Chaves, and Lea counties, totaling approximately 15.2 million ac (6.1 million ha). Metropolitan areas in the ecoregion include Las Cruces, Deming, Carlsbad, Artesia, and Roswell. Counties in the ecoregion experienced an average 24% increase in human population between 1990 and 2000 (US Census Bureau, 2001). Chihuahuan semi-desert grasslands and desert scrub vegetation dominate (Bell *et al*. 2004), although SWReGAP identified and mapped 53 landcover types in the New Mexico portion of the Ecoregion.

Colorado Plateau Ecoregion

The Colorado Plateau Ecoregion encompasses the Four Corners region of Arizona, Colorado, New Mexico, and Utah and is a geologically complex region of badlands, sheer-walled canyons,

buttes, mesas, plains, dunes, and isolated mountain ranges (Truhy *et al*. 2002). Several major rivers flow through this ecoregion, including the Colorado, Little Colorado, San Juan, and Escalante rivers. These rivers have carved large canyons through the plateau. The ecoregion contains 48.5 million ac (19.6 million ha) of mostly public and tribal land, and elevation ranges from 1,200 ft (370 m) in the Grand Canyon to 12,700 ft (3,870 m) in the La Sal Mountains. The climate within the Colorado Plateau Ecoregion is often described as "desert" because the average yearly rainfall is less than 10 in (25 cm). Most of the precipitation occurs in the winter in the form of snow, allowing much of the water to infiltrate the soil (Truhy *et al*. 2002).

More than 300 plant species in the Colorado Plateau are not found anywhere else in the world.

Ecological importance of this ecoregion lies in its geologic features and diverse and unique fauna and flora. More than 300 plant species extant here are found nowhere else in the world (Truhy *et al*. 2002). Habitat conservation concerns include drying of wetlands, damming of rivers and tributaries, invasion of exotic species, suppression of natural fire patterns, and land uses such as livestock grazing, and mining. Species such as the grizzly bear, gray wolf, lynx, and river otter have been extirpated from this region for decades.

About 12%, approximately 6.2 million ac (2.5 million ha), of the Colorado Plateau Ecoregion occurs in two areas of the northwestern corner of New Mexico. The Chuska Mountains on the west, the San Mateo Mountains to the south, and the San Pedro Mountains to the east border the northernmost area. The San Juan River cuts through this part of the plateau in an east-west direction. The southern area extends southwest of Gallup to the western border and is bordered by the Zuni Mountains to the northwest. The Zuni River flows through this part of the plateau.

Southern Rocky Mountains Ecoregion

The Southern Rocky Mountains Ecoregion, two-thirds of which is publicly owned, encompasses nearly 40 million acres (16 million ha) across portions of southern Wyoming, central Colorado, and northern New Mexico. Two major mountain belts and the intermountain valleys between characterize this ecoregion. Elevation ranges from 3,700 ft (1,127 m) to over 14,000 ft (4,267 m), both extremes occurring in Colorado. High rugged glaciated mountains, plateaus, alpine cirques, glacial moraines, and broad valleys were formed through glacial activity (Neely *et al*. 2001). The climate is a temperate semiarid steppe influenced by the prevailing west winds and the general north-south orientation of the mountain belts. Approximately 7.2 million ac (2.9 million ha) (18%) of the ecoregion occurs in New Mexico. The Sangre de Cristo and the San Juan mountain ranges form the southern portions of the eastern and western mountains belts, respectively. The major intermountain valley between these ranges is the Rio Grande.

Southern Shortgrass Prairie Ecoregion

The Southern Shortgrass Prairie occupies more than 67 million ac (27 million ha) of northeastern New Mexico, northern Texas, and small portions of western Oklahoma. New Mexico contains 22.2 million acres (9 million ha) or approximately 33% of the ecoregion. The western part of this ecoregion is characterized by high plains plateaus broken by escarpments (The Nature Conservancy 2004). Soils in the ecoregion are diverse, ranging from Aridisols to Mollisols. Much of the topography is flat to rolling plains dissected by canyons and caprock escarpments. In addition to the relatively level plains, the ecoregion is topographically diverse and includes

isolated volcanic formations (The Nature Conservancy 2004). Depressional basins, known as playas, punctuate the relatively flat portions of the ecoregion and represent significant wetland habitat for migratory waterfowl, shorebirds, and other species. Average annual rainfall in the southwestern part of the ecoregion is approximately 13 in (325 mm).

The Southern Shortgrass Prairie Ecoregion lies within the Southwest Plateau and Plains Dry Steppe and Shrub Province (Bailey 1995) and is bordered by the Central Shortgrass Prairie Ecoregion on the north, Edwards Plateau and Chihuahuan Desert Ecoregions on the south, Central Mixed-grass Prairie and Crosstimbers and Southern Tallgrass Prairie Ecoregions to the east, and the Southern Rocky Mountains and Arizona-New Mexico Mountains Ecoregions to the west.

The ecoregion was historically dominated by expanses of shortgrass prairie, with blue grama (*Bouteloua gracilis*) and buffalo grass (*Buchloe dactyloides*). The development and maintenance of this system was dependent on several ecological processes, most likely driven by climate. Bison grazing and fire were also important processes that maintained the grasslands of the shortgrass prairie (TNC 2005). Today Chihuahuan desert grasslands are dominant over shortgrass prairie in arid areas towards the southwestern part of this ecoregion and shortgrass prairie is replaced by mixed-grass prairie to the east where greater moisture is available.

The varied topography and geologic features in this ecoregion allow for a wide range of floral and faunal communities. Other important habitats in the New Mexico part of the Southern Shortgrass Prairie Ecoregion include juniper and piñon-juniper woodlands and sand shrublands. Changes in natural processes have led to shrub invasion of the prairie systems. Riparian woodlands are typically dominated by eastern cottonwood (*Populus deltoides*); however tamarisk (*Tamarix* sp.) and Russian olive (*Eleagnus angustifolia*) are significant non-native invaders (The Nature Conservancy 2004).

Watersheds

Eight major watersheds serve as our aquatic habitat ecological framework in New Mexico.

Canadian Watershed

The Canadian Watershed, in northeast New Mexico, encompasses about one-sixth the land area of the state or about 10.9 million ac (4.4 million ha) (New Mexico Water Quality Control Commission 2002). Canadian River tributaries flow east and southeast from their origins on the east slopes of the Sangre de Cristo cordillera of northern New Mexico and southern Colorado. As it traverses the Great Plains in a southerly and then easterly direction several perennial tributaries, including the Vermejo, Cimarron, Mora, and Conchas Rivers, join the South Canadian River before it exits New Mexico to Texas near Logan. The Upper Canadian, Middle Canadian, Upper Beaver, and the Dry Cimarron are the only perennial sub-basins.

Settlement and irrigation withdrawal along high mountain valleys in the Mora River dates back to the 1700's. Since the late 1800's, the area has been subject to extensive logging, grazing, and mining. Numerous impoundments and diversions have been built throughout the upper drainage for irrigation and municipal water. Livestock grazing continues to be the primary land use throughout the Canadian River drainage. Logging activities are now limited to small tracts in the

upper tributaries. Most coal mines were abandoned by the 1950's. Two large dams, Conchas River (constructed 1938) and Ute Dam on the Canadian River (constructed 1962), impound reservoirs and modify natural flows as the river approaches the New Mexico-Texas border.

Gila Watershed

The Gila River watershed lies within southwestern New Mexico, and is comprised of two major streams, the Gila and San Francisco Rivers. In high elevation (ca. 10,000 ft; 3,000 m) headwaters, the small, canyon-bound streams are bordered by blue spruce (*Picea pungens* Engelm), Douglas fir (*Pseudotsuga menziesii*), and aspen (*Populus tremula*). As the streams descend and coalesce, ponderosa (*Pinus ponderosa*), juniper, and piñon (*pinus edulis*) become the dominant conifers and stands of willow (*Salix* spp.) are common in moderate gradient reaches. Headwater streams of the Gila join to form three forks (West, Middle, and East) in the Mogollon Mountains. From their juncture, the Gila River flows westerly and exits the Mogollon Mountains just east of Gila. Along its mountain course, the river is bordered by ponderosa, piñon, juniper, cottonwood, Arizona sycamore (*Platanus wrightii*), boxelder (*Acer negundo*), and Arizona walnut (*Juglans major*).

The primary land uses along the river in the Cliff-Gila Valley are livestock grazing and some irrigated cropland. Water is seasonally diverted from the river. At the western end of the valley, the river is narrowly confined as it flows through the Middle Box. Downstream of the Middle Box, the Gila River flows across desert grasslands and shrublands to exit New Mexico. Livestock grazing is the primary land use in the lower reaches of Gila River in New Mexico, but some irrigated cropland is present near Virden. Arizona sycamore, cottonwood, and mesquite (*Prosopis* spp.) comprise the primary woody riparian vegetation in the lower reaches. US Forest Service administers mountainous portions of the Gila Watershed. Substantial portions of this watershed are within the Gila and Aldo Leopold wildernesses. The Bureau of Land Management and Forest Service administer portions of the lower watershed, but most lands are privately owned. The Gila River is the last main stem in New Mexico without a major water development.

Mimbres Watershed

The Mimbres Watershed encompasses parts of Hidalgo, Luna and Grant Counties in New Mexico. However, almost all of the perennial waters from the Mimbres River are within Grant County. Its lower most and few permanently watered reaches are in northern Luna County. Formerly, small farms, orchards, and dispersed livestock grazing in uplands were the predominant land use in much of the Mimbres Valley. Now, much of the valley is a checkerboard of small residential ranchettes.

The Mimbres River occupies a small endorheic basin in southwest New Mexico. Headwaters are along west- and south-facing slopes of the Black Range flow southward and dissipate onto the desert north of Deming. Much of the permanently watered portion of the river is in the Mimbres Valley, where the system is more cienega in character than riverine. Uplands are largely under Forest Service jurisdiction and valley lands are largely privately owned. Although rural, the valley has been subdivided into numerous small tracts, many of which have dwellings with private wells and septic systems. On private lands, the river channel is frequently mechanically

realigned and woody riparian vegetation removed. The Nature Conservancy and NMDGF manage small tracts along the river, which provide some protection for aquatic habitats.

Pecos Watershed
The Pecos River is the primary drainage in the Pecos Watershed. The river rises on the eastern slope of the Sangre de Cristo Mountain range in Mora County, New Mexico, and runs south through San Miguel, Guadalupe, De Baca, Chaves, and Eddy counties in New Mexico before it enters Texas.

The Pecos Watershed encompasses 12.3 million ac (4.0 million ha) in New Mexico. Principal New Mexico cities in the watershed include Las Vegas, Santa Rosa, Fort Sumner, Roswell, Artesia, and Carlsbad. Counties in the Pecos Watershed have experienced positive population growth from 1990-2000 (New Mexico Economic Development Data), with only De Baca County showing slight population declines. Land use in this watershed is mainly rangeland, with some irrigated cropland and pastureland along the Pecos River. Roughly 10% of the industry in the lower Pecos Valley is agriculture based (De Baca, Chavez, and Eddy Counties). Primary crops include small grains, alfalfa, and other hay crops. Oil and gas development occurs within the lower Pecos River valley.

Rio Grande Watershed
The Rio Grande Watershed originates in the San Juan Mountains of southern Colorado and flows south through central New Mexico for the entire length of the State. At El Paso, Texas, the drainage area is approximately 20.1 million ac (8.3 million ha), including the drainage area in Colorado (US Geological Survey 1996). There are a number of streams that drain into the Rio Grande. These include: 1) the Rio Chama, which joins the Rio Grande in north central New Mexico and is the most significant tributary, 2) the Jemez River which joins the Rio Grande near Bernalillo, and 3) the San Jose/Rio Puerco Drainage which also joins the Rio Grande near Bernalillo. Smaller watersheds drain mountains in southern New Mexico. These drainages lack the diversity of those to the north, and many of them are ephemeral. Flow in the Rio Grande, typically low in the winter, is most significantly affected by snowmelt and summer rain events. A spring peak generally occurs between early April and mid May from snow melt. Low flow returns in June followed by smaller peaks of shorter duration associated with monsoonal rain events. Fall generally has decreasing flow (Bullard and Wells 1992). This historic flow regime has been greatly affected by irrigation diversions and agricultural reservoirs in the lower part of the system. Irrigation flows have increased the relative magnitude and duration of summer peaks and reduced the peak associated with snowmelt.

Most lands within the Rio Grande Watershed are under federal and quasi-federal ownership. The headwaters typically occur in National Forests (Carson, Santa Fe, Cibola, and Gila). The main stem of the Rio Grande flows through large tracts of Bureau of Land Management holdings, as well as the Middle Rio Grande Conservancy District and Elephant Butte Irrigation District. Cultivated cropland or orchards occupy about 7% of the basin. This form of agriculture is particularly dense in the Española Valley, Middle Rio Grande Valley, and the Mesilla Valley. Other reaches are used extensively for livestock grazing.

San Juan Watershed
In New Mexico the San Juan River Watershed occurs almost entirely within San Juan County. The San Juan River originates in the San Juan Mountains of southwestern Colorado, enters New Mexico northeast of Farmington, and flows westward for about 93 mi (150 km) to exit the state near the Four Corners area. Navajo Dam impounds the upper 19 mi (30 km) of the river in New Mexico. From Navajo Dam downstream to Farmington the river is restricted to a single, moderately incised channel and habitats are mainly cobbled riffles, moderately deep runs, and large pools. Gradient diminishes as the river progresses downstream from Farmington to Shiprock, but flow remains mostly in a single channel. Downstream of Shiprock the channel is frequently divided among two, three, or four courses. Habitat diversity increases with channel complexity. In addition to habitats common in upstream reaches backwaters, embayments, shoals, and secondary channels (having their own mix of habitats) are present. Navajo Dam controls flows in the river and several low-head diversion dams seasonally diminish discharge. The San Juan River within New Mexico is permanently-watered, but permanently flowing tributaries are currently limited to the Navajo, Animas, and Mancos rivers. The San Juan River upstream of Four Corners drains about 6.9 million ac (2.8 million ha) including portions of the system in Colorado. The Bureau of Land Management administers much of the watershed upstream of Farmington and large portions of the watershed are within Navajo Nation and Jicarilla Apache jurisdiction.

Aquatic habitats of the San Juan Watershed are influenced by regulated flows, channelization, water diversion, runoff from municipalities, roads, and row-cropped agricultural lands, and petroleum-extraction activities. Currently, Navajo Reservoir operates to mimic a natural hydrograph as per conditions of a Biological Opinion issued to Bureau of Reclamation by the US Fish and Wildlife Service. Considerable data on water quality and habitats of the main stem of the San Juan River are available in various reports produced by the San Juan River Basin Recovery Implementation Program.

Tularosa Watershed
The Tularosa Basin encompasses approximately 3.2 million ac (1.2 million ha) in south central New Mexico in the northern Chihuahuan Desert. It is a closed basin, meaning that all of the water within the watershed remains in the watershed and that there is no inlet or outlet. Because much of the Tularosa Basin is federal government property (White Sands Missile Range, Holloman Air Force Base, White Sands National Monument), there has been limited development in the watershed.

The closed Tularosa Basin includes parts of Torrance, Socorro, Lincoln, Otero, and Dona Ana Counties and the municipalities of Alamogordo, Carrizozo, and Mountainair. Between 1990 and 2000, population growth in the basin varied from a 65% increase in Torrance Country to a 20% increase in Otero County.

Zuni Watershed
The Zuni River drains about 800,000 ac (300,000 ha) as it flows from its headwaters in west-central New Mexico to the Little Colorado River in Arizona. Continuous flow is absent from the headwaters downstream to the Arizona/New Mexico border and surface flow is generally only continuous during heavy spring run-off. Many stream reaches are dry except near perennial

springs. Headwaters of the Zuni River watershed include 1st and 2nd order streams such as Rio Nutria and Tampico Draw. Lower areas of the watershed include the main stem of the Zuni River, a 3rd and 4th order system, and associated impoundments such as Black Rock Reservoir. The Little Colorado River Watershed in New Mexico includes parts of San Juan, McKinley, Valencia, and Catron Counties and the municipalities of Gallup, Zuni, Quemado, and Ramah. Landownership is primarily private and Forest Service in the upper watershed and tribal in the lower areas.

Post-European settlement changes to the landscape and subsequent effects on the Zuni River watershed are well documented (see *Zuni River Watershed Plan*, NRCS 1998, for a summary). The watershed was severely degraded by extensive logging and overgrazing in the late 1800s and early to mid 1900s. Resultant removal of vegetation increased surface erosion, gullying, and headcutting and caused wide discharge fluctuations and loss of water from the system. The effects were so severe that the Pueblo of Zuni brought litigation against the United States government in the early 1970s. The settlement, entitled the Zuni River Watershed Act of 1990, seeks to restore tribal lands damaged because of upstream misuse of resources.

Subsequent to impacts of the early 20th century, the Zuni River was dammed for flood control, irrigation storage, and recreational fishing. In addition, water withdrawals for irrigation and human consumption led to decreased surface discharge in the system. Water quality in the Zuni River watershed is largely unknown; however, limited monitoring in the Zuni River above Black Rock Reservoir indicates that the water is fairly hard, with a mean total dissolved solids concentration of 537 mg/l and heavy metals well below allowable standards.

Habitat/Vegetation Classification Systems

Within New Mexico, SWReGAP mapped 89 land cover classes. Rare land cover types and riparian areas were generally poorly mapped due to limitations of remote sensing techniques.

Habitat and vegetation classification systems are hierarchical systems that describe units used for analyses at the state or local level. Habitat conservation is an important component of species-level conservation and can serve as a mechanism for conserving more common species that are not treated individually in the CWCS.

We employed land cover types modeled by the Southwest Regional Gap Analysis Project (SWReGAP)(NatureServe 2004b) as our terrestrial habitat classification system. The SWReGAP land cover was created by classifying remotely sensed Enhanced Thematic Mapper plus (ETM+) satellite imagery. SWReGAP mapped 125 land cover classes throughout the states of Arizona, Colorado, New Mexico, Nevada, and Utah. Within New Mexico there were 89 land cover classes mapped (Appendix D). Rare land cover types and land cover types occurring in linear strands (e.g., riparian vegetation) were generally poorly mapped due to limitations of remote sensing techniques.

The New Mexico Department of Game and Fish (NMDGF) identified 23 aquatic habitats that are important to the aquatic fauna of New Mexico. These habitat types ranged from ephemeral playas to large 5th order perennial streams (Appendix E). The diversity of aquatic habitats varies among and within watersheds.

Key Habitat Types

New Mexico Department of Game and Fish identified 19 key habitat types, 9 terrestrial and 10 aquatic, from the 89 land cover types modeled by SWReGAP and 23 aquatic habitat types (Approach Chapter; Table 2-4).

Nineteen key landscape habitat types were identified:
- 9 terrestrial, and
- 10 aquatic.

Descriptions of Key Terrestrial Habitat Types

Chihuahuan Semi-Desert Grasslands

Chihuahuan Semi-desert Grasslands is a broadly defined desert grassland, mixed shrub-succulent or xeromorphic tree savanna that is typical of the borderlands of Arizona, New Mexico and northern Mexico. This intermingled and naturally fragmented habitat type contains a highly varied flora with taxa from the lower and warmer elevations as well as taxa from the evergreen-oak woodland and chaparral of the higher and cooler elevations (McClaran 1995). It is found on gently sloping bajadas and on mesas, and steeper piedmont and foothill slopes in the Chihuahuan Desert. This habitat type also includes relatively small depressions on broad mesas and plains, and valley bottoms that receive runoff from adjacent areas. These depressions have deep, fine-textured soils that are neutral to slightly saline/alkaline. Vegetation on the bajadas, mesas, and piedmont slopes is typically characterized by diverse perennial grasses. Common grass species include black grama (*Bouteloua eriopoda*), hairy grama (*B. hirsuta*), Rothrock's grama (*B. rothrockii*), sideoats grama (*B. curtipendula*), blue grama, plains lovegrass (*Eragrostis intermedia*), bush muhly (*Muhlenbergia porteri*), curlyleaf muhly (*Muhlenbergia setifolia*), James' galleta (*Pleuraphis jamesii*), tobosagrass (*Pleuraphis mutica*), and alkali sacaton (*Sporobolus airoides*). Succulent species include agave, dasylirion, and yucca. Vegetation in the depressions is typically dominated by tobosa swales or other mesic graminoids such as western wheatgrass (Pascopyrum smithii), vine mesquite (*Panicum obtusum*), alkali sacaton, or big sacaton (*Sporobolus wrightii*). With tobosa swales, sand-adapted species such as soaptree yucca (*Yucca elata*) may grow at the swale's edge in the deep sandy alluvium that is deposited there from upland slopes. Alkali sacaton and big sacaton are more common in alkaline soils (Johnson 1974, Dinerstein *et al*. 2000, NatureServe 2004b).

Photo of soaptree yucca (*Yucca elata*) in Chihuahuan semi-desert grassland habitat. This photo records a brief moment in time, and does not portray the range of conditions of this habitat type. Photo provided by NMCFWRU.

Intermountain Basins Big Sagebrush Shrubland

The Intermountain Basins Big Sagebrush shrubland is a cold desert located in the northwestern to north central part of New Mexico (Dick-Peddie 1993), and typically occurs in broad basins between mountain ranges, plains and foothills at altitudes of 4,920-7,545 ft (1,500-2,300 m). Soils are typically deep, well-drained and non-saline. These shrublands are dominated by basin big

sagebrush (*Artemisia tridentate tridentate*) and/or Wyoming big sagebrush (*A. t. wyomingensis*), while scattered Juniper, greasewood (*Sarcobatus vermiculatus*) and saltbrush (*Atriplex* spp.) may also be present. Rubber rabbitbrush (*Ericameria nauseosa*), yellow rabbitbrush (*Chrysothamnus viscidiflorus*), antelope bitterbrush (*Purshia tridentate*), or mountain snowberry (*Symphoricarpos oreophilus*) may codominate disturbed stands. Perennial herbaceous components typically contribute less than 25% vegetative cover. Common graminoid species include Indian ricegrass (*Achnatherum hymenoides*), blue grama, streambank wheatgrass (*Elymus lanceolatus*), Idaho fescue (*Festuca idahoensis*), needle and thread (*Hesperostipa comata*), basin wildrye (*Leymus cinereus*), James' galleta, western wheatgrass, Sandberg bluegrass (*Poa secunda*), or bluebunch wheatgrass (*Pseudoroegneria spicata*) (NatureServ 2004b).

Madrean Encinal habitat in New Mexico. This photo records a brief moment in time, and does not portray the range of conditions of this habitat type. Photo provided by SWReGAP.

Madrean Encinal

Madrean Encinal occurs on foothills, canyons, bajadas and plateaus in southern New Mexico. These woodlands are dominated by Madrean evergreen oak species. Emory oak (*Quercus emoryi*) is the most common tree species in Madrean Encinals, and is found in associations with varying intermixtures of Mexican blue oak (*Q. oblongifolia*), gray oak (*Q. grisea*) silverleaf oak (*Q. hypoleucoides*), and Arizona white oak (*Q. arizonica*) (Ffolliott 1980, Brown 1982, McPherson 1992, McPherson 1997, McLaren and McPherson 1999). Arizona cypress (*Cupressus arizonica*), piñon, and juniper trees may be present, but do not codominate. Tree stand density and openess of the landscape are related to local site characteristics such as soils, fire disturbance and land use histories (Gottfried *et al.* 1995, Ffolliott 2002). Lower elevation stands are typically open woodlands or savannas where they transition into desert grasslands, chaparral, or desertscrub. Chaparral species include pointleaf manzanita (*Arctostaphylos pungens*), alderleaf mountain mohagany (*Cercocarpus montanus*), cliffrose and bitterbrush (*Purshia* spp.), Wright's silktassel (*Garrya wrightii*), Sonoran scrub oak (*Quercus turbinella*), beechleaf frangula (*Frangula betulifolia*), and sumac (*Rhus* spp.) (NatureServe 2004b).

The three-needled Mexican piñon (*Pinus cembroides*), alligator juniper (*Juniperus deppeana*), and red berry juniper (*J. erythrocarpa*) are often found in Madrean Encinal habitats of southern New Mexico and Arizona (Gottfried *et al.* 1995). Madrean Encinal also includes seral stands dominated by shrubby Madrean oaks typically with a strong graminoid layer that is dominated by warm-season grasses such as threeawn (*Aristida* spp.), blue grama, sideoats grama, Rothrock's grama, Arizona cottontop (*Digitaria californica*), plains lovegrass, curly-mesquite (*Hilaria belangeri*), green sprangletop (*Leptochloa dubia*), muhly (*Muhlenbergia* spp.), James' galleta, or Texas bluestem (*Schizachyrium cirratum*) (NatureServe 2004b). Common grass species include sideoats grama, blue grama, hairy grama, and purple grama (*Bouteloua radicosa*), plains lovegrass and Mexican lovegrass (*Eragrostis mexicana*), muhly's bullgrass (*Muhlenbergia emersleyi*), and longtongue (*M. longiligula*) (Brown 1982, McClaren *et al.* 1992, McPherson 1992, McPherson 1994, McPherson 1997, McLaren and McPherson 1999).

Madrean Pine-Oak Conifer-Oak Forest and Woodland

Madrean Pine-Oak Conifer-Oak Forest and Woodland occurs on mountains and plateaus in southern New Mexico and is composed of Madrean pines (Arizona (*Pinus arizonica*), Apache (*Pinus engelmannii*), Chihuahuan (*Pinus leiophylla*), or southwestern white (*Pinus strobiformis*) pines) and evergreen oaks (Arizona white, Emory, and gray oaks) intermingled with patchy shrublands on most mid-elevation slopes (4,920-7,545 ft; 1,500-2,300 m). Other tree species include Arizona cypress, alligator juniper, Mexican piñon, border piñon (*Pinus discolor*), and ponderosa pine (with Madrean pines or oaks). Soil moisture could at times be the principal limiting factor for vegetation in this dry region (Felger and Johnson 1995). Subcanopy and shrub layers may include typical encinal and chaparral species such as *Agave* spp., Arizona madrone (*Arbutus arizonica*), Pringle manzanita (*Arctostaphylos pringlei*), pointleaf manzanita, Wright's silktassel, beargrass (*Nolina* spp.), and Sonoran scrub oak. This habitat type can also be characterized by large- and small-patch forests and woodlands dominated by Douglas fir, Coahuila fir (*Abies coahuilensis*), or white fir (*Abies concolor*), and Madrean oaks such as silverleaf oak and netleaf oak (*Quercus rugosa*). Some stands have moderate cover of perennial graminoids such as bullgrass, longtongue muhly, screwleaf muhly (*Muhlenbergia virescens*), and Texas bluestem (NatureServe 2004b). Fires are frequent with perhaps more crown fires than ponderosa pine woodlands, which tend to have more frequent ground fires on gentle slopes. The current distribution of Madrean pine-oak and oak-conifer forests and woodlands is the result of shifting climatic conditions over the past 24,000 years (Jackson 1970). During the late Quaternary, 8,000 to 35,000 years before present, temperatures in the southwestern US were 5-6 degrees cooler and precipitation was 20-25% greater than current conditions (Merrill and Pewe 1977).

Analysis of plant matter in ancient packrat middens has allowed documentation of the changing distributions of vegetation types over the past 22,000 years in the Apache Highlands ecoregion (Van Devender and Spaulding 1979). The study of ancient pollen grains from the region indicates an upward vertical movement of vegetation zones of at least 3,000-4,000 ft (915 to 1,220 m) during pluvial times (Hevly and Martin 1961). This displacement allowed Rocky Mountain forest flora to spread southward into the Madrean pine-oak and oak-conifer forests and woodlands of the Southwestern US. In general, these highest forest zones are more representative of Rocky Mountain flora, with the lower elevation Madrean Encinal more representative of the Madrean flora of Mexico. Climatic patterns at local and regional scales have influenced the establishment and survival of these vegetational systems over the last 24,000 years (Gottfried *et al.* 1995).

Rocky Mountain Alpine-Montane Wet Meadow

Rocky Mountain Alpine-Montane Wet Meadows are high-elevation communities found throughout the Rocky Mountains and Intermountain regions, dominated by herbaceous species found on wetter sites with very low-velocity surface and subsurface flows. They range in elevation from 3,280-1,800 ft (1000-3600 m). Soils of this system may be mineral or organic and display hydric soil characteristics, including high organic content and/or low chroma and redoximorphic features. The most important factor controlling the distribution and growth of alpine plants is soil moisture (Billings and Mooney 1968). These habitat types can occur as large meadows in montane or subalpine valleys, as narrow strips bordering ponds, lakes, and streams, and along toe slope seeps and are typically found on flat areas or gentle slopes, but may also

occur on sub-irrigated sites with slopes up to 10%. In alpine regions, sites typically are small depressions located below late melting snow patches or on snow beds. This habitat often occurs as a mixture of several plant associations, often dominated by graminoids, including slimstem reedgrass (*Calamagrostis stricta*), white marsh marigold (*Caltha leptosepala*), heartleaf bittercress (*Cardamine cordifolia*), sheep sedge (*Carex illota*), smallwing sedge (*Carex microptera*), black alpine sedge (*Carex nigricans*), mountain sedge (*Carex scopulorum*), Northwest Territory sedge (*Carex utriculata*), native sedge (*Carex vernacular*), tufted hairgrass (*Deschampsia caespitosa*), fewflower spikerush (*Eleocharis quinqueflora*), Drummond's rush (*Juncus drummondii*), icegrass (*Phippsia algida*), alpine yellowcress (*Rorippa alpine*), arrowleaf ragwort (*Senecio triangularis*), Parry's clover (*Trifolium parryi*), and American globeflower (*Trollius laxus*). Often alpine dwarf-shrublands, especially those dominated by willow (*Salix*), are immediately adjacent to the wet meadows. Wet meadows are tightly associated with snowmelt and typically not subjected to high disturbance events such as flooding (NatureServe 2004b).

Rocky Mountain Montane Mixed Conifer Forest and Woodland

Rocky Mountain Montane Mixed Conifer Forest and Woodland is a highly variable habitat of the montane zone of the Rocky Mountains. These are mixed-conifer forests occurring on all aspects at elevations ranging from 3,900-10,800 ft (1,200-3,300 m). Rainfall averages less than 30 in (75 cm) per year with summer "monsoons" during the growing season contributing substantial moisture. Douglas fir and white fir are most common canopy dominants, but Engelmann spruce (*Picea engelmannii*), or blue spruce may be present, with ponderosa pine being present to codominant. Douglas fir forests occupy drier sites, and white fir-dominated forests occupy cooler sites, such as upper slopes at higher elevations, canyon sideslopes, ridgetops, and north- and east-facing slopes which burn somewhat infrequently. Blue spruce is most often found in cool, moist locations, often occurring as smaller patches within a matrix of other associations. This system also includes mixed conifer/aspen stands. As many as seven conifers can be found growing in the same occurrence, and there are a number of cold-deciduous shrub and graminoid species common, including a few maple (*Acer* spp.) and blueberry (*Vaccinium*) species, gray alder (*Alnus incana*), kinnikinnick (*Arctostaphylos uva-ursi*), water birch (*Betula occidentalis*), redosier dogwood (*Cornus sericea*), Arizona fescue (*Festuca arizonica*), fivepetal cliffbush (*Jamesia Americana*), creeping barberry (*Mahonia repens*), Oregon boxleaf, (*Paxistima myrsinites*), Kuntze mallow ninebark (*Physocarpus malvaceus*), New Mexico locust (*Robinia neomexicana*), mountain snowberry, and Gambel oak (*Quercus gambelii*). Herbaceous species include fringed brome (*Bromus ciliatus*), Geyer's sedge (*Carex geyeri*), Ross' (*Carex rossii*), dryspike sedge (*Carex siccata*), screwleaf

Rocky Mountain Montane Mixed Conifer Forest and Woodland habitat in New Mexico. This photo records a brief moment in time, and does not portray the range of conditions of this habitat type. Photo provided by SWReGAP.

muhly, bluebunch wheatgrass, sprucefir fleabane (*Erigeron eximius*), Virginia strawberry (*Fragaria virginiana*), smallflowered woodrush (*Luzula parviflora*), sweetcicely (*Osmorhiza berteroi*), bittercress ragwort (*Packera cardamine*), western meadow-rue (*Thalictrum occidentale*), and Fendler's meadow-rue (*Thalictrum fendleri*) (NatureServe 2004). Naturally occurring fires are characterized by a high degree of variable return intervals and lethality due to the range of moisture found in this habitat.

Western Great Plains Sand Sagebrush

Western Great Plains Sand Sagebrush is found mostly in southeastern areas New Mexico. The climate is semi-arid to arid. Soils are somewhat to excessively well-drained, deep and sandy and are often associated with dune systems and ancient floodplains. This habitat type is characterized by a sparse to moderately dense woody layer dominated by sand sagebrush (*Artemisia filifolia*). In some areas, this habitat may actually occur as a result of overgrazing in prairie habitats, leading to decreasing dominance of some of the grass species such as sand bluestem (*Andropogon hallii*), giant sandreed (*Calamovilfa gigantean*), and little bluestem (*Schizachyrium scoparium*). Associated species can vary with geography, amount and season of precipitation, disturbance and soil texture. These species include several graminoid species, such as sand bluestem, little bluestem, sand dropseed (*Sporobolus cryptandrus*), giant sandreed, needle and thread, and grama spp.; other shrub species, such as soapweed yucca (*Yucca glauca*), honey mesquite (*Prosopis glandulosa*), skunkbush sumac (*Rhus trilobata*), and Chickasaw plum (*Prunus angustifolia*); and, in the southern range, Havard oak (*Quercus havardii*). Havard oak is able to resprout following a fire and thus may persist for long periods of time once established. Fire and grazing are the most important dynamic processes for this type, although drought stress can impact this system significantly in some areas (NatureServe 2004).

Western Great Plains Shortgrass Prairie

Western Great Plains Shortgrass Prairie is found primarily in the eastern third of New Mexico and occurs primarily on flat to rolling uplands with loamy, ustic soils ranging from sandy to clayey. This habitat forms a matrix system with blue grama dominating. Associated graminoids may include purple threeawn (*Aristida purpurea*), sideoats grama, hairy grama, buffalograss, needle and thread, prairie Junegrass (*Koeleria macrantha*), western wheatgrass, James' galleta, alkali sacaton and sand dropseed. Although mid-height grass species may be present especially on more mesic land positions and soils, they are secondary in importance to the sod-forming short grasses. Sandy soils have higher cover of needle and thread, spike dropseed (*Sporobolus cryptandrus*), and soaptree yucca. Scattered shrub and dwarf-dwarf species such as sand sagebrush, prairie sagewort (*Artemisia frigida*), big sagebrush (*Artemisia tridentate*), fourwing saltbrush (*Atriplex canescens*), spreading buckwheat (*Eriogonum effusum*), broom snakeweed (*Gutierrezia sarothrae*), wolfberry (*Lycium palida*), may also be present. High variation in amount and timing of annual precipitation impacts the relative cover of cool and warm season herbaceous species. Large-scale processes such as climate, fire, and grazing influence this habitat. Fire is less important than other prairie habitats because the often dry and xeric climate conditions can decrease the fuel load and thus the relative fire frequency. The short grasses that dominate this habitat type are extremely drought and grazing-tolerant. These species evolved with drought and large herbivores and, because of their stature, are relatively resistant to overgrazing (NatureServe 2004).

Riparian Habitats

Riparian habitats are assemblages of plant, animal, and aquatic communities whose presence can be either directly or indirectly attributed to stream-induced or related factors (Kauffman and Krueger 1984). These habitats tend to support a greater diversity of plants and animals than upland habitats. A significant percentage of all wildlife in the Southwest uses riparian habitat (Thomas *et al.* 1979, Johnson *et al.* 1977) and approximately 80% of all sensitive and specially classified vertebrate species in New Mexico depend upon riparian or aquatic habitat at some time during their life cycle (New Mexico Department of Game and Fish 2000).

Riparian habitat in New Mexico. This photo records a brief moment in time, and does not portray the range of conditions of this habitat type. Photo provided by NMCFWRU.

Wetlands and riparian ecosystems comprise less than 1% of New Mexico (Dahl 1990, Henrickson and Johnston 1986, Allen and Marlow 1992). Riparian habitats occur where water is perennial, intermittent, or ephemeral. Their relatively small size, elevational continuum, complexity, and variation present a significant challenge to mapping their aerial extent. Thus, there are no reliable estimates for the acreage of riparian habitats in New Mexico.

Dick-Peddie (1993) classified riparian habitats in New Mexico into: 1) alpine riparian, 2) montane riparian, 3) floodplain-plains riparian, 4) arroyo riparian, and 5) closed basin riparian. Alpine riparian areas are similar to subalpine grasslands (Dick-Peddie 1993) communities and are discussed in the Alpine Wet Meadow section in the Southern Rocky Mountain Ecoregion. We grouped arroyo riparian and closed basin riparian types because of their similarity in New Mexico.

Riparian habitat in New Mexico. This photo records a brief moment in time, and does not portray the range of conditions of this habitat type. Photo provided by NMCFWRU.

Sixteen SWReGAP land cover types illustrate riparian habitats in New Mexico (Table 3-4). Floodplain-Plains riparian communities occur primarily along the major rivers of New Mexico. Xeric riparian communities included basins, playas, alkali sinks, and arroyos. Many of New Mexico's riparian communities have been altered by invasive species. Their presence in riparian communities is sufficient enough to be mapped using remotely sensed data (SWReGAP: http://fws-nmcfwru.nmsu.edu/swregap/). While this community is likely more prevalent in the floodplain-plains riparian communities, invasive riparian communities are present throughout New Mexico riparian systems.

Table 3-4. SWReGAP land cover types (NatureServe 2004b) used to illustrate riparian communities in New Mexico.

Riparian Type	SWReGAP Land Cover Types
Montane Riparian	
	Rocky Mountain Bigtooth Maple Ravine Woodland
	Rocky Mountain Subalpine-Montane Riparian Shrubland
	Rocky Mountain Subalpine-Montane Riparian Woodland
	Rocky Mountain Lower Montane Riparian Woodland and Shrubland
	North American Warm Desert Lower Montane Riparian Woodland and Shrubland
Floodplain-Plains Riparian	
	Western Great Plains Riparian Woodland and Shrubland
	North American Warm Desert Riparian Woodland and Shrubland
	North American Warm Desert Riparian Mesquite Bosque
	North American Arid West Emergent Marsh
Xeric Riparian	
	Inter-Mountain Basins Greasewood Flat
	Inter-Mountain Basins Greasewood Wash
	Inter-Mountain Basins Playa
	North American Warm Desert Wash
	North American Warm Desert Playa
	Western Great Plains Saline Depression
Invasive Riparian Communities	
	Invasive Southwest Riparian Woodland and Shrubland

Rocky Mountain Bigtooth Maple Ravine Woodland

This ecological system occurs in scattered localities in New Mexico. It is dominated by bigtooth maple (*Acer grandidentatum*) but can include mixed stands of Gambel oak or with scattered conifers. Some stands may include box elder (*Acer negundo*) or quaking aspen (*Populus tremuloides*) as minor components (NatureServe 2004b).

Rocky Mountain Subalpine-Montane Riparian Shrubland

The montane/subalpine riparian shrubland ecological system is a linear and small patch system confined to specific environments occurring on floodplains or terraces of the upper Rio Grande and its tributaries (Rondeau 2001). It primarily occurs in shallow broad valleys. This ecological system can be found within a broad elevation range, from approximately 8,000-11,000 ft (2,400-3,350 m). It often occurs as a mosaic of multiple communities that are shrub-dominated. The dominant shrubs reflect the large elevational gradient and include gray alder, dwaft birch (*Betula glandulosa*), water birch, redosier dogwood, and willow species (*Salix* spp.) (NatureServe 2004b). Generally, the upland vegetation surrounding these riparian systems is either conifer or aspen forests, while adjacent riparian systems range from herbaceous-dominated communities to tree-dominated communities. Beavers are primary users and drivers of this ecological system and the foremost species necessary to maintain its hydrology. Annual and episodic flooding is important, too, as any alteration of the flooding regime may produce changes to plant composition or community composition (Kittel *et al*. 1999). Aquatic species and water quality may be as important as vegetation as indicators of system health.

Rocky Mountain Subalpine-Montane Riparian Woodland
The montane/subalpine riparian forest and woodland ecological system is a linear system confined to specific environments occurring on floodplains or terraces of rivers and streams (Rondeau 2001). It is the primary riparian matrix of the upper Rio Grande watershed. The montane/subalpine riparian woodland ecological type forms small patches within this linear-matrix system. Upper montane/subalpine riparian forest and woodland occurs at higher elevations (8,000-11,000 ft; 2,400-3,350 m) and contains a mosaic of one or two communities dominated by either white and subalpine fir, Englemann and blue spruce, or aspen (Fullerton and Batts 2003, NatureServe 2004b).

Rocky Mountain Lower Montane Riparian Woodland and Shrubland
The lower montane riparian woodland ecological system is a linear system confined to specific environments occurring on floodplains or terraces (Rondeau 2001). It is scattered throughout the upper watershed within a broad elevation range, from approximately 3,000-9,000 ft (900-2,700 m). This system often occurs as a mosaic of multiple communities that are tree-dominated with a diverse shrub component. The plant associations connected to this system reflect a variety of elevations, stream gradients, floodplain widths, and flooding events. The dominant trees may include boxelder, cottonwood, balsam poplar (*P. balsamifera*), Douglas fir, blue spruce, or Rocky Mountain juniper (*Juniperus scopulorum*). Dominant shrubs include Rocky Mountain maple (*Acer glabrum*), gray alder, birch, dogwood, and willow species. The upland vegetation surrounding this riparian system can range from forests to grasslands (NatureServe 2004b).

North American Warm Desert Lower Montane Riparian Woodland and Shrubland
This system consists of mid-low elevation (3,600-5,900 ft; 1,100-1,800 m) riparian corridors along perennial and seasonally intermittent streams throughout canyons and valleys of southern New Mexico. This system occurs along the upper Gila River and its tributaries, the upper San Francisco River and its tributaries, the upper Zuni River and its tributaries, and probably the upper reaches of streams draining the east slopes of the Sierra Blanca, Sacramento Mountains, and Guadalupe Mountains. Dominant species of this system include gray alder, river hawthorn (*Crataegus rivularis*), stetchberry (*Forestiera pubescens*), cottonwood (*Populus* spp.), wild plum (*Prunus virginina*), skunkbush sumac, and willow species (NatureServe 2004b). The surrounding upland systems range from grasslands, to shrublands and woodlands. Within the levees between Las Cruces and El Paso, this habitat is extremely fragmented and of low quality (Fullerton and Batts 2003). There is little or no regeneration due to the lack of floods, and to frequent mowing inside the levees. There are isolated pockets of remnant cottonwood–willow habitat, but saltcedar is dominant.

Western Great Plains Riparian Woodland and Shrubland
This ecological system is found in medium and small rivers and streams throughout eastern New Mexico. It can occur as far west as the Rio Grande. Dominant species can include cottonwood, willow, silver sagebrush (*Artemisia cana*), western wheatgrass, spike dropseed, and little bluestem (NatureServe 2004b).

North American Warm Desert Riparian Woodland and Shrubland
This ecological system consists of low elevation (< 3,900 ft; 1,200 m) riparian corridors along medium to large perennial streams throughout New Mexico. It occurs along the main stems and

tributaries of lower Gila River, lower San Francisco River, the lower Zuni River, and probably the lower reaches of streams draining the east slopes of the Sierra Blanca, Sacramento Mountains, and Guadalupe Mountains (NatureServe 2004b).

North American Warm Desert Riparian Mesquite Bosque
This ecological system consists of low-elevation (< 3,600 ft; 1,100 m) riparian corridors along intermittent streams in southern New Mexico. The dominant trees include honey mesquite with shrubs including seep willow (*Baccharis salicifolia*), arrow-weed (*Pluchea sericea*), and coyote willow (*Salix exigua*)(NatureServe 2004b).

North American Arid West Emergent Marsh
This ecological system occurs throughout the arid and semi-arid regions of New Mexico. These marshes can occur in depressions, around lakes, and along streams and rivers. Soils have anaerobic characteristics and plants that occur are adapted to saturated soil conditions. Common plants include species of sedges (*Scirpus* spp.) and/or cattail (*Typha* spp.), rush (*Juncus* spp.), pondweed (*Potamogeton* spp.), and reed (*Phalaris* spp.)(NatureServe 2004b).

Inter-Mountain Basins Greasewood Flat
This ecological system is a complex of many communities dominated or codominated by greasewood, fourwing saltbush (*Atriplex canescens*), shadescale saltbush (*Atriplex confertifolia*), or winterfat (*Krascheninnikovia lanata*). It occurs near drainages on stream terraces and flats or may form rings around more sparsely vegetated playas and can be open to moderately dense shrublands (NatureServe 2004b).

Inter-Mountain Basins Greasewood Wash
This ecological system is barren and sparsely vegetated restricted to intermittently flooded streambeds and banks. Shrubs include greasewood, rubber rabbitbrush, Apache plume (*Fallugia paradoxa*), and/*or* silver sagebrush. A continuous or intermittent linear canopy in and along drainages occurs but does not extend out into flats. Saltgrass (*Distichlis spicata*) meadows can occur where water remains for the longest periods (NatureServe 2004b).

Inter-Mountain Basins Playa
This ecological system is comprised of barren and sparsely vegetated playas found in the intermountain west. The system is characterized by species such as iodinebush (*Allenrolfea occidentalis*), greasewood, spiny hopsage (*Grayia spinosa*), lemmon's alkali grass (*Puccinellia lemmonii*), basin wildrye, inland saltgrass, and saltbrush (NatureServe 2004b).

North American Warm Desert Wash
This ecological system occurs in intermittent washes or arroyos that dissect bajadas, mesas, and plains of the warm deserts. This habitat type occurs as linear or braided strips within desert vegetation matrix. The vegetation can be quite variable ranging from sparse to moderately dense often on the banks, but can occur within the steam channel. Species that are dominant in this system include catclaw acacia (*Acacia greggii*), cut-leaf brickellia (*Brickellia laciniata*), desert broom (*Baccharis sarothroides*), desert willow (*Chilopsis linearis)*, Apache plume, burro brush (*Hymenoclea monogyra* and *H. salsola*), mesquite, littleleaf sumac (*Rhus microphylla*), and greasewood (NatureServe 2004b).

North American Warm Desert Playa
This ecological system is comprised of barren and sparsely vegetated playas found across the warm deserts. Larger playas have vegetation rings which are formed in response to salinity. Species characterizing this system include iodinebush, inland saltgrass, common spike rush (*Eleocharis palustris*), ricegrass (*Oryzopsis* spp.), dropseed, and saltgrass (NatureServe 2004b).

Western Great Plains Saline Depression
This ecological system is comprised of shallow lakes and depressions with strongly saline soils. Salt encrustations can occur on the surface in some these areas and vegetation must be salt-tolerant species such as inland saltgrass, alkali sacaton, and foxtail barley (*Hordeum jubatum*). During wet years, less tolerant species can occur as the increase in precipitation dilutes the salt concentration (NatureServe 2004b).

Invasive Southwest Riparian Woodland and Shrubland
This is a semi-natural system predominantly comprised of saltcedar and Russian olive (*Elaegnus angustifolus*) (NatureServe 2004b). This vegetation type can occur throughout the state but is often found within perennial drainages and around lakes.

Ten key aquatic habitats were identified in New Mexico.

Descriptions of Key Aquatic Habitat Types
Perennial Marsh/Cienega/Spring/Seep
Perennial marsh/cienegas occur statewide as geographically isolated wet depressions or seeps that are hydrologically supported by seasonal discharge of shallow groundwater aquifers and precipitation events. These wet areas collect and hold water that commonly supports moisture-loving plants (e.g., marsh emergents), soils, and wildlife.

Perennial Large Reservoir
Large reservoirs (>1,000 ha) occur on many of New Mexico drainages. Elephant Butte, Navajo, Heron, El Vado, Abiquiu, Ute, Sumner, Brantly, Red Bluff, Caballo, Conchas, Cochiti, and Eagle Nest are large reservoirs in New Mexico. These reservoirs are managed for irrigation and/or flood control. They support a diverse sport fishery of primarily non-native fish. Dams associated with these large reservoirs alter the natural flow regime and influence up- and down-stream habitats.

Perennial 1st and 2nd Order Stream
Headwater streams are 1st order streams. When two 1st order streams join, they form a 2nd order stream. Perennial 1st and 2nd order streams occur in all watersheds except the San Juan.


Perennial 1st and 2nd Order Stream habitat in New Mexico. This photo records a brief moment in time, and does not portray the range of conditions of this habitat type. Photo provided by NMCFWRU.

Perennial 3rd and 4th Order Stream
When two 2nd order streams join, they form a 3rd order stream. Similarly, when two 3rd order streams join, they form a 4th order stream. Perennial 3rd and 4th order streams occur in all watersheds except the Tularosa.

Perennial 3rd and 4th Order Stream habitat in New Mexico. This photo records a brief moment in time, and does not portray the range of conditions of this habitat type. Photo provided by NMCFWRU.

Perennial 5th Order Stream
When two 4th order streams join, they form a 5th order stream. In New Mexico, 5th order streams are the Rio Grande, Pecos, San Juan and Gila River.

Perennial Tank
Perennial tanks occur statewide and are hydrologically supported by natural springs, seepage from permanent streams, and precipitation events. These permanent tanks collect and hold water for sufficient periods to support wildlife and numerous emergent and submerged aquatic plants. Cattails and larger sedges often form thick mats on the stabilized banks that may extend some distance into the tank.

Ephemeral 1st and 2nd Order Stream
Based on US Geological Survey maps (1:2,000,000 Digital Line Graph), approximately 80 percent of the drainages in New Mexico are ephemeral. More than 3,900 miles of intermittent streams exist within geographically isolated, closed basins statewide (NMDGF 2003).

Ephemeral Man-Made Catchments
In New Mexico, man-made depressions occur statewide and serve as ephemeral catchments for seasonal run-off waters. These depressions are variously termed dirt tanks, stock tanks, drinkers, and catchments. Roadside pools, created as borrow pits or storm water run-off storage basins, also are included in this category.

Perennial tank habitat in New Mexico. This photo records a brief moment in time, and does not portray the range of conditions of this habitat type. Photo by provided by NMCFWRU.

Ephemeral Natural Catchments
Ephemeral natural catchments exist in all ecoregions of New Mexico (Cole 1996, Jones 1997) as geographically isolated wetlands that are commonly termed "playas" or "prairie potholes" (NMAC 2000). Ephemeral natural catchments vary in size from less than an acre to several hundred acres, and can occur at any elevation as a network of isolated wetlands within endorheic basins or flyways (Central or Intermountain West), or as isolated depressions found statewide.

Playas of the Southern High Plains of eastern New Mexico and adjacent states (Colorado, Oklahoma, Texas) are perhaps the most recognized and well-studied type of ephemeral wetland in the state (Smith 2003), where it is estimated that some 2,460 playa lakes occur on the "Llano Estacado" south of the Canadian River drainage (Guthery and Bryant 1982). However, playa lakes represent but one type of a great diversity of ephemeral wetland habitat types found throughout New Mexico. Additional descriptive names of ephemeral natural catchments may include: salt basins (salterns, flats or lakes), alkali flats, tinajas (rock pools), grassland and woodland vernal pools, karst sinkholes, swales, among others (Witham 1998, Erikson and Belk 1999, Lang and Rogers 2002, Tiner *et al.* 2002, Tiner 2003, Zedler 2003).

Ephemeral natural catchment habitat in New Mexico. This photo records a brief moment in time, and does not portray the range of conditions of this habitat type. Photo provided by NMCFWRU.

Ephemeral Marsh/Cienega/Seeps/Springs

Ephemeral marsh/cienegas occur statewide as geographically isolated wet depressions or seeps that are hydrologically supported by seasonal discharge of shallow groundwater aquifers and precipitation events. These seasonally wet areas collect and hold water for sufficient periods that commonly support moisture-loving plants (e.g., marsh emergents), soils, and wildlife.

WILDLIFE SPECIES AND STATUS

Game Species

New Mexico has 103 game species that require either a big game license, federal migratory bird permit, fishing license, furbearer license, small game license, or duck stamp to harvest. This list includes 30 species of mammals, 29 fish, 43 birds, and one amphibian (see Bison-M database for greater details; http://fwie.fw.vt.edu/states/nm.htm).

State Threatened and Endangered Species

The New Mexico Department of Game and Fish emphasizes the need for identifying and protecting endangered wildlife in New Mexico. More than 75 taxa have been extirpated from one or more counties, including six that are considered to be extinct and 19 which have been extirpated from the state (NMDGF 2004a).

A total of 118 species and subspecies are on the 2004 list of state-threatened and state-endangered New Mexico wildlife (NMDGF 2004a). The list includes two crustaceans, 25 molluscs, 23 fishes, six amphibians, 15 reptiles, 32 birds, and 15 mammals. An additional seven species of mammals have been listed as restricted to facilitate control of traffic in federally protected species within New Mexico. A species is state-endangered if it is in jeopardy of extinction or extirpation from the state; a species is state-threatened if it is likely to become endangered within the foreseeable future throughout all or a significant portion of its range in New Mexico. Only species or subspecies of mammals, birds, reptiles, amphibians, fishes, molluscs, and crustaceans native to New Mexico may be listed as threatened or endangered under the Wildlife Conservation Act. During the Biennial Review, species may be upgraded from threatened to endangered or downgraded from endangered to threatened, based upon data, views, and information regarding the biological and ecological status of the species. Investigations for new listings or removals from the list (delisting) can be undertaken at any time, but require additional procedures from those for the Biennial Review. The 2004 Biennial Review contained recommendations regarding the listing status for each of the 125 species or subspecies listed as threatened, endangered, or restricted under the New Mexico Wildlife Conservation Act (NMDGF 2004a). Of these, 123 were recommended to retain their current listing status. Two species, the Jemez Mountains salamander (*Plethodon neomexicanus*) and sand dune lizard (*Sceloporus arenicolus*), were up-listed from state threatened to state endangered. Both species persist within very limited ranges and have been experiencing increasing threats to their habitats within recent years. Changes from threatened to endangered confer no regulatory authority to the NMDGF over the habitat of these species. However, state-endangered status emphasizes the importance of, and demonstrate the ability for, state-level management to support the long-term persistence of otherwise imperiled native wildlife.

Federal Threatened and Endangered Species

The U.S Fish and Wildlife Service lists 29 New Mexico animal species as threatened or endangered species (USFWS 2005). The list includes one crustacean, two molluscs, 12 fishes, one amphibian, one reptile, eight birds, and five mammals.