RIO GRANDE WATERSHED

The Rio Grande originates in the San Juan Mountains of southern Colorado and flows south through the entire length of New Mexico. The Rio Grande Watershed is approximately 1.9 million ac (0.8 million ha) in New Mexico (U. S. Geologic Service 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 is affected by snowmelt and summer rains. The typical annual cycle is characterized by a low winter flow, a spring peak between early April and mid-May corresponding to snow melt, a low flow in June followed by smaller peaks associated with monsoon rains, and decreasing flow through the fall (Bullard and Wells, 1992). This flow regime has been greatly altered by irrigation diversions and agricultural reservoirs. Irrigation flows have increased the relative magnitude and duration of summer peaks and reduced peak flows associated with snowmelt.

Most lands within the Rio Grande Watershed are under federal and quasi-federal ownership. The main stem of the Rio Grande flows through large tracts of Bureau of Land Management, Middle Rio Grande Conservancy District, and Elephant Butte Irrigation District lands. About 7% of the watershed is occupied by cultivated cropland or orchards. Agriculture is particularly dense in the Española, Middle Rio Grande, and the Mesilla valleys. Other reaches flow through lands used for livestock grazing. Counties within the Rio Grande Watershed host 63% of New Mexico's human population (US Census Bureau 2002). Bernalillo County alone has 31% of the state's population. The estimated population growth within the watershed between 1990 and 2000 was 19%.

Aquatic habitats in the Rio Grande Watershed are diverse. Key habitats in this watershed include perennial large reservoirs, perennial marsh/ cienega/spring/seeps, perennial 1st and 2nd order streams, perennial 3rd and 4th order streams, and 5th order streams (Fig. 5-13).

Numerous species have been introduced into the Rio Grande Watershed. Common carp (*Cyprinus carpio*) are widespread and non-native salmonids, including rainbow trout (*Oncorhynchus mykiss*), cutthroat trout subspecies (*O. clarki*), brook trout (*Salvelinus fontinalis*), and brown trout (*Salmo trutta*) are present in many of the 1st and 2nd order mountain streams within the drainage, as well as in the tailwaters of large reservoirs. Kokanee salmon (*Oncorhynchus nerka*), rainbow trout, and brown trout are present in reservoirs more than 6,234 ft (1,900 m) elevation. Warm/cool water fishes including largemouth bass (*Micropterus salmoides*), smallmouth bass (*M. dolomieui*), walleye (*Sander vitrius*), northern pike (*Esox luciens*), white bass (*Morone chrysops*), crappie (*Pomoxis* spp.), and sunfishes (*Lepomis* spp.) are present in many of the waters below 6,234 ft (1,900 m) elevation. The Asian clam (*Corbicula fluminea*), first introduced to lower the Rio Grande (Metcalf, 1966), has since been observed in most reaches, including irrigation systems, upstream to Cochiti Reservoir. The non-native northern crayfish (*Orconectes virilis*) and red swamp crayfish (*Procambarus clarkii*) are also known to inhabit the Rio Grande Watershed.

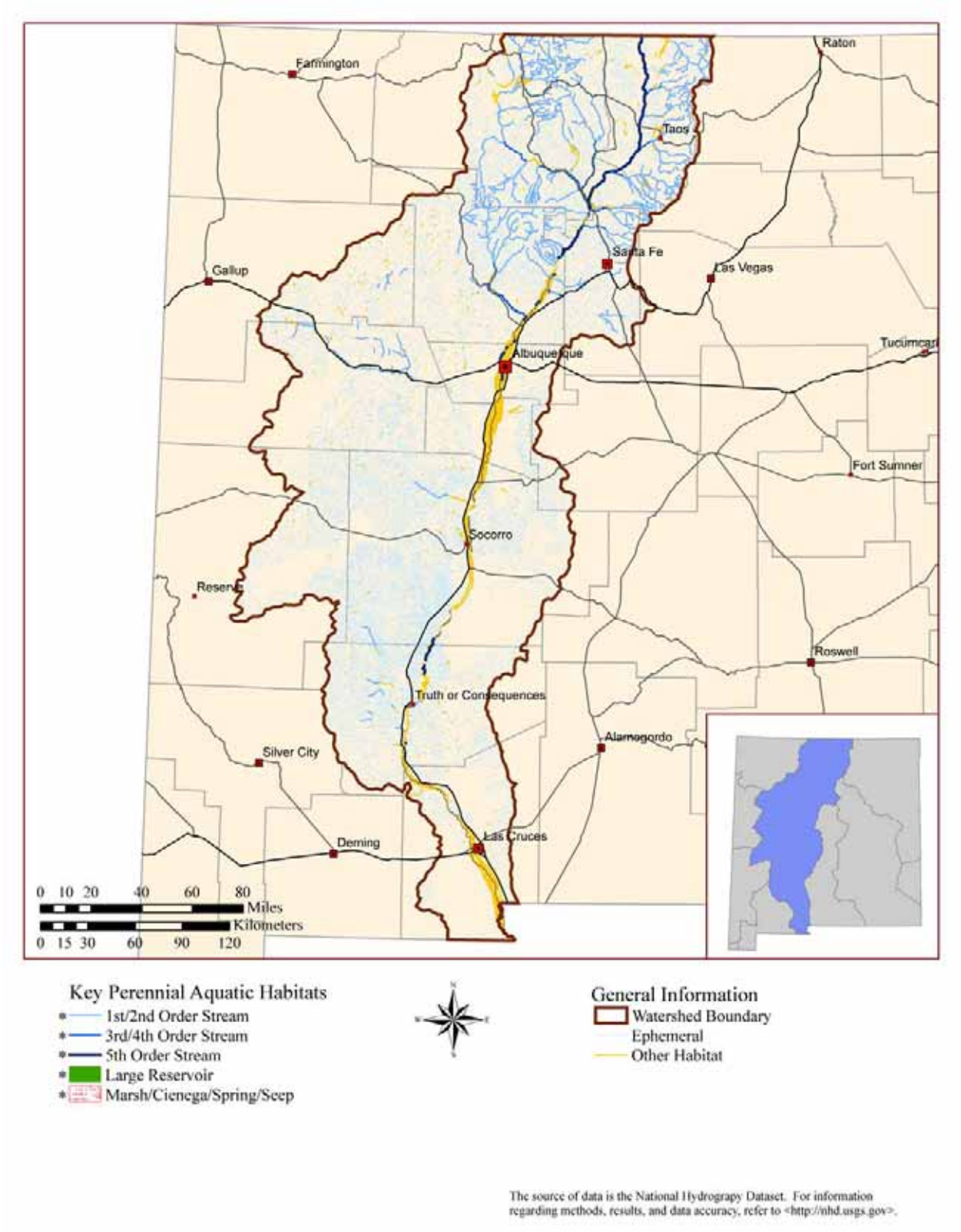

Figure 5-13. Key perennial aquatic habitats in the Rio Grande Watershed in New Mexico. Key habitats are designated with an asterisk (*).

Species of Greatest Conservation Need

Fifty-three Species of Greatest Conservation Need (SGCN), excluding arthropods other than crustaceans, have been identified in the Rio Grande Watershed (Table 5-15). Twenty-seven species (51%) are classified as vulnerable, imperiled, or critically imperiled both statewide and nationally. Eight SGCN are secure both nationally and in New Mexico. Conservation status codes (abundance estimates) for each SGCN are provided in Appendix H. The Mexican tetra (*Astyanax mexicanus*), speckled chub (*Macrhybopsis aestivalis aestivalis*), Rio Grande shiner (*Notropis jemezanus*), blue sucker (*Cycleptus elongatus*), and gray redhorse (*Moxostoma congestum*) are considered extirpated from key habitats in the Rio Grande Watershed. Perennial springs scattered along the western flank of the Rio Grande Watershed provide habitat for several invertebrate SGCN known only from Socorro County. These endemic taxa include the Socorro isopod (*Thermosphaeroma thermophilum*), Alamosa springsnail (*Pseudotryonia alamosae*), Chupadera springsnail (*Pyrgulopsis chupaderae*), and Socorro springsnail (*Pyrgulopsis neomexicana*). Hyalellid amphipods occur in most of these spring-fed habitats. Conservation concerns for birds, mammals, amphibians, and reptiles are primarily addressed in the statewide distributed riparian habitats section and/or the discussion of terrestrial habitats in each ecoregion. Additional concerns for molluscs and crustaceans are addressed in the statewide distributed ephemeral habitats and perennial tanks section.

Table 5-15. Species of Greatest Conservation Need in the Rio Grande Watershed in New Mexico.

	Perennial				
Common Name	Large Reservoir	Marsh/Cienega/ Spring/Seep	1st and 2nd Order Stream	3rd and 4th Order Stream	5th Order Stream
Fish					
Rio Grande Cutthroat Trout			X	X	
Mexican Tetra		E[1]	E		
Speckled Chub					E
Rio Grande Chub			X	X	X
Rio Grande Silvery Minnow		X			X
Rio Grande Shiner					E
Rio Grande Sucker			X	X	X
Blue Sucker					E
Smallmouth Buffalo	X				X
Gray Redhorse					E
Blue Catfish	X				X
Birds[2]					
Eared Grebe	X	X		X	X
American Bittern		X			
White-Faced Ibis	X	X			
Northern Pintail	X	X		X	X
Osprey	X			X	X
Bald Eagle	X	X		X	X
Northern Harrier		X			
Common Black-Hawk		X	X	X	X

Table 5-15 Cont.

Common Name	*Perennial* Large Reservoir	Marsh/Cienega/ Spring/Seep	1st and 2nd Order Stream	3rd and 4th Order Stream	5th Order Stream
Birds Cont.					
Peregrine Falcon	X	X		X	X
Sandhill Crane	X	X		X	
Snowy Plover	X			X	
Interior Least Tern	X			X	X
Southwestern Willow Flycatcher		X		X	X
Bell's Vireo				X	X
Bank Swallow				X	X
Lucy's Warbler		X		X	X
Yellow Warbler		X	X	X	X
Painted Bunting				X	X
Mammals[2]					
Western Red Bat		X			
Spotted Bat		X			
Allen's Big-Eared Bat		X			
American Beaver	X	X	X	X	X
NM Meadow Jumping Mouse		X			
Desert Bighorn Sheep		X			
Amphibians[2]					
Tiger Salamander		X			
Western Boreal Toad		X	X		
Western Chorus Frog		X	X	X	
Plains Leopard Frog		X		X	X
Chiricahua Leopard Frog		X	X	X	X
Northern Leopard Frog	X	X	X	X	X
Reptiles[2]					
Western Painted Turtle	X			X	X
Big Bend Slider	X				X
New Mexico Garter Snake		X	X	X	X
Molluscs[2]					
Chupadera Pyrg Snail		X			
Socorro Pyrg Snail		X			
Alamosa Springsnail		X	X		
Wrinkled Marshsnail			X		
Creeping Ancylid Snail				X	X
Ovate Vertigo Snail		X			
Blunt Ambersnail		X			
Crustaceans[2]					
Sideswimmers / Scuds		X	X	X	X
Socorro Isopod		X			

[1] Species is considered extirpated from habitat type.

[2] Additional concerns for these taxa are addressed in the Statewide Distributed Riparian Habitats, Statewide Distributed Ephemeral Habitats and Perennial Tanks and/or Ecoregion and terrestrial habitat sections.

Perennial Large Reservoir

Habitat Condition

The main stem of the Rio Grande and its major tributaries have been dammed to form five irrigation reservoirs. These include Heron, El Vado, Abiquiu, Bluewater, and Elephant Butte and three flood control lakes Cochiti, Jemez Canyon, and Caballo. Most of these reservoirs are in canyon topography where rocky substrate and decaying woody vegetation provide the majority of fish habitat. Hydrology is typically governed by irrigation demands. Typically water is stored through the winter and into spring runoff. Large drawdowns occur throughout the irrigation season, generally late April through September. Lowest reservoir water levels typically occur at the end of October, the highest levels generally occur in early April.

Problems Affecting Habitat or Species

Reservoir Hydrology
Reservoir hydrology can have major impacts on fish communities within them. Spawning and recruitment typically occurs coincident to irrigation season, thus fish populations can be greatly affected by lower reservoir levels. Reservoir releases may adversely affect riverine fishes through displacement, modified thermal regime, or habitat modification.

Non-Native/Invasive Species
The fish assemblages of perennial large reservoirs are composed almost entirely of non-native fishes. Non-native piscivores may affect native fish species within a reservoir via predation or competition. However, the abundance of non-native prey species within these reservoirs buffers species of conservation concern such as the smallmouth buffalo (*Ictiobus bubalus*) and blue catfish (*Ictalurus furcatus*) from predation impacts. Crayfish, non-native sunfish, catfish, and bullfrogs (*Rana catesbeiana*) are known to cause localized reductions in native ranid frogs. They may also exert a negative influence on native turtle populations by consuming hatchling turtles. Eurasian milfoil (*Myriophyllum spicatum*) has been collected in Cochiti and Elephant Butte Reservoirs indicating that despite their relative remoteness from contaminated waters, New Mexico systems may be vulnerable to aquatic nuisance species.

Commercial Harvest
Another potential factor affecting the population of smallmouth buffalo is commercial harvest, although commercial fishing in New Mexico reservoirs has decreased substantially in the last 20 years.

Information Gaps

Generally, the importance and effects of large reservoirs in the Rio Grande Watershed on SGCN are poorly understood. Information gaps that impair our ability to make informed conservation decisions are outlined below.

- Trophic dynamics within New Mexico reservoirs (especially within the Rio Grande Watershed) have not been thoroughly investigated.

- The role of introduced piscivores within the reservoir community is not well understood.

- Reservoirs provide the bulk of smallmouth buffalo habitat within New Mexico, but little recent information exists regarding population dynamics and biology of this species within these habitats.

- While reservoirs have been implicated as a source of non-native expansion and persistence in New Mexico watersheds, the role of reservoirs as refugia for SGCN has not been thoroughly investigated.

- Blue catfish have often been stocked within the basin. The genetic status of blue catfish within the basin has not been assessed to ascertain whether a native strain still exists within the Rio Grande watershed.

- The existing environmental conditions or thresholds that limit populations of SGCN are unknown.

- Information is lacking on the extent to which invasive and non-native species may alter perennial large reservoirs and limit populations of SGCN.

Research, Survey, and Monitoring Needs

The New Mexico Department of Game and Fish have conducted regular surveys of reservoir fisheries within the Rio Grande Watershed since 2001. Data gathered include population composition, size distribution, and species diversity. Resultant baseline information may be used to assess smallmouth buffalo populations. In addition, NMDGF has completed a pilot study of trophic dynamics in Elephant Butte Reservoir that will allow managers to design methods to adequately evaluate trophic relationships in Rio Grande reservoirs. Routine monitoring of sport and commercial fishing take by NMDGF also allows managers to assess the effects of consumptive use on fishery resources. NMDGF, New Mexico Environment Department, and New Mexico Department of Health periodically test for contaminants within fish inhabiting large reservoirs. Additional research and survey work that would enhance our understanding of large reservoirs and SGCN is outlined below.

- NMDGF needs to further understand the relationships between non-native piscivores and SGCN within and around large reservoirs in the Rio Grande Watershed.

- Investigate the extent to which invasive and non-native species alter perennial reservoir habitats and limit populations of SGCN.

- Investigate SGCN movements into and out of reservoirs and relationships between the reservoirs and the surrounding watershed.

- Targeted work on the status of smallmouth buffalo has not been conducted since the early 1970s and our knowledge and data need to be updated.

- A general status review of the SGCN within the Rio Grande Watershed is needed.

- Investigate water withdrawal schedules in large reservoirs to provide a better understanding of how reservoir levels potentially affect spawning fish and nursery habitats. This information will help in designing sustainable watershed conservation and management practices.

Desired Future Outcomes

Desired future outcomes that would maximize the contribution of large perennial reservoirs to SGCN conservation include:

- Perennial large reservoirs of the Rio Grande Watershed persist in the condition, connectivity, and quantity necessary to maintain viable and resilient populations of resident SGCN while sustaining diverse land uses with reduced resource use conflicts.

- Water operations are conducted so as not to pose significant threats to the persistence of these SGCN communities.

- Sport and commercial harvest are managed in a manner that is consistent with best management practices.

- Adverse effects of non-native fishes emigrating from reservoirs into surrounding habitats are minimized.

- SGCN within this habitat are not adversely affected by the spread of aquatic nuisance species or other non-endemic species.

Prioritized Conservation Actions

The conservation of New Mexico's biodiversity in perennial large reservoirs will require a variety of conservation actions focused on both native and non-native species and habitat requirements of SGCN. Monitoring of species and habitat will be employed to evaluate the effectiveness of the conservation actions described below. Those found to be ineffective will be modified in accordance with the principles of adaptive management. Conservation actions, in order of priority, which assist in achieving desired future outcomes, are outlined below.

1. Work with water management agencies such as the US Bureau of Reclamation and US Army Corps of Engineers to continue to balance irrigation demands with the needs of fish communities within large reservoirs.

2. Assist efforts by conservancy districts and US Bureau of Reclamation to promote water conservation activities such as lining irrigation supply and return ditches.

3. Work with public and private land managers to develop strategies for preventing the movement of non-natives into surrounding areas and to educate anglers on the importance of not introducing fish into these habitats.

4. Collaborate with federal and state agencies and affected publics to create an understanding of the functions, services, and values of large reservoirs. Emphasize opportunities to educate anglers of the risk posed by undesirable non-native fishes to both sport and native fishes.

5. Work with federal and state agencies, private landowners, research institutions, and universities to design and implement projects that will provide information about SGCN and the perennial large reservoirs outlined in the Research, Survey, and Monitoring Needs section.

Perennial Marsh/Cienega/Spring/Seep

Habitat Condition

Historically, over-bank flooding provided the majority of marsh/cienega habitat along the Rio Grande. Now greatly reduced through channelization and other water control activities, the most extensive marsh/cienega habitat occurs at the Low Flow Conveyance Channel (LFCC) in Sierra and Socorro counties where breaches in the dykes have flooded significant amounts of the bosque and created backwaters, oxbow lakes, and marshes. Smaller portions of this habitat type occur in the bosques at Albuquerque, Escondida, and Truth or Consequences.

Perennial spring-fed habitats (marshes, cienegas, seeps) occur sporadically throughout the Rio Grande Watershed as isolated wetlands that discharge surface water to localized aquatic systems. These localized systems eventually recharge shallow aquifers within the basin and contribute surface flows to perennial tributaries of the Rio Grande.

Problems Affecting Habitats or Species

Dewatering
Dewatering, channelization, and land conversion have greatly reduced these habitats through the middle Rio Grande Valley. Water tables have been lowered and areas that were formerly perennial cienegas and marshes have become ephemeral or no longer exist. This has caused a decline in a number of species including western painted turtles (*Chrysemys picta bellii*), leopard frogs (*Rana* spp.), and New Mexico garter snakes (*Thamnophis sirtalis dorsalis*). Plans to reconstruct the LFCC will significantly reduce flooding in that area and existing marsh habitat will be further reduced.

Habitat Conversion
Habitat conversion processes that most adversely affect SGCN of perennial marshes/cienegas/springs/seeps include alterations that drain, fill, channelize or impound wetlands. Capping spring sources may likewise permanently alter natural wetlands. Habitat desiccation resulted in the near extinction of the Socorro isopod (*Thermosphaeroma thermophilum*) in 1998 and

vandalism has further damaged this species' habitat (Lang *et al.* In Review). Proposed development of mineral resources within the Alamosa Creek drainage above the Monticello Box has the potential to adversely affect aquatic habitats for the Alamosa springsnail, ovate vertigo land snail (*Vertigo ovata*), and Chiricahua leopard frog (*R. chiricahuensis*).

Information Gaps

Information gaps that impair our ability to make informed conservation decisions for perennial marshes/cienegas/springs/seeps in the Rio Grande Watershed are outlined below.

- Comprehensive data are incomplete on the distribution and abundance of fish, invertebrates, and amphibians and the location and condition of marsh/cienega/spring/seep habitats in the Rio Grande Watershed.

- Extensive work has been conducted within the Middle Rio Grande Valley regarding riparian habitats and wetlands. Beyond this, from Angostura to San Marcial Diversion, information is lacking.

- Information is incomplete regarding the effects of chemical and physical removal of saltcedar (*Tamarix spp.*) on biological communities, particularly invertebrates and amphibians.

- Little is known about the extent to which habitat conversion alters or poses a threat to perennial marsh/cienega/spring/seep habitats in the Rio Grande Watershed.

Research, Survey, and Monitoring Needs

Federal agencies including the US Fish and Wildlife Service, US Army Corps of Engineers, US Bureau of Reclamation, and their contractors are conducting significant studies and restoration efforts directed towards the Rio Grande silvery minnow (*Hybognathus amarus*). Environmental impact statements have been and are being developed for Rio Grande water operation planning, reconstruction of the LFCC, bosque rehabilitation projects, and various irrigation related projects. Additional research and surveys that would enhance our understanding of perennial marsh/cienega/spring/seep habitats and SGCN of the Rio Grande Watershed are outlined below.

- Continued monitoring of perennial marsh/cienega/spring/seep habitats and their associated biotic communities is needed to intelligently assess potential threats to SGCN and their habitats.

- Increased mapping and population assessment activities should be conducted in disjunct spring/seep habitats within the watershed.

- Little is currently known of the SGCN that rely upon perennial marsh/cienega/ spring/seep habitats. Research is needed on their distribution, biology, population stability, and microhabitat use.

- A comprehensive survey is needed of aquatic macroinvertebrates of perennial marsh/cienega/spring/seep habitats in the Rio Grande Watershed.

- Investigations are needed on the extent to which land use activities fragment and alter perennial marsh/cienega/spring/seep habitats. This information is important in understanding how different land use intensities and frequencies of disturbances affect associated SGCN.

Desired Future Outcomes

Desired future outcomes for perennial marsh/cienega/spring/seep habitats in the Rio Grande Watershed include:

- Perennial marsh/cienega/spring/seep habitats persist in the condition, connectivity, and quantity necessary to sustain viable and resilient populations of resident SGCN and host a variety of land uses with reduced resource use conflicts.

- Perennial marsh/cienega/spring/seep communities are stable.

- There is no net loss of this habitat type in the watershed and, where possible, additional habitat is created.

- Dewatering and channelization no longer adversely affect the persistence of SGCN dependent on perennial marsh/cienega/spring/seep habitats.

- The spread of aquatic nuisance species or other non-native species is controlled or minimized to a level that SGCN within this habitat are not adversely affected.

Prioritized Conservation Actions

Approaches for conserving New Mexico's biological diversity at the species or site-specific level are inadequate for long-term conservation of SGCN. Conservation strategies should be ecosystem-based and include public input and support (Galeano-Popp 1996). Monitoring of species and habitat will be employed to evaluate the effectiveness of the conservation actions described below. Those found to be ineffective will be modified in accordance with the principles of adaptive management. Conservation actions, in order of priority, which assist in achieving desired future outcomes, are outlined below.

1. Work with landowners within the watershed to protect marsh/cienega habitats along the Rio Grande. This work should include the review and contribution to National Environmental Policy Act (NEPA) documentation for repairs/reconstruction of the LFCC as well as continued participation in Rio Grande operations multi-agency planning efforts.

2. Continue to actively pursue the cooperation of private landowners in the protection and recovery of the Chupadera springsnail.

3. Coordinate and cooperate with federal and state agencies and affected publics to implement the draft aquatic nuisance species management plan for the state, which includes perennial marsh/cienega/spring/seep habitats in the Rio Grande Watershed.

4. Collaborate with federal and state agencies and affected publics to adopt standardized monitoring and survey methods to track gains and losses of perennial marsh/cienega/spring/seep habitats in the Rio Grande Watershed.

5. Collaborate with federal and state agencies, private landowners, research institutions, and universities to monitor perennial marsh/cienega/spring/seep communities to assess and eliminate potential adverse effects posed by introduced species.

6. Promote saltcedar management activities that do not adversely affect endemic communities and provide demonstrable positive effects on aquatic habitats.

7. Work with federal and state agencies, private landowners, research institutions, and universities to design and implement projects that will provide information about SGCN and the perennial marsh/cienega/spring/seep outlined in the Information Gaps or Research, Survey, and Monitoring Needs section.

Perennial 1st and 2nd Order Stream

Habitat Condition

The headwaters of the tributaries draining into the Rio Grande Watershed arise in the Sangre de Cristo, San Juan, Jemez, and Zuni mountains. Typically these waters are small 1st and 2nd order streams flowing through montane vegetation. Most of these streams are degrading with bedrock, cobble, and/or gravel substrate. Typically, these streams are the least impacted by human activity. There is some channelization and dewatering within these systems, but not to the degree noted lower in the watershed. Lower elevation 1st and 2nd order streams in the Rio Grande Watershed are generally ephemeral, unless directly associated with a spring.

Problems Affecting Habitat or Species

Sedimentation
Sedimentation resulting from improper grazing or logging and associated infrastructure presents the most serious potential adverse effect to the substrate of these small 1st and 2nd order streams.

Non-Native Species
Native species such as the Rio Grande cutthroat trout (*Oncorhynchus clarki virginalis*), Rio Grande sucker, and Rio Grande chub may also be adversely affected by the presence of non-native salmonids through hybridization, competition, or predation. The eastern most distribution of the Chiricahua leopard frog is in these streams. Populations of frogs are known to be declining as a result of the chytrid fungus (*Batrachochytrium dendrobatidis*).

Diseases and Pathogens
The presence of whirling disease in rainbow trout was confirmed in New Mexico the spring of 1999. Since this confirmation, portions of the San Juan, Rio Grande, Canadian, and Pecos Watersheds in New Mexico have tested positive for *Myxobolus cerebralis* (whirling disease causal agent) (Hansen 2002). Routine testing and remediation procedures have begun in New Mexico's hatcheries and a testing program has been initiated in coldwater streams and reservoirs. These waters may have been contaminated through inadvertent stocking of infected rainbow trout or by natural or anthropogenic vectors. Very little is known regarding whether the disease exists in Rio Grande cutthroat trout. However, it is likely that if *M. cerebralis* were to spread to Core Conservation Areas for Rio Grande cutthroat trout, the species would be at risk of infection.

Information Gaps

Information gaps that impair our ability to make informed conservation decisions for 1st and 2nd order stream habitats in the Rio Grande Watershed are outlined below.

- It is unknown how long-term fragmentation of the watershed has affected the viability and genetic diversity of Rio Grande cutthroat trout.
- The potential and risk for whirling disease to spread among salmonids of 1st and 2nd order stream habitats is uncertain until investigations into the extent of *M. cerebralis* distribution within the watershed has been completed.
- Population information is incomplete for non-game species such as the Rio Grande sucker in perennial 1st and 2nd order stream habitats.
- There is little information available about invertebrates in perennial 1st and 2nd order stream habitats of the Rio Grande Watershed.
- We lack information about SGCN life history and habitat use in perennial 1st and 2nd order stream habitats. This information is needed for sound comprehensive habitat management.
- Little is known about the intensity, scale, and extent of different land use activities that degrade 1st and 2nd order stream habitats and their effects on populations of SGCN.

Research, Survey, and Monitoring Needs

NMDGF has developed and implemented a long-range management plan for Rio Grande cutthroat trout. Efforts are currently focused on assessing population status and genetic composition, increasing the current range of the species, and securing current populations from introgression. NMDGF also conducts periodic surveys of 1st and 2nd order streams to assess sport fish populations and gather data on native species including Rio Grande chub and Rio Grande sucker. Additional research and surveys that would enhance our ability to make informed conservation decisions are outlined below.

- Research and survey work is needed to obtain comprehensive population data for Rio Grande sucker and Rio Grande chub in 1st and 2nd order streams of the watershed.

- There is a need to complete the ongoing investigation into the distribution of *M. cerebralis* to determine the risk of whirling disease to Rio Grande cutthroat trout by this parasite.

- Genetic inventory studies of Rio Grande cutthroat trout are needed to evaluate the effects of population fragmentation as well as potential threats of introgression in perennial 1st and 2nd order streams.

- A recovery plan is nearing completion for the Chiricahua leopard frog. Recovery efforts that need research or survey work include further cataloging of the distribution of the species, identifying methods for minimizing impacts from non-native fish species, and determining how to reduce the spread of chytrid fungus within the range of the species.

- An assessment is needed of the current stocking of non-native fish species and means to minimize potential conflicts with SGCN.

- Field studies are recommended that focus on habitat use patterns of all SGCN that are perennial 1st and 2nd order stream obligates.

- Research, surveys, and monitoring are needed for SGCN, especially invertebrate species. Little is currently known of the extent of their distribution, their biology, or stability of their populations and microhabitats in 1st and 2nd order streams of the watershed.

- Research is needed to characterize population dynamics and species interactions in perennial 1st and 2nd order stream habitats.

Desired Future Outcomes

Desired future outcomes for perennial 1st and 2nd order stream habitats in the Rio Grande Watershed include:

- Perennial 1st and 2nd order stream habitats in the watershed persist in the condition, connectivity, and quantity necessary to sustain viable and resilient populations of resident SGCN, facilitate uninterrupted movement patterns of native aquatic and terrestrial SGCN, and host a variety of land uses with reduced resource use conflicts.

- Threats are eliminated to Rio Grande cutthroat trout due to competition, disease, and or introgression with non-native salmonids.

- Threats are eliminated to the Chiricahua leopard frog due to chytrid fungus and competition or predation by non-native species.

- The stability of SGCN, such as the Rio Grande sucker and Rio Grande chub, is assured and sub-populations have connectivity that allows some degree of gene flow and long-term physical security.

- Non-native species that threaten the persistence of SGCN in perennial 1st and 2nd order stream habitats have been removed or populations reduced to minimize effects to SGCN.

Prioritized Conservation Actions

Approaches for conserving New Mexico's biological diversity at the species or site-specific level are inadequate for long-term conservation of SGCN. Conservation strategies should be ecosystem-based and include public input and support (Galeano-Popp 1996). Monitoring of species and habitat will be employed to evaluate the effectiveness of the conservation actions described below. Those found to be ineffective will be modified in accordance with the principles of adaptive management. Conservation actions, in order of priority, which assist in achieving desired future outcomes, are outlined below.

1. Collaborate with federal and state agencies, private landowners, research institutions, and universities to complete an inventory of the distribution of the whirling disease parasite (*M. cerebralis*) within the watershed.

2. Include non-game species in NMDGF fish survey analysis to improve baseline information regarding distribution and status of SGCN within the watershed.

3. Work with federal and state agencies, tribes, NGOs, and affected publics to increase connectivity of Rio Grande cutthroat trout populations within this habitat type by incorporating a "metapopulation" strategy into restoration efforts. The metapopulation theory assumes that an environment consists of discrete patches of suitable habitat surrounded by unsuitable habitat, interconnected through patterns of gene flow, extinction, and re-colonization (Lande and Barrowclough 1987, Hanski 1999). Increasing connectivity for trout should also benefit other SGCN within this habitat type, as well as maintaining their populations through these efforts is a focus of restoration activities, such as saving founder populations during stream treatments.

4. Work with land managers to develop methods that reduce the adverse effects of non-native aquatic species on native SGCN in the watershed.

5. Work with US Fish and Wildlife Service and other federal agencies to implement the *Chiricahua Leopard Frog Recovery Plan* and develop and implement strategies to reduce the spread of chytrid fungus.

6. Work with federal and state agencies, private landowners, research institutions, and universities to design and implement projects that will provide information about SGCN and perennial 1st and 2nd order stream habitats outlined in the Information Gaps or Research, Survey, and Monitoring Needs section.

Perennial 3rd and 4th Order Stream

Habitat Condition

The Rio Chama, Rio San Jose/Rio Puerco, and Jemez River systems are the major 3rd and 4th order stream habitats in the Rio Grande Watershed. Historically these channels were degrading with complex morphology greatly influenced by seasonal hydrology and sediment motion. As the streams increased in size, meanders, over-bank flooding, and braiding provided habitat for numerous native species. Substrates typically consist of cobble, gravel, and sand with decreasing particle size associated with decreased stream gradient near the confluence with the main stem of the Rio Grande. Human influence is greater upon these streams than it is for the higher elevation 1st and 2nd order streams and irrigation diversion and excessive sedimentation have affected all of these river systems. Formerly complex habitats have been simplified and Rio Grande silvery minnow and western painted turtle no longer occupy the Chama and Jemez Rivers.

Problems Affecting Habitat or Species

Modification of Natural Processes
Sedimentation has had significant effects on perennial 3rd and 4th order stream habitats in the Rio Grande Watershed. Erosion from surrounding land use and changes in sediment transport in rivers due to damming have altered channel morphology. Diversion and damming of rivers have affected temperature and flow regimes and fragmented fish populations due to physical barriers and reduced availability of suitable habitat.

Diseases and Pathogens
Portions of the San Juan, Rio Grande, Canadian, and Pecos Watersheds in New Mexico have tested positive for *Myxobolus cerebralis* (whirling disease causal agent) (Hansen 2002). Routine testing and remediation procedures have begun in New Mexico's hatcheries and a testing program has been initiated coldwater streams and reservoirs that may have been inadvertently stocked with rainbow trout carrying the disease or infested through transmission by natural or anthropogenic vectors. Very little is known regarding whether the disease exists in Rio Grande cutthroat trout. However, it is likely that if *M. cerebralis* were to spread to Core Conservation Areas for Rio Grande cutthroat trout, the species would be at risk of infection.

Information Gaps

Information gaps that impair our ability to make informed conservation decisions for 3rd and 4th order stream habitats in the Rio Grande Watershed are outlined below.

- Perennial 3rd and 4th order streams formerly provided connectivity to Rio Grande cutthroat trout populations. It is unknown how long-term fragmentation of the watershed has affected the viability and genetic diversity of Rio Grande cutthroat trout and other native species.

- The potential and risk for whirling disease to spread among salmonids of 3rd and 4th order stream habitats is uncertain until investigations into the extent of *M. cerebralis* distribution within the watershed has been completed.

- Population information is incomplete for non-game species such as the Rio Grande sucker.

- SGCN life history and habitat use information needed for comprehensive habitat management.

- Little is known about the intensity, scale, and extent of different land use activities that degrade habitats and their effects on populations of SGCN.

Research, Survey, and Monitoring Needs

NMDGF has developed and implemented a long-range management plan for Rio Grande cutthroat trout. Efforts are currently focused on assessing the status and genetic composition of populations, increasing the current range of the species, and securing current populations from introgression. NMDGF conducts periodic surveys of perennial 3rd and 4th order streams to assess sport fish populations and gather data on native species, including the Rio Grande chub and the Rio Grande sucker. Additional research, survey, and monitoring needs that would enhance our ability to make informed conservation decisions are outlined below.

- Research is needed to obtain comprehensive population data for Rio Grande sucker and Rio Grande chub in perennial 3rd and 4th order streams of the Rio Grande Watershed.

- There is a need to complete the ongoing investigation into the distribution of *M. cerebralis* to determine the risk of whirling disease to Rio Grande cutthroat trout by this parasite.

- Genetic inventory studies of Rio Grande cutthroat trout are needed to evaluate the effects of population fragmentation as well as potential threats of introgression in perennial 3rd and 4th order streams.

- Field studies are recommended that focus on habitat use patterns of all SGCN that are perennial 3rd and 4th order stream obligates.

- Research is needed to characterize population dynamics and species interactions in these perennial 3rd and 4th order stream habitats.

Desired Future Outcomes

Desired future outcomes for perennial 3rd and 4th order stream habitats in the Rio Grande Watershed include:

- Perennial 3rd and 4th order stream habitats in the Rio Grande Watershed persist in the condition, connectivity, and quantity necessary to sustain viable and resilient populations of resident SGCN, facilitate uninterrupted movement of native aquatic and terrestrial SGCN, and host a variety of land uses with reduced resource use conflicts.

- Potential adverse effects upon Rio Grande cutthroat trout due to competition, disease, and or introgression with non-native salmonids are eliminated.

- The stability of SGCN, such as the Rio Grande sucker and Rio Grande chub, are assured.

- The risk of habitat fragmentation and dewatering is eliminated or minimized by employing water operations that retains adequate water in perennial 3rd and 4th order stream habitats for SGCN.

- Land uses in and around stream habitats increase stream diversity.

Prioritized Conservation Actions

Approaches for conserving New Mexico's biological diversity at the species or site-specific level are inadequate for long-term conservation of SGCN. Conservation strategies should be ecosystem-based and include public input and support (Galeano-Popp 1996). Monitoring of species and habitat will be employed to evaluate the effectiveness of the conservation actions described below. Those found to be ineffective will be modified in accordance with the principles of adaptive management. Conservation actions, in order of priority, which assist in achieving desired future outcomes, are outlined below.

1. Collaborate with federal and state agencies, private landowners, research institutions, and universities to complete inventory of the distribution of the whirling disease parasite *M. cerebralis* within the Rio Grande watershed to mitigate threats to Rio Grande cutthroat trout.

2. Include non-game species in NMDGF fish survey analysis to improve baseline information regarding distribution and status of SGCN within the watershed.

3. Work with federal and state agencies, tribes, NGOs, and affected publics to increase connectivity of Rio Grande cutthroat trout populations within this habitat type by incorporating a "metapopulation" strategy into restoration efforts. The metapopulation theory assumes that an environment consists of discrete patches of suitable habitat surrounded by unsuitable habitat, interconnected through patterns of gene flow, extinction, and re-colonization (Lande and Barrowclough 1987, Hanski 1999). Increasing connectivity for trout should also benefit other SGCN within this habitat type,

as long as maintaining their populations through these efforts is a focus of restoration activities such as saving founder populations during stream treatments.

4. Collaborate with federal and state agencies, private landowners, research institutions, and universities to investigate habitat modification strategies and work with land managers and private landowners to implement modifications when appropriate.

5. Work with water management agencies to minimize impacts of water management in the watershed to avoid dewatered conditions.

6. Assist efforts to reduce sedimentation and promote water conservation activities such as lining irrigation supply and return ditches.

7. Encourage land uses that increase stream diversity within this habitat type.

8. Work with federal and state agencies, private landowners, research institutions, and universities to design and implement projects that will provide information about perennial 3rd and 4th order stream habitats and associated SGCN outlined in the Information Gaps or Research, Survey, and Monitoring Needs sections.

Perennial 5th Order Stream

Habitat Condition

The main stem of the Rio Grande is a 5th order stream as it enters New Mexico. It flows through a narrow, deeply incised canyon with a very narrow floodplain, approximately 50 ft (15 m), until it nears the confluence with the Rio Chama (Sublette *et al.* 1990). The Rio Chama also flows through a deeply incised canyon for much of its length. Piñon-juniper parkland is the dominant vegetation community found along these reaches.

Downstream of the confluence of the Rio Chama, the Rio Grande again enters a deeply incised canyon until it reaches a broad valley of low relief near Cochiti Lake. The remainder of its course flows with decreasing gradient until it reaches the New Mexico border near El Paso. Here the historic floodplain was wide and diverse. It included numerous meanders and oxbows (Crawford *et al.* 1993) and the reach was agrading. However dams on the river have altered this regime to degrading immediately below the dam and agrading elsewhere. Degrading streambeds of the Rio Grande are typically boulder, cobble, or gravel. Agrading portions typically have sandy substrate with increasing silt influence and decreasing stream gradient.

Before channelization, channel morphology was complex with meanders, oxbows, and braiding. The floodplain also experienced frequent over-bank flows generating off-river ponds and marshes. Vegetation around the Rio Grande varies from piñon/juniper parklands at the upper end through various Chihuahuan desert shrub communities in the southern portion of the state.

Problems Affecting Habitat or Species

Modification of Natural Processes
The Rio Grande has been greatly affected by anthropogenic activity as previously noted immediately above and within perennial large reservoirs. Diversion and dewatering may pose the greatest adverse affect to fish occupying this habitat, but other habitat stressors exist. Diversions and dams effectively fragment 5th order stream habitat by blocking the passage of fish. Agricultural return flows alter water chemistry and sediment load. Large dams alter water quality in tail waters. Channelization has reduced channel diversity and eliminated over-bank flow for significant stretches in the southern half of the system.

A number of species of conservation concern such as the bluntnose shiner, gray redhorse, blue sucker, and Rio Grande shiner have been extirpated from the watershed, primarily through habitat alteration. Non-native predators and disease likely caused the extirpation of the northern leopard frog. Big Bend sliders are now mostly confined to perennial reservoirs due to water diversion and alteration of the river channel.

Information Gaps

Information gaps that impair our ability to make informed conservation decisions for 5th order stream habitats in the Rio Grande Watershed are outlined below.

- Underlying causes of the decline of Rio Grande silvery minnow are not clearly understood, particularly as related to habitat changes within the drainage. Current management for the species has subsequently consisted of temporary and reactive measures.

- Long-term effects of habitat fragmentation on population viability and genetic diversity of native species within 5th order streams are not clearly understood.

- While reservoirs have been implicated as a source for non-native species expansion and persistence in New Mexico watersheds, the role of reservoirs as refugia for SGCN has not been thoroughly investigated.

- Effects of habitat modification on potential expansion of aquatic nuisance species have not been documented.

- Information is not complete regarding the effects of chemical and physical saltcedar removal on biological communities, particularly invertebrates and amphibians, along the middle Rio Grande.

Research, Survey, and Monitoring Needs

Federal agencies including the USFWS, US Army Corps of Engineers, and US Bureau of Reclamation (BOR), are conducting significant studies and restoration efforts for the Rio Grande silvery minnow. BOR has experimented with channel modification to improve minnow

recruitment. Environmental impact statements have been and are being developed for Rio Grande water operation planning, reconstruction of the LFCC, bosque rehabilitation projects, and various irrigation related projects. Additional research, survey, and monitoring needs that would enhance our ability to make informed conservation decisions are outlined below.

- Investigate the underlying causes of the decline of Rio Grande silvery minnow related to habitat changes within the drainage.

- Research is needed on the effects of habitat fragmentation on the population viability and genetic diversity of SGCN in 5th order stream habitats of the watershed.

- Explore the role of reservoirs as refugia for SGCN, and the biological connectivity of large reservoirs to 5th order stream habitats.

- Research is warranted on the effects of habitat fragmentation and modification in terms of reduced gene flow and the potential expansion of aquatic nuisance species.

- The effects of saltcedar removal on biological communities (particularly invertebrates and amphibians) along the Rio Grande through chemical and physical means needs to be investigated.

Desired Future Outcomes

Desired future outcomes for the Rio Grande include:

- The Rio Grande persists in the condition, connectivity, and quantity necessary to sustain viable and resilient populations of resident SGCN, facilitate uninterrupted movement patterns of native aquatic and terrestrial SGCN, and host a variety of land uses with reduced resource use conflicts.

- Threats to the Rio Grande silvery minnow are eliminated and the minnow is downlisted.

- Effects of habitat fragmentation are reduced and gene flow for SGCN is unrestricted through most of the Rio Grande.

- Riverine habitats increase in diversity and host stable native fish communities.

- Land and river management practices that threaten SGCN are minimized.

- Water operations are modified such that species formerly inhabiting the Rio Grande may be restored to the system.

- Non-native species that threaten native species in the Rio Grande have been removed or their populations reduced so as to minimize effects to native species.

Prioritized Conservation Actions

The Rio Grande extends from the north to the south across the entire state. It hosts a variety of economic, recreational, and environmental uses and concerns and supports a significant amount of New Mexico's biodiversity. Monitoring of species and habitat will be employed to evaluate the effectiveness of the conservation actions described below. Those found to be ineffective will be modified in accordance with the principles of adaptive management. Conservation actions, in order of priority, which assist in achieving desired future outcomes, are outlined below. Additional conservation actions related to the Rio Grande are located in the Riparian Habitat section.

1. Continue work on identifying recruitment limitations for the Rio Grande silvery minnow.

2. Assist agencies responsible for Rio Grande silvery minnow recovery whenever possible.

3. Work with federal and state agencies, private landowners, research institutions, and universities to investigate the role of irrigation supply and return ditches as refugia for SGCN and the biological connectivity of large reservoirs to 5th order stream habitats.

4. In cooperation with other agencies, develop and implement an aquatic nuisance species prevention/abatement program.

5. Collaborate with federal and state agencies and NGOs to monitor Rio Grande plant and animal communities to assess problems posed by introduced species, and to eliminate threats where possible. Promote saltcedar management activities that pose the least harm to endemic communities.

6. Collaborate with federal and state agencies, private landowners, research institutions, and universities to investigate habitat modification strategies and work with land managers and private landowners to implement them when appropriate.

7. Work with water management agencies to minimize impacts of water management in the Rio Grande Watershed and avoid dewatered conditions.

8. Assist efforts to reduce sedimentation and promote water conservation activities such as lining irrigation supply and return ditches.

9. Work with federal and state agencies, landowners, research institutions, and universities to design and implement projects that will provide information about SGCN and perennial 5th order stream habitats outlined in the Research, Survey, and Monitoring Needs sections.