ARIZONA-NEW MEXICO MOUNTAINS ECOREGION

The Arizona-New Mexico Mountains Ecoregion encompasses the highlands of eastern Arizona and central and western New Mexico covering 29 million ac (12 million ha) of land. Most (78%) of the ecoregion occurs in New Mexico. This diverse physiographic region has elevations ranging from 4,500 ft - 12,600 ft (1,371 m - 3,840 m) and contains a number of mountain ranges, steep foothills, plateaus, and desert plains.

The more prevalent terrestrial habitats include Madrean pine-oak, conifer-oak forests and woodlands, Rocky Mountain forests and woodlands, and Rocky Mountain montane mixed conifer, in the higher elevations. Piñon-juniper/juniper savanna, steppe and grasslands, Chihuahuan semi-desert grasslands, and Western Great Plains shortgrass prairie are found in the lower elevations. Riparian forests, usually populated with ponderosa pine (*Pinus ponderosa*) and white fir (*Abies concolor*), are also found throughout. Key habitats identified in this ecoregion include: Madrean Encinal, Madrean Pine-Oak/Conifer-Oak Forests and Woodlands, Rocky Mountain Montane Mixed-Conifer Forests and Woodlands, and Western Great Plains Shortgrass Prairie (Fig. 5-2).

The Arizona-New Mexico Mountains Ecoregion contains the headwaters of a number of important streams and rivers, including the Little Colorado, Gila, San Francisco, and the Mimbres Rivers. 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).

Species of Greatest Conservation Need

The Arizona-New Mexico Mountains Ecoregion has 80 Species of Greatest Conservation Need (SGCN), excluding arthropods other than crustaceans (Table 5-4). The majority (45 species) reside within the Madrean Pine-Oak / Conifer-Oak Forests and Woodlands. The Rocky Mountain Mixed-Conifer Forest and Woodland was also species rich with 37 SGCN. Approximately 37 species (46%) of the SGCN in the Arizona-New Mexico Mountains Ecoregion are considered vulnerable, imperiled, or critically imperiled both statewide and nationally. Twenty-one species (26%) are nationally secure, but are considered vulnerable, imperiled, or critically imperiled in New Mexico, and 22 species (28%) are secure both statewide and nationally. Conservation status codes (abundance estimates) for each SGCN are provided in Appendix H. Some associated SGCN, such as mule deer (*Odocoileus hemionus*) and mourning dove (*Zenaida macroura*), are common throughout the region while others, such as the Sacramento Mountain salamander (*Aneides hardii*) are uncommon and localized. Additional conservation concerns for taxa associated with this ecoregion are addressed in 1) Statewide Distributed Ephemeral Habitats and Perennial Tanks, 2) Statewide Distributed Riparian Habitats, or 3) Watersheds with aquatic key habitats sections.

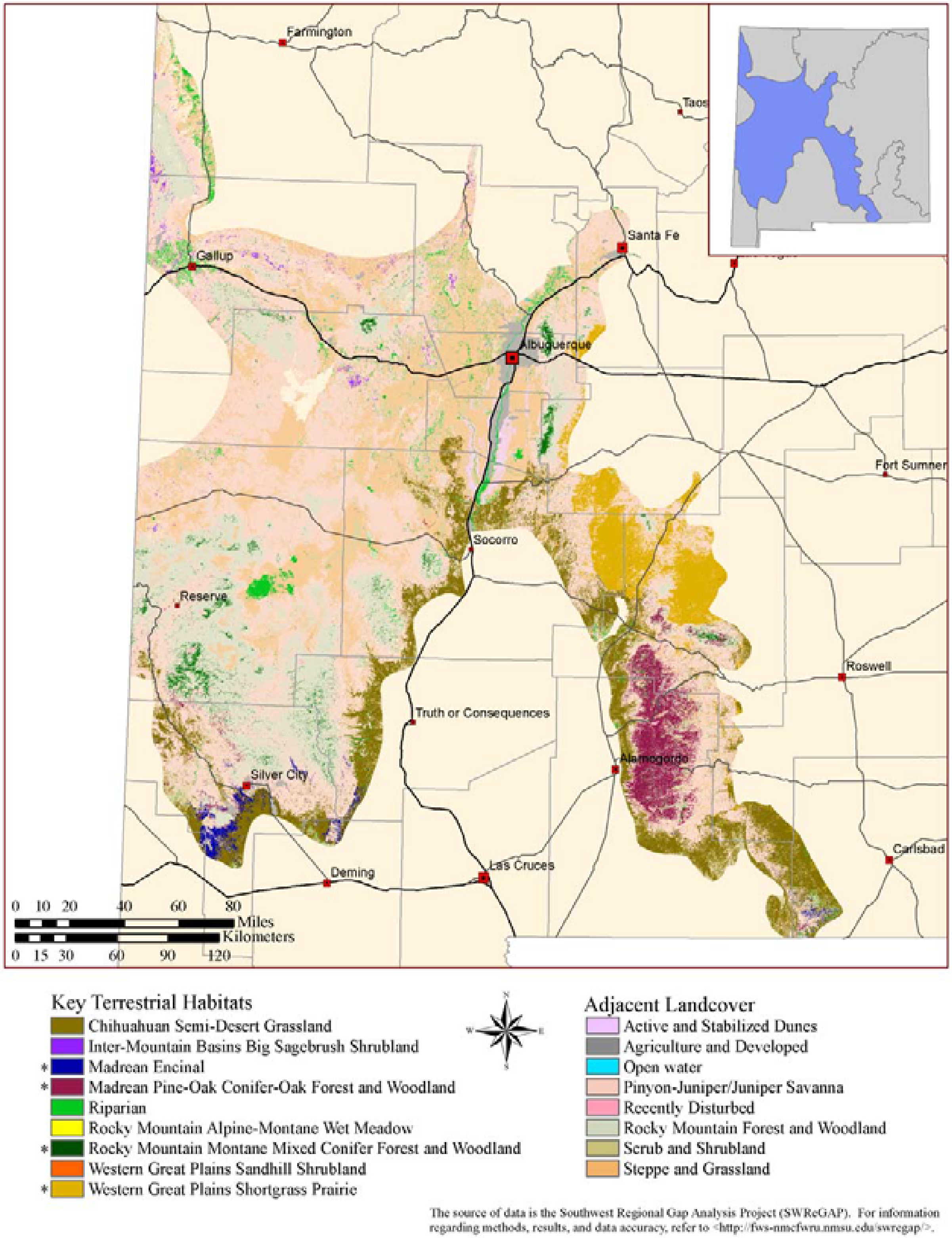

Figure 5-2. Key terrestrial habitats in the Arizona-New Mexico Mountains Ecoregion in New Mexico. Adjacent land cover types are given to provide an indication of vegetation surrounding key habitats. Key habitats are designated with an asterisk (*).

Table 5-4. Species of Greatest Conservation Need in the Arizona-New Mexico Mountains Ecoregion in New Mexico.

Common Name	Madrean Encinal	Madrean Pine-Oak / Conifer Oak	Rocky Mountain Mixed-Conifer Forest and Woodland	Western Great Plains Shortgrass Prairie
Birds				
Osprey			X	
Ferruginous Hawk	X			X
Northern Goshawk		X	X	
Golden Eagle		X	X	X
Bald Eagle			X	X
Peregrine Falcon		X	X	
Blue Grouse		X	X	
Montezuma Quail	X	X		
Scaled Quail		X		X
Sandhill Crane				X
Mountain Plover				X
Wilson's Phalarope				X
Band-Tailed Pigeon	X	X	X	
Mourning Dove	X	X		X
Mexican Spotted Owl		X	X	
Elf Owl	X	X		
Burrowing Owl				X
Black Swift			X	
Williamson's Sapsucker		X	X	
Greater Pewee	X	X		
Olive-Sided Flycatcher		X	X	
Loggerhead Shrike	X	X		X
Gray Vireo	X	X		
Pinyon Jay		X	X	
Juniper Titmouse	X	X		
Red-Faced Warbler		X		
Lucy's Warbler		X		
Yellow Warbler		X	X	
Black-Throated Gray Warbler	X	X		
Red-Faced Warbler			X	
Grace's Warbler		X	X	
Painted Redstart	X	X		
Baird's Sparrow				X
Grasshopper Sparrow				X
Yellow-Eyed Junco	X	X		
Mammals				
New Mexico Shrew			X	
Spotted Bat			X	
Arizona Myotis Bat				X
Allen's Big-eared Bat	X	X	X	
Black-Tailed Prairie Dog				X
Yellow-Nosed Cotton Rat	X	X		

Table 5-4 Cont.

Common Name	Madrean Encinal	Madrean Pine-Oak / Conifer Oak	Rocky Mountain Mixed-Conifer Forest and Woodland	Western Great Plains Shortgrass Prairie
Mammals Cont.				
Penasco Least Chipmunk		X		
Abert's Squirrel			X	
American Beaver			X	
Arizona Montane Vole			X	
Mexican Gray Wolf	X	X	X	
Black Bear	X	X	X	
White-Nosed Coati		X		
Jaguar		X		
Mule Deer	X	X	X	X
Coues' White-Tailed Deer	X	X		
Amphibians				
Chiricahua Leopard Frog	X	X		
Plains Leopard Frog	X			X
Tiger Salamander	X	X	X	X
Sacramento Mountains Salamander			X	
Reptiles				
Sonoran Mud Turtle	X	X		
Ornate Box Turtle				X
Madrean Alligator Lizard	X	X		
Collared Lizard	X	X		X
Sonoran Mountain Kingsnake	X	X		
Milk Snake	X			X
Western Diamondback Rattlesnake	X			X
Banded Rock Rattlesnake	X	X		
Mexican Garter Snake	X			
Desert Massasauga				X
Molluscs				
Cockerell Holospira Snail	X			
Jemez Mountains Woodlandsnail			X	
Dry Creek Woodlandsnail		X		
Cook's Peak Woodlandsnail		X		
Iron Creek Woodlandsnail	X	X	X	
Silver Creek Woodlandsnail		X	X	
Rocky Mountainsnail			X	
Mineral Creek Mountainsnail			X	
Black Range Mountainsnail			X	
Black Range Mountainsnail			X	
Socorro Mountainsnail	X		X	
Amber Glass Snail			X	
Marsh Slug Snail			X	
Three-Toothed Column Snail	X	X		
Spruce Snail			X	

Madrean Encinal and Madrean Pine-Oak Conifer-Oak Forests and Woodlands

The Madrean Encinal and the Madrean pine-oak, conifer-oak forest and woodland habitat types in the Arizona-New Mexico Mountains Ecoregion have similar problems, information gaps, research, survey, and monitoring needs, desired future outcomes, and conservation actions. Therefore, we present information on these two habitat types collectively and call them "Madrean Forests and Woodlands."

Habitat Condition

Madrean Encinal oak woodlands in the Arizona-New Mexico Mountains Ecoregion generally occur at elevations between 4,000 ft - 4,986 ft (1,520 m - 1,220 m). At the lower ecotone, where conditions are drier, Madrean Encinal oak woodlands merge with oak savanna and eventually semi-desert grassland. At middle elevations, Madrean Encinal oak woodlands grade into Madrean pine-oak forests, and at the highest elevations into conifer-oak and pine forests (Ffolliott 2002).

Emory oak (*Quercus emoryi*) is the most common tree species in Madrean Encinal 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, 1997, McClaran and McPherson 1999). Interspersed within the Madrean Encinal are shrubs, grasses, forbs and succulents.

Within Madrean pine-oak, conifer-oak forests and woodlands, pines or other conifers generally form the overstory while oaks generally form the understory. There are extensive areas of pine-oak woodland in the Arizona-New Mexico Mountains Ecoregion of the Southwest. Pine-oak woodland is included within the concept of Madrean evergreen woodland. The pine forest is called Madrean Montane Conifer Forest (Brown 1982). Within this habitat type, the abundance of oaks may be a consequence of over harvesting of pines (Felger and Johnson 1995). At higher elevations within the pine-oak forests and woodlands, pines become more dominant as their density increases so that the vegetation could be called forest rather than woodland. This pine-oak forest is dominated by one species of pine, usually Arizona pine (*Pinus ponderosa* var. *arizonica*), ponderosa pine (*P. ponderosa* var. *scopulorum*), or white pine (*P. strobiformis*). Scattered individuals or small groups of oaks, primarily Gambel oak (*Q. gambelii*), and net-leaf oak (*Q. rugosa*), occur with these pine stands. Gambel oak is the only winter-deciduous oak in this area. In the northernmost of these isolated mountain ranges, Arizona pine is replaced by ponderosa pine at higher elevations (Felger and Johnson 1995).

Precipitation in the Madrean forests and woodlands ranges from 12 - 40 in (305 - 1,015 mm) per year. Generally half of this precipitation occurs between May and August. The frequency of freezing temperatures increases northward within the Madrean forests and woodlands that limits plant species diversity (Gottfried *et al.* 1995). Bi-modal emergence of perennial and annual plants occurs in early spring following winter rains and during the summer monsoons (McPherson 1994, 1997).

The distribution, structure and health of Madrean forests and woodlands in the Arizona-New Mexico Mountains Ecoregion have been affected by human activities for millennia. The Madrean forests and woodlands were important to prehistoric people (Propper 1992), who gathered wood for fires and construction materials, acorns for food and ceremonial purposes, and piñon nuts and juniper berries for winter food (Gottfried *et al.* 1995). Settlers, miners, and ranchers used woodlands in the late 1800s and early 1900s for timber and smelter fuel (Bahre and Hutchinson 1985). Madrean forests and woodlands were heavily grazed by livestock in the 1880s and continue to be grazed today, although at much lower stocking rates (Weltzin and McPherson 1995). However, Madrean forests and woodlands have not been subjected to large-scale range improvement practices (Ffolliott and Guertin 1987, McClaran *et al.* 1992).

Natural mortality of oak trees appears to be low, possibly due to the long established practice of harvesting older trees. All evergreen oak tree species in the Madrean forests and woodlands are susceptible to infection by fungi, especially *Inonotus andersonii*, a major cause of wood decay (Fairweather and Gilbertson 1992). Oak densities vary considerably, and range from a few scattered individuals to several hundred stems per hectare. Volumes of wood vary from less than 1 to more than 53 yd^3 per ac (2 to more than 100 m^3 per ha) (Ffolliott and Gottfried 1992). Annual growth rate is relatively slow, ranging from 0.13 to 0.26 yd^3 per ac (0.25 to 0.50 m^3 per ha), with an annual growth rate of less than 1% (Gottfried *et al.* 1995). Tree density is related to local site characteristics such as soils, fire disturbance and land use histories (Gottfried *et al.* 1995, Ffolliott 2002). Tree species composition and density varies with elevation, latitude, disturbance regime, slope, and aspect. Stand-level disturbances caused by fire, disease, vegetation control, and land-clearing activities have been relatively minor in Madrean forests and woodlands (Kruse *et al.* 1996). However, when they do occur, these disturbances are likely to affect stand structure and productivity (Ffolliott and Gottfried 1992, Gottfried *et al.* 1995, McClaran and McPherson 1999). Historically, fires affected species composition, stand density, and size-class distributions (Niering and Lowe 1984, Barton 1991, Kruse *et al.* 1996).

The Madrean forests and woodlands are an area of exceptionally high biological diversity and biogeographical interest (DeBano and Ffolliott 1995). These habitat types occur within a topographically and geologically complex region (Felger and Johnson 1995). The complex topography and steep elevation gradients within the Madrean forests and woodlands result in a rich assemblage of floral and faunal species. The complex geology and topography of the region creates unusual and striking assemblages of habitats and plant and animal associations. Floral and faunal species occur that are more commonly associated with the New World tropics than with the Southwestern Borderlands and plant and animal species co-mingle here that would otherwise be separated by large distances and climatic regimes (Felger and Wilson 1995).

Problems Affecting Habitats or Species

Analyses using the scientific literature and New Mexico Department of Game and Fish (NMDGF) staff suggest that climate change, fire management, fragmentation and loss of habitat from urban/residential/commercial industrial development, large-scale mining, roads, highways and utility corridors, and off-road vehicle use are the primary factors adversely affecting the conservation of SGCN of Madrean forests and woodlands in the Arizona-New Mexico Mountains Ecoregion.

Climate Change and Drought
Climate change may occur in the Southwest from increased atmospheric concentrations of CO_2 and other greenhouse gases. Effects may include increased surface temperatures, changes in the amount, seasonality, and distribution of precipitation, more frequent climatic extremes, and a greater variability in climate patterns. Such changes affect vegetation at the individual, population, or community level, precipitate changes in ecosystem function and structure (Weltzin and McPherson 1995), and will likely affect competitive interactions between plant and animal species currently co-existing under equilibrium conditions (Ehleringer *et al*. 1991) (See Statewide Assessments and Strategies, Chapter 4, for greater details).

Subsequent specific outcomes for Madrean forest and woodland habitats are unpredictable and remain uncertain (Weltzin and McPherson 1995). However, plants respond differently to changes in atmospheric gases, temperature and soil moisture, in part based on their C_3 or C_4 photosynthetic pathways (Bazzaz and Carlson 1984, Patterson and Flint 1990, Johnson *et al*. 1993). For example, increases in winter precipitation favor tree establishment and growth at the expense of grasses, while increases in temperature and summer precipitation favor grasslands expanding into woodlands (Bolin *et al*. 1986). Recent research has investigated shifts in the Madrean Encinal oak woodland/semi-desert grassland boundary (Hastings and Turner 1965, Bahre 1991, McPherson *et al.* 1993). Paleo-ecological data gathered from packrat middens suggest that Madrean Encinal oak woodland have moved higher in elevation as a result of warmer and drier climatic conditions since the Pleistocene. Bahre (1991) suggests that the distribution of Madrean Encinal oak woodland has been stable since the 1860s.

Drought, defined as an extended period of abnormally dry weather, is one of the principal factors limiting seedling establishment and forest productivity (Schulze *et al*. 1987, Osmond *et al*. 1987). Soil moisture is directly altered by drought conditions. The distribution and vigor of some oak woodlands and savannas is controlled primarily by soil moisture gradients (Griffin 1977, Pigott and Pigott 1993). Drought and climate change can have a substantial effect on the Madrean forest and woodland habitats. Further, these factors can alter fire frequency, intensity, and timing by changing the amount and accumulation of fine fuels (Clark 1990, Haworth and McPherson 1994). Unfortunately, due to the complexity of interactive relationships between global, regional and local biotic and abiotic factors, and political decisions at national and international levels, the effects of climate change on fire regimes in the Madrean forests and woodlands are difficult to predict (Weltsin and McPherson 1995).

Natural Disturbance Regimes
The primary natural disturbances (non-anthropogenic forces that alter habitats) in the Madrean woodland and forests are fire, wind, and insects. Changes in the frequency, intensity, and timing of natural fires have altered the distribution of current vegetation. Madrean woodland and forest density was relatively low prior to European settlement (Moody *et al*. 1992, Covington and Moore 1994). In these less dense woodlands, most fires were low intensity ground fires that tended to reduce understory vegetation (Gottfried *et al*. 1995). The elimination of episodic fires after 1893 may be attributed to excessive livestock grazing and fire suppression (Grissino-Mayer *et al*. 1995, Weltzin and McPherson 1995). Historic (late 1800s) improper grazing practices in Madrean woodlands and forests eliminated the herbaceous fine fuels layer. The reduction of these fine fuels prevented the spread of low-intensity, ground-hugging fires, and reduced grass

competition, thereby allowing tree establishment (Gottfried *et al*. 1995). Fire suppression has further eliminated the natural fire regime that historically kept stand densities relatively low. Fire suppression allowed the increase of ladder fuels and heavy fuel loading conditions. Catastrophic, stand-replacing crown fires have become more common because of these changes (Covington and Moore 1994).

Grazing Practices

Livestock grazing has economic and cultural values that are important to individuals, communities and the State. Impacts to rangeland wildlife by livestock grazing are largely dependent on the grazing management practices used. Domestic and wildlife grazing practices that reduce the ability of the land to sustain long term plant and animal production (Wilson and MacLeod 1991) have influenced plant communities and fish and wildlife habitat in New Mexico for more than a century. Peer-reviewed scientific literature implies that livestock grazing has impacted terrestrial and riparian/aquatic habitats in New Mexico (Armour *et al*. 1994, Fleischner 1994, The Wildlife Society 1996, Belsky and Blumenthal 1997). Improper grazing by livestock can reduce vegetative cover, increase soil erosion, and aggravate local flooding (Felger and Wilson 1995).

Many of these impacts began as early as the late 1800s when large herds of livestock were present. Impacts of improper grazing practices have included: 1) competition with wildlife for water, forage, and space; 2) degradation of forage and cover by altering vegetation composition and structure; 3) impacts on stream hydrology, siltation, and water quality; and 4) reduced soil permeability and potential to support plants due to soil compaction. Improper grazing can diminish wildlife habitat in Madrean woodland and forest. In contrast, prescribed grazing is a management tool that can be used to benefit wildlife (Holechek *et al*. 1982, Kirby *et al*. 1992, Holecheck *et al.* 2004).

Animal Herbivory

Animal herbivory is the most common source of mortality for low-elevation oaks of southern Arizona (McPherson 1993, Peck and McPherson 1994). Herbivory by invertebrates is a potentially important source of seedling mortality that is commonly overlooked in field studies. Invertebrates have been found to defoliate oak seedlings primarily during the summer (Peck and McPherson 1994, Weltzin and McPherson 1995). Vertebrates kill Emery oak seedlings primarily during autumn and winter months (Weltzin and McPherson 1995). Differential population dynamics of herbivorous animal species, combined with temporal and spatial variability of herbivory (McPherson 1993, Peck and McPherson 1994, Weltzin and McPherson 1995) combine to determine the timing and intensity of herbivory-related mortality on young oaks (Weltzin and McPherson 1995).

Loss of Biological Diversity

Intact Madrean forest and woodland habitats once extended into the American tropics, but accelerating deforestation is fragmenting habitats and populations of plant and animal species (Felger and Johnson 1995). Trees within Madrean forest and woodland habitats are most often harvested for fuel and fence posts, but also for value-added wood products such as furniture and home construction (Ffolliott 1989, Ffolliott and Gottfried 1992, Maingi and Ffolliott 1992).

Natural regeneration of Madrean oak woodlands is low. Factors that may be responsible for low recruitment of oaks include herbivory by livestock and wildlife, competition for water, light and minerals, and climatic and edaphic conditions. A combination of these and possibly other unknown factors likely interact to produce low rates of seedling re-establishment (Weltzin and McPherson 1995). However, demands for oak woodlands are expected to increase (Conner *et al*. 1990, Van Hooser *et al*. 1990, Ffolliott and Gottfried 1992, Gottfried *et al*. 1995).

Biological diversity in the Madrean forests and woodlands is rapidly eroding (DeBano and Ffolliott 1995). Cutting trees of the tallest height classes reduces the structural diversity of oak forest and woodland stands (Sharman and Ffolliott 1992). Taller trees provide more habitat niches for non-game birds than do shorter trees (Balda 1969). Thus, tree harvesting can reduce bird diversity by simplifying woodland structural diversity (Ffolliott 2002).

Non-Native Species
In 1998, non-native species were implicated in the decline of 42% of species listed under the federal Endangered Species Act (Center for Wildlife Law 1999). Once established, non-native species have the ability to displace native plant and animal communities, disrupt nutrient and fire cycles, and alter the character of the community by enhancing additional invasions (Cox 1999, Deloach *et al.* 2000, Zavaleta *et al.* 2001, Osborn *et al.* 2002). Exotic species colonization of the Madrean Archipelago region is increasing, with more than 60 non-native plants having successfully established themselves in the isolated mountain ranges of Arizona (Warshall 1995).

Habitat Alteration and Fragmentation
Human populations are increasing in the region and demands for fuel wood are accelerating. Privately owned forest and woodlands are being converted to residential areas, fragmenting wildlife habitats, increasing wildland/urban interface fire risks, and generally accelerating land management conflicts. Associated increasing demands for water in these communities are outpacing the ability of natural systems to provide new freshwater sources (Felger and Wilson 1995). Sustainability of Madrean woodland and forest habitats is questionable under increasing pressures from human activities and altered fire regimes (Gottfried *et al*. 1995).

Much of the Madrean forests and woodlands of southwestern New Mexico and southeastern Arizona is administered by the US Forest Service. They are charged with potentially conflicting mandates of “multiple use” that include: 1) conserving wildlife, habitats and ecosystem function; 2) generating revenue from timber sales; 3) maintaining livestock grazing leases; and 4) providing ever increasing opportunities for urban recreation (Felger and Wilson 1995). There is growing pressure to develop more Madrean forest and woodland habitats within national forests for camping, hiking, mountain biking, off-road vehicle use, and new or improved roads for access (Warshall 1995).

Groundwater Depletion
Groundwater levels in Southwest and regional wetlands have dropped significantly because of pumping for agricultural crop irrigation. One example in Madrean forests and woodlands is San Simon Cienega, which was once a functioning wetland, but has since been drying out due at least in part to groundwater pumping (Dinerstein *et al*. 2000).

Mining

Historic and current hard rock mining activities may adversely affect ecosystem function, resilience and sustainability within the Madrean forests and woodlands in the Arizona-New Mexico Mountains Ecoregion. Large underground bodies of primarily copper ore have led to extensive industrial mining complexes in the area. Associated ecosystem stressors include: 1) habitat fragmentation and loss; 2) acid drainage from chemical reactions with surface waste rock that create heavy metal contamination poisonous to wildlife (Drabkowski 1993, Starnes and Gasper 1996, Reece 1995, Hilliard 1994); 3) large permanent pit lakes that contain toxic water (a danger primarily to waterfowl) (Miller *et al.* 1996); 4) groundwater pollution; 5) air pollution and associated acid-rain fallout; 6) increased frequencies of road killed fauna; and 7) the potential for bioaccumulation of heavy metals in soils and vegetation at levels dangerous to wildlife.

Borderland Security Activities

Increasing security measures are being implemented throughout the United States/Mexico borderlands region to intercept illegal drug shipments, illegal immigrants, and other unauthorized activities (US Department of Justice, Immigration and Naturalization Service 2000). Increased road building and traffic along the borderlands causes habitat destruction, loss, and fragmentation, diminishes the utility of habitat for wildlife, increases road kill, poaching, and illegal collecting of wildlife (Forman *et al.* 2003).

Recreation and Tourism

Recreation and tourism activities in the Madrean forests and woodlands generate income for the region. Hunting for species such as deer, quail and collared peccary (*Tayassu tajacu*) has long been a dominant recreational use (McClaran and McPherson 1999). Non-consumptive recreational uses in Madrean forests and woodlands include hiking, camping, sightseeing, bird watching, and picnicking (Conner *et al.* 1990). Although comprehensive statistics are lacking that document the level of these recreational uses, it is clear that recreational uses of Madrean forests and woodlands are increasing and their impact on habitats and species should be considered in conservation planning (Conner *et al.* 1990, McClaran *et al.* 1992).

Information Gaps

Information gaps that impair our ability to make informed conservation decisions are outlined below.

- The location, timing, duration, frequency and intensity of all of the problems identified that potentially affects Madrean forest and woodland habitats and/or SGCN.

- The impacts of the ongoing activities of the Joint Task Force Six activities on the borderlands of New Mexico. These activities include maneuvers and encampments that can destroy habitat, spread invasive weed species, increase road kill, and alter sensitive wildlife behavior.

- The impacts on Madrean forest and woodland SGCN and habitats from increased daytime and nighttime traffic associated with Border Patrol surveillance and monitoring activities and illegal immigration is unknown.

Research, Survey, and Monitoring Needs

The processes that have impacted the Madrean forests and woodlands in the past and the anticipated levels of future development serve as a backdrop for defining current research, survey, and monitoring needs. Research, survey, and monitoring needs that would enhance our understanding of these habitats are outlined below.

- Enhance our understanding of habitat connectivity by acquiring population-level information of dispersal behavior, daily and seasonal movements of SGCN through Madrean woodland and forest habitats, how different types of habitat fragmentation (such as timber removal, and housing developments) affect these movements, and how climate change may ultimately affect species distributions.

- Determine the extent, age class, structural characteristics, and regeneration rates of the Madrean woodlands and forests so as to provide predictive power and applicability to ecosystem-based management.

- Determine the minimum viable habitat size and forest age-class structure necessary to support SGCN that migrate vertically among the bands of Madrean habitats within the isolated mountain ranges of the Madrean Archipelago.

- Determine how global and regional climate change will affect vegetation patterns and community and ecosystem-level dynamics in Madrean pine-oak, conifer-oak forests and woodlands.

- Conduct research to enhance our knowledge of the natural history, population biology, and community ecology of SGCN within Madrean woodland and forest habitats.

- Conduct research to increase our knowledge of SGCN distribution, abundance, and population trends within the Madrean woodland and forest habitats of the Arizona-New Mexico Mountains Ecoregion.

- Evaluate the effectiveness of prescribed fire in reducing the potential for catastrophic stand-replacing fires in the Madrean woodlands and forests.

- Determine how SGCN of Madrean woodland and forests respond to prescribed livestock grazing, fuel wood harvesting, increased recreational use, exotic species invasions and increased human population.

- Assess the impacts of prescribed livestock grazing on the structure of Madrean woodlands and forests.

- Determine how the timing, intensity, and duration of prescribed livestock grazing affect SGCN.

- Determine how prescribed grazing affects natural disturbance regimes such as wildland fire in Madrean woodland and forest habitats.

- Identify wildlife travel corridors connecting the Madrean woodland and forest habitats in isolated mountain ranges so they may be protected and managed to maintain connectivity. Information needed for understanding habitat connectivity includes population-level information on dispersal behavior, daily and seasonal movements of SGCN through Madrean habitats, how different types of habitat fragmentation (such as timber removal, housing developments, etc.) affect these movements, and how climate change may ultimately affect species distributions.

- Determine the effects of natural and prescribed fire on the structure of vegetative communities in the Madrean woodlands and forests and the subsequent effects upon vertebrate and invertebrate populations. Evaluate the effectiveness of prescribed fire as a tool to reduce the potential for catastrophic fire (DeBano and Ffolliott 1995).

- Determine if coppicing (post-cutting sprouting from roots and stumps) is an effective supplement to the episodic regeneration of oaks from seed. Is coppicing sufficient to maintain habitat composition, structure, and biological diversity?

- There is a need for additional investigations of hydrologic relationships in the Madrean woodlands and forests that will provide a better understanding of interception, transpiration, and infiltration processes (Lopes and Ffolliott 1992, Haworth and McPherson 1994, Baker *et al*. 1995, Ffolliott and Gottfried 1999). This information is crucial for determining effective and sustainable conservation and management practices at the watershed level (Ffolliott *et al*. 1993).

- There is a need to develop collaborative survey and monitoring protocols for invertebrate SGCN that are not currently being monitored.

Desired Future Outcomes

Desired future outcomes for Madrean forests and woodlands include:

- Madrean forest and woodland habitats exist 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 conflicts.

- Partnerships have been established among state and federal government agencies, NGOs and private landowners for the implementation of collaborative and coordinated initiatives to conserve SGCN and the functionality of the Madrean forest and woodland habitats upon which they depend.

- Special habitats within the Madrean forests and woodlands, such as cienegas, limestone outcrops, talus slopes, caves, and perennial streams, are protected and monitored long-term for condition as necessary to ensure conservation for SGCN that rely on these habitats.

- A scientific basis for ecosystem management in the Madrean forest and woodland habitats has been established and implemented. Systems management of the ecosystem, rather than functional management of individual species or other natural resources such as timber, is policy and is validated through region-wide forest plans.

- Wide public support is garnered for long-term conservation strategies to restore native species and SGCN to viable populations within Madrean forest and woodland habitats.

- Sustainable harvest prescriptions are developed that allow adequate levels of harvest for fuel wood and other wood products. Major harvest activities replicate natural disturbance patterns.

- Stand-replacing wildfires have become less common in the Madrean forest and woodland habitats and no longer alter existing habitats beyond the range of natural variation under which SGCN evolved.

- Colonization of exotic species is stopped. Existing populations of exotic species are controlled or eliminated.

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. Create public awareness and understanding of ecosystem function, values, and products and the scope and scale of human impacts important to SGCN.

2. Collaborate with governmental agencies, land conservation NGOs and private landowners to identify and conserve riparian and other important wildlife habitat corridors linking Madrean Archipelago isolated mountain ranges by implementing conservation easements and/or land purchases for wildlife conservation.

3. Encourage government and private land managers to conserve and restore Madrean watersheds through management practices that reduce erosion, gully formation and soil loss, and maintain native biodiversity.

4. Maintain awareness of the introduction and spread of exotic plants and animals and encourage control or eradication where necessary to maintain or restore native biodiversity.

5. Collaborate with government agencies and private landowners to develop measures, such as closure of unnecessary roads within and adjacent to Madrean forest and woodland habitats, so that habitat fragmentation might be reduced.

6. Encourage the US Forest Service to conserve biological diversity through development and implementation of an ecosystem management approach.

7. Encourage thinning and fuel-reducing initiatives to open dense stands of trees that have become susceptible to insects, diseases, or stand-replacing wildfires that may alter conditions to which SGCN are adapted.

8. Work with the US Forest Service in conducting prescribed burning in Madrean forest and woodland habitats to protect breeding birds, avoid riparian areas, and otherwise conserve SGCN.

9. Work with government and private landowners to develop strategies for the sustainable harvest of wood products that will maintain oak regeneration and protect native biodiversity.

10. Pursue enactment of laws or policies that protect closed basins within Madrean forest and woodland habitats from the impacts of dredge and fill activities and future development.

11. Encourage the land management agencies to schedule prescribed burns that avoid desert bighorn sheep (*Ovis canadensis mexicana*) lambing areas from mid-December through mid-February.

12. Work with land management agencies, private land managers, and the agriculture industry to identify and promote grazing systems on rangelands that ensure long-term ecological sustainability and integrity and are cost effective for livestock interests. Such practices may include collaborative development of grazing management plans, altering domestic and wildlife stocking rates, time and use, and distribution where forage availability is inadequate, and promoting "grass banking" opportunities that allow degraded rangelands to recover.

Rocky Mountain Montane Mixed-Conifer Forests and Woodlands

Habitat Condition

Rocky Mountain Montane Mixed-Conifer Forests and Woodlands form an indiscrete vegetation band dominated by Douglas fir (*Pseudotsuga menziesii*) that blends with true firs and spruces in the sub-alpine coniferous forest between elevations from 8,000 - 10,000 ft (2,438 - 3,048 m). The montane mixed-conifer forests and woodlands blends into ponderosa pine (*Pinus* *ponderosa*) forests at lower elevations. However, within the montane mixed-conifer forest, Douglas fir seldom grows in pure stands, but mixes with blue spruce (*Picea pungens*) and white fir (*Abies concolor*). Blue spruce is often associated with frost pockets and is found along stream sides and on lower slopes where cold air drains. Following disturbances, Gambel oak (*Quercus gambelii*) and aspen (*Populus tremuloides*) are often prominent. Dick-Peddie (1993) described the Rocky Mountain montane mixed-conifer forest as being among the most widespread and productive vegetative types in New Mexico. Ample precipitation maintains well-watered soils for most of the long growing season.

Fire and logging are the primary disturbances within the mixed-conifer woodlands. Natural fires historically occurred about every 10 years up until the late 1800s when fire suppression policies were implemented (USGS 1998). Dick-Peddie (1993) speculated that erratic fire behavior created a patchy mosaic of stands in various successional stages. These fires might flare up into crown fires in some areas and miss other areas completely. Aspen are often present at sites where high intensity fires have occurred. The elimination of fire in southwestern mixed-conifer forests has caused a major change in species composition and structure in the past century (Samson *et al.* 1994).

In the Southwest, lower elevation mixed-conifer forests with more open stand structures had ponderosa pine as a co-dominant species. However, dense sapling understories of the more fire-sensitive Douglas fir and white fir species developed in the mixed-conifer forest as a result of fire suppression and subsequent tree regeneration. Forest stand inventory data from Arizona and New Mexico show an 81% increase in the areal extent of mixed-conifer forests between 1962 and 1986. This is explained by the trend toward more fire-sensitive tree species (US Forest Service 1993). Fire suppression has also contributed to reduced aspen stands and the habitat they provide for a variety of wildlife species. Logging in Rocky Mountain Montane Mixed-Conifer Forest and Woodland habitats has created extensive road networks, furthered habitat fragmentation, and replaced fire as a determinant of stand succession.

Improper grazing practices (grazing practices that reduce long-term plant and animal productivity) in Rocky Mountain Montane Mixed-Conifer Forest and Woodland habitats have created competition with wildlife for water, forage, and space. These practices have altered vegetation composition and structure, increased siltation, affected stream hydrology and water quality, and reduced soil permeability and the potential to support plants due to soil compaction. Further, both excessive domestic livestock and native ungulate browsing may damage aspen suckers and weaken aspen clones, in turn making trees more susceptible to invasion from disease and insects.

Problems Affecting Habitats or Species

Review of the scientific literature indicates that associated effects of climate change, drought, changes to natural fire regimes, and insect attack are the factors most adversely affecting mixed-conifer habitats in the Arizona-New Mexico Mountains Ecoregion. High biological productivity within montane mixed-conifer forests explains why extractive resource use, such as logging and grazing have been an important economic consideration. Sustained or increased intensities of these activities may reduce biodiversity and productivity (Dick-Peddie 1993).

The synergistic effects of factors that influence habitats make it difficult, or perhaps impossible, to separate out individual factors that influence habitats or the SGCN. Multiple factors are closely linked in cause and effect relationships. Adverse consequences from multiple ecosystem stressors can have cumulative effects that are more significant than additive effects. One or more stressors may predispose biotic organisms to additional stressors (Paine *et al.* 1998). A greater discussion of the synergistic effects is provided in Chapter 4.

Climatic Change and Drought

The effects of climatic change on the Rocky Mountain Montane Mixed-Conifer Forests and Woodlands are difficult to predict, largely due to the complexity of interactive relationships between global, regional and local biotic and abiotic factors (Weltsin and McPherson 1995). However, the effects of climatic change on habitat types in New Mexico are significant and are presented in detail in Chapter 4.

Drought, defined as an extended period of abnormally dry weather, is considered to be one of the most significant factors affecting Rocky Mountain Montane Mixed-Conifer Forests and Woodlands because it alters landscape and atmospheric conditions in favor of habitat conversion processes. Drought can limit seedling establishment and forest productivity by altering soil moisture gradients (Osmond *et al*. 1987, Schulze *et al*. 1987). Further, drought alters fire frequency, intensity, and timing in forest habitats by changing the amount and accumulation of fine fuels (Clark 1990, Haworth and McPherson 1994).

Fire Suppression

The disruption of natural fire cycles caused by fire suppression can significantly alter Rocky Mountain Montane Mixed-Conifer Forest and Woodland habitats in New Mexico (see Chapter 4). Mac *et al.* (1998) estimated the mean fire occurrence interval in the montane mixed-conifer forest at about every 10 years up until the late 1800s when fire suppression policies were implemented. Prior to that time, historic wild-land fires within ponderosa pine and lower Rocky Mountain Montane Mixed-Conifer Forests and Woodlands were frequent and naturally occurring. They were low-intensity ground fires that helped maintain stands of older trees with open, park-like structure (Moir and Dieterich 1988). Within higher elevation mixed conifer and spruce-fir forests, wildfires were less frequent and generally of the higher intensity, stand-replacing type.

Insects and Disease

Native insects and diseases are an integral part of forest ecosystems. They help recycle forests by decomposing trees and releasing nutrients necessary for forest growth. However, insect and disease outbreaks can seriously impede conifer regeneration and affect resources valued by humans for aesthetic, recreational, water, and wildlife considerations (see Chapter 4).

Many different species of bark beetles affect southwestern mixed-conifer forests. Most bark beetle species are relatively host-specific, limiting their activities to primarily one tree species. Some of the more important species that attack ponderosa pine trees in New Mexico include the mountain pine beetle (*Dendroctomus ponderosae*), western pine beetle (*D. brevicomis*), roundheaded pine beetle (*D. adjunctus*), and pine engraver (*Ips pini*). The Douglas fir beetle (*D. pseudotsugae*), and the fir engraver (*Scolytus ventralis*) prefer white fir, while the spruce beetle

(*Dendroctomus rufipennis*) attacks Engelmann spruce (*Picea englemannii*) (Wilson and Tkaz 1994). The direct effects of bark beetle infestation on trees include mortality and top-killing (Stark 1982). The US Forest Service, in 2003, mapped conifer mortality attributed to bark beetles on about 2,700,000 ac (1,092,653 ha) in Region 3 alone (US Forest Service 2004).

White fir and Douglas fir are also the preferred host species for western spruce budworm (*Choristoneura occidentalis*). When fire is suppressed, the density of these tree species increases and they become more susceptible to intense and synchronous outbreaks of spruce budworm. Between the 1920 and 1993, there were five major outbreaks of western spruce budworm in New Mexico. The most recent outbreak covered approximately 700,000 ac (283,280 ha) at its peak (Fellin *et al.* 1990).

Aspen is subject to fungus including white tree rot (*Phellinus* spp.), sooty-bark cankers (*Encoelia pruinosa*), and several root rots. Sooty-bark canker is the most lethal canker on aspen in the West and tends to occur on the larger trees at all sites (Johnson *et al.* 1995). A study conducted in Colorado and New Mexico indicated that trunk cankers, developed from logging injuries, were the major cause of aspen death (Johnson *et al.* 1995). Approximately 20% of residual trees in partially cut stands died five years after the stand was harvested. Two years later, 40% of the remaining residual trees were infected with various cankers, indicating that tree mortality would increase. Insect attacks can come from aspen tortrix (*Choristoneura conflictana*) and western tent caterpillar (*Malacosoma californicum*).

On a positive note, several SGCN of the Rocky Mountain Montane Mixed-Conifer Forests and Woodlands are likely to benefit from the occurrence of native insects and diseases, or their effects on the habitat. These include Williamson's sapsucker (*Sphyrapicus thyroideus*), olive-sided flycatcher (*Contopus cooperi*), yellow warbler (*Dendroica petechia*), red-faced warbler (*Cardellina rubrifrons*), Grace's warblers (*Dendroica graciae*), Mexican spotted owl (*Strix occidentalis lucida*), Jemez Mountains salamander (*Plethodon neomexicanus*), black bear (*Ursus americanus amblyceps*), and Allen's big-eared bat (*Idionycteris phyllotis*).

Extractive Resource Uses
The high productivity of the montane mixed-conifer forest creates a place where extractive resource use, such as grazing and logging, is relatively common. Further, this habitat type is open for increased oil and gas exploration. Sustained uses for these activities may reduce biodiversity and productivity.

Livestock grazing has economic and cultural values that are important to individuals, communities, and to the state. Improper grazing practices are considered those practices that reduce long-term plant and animal productivity (Wilson and MacLeod 1991), and include domestic livestock and wildlife. Improper grazing practices have influenced vegetation communities and fish and wildlife habitat in New Mexico for more than a century (See Chapter 4 for greater details). Improper grazing has reduced vegetative cover, increased soil erosion, and aggravated local flooding (Felger and Wilson 1995). Impacts of improper grazing practices in Rocky Mountain Montane Mixed-Conifer Forests and Woodlands include: 1) competition with wildlife for water, forage, and space; 2) degradation of forage and cover by the altering of vegetative composition and structure; 3) alteration of stream hydrology and water quality; 4) increased siltation; 5) and reduced soil permeability and the potential to support plants due to soil compaction. Further, both excessive domestic livestock and native ungulate browsing may damage aspen suckers and weaken aspen clones, in turn making trees more susceptible to invasion from disease and insects.

Logging has been one of the primary disturbance factors in Rocky Mountain Montane Mixed-Conifer Forests and Woodlands in the Southwest. Conifer forests and woodlands in New Mexico now generally occur in early and middle successional stages. Stand succession that would have occurred due to fires has been replaced through logging. However, the patchy mosaic that erratic fire behavior creates is usually not successfully duplicated through logging. The natural processes associated with fire are not fully understood and it is not clear what effects may result from replacing fire with logging (Dick-Peddie 1993). Logging has created extensive road networks furthering habitat fragmentation in the Rocky Mountain Montane Mixed-Conifer Forests and Woodlands and other New Mexico forests.

Fuel wood collection in and of itself is not recognized as a factor significantly affecting the mixed-conifer habitat type. However, woodcutters sometimes remove standing snags and downed logs that are important for wildlife habitat and ecosystem function. Roads developed for fuel wood collection fragment habitat and may function as artificial firebreaks. The Carson National Forest had approximately 3,587 mi (5,772 km) of open road and the Santa Fe National Forest had approximately 3,750 mi (6,035 km) of existing road in the late 1980s.

Currently, the amount of oil and gas exploration that occurs within Rocky Mountain Montane Mixed-Conifer Forests and Woodlands within the Arizona-New Mexico Mountains Ecoregion is very limited. Oil and gas exploration is not considered a substantial factor affecting SGCN at this time.

Recreational Use
Recreational uses of the mixed-conifer habitat type include skiing, hiking, mountain biking, horseback riding, snowmobiling, off-road vehicles, rock climbing, and camping. The overall effect of these activities is not fully understood, nor is there full comprehension of how much recreational use can be tolerated before wildlife or wildlife habitats are adversely effected. Commercial ski areas are usually located within this habitat type, and their presence clearly results in habitat conversion.

Non-Native Species
As of 1998, non-native or invasive species have been implicated in the decline of 42% of species listed under the federal Endangered Species Act (Center for Wildlife Law 1999). Once established, non-native species have the ability to displace native plant and animal species, disrupt nutrient and fire cycles, and alter the character of the community by enhancing additional invasions (Cox 1999, Deloach *et al.* 2000, Zavaleta *et al.* 2001, Osborn *et al.* 2002). The occurrence or rate of spread of non-native or invasive species within Rocky Mountain Montane Mixed-Conifer Forests and Woodlands is unknown. The State Forest and Watershed Health Plan devotes significant planning to the management of non-native invasive phreatophytes (New Mexico Energy, Minerals, and Natural Resources Department 2004).

Information Gaps

Information gaps are outlined below that impair our ability to make informed conservation decisions regarding mixed-conifer forest and woodland habitats and SGCN.

- Abundance, distribution and trend information is absent or sparse for many SGCN. There is no central clearinghouse for biological information and no one agency has ready access to all available information. In addition, the requirements for area-sensitive species have not been clearly defined.

- The location, timing, duration, frequency and intensity of most factors influencing Rocky Mountain Montane Conifer Forests and Woodlands and associated SGCN are poorly understood. For example, information is needed on the effects that location, timing, intensity, and duration of prescribed burns and fuel reduction/logging activities have on SGCN, such as the Sacramento Mountain salamander. Further, there is a long history of grazing by domestic livestock and native ungulates in this habitat type. Perceived effects include subsequent soil erosion and altered fire cycles. However, there is little understanding of the mechanisms by which these effects occur.

- It is not clear how the Healthy Forest Initiative and Healthy Forest Restoration Act will affect SGCN such as northern goshawks (*Accipiter gentilis*), and Mexican spotted owls, which rely on old-growth mixed-conifer forests.

- While many aspects of fire are understood, the role that natural fire, particularly the differing intensities of fire, has played within the entire ecosystem is not well understood. Site-specific fire histories and methods are unknown regarding natural fire regimes.

- The intensity, scale, extent, and causes of forest fragmentation have not been determined in the Rocky Mountain Montane Mixed-Conifer Forests and Woodlands and the effects of forest fragmentation on associated SGCN are unknown.

- Community structure and many life history attributes of SGCN are unknown.

- Environmental conditions that limit populations of SGCN are unknown.

- The intensity, scale, extent, and causes of man-caused habitat fragmentation are unknown.

- Information of area-sensitive species requirements is needed, including the location of key migration corridors, degree of habitat fragmentation, and spatial locations of fragmented areas.

- The extents to which invasive species alter disturbance regimes and population viability are unknown within Rocky Mountain Montane Mixed-Conifer Forests and Woodlands.

- There is little known about aspen succession (Dick-Peddie 1993). In aspen stands that have predominantly changed to conifers, information is lacking about how many aspen should remain in order to provide adequate regeneration after a fire removes the conifers. The occurrence of aspen succession resulting in montane and sub-alpine grasslands is not well understood.

Research, Survey, and Monitoring Needs

Research and survey topics are outlined below that would enhance our understanding of Rocky Mountain Montane Mixed-Conifer Forest and Woodland habitats and SGCN.

- Abundance, distribution and trend information needs to be determined for many SGCN and area-sensitive species.

- Research is needed to assess the attributes of habitats that are required so that viable populations of SGCN may persist.

- Basic research is needed on SGCN vertebrate and invertebrate community structures, natural history, and ecological relationships.

- Determine how SGCN respond to prescribed livestock grazing, fuel wood harvesting, increased recreational use, exotic species invasions and increased human population growth (DeBano and Ffolliott 1995).

- Determine the necessary habitat size and forest age-class structure needed to support SGCN that migrate vertically during daily and seasonal movements to fulfill their ecological needs for food, shelter, water and space.

- Environmental conditions that limit populations of SGCN need to be determined.

- Much work is needed to understand the relationships between climate change, drought, fire and fire suppression activities, phytophagous insect attacks, and habitat fragmentation resulting from roads and increased human developments.

- Determine how global and regional climate change will affect vegetation and community and ecosystem-level dynamics.

- Rocky Mountain Montane Mixed-Conifer Forests and Woodlands are disturbance forests with predominantly seral communities (Dick-Peddie 1993). To adequately restore fire as a management tool, there must be a clear understanding of historic fire regimes from regional to site-specific scales.

- There is a continuing need to increase our understanding of the effects of post-fire treatments within the context of ecological and societal goals for forested public lands of the West (Beschta *et al.* 2004).

- Research is needed to evaluate the effectiveness of prescribed burns in reducing the potential for catastrophic stand-replacing fires.

- Determine the effects of natural and prescribed burns on the structure of vegetative communities and the subsequent effects upon vertebrate and invertebrate populations.

- Research is needed regarding the ecological effects of logging as compared with fire. The natural processes associated with fire are not fully understood and it is not clear what effects may result from replacing fire with logging (Dick-Peddie 1993).

- Research is needed to explore the best methods of mimicking natural disturbance regimes within the historic natural range of variability. Ecological forestry assumes that native species evolved under natural conditions. Management within this natural range of variability should ensure that native species persist (Seymour and Hunter 1999).

- Research is needed to determine how SGCN respond short-term and long-term to phytophagous insect outbreaks and the potential habitat fragmentation caused by these attacks at the community, species, population and individual levels.

- Studies are needed to identify wildlife travel corridors that connect the Rocky Mountain Montane Mixed-Conifer Forests and Woodlands to different mountain ranges of the Arizona-New Mexico Mountains Ecoregion. Information needed for understanding and managing for habitat connectivity includes: 1) population-level information of dispersal behavior, seasonal movements of SGCN; 2) how different types of habitat fragmentation affect movements; and 3) how climate change may ultimately affect species distributions.

- Research is needed to determine the intensity, scale, extent, and causes of forest fragmentation and how SGCN respond to habitat fragmentation at the community, species, population and individual levels.

- The species-specific effects of natural and human-caused habitat fragmentation on SGCN need to be determined.

- Research is needed to assess the impacts of prescribed livestock grazing on the structure of Rocky Mountain Montane Mixed-Conifer Forests and Woodland habitats.

- Research is needed to determine how the timing, intensity, and duration of prescribed grazing affect SGCN life history.

- Determine how grazing ultimately affects natural disturbance regimes (McPherson 1992).

- Determine the areal extent, age class, structural characteristics, and regeneration rates to provide predictive power and inform an ecosystem management approach.

- The extent to which invasive species may alter disturbance regimes and population viability needs to be determined.

- There is a need for additional investigations of hydrologic relationships that will provide better understanding of infiltration, interception, and transpiration processes, and how disturbances such as drought and fire affect these processes. This information is necessary for determining effective and sustainable conservation and management practices (Ffolliott *et al*. 1993).

Desired Future Outcomes

Desired future outcomes for the Rocky Mountain Montane Mixed-Conifer Forests and Woodlands include:

- Rocky Mountain Montane Mixed-Conifer Forest and Woodland habitats persist in the condition, connectivity, and quantity necessary to sustain viable and resilient populations of SGCN and host a variety of land uses with reduced resource use conflicts.

- Partnerships have been established among government agencies, NGOs and private landowners for the implementation of collaborative and coordinated initiatives to conserve SGCN and the functionality of the habitats upon which they depend.

- Long-term conservation strategies that restore native species to viable populations garner wide public support.

- Stand-replacing wildfires have become less common and no longer alter existing habitats beyond the range of natural variability under which SGCN evolved.

- Post-fire management activities that are detrimental to SGCN and/or ecosystem function and recovery are no longer practiced.

- Prescriptions have been developed for the Rocky Mountain Montane Mixed-Conifer Forests and Woodlands that allow adequate and sustainable levels of human harvest of fuel wood and other wood products, are compatible with the tenets of ecological forestry, and replicate natural disturbance patterns.

- Decisions to implement control measures for phytophagous insect outbreaks are informed and balanced by considerations of the role of these events in maintaining forest health and ecosystem function (Schowalter 1994).

- Consistent standards that ensure future habitat integrity and functionality for the wildland urban interface are jointly established and adopted by private landowners, counties, municipalities, federal and state land management agencies.

- Local zoning regulations are in place to help reduce wildfire threats to private residences at the wildland urban interface in Rocky Mountain Montane Mixed-Conifer Forests and Woodlands and funds that are currently directed toward these threats have been redirected to re-establishing naturally functioning ecosystems in forest interiors.

- Major migration/movement corridors are intact and maintaining connectivity and availability of SGCN habitats.

- Oil and gas extraction activities have not compromised the condition, connectivity, and quantity of Rocky Mountain Montane Mixed-Conifer Forests and Woodlands on the Valle Vidal. The capacity of this property to sustain viable and resilient populations of SGCN has not been diminished.

- Livestock and large ungulate grazing are maintained at levels that sustain the full range of ecosystem functions and persistence of SGCN.

- Aspen stands are maintained at a sufficient level to sustain obligate SGCN and associated plant and wildlife species.

- Special habitats such as cienegas, limestone outcrops, talus slopes, caves, and perennial streams are protected and are being monitored long-term for condition to ensure conservation for SGCN that rely on these habitats.

- Scientific ecosystem management has been established and implemented and is evidenced in forest management plans.

- Colonization by exotic species is stopped and existing populations of exotic species are controlled or eliminated.

- Activities implemented under the Healthy Forest Initiative and Healthy Forest Restoration Act are focused on removing ladder fuels and smaller diameter trees and protecting human structures and neighborhoods in the wildland urban interface. These activities avoid the unnecessary removal of large, old-growth trees and snags important as wildlife habitat.

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 land management agencies and private landowners to develop a fire management regime that promotes restoration of vegetative communities more nearly approximating those that historically supported SGCN. Approaches might include encouraging the US Forest Service to supplement lightning-caused fires with prescribed burning.

2. Collaborate with state and federal agencies, the New Mexico State Legislature, NGOs, and private landowners to conserve riparian and other important wildlife habitat corridors linking Rocky Mountain Montane Mixed-Conifer Forests and Woodlands between other habitats and ecoregions. Approaches might include conservation easements and/or fee-simple purchases from willing sellers.

3. Collaborate with state and federal agencies and private landowners to reduce habitat fragmentation. Approaches might include the closure of unnecessary interior and adjacent roads and minimizing new road building on associated national forests.

4. Work with the US Forest Service to promote compliance with the principles of ecological forestry for any land management activities conducted within Rocky Mountain Montane Mixed-Conifer Forests and Woodlands.

5. Work with federal and state agencies, private landowners, research institutions, and universities to design and implement projects that will provide the information about SGCN and the Rocky Mountain Montane Mixed-Conifer Forests and Woodlands outlined in the Research, Survey, and Monitoring Needs section above.

6. Work with the US Forest Service and effected publics to develop strategies for the sustainable harvest of wood products that will retain old-growth trees and large diameter snags needed by SGCN and the communities that support them.

7. Encourage thinning and fuel-reducing initiatives, where necessary, to open dense stands that have become susceptible to insects, diseases, or stand-replacing wildfires that may alter conditions to which SGCN are adapted.

8. Work with the US Forest Service to ensure that fuel reduction treatments are focused upon removing smaller diameter ladder fuels and thickets to protect human structures and neighborhoods in the wildland urban interface. These interventions should avoid removal of large old-growth trees and snags important as wildlife habitat.

9. Encourage government and private land managers to conserve and restore the watersheds, wetlands, and wet meadows of the Rocky Mountain Montane Mixed-Conifer Forests and Woodlands through management practices that maintain native biodiversity and reduce erosion, gully formation, and soil loss.

10. Work with the US Forest Service and effected livestock and hunting interests to ensure that livestock and large ungulate grazing occur at levels compatible with sustaining viable populations of SGCN.

11. Monitor the introduction and spread of exotic plants and animals into Rocky Mountain Montane Mixed-Conifer Forests and Woodlands and encourage control or eradication where necessary to maintain or restore native biodiversity.

12. Work with the US Forest Service in conducting prescribed burning in Rocky Mountain Montane Mixed-Conifer Forest and Woodlands to protect breeding birds, avoid riparian areas, and otherwise conserve SGCN.

13. Work with land management agencies, private land managers, and the agriculture industry to identify and promote grazing systems on rangelands that ensure long-term ecological sustainability and integrity and are cost effective for livestock interests.

14. Work with the US Forest Service to ensure that livestock and large wild ungulate grazing levels are managed to avoid disruption of natural disturbance regimes.

15. Collaborate with US Forest Service to designate areas for off-road vehicle use that avoid disturbance to SGCN or their habitats and to discover ways to mitigate such disturbance where it presently occurs.

16. Work in partnership with private landowners, counties, municipalities, federal and state land management agencies to mitigate and reduce impacts related to urbanization of Rocky Mountain Montane Mixed-Conifer Forest and Woodland habitats. Approaches might include establishment of development standards that ensure continued habitat integrity and functionality.

17. Work with counties and municipalities to create local zoning regulations that help reduce wildfire threats to private residences in areas of wildland urban interface and to direct financial resources to re-establishing naturally functioning ecosystems in forest interiors.

18. Work with the US Forest Service and oil and gas companies to minimize oil and gas development and associated effects in the Rocky Mountain Montane Mixed-Conifer Forests and Woodland.

19. Encourage the US Forest Service to conserve the biological diversity of the Rocky Mountain Montane Mixed-Conifer Forests and Woodlands through development and implementation of an ecosystem management approach.

20. Work with the US Forest Service to employ prescribed burns and let-burn policies that will promote return of aspen groves to their historic distribution and abundance within the Rocky Mountain Montane Mixed-Conifer Forests and Woodlands.

21. Collaborate with state and federal agencies to minimize installation of developed recreation sites in aspen stands to reduce exposure of aspens to injury and fungal infections.

22. Develop projects and partnerships to assess SGCN distribution, abundance, population trends, basic life history attributes, population biology, community ecology, and responses to anthropogenic and natural habitat disturbances.

23. Partner with US Forest Service, NGOs, and private landowners to identify, protect, and monitor special SGCN habitats such as cienegas, limestone outcrops, talus slopes, caves, and perennial streams.

24. Create public awareness and understanding of ecosystem function, values, and products and the scope and scale of human impacts on the condition of Rocky Mountain Montane Mixed-Conifer Forests and Woodland important to SGCN.

25. Collaborate with land management agencies, conservation organizations, and educational groups to teach the public about the potential adverse effects of continued climate change on SGCN and their habitats.

26. Work with the US Forest Service and NM State Forestry Division to teach the public about of the ecology of phytophagous insects and their role in sustaining healthy ecosystem function.

27. Work with the US Forest Service, NM State Forestry Division, and private landowners to prevent the conduct of post-fire management activities that are detrimental to SGCN and/or ecosystem function.

Western Great Plains Shortgrass Prairie

Habitat Condition

The majority of literature associated with the Western Great Plains Shortgrass Prairie describes the entire land cover type and is not specific to New Mexico. Thus, the information presented in this section should be considered within this broad context.

The current state of the shortgrass prairie is a product of both evolution and historical land use. Prairies in North America evolved with frequent disturbances, including fire, drought, grazing, and storms (Kaufman *et al.* 1988). The combined effects of these factors created an extensive mosaic of environments that accommodated a rich diversity of plant and animal species (Collins and Barber 1985, Plumb and Dodd 1993).

Disturbances created by prairie mammals significantly affected the diversity of the prairie ecosystem. Several authors (Anderson 1982, Plumb and Dodd 1993, Rickets *et al.* 1999) suggest that the dominant, sod-forming perennial grassland plants of this region evolved under intensive grazing by wild ungulates. As a result, woody vegetation was suppressed and the evolution of grazing-tolerant plants was favored. The disturbances created by foraging bison (*Bison bison*), pronghorn (*Antilocapra americana*) and elk (*Cervus elaphus*) significantly affected vegetation, nutrient cycles, soil structure and composition and, as some areas were heavily grazed and others left untouched, created a mosaic of habitats across the prairie.

In this ecoregion, Callenbach (1996) reported that bison seasonally ranged as far west as the San Augustine Plains and the grasslands of northeastern Arizona in the late prehistoric period. Herds of bison within the Estancia Valley and the Galisteo Basin were either exterminated or driven eastward by pressure from Navajo, Apache, Pueblo and early Hispanic hunters (Bailey 1971, Hammond and Rey 1966, Weber 1988). It is estimated that prairie dogs occupied roughly 154,441 mi^2 (400,000 km^2), or 20% of the available shortgrass and midgrass prairies (Benedict 1996). Their presence also altered vegetation, created open habitat, and modified soil, nutrient, and energy cycles. Prairie dog burrows turned the soils, allowed annual forbs and grasses a foothold in the dominant perennial grassland, and sustained prairie biodiversity. Wild bison have since been extirpated and prairie dogs significantly reduced as the prairie ecosystem has been converted, fragmented and otherwise altered (Benedict 1996) by human activities.

Despite the shortgrass prairie's apparent evolutionary adaptation to grazing, historic grazing by domestic livestock has been an agent of change. Much of this effect occurred in the late 1880s when livestock numbers peaked and shortgrass prairies were grazed beyond their sustainable use. Barbour (1988) stated, "When the shortgrass prairie was first grazed by domestic livestock, the original grasses persisted probably because of their low stature and natural resistance to grazing pressure. As abuses occurred and the grasses declined, weedy perennial species such as cacti (*Opuntia* spp.), snakeweed (*Gutierrezia sarothrae*) and yucca (*Yucca* spp.) increased. Invading annual plants included brome (*Bromus* spp.), Russian thistle (*Salsola tragus*), barley (*Hordeum* spp.), and fescue grasses (*Festuca* spp.)." The frequency of natural fires diminished due to the resultant reduction in fuels and by increased fire suppression. The compounding effects fostered an invasion of shrubs and trees into historic shortgrass prairies (Brown 1982).

As for the current state of the shortgrass prairie, Dick-Peddie (1993) wrote, "The succession from plains-mesa grassland to juniper savanna will probably continue in many areas of the state. At the lower (drier) boundaries of plains-mesa grassland, many acres of grama grassland will become desert grassland, and much of the present desert grassland will become Chihuahuan or Great Basin desert shrubland. On many sites, these successional trends, which range users consider deterioration of grassland, were set in motion early in this century; subsequent range management efforts are unlikely to halt, let alone reverse the trend."

Agricultural cultivation has also affected the shortgrass prairie. The dust bowl of the 1930s originated in southeastern Colorado, southwestern Kansas, and the panhandles of Texas, Oklahoma, and eastern New Mexico, where the shortgrass prairie was plowed for dryland farming. These fields remain discernable today, decades after cultivation ceased and the fields were abandoned. The persistence of threeawn species in these areas may be the result of plowing-induced changes in the soil. These changes require long periods of time for restoration. An accompanying reduction in soil phosphorus may leave the site more suitable for these species than for the climax plants that are so slow to reestablish (Barbour and Billings 1988).

Where irrigation augments natural precipitation, high levels of crop production continue to be attained (Stoddart 1975). This observation is supported by Ricketts (1999) who stated, "Much of the area was severely affected by largely unsuccessful efforts to develop dryland cultivation. The dustbowl of the 1930s was centered in this ecoregion and stands as proof of the unsuitability of this area for farming, unless heavily irrigated." However, water pumped from the aquifer is not replaced at the same rate that it is removed and the water table has receded. Gleick (1993) reported that the aquifer is sustaining an overdraft rate that is approximately 140% above its recharge rate.

Problems Affecting Habitats or Species

Analyses based on the scientific literature and NMDGF staff suggests that modification of disturbance regime, loss of keystone species, and conversion of the prairie to agriculture are factors that are influencing the biodiversity of Western Great Plains Shortgrass Prairie habitats.

Loss of Keystone Species
The capacity of the Western Great Plains Shortgrass Prairie to sustain its composition, structure, and ecological processes has been diminished through the loss or reduction of keystone species and subsequent alteration of the historic disturbance regimes of which they were part. Keystone species are those animals that have a significant overall effect on the structure or function of habitat types or ecosystems. Their effect is disproportionate to their abundance.

Free-ranging bison have been extirpated from the shortgrass prairie and domestic livestock have taken their place. Bison foraged on different plants than domestic livestock (Peden *et al.* 1974, Plumb and Dodd 1993). Bison removed vegetation in a way that often created patches of open habitat that differed in vegetative composition from the surrounding ungrazed areas (Benedict 1996). Disturbance from cattle grazing tends to produce a more uniform effect. The construction of water developments for livestock has expanded grazing into historically inaccessible areas. Prairie dogs also created large patches of habitat that differed from the surrounding landscape and provided essential habitat for many other animals (Benedict 1996). Although they still exist on the landscape, prairie dogs are much reduced and are susceptible to elimination from poisonings and outbreaks of sylvatic plague (*Yersinia pestis*) (Miller *et al.* 1994). Further, their potential to maintain viable and resilient populations and to sustain the biodiversity they create is in doubt because, according to Pizzimente (1981), colonies are becoming isolated and genetic exchange through immigration is becoming less likely.

Grazing Practices
Grazing practices on the Western Great Plains Shortgrass Prairie are varied and may potentially alter grassland habitats. The intensity and length of the grazing season, in combination with extant environmental conditions, has the potential to change plant species composition, the percent of vegetative cover, and the physical habitat structure (Bock *et al.* 1984). Modifications to vegetative parameters affect associated fauna and cause subsequent changes in plant diversity and structure affecting animal diversity. Sites subjected to improper grazing practices, those that reduce the ability of the land to support long-term animal and plant production, may lose faunal specialist species that may or may not be replaced with generalist species (Bock *et al.* 1984). Excessive livestock grazing may also encourage shrub encroachment through the reduction in grasses and the competition they provide to woody plant seedlings (Humphrey 1958). However, Mack and Thompson (1982) reported that grazed areas in the shortgrass prairie tend to be recolonized by predominantly native plants. The specific effects of current grazing practices on the biodiversity of the Western Great Plains Shortgrass Prairie are poorly understood.

Invasive Species
Invasive species can be plants, animals, or other organisms including microbes. The US Department of State (1999) cautioned that the introduction of non-native species has the

potential to cause economic, environmental, or human health problems. Many ecologists have acknowledged the problems caused by invasion of non-native species into communities or ecosystems and the associated negative effects on global patterns of biodiversity (Stohlgren *et al.* 1999). Once established, invasive species have the ability to displace native plant and animal species, disrupt nutrient and fire cycles, and alter the character of the community by enhancing susceptibility to additional invasions (Cox 1999, Deloach *et al.* 2000, Zavaleta *et al.* 2001, Osborn *et al.* 2002). Lee (1999) and Mitchell (2000) noted that the invasion of non-native species is similar to a biological wildfire that is rapidly spreading across the West. The State Forest and Watershed Health Plan devotes significant planning to the management of non-native invasive phreatophytes (New Mexico Energy, Minerals, and Natural Resources Department 2004). Little is known about the extent or specific effects of invasive species in the Western Great Plains Shortgrass Prairie, making it difficult to assess related problems and develop effective interventions.

Recreational and Off-Road Vehicle Use
The *New Mexico Statewide Comprehensive Outdoor Recreation Plan* (Henkel 2004) identified a moderately increasing trend in off-road vehicle use in New Mexico from the 1996-2001. Recreational off-road vehicle use has also increased in the Western Great Plains Shortgrass Prairie along rivers, lakes and streams, wherever public access is available. Federal and state lands that are not adjacent to water sources receive highly dispersed and varied recreational use.

Problems associated with dispersed recreation include indiscriminate driving on interior undeveloped roads or in roadless areas. The specific effects of recreation and off-road vehicle use on the Western Great Plains Shortgrass Prairie are unknown. However, off-road vehicle travel can cause damage to soils and vegetation (Holechek *et al.* 1998) and impact wildlife by destroying and fragmenting habitat, causing direct mortality, or altering behavior through stress and disturbance (Busack and Bury 1974, Brattstrom and Bondello 1983).

Habitat Fragmentation
The ecological implications of habitat fragmentation have lead many ecologists to identify the process as one of the most significant factors affecting biodiversity (Harris 1984, Wilcox and Murphy 1985, Noss and Cooperrider 1994). Saunders *et al.* (1991) note that urban expansion, agricultural development, power line construction, and road construction have accelerated over the past century, subdividing the natural world into disjunctive remnants of native ecosystems embedded in a matrix of anthropogenic land uses. Such development has caused large areas of formerly contiguous landscapes to become increasingly fragmented and isolated (Finch 2004).

Some authors (Barbour and Billings 1988, Ricketts 1999) believe that the primary factor affecting the Western Great Plains Shortgrass Prairie is conversion to agriculture. Areas that were once difficult to cultivate may now be pressed into service due to new technologies such as four-wheel drive tractors, precision farming, herbicides, and irrigation.

Urban and commercial developments also contribute to the loss of native vegetation, increased water use, ground water depletion, and increased erosion through soil compaction and runoff concentration. These activities may ultimately increase clearing, roads, and vehicular traffic. Subsequent habitat fragmentation may affect SGCN within the shortgrass prairie by: 1) reducing the habitat area for interior species, 2) imposing barriers to dispersal, colonization, and maintenance of meta-population dynamics, 3) altering demographic and genetic structure as a result of isolation and small population size, 4) increasing habitat edge and thereby facilitating predation, parasitism, and invasion by exotic species or habitat generalists, 5) altering biotic relationships, such as plant and pollinator interactions, and 6) altering the physical environment, ecological processes, and natural disturbance regimes (Finch 2004).

Fire Management
The current state of the shortgrass prairie is a product of both evolution and historical land use. Prairies in North America evolved with frequent disturbances, including fire, drought, grazing, and storms (Wright and Bailey 1982, Kaufman *et al.* 1988, Anderson 1990, Debano *et al.* 1998, Rickets *et al.* 1999). Fire frequency and intensity appear to be synchronized by climate conditions, physiographic, edaphic and vegetation conditions (Daubenmire 1968, Swetnam and Betancourt 1990). Historically, grassland fires were caused by lightning and Native Americans (Payne 1982, Bahre 1985). However, widespread cultivation, livestock grazing, and transportation corridors reduced standing biomass of fine fuels, and fragmented the landscape in prairie ecosystems, which decreased grassland fire frequency and intensity (Ford and McPherson 1996, 1998, Hart and Hart 1997, DeBano *et al.* 1998, Frank *et al.* 1998). These changes have virtually eliminated fire as an ecological process and have had a negative overall impact to prairie ecosystems (Engle and Bidwell 2000). Brockway *et al.* (2002) investigated the effects of growing season and dormant season prescribed fire on the Kiowa National Grasslands in New Mexico. Their results indicated that prescribed fire in shortgrass prairie during the growing season appears to place the plant community at a greater risk of decline. Conversely, prescribed fires during the dormant season provided several immediate benefits to the plant species present and increased species diversity. However, Launchbaugh (1964, 1972) believes fire in the shortgrass prairie to be detrimental because it lowers forage yields by diminishing the number of soil tillers and reduces water infiltration and soil moisture. The roll of fire in sustaining the shortgrass prairie has been well researched, yet results are conflicting (Stewart 1951, Launchbaugh 1973, Wilson and Shay 1990, Knoft 1994, Umbanhowar 1996, Kirchner 1997, McDaniel *et al.* 1997, Knopf 1998, Ford 1999, 2001; among others). Thus, this topic warrants additional attention by research scientists.

Energy Exploration and Development
The most common mineral extractions in the Western Great Plains Shortgrass Prairie are oil and natural gas. Oil and gas leasing on federal lands follow standards established by the Bureau of Land Management (BLM) and are subject to further regulation by the New Mexico Energy, Minerals and Natural Resources Department, Oil Conservation Division. The infrastructure of oil and gas extraction (pads, roads, pipelines pump stations, compressors) and related human activities has resulted in habitat fragmentation, disturbance from vehicle traffic, hauling, and maintenance activities, point source pollution, noise, and habitat conversion.

Wind energy facilities are not yet widespread in the Western Great Plains Shortgrass Prairie. However, as alternative sources of energy become more important and as related technology improves, there is potential for more wind energy sites to be developed. Wind-generated electrical energy is environmentally friendly in that it does not create air-polluting and climate-modifying emissions. Nevertheless, wind turbines in large arrays can affect wildlife and habitats. Roads and pads fragment habitat and bats and birds (particularly raptors) are killed in collisions with the moving blades of the wind turbines. Lighted wind towers greater than 200 ft (61 m) tall have the same potential as communication towers to attract and kill night-flying migratory birds and bats through collisions with moving blades (NMDGF 2004b).

Water Withdrawal
Ground water in the shortgrass prairie is currently extracted for residential, agricultural, and industrial uses. As demands for water increase, additional deeper wells are needed. Ground water pumped from the Ogallala Aquifer is not replaced at the same rate as it is removed. There has been a subsequent reduction of the water table. Aquatic habitats are the first to be effected. Further reduction in the water table may alter the extent and species composition of Western Great Plains Shortgrass Prairie.

Military Maneuvers
The military uses portions of air space over the Western Great Plains Shortgrass Prairie for tactical air training. These maneuvers involve low level fights resulting in noise issues in specific areas that may affect some SGCN, especially during the breeding season.

Pollution
Agricultural chemicals, livestock and dairy ground water contamination, and solid waste have the potential to create localized pollution in portions of the Western Great Plains Shortgrass Prairie. The current sources, extent, and effects of such pollution, however, remain to be determined.

Information Gaps

Given the size of the shortgrass prairie in New Mexico and the variety of potential factors that may alter prairie habitats, it is not surprising that there are a number of information gaps related to this ecoregion and SGCN. Information gaps that limit the ability to make informed conservation decisions for the Western Great Plains Shortgrass Prairie are outlined below.

- Minimum biotic and abiotic measurements are lacking that insure habitat sustainability, integrity and current land cover habitat and SGCN condition.

- Specific range or ecological condition information is lacking for the shortgrass prairie. The BLM uses a standardized methodology to estimate ecological condition on their lands. However, much of the Western Great Plains Shortgrass Prairie is not federally managed and there are no estimates of ecological condition on private lands or consistent information between the US Forest Service and BLM.

- The intensity, scale, extent, and causes of fragmentation are largely unknown.

- Information is needed on the specific effects of current grazing practices on the biodiversity of the Western Great Plains Shortgrass Prairie.

- Information is needed on grazing management practices necessary to sustain appropriate levels, composition, and structure of native plants and grasses in the shortgrass prairie for SGCN.

- Short and long-term effects of land management practices such as oil, gas, and wind development; grazing systems, lovegrass monocultures on CRP lands, invasive species, and shrub encroachment on SGCN is poorly understood. Availability and distribution of this information would allow land managers to make more informed conservation decisions.

- There is little information on the abundance, distribution, and trends for most of the SGCN and the environmental conditions or thresholds that limit their populations.

- The response of SGCN to human disturbances is unclear.

- Information is lacking on the effects of habitat fragmentation and requirements for wide-ranging SGCN.

- There is no central clearinghouse for biological information on the Western Great Plains Shortgrass Prairie and SGCN associated with this habitat type that allows all agencies and private landowners to access information to develop conservation actions.

- The extents to which invasive and non-native species occupy, alter, and limit populations of SGCN and into which interventions may be effective, are poorly understood.

- The extent to which off-road vehicle use is affecting SGCN populations is unknown.

- There is a poor understanding of the sources of pollution and the extent to which pollution is altering the Western Great Plains Shortgrass Prairie.

- There is limited information on the role of fire and appropriate fire management protocols in sustaining the shortgrass prairie.

Research, Survey, and Monitoring Needs

Research, survey, and monitoring needs for the Western Great Plains Shortgrass Prairie are primarily derived from our lack of information about factors that influence the integrity of this habitat type and associated information gaps. Research, survey, and monitoring needs that would enhance our understanding of this habitat type and SGCN are outlined below.

- Investigate the extent to which land use activities fragment and alter habitats in relation to patch size, edge effect, temporal needs, and use by SGCN. Examples of these activities include: 1) livestock grazing timing, intensity, and duration; 2) urban development; 3) gas, oil, and water exploration; 4) off-road vehicle use; and 5) non-native species invasions. This information is important in understanding how different land use intensities and frequencies disturb SGCN.

- Conduct research to enhance our knowledge of vertebrate and invertebrate community structures, fundamental natural history requirements, and ecological relationships within the Western Great Plains Sand Shortgrass Prairie. Life history and habitat needs of most of the SGCN and their use of this habitat type are poorly understood.

- Investigate the potential impact that wind energy facilities may have on avian and bat populations. Studies should define important migration/movement corridors for these taxa on both a landscape and local area scale.

- Identify the impacts of fire, grazing, and drought on the Western Great Plains Shortgrass Prairie. Optimal studies would define the roles, mechanisms and impacts via manipulative field-based experiments. Methods that mimic natural disturbance regimes and consider economic impact can be valuable to land managers.

- Investigate the impacts, benefits or detrimental effects of habitat restoration practices, such as tree and shrub removal, reseeding, fire, etc. Millions of dollars are made available annually through various grant programs to federal, state, and private land managers. All restoration methods should be closely evaluated and suggested modification of these practices should be made available to land managers.

- Investigate and recommend invasive species early detection protocols, methods to estimate vectors and pathways of potential invasive species, and effective interventions.

- Define spatial and temporal requirements of wide-ranging SGCN. The identification of habitat corridors is essential for long-term conservation planning.

- Investigate and monitor black-tailed prairie dog populations including rates of town growth, establishment and decline, and the effects of plague and control efforts on prairie dog populations (Johnson *et al.* 2003).

- Investigate options for developing a centralized database of information regarding the condition of the Western Great Plains Shortgrass Prairie. This database would identify data gaps, compare differing methodologies of data collection, and encourage the implementation of national monitoring standards.

Desired Future Outcomes

Desired future outcomes for the Western Great Plains Shortgrass Prairie are focused upon achieving ecological sustainability and integrity of this land cover type. Desired future outcomes include:

- Western Great Plains Shortgrass Prairie persists 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.

- In order to garner public support and recognition of the importance of the shortgrass prairie in New Mexico, economic and social ties to the Western Great Plains Shortgrass Prairie are recognized and accommodated in the quest for ecological sustainability.

- Large natural areas are designated and managed for dispersal, genetic mixing of populations and to accommodate wide-ranging species.

- Partnerships have been established to identify and implement adequate funding for conservation planning, education, and technical, reclamation, survey, and research projects that ensure the future integrity and functionality of the shortgrass prairie for SGCN and resource extraction needs.

- Consistent grassland reclamation standards are established that ensure future habitat integrity and functionality and are adopted by private landowners, counties, municipalities, and federal and state land management agencies.

- Land management plans for federal and state lands include sustainable grazing practices that are fully implemented and complied with.

- A fully funded comprehensive statewide noxious weed control planning committee and program is established. Colonization of noxious weed species is stopped and extant weed populations are controlled or eliminated.

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 and private landowners to ensure the ecological sustainability and integrity of the shortgrass prairie. Methods may include: establishing conservation agreements, agency memorandum of understanding, or land acquisition projects.

2. Work with federal and state agencies, private landowners, research institutions, and universities to design and implement projects that will provide the information about SGCN and the Western Great Plains Shortgrass Prairie outlined in the Research, Survey, and Monitoring Needs section above.

3. Work with land management agencies, private land managers, and the agriculture industry to identify and promote grazing systems on rangelands that ensure long-term ecological sustainability and integrity and are cost effective for livestock interests. Such

practices may include collaborative development of grazing management plans, altering domestic and wildlife stocking rates, time and use, and distribution where forage availability is inadequate, and promoting "grass banking" opportunities that allow degraded rangelands to recover.

4. Support actions that create incentive based or voluntary partnerships with private landowners to conserve and manage their properties to sustain SGCN.

5. Work with federal, state, and private agencies and institutions to identify sources of funding for long-term conservation of SGCN and to maintain tracts of native vegetation as an alternative to converting land to agriculture or urban development. Funding should create incentives for habitat maintenance and improvement on private lands and conservation easements. Employ existing incentive programs to facilitate partnerships with private landowners. These programs include the Conservation Reserve Program (CRP), Landowner Incentive Program, Wetland Reserve Program, Wildlife Habitat Incentives Program, State Wildlife Grants, Private Stewardship Grants Program, Safe Harbor Agreements, and Environmental Quality Incentive Program.

6. Initiate centralization of available data regarding condition of the shortgrass prairie should for the purpose of identifying data gaps, to compare current methodologies of data collection and to encourage the implementation of national monitoring standards.

7. Collaborate with federal and state agencies and affected publics to identify legislative actions, land acquisition, and easement access management protections for the Western Great Plains Shortgrass Prairie. Practices to consider for legislative attention include the regulation of toxicants to control prairie dogs, removal of prairie dogs, regulation of exploitative activities such as rattlesnake roundups, and off-road vehicle management.

8. Counter habitat fragmentation by working with federal, state, and private land managers to modify management of roadside rights-of-way and fencerows to provide useful habitat and corridors that allow wildlife to travel between existing patches of prairie.

9. Collaborate with federal, state, and private agencies and institutions in gaining support for additional open space lands, mitigation mechanisms, and management strategies.

10. Monitor and respond appropriately to proposals to modify programs, such as CRP, that support conservation management and incentives to preclude conversion of wildlife habitat to alternative uses.

11. Identify and pursue opportunities to develop agreements among state and federal agencies that clearly outline responsibilities regarding conservation of shortgrass habitats and resident SGCN.

12. Promote grassland restoration that encourages increased native herbaceous cover.

13. Collaborate with federal and state agencies and effected publics to develop management practices that would increase populations and nesting success of avian species in the shortgrass prairie. Possible management practices may include: 1) maintaining a network of grassland reserves that can act as refugia for grassland birds during periods when agricultural needs reduce the amount of land available to them; 2) maintaining areas that are not grazed or burned for at least three years to provide habitat for species that require taller, denser vegetation; 3) minimize early-season mowing or cutting of hayfields or fields on lands in the CRP; and 4) aggregate fields in CRP to create a few large grasslands.

14. Assist with implementation of *New Mexico's Strategic Plan for Managing Noxious Weeds,* 2000-2001 (http://www.swstrategy.org/library/NM Strategic Plan for Managing weeds.htm). New Mexico's weed management strategy is intended to complement the objectives of agency and inter-agency weed management strategies, including the BLM, *Partners Against Weeds* action plan, the US Forest Service, *Stemming The Invasive Tide*, and the national interagency strategy, *Pulling Together*), as well as *the National Invasive Species Management Plan*, but with a specific focus on opportunities and problems in this state.

15. Collect and distribute information regarding assessments of the short and long-term effects of land management practices such as prescribed fire, habitat rehabilitation. These practices include methods of converting lovegrass monocultures on CRP lands, habitat restoration, shrub removal, wind generation site interventions, oil and gas reclamation, and invasive species management, and grazing systems.

16. Provide a general guide for landowners to restore and maintain a mosaic of vegetative structure that provide habitat for a variety of native wildlife, particularly SGCN, and which contribute to landscape-level habitat restoration.

17. Provide or facilitate public education and wildlife viewing opportunities to raise awareness and appreciation of grassland SGCN, gain support for additional open space lands, build mechanisms for mitigation, and develop management strategies.

18. Work with entities planning development of wind energy facilities in the Western Great Plains Shortgrass Prairie to reduce the potential for adverse effects on SGCN.