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Chapter 1: Wildlife

Introduction

This volume addresses the wildlife and fish of the grasslands in the Southwestern Region of the USDA Forest Service. Our intent is to provide information that will help resource specialists and decisionmakers manage wildlife populations within grassland ecosystems in the Southwestern United States. The information and analysis presented is at a Regional scale.

Many of the references and examples in this volume are from grassland types and/or States outside the Region but are applicable to our discussions. Some species are addressed at length, either because information is available, the species are threatened, endangered, being considered for listing, are sensitive, have special management requirements, or play or have played a special ecological role.

An underlying theme in managing wildlife residing in grassland ecosystems is that wildlife and their environments have evolved together over millennia. Each wildlife species has an important role and function to fill in its grassland environment. The challenge of managing grassland-adapted wildlife species is to sustain or restore, where possible, the processes, attributes, and habitat structures that have codeveloped with populations over time and that may be required by individual wildlife species.

Many human activities have significant effects on wildlife of grasslands, but two in particular are notable and frequently identified in the literature: habitat loss in relation to private farming, and habitat alteration from grazing by domestic livestock. Much of the literature addressing grassland wildlife can be classified under range management topics, especially as it relates to grazing effects and management of livestock.

Historic Conditions

As pioneers moved west in the United States century and a half ago, they found large expanses of prairie comprising grasses suitable for livestock forage, and level ground with soils amenable to growing domestic crops. The development of ranches, farms, towns, railroads, and roads began to fragment and change native grasslands, and this trend continues today. This advancement of civilization has placed an increasing demand on natural resources as fundamental as space, water, air, minerals, water, plants, and animals. Humans cleared native grasses and trees and planted new species. They combated and then controlled a natural process that was considered to be destructive—wildfire. Fire suppression changed various system processes that were important for the maintenance of grasslands. Because early pioneers found water to be a limiting factor in the Southwest, they drilled wells, built dams, and redirected water to meet their needs. As this development of the West progressed, the face of the landscape changed. The combination of fire suppression, water control, and habitat conversion and fragmentation significantly altered native grasslands and respective ecosystem processes that wildlife depended on.

The topic of grassland-associated wildlife in the Southwestern Region of the Forest Service is complex. The grasslands in the Region are subdivided into three distinct areas: the Great Plains, the Great Basin, and the desert grassland. While there are some similarities among wildlife species across the grassland types, each grassland has unique species with unique requirements and roles in its respective ecosystems.

The Great Plains grasslands include the shortgrass steppes of southeastern Colorado and northeastern New Mexico, northwestern Texas, western Oklahoma, and western Kansas. The desert grasslands are in southeastern Arizona, southwestern New Mexico, and Mexico. The Great Basin, a cold desert, is bounded by the Sierra Nevada on the west and Colorado Rockies on the east, and by the Idaho batholith of central Idaho on the north and a vegetation line defined by creosote bush (*Larrea divaricata*)—a warm desert species—and Great Basin sagebrush (*Artemisia tridentata*) in the south. The Great Basin, which is similar to other desert grasslands in the Southwest, was once dominated by perennial grasses but is currently dominated by desert shrubs (Hastings and Turner 1965, Hanley and Page 1982), including creosote (*Larrea tridentata*), tarbush (*Flourensia cernua*), mesquite (*Prosopsis juliflora*), Mormon tea (*Ephedra trifurca*), and acacia (*Acacia* spp.).

The Great Plains, Great Basin, and Desert Grassland remarkably differ in climate. The desert grasslands and the Great Basins are semiarid, whereas the Great Plains is wetter and colder. The grassland ecosystems of Western North America are climatically diverse with differences in productivity, seasonality, and disturbance regimes. These environmental dissimilarities have resulted in different fauna. If our goal is to sustain grasslands, we must understand the climatic and evolutionary constraints operating in each ecosystem and the resulting differences in resilience of these ecosystems and the wildlife species therein.

The grassland ecosystems discussed here are usually described as homogenous types of grass, tallgrass, shortgrass, mixed grass, interspersed with many smaller ecosystems, including wetlands, playas, riparian areas, shrublands, rocky outcrops, and in some locations, scattered trees and shrubs. Each system has a unique fauna, management problems, and needs. Consequently, only the major groups of wildlife and a few of the more important species can be discussed in any detail. By addressing species groups and some key species most of the management needs of other species will, we hope, be met. Most of the species groups and single species will be addressed in relation to functions within their respective grassland ecosystems and with respect to various anthropogenic activities that occur on the grasslands.

Many issues need to be considered when managing wildlife on grasslands, such as:

- Habitat fragmentation caused by urban development, agriculture (farming), changes in plant structure and composition, fencing, and roads.
- The use of chemicals such as pesticides and urban contaminates that have affected wildlife, directly or indirectly.
- Changes in the abundance and types of water sources. For example, playas have been drained to create farmlands, streams have been dammed, diverted, impacted by grazing or have dried up due to lowering water tables, and destruction and changes in riparian zones.
- Population declines of several wildlife species that have played important ecological functions (keystone species) such as bison (*Bison bison*), and prairie dogs (*Cynomys* spp.). Some grassland wildlife species are to the point of being listed or being considered for listing.
- Competition between domestic and wild species. Competition will be of sufficient interest throughout the following discussions that more explanation is merited. Some general definitions of competition as they apply in this report follow.

Factors Influencing Wildlife Populations

Competition

Competition can occur in one of two ways. The first way involves direct use of a common limited resource by the same or different species (Miller 1967, Nelson 1982). On the grasslands, the common resource is vegetation. Many factors influence competition for edible plants between wildlife and domestic herbivores (Vavra and others 1989). Nelson (1982) lists eight ways species could compete for vegetation:

- consumption equivalence
- dietary overlap
- forage quantity and quality
- forage use
- timing of use
- height of foraging reach
- density or stocking rate of animals
- spatial and temporal distribution of animals

These factors are not independent; they can interact in multiple ways to heighten or minimize the actual degree of competition.

The second way competition can occur involves active defense of a territory or other spatial resources by one animal against another Nelson (1982). This can

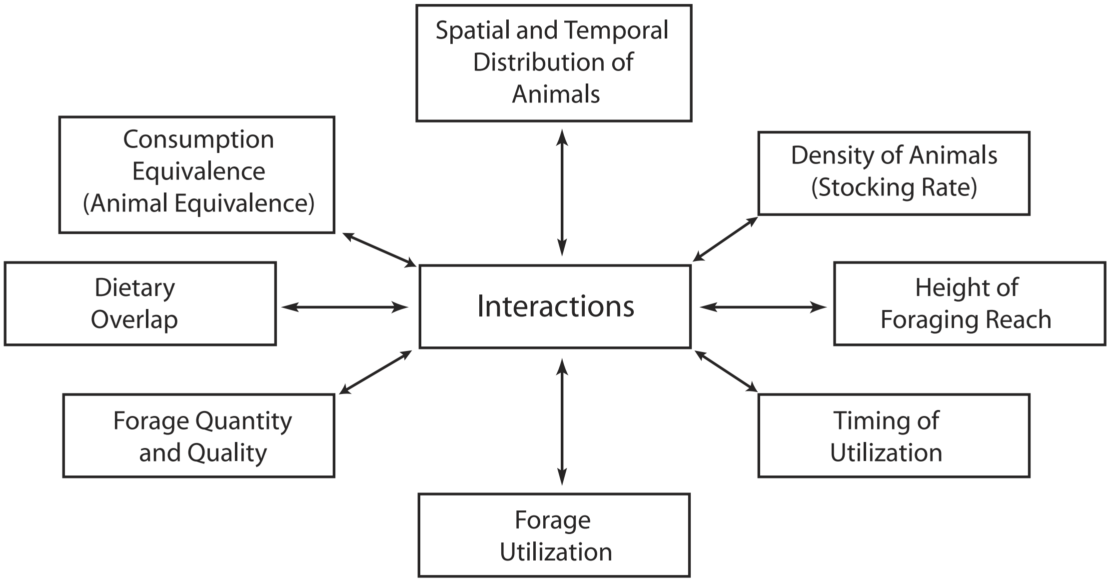

Figure 1-1. Potential interactions among variables that affect ungulate competition for food. Interactions can heighten or reduce the potential for competition in a myriad of ways that are not predicted (Wisdom and Thomas 1996).

also take a more passive form known as disturbance competition, when the mere presence of an animal intimidates or annoys another animal into leaving the area (Nelson 1982).

Figure 1-1 illustrates the competitive interactions among such native ungulates as elk, deer, and such exotic ungulates as cattle and sheep. Although, figure 1-1 depicts general competitive interactions between ungulates, both native and exotic, it is also a good representation of competition between many wildlife and domestic species.

Predators

In all of the grassland ecosystems, predators play an important function of controlling prey populations that may include other predators. Many of the large top carnivorous predators—bears, mountain lions, wolves—have been extirpated from the grasslands.

Important predators in contemporary desert grasslands include coyotes (*Canis latrans*), hawks, owls, bats, the insectivorous desert shrew (*Notiosorex crawfordi*), the grasshopper mouse, snakes, lizards, and toads. Local distributions and numbers of predators can often be linked to prey abundance. For example, studies of coyote and jackrabbit populations in the Great Basin desert showed that jackrabbit abundance rises and falls on a decadal cycle and that coyote populations track the jackrabbit cycle with a 1 to 2 year lag time (Stoddart 1987a,b). Predators are also known to regulate prey populations. Range caterpillar populations have been reduced by as much as 50 percent by rodent predators, as have been various darkling (*Tenebrionidae*) and ground beetles (*Carabidae*) (Parmenter and MacMahon 1988a,b). Insectivorous birds can have a similar impact on grasshoppers as rodent predators (Joern 1986).

Habitat Modification and Fragmentation

Grasslands have been subjected to various kinds of modifications, fire events, climate changes, wildlife uses, and other influences, for millions of years (Colbert and Morales 1992). In the grasslands of North America, native wildlife habitats have been modified, removed completely, or replaced with other kinds of vegetation by humans. As a result, native habitats in some areas have become more disjointed and the vegetation composition and structure have changed. Volume 1 of this assessment describes the causes and consequences of grassland alterations and landscape fragmentation in relation to plant communities, and the following chapters in this volume 2 document many of the effects of habitat modification and fragmentation on wildlife.

Studies of native mammals in disturbed grassland situations reveal that some animals have adapted remarkably well to these changes; for example, coyotes (*Canis latrans*) now use urban areas. However, many larger herbivores, such as bison, elk, antelope, and their respective predators, have not been able to adapt as well to grassland alterations as smaller herbivores. An explanation may be that large herbivores cannot readily adapt to habitat fragmentation because they depend on large geographic ranges and expanses of continuous open grasslands, whereas smaller animals may be able to adjust to fragmented habitats because they have smaller ranges and need smaller amounts of continuous habitat.

Influence of Large Mammals

Effects of large herbivores (ungulates) on plant community composition and structure have been studied in many grasslands worldwide (Frank and McNaughton 1992). Ungulate activities affect many aspects of grassland structure and function, including the physical structure of the environment and the rates of certain ecosystem-level processes, for example, fire frequency and erosion probability (Frank and Evans 1997). The grazing habits of large herds of American bison, for example, resulted in a mosaic pattern of grazed and ungrazed areas. This pattern in turn influenced the occupancy patterns of other mammals in the areas.

Role of Riparian Areas in Grassland Environments

Riparian vegetation, trees, grasses, sedges, and rushes provide shade, cover, and food for many wildlife species. Streamside vegetation filters and traps sediments, which improves water quality and helps to maintain water temperatures and oxygen levels. Leaves, bark, and rotting wood provide homes and food for many insects and many vertebrate species. Insects are prey for birds, small mammals, reptiles, amphibians, and fish. Riparian habitats are important migratory corridors for birds and bats and travel corridors for large mammals such as elk and deer. Fragmented riparian habitats can also lead to isolated populations of animal species preventing both population expansion and gene flow (Ohmart and Zisner 1993).

The management of riparian ecosystems within the Southwestern Region is a special concern because of their importance to so many wildlife species (table 1-1). About three-fourths of the vertebrates in the Southwest, for example, depend on riparian areas for some portion of their life history (Johnson 1989). In the Southwestern Region, 57 percent of the terrestrial vertebrate species on National Forest lands occur in riparian systems (estimated from the Southwest Wildlife Information System 2001). The significance of this habitat type to wildlife becomes even more important when considering that riparian habitats comprise just less than 2 percent of the National Forests in the Southwestern Region (estimated from the Southwest Wildlife Information System 2001).

Table 1-1. The total number of birds, mammals, amphibians, and reptiles and their respective number in riparian habitats, and the percent of the totals on the 11 National Forests in the Southwestern Region. (Data compiled from the Southwest Wildlife Information System, Rickel 2002)

Species group	Total	Riparian	Percent
Birds	458	252	55
Mammals	203	153	75
Amphibians	34	15	44
Reptiles	114	41	36
Totals	**809**	**461**	**57**

Because livestock spend much of their time in riparian zones, where ecological stakes are high, many of the adverse impacts of grazing are magnified in these habitats (Fleischner 1994). Destruction of vegetation adjacent to riparian streams has resulted in siltation of streambed gravels, warming of the water, and elimination of aboveground flows during summer and fall. The United States General Accounting Office (1988) reported that degradation of riparian and aquatic areas was the most serious threat to biodiversity in the West.

Role and Effects of Fire

One of the most important ecological processes of the grasslands has been fire. Fire has occurred either by lighting naturally, or by humans. Anthropologic fires were set by Native Americans and then by pioneers for various reasons; for example, to clear a piece of land for farming, to renew land for farming, to herd large mammals for hunting, and for warfare. Once the grasslands were settled, fires were viewed as more of a setback than a tool, and fire suppression commenced. Fire suppression altered the frequency of wildfire events, causing many grassland ecosystems to shift in plant species composition from areas composed primarily of grasses to areas having increasing numbers of shrubs and trees.

Birds—Some birds react to fire directly; raptors, for example, are attracted to fire and smoke. This response appears to be related to vulnerability and ease of capturing prey that are forced to escape a fire. Raptors are also attracted to burned areas where insects and small mammals are often plentiful and are easy prey. Other bird species are attracted to recently burned grasslands (Clark 1935, Handley 1969, Komarek 1969, Kramps and others 1983, Lyon and Marzluff 1984, Tombak 1986). The attraction is the increased forb composition. Seed production after fire is beneficial to avian herbivores and granivores (Bock and Bock 1990, Bock and others 1976, Lawrence 1966, Wirtz 1977).

Other effects of fire on birds include increased habitat heterogeneity. In shrub-grass complexes, bird diversity and abundance are enhanced if shrub cover and nesting sites are interspersed with open grassy areas maintained by fire (Baldwin 1968, Kramp and others 1983). Fire can have a cleansing effect on bird populations by lowering the numbers of parasites that affect health and vigor of individuals (Kramp and others 1983, Lyon and Marzluff 1984).

Species that use shrubby habitat for nesting and perching are likely to be negatively impacted by fire if shrubs are destroyed. The shrub-associated common yellowthroat (*Geothlypis trichas*), for example, was found to reach highest abundance on unburned areas in mixed-grass prairie (Madden 1995).

Some bird species exhibit both negative and positive response to fires. This dual response is a consequence of requiring different habitats for different purposes. They may be attracted to recently burned grasslands for feeding if productivity of grasses and forbs has been improved. However, they may require shrub-dominated habitats for cover and nesting (Brown 1978, Komarek 1969, Kramp and others 1983, Renwald and others 1978, Wolfe 1973).

Fire or the lack of fire may affect the distribution of bird species. Populations of Baird's sparrow (*Ammodramus bairdii*), grasshopper sparrow (*Ammodramus bairdii*), LeConte's sparrow (*Ammospiza leconteii*), and Sprague's pipit (*Anthus spragueii*) were common to abundant in mixed-grass prairie, where fire has been used as a habitat management tool since the 1970s, but are virtually absent from unburned prairie (Madden 1995). Fire suppression in grasslands can lead to habitat type replacement, with plant community complexes comprising grass species replaced by shrub communities over time. This habitat conversion is likely to have beneficial effects on some bird (and other wildlife) species but detrimental effects on other species. Table 1-2 lists a few grassland bird species and their responses to fire.

Mammals—How mammals respond in the short term to fire is a function of mammal size and mobility. Large mobile mammals such as deer and elk can easily avoid injury during fire (Boeker and others 1972, McCulloch 1969, Dills 1970, Hallisey and Wood 1976). Young ungulates that are less mobile are frequently killed by large fires (Daubenmire 1968, Kramp and others 1983). Most small mammals escape fires by hiding in burrows or rock crevices (Howards and others 1959, Heinselman 1973). Bendell (1974) indicates that soil provides insulation from fire for burrowing animals (Kramp and others 1983).

The most common fire-related deaths for small mammals are from a combination of heat effects and asphyxiation, physiological stress caused by overexertion during escape, trampling by stampeding large mammals, and predation during and after escape from fire (Kaufman and others 1990).

Fires that temporarily remove food and cover may be detrimental to small rodents immediately after fire (Daubenmire 1968, Kaufman and others 1990). However, repopulation of burned areas by small rodents is reported to be nearly complete within 6 months (Cook 1959). Small mammal populations often increase after fire. This response is due to increased availability of forb seeds and insects (Lyon and others 1978). Burned areas often support more diverse animal populations than comparable unburned sites due to increased habitat diversity (Beck and Vogl 1972, Wirtz 1977). Omnivores and carnivores are attracted to burns owing to increased plant diversity and associated small prey populations (Gruell 1980).

Kaufman and others (1990) suggests that most of the effects of fire on small mammals in grasslands are not neutral but instead are either positive or negative. Fire-negative mammals (table 1-3) include species that forage on invertebrates in the litter layer, species that hide in dense vegetation and eat foliage, and species that use, at least partially, aboveground nests of plant debris. Fire-positive mammals (table 1-3) include species that feed on seeds and/or insects (Kaufman and others 1990). They exhibit an increase in populations and habitat use after fire because of an increased availability of forb seeds, insects, new green vegetation, the creation of open areas in otherwise dense habitat, and eventually an increase in forb cover. Increases can be immediate or can occur gradually as the areas begin to revegetate and habitat diversity increases. Carnivores of the southern Great Plains increase in population and habitat use in response to fire-enhanced rodent populations (prey) (Gruell 1980, Kramp and others 1983, Wirtz 1977). Most native ungulates, bison, white-tailed deer, elk, and pronghorn, increase in populations and habitat use after fire. These population responses are due to an increase in forage quality and quantity in newly burned areas.

Ecological Perspective

In this section, the ecosystem management issues of biodiversity, scale, fragmentation, population viability, and keystone species are discussed.

Resource managers must remember that biodiversity, scale, fragmentation, viability, and keystone species are not exclusively separate but are all closely interrelated and interconnected facets of ecosystems, and consequently it is difficult to understand and manage for one issue without understanding how they interact with others.

Biodiversity

Probably one of the most widely cited definitions of biodiversity comes from *Technologies to Maintain Biological Diversity* (Office of Technology Assessment 1987: 9): "Biological diversity refers to the variety and variability among living organisms and the ecological complexity in which they occur." Biodiversity has become one of the focal points of much discussion about ecosystem management. One of today's leading scientists, E.O. Wilson, predicted that, worse than

Table 1-2. Some grassland birds their response to fire and description of their habitat (Kaufman and others 1990).

Species	Response to fire	Habitat description
Common yellowthroat *Geothlypis trichas*	Negative	Shrubs are required for nesting and perching, but nests are destroyed by fire. Yellowthroats were found to reach highest abundance on unburned areas in mixed-grass prairie, where prescribed fire has been used as a management.
Northern bobwhite *Colinus virginianus*	Both negative and positive.	Is attracted to recently-burned grasslands and is most productive in grass-forb habitat. However, it requires scattered woody plants for cover, and populations decrease in shrub-dominated habitats.
Eastern meadowlark *Sturnella magna*	Both negative and positive.	May be attracted to recent burns, but fires that destroy all shrub cover may be detrimental.
White-crowned sparrow *Zonotrichia leucophrys*	Both negative and positive.	Depends on shrub cover, and may decrease habitat use on some burns. But it also aggregates in large groups to feed in open burns.
Lark sparrow *Chondestes grammacus*	Both negative and positive.	Reportedly benefits from litter removal in grasslands and reduction but not complete removal of shrubs.
Baird's sparrow *Ammodramus bairdii* LeConte's sparrow *Ammospiza leconteii* Sprague's pipit *Anthus spragueii* Western meadowlark *Sturnella neglecta*	Positive	These birds were the most common, and abundant birds, overall, in mixed-grass prairie, where fire has been used as a habitat management tool since the 1970s, but were all completely absent from unburned prairie. Baird's sparrow was found to reach high densities in areas that had been frequently burned. The areas were characterized by low litter and high cover variability of forbs and bunchgrass.
Montezuma quail *Cyrtonyx montezumae*	Positive	The decline of Montezuma quail has been linked with widespread replacement of grassland with shrubland in the last 150 years. It may benefit from fires that decrease shrub cover.
Burrowing owl *Anthene cumicularia*	Positive	Populations of the burrowing owls have reportedly declined on grasslands with increases in litter cover. This suggests that the use of fire to reduce litter cover may be beneficial to this species
Lesser prairie-chicken *Tympanuchus pallidicinctus*	Positive	The lesser prairie-chicken is also a grassland species reported to be declining in the Southwest because of decreased grassland habitat due to suppression of grassland.
Sandhill crane *Grus Canadensis*	Positive	Regrowth of grasses, reduced litter, and decreased shrub cover in grasslands following fire is beneficial for the crane.

destruction caused by war, is the loss of genetic and species diversity in destruction of natural habitats because such loss will take millions of years to repair (Wilson 1984). An eloquent quote from Aldo Leopold (1949: 190) captures the same thought:

> The last word in ignorance is the man who says of an animal or plant: "What good is it?" If the land mechanism as a whole is good, then every part is good, whether we understand it or not. If the biota, in the course of eons, has built something we like but do not understand, then who but a fool would discard seemingly useless parts? To keep every cog and wheel is the first precaution of intelligent tinkering.

Biological diversity is of particular interest since our activities affect both vegetative and wildlife diversity. People alter the biodiversity of plant and animal communities both directly and indirectly.

Managing Wildlife Diversity—To maintain suitable grassland conditions for the variety of wildlife species adapted to southwestern grasslands, managers would benefit by developing a comprehensive approach for conserving and enhancing biological diversity, taking into account both species and ecosystem functions and processes (Probst and Crow 1991). In developing such an approach, three interrelated elements of ecosystem diversity must be analyzed and incorporated into management plans and desired future conditions (Crow and others 1993):

- *Compositional diversity*—The diversity of various components of an ecosystem, namely species, communities, and ecosystems within larger systems. The effective protection of these components usually depends on the next two components.

Table 1-3. Examples of mammals that have positive or negative response to fire (Kaufman and others 1990).

Hispid cotton rat (*Sigmodon hispidus berlandieri*)	Negative
Bailey's pocket mouse (*Chaetodipus baileyi baileyi*)	Negative
Pinyon mouse, (*Peromyscus truei truei*)	Negative
White-tailed antelope squirrel (*Ammospermophilus leucurus*)	Negative
Southern red-backed vole (*Clethrionomys gapperi*)	Negative
Western harvest mouse (*Reithrodontomys megalotis*)	Negative
Meadow vole (*Microtus pennsylvanicus modestus*)	Negative
Deer mouse (*Peromyscus maniculatus*)	Positive
White-footed mouse (*Peromyscus lleucopus*)	Positive
Merriam's kangaroo rat (*Dipodomys merriami*)	Positive
Southern grasshopper mouse (*Onychomys torridus*)	Positive
Nuttall's cottontail (*Sylvilagus nuttallii*)	Positive
Thirteen-lined ground squirrel (*Spermophilus tridecemliniatus*)	Positive
Hispid pocket mouse (*Chaetodipus hispidus*)	Positive
Bison (*Bison bison*)	Positive
Elk (*Cervus elaphus*)	Positive
White-tailed deer (*Odocoileus virginianus*)	Positive
Pronghorn (*Antilocapra americana*)	Positive

- *Structural diversity*—The diversity of habitats and how they are arranged relative to each other spatially and temporally. Structural diversity includes the size, shape, and distribution of species and habitat types, communities across landscapes, and patterns of successional change.
- *Functional diversity*—This refers to the diversity of ecological processes that maintain and are dependent on the other components of diversity. Functional diversity includes, for example, competition, predation, parasitism, and other biological interactions, as well as other processes, such as, nutrient retention and cycling. The ecological processes represented by functional diversity provide the "ecological services" necessary to support all organisms, including humans.

As resource managers develop approaches for applying the concepts of biodiversity and communities to designing desired future conditions, they should avoid oversimplifying the complexity of a landscape and wildlife habitat relationships. Communities with similar resources may still vary in the number of species because of different degrees of niche overlap. Niche overlap is the degree two species exploit the same resource; for example, cattle and deer. Communities differ in species requirements for a variety of reasons: differences in climatic stability and predictability, completion, predation, and disturbances (Solbrig 1991). Consequently, as management plans are developed, good field inventories will be needed.

Scale

One of the most significant changes and challenges in moving from traditional management to ecosystem management is to analyze and manage systems at multiple spatial and temporal scales, simultaneously (Fischer and others 2004). In order to maintain and/or restore grassland ecosystem conditions for wildlife, such management approaches need to be developed and implemented with scale in mind (Crist and others 2003, Su and others 2004).

A hierarchical (multiple-scaled) perspective emphasizes three strategic concerns in an analysis of landscape patterns:

- To detect patterns and define their spatial and temporal scales; in other words, define functional patches at a specific scale for a species (Crist and others 2003, Fischer and others 2004, Kotliar and Wiens 1990).
- To infer which factors generate these patterns.
- To relate these patterns to adjacent levels" (Urban and others 1987, Fischer and others 2004).

Spatial Scale—The scale at which nature is viewed determines the patterns and processes detected. Fischer and others (2004) explain that organisms are affected by ecological processes operating at multiple scales, different habitat variables vary over different spatial scales, and some species reflect habitat at one, but not all, spatial scales. For any management needs or problem, spatial and temporal scales must both be carefully defined. There is no "best" scale at which to manage for. The appropriate scale depends on management needs (Noss 1992) and the requirements of the species. When developing plans for managing landscapes, it is essential for managers to address scaling in relation to specific questions and needs.

Temporal Scale—Problems in time correspond to our limited temporal scale of concern in conservation strategies. In many cases these problems involve disturbance. In general, most human impacts on biodiversity represent a change in the environment and/or an increased rate of change. Changes in disturbance regimes threaten biodiversity when they introduce stresses or events either qualitatively or quantitatively different from the disturbance or stresses to which organisms have adapted over evolutionary time (Noss 1992).

Over long time spans, centuries or millennia, grasslands of any size never remain the same. Changes in species distributions most typically result from variation in disturbance regimes and changes in climate. Because species migrate at different rates, grassland communities are ephemeral and unlikely to attain equilibrium (Davis 1981).

Managing Wildlife at Different Scales—Only by examining wildlife populations along habitat gradients encompassing environmental variations within species' ranges can wildlife be effectively managed. Species exhibiting ecological differences in habitat use among areas will likely require different types of management, depending on location. Species that exhibit specific habitat requirements having little variation across their range may require only one set of management strategies (Block and Morrison 1991).

Biodiversity should be considered at a regional scale where attention is paid to species composition as well as diversity. Even if management concerns are strictly focused on a local area, regional ecological processes as well as local processes must be taken into account. Failure to consider regional processes that control local biodiversity may result in the disruption of these processes, as when habitat fragmentation eliminates opportunities for species to migrate in response to changing climate or human activities. Conservation strategies, even for single species, will be most effective when they address ecological phenomena at multiple spatial scales and levels of organization (Noss 1992).

Management practices can often be effective when they mimic natural disturbances, and these practices can account for frequency, intensity, and seasonality of disturbances over multiple spatial scales. Managers are more likely to maintain native biodiversity by using practices that create a variety of habitats required by a range of wildlife species than when they create conditions unlike those occurring in "natural" landscapes (Noss 1992). For example, using prescribed fire to simulate naturally occurring wildfires may help to stimulate growth of suppressed plants, restore lost species, reduce numbers of invasive shrubs, and reduce amounts of senescent vegetation.

Fragmentation

The problem of fragmentation cannot be understated or underestimated. Rosenberg and Rapheal (1986) state that perhaps the most critical problem facing wildlife, worldwide, is the systematic shrinking and fragmentation of their habitat. Fragmentation is the process where patches of habitats are reduced in size and/or isolated from one another by natural disturbances such as fire, earthquakes, or flooding, or by human development (McLellan and others 1986). Although most of the research and literature has focused on forested lands, the concerns and many of the fundamental principles and theories apply to grasslands. Often fragmentation of grasslands and its effects on wildlife and ecosystem processes and functions are subtle. The size and shape of a habitat patch, and species composition and structure of the patch vegetation, determine the wildlife species that occupy any given site. The number and kinds of edge and interior species are typically correlated with patch size and shape.

Population Viability

A fundamental problem for wildlife management is assuring long-term viability of populations of different species. Population viability refers to the probability of continued existence of geographically well-distributed population over a specified period (Marcot and Murphy 1996). Managing viable populations is more complex than simply maintaining minimum population sizes needed for populations to survive over time with random fluctuations. To assess population dynamics accurately, resource managers must consider demographics, ability to disperse, and habitat quantity and quality (Probst and Crow 1991).

Central to all planning efforts that involve population viability analysis is provision of well-distributed and interconnected habitats (Noss and Harris 1986). Although some species' distributions are naturally patchy, in general, the maintenance of distributions and connectivity is the key to sustaining genetically diverse and demographically healthy populations. A population or habitat is well-distributed if it is maintained over the long term across at least its existing range of geographic, environmental, and ecological conditions (Marcot and Murphy 1996).

Keystone Species

An ecological concept that needs explanation before moving on to the rest of this volume is that of keystone species and their role within ecosystems. This understanding of keystone species will be important as various wildlife species and their management are discussed.

Where did the term "keystone species" come from? While Robert Paine, an ecologist, was studying the pattern of life among the intertidal rock species along the coast of Washington State in the 1960s, he found that one species of starfish preyed so skillfully on mussels that it effectively kept the mussels from monopolizing space on the rock. When he removed the starfish from sections of the shoreline, the mussels began to multiply, crowding out limpets, barnacles, and other marine organisms from the rock surfaces. In the absence of the starfish, the total number of species living on the rock (other than the mussels) decreased by half (Baskin 1997). Paine (1969) coined the term "keystone species" to describe species such as the starfish. He presented the characteristics required for a species to be given keystone status: (1) It provides top-down effects (for example, predation) on lower tropic levels, and thus (2) it prevents the monopolization of a critical resource in lower tropic levels. And (3) the synergy of this dualistic top-down (for example, predation) and bottom-up (for example, competition) interaction must stabilize community diversity. This narrowly defined keystone process is relatively rare and functionally nonredundant in ecosystems, making keystone species of great ecological significance (Davic 2002). A keystone species is one whose impacts on its community or ecosystem are large and greater than would be expected from its relative abundance or total biomass (Keystone Species Hypothesis 1969).

Research has shown that not all species are ecologically equal in their importance to a system. Species that are abundant, that dominate space and resources or contribute to controlling processes are not necessarily the most influential in a system. Sometimes, keystone species are less conspicuous and can even be rare (Baskin 1997). Their contribution to the system is disproportionate to other species in the community, and their removal creates ripple effects that might both change the community and also alter ecological processes (Baskin 1997). These community changes can have drastic consequences. If a keystone species becomes extinct, the other species that are dependent on the keystone species may also become extinct. Keystone species help to support the ecosystem of which they are a part (Jain and Krishna 2002, Keystone Species Hypothesis 1969).

Keystone species may be top carnivores that keep prey in check, large herbivores that shape the habitat in which other species live, important plants that support particular insect species that are prey for birds, bats that disperse the seeds of plants, and many other types of organisms (Keystone species 2004). Keystone species may occur at any level of the ecosystem, from plants and herbivores, to carnivores and detritivores.

In many systems, "keystone groups" of species rather than individual species assume the role of keystone species (De Leo and Levin1997).

Functions of Keystone Species—Keystone species can occur in four ways. The first way is when organisms control potential dominants. In terrestrial systems, large and small herbivores play major roles in maintaining vegetation structure and species composition. The effect of herbivores is often to suppress potentially dominant plant species, reducing competitive exclusion of less competitive species, and promoting greater vegetation diversity (Ernest and Brown 2001, Payton and others 2002). A second way a species can be a keystone is to provide a vital resource or resources to a range of organisms (Payton and others 2002). A third way species may be keystone is when mutualism exists. Mutualism is where two species are jointly dependent, and the elimination of one will result in the demise of the other. In this situation they act as keystones for each other. What might be more in keeping with the multispecies concept of keystone species is "group mutualisms." True group keystones arise where there is dependency of several species on a single mutualist, for example, pollinators and groups of plants (Payton and others 2002). The fourth way an organism can be a keystone species is by being an ecosystem engineer. These species modify the physical characteristic of the environment, for example, burrowing, excavating nests, and so forth, providing resources for other species. These groups are not mutually exclusive, and individual species may exhibit characteristics of more than one type (Payton and others 2002).

Management Significations of Keystone Species—Natural resource managers are faced with complex issues and problems and an array of species, communities, and ecosystems. Faced with this complexity and ever-increasing demands for limited resources, the question is: How do I as a land manager adequately maintain these resources? (Payton and others 2002)

Protecting keystone species has become a priority for conservationists. Unfortunately, the keystone functions of a species may not be known until it is too late, that is, when it is listed or is extirpated. Where a keystone species has been identified, efforts to protect it also will help protect the other species in delicately balanced ecosystems (Keystone species 2004).

To determine the ecological importance of a species, a manager's attention must be directed to individual species or groups of species whose decline or removal may result in dramatic changes in the structure and functioning of its biological community (De Leo and Levin 1997).

In assessing the keystone role of an organism it is not always possible to distinguish clearly between the effects it may have as a keystone. For example, a good case could be made for considering large grazers as both keystone ecosystem engineers and as herbivores. By suppressing invasion of woody species and maintaining open grassland vegetation, large grazers profoundly alter the physical structure of the community. Even the classic keystone predator, the starfish, exerts its influence not just as a predator but as the incidental creator of bare patches, which provide recruitment sites for other species. Most organisms probably alter their environment in some way that can be exploited by other species. Whether the engineer can be considered a keystone species is a matter of degree: how profound the physical effect is, how disproportionate it is, how many other species benefit, and how great their dependence on the alteration is (Payton and others 2002).

Monitoring is a major issue and a need the manager has. There have been two basic monitoring approaches employed: single-species (for example, indicators (MIS), umbrellas, or flagships) or whole ecosystems (for example, focals). Each tactic has its advocates and detractors. Single-species monitoring focuses on one species. In contrast, ecosystem or landscape-scale approaches emphasize ecological processes and habitats rather than individual species (Payton and others 2002).

It has been suggested that the keystone species concept may allow managers to combine the best features of single-species and ecosystem-based management approaches. Monitoring keystone species retains a single-species focus while avoiding the need to examine every species, and it emphasizes the mechanisms that directly rather than indirectly control biodiversity. Where it is possible to identify a keystone species that is critical for the continued survival (or demise) of many other species in its community, management of that keystone may be an efficient means of managing a much wider range of biodiversity (Payton and others 2002).

By themselves, keystone species are unlikely to provide a panacea for managers. Not all ecosystems may contain keystone species, and even where keystones are identified they may not be easily managed as part of a conservation strategy (Payton and others 2002).

Summary

During the 19th and early 20th centuries, people moving westward saw the grasslands as a land that could fulfill their dreams of new homes, new opportunities, and new freedoms. The settlement of the grasslands brought many changes that affected wildlife. These changes include conversion of wild habitats to agriculture and urban areas, and the dissecting of the landscape with roads, fences, and rails. This land conversion and dissection have resulted in habitat loss and fragmentation.

Another drastic change to the grassland has been the alteration or loss of riparian habitats and wetlands, affecting many wildlife species that use riparian areas or are riparian obligates. Introduction of farm and ranch livestock has imposed another change by subjecting native species to competition pressures that they had not evolved with. Natural predator-prey relationships have been disrupted as many predators were greatly reduced in number or extirpated because they prey on livestock. Conversely, populations of some prey species have been reduced, at times intentionally, because they were and are deemed as a pest and a nuisance.

Another change that has altered grassland ecosystems has been fire suppression. Suppression of fire has result in changes in the structure and species composition of the vegetation and, consequently, has influenced the wildlife species of the grasslands.

In light of the many, often dramatic, changes people have made to the grassland ecosystems mentioned above and which will be discussed in more detail in the following chapters, it is worth repeating the words of Aldo Leopold (1949: 190):

> The last word in ignorance is the man who says of an animal or plant: "What good is it?" If the land mechanism as a whole is good, then every part is good, whether we understand it or not. If the biota, in the course of eons, has built something we like but do not understand, then who but a fool would discard seemingly useless parts? To keep every cog and wheel is the first precaution of intelligent tinkering.

Over time, many of the wheels and cogs (biological diversity, predator-prey relationships, competition, wild habitats, and so forth) in the grassland ecosystem have been changed, broken, or replaced, resulting in a system that does not work as well as it had originally evolved to work. Consequently, it is wise for land managers to work with the components of the system that are present and strive to have them working as well as possible.

The information in this volume is intended to help manage the wildlife and fisheries components of the grassland ecosystems.

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