

Chapter 4: Factors Influencing Oklahoma's Biodiversity

Oklahoma's biodiversity is the result of a variety of physical characteristics and ecological processes. While physical factors, such as topography and climate, are relatively constant, ecological processes are dynamic and influence biodiversity occurring within the limits of the physical environment. As ecological processes impact local conditions, some species or communities increase while others decrease. This causes the area's biodiversity to fluctuate. Factors seldom act alone; rather, several are usually responsible for changes in biodiversity.

This chapter explores the physical and ecological factors that affect Oklahoma's biodiversity. Many factors increase our biodiversity by allowing species to move into Oklahoma from surrounding areas or by creating biodiversity within our boundaries. Other processes or actions significantly decrease biodiversity. Many of the latter are human actions that interrupt or change ecological processes necessary for creating or maintaining biodiversity.

Physical Factors

Geographic Location

As mentioned in the previous chapter, Oklahoma is rich in biodiversity, due largely to its location and geography. The most dramatic variation occurs along a transect from east to west in the state, with more subtle differences visible along a north and south line. Oklahoma includes examples of all communities occurring in the transition from eastern hardwood forests, southern pine forests and coastal plains to the foothills of the Rocky Mountains.

The large river systems in Oklahoma support high aquatic and wetland biodiversity. Most ecoregions contain characteristic streams and rivers. Rivers also are important to terrestrial species as water sources and as corridors for movement and dispersal.

Landscape Diversity

Oklahoma's variation in topography and geologic formations also has a significant effect in determining what species and communities will occur in an area. Because of the large variation in these features—sandstone mountains in eastern Oklahoma to flat high plains in the Panhandle—species adapted to widely different conditions are able to survive in appropriate locations in the state. Topographic features often create changes in **microclimate** (climate of a small area), allowing a species to survive in a location that may be surrounded by otherwise unsuitable conditions. North-facing slopes receive less direct sunlight and, therefore, are cooler and more moist. Plants and animals adapted to moist situations are able to extend their ranges into the drier parts of the state in areas having north-facing slopes with suitable conditions. Plants and other organisms adapted to dry conditions reach their easternmost limits on south-facing slopes that are more exposed to direct sunlight.

Geologic factors other than topography also influence a given area's biodiversity. Soil types may be especially important in determining the community that is present. Poorly drained soils often result in wetland or bog communities. Caves and springs develop in areas underlain by limestone, such as the Ozark Highlands, or other easily erodible minerals like gypsum in the west. Streams having rocky beds often support different species than streams with sandy or muddy bottoms.

These physical factors often act in combination to create localized environmental conditions. Because Oklahoma has wide ranges in both landscape features and climate, conditions suitable to support many communities or species of the midwestern, southwestern and southeastern United States occur in the state.

Climate

Oklahoma's wide range of climatic conditions is partially responsible for the large amount of biodiversity present in the state. Rainfall and temperatures vary significantly between the eastern and western borders. Average annual precipitation ranges from over 50 inches (127 cm) in southeastern Oklahoma to 18 inches (46 cm) in the Panhandle, while average annual temperatures range from 65° F (18° C) in the southeast to 55° F (13° C) in the Panhandle. Temperature variations result in different lengths in the growing season. Variations in rainfall, growing season, temperature and other factors limit plant and animal species to parts of the state where conditions are suitable. Because of the wide range of conditions, a large variety of organisms find areas suitable for their needs.

Changes in climatic conditions over geologic time also have influenced Oklahoma's biodiversity. When conditions were suitable, species moved into the state. As climatic conditions changed, such as warming during the retreat of ice-age glaciers, species survived in areas where topographic or geologic features caused microclimates to remain suitable. Other species moved into the state as changing conditions made the environment suitable for them, resulting in the biodiversity we have today.

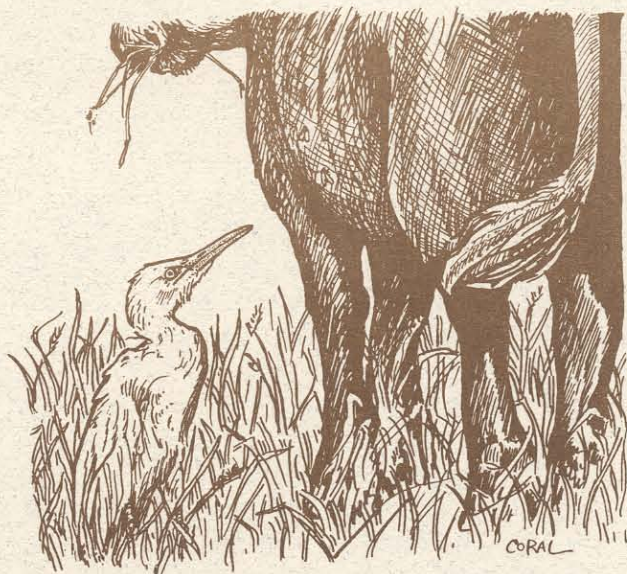
Ecological Processes That Maintain Biodiversity

Dispersal

Most species now occurring in Oklahoma entered the state from surrounding areas, a process called **dispersal**. As physical characteristics and climate changed, conditions in Oklahoma became favorable for various species in surrounding areas. These species dispersed into Oklahoma and inhabited suitable regions. Highly mobile species, such as birds, bats, many insects and wind-dispersed plants, are able to rapidly colonize new areas while less mobile species, such as salamanders and small rodents, disperse slowly and require a continuous corridor of suitable habitat. Because most changes in climate or physical characteristics were very slow, entire species **assemblages**

(groups of species) were able to move into the state. As conditions continued to change, new species and communities moved into Oklahoma while some pre-existing communities survived in isolated pockets or moved to other areas.

The cattle egret, a bird native to Africa, is a recent example of species dispersal. Around 1880, a small flock apparently was blown across the Atlantic Ocean by a storm and landed in northern South America. Since that time, cattle egrets dispersed throughout South America and into North America, reaching Oklahoma in 1962. Although it nests in rookeries with native egrets or herons, the cattle egret has different foraging habits than other heron species found in the state. Rather than feeding on fish and other aquatic life in wetlands, cattle egrets forage on insects and small vertebrates in open upland areas, often in association with grazing cattle. The addition of the cattle egret increased Oklahoma's species diversity by adding a species and its functions to the communities it inhabits.



Cattle egrets have dispersed into North America from Africa.

Dispersal into the state helps maintain genetic diversity within species. Individuals moving into Oklahoma breed with residents and contribute new genes to the population. This keeps Oklahoma's populations from becoming genetically isolated and

suffering from possible negative effects associated with that isolation.

Seasonal migration increases Oklahoma's biodiversity, especially for birds and bats. More than one-third of Oklahoma's breeding birds are Neotropical migrants, birds that breed in North America and winter in Central and South America. These birds enter Oklahoma in the spring to exploit the flush of insects and other invertebrate production that occurs during the growing season. The birds raise their young and then migrate south to spend the winter. Migration enables these birds to use Oklahoma's communities during a season of surplus production and to move to tropical environments during the winter when insects are more scarce here. These birds significantly enhance each level of biodiversity by increasing species diversity during the growing season and influence community structure by feeding on insects and serving as food for predators. This seasonal dispersion results in a yearly fluctuation in the biodiversity of an area.

Corridors, narrow strips of native vegetation connecting similar communities, often allow species to move among blocks of suitable habitat. In central and eastern Oklahoma, rivers and streams may serve as corridors for forest species because they can support strips of forest in areas surrounded by prairies. Many aquatic species disperse in rivers. Grassland species in the Ozark Highlands and Ouachita Mountains rely on dry ridgetops supporting grassland communities for dispersal.

In summary, dispersal not only allows new species and communities to move into the state or some to move out, but also increases biodiversity by allowing gene mixing to occur and by allowing species to move among suitable habitats and colonize new areas.

Isolation

Due to Oklahoma's diverse topography and distribution of natural communities, populations of a species may become isolated. Disturbance, succession or topographic features may cause areas surrounding a local population to become unsuitable for the species, isolating it from other populations. Given sufficient time, these isolated populations often develop unique characteristics.

Populations of species with limited dispersal abilities are more easily isolated. The slimy salamander, a

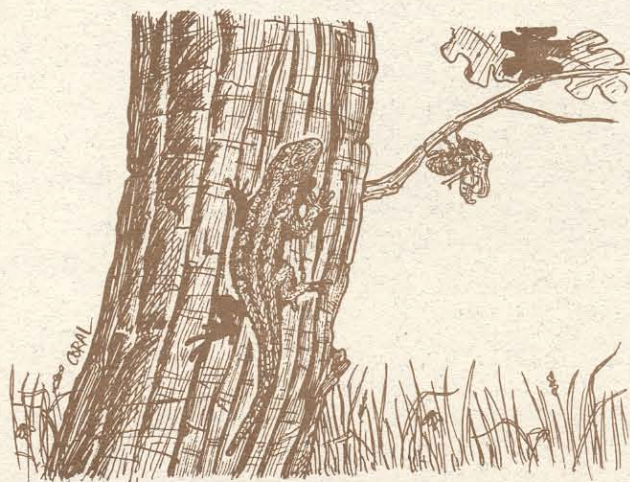
small, black salamander covered with small white dots, inhabits much of eastern Oklahoma in the Ozark Highlands, Arkansas Valley and Ouachita Mountain ecoregions. In the Ouachita Mountains, these salamanders are isolated on ridgetops because the intervening valleys are unsuitable for them. This effectively isolates populations on each mountain. As a result, the slimy salamander has been divided into thirteen species, three of which occur in Oklahoma. Although these species are not easily distinguished by appearance, continued isolation may, in time, result in further divergence that may result in even greater morphological distinctions. Differentiation of these salamander populations has increased the biodiversity of Oklahoma and the world since each species is found only on its respective mountain, such as the Rich Mountain salamander. The Sequoyah slimy salamander is found only in Oklahoma.

Local Adaptation

Isolated populations often manifest genetic differences that help them survive in their localized environments. Because a local population does not need to survive under every condition encountered by the entire species, characteristics that increase survival under local conditions eventually dominate the population. This is termed **local adaptation**.

Local adaptation may occur at a variety of scales. The slimy salamander is specialized to individual ridgetops within the same mountain range. Other species that inhabit a wide range of communities often exhibit adaptations to much larger areas, such as an ecoregion. Fence lizards, small brown or gray lizards, are found throughout Oklahoma and inhabit virtually every terrestrial community. Oklahoma has four subspecies of fence lizards and each is specialized for survival in its own region. The eastern subspecies lives in forested areas in eastern Oklahoma and often climbs trees to escape predators. Its grayish color and a mottled or broken pattern serve as camouflage and allow it to blend with tree bark and sun-and-shade patterns. Fence lizards inhabiting prairies, where the thin lines of grasses and twigs predominate, are brown with four narrow stripes extending from head to tail and little or no mottling on the back. While fleeing along the ground, the stripes cause the lizard to melt into the background of grasses and twigs, confusing

would-be predators. Because the fence lizard encounters such a wide range of conditions in Oklahoma, populations have become specialized (**adapted**) to local conditions they encounter.



Fence lizards in eastern Oklahoma are mottled, which allows them to hide on tree trunks.

Adaptation to local conditions requires genetic diversity so that different traits may be expressed at varying times and places. This results in the species being able to inhabit a much larger range and occupy a greater variety of natural communities.

Speciation

Although isolated populations may become new species, as with the slimy salamander, speciation occurs at such a slow rate that this phenomenon is irrelevant in terms of compensating for human-induced losses in biodiversity. The rate at which many human activities decrease biodiversity is many times greater than the rate at which an isolated population may become distinct from the remainder of its species. Therefore, any increases in biodiversity through speciation are insignificant in slowing current declines in biodiversity. In fact, many factors that decrease biodiversity act so quickly and change conditions so dramatically that populations are extirpated.

Natural Disturbance and Succession

With a few exceptions, Oklahoma's natural communities require occasional or periodic natural distur-

bance for continued existence. While some disturbances only alter existing communities, others eliminate all standing plant material and set back succession to a bare-soil stage. Intensities of natural disturbance vary across the landscape, creating a mosaic of successional stages. This provides a complex community structure that supports our large diversity of species. Fire, floods, droughts and grazing bison and prairie dogs are primary sources of natural disturbance that shaped Oklahoma's biodiversity prior to settlement.

Most of Oklahoma's ecoregions depend on fire to maintain their natural communities. Oak and pine savannas of central and eastern Oklahoma depend on fire to maintain a community with scattered trees and a rather open understory of grasses and wildflowers. Prairies of north-central and western Oklahoma rely on recurring fires to keep woody vegetation from encroaching so that prairie plant species can regenerate. Lightning strikes and Native Americans ignited most fires in the past. Today, prescribed burns can be used to maintain or restore these communities.

Numbering in the millions, plains bison once constituted a major ecological force on the Oklahoma landscape. Like cattle, bison are predominantly grazers, though cattle will eat more **forbs** (broad leaved plants) and **browse** (woody twigs such as shrubs). These and other characteristics of bison resulted in substantially different ecological impacts from those later imposed by its domestic counterpart.

Bison, for example, formed huge herds that moved over vast areas. Their grazing was intensive and short-term, with enough rest periods between herd visits to allow range recovery. Unlike cattle, bison also wallowed, creating depressions in the prairie soils. These wallows formed microhabitats that held moisture longer than the surrounding prairies, enhancing the diversity of small plant and animal species.

In conjunction with fire, bison shaped and maintained a mosaic of habitat conditions on Oklahoma's plains. Fires, both lightning and human-caused, stimulated lush plant growth. Bison, attracted to these sites, grazed them more heavily than adjacent unburned sites. Heavily grazed stretches of prairie were less able to carry the next round of fires. Thus, a shifting mosaic was created by the interaction between fire and bison grazing.

Another form of disturbance important to Oklahoma's biodiversity is the flooding of rivers following periods of heavy precipitation. Large floods scour depressions or cause channel shifts that become isolated from the river. These develop into wetlands and often contain a surprising variety of fish, amphibian, invertebrate and plant species among others. Subsequent flooding helps to refill these wetlands and replenish both species and genetic diversity in the system. The Arkansas darter, a small member of the perch family, relies on these isolated pools for summer survival in northwestern Oklahoma. This fish species occurs in shallow, vegetation-choked pools along the Cimarron River which provide summer refuge. The darters enter the river when floods overflow these pools and wash individuals downstream to new habitat. Floods are responsible for creating and maintaining these unique riverine wetland communities.

Floods also scour away vegetation that has grown in the floodplain and stream channel. Because they seldom completely remove all vegetation from large areas, floods also create a mosaic of successional stages ranging from bare mudflats or sandbars to old growth bottomland forest. Endangered least terns nest on sandbars that have been newly created or scoured of vegetation. Many tree and herbaceous plant species living in bottomland forests require periodic flooding to survive and reproduce. Waterfowl need seasonal flooding to provide the shallow wetlands they use. Several fish species depend on seasonal flooding to trigger spawning; flooded areas also serve as nurseries for many fish species, including popular game fish.

Community or Species Restoration

Restoration of lost species or natural communities also is important to Oklahoma's biodiversity. Efforts to restore extirpated species or those with very low populations have been popular and relatively successful for many years. Several game species in Oklahoma, including white-tailed deer, wild turkey and elk, were nearly eliminated from the state by the early 1900s. Restocking efforts, along with proper population and habitat management, have restored their populations so that they may again be hunted. In fact, some occur in higher numbers now than prior to settlement. Other species successfully reintroduced in Oklahoma include the bald eagle and river otter.

Efforts in Arkansas aided Oklahoma's recovering river otter populations and restoration efforts for black bear in Arkansas have bolstered the species' populations in Oklahoma.

Although important, species restorations usually are expensive and narrow in focus. Now, managers are focusing on restoration of natural communities, allowing natural processes to restore characteristic species. This may be accomplished by restoring ecological processes that develop or shape the community, such as plant succession, fire, flooding or reintroduction of important species such as bison or prairie dogs. This is much more cost-effective than attempting to reintroduce each species individually.

An example of community restoration is an 18-acre (7.3-hectare) playa lake in the Panhandle that was donated to the Oklahoma Department of Wildlife Conservation. The playa had been farmed for wheat for many years so all native vegetation was gone. The playa also was severely degraded by siltation. The Department removed one foot of silt from the center 5 acres (2 hectares) to increase depth and installed a pump to allow regulation of water levels. Native grassland was restored around the perimeter to reduce the amount of silt entering the playa. Many species, both plant and animal, have returned to the recovered wetland.

Ecological Processes That Decrease Biodiversity

Although some ecological processes, such as isolation, may result in a net loss of biodiversity, human activities have been the major cause for declines. As we change the environment to meet our needs, we often alter natural communities so they become unsuitable for many species. The most serious impacts deal with the destruction or degradation of communities and the ecological processes on which they depend.

Although many human actions may result in a loss of biodiversity, few are more obvious than the destruction of natural communities for development, agriculture or other uses. Paving over a native prairie for the

development of a parking lot and shopping center, for instance, obviously results in the loss of that community. Draining or filling wetlands and clearing forests are other examples of destruction of natural communities.

Other activities may not completely destroy the community but degrade it to the extent that biodiversity is decreased. Water pollution may eliminate some aquatic species but not completely destroy the community. Vandalizing caves or disturbing bats so that they abandon the cave degrades the cave's value for the whole cave community. Improper grazing practices resulting in overgrazed pastures or woodlands decreases the value of the community but normally does not render it useless to all species.

Humans often simplify natural communities to meet a particular need. Grain fields, grass lawns and planted pastures are alterations of natural communities that have encouraged single species over large areas, resulting in extensive **monocultures** (areas dominated by a single species). Although monocultures still retain some of the functions of a community, their biological value is decreased and several problems may erupt because of the simplified system. Pest species often attain high numbers in monocultures because species that prey on pests are unable to carry out their life cycles in this simplified system. Studies have shown that planting a variety of crops in a field and leaving hedgerows or other cover nearby encourages predator species that can help control insect or rodent populations that could damage crops.

Habitat Fragmentation

Although habitat fragmentation, in theory, may appear to increase biodiversity by isolating populations and forcing local adaptation, fragmentation on a large scale usually has a serious negative effect on biodiversity. The most obvious effect of fragmentation is loss of habitat for a species, resulting in a population decline. Fragmentation also decreases biodiversity in more subtle ways through disruption of dispersal and edge effects. Each of these is discussed below.

Reduction of habitat size. Fragmentation decreases the amount of area supporting a natural community by reducing the average tract size and total area occupied by the community. This results in losses of species and population declines.

Because less room is available, population sizes are reduced. Even if individual remnants are connected with corridors, less area is suitable for those species, causing their populations to decrease. Because species are not evenly distributed within a community, they may immediately be lost when an area is fragmented, leaving remnant patches with an incomplete sample of the community.

Some species require large expanses of habitat for survival. Small tracts often are smaller than the territories of these species with the result that populations of these species cannot survive. Species affected in this manner usually are large and move across vast areas. Black bears and mountain lions, for example, have large home ranges or territories and require large tracts of forest to support their populations.

Disruption of dispersal. As fragmentation of communities breaks them into smaller fragments, populations of a species become more dependent upon genetic contact with other populations for survival. As communities are fragmented through development or agriculture, small, isolated patches are left with no link to other patches. As a result, each remnant piece must be able to function independently if it is to survive. Members of species able to disperse over long distances may be able to interbreed with individuals in other habitat fragments. However, species decline or are extirpated if the fragment is too small. In heavily fragmented areas, survival of local populations often is totally dependent upon corridors linking suitable habitat fragments.

An example of what may happen in an isolated fragment may be seen in a city park surrounded by development with no link to other tracts of similar habitat. Parks generally are small, populations of resident species usually are reduced to the confines of the park, and because there is no genetic interchange with other populations, species lose genetic diversity due to inbreeding. This stresses the population and may eliminate it over time. Exotic species occurring in large populations in surrounding developed areas are able to outcompete the isolated populations of native species in the park. Therefore, exotic species soon replace the native species and change the structure of the community. Some bird species, which can disperse long distances, still will use the park but exotic species, like house sparrows and rock doves, will become more

common. The small-mammal community probably will become dominated by house mice and Norway rats. Because exotic species usually cause more nuisance problems than the native species they replace, the shift in community structure degrades its value to humans as well. If a corridor to another natural community is maintained, such dramatic community changes may not occur in the park because native species can move along the corridor, interbreed and supplement the population. Similar circumstances would occur in a small woodlot surrounded by agricultural fields or other situations where a fragment becomes isolated.

Edge effect. As an area is fragmented, the amount of **edge** (the boundary between distinct communities) dramatically increases. For years, managers have recognized that many species, including many game species, benefit from moderate levels of edge. However, extensive amounts of edge created by severe fragmentation often have serious effects on many wildlife and plant species.

Creation of edge often changes **microclimate conditions** (climate on a small area) that can alter the community structure. These changes often extend into the community for some distance, creating an **ecotone** (gradient between the two communities). For example, when a forest is fragmented, sunlight penetrates into the forest along the edge of the clearing. Temperatures increase, humidity is lowered and more light reaches the forest floor. Wind velocity is higher along forest edges, causing the area to be drier than in the forest interior. These changes cause the forest-floor microclimate to resemble that of an open grassland and cause a shift in the plant and wildlife species present. These changes are especially important to plants, amphibians and reptiles adapted to living in heavily forested communities; such changes in microclimate often result in extirpation of these populations. Edges and fragmentation also affect grassland communities.

Another consequence of large amounts of edge is decreased reproduction and survival of many wildlife species living in edge habitats. Because edges often support high densities of wildlife and contain sufficient cover, predators concentrate their foraging efforts within edges. Predation rates on birds and small mammals are often higher in edges than in interior

sites. Brown-headed cowbirds pose an additional threat to birds nesting in edge areas. Cowbirds lay eggs in the nests of other bird species, often removing some of the owners' eggs. After hatching, young cowbirds kill other nestlings or starve them by demanding most of the food brought by the foster parents. Cowbirds are most common in edge areas where they sit in trees and scan surrounding areas for nesting activity, seldom venturing deep into interiors of either grassland or forest communities. Extensive fragmentation has increased cowbird populations dramatically and contributed to declines of many other bird species. Cowbird parasitism remains a significant obstacle to the recovery of the endangered black-capped vireo, found only in Oklahoma, Texas and northern Mexico.



Fragmentation makes many bird species vulnerable to brood parasitism by brown-headed cowbirds.

Disruption of Natural Processes

Because fire is such an important component of most of Oklahoma's ecoregions, fire suppression has had a negative impact on a large variety of species and natural communities. As an example, due to fire suppression, various shade-tolerant hardwood species have replaced or filled the understory of shortleaf pine savannas of the Ouachita Mountains, causing a major change in the community structure. Red-cockaded woodpeckers, one of many species that depend on pine savannas, abandoned woodpecker colonies as hard-

woods developed in the understory. Although once widely distributed throughout the Ouachitas, this endangered woodpecker now occurs only in the McCurtain County Wilderness Area where restoration efforts are being conducted, including the reintroduction of fire. Several plant species that have become rare in Oklahoma are abundant in woodpecker colony sites where the pine savanna has been restored. Although wildfires cannot be tolerated today because of human needs, prescribed fires may be used to simulate the functions wildfire historically played. These burns must be carefully planned and implemented to produce the desired results. Too frequent or improper burning can negatively affect biodiversity.

Alteration of stream and river flows by dams or channelization has resulted in a significant loss of aquatic or semi-aquatic and wetland biodiversity in Oklahoma. Seasonal flow fluctuation, including flooding, has been reduced, affecting natural communities and species downstream from the dam. Without floods to build or clear sandbars of vegetation, least tern populations have declined so dramatically that they now are endangered. Isolated pools and wetlands along the stream or river dry up and are lost. Dams also interrupt the life cycles of fish that move upstream to headwater streams to spawn. Paddlefish are unable to move upstream past dams to reach spawning areas in rivers, which often are unsuitable because they are inundated by the reservoir.

Rapid fluctuation in water levels due to erratic releases from dams affects fishes that depend on floods for spawning. When water is released, the increased water flow triggers spawning in several prairie fish species, including speckled chubs, plains minnows and Arkansas River shiners. The fertilized eggs float downriver, where the young hatch and develop. When the release of water is decreased later in the day, eggs and young are stranded on the banks or streambed. This daily fluctuation in river flow may have contributed to the decline in the Arkansas River shiner, a state-listed threatened fish species now proposed for federal listing.

Alterations in predator/prey relationships also decrease biodiversity. Changes in predator or prey populations can affect other species of the food web. For example, mountain lions, once occurring throughout Oklahoma, depend upon deer or other ungulate

populations for food. At the turn of the century, market hunting and habitat destruction nearly eliminated Oklahoma's deer population. In 1917, only an estimated 500 deer remained in the state. With their food source destroyed, mountain lions were unable to survive and disappeared from Oklahoma. Since then, deer have rebounded through good management and mountain lions are returning in low numbers. Changes in prey populations have been a major cause for the disappearance of the mountain lion and for its return.

Historically, the grazing and wallowing of bison had a significant effect on Oklahoma's biodiversity. The extirpation of bison, or confinement to fenced areas, has ended the nomadic grazing habits of bison that contributed to the mosaic that made prairie communities so diverse. Except in a few isolated areas, namely the Wichita Mountains National Wildlife Refuge and The Nature Conservancy's Tallgrass Prairie Preserve, the interaction of bison grazing and fire are no longer present in Oklahoma.

Reduction in Population Size

Most factors that decrease biodiversity usually begin with declines in species' populations. However, as population sizes decline, additional factors may threaten the existence of the species. These include an increased chance of elimination by catastrophe, shifts in population structure and losses of genetic diversity due to genetic drift and inbreeding.

Catastrophes. The damage to a species caused by a catastrophic event, whether natural or human-related, is greater for one having very low numbers or limited distribution. The likelihood that a severe storm, disease outbreak, predation, contaminant spill or habitat alteration will eradicate a species is higher for one that is restricted to a small area or has low numbers.

Population structure. Small populations are more likely to exhibit shifts in population structure than are larger ones. Imbalances in sex or age ratios can have serious ramifications for already imperiled species. For example, siltation and water pollution reduced the population of the Ouachita rock pocketbook, a mussel inhabiting the Kiamichi River in southeastern Oklahoma, until fewer than 1,000 remain today. Recent surveys have shown that the youngest individuals are 12 years old, indicating an age ratio imbalance caused

by the lack of successful reproduction during the last 11 years. The alligator gar is an example of a fish species with an imbalance in both sex and age ratios. The last recorded successful reproduction occurred in 1980, and some biologists suspect that Oklahoma's population is composed primarily of old females.

Genetic factors. **Genetic drift** (shift in genetic traits in a species due to chance factors) can lead to the loss of genetic diversity due to random events, an effect that can be especially pronounced in small populations. In small populations, a comparatively few genes can eventually dominate the population to such an extent that individuals are very similar genetically. Although this may result in local adaptation, genetic drift in very small populations increases the probability of extinction. Genes that cause deleterious effects are often recessive and masked in healthy populations. However, through genetic drift these genes may become more prevalent in the population and begin to be expressed. Reproductive success often is reduced as a result. Other potential problems include genetic deformities, reduced resistance to disease and inability to adjust to changes in the environment. The black-footed ferret, one of the nation's most endangered mammals, once inhabited Oklahoma's prairie-dog towns. Numbers of ferrets became so low that they were thought to be extinct until a very small population was discovered in Wyoming. Although numbers have increased through captive breeding, several genetic problems, including deformed tails, resulting from the limited gene pool have been documented.

Hybridization

Hybridization may result in loss or destruction of biodiversity. Whether it occurs because the species are no longer geographically separated or because the population of one species becomes very low, hybridization may completely eliminate one or both species involved.

The red wolf, a small wolf somewhat larger than a coyote, once occurred throughout the southeastern United States, including portions of Oklahoma. Due to habitat destruction and predator-control efforts, red wolf populations were greatly reduced and fragmented. Because of the difficulty in locating appropriate mates, wolves began interbreeding with coyotes. Because

coyote populations were very high, this hybridization had little effect on that species. However, coyote genes soon swamped those of the wolves to the extent that only a handful of nearly pure red wolves were left when recent restoration efforts began.

Species Eliminations

When a species is lost, species richness declines. Although this is an obvious loss of biodiversity, species eliminations often affect the community or other species in ways that might not be immediately obvious. Some species, such as bison and prairie dogs, perform functions that are vital to the health of the entire biotic community. Many other species depend upon these species or the effects they exert on the community structure. These species are termed **keystone species** because they influence a host of other species through their actions. The loss of a single species may have a ripple effect on the entire community, often resulting in further losses of biodiversity. Because our knowledge of the functions of natural communities is incomplete, the ramifications of losing a species cannot accurately be predicted.

Prior to the early 1900s, gray wolves roamed Oklahoma as its second largest predator. Because wolves commonly killed coyotes, coyote populations were low in areas supporting gray wolves. With the destruction of bison, their primary food source, and intense control from bounty hunters, ranchers and federal predator control agents, the wolf was extirpated from the state by 1934. Since then, coyote populations have increased dramatically and cause problems in some areas. Similar relationships exist between coyotes and red foxes. In areas where coyote populations are significantly depressed through trapping and shooting, red foxes soon become more abundant. Along with the shift in dominant carnivore species, populations of prey species also may change. When a large predator is eliminated, prey species too large for smaller predators may increase rapidly due to the lack of natural controls. Mountain lions and wolves once were major predators of deer. Without control, deer populations often become so dense that they damage the very habitat upon which they depend. Direct human control, usually by hunting, is vital to keep ungulate populations at healthy levels, since natural controls no longer are present.

Species Introductions

Humans have introduced hundreds of species that have spread into Oklahoma's natural communities. Some of these were accidental; others were purposeful. Although introduced species might add to the number of species in the region, they often compete with native species and cause a net loss in biodiversity. While the effects of many are relatively benign, other introductions have had tremendous impacts on natural communities.

Two species intentionally introduced are the European starling and house sparrow, brought to North America from Europe during the 1800s. These species spread rapidly until they are now found nearly continentwide. Highly aggressive, they drive native cavity nesters from their nests and also have become significant agricultural and urban pests. The common carp was introduced to the United States as a food fish, but the expected popularity never developed. However, carp rapidly spread throughout the continent's rivers and streams, severely disrupting many aquatic communities.



Introduced house sparrows drive native cavity nesters, such as wrens, from nesting sites.

Accidental introductions also have affected Oklahoma's biodiversity. The Asiatic clam, introduced into Oregon or Washington during the 1930s, was first found in Oklahoma during the early 1970s. The clam quickly spread throughout Oklahoma's major rivers and reservoirs. Able to reach densities of tens of

thousands per square meter, these filter feeders remove so many nutrients from the water that native mussel species may be unable to meet their nutrient needs. The clam's high densities also create economic problems by clogging water intake pipes of water plants and industries, and require expensive maintenance procedures. The zebra mussel, a Eurasian species found in Oklahoma in 1993, has caused similar problems in other states. The problems associated with water systems is greater for this species because it attaches to the pipes, requiring regular scraping for removal rather than the high-pressure spraying used for Asiatic clams. The zebra mussel may increase in Oklahoma and cause similar problems here. Fire ants, accidentally introduced to Alabama from Brazil, have reached into central Oklahoma from the south. These aggressive ants eliminate native ant species and may affect other insect and insectivore populations. Reaching very high densities, fire ants can quickly overcome young, small or weak wildlife they happen to find. They have become significant pests both in urban and rural areas and control is difficult and expensive.

Because plants are so important in the physical structure of natural communities, introduced plants potentially may completely alter a community. Although some plants have been accidentally introduced, many have been distributed and encouraged for a variety of reasons, including soil conservation, livestock forage and wildlife value. However, many of these plants disperse from the planted site and become extensive pests, outcompeting native plant communities and altering the community structure. Sericea lespedeza, for example, was promoted and planted for many reasons. It was useful for quickly establishing plant cover on newly disturbed or poor sites. Rapidly spreading into other areas, sericea has become a serious pest. Old world bluestems, including the "plains bluestem" mix, are Asian grasses that have been promoted as good cover plants. Because they are termed "bluestems" many landowners believe they are planting native grasses. However, these species quickly spread and become major pests. These "bluestems" are even able to invade and become pests in manicured Bermuda-grass lawns. Johnson grass, native to the Mediterranean region, also has signifi-

cantly changed portions of Oklahoma's prairies. Japanese honeysuckle and kudzu often blanket trees and shrubs and destroy the forest community. Where they outcompete native plants, introduced plants can form large monocultures that support very few species.

Myths or Misunderstanding

Although not an ecological process, misunderstanding and misinformation about various wildlife species have profound effects on Oklahoma's biodiversity. Acting on false information, people often destroy populations of species. Myths about vampire bats, the prevalence of rabies in bats and other folk tales, for example, have been a major factor in the destruction of many populations of bats. With education about the benefits bats can provide, myths can be dispelled and people's views often change from that of fear and horror to a desire to protect them or even to attract them to their yards. People's fear of snakes, poisonous and nonpoisonous, has resulted in the demise of innumerable snakes, most of which are truly beneficial. Many people blame hayfever problems on goldenrod and mow or spray to try to alleviate their problems. In actuality, the cause for the allergies is ragweed, which blooms about the same time as the harmless goldenrod.

Perhaps no species suffers from misunderstanding more than the prairie dog. Because people believed that prairie dogs compete with cattle for food and that cattle break legs in their burrows, prairie-dog towns have been destroyed, even by governmental agencies, for much of the last century. Eradication efforts have been so successful that the current population of prairie dogs is only a small fraction of historic numbers. A recent study estimated that prairie-dog towns cover only two percent of the area they occupied historically. In reality, the relationship between cattle and prairie dogs appears to be considerably more benign than most people believe. Before cattle arrived, bison and other herbivores grazed extensively in prairie-dog towns because the vegetation was new growth, rich in nutrients and highly digestible. Rather than competing with ungulates, prairie dogs increase forage value by keeping vegetation cropped so new growth is available throughout the growing season. The rich plant and animal communities that develop around prairie-dog



Contrary to popular myth, bats pose little human threat and provide control of invertebrate pests.

towns also indicate that they have little negative impact on other species. In grazing, cattle show a preference similar to that of bison for prairie-dog towns. Furthermore, controlled studies indicate that weight gain of cattle raised upon prairie-dog towns is similar to that of cattle raised elsewhere. Because they move slowly while grazing, cattle seldom break legs by stepping into prairie-dog burrows. However, destruction of prairie-dog towns, primarily by agriculture, has resulted in the nationwide endangerment of the black-footed ferret and the decline of many other species, such as the burrowing owl. This near extermination has resulted primarily because of widespread misinformation regarding the impacts prairie dogs have on grazing animals.

Rising Demands on Resources

The driving force behind most of the factors that reduce biodiversity is the increasing pressure to produce more commodities for human consumption. Whether due to human population growth or high levels of consumption, increased demand for natural resources and commodities results in higher rates of decline in biodiversity. For every species, there is a point where increases in population size degrade their habitat, eventually making it unable to support their numbers. This maximum sustainable population level is called that species' **carrying capacity**. Humans

also are able to expand their numbers or resource demands to the extent that they make their environment unable to support them. However, unlike other species, we have the ability to recognize these impacts and find solutions to remedy them. We must reach a sustainable level of population size and consumption rate that provides a suitable standard of living and maintains a healthy environment.

Although human population trends in the United States indicate that this nation's population is not increasing appreciably, our lifestyle places high demands on the environment. We must explore new ways to reduce our impacts on biodiversity, whether through more efficient production or reduced waste, so we do not decrease the biodiversity of our environment to the point that makes it unsuitable for us and the diversity of all forms of life

Summary

Most of the factors that maintain or create biodiversity in Oklahoma result in a variety of conditions across the landscape and occur over a long period of time so that species are able to successfully exploit the suitable habitats. Physical factors set the stage on which the ecological processes act to produce the biodiversity within our state.

Maintenance or conservation of biodiversity requires the presence of ecological processes. Most of the factors that decrease biodiversity are interruptions of those ecological processes. A project may not immediately impact the area's biodiversity; however, if the action interrupts important ecological processes or fragments or isolates a community, it may cause long-term losses. When designing a project or determining the need for a proposed action, people should consider whether their action will maintain or decrease biodiversity.

Continued education about biodiversity, conservation and Oklahoma's species and communities will help dispel myths and inform people of ways they can contribute to the conservation and restoration of our state's rich natural heritage.



The nomadic grazing habits of large bison herds created a mosaic of habitat structure on Oklahoma's prairies, ranging from heavily grazed to ungrazed conditions.