Chapter 3: Oklahoma's Biodiversity

Because of its location and geographic expanse, Oklahoma has a wealth of biodiversity. With a linear shape and midcontinent location, the state extends from the Rocky Mountain foothills to the eastern Ozark Highlands, Ouachita Mountains and South Central Plains. Variations in topography, elevation and precipitation produce a wide variety of communities ranging from dry shortgrass prairies to flooded cypress swamps.

Community Diversity

Oklahoma contains parts of 12 **ecoregions** (large divisions based on natural communities, geology and land use) as mapped by J. M. Omernik (see page 18), tying with Texas for the most in the nation. We know that 634 native vertebrate species breed in Oklahoma and an estimated 2,500 plant species occur in the state. Many more species migrate through the state during spring and fall. The number of species of fungi, insects and other invertebrates are unknown, although they certainly outnumber all others combined. A biologist in Latimer County has identified 3,600 species of beetles in that county alone. He has found additional species only a few miles away in LeFlore County.

Because plants form the primary visual structure of an area, communities are generally named and described based on characteristic plant species. For example, a hardwood forest in eastern Oklahoma would be described as being dominated by large oaks and hickories with a well-developed **understory** (layers of trees and tall shrubs growing under the tallest trees) of redbuds, dogwoods and other small trees. However, these communities support many animal species that depend on these particular plant species. Because of this relationship, vegetative characteristics of communities are used here to describe Oklahoma's ecoregions.

However, for many wildlife species, especially vertebrates, the physical structure of the community (e.g., trees, fallen logs, ground cover, water and rocks) is more important for their survival than the presence of certain plant species. For example, wrens will use cavities in any tree species as long as surrounding habitat is suitable.

South Central Plains

Distribution. The South Central Plains ecoregion, part of the Gulf Coastal Plain, occurs in southern Arkansas, northwestern Louisiana, northeastern Texas and the extreme southeastern portion of McCurtain County in southeastern Oklahoma. In Oklahoma, it is bounded by the Ouachita Mountains on the north and on the west by the Central Oklahoma/Texas Plains on the west.

Physical characteristics. This ecoregion is the warmest and most humid in the state. The average annual temperature is 65.6° F (18° C) and the average annual precipitation is 45.4 inches (115 cm). The growing season is about 240 days.

The area is characterized by level to gently rolling plains with a gentle dip to the southeast, while elevation averages around 400 feet (122 m) above sea level. The rich black limestone soils in the region are among the most fertile in the state.

Drainage is south or southeast to the Red River. Streams are sluggish and have steep mud banks.

Species diversity. Three hundred and fifteen vertebrate species are native to this ecoregion. Six species have been **extirpated**, eliminated from the state, and nine have been introduced. Two species are

Table 3.1: Numbers of Species of Various Taxonomic Groups and Classifications in Each Ecoregion.[a]

Taxonomic Group	Ecoregion					
	South Central Plains	Ouachita Mountains	Arkansas Valley	Ozark Highlands	Central Irregular Plains	Flint Hills
Fish						
Total[b]	91	76	90	83	99	40
Native[c]	86	72	83	78	92	37
Introduced	5	4	7	5	7	3
Extirpated	0	0	0	0	0	0
Federal list: E, T, C[d]	0, 0, 0	0, 1, 0	0, 1, 0	0, 2, 1	0, 1, 0	0, 0, 0
State list: E, T, SC[e]	0, 1, 14	0, 0, 3	0, 2, 8	1, 0, 10	0, 2, 9	0, 1, 1
Restricted to ecoregion[f]	2	3	0	7	1	0
Amphibians						
Total	29	34	28	29	26	18
Native	29	34	28	29	26	18
Introduced	0	0	0	0	0	0
Extirpated	0	0	0	0	0	0
Federal list: E, T, C	0	0	0	0	0	0
State list: E, T, SC	0	0	0	0	0	0
Restricted to ecoregion	1	4	0	4	0	0
Reptiles						
Total	57	57	55	54	54	50
Native	57	57	55	54	54	50
Introduced	0	0	0	0	0	0
Extirpated	0	0	0	0	0	0
Federal list: E, T, C	0, 1, 0	0, 1, 0	0, 0, 0	0, 0, 0	0, 0, 0	0, 0, 0
State list: E, T, SC	0, 1, 1	0, 1, 2	0, 0, 2	0, 0, 1	0, 0, 2	0, 0, 2
Restricted to ecoregion	1	0	0	1	0	0
Birds[g]						
Total	116	114	113	117	122	111
Native	113	111	110	114	129	108
Introduced	3	3	3	3	3	3
Extirpated	3	3	3	2	3	2
Federal list: E, T, C	0, 0, 0	1, 0, 0	1, 0, 0	0, 0, 0	1, 0, 0	0, 0, 0
State list: E, T, SC	0, 0, 0	1, 0, 0	1, 0, 0	0, 0, 0	1, 0, 0	0, 0, 0
Restricted to ecoregion	0	0	0	0	0	0
Mammals						
Total	31	56	37	38	38	31
Native	30	54	36	36	36	30
Introduced	1	2	1	2	2	1
Extirpated	3	1	1	1	3	3
Federal list: E, T, C	0	1, 0, 0	0	2, 0, 0	0	0
State list: E, T, SC	0, 0, 1	0, 0, 12	0, 0, 6	0, 0, 3	0, 0, 8	0, 0, 1
Restricted to ecoregion	1	1	0	0	0	0

[a] Numbers are not additive; many species occur in multiple ecoregions.

[b] Includes native and introduced species.

[c] Includes extirpated species.

[d] 1996 Federal Rare and Endangered Species List: E=endangered, T=threatened, C=candidate.

Table 3.1 (continued)

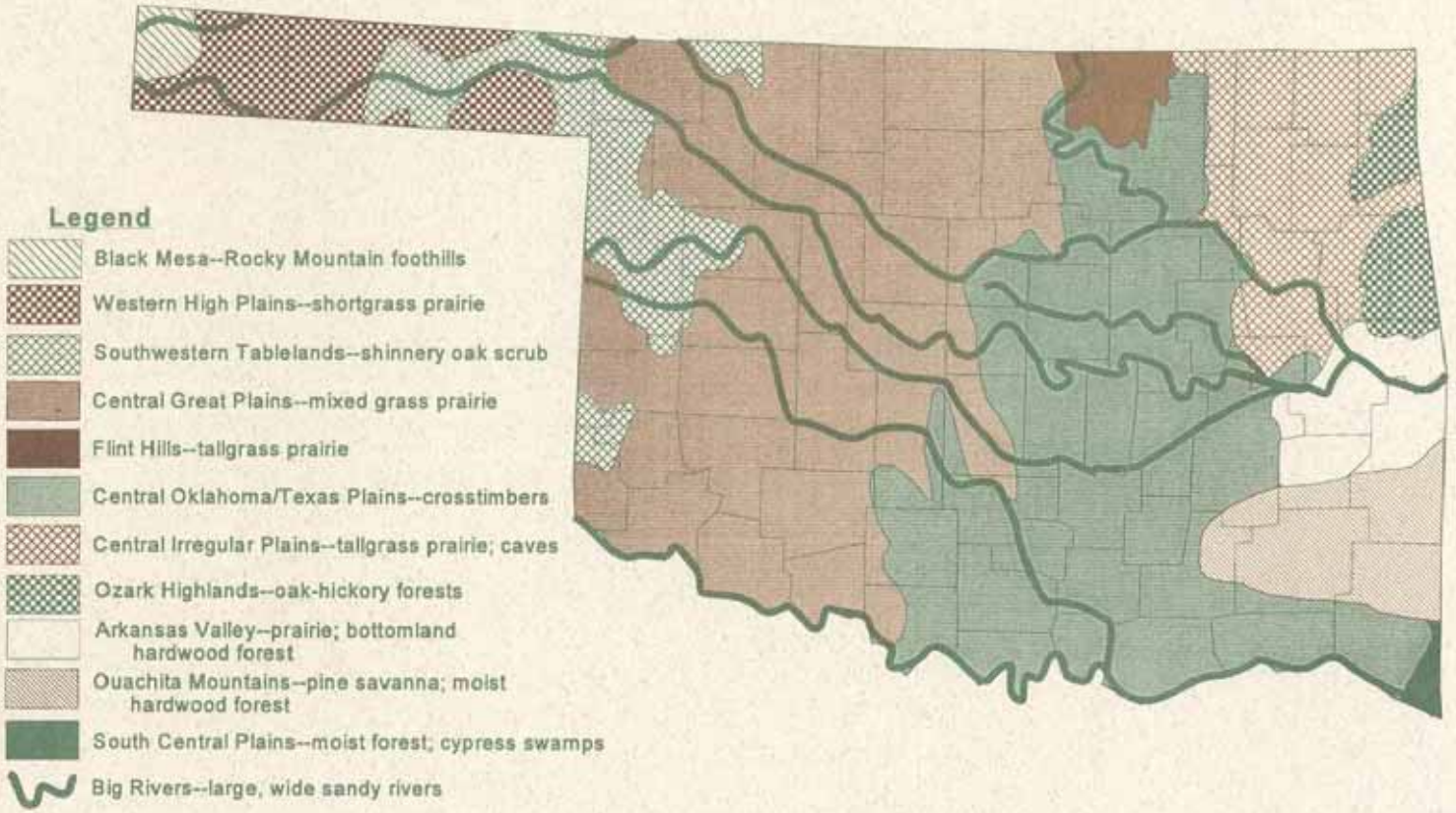
Taxonomic Group	Ecoregion					
	Central Oklahoma/ Texas Plains	Central Great Plains	Southwestern Tablelands	Western High Plains	Black Mesa	Big Rivers
Fish						
Total	91	49	21	20	18	100
Native	86	43	17	16	14	96
Introduced	6	6	1	4	4	4
Extirpated	1	0	2	2	2	0
Federal list: E, T, C	0, 0, 0	0, 0, 1	0, 0, 0	0, 0, 0	0, 0, 0	0, 0, 1
State list: E, T, SC	0, 2, 16	0, 1, 7	0, 1, 3	0, 1, 1	0, 1, 0	0, 2, 10
Restricted to ecoregion	0	0	0	0	0	5
Amphibians						
Total	35	21	16	11	9	
Native	35	21	16	11	9	
Introduced	0	0	0	0	0	
Extirpated	0	0	0	0	0	
Federal list: E, T, C	0	0	0	0	0	
State list: E, T, SC	0	0	0	0	0	
Restricted to ecoregion	0	0	0	0	0	
Reptiles						
Total	69	64	50	36	35	
Native	69	64	50	36	35	
Introduced	0	0	0	0	0	
Extirpated	0	0	0	0	0	
Federal list: E, T, C	0, 1, 0	0, 0, 0	0, 0, 0	0, 0, 0	0, 0, 0	
State list: E, T, SC	0, 1, 2	0, 0, 2	0, 0, 1	0, 0, 1	0, 0, 1	
Restricted to ecoregion	1	0	2	0	0	
Birds[g]						
Total	120	137	103	94	87	9
Native	117	133	99	90	84	9
Introduced	3	4	4	4	3	0
Extirpated	4	1	1	1	1	0
Federal list: E, T, C	1, 0, 0	2, 0, 0	1, 0, 0	0, 0, 1	0, 0, 0	1, 0, 0
State list: E, T, SC	1, 0, 0	2, 0, 0	1, 0, 0	0, 0, 0	0, 0, 0	1, 0, 0
Restricted to ecoregion	0	0	0	0	0	0
Mammals						
Total	48	70	33	35	48	
Native	44	67	31	33	48	
Introduced	4	3	2	2	0	
Extirpated	5	4	6	4	5	
Federal list: E, T, C	0	1, 0, 0	0	0, 0, 1	0, 0, 1	
State list: E, T, SC	0, 0, 1	0, 0, 10	0, 0, 3	0, 0, 5	0, 0, 8	
Restricted to ecoregion	3	3	0	0	10	

[e] 1996 State Rare and Endangered Species List: E=endangered, T=threatened, SC=special concern. Federally endangered and threatened species also are listed as state endangered or threatened.

[f] Species are found only in this ecoregion in Oklahoma, but may occur in other states.

[g] Includes only bird species breeding in Oklahoma.

Ecoregions of Oklahoma



Map based on Omernick, J.M. 1987. Ecoregions of the conterminous United States. Map (scale 1:7,500,000). Annals of the Association of American Geographers 77:(1):118-125.

federally or state endangered or threatened and 16 are are of special concern.

Natural communities. This ecoregion contains some of Oklahoma's most unusual communities, many of which are characterized by species inhabiting very moist soils. Some of these communities and species are found only in this part of the state, although they are widespread throughout the southeastern United States. The dominant community in the South Central Plains is a moist upland forest dominated by sweetgum, black gum, American holly and various oaks. Stands of loblolly pines occur in moist locations. These, along with other species, form tall, dense forests with well shaded floors. Trees of various ages and heights form several canopy layers. Shrub cover may be extensive in openings or areas having sufficient light reaching the ground. Vines such as grape, poison ivy and greenbriar often reach into upper levels of the canopy, creating a dense mass of hanging vines. Ferns and other shade-tolerant plants often cover the forest floor.

Cypress swamps occurring in McCurtain County are reminiscent of the southeastern United States.

Swampy areas occur in low-lying depressions and along rivers and streams. Bald cypress, willow oak, water oak and white oaks form rich, multi-layered forests in these areas. Vines hanging from trees increase the structural complexity of the community. Some sites are flooded most of the year, especially cypress swamps, and develop highly diverse terrestrial and aquatic animal communities.

Drier upland sites are dominated by oak woodlands intermixed with pines. In arid sites, these areas are dominated by scattered bluejack oaks, which form unique communities, with very open understories. Blueberry bushes form a thick, low ground cover and a variety of wildflowers occur on the forest floor.

Tallgrass prairie communities occur in scattered openings. Several plant species that sprout from seeds in cleared portions of the forest include big and little bluestem, Indian grass and a host of wildflowers, forming the structure for a complete tallgrass prairie community. These openings soon become overgrown by trees and return to forest in the absence of repeated disturbance.

In larger wetland areas, an open wetland community occurs, lined by thick canebrakes. Water lilies, lotuses, rushes and cattails often are dominant plant species.

Ouachita Mountains

Distribution. The Ouachita Mountains occur in west-central Arkansas and southeastern Oklahoma. This ecoregion is bounded on the north by the Arkansas Valley and on the west and south by the Central Oklahoma/Texas Plains and South Central Plains.

Physical characteristics. This region's climate is mild and receives the most precipitation in the state. The average temperature is about 63° F (17.2° C). Yearly rainfall averages around 50 inches (127 cm) and the growing season is 210 to 230 days.

This is the most mountainous region in Oklahoma. Sandstone ridges, oriented in an east-west direction, are separated by broad valleys and dominate the landscape. Primary mountain uplifts are the Winding Stair, Kiamichi, Jackfork, Pine, Rich and Blackfork. Summit elevations decline from 2,850 feet (878 m) above sea level on Rich Mountain near the Arkansas border to 750 feet (229 m) above sea level in Atoka County. Ridges rise 1,800 feet (549 m) above the valleys at the Arkansas border and 250 feet (76 m) in Atoka County. The overall slope of the region is south to southwest.

The primary rivers—Kiamichi, Glover and Little—flow south into the Red River. All have clear,

swift-flowing tributaries. Stream beds contain large gravel, rocks or boulders and rock or gravel bottoms.

Species diversity. Three hundred and twenty-eight vertebrate species are native to this ecoregion. Four vertebrate species have been extirpated and nine have been introduced. Three species are federally-listed endangered and 17 are of special concern.

Natural communities. The ridgetops and south-facing slopes of these mountains once were covered by extensive stands of shortleaf pines with scattered oaks and hickories. The open nature of these forests allowed a heavy cover of tallgrass prairie plants and huckleberries to develop on the forest floor. Periodic fires kept the understory relatively free of tall woody vegetation, resulting in a parklike appearance called a "savanna." Bare rock outcrops are common in these communities.

Shortleaf pine savannas support many fire-dependent species, such as the red-cockaded woodpecker.

North-facing slopes and ravines often support a moist forest dominated by hickories, maples, sweetgum and oaks, such as white, northern red and chinquapin. These communities contain many more tree and shrub species than the drier pine forests and have well-developed understory and shrub layers. Ground cover often is sparse and scattered due to the dense shade and thick carpet of leaves. Stunted white oaks form a dwarf forest community along some of the highest ridges.

Tall, bottomland forests occur along streams and other bodies of water. Water and willow oaks, hickories, sweetgum, black gum and basswood dominate these forests. The overstory canopy reaches 100 feet (30 m) in height with two to four other foliage layers beneath. A rich diversity of understory trees and shrubs combine with younger trees of the overstory to form this lush understory. These include flowering dogwood, ironwood, beech, spicebush and buttonbush. In areas where light reaches the ground, lush herbaceous vegetation covers the forest floor. Greenbriar, poison ivy and grapes are common vines climbing into branches of overstory trees.

Tracts of open tallgrass prairie are small and uncommon in this ecoregion. When the forest is cleared, prairie plants grow from seeds that have been dormant in the soil. Animal species that inhabit prairies move into these clearings after the plant community has developed. These clearings rapidly revert to forest if they are not disturbed.

The physical structure of some communities in this ecoregion is dominated by geologic features of the area. Rock slides create unique environments for plants and animals. Scattered trees and shrubs grow between the rocks where soil is shallow. Among the trees are open areas of broken rock that, in moist locations, often are covered by mosses. These rocky areas provide sunning surfaces for reptiles and crevices serving as escape habitat. Mammals, insects and other animals also use crevices between rocks for living quarters. Larger crevices and rock shelters serve as summer bat roosts.

Arkansas Valley

Distribution. The Arkansas Valley ecoregion consists of the lower Arkansas river valley from east-central Oklahoma to central Arkansas. This broad valley separates the rugged Ozark Highlands to the north from the Ouachita Mountains to the south. The Central Oklahoma/Texas Plains form the western border.

Physical characteristics. Annual precipitation in this ecoregion averages about 44 inches (111 cm) and temperature averages 62° F (17° C). The growing season averages 216 days.

Most of the area is characterized by flat lowlands with poor natural drainage. Several isolated hills are

scattered through the plain. The San Bois Mountains, rising 1,231 feet (375 m) above the surrounding plain, are the highest of these hills with an elevation of 1,831 feet (558 m) above sea level. Soils in the area are generally poor except along larger streams.

This ecoregion drains into the Canadian and Arkansas rivers. Tributaries are slow, clear streams.

Species diversity. Three hundred and twelve vertebrate species are native to this ecoregion. Four vertebrate species have been extirpated and 11 have been introduced. Two species are federally-listed endangered and 16 are of special concern.

Natural communities. The Arkansas River Valley forms a break between the Ozark Highlands to the north and the Ouachita Mountains to the south not only in geologic formation but also in community composition. This ecoregion contains some communities found more extensively in the Central Oklahoma/Texas Plains to the west, causing a break in the eastern hardwood forests that are prevalent in the hills and mountains.

Dry forests of post oak, blackjack oak and scattered hickories dominate rugged areas and extend into the plains. These forests contain relatively short, scattered trees (approximately 50 feet [15 m] tall), a significant cover of tallgrassprairie plants on the floor and little or no understory layer.

Wide bands of bottomland hardwood forests line the rivers in the Arkansas Valley ecoregion.

Shortleaf pine savannas and mixed pine-hardwood forests occupy ridgetops of this ecoregion. Because these forests are an extension of those dominating the Ouachita Mountains, they are similar in structure and function.

Tallgrass-prairie communities containing bluestems, Indian grass, switchgrass and other tall grasses dominate much of the broad valley. A wide variety of wildflowers and other plants also are present in great numbers. Prairie communities often are scattered between dry upland forests and bottomland hardwood forests that occur along streams. Fire is an important component in maintaining these communities.

Lush forests of oak, elm and hackberry occur along streams and rivers. These tall forests (about 100 feet [30 m]) usually have two or three other levels of trees below the overstory and often accumulate dense mats of leaves and other litter. Scattered clumps of low vegetation thrive in these heavily shaded forests, except in openings, where a lush growth of herbaceous plants cover the ground. Grape, poison ivy and greenbriar vines are common.

Ozark Highlands

Distribution. The Ozark Highlands ecoregion is located in northeastern Oklahoma, the southern half of Missouri and northern Arkansas. The Central Irregular Plains form the western boundary and the Arkansas Valley borders the Ozarks on the south.

Physical characteristics. The average annual temperature for this ecoregion is 60° F (16° C) and the annual rainfall averages about 42 inches (107 cm). The growing season averages 209 days.

The topography of this ecoregion consists of rugged hills and low mountains formed by the eroded Ozark Plateau. The greatest elevation of these highlands in Oklahoma is approximately 1,500 feet (457 m). Hills rise up to 400 feet (123 m) over stream valleys in this part of the Ozarks. As a whole, the surface slopes toward the southwest. Because the underlying geologic formations are primarily of limestone, caves, sinkholes and springs are common throughout the area. Soils are fertile but quite stony.

Drainage is primarily to the Grand and Illinois rivers. All of the numerous tributaries are clear, cool and rather swift-flowing. Extensive underground drainage results in a large number of springs.

Species diversity. Three hundred and eleven vertebrate species are native to this ecoregion. Three

vertebrate species have been extirpated and 10 have been introduced. Three species are federally-listed endangered and one is a candidate for listing. Oklahoma lists 14 species as being of special concern.

Natural communities. Dry oak-hickory forests occur on well-drained soils of slopes, hills and plains and are the major component of the Ozark landscape. Trees are medium in height at 20 to 60 feet (6 to 18 m). The relatively open canopy allows a thick understory of slow-growing shrubs and trees. Areas of exposed rock are common. Blackjack oak, post oak, white oak, black hickory and winged elm are common overstory trees and coralberry, huckleberry and sassafras are representative of the understory.

A taller forest community is present in protected ravines and on moist or north-facing slopes where soils are deep and well drained. These forests are 60 to 90 feet (18 to 27 m) in height. The closed canopy shades most of the forest floor, where shade-tolerant shrubs and trees form a well-developed understory. Sugar maples are scattered among white oaks, chinquapin oak and hickories in the overstory. Common understory trees include redbud, flowering dogwood and pawpaw; spicebush, sassafras and coral berry are common shrubs. Shade-tolerant herbaceous plants often blanket the forest floor in early spring before tree leaves produce shade. These include May apple, dogtooth violet and bloodroot. Mosses, ferns and liverworts also are abundant on the moist forest floor.

Very dry, rocky ridgetops and open slopes support tallgrass prairie communities that are sparsely vegetated with stunted grasses; red cedars, post oaks and blackjack oaks may be present in small numbers and limestone outcroppings are common. Prairies on slopes with deeper soils are more lush and heavily vegetated, closely resembling tallgrass prairies to the west. Big and little bluestem, Indian grass and a variety of wildflowers are characteristic of these tallgrass communities.

Bottomland hardwood forests occur along floodplains of larger streams in the Ozark Highlands. These forests have tall overstories of oak, sycamore, cottonwood and elm. Flash flooding scours understories and keeps them clear of most vegetation. The forest floor is often covered with gravel, sand or a thick layer of humus and grasses.

Cool Ozark streams support many aquatic species and serve as foraging areas for many bat species.

In many areas, the limestone formation underlying the Ozark plateau has dissolved, forming caves that support a remarkably diverse animal community. These systems are unique ecologically in that no living plant component is present to form the base of the food chain. Rather, these communities depend upon roosting bats and floods to carry energy into the cave in the form of guano and plant debris. Many of these caves have streams flowing along the floor, containing **obligatory** cave species (species found only in caves). Other wildlife species also use these caves for shelter and other purposes.

Central Irregular Plains

Distribution. The Central Irregular Plains ecoregion occurs in northeastern Oklahoma and extends into Kansas, Missouri and Iowa. The Ozark Highlands form the eastern boundary, the Arkansas Valley borders to the south

and the Central Oklahoma/Texas Plains and Flint Hills form the western border.

Physical characteristics. The average annual temperature for this ecoregion is 60° F (16° C) and average rainfall is about 40 inches (102 cm) annually. The growing season is approximately 218 days.

Low rolling hills dominate the landscape, which gently slopes to the southeast. Some hills in the northern portion are slightly higher than 1,000 feet (305 m) in elevation and rise about 200 feet (61 m) above the valleys. Soils are relatively deep and fertile except on limestone outcrops.

The Arkansas, Grand and Verdigris rivers drain the ecoregion. Tributaries are sluggish, muddy and form broad floodplains.

Species diversity. Three hundred and twenty-seven vertebrate species are native to this ecoregion. Six vertebrate species have been extirpated and 12 have been introduced. Four species are federally-listed endangered and 19 are of special concern.

Natural communities. The Central Irregular Plains are essentially a band of tallgrass prairie separating the forested Ozark highlands and Central Oklahoma/Texas Plains. Tall grasses, up to 8 feet (2.5 m) in height, dominate the prairie plant community. Although tall, these grasses grow in distinct bunches, enabling small animals to move freely through the prairie. Big and little bluestem, Indian grass and switchgrass are the primary grass species. Sunflower, Indian blanket, blazing star and other wildflowers grow among the grasses. These provide nectar for hummingbirds and insects and seeds for small mammals and birds. These grasslands are relatively free of shrubs except at borders with woodlands or clumps of persimmon trees in drainages. In dry locations, limestone and gravel often are exposed, forming sparsely vegetated or bare outcroppings.

Dry upland forests, similar to those dominating the Ozark Highlands, occur in draws and ravines where water is more available. Dominated by post oak, blackjack oak and black hickory, these forests are short and open. A heavy cover of grasses and herbaceous plants of the prairie grow in unshaded parts of the forest floor. Sumac, coral berry and persimmon form dense thickets along forest borders.

Broad floodplains support forests of elm, oak, hackberry, cottonwood and sycamore. Because streams slope gently, the forest floor is not as heavily scoured as bottomlands in the Ozarks. The floor is heavily shaded with little undergrowth and a layer of leaf mold often is present. In unshaded areas, shrubs—such as sumac, elderberry and strawberry-bush—grasses and other herbaceous plants occur. In poorly drained sites, sedges and buttonbush form thickets and willows occur along edges of floodplain wetlands.

Eastern forests gradually blend into tallgrass prairies in the Central Irregular Plains.

Caves, like those found in the Ozarks, have formed in areas of limestone outcroppings. Bat droppings and debris washed into the caves during floods provide the energy necessary to support the many unique cave species. These caves also contain obligatory cave species, as do those in the Ozarks. Other species able to live outside caves also use caves for shelter and foraging areas.

Central Oklahoma/Texas Plains

Distribution. The Central Oklahoma/Texas Plains begin in north-central Oklahoma and extend into central Texas, with the portion in Oklahoma becoming wider in the southern half. The Central Great Plains form the entire western border, the Flint Hills form the

northern border and the Central Irregular Plains, Arkansas Valley, Ouachita Mountains and South Central Plains join this ecoregion on the east.

Physical characteristics. Average annual temperature in the Central Oklahoma/Texas Plains is 61° F (16° C) and rainfall averages 40 inches (102 cm). The growing season is about 220 days but varies from north to south.

Overall, the plain slopes to the southeast. Elevation varies from 1,200 feet (366 m) in the western and northern parts to 600 feet (183 m) along the Red River. The topography of this region is rolling or rough with pronounced hills and escarpments. Soils are deep and fertile. The Arbuckle Mountains, a range of rugged hills, occur in the southern part of this ecoregion.

The Cimarron, North Canadian, Canadian, Washita and Red rivers provide the major drainage. In general, this region's rivers and their tributaries are sluggish, muddy and braided, divided into several channels by sandbars. They usually have broad floodplains. Streams draining the Arbuckles are an exception, in that they are clear, cool and swift, typical of mountainous areas.

Species diversity. Three hundred and fifty-one vertebrate species are native to this ecoregion. Ten species have been extirpated and 13 have been introduced. Four species are federally- or state-listed threatened or endangered, and 19 are of special concern.

Natural communities. The rolling sandstone hills of the Central Oklahoma/Texas Plains support a mosaic of natural communities and are a transition zone between the large eastern forests and the vast grasslands of the plains. In more level northern and southern portions of the ecoregion, prairie communities cover most of the landscape, with woodlands occurring on some slopes, in draws and along streams and rivers. Throughout the central part of the ecoregion, dry upland forests blanket the hills and bottomland forests occur along streams. Small prairies are scattered throughout this part of the ecoregion.

Upland forests occurring in this ecoregion are called **crosstimbers**. When explorers first crossed Oklahoma territory, they encountered large grasslands after leaving the eastern mountains. They then entered a wide belt of timber that "crossed" the plains and termed it "crosstimbers." These open forests consist of short post oaks and blackjacks up to about 40 feet (12 m) in height. Black hickories are scattered among the oaks on moist sites. Redbud, roughleaf dogwood and other small trees and shrubs are common in open areas. In drier, less suitable locations, trees are shorter and more scattered. These oaks have rounded canopies that extend to the ground, leaving no opportunity for development of an understory. Between trees, a dense layer of shrubs or plants characteristic of tallgrass prairie covers the ground. Sumac, coral berry and low shrubby oaks often completely fill the space between trees. Fire, an important force in this community, often burns along the forest floor, killing lower tree limbs and reducing shrub cover. The resulting open, park-like community is termed a **savanna**. Unburned stands develop into very dense forests of post oak and blackjack oak. These forests are virtually impenetrable by humans. Patches that are unburned, or burned with different intensities, create a mosaic of vegetative structure along with areas that are unburned, ranging from thick shrub layers to open savannas. This diversity in structure enables a wide diversity of plants and animals to inhabit the crosstimbers.

The mosaic of grasslands and woodlots in the "crosstimbers" supports a diversity of species.

Grasslands in this ecoregion are primarily tallgrass prairies composed of bluestems, Indian grass and switchgrass in deep, moist soils, with scattered pockets of species typical of western shortgrass prairies. In dry, rocky sites, tall grasses are mixed with grama and other short grasses characteristic of the shortgrass prairies. A diversity of wildflowers is present, providing nectar for hummingbirds and insects and seeds for a variety of wildlife.

Post oaks and blackjack oaks growing in bottomland communities are taller than those in upland sites. Hackberry, river birch, willows and cottonwoods are common along streams in this ecoregion. In more open sites, cottonwoods, willows, sedges and rushes line rivers and streams. Bottomland forests of this ecoregion show the beginning of a transition from eastern to western communities. Bottomland forests in eastern Oklahoma, where rainfall is abundant, are very diverse in physical structure and in the number of species forming the community. Many species of trees, shrubs and herbaceous vegetation form the physical structure of these communities. In western areas where water is more scarce, the plant community structure is simpler and is comprised of fewer species. Bottomland forests in the west are dominated by willows and cottonwoods. Many tree species requiring very moist conditions drop out in this ecoregion and other species growing on moist upland sites in the east are restricted to streamsides here. More sunlight reaches the forest floor in the west and greater amounts of herbaceous vegetation develop.

A few sandstone caves are scattered throughout the ecoregion. Because they tend to be very small, they support only sporadic populations of bats during summer months. The caves are too small to support other cave life or hibernating bats.

Arbuckle Mountains. The Arbuckle Mountains, located primarily in Murray and Carter counties, are a distinct feature in this ecoregion. The eroded limestone plateau is higher and more rugged than surrounding plains. Although most communities in these mountains are present in surrounding areas, moist hardwood forests similar to those in the Ouachitas are rather extensive along ravines and streams of the Arbuckles. Exposed rock ledges and bluffs are common throughout the area. Streams are clear, cool and fast-running and springs are abundant. These contrast with the slow, muddy streams of surrounding plains. Many plant and animal species found here are isolated populations and are characteristic of mountains in eastern Oklahoma. Arbuckle caves contain bats and other species.

Flint Hills

Distribution. The Flint Hills are located in Kansas and northeastern Oklahoma. In Oklahoma, this ecoregion occurs primarily in Osage County with a small portion extending into Kay County. The Central Oklahoma/Texas Plains form most of the border, with the Central Irregular Plains to the east and the Central Great Plains on the west.

Physical characteristics. The annual temperature of the Flint Hills averages approximately 60° F (16° C) with an overall rainfall of 40 inches (103 cm) The growing season is about 200 days.

This ecoregion is characterized by rolling hills with pronounced draws along streams. The elevation slopes from 1,200 feet (366 m) in the northwestern part of the ecoregion to 800 feet (244 m) in the eastern portion. Except on limestone cliffs and slopes, soils are relatively deep and fertile.

The Arkansas River, which forms the western and southern boundaries, and its tributaries drain the ecoregion. Streams are low gradient but clear, and flow through relatively narrow floodplains.

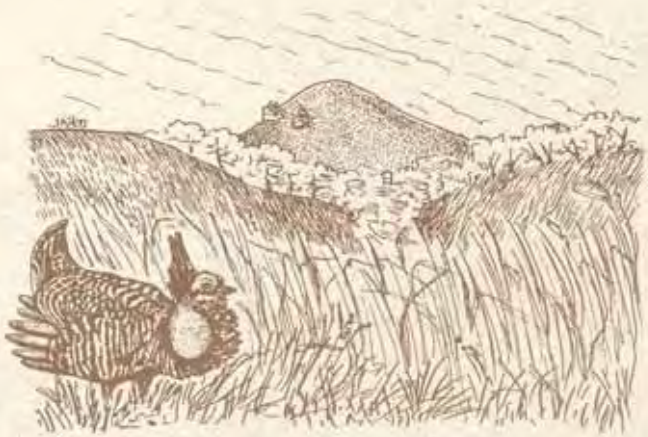
Species diversity. Two hundred and forty-three vertebrate species are native to this ecoregion. Five species have been extirpated and seven have been introduced. One species is state-listed as threatened and four are of special concern.

Natural communities. Tallgrass prairies, containing some of the most lush prairie vegetation in the state, dominate the rolling Flint Hills. Big and little bluestem, Indian grass and switchgrass are the primary grasses and reach heights up to 10 feet (3 m). A wide variety of wildflowers grow among grass clumps, as in the grasslands of the Central Irregular Plains. On dry sites with thin soils over limestone outcrops, short grasses, such as grama and buffalo-grass, form a shorter, more sparse prairie. Prickly pear and yucca also are common in these dry sites. Fire, as in most

prairie communities, is essential to regenerate the prairie plants and keep red cedar and other woody vegetation from encroaching.

Dry upland forests, dominated by blackjack and post oak, occur on moist areas and some north-facing slopes. Similar to dry forests in the Central Irregular Plains, these forests, also called crosstimbers, are short (about 40 feet [12 m] high) and open, having a heavy cover of shrubs and prairie plants on the forest floor. Common shrubs include persimmon, sumacs and small oaks. These forests are more extensive in the Central Oklahoma/Texas Plains ecoregion. In the absence of fire, these forests develop into very dense stands that are nearly impenetrable by humans.

Bottomland forests form narrow borders along streams. Cottonwoods, hackberries, elms and oaks form tall (about 100 feet [30 m]) and expansive canopies. Because of the linear nature of these forested strips, light angles in from the sides, allowing lush vegetation to develop on the forest floor. Dense stands of tall herbaceous vegetation, such as giant ragweed, grow under the trees. Shrubs and vines, including grape, poison ivy and greenbriar, form dense thickets.



Tallgrass prairies, the home of the greater prairie-chicken, blanket the Flint Hills.

Central Great Plains

Distribution. The Central Great Plains extends from Nebraska to central Texas, passing through the western half of Oklahoma. The Flint Hills and Central Oklahoma/Texas Plains ecoregions form the eastern boundary and the Southwestern Tablelands form the western border.

Physical characteristics. Average temperature in this ecoregion is 60° F (16° C) and annual rainfall is about 27 inches (69 cm). The growing season is around 213 days but varies between northern and southern portions.

The surface slopes from 2,000 feet (609 m) in the west to less than 1,000 feet (305 m) in the southeastern part of the region. Rolling hills and plains are characteristic landforms. Most hills rise 100 feet (30 m) or less above surrounding areas; however, some elevations in the gypsum hills and the Wichita Mountains reach higher than 2,300 feet (701 m) above sea level, or 600 feet (183 m) above surrounding plains. Caves are common in gypsum hills, while boulder-strewn slopes of granite are common in the Wichitas. Soils usually are deep and fertile except on outcrops in the Wichita Mountains and gypsum hills.

The Salt Fork, Cimarron, North Canadian and Canadian rivers flow to the Arkansas River, draining the northern and central part of the area. The Washita and the North Fork of the Red River drain the southern portion. Tributaries are sluggish and muddy, typical of streams in the plains.

Species diversity. Three hundred and twenty-eight vertebrate species breed in this ecoregion. Five species have been extirpated and 13 have been introduced. One species is state-listed as threatened (and is a candidate for federal-listing) and 19 are of special state concern.

Natural communities. Grasslands cover most of this ecoregion, with woodlands scattered in ravines and along streams. Fingers of crosstimbers reach into the prairie from the east and form a heavily dissected eastern boundary. These woodlands are confined to moist slopes and ravines and become more restricted in the west. The crosstimbers of this ecoregion are less diverse in plant species than those to the east. Mes-

quite and shinnery oak woodlands extend into the ecoregion from the west. The Wichita Mountains and, to a lesser extent, gypsum hills contrast with surrounding, flat plains and increase the diversity of the ecoregion.

Tall- and shortgrass prairie species intermingle to form the prairies of the Central Great Plains.

This ecoregion is a transition zone from tallgrass to shortgrass prairie communities and consists of mixtures of species from both communities; hence the name "mixed-grass prairie." Little bluestem, a grass species common on tallgrass prairie, is dominant in this community. Reaching to about 20 inches (0.5 m) in height, little bluestem forms a medium-height prairie. In eastern portions of the ecoregion, little bluestem forms a dense sod, similar to that found in tallgrass communities. In more arid western parts of the ecoregion, little bluestem and other grasses occur in isolated bunches, separated by short grasses and bare ground. Tall grasses, most common in areas having deep, moist soil, become less common westward. Shortgrass communities, with buffalo grass and grama grasses, are most prevalent on thin soils. An array of herbaceous plants occur in areas where grasses do not use all available moisture. Many of these plants bloom early in the year, before grasses are tall enough to compete for sunlight and water, and then die back. Other species depend on deep root systems to provide sufficient water for growth during the summer and fall. These plants often form isolated patches where they dominate the community. Due to competition for water in western parts of this ecoregion, woody plants are absent from most of the grassland community except where water is locally available.

Forests occurring along rivers and streams show a pronounced transition from eastern to western bottomland forest communities. Many eastern tree species reach their western limits along streams in this ecoregion, eventually leaving cottonwoods and willows as dominant tree species. Deep, moist ravines often contain isolated patches of eastern forests, separated by cottonwood-dominated riparian forests. Along the moisture gradient, physical structure also is simplified. Understory layers and vines quickly disappear. Overstory trees are shorter and more scattered, allowing a heavy layer of grasses and herbaceous vegetation to develop on the forest floor. Forests also become more restricted to streamsides, forming narrow strips along streams.

Savannas, formed of shortgrass prairie species mixed with tall, thorny shrubs—primarily mesquite—extend from Texas into the southwestern corner of Oklahoma. These are scattered throughout the uplands. The tall shrubs or small trees (8 to 15 feet [2.5 to 4.5 m]) support an array of animals that are primarily found farther west in more extensive mesquite savannas.

Natural salt springs occur at or near the surface of several low sandy tracts throughout this ecoregion. The largest salt flat is the Great Salt Plains in Alfalfa County, which provides nesting and foraging habitat for shorebirds and endangered least terns. Salt marsh vegetation, characteristic of coastal marshes, grows around large salt flats created by these springs. The Red River pupfish, found only in Oklahoma and Texas, is adapted to live in the saline waters of southwestern Oklahoma streams.

Red Rock Canyon in Caddo County containssome of the most diverse forests of this ecoregion. The name actually refers to a system of rugged canyons that support forests containing species more characteristic of ecoregions to the east, such as sugar maples.

Wichita Mountains. The Wichita Mountains are granitic outcrops rising abruptly from the surrounding plain. This range of mountains runs east and west from Comanche to Greer counties. Much of the area is contained within the Wichita Mountains National Wildlife Refuge and Quartz Mountain State Park.

The rugged terrain of these mountains creates diverse conditions, including some suitable for communities characteristic of eastern ecoregions. These areas support blocks of natural communities that are isolated from other communities of their type. Bottomlands and enclosed valleys contain forests similar to the diverse moist forests and bottomland hardwoods in eastern Oklahoma. These contain eastern plant species at the western edge of their range. Rather large tracts of crosstimbers occur on slopes of the mountains and extend into valleys, grading into tallgrass prairies in moist valleys. Stands of live oaks also occur on a few slopes.

Dry hilltops and overgrazed lowlands contain shortgrass communities typical of drier portions of the ecoregion. Isolated patches of mesquite also occur.

Many slopes contain large granitic boulders with little, if any, vegetation. In areas where the rock has weathered, grasses, sandsage, various herbs and a few cedars and oaks grow among the boulders. All of this vegetation is stunted, due to the lack of soil and water. A wide diversity of lichens covers many of the boulders. Reptiles and other animals live on these dry, rocky slopes.

A few scattered granitic caves support summer populations of bats. Because granite does not weather rapidly, these caves are usually too small to serve as maternity caves or **hibernacula** (hibernation sites) for bats. Other animals enter the caves for shelter.

Gypsum hills and redbed clay plains. Three formations of gypsum are present in this ecoregion and form a series of rolling hills and eroded canyons. One formation is in the southwest corner of the state, one is in Washita and Custer counties and the third runs northwest from Canadian County to Harper County. This latter formation turns parallel to, and on the north side of, the North Canadian River. Here, surrounding the gypsum formation, are flat to rolling redbed plains with soils of red shale and sandstone.

A unique community occurs in areas where there are large expanses of exposed rock. A diverse array of wildflowers grows in cracks in the rock. Because grasses are absent in this community, wildflowers are able to grow without the usual competition from grasses for sunlight and water. This reduced competition is largely responsible for the unusual diversity of plant species.

Large caves have been eroded into the gypsum hills and contain some of the largest colonies of bats, primarily Mexican free-tailed bats and cave myotis, in Oklahoma. Mexican free-tailed bats form colonies of several million and use the caves as summer roosts and maternity colonies, migrating to Brazil in the fall. Cave crickets and other invertebrate and bat species use the caves year-round. Although these caves do not support as rich a community as the limestone caves of northeastern Oklahoma, many species of wildlife use them for shelter and hibernating sites.

Western sand dunes. Sand dunes occur along all major rivers in this ecoregion, except the Washita River, and are most extensive on their north banks. Although some are still active (moved by wind and water), most dunes are at least partially stabilized by vegetation. Sandsage, rounded shrubs about two to 3 feet (1 m) high, form a large part of the cover. Bluestems and Indian grass grow in bunches among the sandsage. Other woody shrubs, such as fragrant sumac, hackberry and sand plum, form dense thickets but seldom exceed 5 feet (1.5 m) in height. Wildflowers, such as Indian blanket, are well distributed throughout vegetated areas. Bare sand occurs between clumps of vegetation. Bottomland forests typical of the rest of the ecoregion often are present along river borders.

Narrow strips of stabilized dunes along the north sides of the Cimarron and North Canadian rivers in the northwestern part of the ecoregion support well-developed forest types that are remarkably diverse for this region. Overstory trees include species typical of forests of eastern or central Oklahoma: American elm, hackberry, chittamwood, post oak and blackjack oak. Various shrubs and tall grasses typical of the ecoregion occur along the forest floor.

Small natural wetlands form between dunes in areas where the water table is high. Various rushes, sedges, cattails and other wetland plants provide the base for wetland communities. These communities are important for many wetland species, including migrating shorebirds and waterfowl.

Southwestern Tablelands

Distribution. Most of the Southwestern Tablelands ecoregion is located in Colorado and New Mexico with fingers extending into Texas and northwestern Oklahoma. This ecoregion is bounded by the Central Great Plains on the east and Western High Plains on the west.

Physical characteristics. The average annual temperature of this ecoregion is approximately 58° F (14° C) and it receives an average of 21 inches (53 cm) of precipitation annually. The growing season averages about 196 days.

Tablelands are flat plains that slope from 3,000 feet (914 m) above sea level in the west to 2,000 feet (609 m) in the east. The eastern boundary roughly follows the 2,000-foot contour. Soils are deep and fertile.

The North Canadian and Canadian rivers drain most of the region, cutting narrow V-shaped valleys in the plains. Sluggish and muddy streams are typical of the plains.

Species diversity. Two hundred and thirteen vertebrate species are native to this ecoregion. Nine species have been extirpated and seven have been introduced. One species is state-listed as threatened (now proposed for federal listing) and seven are of special concern.

Natural communities. In Oklahoma, the shinnery oak scrub community is found only in this ecoregion. Except in the Panhandle, various oak species form thick, circular clumps, called **mottes**. Center trees in mottes reach maximum heights of 10 to 15 feet (3 to 4.5 m) and their offspring radiate from the center, becoming progressively shorter and more closely spaced. These outer sprouts are often only 2 feet (0.6 m) in height and reach densities of 50 to 100 per square yard (60-120 per m^2). Except along margins, this dense growth of oak sprouts effectively eliminates all other plants within the motte. Although they are small, these oaks may produce heavy crops of acorns, providing a valuable food source for many wildlife species. Mixed-grassland plant species, dominated by little bluestem, are common in spaces between mottes.

All other natural communities in this ecoregion are more extensive in surrounding ecoregions. Mixed-grass prairie dominates other upland areas in most of the ecoregion and shortgrass prairies dominate in the Panhandle. These grasslands are similar to those occurring in surrounding ecoregions. Little bluestem dominates mixed-grass sites, while grama and buffalo grasses dominate shortgrass communities.

Oak mottes, rounded clumps of shinnery oaks, are characteristic of the Southwestern Tablelands.

Cottonwoods dominate bottomland forests occurring along rivers and streams. Some areas have elms and hackberries scattered among the cottonwoods. Sometimes cottonwoods are thinly scattered, with thick stands of shrubby willows present underneath.

Western sand dunes. Sand dunes occur along all major rivers in this ecoregion except the Washita River, especially along their northern banks. Rounded shrubs of sandsage interspersed by bluestems, Indian grass and wildflowers grow in scattered clumps separated by patches of bare sand. Fragrant sumac, hackberry and sand plum form dense, short thickets. The amount of vegetation varies among dunes, with some having only sparse vegetation while others are almost completely covered with plants. Bottomland forests, typical throughout the rest of the ecoregion, often are present along stream borders.

Western High Plains

Distribution. The Western High Plains extend from southern South Dakota into Texas, including most of Oklahoma's Panhandle. The Southwestern Tablelands ecoregion forms the eastern boundary.

Physical characteristics. This ecoregion has an average annual temperature of 57° F (14° C) and receives about 20 inches (51 cm) of precipitation annually. The growing season is about 190 days.

With a gentle slope to the east, elevations range from over 4,400 feet (1,340 m) in southwestern Cimarron County to 2,800 feet (853 m) in south-central Beaver County. The topography consists of smooth plains between narrow valleys cut by streams. Soils are deep and fertile.

The North Canadian (Beaver) and Cimarron rivers drain this ecoregion. These rivers and their tributaries are sluggish, muddy streams and lie in narrow V-shaped valleys. Springs were abundant historically but many have dried as the water table has been lowered by irrigation.

Species diversity. One hundred and eighty-seven vertebrate species are native to this ecoregion. Seven species have been extirpated and 10 have been introduced. One species is state-listed as threatened (now proposed for federal listing) and eight are candidates or of special concern.

Natural communities. The shortgrass prairie community forms much of the Western High Plains ecoregion. Dominated by grama grasses and buffalo grass, dense sods of shortgrasses (3 to 5 inches [7.6 to 12.7 cm]) cover the ground in areas having adequate soil. Sites with rock or gravel near the surface support patches of grass separated by bare ground. Adapted to drought conditions, these shortgrasses grow rapidly during spring and become dormant during periods of drought. They resume growth when rainfall supplies adequate moisture. Various wildflowers occur scattered among the grasses, although not as abundant or diverse as in eastern prairies. Prickly pear and other cacti are found throughout the community and may form extensive clumps. Due to the lack of water, trees and woody shrubs are uncommon. In wetter areas with deep soils, small mixed-grass prairie communities typical of the Central Great Plains are present.

Pronghorn and prairie dogs are characteristic of the High Plains shortgrass prairies.

The Western High Plains contain **playa lakes**, a unique wetland community. These shallow, circular depressions fill with water draining off the surrounding plain. Because the evaporation rate in the area greatly exceeds the precipitation, these wetlands are wet for relatively short periods of time. Ranging from less than 1 acre (0.4 hectares) to several hundred acres in size, these communities form the most significant wetlands in the southern part of the **Central Flyway**, the migration route of waterfowl and shorebirds in midwestern North America. Playas are vital wintering or stopover places for migrating waterfowl and other wetland birds. The wet-dry cycle that occurs every year results in high levels of productivity in these wetlands. Wheat grass and vine mesquite are common plant species in playas, and smartweed grows in those that remain wet for longer periods.

Narrow strips of open cottonwood forests are present along some streams. A dense cover of shrubby willows often grows under the cottonwoods. Wild plums form scattered thickets throughout bottomlands. Herbaceous plants and grasses grow taller in these areas due to more available water. Because these scrub riparian forests are often the only woodland communities in the area, they are especially important to forest wildlife species occurring in the ecoregion.

This ecoregion contains the largest prairie-dog towns in Oklahoma. These towns support a unique

biological community. By digging burrows, prairie dogs create an additional component of physical structure in the community. Burrows, which may be 15 to 20 feet (4.5 to 6 m) deep, serve as shelters for many types of animals, including burrowing owls, foxes and a variety of reptiles and amphibians. Soil excavated during the tunnel building is deposited as mounds at entrances, providing suitable conditions for species requiring disturbed soil. The short vegetation found in the towns provides important nesting habitat for several bird species, including the long-billed curlew.

Western sand dunes. Narrow belts of sand dunes occur along the Cimarron and North Canadian (Beaver) rivers in the northeastern portion of this ecoregion. Sandsage, which forms short, rounded shrubs, makes up a large part of the ground cover. Scattered bunches of bluestems and Indian grass occur between the sandsage. Open areas of sand are prevalent between clumps of vegetation. Dense thickets of sand plum, stinking sumac and hackberry occur in isolated pockets and are seldom more than 5 feet (1.5 m) high. Scrub riparian communities occur at the edges of streams as in the remainder of the ecoregion.

Black Mesa

Distribution. The Black Mesa ecoregion is located in the northwestern quarter of Cimarron County in the Oklahoma Panhandle and extends into Colorado and New Mexico. It is bordered on the south and east by the Western High Plains.

Physical characteristics. This is the coolest and driest region of the state. Average annual temperature is 55° F (13° C) and annual precipitation is 18 inches (46 cm). The growing season is 179 days.

The topography consists of a series of flat-topped mesas deeply dissected by tributaries of the Cimarron River. Sandstone mesas are capped with black, basaltic lava up to 100 feet (30 m) in thickness. The elevation slopes toward the east from nearly 5,000 feet (1,524 m) to 4,000 feet (1,219 m). Many mesas rise 400 feet (122 m) above the valley floors. The highest point in the state—4,973 feet (1,516 m)—is atop Black Mesa itself.

Species diversity. One hundred and seventy-eight vertebrate species are native to this ecoregion. Six species have been extirpated and three have been introduced. No species are federally-listed as threatened or endangered, but nine are candidates or of special concern.

Natural communities. Shortgrass prairies, common to the surrounding Western High Plains, cover mesa tops. Short grasses of 3 to 5 inches (8-13 cm)—primarily grama grasses and buffalo grass—form dense sods or patches separated by bare soil. Various wildflowers grow among the grasses, although not as abundant or diverse as in eastern prairies. Prickly pear, cholla and other cacti are scattered throughout the community, occasionally forming extensive clumps. Trees and woody shrubs are restricted to ravines and steep slopes. In more moist areas with deep soils, small mixed grass prairie communities, characteristic of the Central Great Plains, are present. A characteristic unique to these mesa-top prairies is the presence of many scattered lava fragments.

Rugged mesas of the Black Mesa ecoregion link Oklahoma with the Rocky Mountains.

Plant and animal species inhabiting ravines and mesa slopes are extensions of communities characteristic of Rocky Mountain foothills. Low shrubs up to 5 feet (1.5 m) tall—primarily netleaf hackberry—cover

some rocky slopes. Junipers are sparsely scattered through this scrub community. Juniper, pinyon pine and some western oak species occur most commonly on north-facing slopes. These are usually sparse, open forest types and are separated by large sandstone blocks.

Big Rivers

Distribution. "Big Rivers" are unique among the ecoregions of Oklahoma in that they are statewide, cutting across and embedded within most of the other ecoregions. However, it is easy to recognize these systems as a distinct ecoregion because (1) they are distinct from the terrestrial environments in which they are embedded, (2) they are similar in physical characteristics and species composition throughout the state, and (3) their vertebrate species largely consists of those not common elsewhere in the state.

The Big Rivers ecoregion includes the river beds of the following rivers and lower reaches of their tributaries: Red, Washita, Canadian, North Canadian (Beaver), Deep Fork, Cimarron and Arkansas rivers as well as part of the Grand River.

Physical characteristics. The Big Rivers span the range of climatic conditions in Oklahoma, from the moist eastern part to the arid western regions. Topography of the Big River ecoregion slopes gently to the southeast.

Rivers included in this ecoregion are typically wide, shallow and low-gradient. The size and persistence of flow in the rivers largely reflect the distribution of precipitation and the rate of evaporation. Roughly east of Interstate Highway 35, most of the large rivers have permanent water and substantial flow, while portions in western Oklahoma depend upon recent rainfall for flow or even presence of water. For example, it is common to find extensive reaches of the upper Cimarron River or North Fork of the Red River dry during certain periods of the year.

Most large rivers have beds of gravel, mud, or sand, with very fine sediments. Greater flows in eastern portions create deeper channels, often with water filling the channel from bank to bank. To the west, riverbeds are sand-bottomed with multiple (braided) channels when flow is present. In the middle and western parts of Oklahoma, the Big Rivers have a wide bed and usually are shallow enough to be waded. Only in eastern Oklahoma are the rivers too deep to wade.

Some of the most important features of the large rivers in the eastern part of the state are their microtopography; they typically consist of long pools, eventually breaking down over sand ridges. In western regions, most pools are shallow, but occasional pools, especially if scoured around snags, can become relatively deep and harbor larger fishes. Another important small-scale feature of large rivers is the presence of sand ripples on the bottom. These small "ridges and valleys" produced by water flowing over the otherwise smooth sand of the riverbed produce shelter from currents, which is important to some fish species. Finally, an important feature of the Big River ecoregion is the presence of unique habitats at stream mouths. When smaller streams, even intermittent creeks, flow into the main river channel, they often induce scouring and create habitat that is substantially deeper. These deep aquatic habitats (often with tree canopy) are particularly important places for larger fishes and serve as nurseries for larval fishes.

Species diversity. The unique fish assemblage of the Big Rivers is the basis for recognizing this ecoregion because it is unique from other streams in the state. The endangered least tern nests primarily on sandbars occurring in this ecoregion, and several other shorebirds use the sandbars and associated mudflats extensively. Many species of other taxa use the rivers but are more closely associated with the terrestrial ecoregions surrounding the river. Because of this association, numbers of species using the Big Rivers ecoregion are not shown. However, due to alterations in flow and other characteristics, 1 species is a candidate for listing as federally endangered and 10 are are of special state concern.

Natural communities. Because vascular plants are not abundant in this ecoregion, physical characteristics of the riverbed discussed above, such as pools, sandbars and ripples, often determine the distribution of species. It is common to find rooted aquatic plants like cattail and small patches of floating "pondweeds" (e.g., *Potamageton*) in backwater pools but these plants cannot survive in areas with strong currents and frequent scouring. Attached and floating algae are

prominent features of pools in large rivers during low flow, often forming the only physical structure for small fishes (e.g., mosquitofish, which are particularly associated with algae).

Vertebrates are dominated by a characteristic assemblage of fishes, with at least 34 species most often found in large river mainstems and approximately 20 of these being relatively common in at least some of the large rivers of the state. In the eastern part of the state, where more water results in deeper pools and channels, large-bodied species are prominent, including paddlefish, some gars, members of the shad family, river redhorse, buffalo, carpsuckers, and large catfishes. In central and western Oklahoma, physical sizes of pools decrease and the fish fauna consists primarily of smaller species such as plains minnows, red shiners, emerald shiners, Arkansas River shiners or Red River shiners (depending upon the drainage), chub shiners, and inland silversides. In far southwestern Oklahoma, the high salinity of the Red River and its tributaries results in only two fish species being present: Red River pupfish and plains killifish.

Sandbars divide large rivers in the Big Rivers ecoregion into many shallow channels.

The aquatic communities of large rivers cannot be isolated from adjacent terrestrial communities. Many species extensively use both the riverbed and adjacent terrestrial communities. Egrets and herons often nest in trees or woodlots and forage in the large rivers. Raccoons, otters, mink and many other species also use large rivers as well as adjacent terrestrial communities. Conservation of the Big River ecoregion also relies on proper conservation and management of adjacent land to maintain water quality and adequate flows in the rivers.

Species Diversity

Oklahoma's large variety of natural communities supports a correspondingly large variety of species. Although we know very little about some groups of species, the information we have on other groups illustrates the extensive biological diversity in Oklahoma. Because all of Oklahoma's ecoregions and natural communities extend into other states, few species occur only in Oklahoma. Many species occur in multiple ecoregions or communities, but some are very specific in their requirements and occur only within one ecoregion or community.

Following is a discussion of some taxonomic groups that occur in Oklahoma (see Table 3.2).

Animals

Molluscs. Oklahoma has 201 mollusc species: 111 terrestrial snails and slugs, 31 aquatic snails and 59 bivalves (clams and mussels). Mollusc species occurring in the arid western part of the state are aquatic or confined to communities where moisture is available throughout most of the year. The greatest variety of molluscs occurs in eastern parts of the state where rivers and streams are abundant and moisture is available in most terrestrial habitats. The Ozark Highlands and Ouachita Mountains are known to have very diverse mollusc fauna and are responsible for the large variety of species in eastern Oklahoma. Several species of terrestrial snails and freshwater mussels are **endemic** to Oklahoma, meaning they are found only in this state.

Eight mollusc species have been introduced into Oklahoma, including three terrestrial snails, three aquatic snails and two bivalves. The Asiatic clam has had a significant negative effect on aquatic communities and caused problems for water and utility companies, while the zebra mussel has the potential to create even greater problems if it becomes established in Oklahoma.

Freshwater-mussel populations have declined dramatically in the state and the rest of the country.

Table 3.2: Species Richness of Various Taxonomic Groups in Oklahoma

Taxonomic group	Native[a]	Exotic	Extirpated	Federal list E, T, C[b]	State list E, T, SC[c]	Endemics[d]
Aquatic arthropods	?[e]	?	?	0	1, 0, 2	?
Terrestrial arthropods	?	?	?	1, 0, 0	1, 0, 2	?
Molluscs	194	8	0	1, 0, 0	2, 0, 4	?
Fish	165	10	0	0, 3, 2	1, 5, 32	1
Amphibians & reptiles	132	1	0	0, 1, 0	0, 1, 23	0
Birds	182 breeding[f] 182 winter 289 migrant	4	6	9, 1, 1	6, 1, 11	0
Mammals	101	4	4	3, 0, 1	3, 0, 21	0
Plants	est. 2170	est. 380	?	0, 2, 0	0, 0, 0[g]	0
Other	?	?	?	0	0	?

[a] Includes extirpated species.
[b] 1996 Federal Rare and Endangered Species List: E=endangered, T=threatened, C=candidate.
[c] 1996 State Rare and Endangered Species List: E=endangered, T=threatened, SC=special concern; federally endangered and threatened species also are listed as state endangered and threatened.
[d] Species found only in Oklahoma.
[e] Numbers of species unknown.
[f] Categories are not exclusive.
[g] Oklahoma has no legal list of threatened or endangered plant species.

Deterioration of water quality, increased sedimentation and impoundments all have contributed to the decline. As a result of these problems, several species may be extirpated within our borders. The Ouachita rock-pocketbook, a mussel, is federally-listed endangered and the Neosho mucket, also a mussel, is state endangered and a federal candidate. Four other species, three mussels and one snail, are listed as species of special concern.

Arthropods—insects, spiders and ticks. Arthropods are considered by many scientists as the dominant group of animals due to their sheer abundance, species richness, and vital roles in maintaining functioning ecosystems. Insects especially serve important roles in decomposition, pollination and as food sources for many birds, fish and other animals. Because they are not well studied, accurate counts of arthropod species are not available. Scientists estimate there are about 200,000 insect species in North America. Oklahoma with its many ecoregions probably contains at least 10,000 species of insects, and some recent studies indicate that the southwestern region of the United States (Texas, Oklahoma, New Mexico and Arizona) has the highest insect diversity in the nation. Butterflies are probably the best known group in the state, but the current list of 166 species in Oklahoma is incomplete and further study will probably result in documentation of over 200 species. Of the 32 North American insect orders, 30 occur in Oklahoma. There is a great need for studies of these orders, especially

the more abundant ones of beetles (Coleoptera), moths and butterflies (Lepidoptera), flies (Diptera) and ants, bees and wasps (Hymenoptera).

Insects and their relatives not only are the most abundant on land in terms of species, but also surpass other animals in sheer numbers and biomass. One estimate states that 400 pounds of insects exist per acre (447 kg per hectare) in the United States compared to an average of only 14 pounds of humans per acre (34.6 kg per hectare)! Soil-dwelling arthropods reach large populations and records of hundreds of millions per square yard are not unusual.

Several groups of aquatic arthropods commonly occur throughout Oklahoma. Some of these include damselflies, dragonflies, mayflies, water bugs, caddisflies, water beetles, flies, aquatic sowbugs, sideswimmers and crayfishes. The cave crayfish is state endangered. Two species of cave amphipods are state-listed as species of special concern.

Due to a lack of information on distribution and identification, it is impossible to estimate the vast number of aquatic arthropod species occurring in Oklahoma. However, several general observations can be made. More species of aquatic arthropods are found in waters having a diversity of microhabitats available for many different species to exploit. For example, rocky streams of the Ouachita Mountains usually possess a greater diversity of microhabitats and, therefore, more species than a muddy creek in the Central Oklahoma/Texas Plains. Also, fewer species of arthropods are found in aquatic environments heavily impacted by human activities.

Terrestrial arthropods are significant players in the normal functioning of many ecosystems. Their absence would severely alter the abundance of many plant and animal species. Many bees, butterflies, moths and flies are essential pollinators of cultivated and native plants. Insects such as termites and wood-boring beetles aid in decomposition of organic matter and nutrient recycling. Insects serve as important food sources for birds, fish and many mammals and are vital for the normal reproductive functions of these animals. Direct benefits to man from insects are evident in the silk and honey industries, but their indirect benefits as natural enemies that limit populations of pest insects are now becoming more understood and appreciated. Despite their abundance and vital roles, very little is known about the distribution or specific ecological functions of most arthropods.

Insect diversity has likely suffered from habitat destruction and pesticide use. Removal of habitat for commercial development and extensive monoculture agriculture eliminates plants and specific habitats for many insects. Overuse and improper use of pesticides reduces populations of many insects, including beneficial insect predators and pollinators. For example, even the U.S. population of the common domesticated honey bee is declining, raising concern to agriculture and conservation. Destruction of wetland areas has likely affected many insects that require water to complete their life cycle. However, due to our limited knowledge of this diverse group, it is very difficult to accurately document the loss of an insect species. Nevertheless, 30 species of insects and spiders are on the federal endangered, threatened or rare lists. In Oklahoma, one insect, the American burying beetle, is on the state and federal endangered species lists and another species, the prairie mole cricket, has been a candidate for the federal threatened list.

Study of insect biodiversity needs to be an important component of any program to assess and conserve our natural biological heritage. Although their influence in natural communities is often overlooked or not appreciated, arthropods are vital to maintaining most terrestrial and freshwater ecosystems.

More sampling throughout the state and greater taxonomic expertise are necessary before distributions of aquatic arthropods are known and numbers can be estimated.

Fish. The native fish **fauna** (a group of animal species) of Oklahoma comprises 175 species in 26 families. These include "living fossils" like the shovelnose sturgeon, paddlefish, four species of gar, and bowfin; all are relicts of ancient families more than 100 million years old. More than 70% of the native fishes are in five families: minnows (47 species), darters (31 species), sunfishes (18 species), suckers (15 species), and catfishes (13 species). The names of some of the other families illustrate the diversity of Oklahoma's native fishes: lamprey, eel, herring, pickerel, livebearer, pupfish, killifish, silversides, mullet, cavefish, pirate perch, bass and drum.

No fish species is restricted to Oklahoma. However, two major **centers of endemism** (areas with many species occurring only in those locations) for North American fishes are represented in the state in the Ozark Highlands and the Ouachita Mountains. Seven endemics of the Ozark Highlands and four of the Ouachita Mountains occur in Oklahoma and neighboring states. The Ozark Highlands and the Ouachita Mountains also have a variety of species like the smallmouth bass that are adapted to clear, rocky-bottomed, upland streams and are virtually absent elsewhere in the state, except in springfed streams of the Arbuckle and Wichita mountains.

Other ecoregions also contribute significantly to fish diversity in Oklahoma. The South Central Plains in extreme southeastern Oklahoma has a distinctive fauna adapted to heavily vegetated sloughs, oxbows and cypress swamps. The plains streams in central and western Oklahoma harbor a number of fishes adapted to frequent spring and early-summer flooding and late summertime low flow. Some of these fishes are restricted to either the Arkansas or the Red River drainages, the two major river systems in the state.

Ten fish species have been introduced to Oklahoma. The common carp has caused significant damage to many aquatic communities and is probably the most noxious of the introduced fish.

Three fish species occurring in Oklahoma (Neosho madtom, leopard darter and Ozark cavefish) are federally-listed as threatened, one is proposed for listing as endangered and two others are candidates for listing. Oklahoma lists four additional species as either endangered or threatened with extirpation from the state. The state lists an additional 31 species that need further investigation before a decision can be made regarding their status in Oklahoma.

Several native species have declined in numbers during the past several decades, while others have expanded their distribution in the state. Most of these population changes result from habitat alterations caused by human activities. Habitat changes include: altered water-flow regimes; changes in turbidity, sedimentation and temperature (especially below reservoirs); and increased levels of domestic, agricultural, and industrial pollutants. Some changes in abundance and distribution are due to human transport of fishes between the Red and Arkansas river basins in Oklahoma and introductions of non-native species.

Reptiles and amphibians. Oklahoma is rich in reptiles and amphibians, with 133 species from 26 families, including salamanders, toads, frogs, turtles, lizards, snakes and a single species of alligator. In fact, in total count of species of both reptiles and amphibians, Oklahoma is only exceeded by a few states like Texas, Florida, and Georgia. Much of this variety is due to the number and contrasting characteristics of Oklahoma's ecoregions and its location in the center of the continent. Many species also are found as **disjunct populations** in Oklahoma, populations left behind as species' ranges shrank and shifted following climatic changes. None of Oklahoma's species are endemic to the state, although three salamander species with very restricted ranges are found in the Ouachita Mountains of eastern Oklahoma and barely extend into neighboring Arkansas.

The largest numbers of Oklahoma reptile and amphibian species occur in the extensive Central Oklahoma/Texas Plains ecoregion of the state, but two rather small ecoregions in Oklahoma, the South Central Plains and the Ouachita Mountains, also harbor large numbers of these species. Many species in these two ecoregions are found only in this part of the state.

One reptile species, the Mediterranean gecko, has been introduced in Oklahoma. This species survives in a few buildings on the University of Oklahoma campus and probably has had little impact on native species.

Most of Oklahoma's reptiles and amphibians seem to have healthy, stable populations, although the status of several species is unknown or declining. Numbers of Texas horned lizard numbers are decreasing in Oklahoma and neighboring states. The round-tailed horned lizard is found in Oklahoma only in a small disjunct population on Black Mesa. Part of this population is protected since it occurs on at Black Mesa State Park. Among reptiles, numbers of alligator snapping turtles, map turtles, lesser earless lizards, side-blotched lizards, northern scarlet snakes, mud snakes, Texas garter snakes, Texas longnose snakes, Gulf crayfish snakes and desert massasaugas may be declining. Among amphibians, numbers of four-toed salamanders, grotto salamanders, mole salamanders, ringed salamanders, three-toed amphiumas, western

bird-voiced treefrogs and western lesser sirens may be declining. Although Oklahoma salamanders, Ouachita dusky salamanders, Rich Mountain salamanders, Sequoyah slimy salamanders and Kiamichi slimy salamanders have restricted ranges, they seem to be maintaining stable and viable populations.

Oklahoma's declines in reptile and amphibian populations are mainly due to loss of breeding habitat and forest fragmentation, although widespread use of pesticides and increased contamination of aquatic habitats also play a role. More species from the eastern, wetter ecoregions than from the western, drier ones appear to be at risk.

Each group of reptiles and amphibians is treated separately below.

Amphibians—salamanders. Oklahoma has 24 species of salamanders, representing six families and ten genera. Four species are endemic to the Ozark Highlands, four to the Ouachita Mountains, and two to the South Central Plains. Ranges of three of the species endemic to the Ouachita Mountains (Rich Mountain salamander and Sequoyah and Kiamichi slimy salamanders) stretch a short way into Arkansas. Oklahoma has no endangered salamanders, but the Ouachita dusky salamander is a candidate species for possible federal listing. Nine species are of special concern. Three species have Oklahoma populations disjunct from the rest of their range.

Amphibians—frogs and toads. Twenty-seven species of frogs and toads occur in Oklahoma. These represent five families and seven genera. One species, the bird-voiced treefrog, is restricted to the South Central Plains in Oklahoma. Oklahoma has no endangered frogs and toads, but two are listed by the state as special concern species: the bird-voiced treefrog and the squirrel treefrog (the latter is probably extirpated from Oklahoma). Three species have Oklahoma populations disjunct from the rest of their ranges. Both species of gray treefrog are found in Oklahoma; these are indistinguishable by appearance, but their calls and genetic make-up are different enough to qualify them as separate species.

Reptiles—turtles. Oklahoma has 17 species of native turtles, representing four families and 11 genera. One species, the map turtle, is restricted to the Ozark Highlands in Oklahoma, but its range extends into neighboring states. The map turtle and alligator snapping turtle are state-listed as species of special concern. Three species have disjunct populations in the state.

Reptiles—alligators. Oklahoma has a single species of alligator, the American alligator, occurring in the South Central Plains and southern parts of the Central Oklahoma/Texas Plains. It is not very abundant in Oklahoma, but reaches its highest densities in cypress swamps. The American alligator is federally and state-listed as threatened, primarily to protect the rarer American crocodile that closely resembles it, but is not found in Oklahoma. American alligators are much more common in the southeastern United States.

Reptiles—lizards. Oklahoma has 17 species of lizards, representing seven families and 10 genera, with one endemic species—the round-tailed horned lizard. Three species are listed as species of special concern by the state. Four lizard species have disjunct populations within the state.

Reptiles—snakes. Forty-six species of snakes in three families and 26 genera are found in Oklahoma, including seven species of venomous snakes. Two species of garter snakes are confined to the Southwestern Tablelands ecoregion in Oklahoma and a third species is found in Oklahoma only in the South Central Plains. None of Oklahoma's snakes is threatened or endangered, but seven species are listed as species of special concern in Oklahoma. Three species have disjunct populations in the state.

Birds. Currently, Oklahoma has 182 species of breeding resident birds, 182 species of winter resident birds and 289 migrant species (categories are not exclusive and certain very rare species have been excluded). Four resident birds are exotic species. The species occurring in Oklahoma represent 17 of the 28 orders of living birds.

Six species have become extinct or been extirpated from Oklahoma: American swallow-tailed kite, sage grouse, sharp-tailed grouse, passenger pigeon, Carolina parakeet and ivory-billed woodpecker. The peregrine falcon, whooping crane, eskimo curlew (probably now extinct), interior least tern, red-cockaded woodpecker and black-capped vireo are federally-listed as endangered, while the mountain plover is a candidate for federal listing. The snowy plover, long-billed curlew, golden eagle, Swainson's hawk, ferruginous hawk, prairie falcon, barn owl, burrowing owl, migrant

loggerhead shrike, Bell's vireo and Bachman's sparrow are listed as species of special state concern.

For its size, Oklahoma is remarkably rich in bird species, having a total number second only to the state of Texas. Excluding the Big Rivers ecoregion, the fewest number of breeding species, 87, is found in the Black Mesa ecoregion; many of the species found there, however, are found nowhere else in the state. The largest number of breeding species, 137, is found in the Central Great Plains ecoregion.

Four bird species have been introduced in Oklahoma. The European starling, house sparrow and rock dove (common pigeon) dominate most urban areas and compete with native species for food and nesting sites. Starlings and house sparrows are especially aggressive and, where they are common, nearly eradicate certain native cavity nesters. The ring-necked pheasant was introduced as a game bird and is found in northern and western parts of the state.

The primary threats to Oklahoma birds have been habitat loss and fragmentation. These have been most acute for prairies and wetlands. One result of fragmentation and other factors has been an increase in the number of brown-headed cowbirds. This species, a nest parasite, is a serious immediate threat to the black-capped vireo, and appears to have significantly reduced the populations of several other bird species, particularly in central and western Oklahoma.

Mammals. Oklahoma has 101 native species of mammals from 24 families. Four species of rodents have been introduced and populations or individuals of several domestic mammals (especially dogs, cats and pigs) also now occur in the wild. Eight of the world's 21 mammalian orders are represented in Oklahoma: 1 marsupial, 6 insectivores (shrews and moles), 21 bats, 1 armadillo, 4 rabbits, 49 rodents, 22 carnivores and 5 artiodactyls (deer, elk, pronghorn and bison).

Four species of carnivorous mammals (black-footed ferret, red wolf, gray wolf and grizzly bear) are now extinct in the state. The ferret, a habitat specialist, requires extensive prairie-dog towns for survival while the other species are large carnivores that require extensive areas over which they are effectively protected. Bison and elk, our largest native herbivores, occur only as fenced populations and are not free-ranging.

Four mammal species have been introduced in Oklahoma. The house mouse, Norway rat and black rat often dominate urban areas and are the most common rodent pests in buildings. Nutria, an aquatic rodent, was released into the wild by fur farms.

Two mammalian species, the Indiana bat and the gray bat, are federally listed as endangered, and the Ozark big-eared bat is federally listed as an endangered subspecies. These bats have declined as a result of disturbances to cave habitats, loss of bottomland forests and pesticide use. Twenty species and one subspecies are listed as species of special concern by Oklahoma.

The major threat to the variety of Oklahoma mammals comes from habitat alterations for urban and agricultural development. Pesticide use and various pollutants certainly impact some species. Most large carnivores, including grizzly bears and gray wolves, have been extirpated because of human actions. Red wolves have become extirpated from Oklahoma through "genetic swamping" because of hybridization with coyotes and domestic dogs. The black footed-ferret disappeared from Oklahoma due to extensive poisoning programs to control prairie dogs, the ferret's primary food source. Several bat species are endangered due to vandalism, pesticides and destruction of roost sites.

Fungi

The Kingdom Fungi includes a diversity of organisms that occupy practically all communities. Their role in nature is multifold. Fungi are the major decomposers of dead vegetation—they are natural recyclers. Some are plant pathogens such as the organism that causes Dutch elm disease. Other pathogens include the rusts and smuts, which attack agricultural crops as well as native plants. Still other fungi form an association with roots of plants, such as mycorrhizae. This is a symbiotic association that is obligate and beneficial to both the fungus and the higher plant. The vast majority of land plants have mycorrhiza associations.

Examples of fungi include slime molds, water molds, yeasts, rust and smut fungi, mushrooms, puffballs, bracket fungi, morels and a host of other molds that occur naturally in soil. Some fungi also can become a nuisance and cause spoilage of stored grains or fruits. Lichens, which are composed of a fungus and an alga, are classified with the fungi as well.

Although all of these types of fungi occur in Oklahoma, they are poorly documented. This is due in part to the lack of specialists that have worked in the state, coupled with the fact that the fungal organisms are seldom visibly apparent in the environment except for those that produce visible reproductive structures. Special techniques often are required to isolate and culture many fungus groups. It is therefore impossible at this time to assess the fungal diversity in the state (with perhaps the exception of plant pathogens that are known because of their economic importance), and difficult to predict which, if any, might be endangered or threatened.

The diversity of ecoregions in Oklahoma should provide for a rich diversity of fungal species, yet we lack basic information on the diversity and abundance of fungi in general to know which fungi might be characteristic of each ecoregion. In some cases, however, it is possible to predict where certain fungal groups might be most abundant. For example, diversity of mushroom and bracket-type fungi is always high in wooded habitats. Trees, such as oaks, hickories and pines, form mycorrhizae with mushroom-type fungi. Where these trees occur, their associated fungi will appear; where the trees are absent, the fungi likewise will be absent. Forested areas also provide abundant leaf litter and woody debris that support decomposer mushrooms and bracket fungi. Thus, the eastern ecoregions will support a rich diversity of mycorrhizal and **saprotrophic** (obtain their food from other plants) fleshy fungi. Arid and less wooded areas are not devoid of these fungi but contain fewer species. Some earthstars and puffballs actually are more common in arid, non-wooded communities.

In general, extensive collecting of all fungal groups is needed throughout the state. For most groups, baseline studies of fungal diversity have not been conducted. This information will be needed before estimates of the total number of species can be made.

Plants

Oklahoma has approximately 2,550 vascular plant species in 850 genera and 172 families. Approximately 85% (2,170) of the species are native to the state. Oklahoma has no truly endemic plants, although several species are restricted to this and adjacent states.

The large number of plant species in Oklahoma is a function of the high diversity of environments present. Moist eastern ecoregions support species typical of eastern North America, and subarid western ecoregions support species typical of the desert West and a few from the Rocky Mountains. The very diverse flora of North America's southeastern coastal plain are well represented in the South Central Plains in Oklahoma. Unusual geological substrates such as gypsum deposits, salt flats, lava flows and granite outcrops create unique local environments that in turn support unique flora.

Natural disturbances, especially fires, maintain high plant diversity because they prevent one species from dominating the community. However, the high diversity in moist, rich forest understories in eastern ecoregions can be suppressed by disturbance.

There is a general trend of decreasing plant diversity from east to west, although exceptions do occur. This trend is caused by two important ecological gradients: decreasing moisture and lower geological diversity.

The vascular-plant diversity in Oklahoma is facing a number of threats. Foremost among these is a dramatic change in the fire regime from what occurred historically. Many Oklahoma species are adapted to some level of fire. If fire is used improperly or excluded from a landscape, either by active suppression or by increasing the number of fire breaks such as roads, fire-tolerant and fire-dependent species may become replaced by more competitive but fire-intolerant species. The result is a landscape with lower diversity. The most widespread example of how natural communities depend upon fire in Oklahoma is the red cedar invasion of prairies. Although it is a native species (probably originally confined to cliff faces and ravines along major rivers), red cedars now form dense stands where grasslands once occurred. Not only do red cedars depress the diversity of other plants, they also can become a serious fire hazard.

Although fire is vital to many of Oklahoma's natural communities, it should not be used casually. Great care must be taken to ensure that fires set for management purposes do not become uncontrolled wildfires. Today, fire cannot be allowed to burn uncontrolled across the landscape because property and human life must be protected. However, knowledgeable land managers can safely use controlled fires

to mimic conditions that enhance the diversity of Oklahoma's natural communities.

Exotic species also threaten plant diversity. Of the nearly 400 exotic plant species occurring in Oklahoma, several create serious threats to native communities. These include Japanese honeysuckle, kudzu, Japanese brome, cheatgrass, Johnson grass, tall fescue, privet, Bermuda grass and plains bluestem. These species often form monocultures and eliminate native species. While most exotic plant species show no known impact, it is difficult to predict whether they, or additional introductions, might become pests in the future.

Land use changes can adversely impact native plant diversity in a number of ways. Urbanization replaces natural communities with asphalt, pavement or other substrates unsuitable for native plants. Converting native plant communities to cropland also causes habitat loss. Another example is the conversion of native forest to intensively managed pine plantations; this not only reduces tree diversity, but also the diversity of understory shrubs and herbaceous species. Some effects of changing land use are more subtle. For example, the building of a road may result in changing the local hydrology, which may alter a nearby wetland.

A few plant species are threatened by overcollecting. Cacti are often collected and sold as house plants. The prairie coneflower is the source of a valuable medicine which is growing in popularity. Coneflower populations in a number of locations have been substantially lowered by collecting. Although it is difficult to assess the damage done by picking of trailside wildflowers, plant diversity often is lower along high-traffic hiking trails.

Perhaps the most overlooked threat to our flora is our lack of knowledge. Because Oklahoma has little detailed information on the ranges of plant species, it is very difficult for botanists to monitor their distribution. It is possible for plant species to become endangered before scientists are aware of any decline.

Fortunately, the prospects for Oklahoma's plant diversity are not entirely negative. Proper fire management can be used to enhance biodiversity, reduce danger of catastrophic wildfires and improve range conditions for livestock. If carefully designed, land development does not have to adversely affect biodiversity. Native plants can be used in landscaping and wildlife plantings. While it may not be possible to regain some of our lost natural communities, the emerging science of restoration ecology offers hope that degraded land can be converted to areas with high biodiversity value.

Genetic Diversity

Genetic diversity is complex to measure and cannot be addressed on a statewide level. Although it is difficult to manage, genetic variability may be important in special circumstances in which a population is very low and isolated, such as in endangered species. Oklahoma's red-cockaded woodpecker population has been declining steadily for several years, and reduced fertility and survival of young may be caused by a lack of genetic diversity. In these cases, additional individuals may be released into the population to provide additional genes.

Summary

Oklahoma harbors high levels of biodiversity at each of the three levels: genetic diversity, species diversity and community diversity. Its ecoregions include natural communities along a gradient ranging from structurally complex moist forests with cool, clear streams to structurally simpler arid shortgrass prairies having intermittent, warm, sand-bottomed streams. These diverse communities support a large variety of plant and animal species.

Some of Oklahoma's species and natural communities occur in few other places in the world. These species and communities that most typify Oklahoma or are limited exclusively or primarily to Oklahoma's ecoregions should receive special attention for biodiversity conservation.

Nineteen of Oklahoma's species are federally-listed as threatened or endangered and an additional five are state-listed as threatened or endangered. Four species are candidates for federal listing and 78 are listed in Oklahoma as species of special concern, indicating possible declines in their populations.

Oklahoma has a rich heritage in its wealth of biodiversity. In order for us to have these resources for future use and enjoyment or to pass on to future generations, we must conserve biodiversity at all levels by maintaining our natural communities as functioning ecosystems.

One value of biodiversity is instilling appreciation in children for beneficial species, such as the Great Plains rat snake.