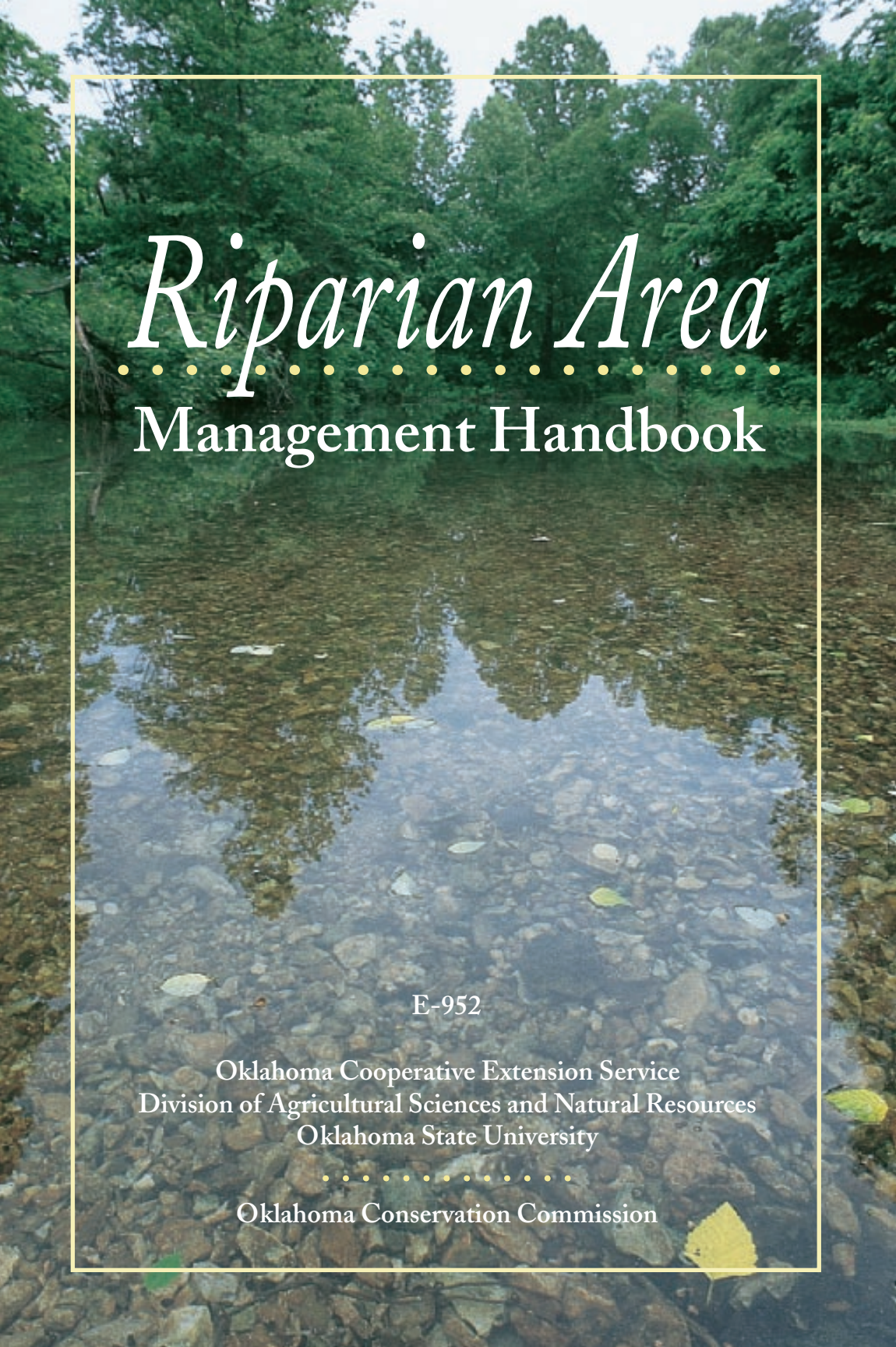

Riparian Area

Management Handbook

E-952

Oklahoma Cooperative Extension Service
Division of Agricultural Sciences and Natural Resources
Oklahoma State University

Oklahoma Conservation Commission

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Anna Fallon, Project Manager, Extension Engineer/Environmental Scientist
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July 1998

Foreword

The **riparian** management project is a joint effort of the Oklahoma Cooperative Extension Service and the Oklahoma Conservation Commission. The project began in 1994 with the grant "Management Program for Riparian Areas to Protect Water Quality" from the U.S. Environmental Protection Agency (EPA) Wetlands Program.

The project had three levels of activity: a technical staff, an advisory committee, and a technical review group. The technical staff, composed of faculty, students, and staff from Oklahoma State University and a professional from the Natural Resources Conservation Service, was responsible for day-to-day research and report preparation. Input from commodity and interest groups was solicited through the advisory committee.

The technical review group consisted of professionals from state and federal environmental agencies, including the Oklahoma Biological Survey, Oklahoma Department of Environmental Quality, Oklahoma Water Resources Board, Oklahoma Department of Wildlife Conservation, Oklahoma Department of Agriculture - Forestry Services, Office of the Secretary of Environment, the USDA Natural Resources Conservation Service, and the U.S. Forest Service. The technical review group helped prepare materials and reviewed documents for technical content.

Project Goals

Project goals and objectives were to:

- Establish technical guidelines for riparian protection and management measures;
- Develop a working partnership of federal and state agencies, landowners, producer groups, and environmental groups;
- Provide a basis for public education and understanding of the role of riparian areas in protecting water quality; and
- Recommend policy options for state riparian programs.

Purpose of This Handbook

This handbook provides a resource of riparian-related information to the general public and technical staffs in counties and conservation districts.

The handbook begins with background information on the function and importance of riparian areas and is followed by a chapter describing the ecoregions of Oklahoma. The balance of the handbook focuses on specific aspects of riparian management, including grazing, wildlife, vegetation, and channel stability. Members of the technical review group and the technical staff, drawing on their unique areas of expertise, authored chapters. This handbook also contains a stand-alone chapter on the Riparian Buffer System (RBS), which is a blueprint for an engineered stream protection system.

Recommendations may differ slightly from chapter to chapter in this handbook. This is an expected consequence of different management objectives. For instance, if streambank erosion is a particular concern, one may opt to plant a species that has low wildlife value but is quick rooting (and possibly short-lived). On the other hand, if one's objective is to attract wildlife, this species would not be recommended.

A Note on Terminology

One of the things that became apparent at the beginning of this project is the inconsistency of riparian terminology. There are riparian areas, buffer strips, vegetated buffers, filter strips, and bottomland hardwood forests. Although there do not appear to be any hard and fast rules, the key words to be aware of are "riparian" and "buffer."

In general, riparian areas are considered to be features of the landscape that may or may not be forested, depending on location. In Oklahoma, forested riparian areas are often referred to as bottomland hardwood forests.

The term buffer, as in "buffer strip," "grassed buffer," or "forested buffer," suggests a function and a location between two different areas. Buffers are considered management tools and are usually found at the edge of some land-disturbing activity, such as cropland or a construction site. A riparian buffer, therefore, is an area adjacent to a water body that is being managed for its pollution-prevention attributes.

To avoid confusion, the technical review group set a definition for riparian area. The group defined riparian areas as:

> *The geographically delineated areas with distinct resource values that occur adjacent to streams, lakes, ponds, wetlands, and other specified water bodies.*

This definition was chosen so it would be inclusive of the diverse conditions found in Oklahoma. It should be noted that, in some cases, riparian areas also qualify as wetlands.

Note: Words that are defined in the glossary appear in bold throughout the text.

Anna Fallon
Project Manager

Introduction

Many of us have sought out the cool refuge of a tree-lined streambank on a sweltering day or enjoyed watching the birds, deer, and other wildlife that are drawn to the land-water interface. This interface is a unique landscape feature called a "riparian area." Riparian areas are the lands adjacent to water bodies—from creeks and rivers to lakes, ponds, and wetlands.

Our association with riparian areas dates back to our earliest history when man sought out these zones because of their abundance of food, water, and raw materials. Although we are long past relying upon these areas for food or fiber, riparian areas have not lost their importance to man or society.

Riparian areas provide an extensive list of benefits to both man and the environment. Because of their unique position between land and water, riparian areas act as a buffer between upland terrestrial activities and the water. They store water and reduce the effects of flooding, recharge ground water supplies, reduce erosion and trap sediment and other pollutants, provide shelter and food for wildlife, and help mitigate the effects of **nonpoint source pollution**.

A Threatened Resource…

Our understanding of the benefits riparian areas provide comes at a time when many riparian areas have already been severely damaged by the removal of native vegetation, erosion, and channelization (straightening of channels).

Threats to riparian areas continue from many sectors. Ironically, it is primarily the location and attractiveness of this land that has jeopardized its existence.

Riparian forests or bottomlands are fertile and often valued as prime farmland. Many riparian areas have been cleared for use as pastureland or for row crops or other agricultural activities. Many of these activities use fertilizers and pesticides, increasing the potential for both ground and surface water pollution.

Riparian areas are often considered prime water-front property by developers. Urban encroachment, channelization, and other water resource development activities have contributed to the destruction and alteration of native riparian areas.

In Oklahoma…

Riparian area destruction is a critical issue. A century of farming and urbanization without concern for riparian areas has left its mark.

The Oklahoma landscape, crisscrossed by large rivers, contained millions of acres of riparian land prior to European settlement. Estimates suggest that less than 15 percent of the original riparian forest remain in the 28 easternmost counties (Brabender et al. 1985). Projections for the future show little sign of riparian destruction slowing.

Riparian losses in Oklahoma have been described and quantified in reports such as *Bottomland Hardwoods of Eastern Oklahoma* and *Riparian Areas of Western Oklahoma.* Written in the late 1980s, these documents helped call attention to the importance and rapid destruction of Oklahoma's riparian areas.

A National Concern…

Riparian area destruction or degradation is not just a local issue, but rather a national concern. National initiatives and task forces have been created to help reduce the rate of riparian destruction and promote protection and preservation.

Everyone from the President on down is becoming familiar with riparian issues. In his State of the Union Address in February 1997, President Bill Clinton announced his American Heritage Rivers Initiative, a program that is intended to study and protect America's rivers. In the spring of 1997, Secretary of Agriculture Dan Glickman targeted 2,000 miles of streambank to be enrolled in the conservation reserve program. In addition, U.S. Army Corps of Engineers officials have been quoted as "rethinking" their structure-oriented floodplain policy. Clearly, concern is starting to focus on this topic.

Full Circle

Our relationship with riparian areas has come full circle from the early days of dependence, to destruction, to the renewed realization of the importance of riparian areas. Many now recognize and understand the connectivity of all things and that by altering one aspect of an ecosystem, everything and everyone is affected.

Because of their unique place between land and water, healthy riparian areas benefit virtually everyone—aquatic and terrestrial species alike. Author Norman Maclean put it well when he stated, "everything merges into one—and a river runs through it."

Literature Cited

Brabander, J. J., R.E. Masters, and R.M. Short. 1985. Bottomland Hardwoods of Eastern Oklahoma. A Special Study of Their Status, Trends, and Values. U.S. Fish and Wildlife Service and Oklahoma Department of Wildlife Conservation publication.

Stinnett, D.P., and R. Smith. 1987. Riparian Areas of Western Oklahoma. A Special Study of Their Status, Trends, and Values. U.S. Fish and Wildlife Service and Oklahoma Department of Wildlife Conservation publication.

B. Hoagland, Okla. Biological Survey

Key Points:

Riparian areas provide many valuable benefits and functions. Healthy riparian areas:

- Store water and help reduce floods,
- Provide food and shelter for wildlife,
- Stabilize streambanks,
- Are repositories of biological diversity,
- Shade streams and help maintain water temperature, and
- Play an important role in mitigating or controlling the effects of nonpoint source pollution.

Benefits and Functions of Riparian Areas

Anna Fallon, Oklahoma State University
Michael Smolen, Oklahoma State University

Healthy riparian areas provide a host of on-site and off-site benefits to man and the environment. Riparian areas play an important role in improving water quality, protecting the streamside environment, and preserving biodiversity. The landowner profits by preventing erosion from streambanks, increasing forage and timber products, improving fishing and hunting opportunities, and preserving the quality of the land and water for posterity. Society benefits from improved water quality and environmental values, such as biodiversity and aesthetics. Often, there are additional off-site benefits, such as reduced flood damage.

B. Hoagland, Okla. Biological Survey

A healthy riparian area is vital to protecting water resources.

Water Pollution

Perhaps one of the most recognized riparian area benefits is the reduction of nonpoint source (NPS) pollution. NPS pollution is the number one threat to Oklahoma's water. In contrast to point sources that originate from defined out-

lets such as pipes or channels, NPS pollution originates from undefined or diffuse sources such as fields or city streets. NPS pollutants include sediment, pesticides, and fertilizers. These pollutants are discussed in the following box.

Sediment

Sediment can interfere with the feeding and reproduction of fish and aquatic insects, disturbing the food chain. Large deposits of sediment clog channels and floodplains, greatly increasing the erosion of streambanks and causing more flood damage.

Pesticides and Fertilizers

Many pesticides bind to soil particles and enter waterways with eroded soil. They are damaging not only to aquatic organisms, but to humans as well. Insecticides are of concern because of their effects on aquatic insects that other organisms rely on for food. Herbicides may damage phytoplankton, the base of the aquatic food chain. There are not many documented ecological effects of fungicides, but many are possible.

Fertilizers act as nutrients for aquatic plants, just as they do for crops and lawns. The phosphorus and nitrogen found in fertilizer enrich the aquatic environment, promoting growth of algae and aquatic vegetation beyond what is sustainable. Excess algal growth decreases water clarity and can deplete oxygen, causing fish kills.

Riparian areas are important in controlling NPS pollution because riparian vegetation helps to retain sediments and other pollutants. Riparian vegetation acts to slow and trap pollutants coming from upland sources that would otherwise flow unimpeded into the water. Trapped pollutants are utilized by non-woody plants for short-term removal or sequestered in woody tissue for long-term removal. Various microbial processes may break down pollutants so that they are immobilized or rendered nonpolluting.

The ability of a riparian area to function as a buffer depends on many factors, including but not limited to the type and density of plants, topography, season, and width of the buffer or flow path. Not all riparian areas are able to remove pollutants at the same rate or in the same manner. Most of the research to date has focused on the removal efficiencies of forested riparian buffers and grass filter strips. Removal of sediment-bound phosphorus has been documented at 80 percent or higher in riparian forest buffer systems. Nitrogen removal efficiencies in forest buffer systems are also high particularly in shallow ground water (Jacobs and Gilliam 1985).

Streamside Environment

Long before riparian areas were considered a **best management practice (BMP)** for NPS pollution, they played an important role in **ecosystem** health. Riparian areas help stabilize streambanks, provide sources of energy for aquatic life, provide cover and food for terrestrial species, and are important repositories of biological diversity.

Riparian areas contribute in many ways to aquatic ecosystems. Vegetation along banks contributes to bank stability and helps reduce the amount of sediment entering waterways from bank erosion. Loss of bank stability can lead to loss of habitat through stream widening (or through stream narrowing) when forest is replaced by sod (Chesapeake Bay Program 1995). Shade that is provided by overhanging vegetation helps moderate stream temperatures and reduces algal production. Riparian areas also function as an energy source in waterways, providing dissolved carbon compounds and particulate organic matter to streams (Welsch 1991).

Terrestrial species rely on riparian areas for food and cover. As the human population grows and expands into former wild areas, wildlife is pushed into smaller and smaller areas. Riparian tracts are becoming increasingly important as repositories of biological diversity. Riparian areas also serve as effective corridors for wildlife movement between fragmented habitat areas.

Conclusion

Because riparian areas are located between land and water, their health and preservation benefits both terrestrial and aquatic ecosystems. Riparian areas provide critical habitat for terrestrial species, food and energy for aquatic species, and protection for water resources. Good management and protection of riparian areas is in the best interest of society and helps preserve the land and water for posterity.

Literature Cited

Chesapeake Bay Program. 1995. Water Quality Functions of Riparian Buffer Systems in the Chesapeake Bay Watershed. EPA Pub. No. EPA 903-R-95-004. U.S. EPA.

Welsch, D.J. 1991. Riparian Forest Buffers. USDA-FS Pub. No. NA-PR-07-91. USDA-FS, Radnor, Penn.

Jacobs, T.C., and J.W. Gilliam. 1985. Riparian losses of nitrate from agricultural drainage waters. *J. Environ. Quality.* 14:472-478.

B. Hoagland, Okla. Biological Survey

Key Points:

Ecoregions provide a framework to group similar areas based on factors such as soils, land use, and potential types of natural vegetation. The ecoregions presented here depict the "big picture" and describe relatively large areas of the state. Unique areas exist within these ecoregions that differ from the general description. This chapter contains information about each of Oklahoma's 11 ecoregions. (Oklahoma has the second highest number of ecoregions in the continental U.S.)

Consider the ecoregion's description when selecting vegetation for planting in a riparian area.

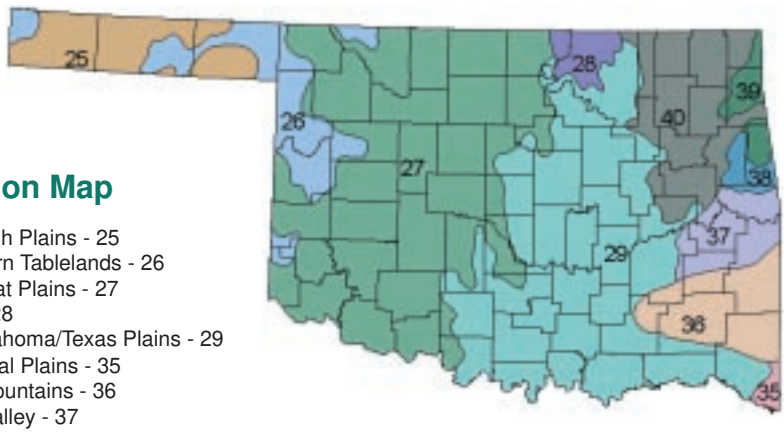
Ecoregions

Bruce Hoagland, Oklahoma Biological Survey and the University of Oklahoma
Scott Stoodley, Oklahoma State University

(This information has been adapted from Oklahoma's Biodiversity Plan: A Shared Vision for Conserving Our Natural Heritage, *edited by Norman Murray, Oklahoma Department of Wildlife.)*

Oklahoma is a biologically rich and diverse state, a fact well depicted on the accompanying ecoregion map. Ecoregions are defined as relatively homogenous areas that can be mapped using factors such as land surface form, soils, land use, and potential natural vegetation.

Level III Ecoregion Map



Western High Plains - 25
Southwestern Tablelands - 26
Central Great Plains - 27
Flint Hills - 28
Central Oklahoma/Texas Plains - 29
South Central Plains - 35
Ouachita Mountains - 36
Arkansas Valley - 37
Boston Mountains - 38
Ozark Highlands - 39
Central Irregular Plains - 40

Source: James Omernik, Environmental Protection Agency, 1996.

The ecoregion framework can play a role in riparian management. Ecoregion maps assist individuals and managers in understanding regional patterns and potentials of riparian resources. Understanding these regional differences will help people understand the naturally occurring condition of their respective riparian areas. It could also aid in determining whether an existing riparian area is in a degraded or natural state.

Ecoregions of Oklahoma

In this chapter, descriptions are provided for each of Oklahoma's 11 ecoregions. This information includes species diversity, natural communities, and physical geography of each ecoregion.

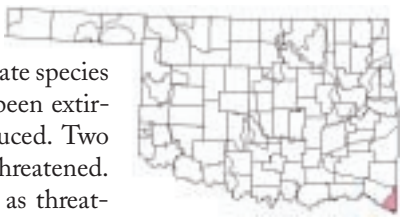
The ecoregion discussions are broken into two parts: species diversity and natural communities. The species diversity section addresses the number of vertebrates (primarily mammals and birds) found within each ecoregion. It should be noted that vertebrate distributions are not always limited to one ecoregion. For example, there are 328 vertebrate species listed for the Ouachita Mountains and 312 for the Arkansas Valley. However, most of these species will be found in both ecoregions. Likewise, fox squirrels are included in a species count for the Ozark Highlands, but are common in the Arkansas Valley and other ecoregions. Few species are found in only one ecoregion.

There are 634 native vertebrate species (fish, birds, and mammals) that reside in Oklahoma and many more that migrate through the state during the fall and spring. The total number of invertebrate species (worms, insects, mussels, crayfish, etc.) is not known. There are approximately 2,500 species of vascular plants (ferns, trees, grasses, sedges, and various wildflowers) in Oklahoma. The total number of algal, fungal, and moss species is currently unknown.

Oklahoma is host to a wide variety of natural communities. Biologists name communities based on the most common or characteristic plants present, because plants are the most easily observed component of a community.

Although a community is named after characteristic plant species, the physical structure of the community (e.g., number and age of trees, fallen logs, ground cover, water availability, rocks) may be more important for animal survival than the plant species present. For example, wrens will nest in tree cavities regardless of the tree species as long as surrounding habitat is suitable.

South Central Plains - 35



Species diversity - Three hundred fifteen vertebrate species are native to this ecoregion. Six species have been extirpated (made extinct) and nine have been introduced. Two species are federally listed as endangered or threatened. Sixteen species are state candidates for listing as threatened, endangered, or of special concern.

Natural communities - The South Central Great Plains ecoregion contains some of Oklahoma's most unusual biological communities. Although these communities are found only in southeast Oklahoma, they are widespread throughout the southeastern United States.

The dominant communities in the South Central Plains are moist upland forests dominated by sweetgum, hickories, black gum, and/or various species of oak. Stands of loblolly pine may occur on moist soils, but undisturbed examples are rare. These forests are tall with dense canopies. The shade is so dense in some stands that only ferns and other shade-tolerant plants can grow there. In natural stands, trees are of various ages and heights, creating layers of vegetation.

The multilayered nature of these communities actually increases animal diversity. Some animal species occupy the canopy or uppermost strata, while others are adapted to life in the shrubs or on the forest floor. Canopy openings (created by fallen trees, etc.) and forest edges receive increased amounts of light. The result is a profuse growth of shrubs and vines (such as grapes, poison ivy, and greenbriar) and groups of animals adapted for life in disturbed areas. All of these components—multiple vegetation layers, canopy gaps, and forest edges—contribute to the structural complexity of a natural community and, therefore, species diversity and habitat quality.

Swamps are a prevalent natural community in this ecoregion. They occur in low-lying areas along rivers and streams. Bald cypress, willow oak, overcup oak, water oak, planer elm, water hickory, and nutmeg hickory form species-rich, multilayered forests in these areas. The tree species present are determined by how long a site remains flooded. For example, bald cypress is most abundant in sites that are flooded for most of the year. Sites that are flooded in the spring but draw down (dry out) by early summer are dominated by mixed oak species.

Not all wetlands in this ecoregion are forested. Permanently flooded ponds and lakes host open wetland communities with thick canebrakes, southern wild rice, water lilies, lotuses, rushes, and cattails. Drier upland sites are also dominated by oaks, but by different species from those that occur in the wetlands. Such sites may be forests or woodlands intermixed with pines. Understory species consist of blueberries, shrubby St. John's wort, and a variety of wildflowers and grasses. A unique and very rare natural community type in this region is the bluejack oak woodland that occurs on deep, sandy soil.

Grassland communities are also found in this ecoregion. Forest and woodland openings dominated by grass species such as little bluestem, Indiangrass, and side oats grama may persist for many years. Pimple prairies, which are associated with mima mound topography, are a unique grassland type. Glades and pimple prairies are dependent on fire to prevent encroachment of trees and other woody species. Some grasslands or old fields in the ecoregion are the product of forest clearing and are dominated by the grass broomsedge, but other tallgrass prairie species may be present. However, these grasslands typically return to forest cover in the absence of repeated disturbance.

Ouachita Mountains - 36

Species diversity - Three hundred 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 as endangered and 17 are candidates or of special concern.

Natural Communities - Ridgetops and south-facing slopes in the Ouachita Mountains were once covered by shortleaf pine woodlands, with scattered oaks and black hickory. Farkleberry and other blueberries are the main understory shrubs. Grasses (primarily little bluestem) are the predominant herbaceous cover in these woodlands, which were kept open by periodic fires. Glade and sparsely vegetated rock outcrop communities are also common.

North-facing slopes and ravines often support forests dominated by tree species that cannot tolerate the harsh dry conditions found on ridgetops and south-facing slopes. Mockernut and bitternut hickories, maples, and sweetgum, as well as white, northern red, and chinquapin oaks are common. There are more tree and shrub species in these communities than in the drier pine forests. Therefore, the understory vegetation is well developed, but the ground cover is often sparse and scattered due to dense shade and the thick carpet of leaves. One of the unique communities found in this ecoregion is composed of dwarf white and blackjack oaks which occur on shallow soil along high ridges.

Bottomland forests occur along streams and other bodies of water. Water and willow oaks, hickories, sweetgum, and black gum dominate these forests. Bottomland forests are tall and the canopy may reach 100 feet (30m) in height, with two to four vegetation layers beneath. These communities have a rich diversity of understory trees and shrubs, including flowering dogwood, ironwood, spicebush, and buttonbush. American beech and cucumber magnolia are trees common in the eastern United States, but they extend to this part of Oklahoma.

As in other forests, when canopy gaps are formed, increased amounts of light reach the ground and a lush growth of herbaceous vegetation and vines result. Grassland communities are fairly rare in this ecoregion and are typically restricted to glades and south-facing slopes. Grasslands composed of broomsedge and some tallgrass prairie species may form when forests are cleared, but they eventually revert to forest vegetation in the absence of disturbance. It is interesting to note that Thomas Nuttall, a naturalist traveling through parts of Oklahoma in the early nineteenth century, reported that extensive grasslands covered the Kiamichi River Valley.

Another interesting community type in the Kiamichi Mountains is created by rock slides, which produce unique habitats for plants and animals. Trees and shrubs grow among the rocks, but soils are shallow. Mosses grow in moist crevices. Rocky areas provide sunning surfaces for reptiles. The many crevices found in these areas also serve as dens as well as escape habitat for many mammals, insects, and other animals. Larger crevices and rock shelters serve as summer bat roosts.

Arkansas Valley - 37

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

Natural communities - The Arkansas River Valley forms a geological break between the Ozark Highlands to the north and the Ouachita Mountains to the south. Some of the natural communities found in this ecoregion are more common in the Central Oklahoma/Texas Plains to the west.

Dry forests and woodlands of post oak, blackjack oak, and black hickories dominate rugged areas and extend into the plains. The trees in these communities are relatively short [approximately 50 feet (15m) tall], and a significant portion of the vegetation cover is provided by grass species. Understory shrubs include blackhaw, farkleberry, and St. Andrew's Cross. Shortleaf pine woodlands may be found on ridgetops of this ecoregion and are structurally similar to the Ouachita Mountains communities. Likewise, north-facing slopes and ravines support forests composed of maples, white oak, northern red oak, and chinquapin oak.

Tallgrass prairie communities, composed of big and little bluestem, Indiangrass, switchgrass, and other grasses, are common in the broad valleys. A wide variety of wildflowers and other plants also are present. Prairie communities often are scattered between dry upland forests and the bottomland hardwood forests that occur along streams. As in all grasslands, fire discourages the growth and invasion of woody plants and is important for grassland maintenance.

Lush forests of oak, elm, and hackberry occur along streams and rivers. These forests are often taller than those in the uplands [about 100 feet (30m)] and may have two or three understory layers. Dense mats of dead leaves and other litter accumulate on the forest floor. Scattered clumps of low vegetation thrive in these heavily shaded forests, except in canopy openings, where a lush growth of herbaceous plants and vines is common.

Ozark Highlands - 39

Species diversity - Three hundred eleven vertebrate species are native to this ecoregion. Three vertebrate species have been extirpated and 10 have been introduced. Three species are federally listed as endangered and 14 are candidates or of special concern.

Natural communities - Dry oak-hickory forest and woodlands occur on well-drained soils on slopes, hills, and plains. Trees are of medium height, averaging 20 to 60 feet (6 to 18m). The canopy is relatively open and allows for an understory composed primarily of grasses. Exposed rock is common. Blackjack oak, post oak, black hickory, and winged

elm are common in the canopy and coralberry, huckleberry, and blackhaw in the understory.

Forest communities on north-facing slopes and ravines grow on moister soils under cooler conditions. The trees here often attain average heights of 60 to 90 feet (18 to 27m). Sugar maple, white oak, chinquapin oak, mockernut hickory, and bitternut hickory are common in the overstory. The canopy is closed and often produces dense shade. Therefore, the forest floor is available only to shade-tolerant shrubs (e.g., flowering dogwood, pawpaw, spicebush, and bladdernut); herbaceous plants (e.g., may apple, dogtooth violet, and bloodroot); and mosses, ferns, and liverworts. This is why herbaceous species often blanket the forest floor in early spring before tree leaves produce shade.

Ridgetops and south-facing slopes support grassland communities. Some of these communities are sparsely vegetated glades and rock outcrops. Prairies may develop on slopes with deeper soils. Big and little bluestem, Indiangrass, and a variety of wildflowers are characteristic of these tallgrass communities.

Bottomland hardwood forests occur along the floodplains of larger Ozark streams. The overstories of these forests are composed of shumard oak, sycamore, cottonwood, and elms. Understory vegetation may be sparse due to annual **scouring** floods. Soils in these forests are often gravelly with sand or a thick layer of humus.

In places, the limestone formations underlying the Ozark Highlands have dissolved, forming sinkholes and caves (a landform type known as Karst topography). These habitats can support remarkably diverse animal communities. The caves are indeed unique, because no light enters these habitats, and green plants, the base of most terrestrial food chains, are absent. Animals that live in cave streams (blind fish and crayfish) must rely on the guano (droppings) produced by roosting bats and material carried into the caves by floods for energy. Other wildlife species also use the caves for shelter.

Central Irregular Plains - 40

Species diversity - Three hundred 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 as endangered and 20 are candidates or of special concern.

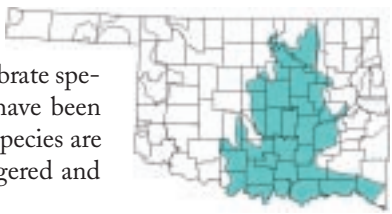
Natural communities - The Central Irregular Plains ecoregion is essentially a band of tallgrass prairie separating the forested Ozark Highlands from the Central Oklahoma/Texas Plains. Tall grasses such as big and little bluestem, Indiangrass, and switchgrass are the dominant species. In lowland areas, species such as big bluestem and Indiangrass may grow in excess of eight feet (2.5m) in height. Sunflower, Indian blanket, blazing star, and other wildflowers grow among the grasses. The diverse numbers of wildflowers provide nectar for hummingbirds and insects and seeds for

small mammals and birds. Fire is important in maintaining these grasslands. In the absence of fire, woody plants such as sumac, blackberries, and persimmons invade grassland communities. Dry, shallow soils composed of gravel support glades vegetated by side oats and hairy grama. Dry upland forests and woodlands composed of post oak, blackjack oak, and black hickory occur on hilltops and ridgelines. The trees in these forests are short and the canopy is open. Prairie grasses and wildflowers are abundant 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 these streams slope gently, the forest floor is not as heavily scoured as bottomlands in the Ozarks. The forest floor is heavily shaded, allowing for limited understory development. In poorly drained sites, sedges, willows, and buttonbush form thickets along wetland edges.

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

Central Oklahoma/Texas Plains - 29



Species diversity - Three hundred 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 as threatened or endangered and 20 are candidates or 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 western grasslands. In the more level northern and southern portions of the ecoregion, prairie communities cover most of the landscape, with woodlands on 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. Prairies are scattered throughout this ecoregion.

Upland forests occurring in this ecoregion are called crosstimbers. The origin of this term is obscure, but the most likely explanation is that when settlers and explorers first crossed Indian Territory, they encountered extensive grasslands after leaving the eastern mountains. On the horizon, they could see a wide belt of "timber" that "crossed" the plains. These open forests consist of short post oaks and blackjacks up to about 40 feet (12m) 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. Blackjack oaks have rounded crowns that may extend to the ground. Understory development is limited. Fire is an important force in this community, reducing shrub cover and

burning away low tree limbs. Unburned stands may develop into dense forests of post oak and blackjack oak.

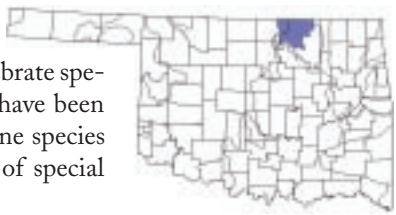
Grasslands composed of big and little bluestem, Indiangrass, and switchgrass are predominant in this ecoregion. Scattered pockets of species typical of western shortgrass prairies can be found on dry, shallow soils and interspersed clay layers. The diversity of wildflowers is high, providing nectar for hummingbirds and insects and seeds for a variety of wildlife. Hackberry, American elm, red elm, black walnut, green ash, and cottonwood are common along streams in this ecoregion. Post oaks are also found in bottomlands, but grow taller than those on upland sites. In more open sites, cottonwoods, willows, sedges, and rushes line rivers and streams.

Bottomland forests of this ecoregion also serve as a transition from eastern to western natural communities. Bottomland forests in eastern Oklahoma, where rainfall is abundant, are very diverse in the number of species. In western areas, where water can be scarce, the plant community is composed of fewer species. Willows and cottonwoods dominate bottomland forests in the west. Eastern bottomland species which require very moist conditions cannot persist in western portions of the ecoregion, and they are replaced on floodplains by eastern species that grow on moist upland sites. Also, more sunlight reaches the forest floor at some western sites, resulting in greater amounts of herbaceous vegetation development.

A few sandstone caves are scattered throughout the ecoregion. They are typically small and support only sporadic populations of bats during the summer months. They are too small to support hibernating bats or other cave life.

Arbuckle Mountains - The Arbuckle Mountains are a distinct feature within this ecoregion. Although the highest peaks are located in Murray and Carter counties, the Arbuckle Mountains do extend east into Pontotoc and Johnston counties. In Murray and Carter counties, the Arbuckle Mountains are composed of eroded limestone and conglomerate which produces topography more rugged than the surrounding plains. Although most natural communities in the Arbuckle Mountains are similar to others in the ecoregion, unique species and communities do occur in this area. Several species common on the Edward's Plateau of central Texas can be found in the Arbuckle Mountains (e.g., short-lobed oak, Texas ash, and Buckley's oak). The moist bottomland forest have several species common in eastern Oklahoma. Clear, cool, fast-running spring-fed streams are common. The animal species found in this ecoregion are similar to those found in the eastern part of the state.

Flint Hills - 28



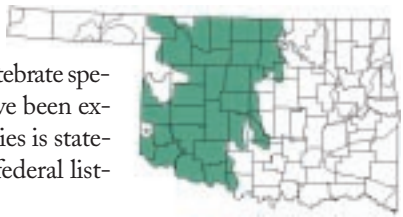
Species diversity - Two hundred forty-three vertebrate species are native to this ecoregion. Five species have been extirpated and seven have been introduced. One species is state threatened and four are candidates or of special concern.

Natural communities - This ecoregion is strongly associated with lush, tallgrass prairies. They are the products of gently rolling topography, which is conducive to natural fires. Big and little bluestem, Indiangrass, and switchgrass (the "big four" prairie grasses) are the primary grasses. In lowland sites, big bluestem and Indiangrass may reach 10 feet (3m) in height. These grasslands are rich in wildflower species. Dry, shallow soils are vegetated by short grass species, such as side oats, blue, and hairy gramas. Prickly pear cactus and yuccas may also be common. As in all grasslands, fire is essential for prairie regeneration and control of redcedar and other woody plants.

Dry upland forests, dominated by blackjack and post oak, occur in moist areas. These forests are also referred to as crosstimbers. The trees are relatively short (about 40 feet [12m] high) with open canopies. A heavy cover of shrubs and prairie plants on the forest floor is common. Historically, fire maintained a mosaic of crosstimber forest, woodland, and grassland habitats.

Bottomland forests form narrow borders along streams. Cottonwoods, hackberries, elms, and oaks form tall forests (about 100 feet [30m]) with expansive canopies. Because these forests are narrow, light can penetrate beneath the canopy, resulting in lush forest floor vegetation. Dense thickets of grapevines, poison ivy, and greenbriar are common.

Central Great Plains - 27



Species diversity - Three hundred twenty-eight vertebrate species are native to this ecoregion. Five species have been extirpated and 13 have been introduced. One species is state-listed as threatened (but has been proposed for federal listing) and 21 are candidates or of special concern.

Natural communities - Grasslands cover most of this ecoregion, with woodlands scattered in ravines and along streams. Narrow bands of crosstimbers vegetation extend into the prairie from the east. Mesquite and shinnery oak woodlands extend into the ecoregion from the west. The Wichita Mountains and, to a lesser extent, the Gypsum Hills provide not only a visual contrast to the plains, but also provide unique habitats that increase the species diversity in the ecoregion.

The grasslands in this ecoregion represent a transition zone between tallgrass and shortgrass prairie communities. These grasslands consist of a mixture of species from both communities and are called the mixed grass prairie. Little bluestem, side oats grama, and dropseeds are the dominant grass species. These grasses average about 20 inches (50 cm) in height. 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, with wildflowers in the spaces between. Tallgrass prairie communities can be found on deep, moist soils, and shortgrass communities are prevalent on thin soils.

Herbaceous plants occur in areas where grasses do not use all the available moisture. Many plants bloom early in the year before they are shaded by grasses. Other species

depend on deep root systems to provide sufficient water for summer and fall growth.

Woody plants are not abundant in many parts of the ecoregion due to insufficient water. Exceptions are the forests found along rivers and streams. Cottonwoods and willows are the most important trees in these forests, but hackberries and elms may be abundant. An interesting feature in this ecoregion is the sandstone canyons in Caddo and Canadian counties, where sugar maple and other eastern species can be found.

Mesquite woodlands extend from Texas into the western Oklahoma counties. Mesquite is a tall shrub or small tree that may attain eight to 15 feet (2.5 to 4.5m) in height. Prairie vegetation is scattered throughout these woodlands. A diverse array of animals, many of which are more typical further west, can be found in mesquite woodlands.

Salt flats and springs occur throughout the ecoregion in association with the Gypsum Hills. The largest salt flat is the Great Salt Plains in Alfalfa County, which provides nesting and foraging habitat for shorebirds and the endangered least tern. Salt marsh vegetation, with species characteristic of coastal marshes, is associated with these habitats. The Red River pupfish, found only in Oklahoma and Texas, is adapted to live in the saline waters in streams in southwestern Oklahoma.

Wichita Mountains - The Wichita and Quartz Mountains are granitic remains of a once taller mountain chain. They now appear as low mountains and outcrops that rise abruptly from the surrounding plain. These mountains run from east to west and occur primarily in Comanche, Kiowa, and Greer counties. The Wichita Mountains National Wildlife Refuge and Quartz Mountain State Park provide excellent examples of the habitats found in this area.

Large tracts of crosstimbers occur on mountain slopes, extending into the valleys. Stunted oaks and cedars also grow among the large boulder fields, and some areas are devoid of vegetation. A colorful palette of lichens covers many of the boulders. Reptiles and other animal species live on these dry, rocky slopes. Mixed grass prairie vegetation is abundant, but tallgrass prairie occurs on moist sites. Dry hilltops and overgrazed lowlands contain shortgrass communities typical of drier portions of the ecoregion. Mesquite woodlands are also present.

The rugged terrain of these mountains creates diverse habitats that can support plant communities more characteristic of eastern Oklahoma. For example, sugar maples can be found in some of the canyons in this ecoregion. Lush bottomland forest vegetation grows in the valleys and canyons. These forests are diverse and have many plant species found in eastern Oklahoma. In Oklahoma, the plateau live oak can be found only in the Wichita and Quartz Mountains. It is also common in central Texas.

A few scattered granitic caves support summer populations of bats. Because granite is resistant to weathering, 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 Plains - Three gypsum formations are present in this ecoregion. The topography is characterized by mesas and deeply eroded canyons. Many of the plant species found here are adapted to high concentrations of salt in the

soil. In Oklahoma, redberry juniper is found only in the Gypsum Hills.

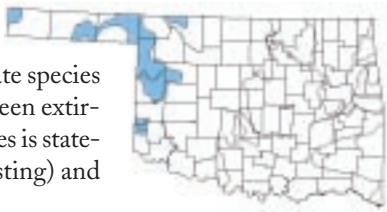
Gypsum is highly erodible and several large caves are found in the Gypsum Hills. Oklahoma's largest bat colonies (primarily Mexican free-tailed bats and cave myotis) are found here. Mexican free-tailed bats form colonies of several million individuals. They use the caves as summer roosts and maternity colonies, and then migrate to Brazil in the fall. In addition to other bat species, cave crickets and invertebrates use the caves year-round. Although gypsum caves do not support as many species as the limestone caves of northeastern Oklahoma, they are nonetheless important shelter and hibernating sites for wildlife.

Rolling redbed plains surround the gypsum hills. The high content of iron in these soils produces the characteristic red color. The soils are derived from Permian sandstone and shale. Mixed grass prairie vegetation is typical of this region.

Western sand dunes - Sand dunes occur along all major rivers in this ecoregion, except the Washita River, and are most extensive on the north banks. Although some are still active (moved by wind and water), most dunes are at least partially stabilized by vegetation. Most of the cover is provided by sandsage, a small rounded shrub that grows from two to three feet (1m) in height. Dense thickets of fragrant sumac and sand plum, which seldom exceed five feet (1.5m) in height, are also common. Sand bluestem, little bluestem, and giant sand reed grow among the sandsage. Many wildflowers unique to deep sandy soils, such as spectacle pod and silky prairie clover, are also common. Bare sand and blowouts occur between clumps of vegetation.

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 - 26



Species diversity - Two hundred 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 eight are candidates or of special concern.

Natural communities - In Oklahoma, the shinnery oak scrub community is found only in this ecoregion (excluding the Panhandle). Shinnery oak forms dense, circular clumps called mottes. These trees reproduce by root suckering, so all the trees in a motte may be actually a single plant. Stems in a motte may reach 10 to 15 feet (3 to 4.5m) in height, but stems on the motte edge may only reach 2 feet (0.5m) in height. Woody growth is so dense within the motte that few other plants are to be found. Although they are small, these oaks may produce heavy acorn crops, providing a valuable food source for many wildlife species. Mixed grassland plant species, dominated by little bluestem, are common in spaces between mottes.

Mixed grass prairie dominates other upland areas in most of the ecoregion, but gives way to shortgrass prairie in the Panhandle. The species composition of these grasslands is similar to those in surrounding ecoregions. Little bluestem dominates mixed grass sites, while blue grama and buffalograss dominate shortgrass communities.

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

Western sand dunes - Except for the Washita River, sand dunes occur along all major rivers in this ecoregion, especially along their northern banks. Community structure and species composition is very similar to that described in the Central Great Plains section.

Black Mesa

Species diversity - One hundred seventy-eight vertebrates 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 - Many plant and animal species inhabiting ravines and mesa slopes are eastward extensions of natural communities in the Rocky Mountain Foothills. The mesa tops and much of the lowland areas between the mesas are occupied by shortgrass prairie. The most common species are blue grama, hairy grama, side oats grama, galleta grass, and buffalograss. They form dense sods and grow from three to five inches in height. Various wildflowers, such as plains zinnia and bush morning glory, grow among the grasses. Prickly pear, cholla, and other cacti are scattered throughout. Trees and shrubs are restricted to ravines and steep slopes. Low shrubs up to five feet (1.5m) tall—primarily hoptree, stinking sumac, and netleaf hackberry—cover rocky slopes. One-seed juniper woodland communities are scattered on mesa slopes. Mountain mahogany, Apache plume, Gambel's oak, and pinyon pine can also be found in this community.

Western High Plains - 25

Species diversity - One hundred 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 seven are candidates or of special concern.

Natural communities - The shortgrass prairie community forms much of the Western High Plains ecoregion. Gramagrass and buffalograss are dominant. They form dense sods and grow from three to five inches (7.6 to 12.7cm) in height. Short grass species are adapted to drought conditions and grow rapidly during the spring, becoming dormant during periods of drought. Various wildflowers, such as plains zinnia and plains blackfoot, occur among the grasses. Prickly pear and other cacti are also present. 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.

The Western High Plains contain a unique wetland community known as playa lakes. 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 one acre to several hundred acres in size, the 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 may result in high levels of productivity. Wheat grass and vine mesquite are common grasses in playas. Smartweed grows in playas 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. Herbaceous plants and grasses grow taller in these areas due to more available water. These riparian forests are communities that are important to forest wildlife species occurring in the ecoregion.

This ecoregion contains the largest prairie dog towns in Oklahoma. Although greatly reduced in size and number, these towns support a unique 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 6m) deep, serve as shelters for many wildlife species, 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 resulting vegetation associated with these 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. Community structure and species composition is similar to that of the Central Great Plains section.

Boston Mountains - 38

The Boston Mountains ecoregion is located in northeastern Oklahoma and northwestern Arkansas. It is bordered by the Central Irregular Plains ecoregion on the west, the Arkansas Valley on the south, and the Ozark Highlands on the north. The topography of this ecoregion consists of rugged hills and low mountains very similar to the Ozark Highlands. However, the Boston Mountains are composed of Pennsylvanian sandstone, as opposed to the Mississippian limestones of the Ozark Plateau. Land use is forest and grazed woodlands. Soils are primarily ultisols.

Natural communities - The potential natural vegetation is charcterized by an oak/hickory mixture and is very similar to that of the Ozark Highlands. Refer to the Ozark Highlands for a more detailed description.

This section is a guide to vegetation for planting riparian areas. It focuses on native species available for planting in Oklahoma. Select riparian vegetation based on ecoregion and site conditions.

Vegetation

Bruce Hoagland, Oklahoma Biological Survey and the University of Oklahoma

Vegetation plays a key role in determining the quality and effectiveness of any riparian buffer strip. The purpose of this chapter is to serve as a tool for developing riparian buffer zone plantings. This guide will focus on the development of riparian buffer strips with native species in mind. Native species have developed a niche through the course of natural history and play a vital, irreplaceable role in the efficient and effective functioning of every riparian system.

Invasive exotic species pose threats to the quality and effectiveness of riparian buffer strips and will not be considered in this chapter. Invasive exotics are plants outside of their native range that have been introduced by humans. These species include introductions from other continents, ecoregions, or ecological sites. In riparian zones, invasive exotic plants can cause a multitude of problems, including undesirable changes in stream flow dynamics, **biological diversity**, wildlife habitat, and forage production. These problems may even extend into adjacent uplands, as in the case of eastern redcedar.

In their natural habitats, exotic species are held in check by ecological forces, such as fire, competition, herbivory, and disease. Once introduced into an ecosystem without natural checks, some compete aggressively with indigenous species and may drastically change ecological communities and reduce natural diversity. Exotic plants such

Mike Smolen, Okla. Coop. Extension Service

Riparian areas are home to a diverse assemblage of plant species, ranging from water-loving grasses and forbs to shrubs and trees.

as tamarisk and eastern redcedar compete with native plants and prevent the establishment of preferred tree seedlings, such as cottonwood and willow. They also compete with native grasses, forbs, legumes, and shrubs that may be indigenous to riparian zones.

Oklahoma has a rich biological heritage, due to the fact that the state is at a biogeographical crossroads between the eastern and western United States. The flora is so diverse that one can encounter shortgrass prairie vegetation in the Panhandle and eastern deciduous forests in the eastern portions of the state.

Precipitation, elevation, and temperature collectively form a distinct environmental gradient across the state. Average annual precipitation declines from 51 inches (130cm) in McCurtain County in the southeastern corner, to 16 inches (41cm) in Cimarron County in the far northwest. This trend is complemented by a 4,613-foot (1,406m) increase in elevation, from 360 feet (110m) above sea level in McCurtain County to 4,973 feet (1,516m) atop Black Mesa in the Panhandle.

These environmental factors interact with a latitudinal decrease in average annual temperature from 61°F (16°C) in southern Oklahoma to 55°F (13°C) along the border with Kansas. These factors make plant species recommendations for riparian buffer strips in Oklahoma more complicated than for other states.

The tables following this chapter assemble planting information into a single source. Table 1 lists major riparian vegetation associations. The table is divided into forest and woodland associations, shrubland associations, and herbaceous associations. Refer to the ecoregion map on page 5 to identify specific ecoregions within the state. It is important to identify the appropriate ecoregion for a site in order to use these tables efficiently and effectively. Scientific and common names are given for each vegetation type, along with distribution and details about habitat preferences. These associations indicate the dominant species within a habitat type.

Table 2 lists native woody species useful for riparian buffer zone plantings and the ecoregion in which they can be found. Most of the woody species mentioned in Table 1 will be found here.

Information on the commercial availability, wildlife value, type of root system, growth rate, distribution, and natural history for 46 riparian species can be found in Table 5 of the Appendix. This information will assist the user in determining appropriate vegetation based on site-specific conditions.

It should be noted that it might not always be appropriate to plant trees in riparian areas. In the Panhandle and parts of western Oklahoma, herbaceous species may be more appropriate for riparian plantings. Native vegetation in these regions is dominated by grass and forb species. The geology, soils, and hydrology of the area do not provide the biological requirements for many tree species. In this scenario, the total number of woody plant species is low and restricted to small woodland patches. There-

fore, extensive plantings of woody species are likely to meet with limited success. Several native herbaceous vegetation types are listed in Table 1.

Vegetation associations presented in Table 1 represent mature natural communities. Riparian species plantings will vary by region and require several years to mature before resembling the vegetation associations listed in Table 1. Over time, the naturally occurring seedbank will contribute to the composition of the riparian area. Riparian area plantings should be considered carefully before action is taken. If in doubt, consult with your local conservation district personnel prior to planting.

To use the tables, first determine the ecoregion of the site to be planted. Next, consult Table 2 to determine the species that would perform best for a riparian buffer zone planting. Not all of the species listed in Table 2 are appropriate for planting in every ecoregion. Cleveland County, located in ecoregion 27 (Central Great Plains), may be used as an example. Table 1 lists 24 potential riparian vegetation associations within the Central Great Plains ecoregion. Three of these are limited to saline soils (i.e., salt flats, salt marsh, and salt grass-American bullrush) and would be appropriate only for planting under these conditions. The remaining 21 vegetation types are widespread in ecoregion 27 and would be appropriate for most locations. The detailed information provided in Table 5 of the Appendix (A List of Common Woody Species in Oklahoma Riparian Zones) offers insight as to growth rates, root type, wildlife value, and commercial availability of the plants.

Table 1. Major vegetation types that occur in Oklahoma riparian zones (Hoagland 1997).

VEGETATION ASSOCIATIONS Forest and Woodland Associations	Ecoregions 25	26	27	28	29	35	36	37	38	39	40
Acer rubrum - Liquidambar styraciflua forest association Common name: red maple - sweetgum forest. Distribution: southeastern Oklahoma (Bryan, Choctaw, Latimer, LeFlore, McCurtain, and Pushmataha counties). Habitat: wet to moist soils in riparian corridors.					●	●					
Acer negundo - Acer saccharinum forest association Common name: boxelder forest. Distribution: eastern and southeastern Oklahoma, excluding the Coastal Plains. Habitat: wet to moist soils in riparian corridors.				●	●		●	●	●	●	●
Platanus occidentalis - Acer saccharinum forest association Common name: silver maple - sycamore forest. Distribution: stream margins throughout eastern Oklahoma. Habitat: wet to moist soils in riparian corridors.					●	●	●		●	●	●
Acer saccharum - Quercus rubra - Carya cordiformis forest association Common name: sugar maple - oak forest. Distribution: eastern tier counties of Oklahoma (Adair, Cherokee, Delaware, LeFlore, Mayes, McCurtain, Muskogee, Ottawa, and Sequoyah counties). Habitat: floodplains and mesic slopes.					●			●	●	●	

Vegetation Associations	Ecoregions 25	26	27	28	29	35	36	37	38	39	40
Fraxinus pennsylvanica - Ulmus (americana, rubra) - Celtis laevigata forest association Common name: green ash - American elm - sugarberry forest. Distribution: frequent throughout Oklahoma, excluding the Panhandle. Habitat: wet to moist soils in riparian corridors.			●	●	●	●	●		●	●	●
Liquidambar styraciflua - Quercus nigra - Celtis laevigata/Carpinus caroliniana forest association Common name: sweetgum - water oak - sugarberry forest. Distribution: southeastern Oklahoma (Choctaw, Latimer, LeFlore, McCurtain, and Pushmataha counties). Habitat: wet to moist soils of bottomlands and floodplains.					●	●	●				
Liquidambar styraciflua - Quercus phellos/Carpinus caroliniana forest association Common name: sweetgum - willow oak forest. Distribution: southeastern Oklahoma (Choctaw, Latimer, LeFlore, McCurtain, and Pushmataha counties). Habitat: wet to moist soils of bottomlands and floodplains.					●	●	●				
Nyssa sylvatica - Liquidambar styraciflua forest association Common name: blackgum - sweetgum forest. Distribution: eastern Oklahoma (Choctaw, Latimer, LeFlore, and Pushmataha counties). Habitat: wet to moist soils of bottomlands and floodplains.					●	●					
Nyssa sylvatica - Quercus phellos/Carpinus caroliniana forest association Common name: blackgum - willow oak forest. Distribution: eastern Oklahoma (Choctaw, Latimer, LeFlore, Pushmataha counties). Habitat: wet to moist soils of bottomlands and floodplains.					●	●					

Vegetation Associations	Ecoregions 25	26	27	28	29	35	36	37	38	39	40
Pinus taeda - Fraxinus pennsylvanica - Ulmus americana/Chasmanthium sessiliflorum forest association Common name: loblolly pine - green ash forest. Distribution: limited to the Coastal Plain area of McCurtain County. Habitat: floodplains and backswamps.					●						
Pinus taeda - Quercus phellos - Quercus nigra forest association Common name: loblolly pine - willow oak forest. Distribution: limited to the Coastal Plain area of McCurtain County. Habitat: floodplains and backswamps.					●						
Populus deltoides - Salix amygdaloides woodland association Common name: cottonwood - peachleaf willow woodland. Distribution: rare and localized in the Oklahoma Panhandle (Texas and western Cimarron counties). Habitat: moist to wet soils in riparian corridors.	●	●									
Populus deltoides - Salix (exigua, nigra) forest association Common name: eastern cottonwood - black willow forest. Distribution: frequent along streams throughout Oklahoma, excluding the Panhandle. Habitat: wet to moist soils in riparian corridors.			●	●	●	●	●	●	●	●	●
Populus deltoides - Ulmus americana - Celtis (laevigata, occidentalis) forest association Common name: western bottomland forest. Distribution: frequent along streams throughout Oklahoma, excluding the Panhandle. Habitat: wet to moist soils in riparian corridors.			●	●	●	●	●	●	●	●	●

Vegetation Associations	Ecoregions 25	26	27	28	29	35	36	37	38	39	40
Quercus lyrata - Carya aquatica forest association Common name: overcup oak - water hickory forest. Distribution: restricted to the Coastal Plain area of McCurtain County. Habitat: backswamps and waterlogged depressions.						●					
Quercus macrocarpa - Quercus (shumardii, muehlenbergii) - Carya cordiformis forest association Common name: bur oak - hickory forest. Distribution: northeast Oklahoma and the Arbuckle Mountains. Habitat: floodplains and other mesic habitats.			●	●	●						●
Quercus nigra - Quercus phellos/Carpinus caroliniana forest association Common name: water oak - willow oak forest. Distribution: southeastern Oklahoma (Choctaw, Latimer, LeFlore, McCurtain, and Pushmataha counties). Habitat: moist to wet soils of bottomlands and floodplains.					●	●					
Quercus nigra - Ulmus rubra - Liquidambar styraciflua/Carpinus caroliniana forest association Common name: water oak - slippery elm - sweetgum forest. Distribution: southeastern Oklahoma (Choctaw, Latimer, LeFlore, McCurtain, and Pushmataha counties). Habitat: moist to wet soils of bottomlands and floodplains.					●	●					
Quercus palustris - Carya illinoensis forest association Common name: pin oak forest. Distribution: limited to the Verdigris and Neosho Rivers in northeastern Oklahoma. Habitat: moist to wet soils of bottomlands and floodplains.											●

Vegetation Associations	Ecoregions 25	26	27	28	29	35	36	37	38	39	40
Salix nigra forest and woodland association Common name: willow grove. Distribution: localized throughout Oklahoma, excluding the Panhandle. Habitat: wet to moist soils in riparian corridors.			●	●	●	●	●	●	●	●	●
Sapindus saponaria woodland association Common name: soapberry woodland. Distribution: throughout Oklahoma. Increasingly abundant in central and western Oklahoma. Habitat: disturbed areas, rocky soils. Often associated with the margins of other woodland associations.		●	●	●	●						
Ulmus americana - Celtis (laevigata, occidentalis) forest association Common name: American elm - sugarberry forest. Distribution: frequent throughout Oklahoma, excluding the Panhandle. Habitat: wet to moist soils in riparian corridors.			●	●	●	●	●	●	●	●	●
Ulmus americana - Quercus muehlenbergii - Celtis (laevigata, occidentalis) forest association Common name: American elm - chestnut oak - hackberry forest. Distribution: frequent throughout Oklahoma, excluding the Panhandle. Habitat: wet to moist soils in riparian corridors.			●	●	●	●	●	●	●	●	●
Taxodium distichum - Lemna minor forest association Common name: bald cypress swamp. Distribution: Coastal Plain region of McCurtain County. Habitat: oxbow lakes, meander cutoffs, and other deep water habitats.						●					

SHRUBLAND ASSOCIATIONS

Forest and Woodland Associations	Ecoregions 25	26	27	28	29	35	36	37	38	39	40
Alnus maritima - Amorpha fruticosa shrubland association Common name: seaside alder - false indigo grove. Distribution: restricted to the Blue River drainage in Johnston and Pontotoc counties. Habitat: cobble bars and riparian zones.					●						
Alnus serrulata shrubland association Common name: smooth alder grove. Distribution: southeastern Oklahoma (Choctaw, Latimer, Leflore, McCurtain, and Pushmataha counties). Habitat: common in palustrine and lacustrine wetland habitats.					●	●	●				
Cephalanthus occidentalis shrubland association Common name: buttonbush grove. Distribution: throughout Oklahoma, excluding the Panhandle. Habitat: common in palustrine and lacustrine wetland habitats.		●	●	●	●	●	●	●	●	●	●
Crataegus crus-galli - Ilex decidua shrubland association Common name: hawthorn - deciduous holly thicket. Distribution: localized in east-central and eastern Oklahoma. Habitat: moist soils and mesic slopes.					●		●	●	●	●	●
Salix exigua shrubland association Common name: sandbar willow shrubland. Distribution: western Oklahoma and along the Arkansas River. Habitat: occurs along the margin of streams and lakes.		●		●	●						

HERBACEOUS ASSOCIATIONS

Forest and Woodland Associations	Ecoregions 25	26	27	28	29	35	36	37	38	39	40
Arundinaria gigantea herbaceous association Common name: canebrake. Distribution: eastern Oklahoma. Habitat: floodplains and alluvial soils.				●	●	●	●	●	●	●	●
Andropogon gerardii - Panicum virgatum herbaceous association Common name: big bluestem - switchgrass prairie. Distribution: found throughout the state. Of limited extent in southeastern and Panhandle of Oklahoma. Habitat: lowlands and mesic deep soils.			●	●	●						●
Distichlis spicata (Heliotropium curvassavicum) herbaceous association Common name: salt flats. Distribution: central and western Oklahoma. Habitat: moist, saline soils (i.e., salt flats and some playa lake basins).	●	●	●		●						
Distichlis spicata - Scirpus americana herbaceous association Common name: saltgrass - American bulrush marsh. Distribution: central and western Oklahoma. Habitat: moist, saline soils.	●	●	●		●						
Distichlis spicata - Sporobolus airoides herbaceous association Common name: salt marsh. Distribution: common in central and western Oklahoma. Habitat: moist, saline soils.	●	●	●		●						

Vegetation Associations	Ecoregions 25	26	27	28	29	35	36	37	38	39	40
Leptochloa fasicularis - Eleocharis (macrostachya, compressa) herbaceous association Common name: spangletop-spikerush meadow. Distribution: abundant in central and western Oklahoma. Habitat: wet depression and the margins of interdunal swales.	●	●									
Heteranthera limosa - Bacopa rotundifolia - Sagittaria latifolia herbaceous association Common name: longleaf mudplantain - water hyssop emergent vegetation. Distribution: reaches its greatest extent in western and central Oklahoma along major streams (i.e., North Fork of the Red River and quaternary deposits around Enid and Weatherford). Habitat: interdunal swales.			●		●						
Juncus effusus herbaceous association Common name: soft rush marsh. Distribution: eastern Oklahoma. Habitat: marshes, seeps, shorelines, and sloughs.					●	●					●
Justicia americana herbaceous association Common name: waterwillow aquatic bed. Distribution: east and east-central Oklahoma. Habitat: banks and cobble bars of slow moving streams and lake margins.					●	●	●	●	●	●	●
Panicum obtusum herbaceous association Common name: vine mesquite meadow. Distribution: throughout central and western Oklahoma, including the Panhandle. Habitat: wet to moist soils in pastures, prairies, riparian areas, and playa lakes.	●	●	●								

Vegetation Associations	Ecoregions 25	26	27	28	29	35	36	37	38	39	40
Panicum virgatum - Tripsacum dactyloides herbaceous association Common name: switchgrass - eastern gramagrass meadow. Distribution: throughout Oklahoma. Habitat: moist soils and lowlands.	●	●	●	●	●						●
Pascopyrum smithii herbaceous association Common name: western wheatgrass meadow. Distribution: western Oklahoma. Habitat: wet-moist, well-drained bottomland soils and depressions.	●	●									
Phragmites australis herbaceous association Common name: common reed marsh. Distribution: northeastern, central and western Oklahoma, excluding the Coastal Plain and Panhandle. Habitat: floodplains, backswamp, and lake margins.		●	●	●	●						●
Polygonum pensylvanicum - Polygonum lapathifolium herbaceous association Common name: Pennsylvania smartweed - nodding smartweed vegetation. Distribution: occur throughout Oklahoma. Habitat: wet depressions, lakes, and ponds.	●	●	●		●						●
Scirpus americanus herbaceous association Common name: bulrush marsh. Distribution: throughout the state, but are of greatest extent in central and western Oklahoma and the Panhandle. Habitat: floodplains, backswamp, and lake margins.	●	●	●		●						

Vegetation Associations	Ecoregions 25	26	27	28	29	35	36	37	38	39	40
Scirpus validus herbaceous association Common name: softstem bulrush marsh. Distribution: throughout Oklahoma, less frequent in far western Oklahoma and the Panhandle. Habitat: floodplains, backswamp, interdunal swales, and lake margins.			●		●						
Spartina pectinata - Eleocharis montevidensis herbaceous association Common name: cordgrass meadow. Distribution: northeastern, central, and western Oklahoma, excluding the Coastal Plain physiographic province and Panhandle. Habitat: floodplains, backswamp, and lake margins.		●	●	●	●						●
Typha angustifolia herbaceous association Common name: narrow-leaved cattail marsh. Distribution: common in northwest Oklahoma and the Panhandle. Habitat: floodplains, backswamp, and lake margins.	●	●	●	●	●						
Typha domingensis herbaceous association Common name: southern cattail marsh. Distribution: throughout Oklahoma. Habitat: floodplains, backswamp, and lake margins.	●	●	●	●	●						●
Typha latifolia herbaceous association Common name: broadleaf cattail marsh. Distribution: throughout Oklahoma, but absent from parts of northwest Oklahoma and the Panhandle. Habitat: floodplains, backswamp, and lake margins.			●	●	●	●	●	●	●	●	●

Table 2. A list of common woody species and the ecoregions in which they occur in Oklahoma riparian zones.

Tree Species	Ecoregion 25	26	27	28	29	35	36	37	38	39	40
Alder, Smooth					●	●	●		●	●	
Ash, Green			●	●	●	●	●	●	●	●	●
Ash, White				●	●	●	●	●	●	●	●
Bald Cypress						●					
Basswood, American							●		●	●	
Birch, River			●	●	●	●	●	●	●	●	●
Blackgum					●	●	●	●	●	●	
Boxelder			●	●	●	●	●	●	●	●	●
Buckeye, Texas			●	●	●	●	●	●	●	●	●
Cottonwood, Eastern	●	●	●	●	●	●	●	●	●	●	●
Elm, American		●	●	●	●	●	●	●	●	●	●
Elm, Red			●	●	●	●	●	●	●	●	●
Elm, Winged					●	●	●	●	●	●	●
Hackberry			●	●	●	●	●	●	●	●	●
Hawthorn, Cockspur			●	●	●	●	●	●	●	●	●
Hawthorn, Downy			●	●	●	●	●	●	●	●	●
Hawthorn, Green			●	●	●	●	●	●	●	●	●
Hickory, Bitternut			●	●	●	●	●	●	●	●	●
Hickory, Mockernut					●	●	●	●	●	●	
Holly, American					●	●	●	●			
Honeylocust				●	●	●	●	●	●	●	●
Hornbeam, American					●	●	●	●	●	●	
Maple, Red					●	●	●	●	●	●	

Table 2. (Continued.)

Tree Species	Ecoregion 25	26	27	28	29	35	36	37	38	39	40
Maple, Silver				●	●		●	●	●	●	●
Maple, Sugar		●	●	●	●	●	●		●	●	●
Mulberry, Red			●	●	●	●	●	●	●	●	●
Oak, Bur			●	●	●			●	●	●	●
Oak, Chinkapin			●	●	●	●	●	●	●	●	●
Oak, Overcup					●	●					
Oak, Red							●	●	●	●	●
Oak, Shumard			●	●	●	●	●	●	●	●	●
Oak, Water					●	●	●	●	●	●	●
Oak, White						●	●	●	●	●	
Oak, Willow					●	●	●	●			
Osage Orange					●			●			
Pecan	●	●	●	●	●	●	●	●	●	●	●
Pine, Loblolly					●						
Possumhaw			●	●	●	●	●	●	●	●	●
Redbud			●	●	●	●	●	●	●	●	●
Soapberry	●	●	●	●	●	●	●	●	●	●	●
Sugarberry			●	●	●	●	●	●	●	●	●
Sweetgum					●	●	●	●			
Sycamore			●	●	●	●	●	●	●	●	●
Walnut, Black	●	●	●	●	●	●	●	●	●	●	●
Willow, Black	●	●	●	●	●	●	●	●	●	●	●
Willow, Coyote			●	●	●	●	●	●	●	●	●

Ed Miller, Oklahoma State University

Key Points:

This chapter identifies special precautions to use when landowner objectives include the production and harvesting of trees in riparian areas.

- Remember that riparian forests provide benefits to both aquatic and terrestrial ecosystems. Forest canopy shades the stream, moderating temperatures and providing organic debris to the aquatic ecosystem. Riparian forests provide ideal habitat for many desirable species of wildlife and promote biodiversity.
- Obtain tree-planting recommendations from professional foresters at the Oklahoma Department of Agriculture - Forestry Services.
- Minimize disturbance when harvesting trees from the riparian area.
- Always use a written contract with clear specification of BMPs when selling timber.

Forest Management in Riparian Areas

Robert Miller, Oklahoma Department of Agriculture – Forestry Services Division (retired)
John Norris, Oklahoma Department of Agriculture – Forestry Services Division

A forested buffer zone is one of the most desirable management alternatives for riparian areas where trees historically occurred. Trees help stabilize streambanks and provide shade and woody debris for the stream. They provide prime habitat for many species of wildlife and an economic incentive when timber or other forest products are sold.

The streamside management zone protects streambanks and channels from erosion, traps nutrients and sediments, and provides shade and habitat for wildlife.

Harvesting trees within a riparian area requires special care to prevent erosion, maintain streambank stability, and protect water quality and stream habitat. It is extremely important to follow the streamside management guidelines found in *Best Management Practices for Forest Road Construction and Harvesting Operations in Oklahoma* (FER-5). This publication is available for free from the Oklahoma Department of Agriculture - Forestry Services Division or the Oklahoma Cooperative Extension Service.

Ecoregion constraints and landowner objectives govern planting recommendations for forested buffers. Although many species are suitable for eastern Oklahoma, some western riparian areas may not support trees at all. Guidance for tree planting, riparian forest management, and BMPs for riparian areas are available from Forestry Services.

Riparian Forest/Aquatic Habitat Relationships

The character and health of the riparian area is often reflected in the aquatic habitat of small streams. Management practices may vary considerably by ecoregion and by stream type, size, and condition. With Oklahoma's hot summers, it is highly desirable that a canopy of trees or shrubs shade the stream, reducing water temperatures and providing organic debris to the stream. On many small streams, a well-developed stand of alder, for example, may provide habitat benefits not available from a large-tree overstory. Such benefits may include food and protective cover, greater bank stability, and lower air temperatures at the water surface. However, shade-intolerant species such as alder need a sparse overstory to prosper.

Harvesting Trees from the Riparian Area

The Riparian Buffer Specifications recommend no logging in the first 15 feet from the top of the streambank except for occasional high value trees. However, where banks have been undercut or the channel is deeply incised, a large bank tree can act as a pry-bar when thrown by wind or ice. Careful harvest of such trees can help protect bank stability.

The recommended best management practice (BMP) for protecting riparian areas is the streamside management zone (SMZ). Forestry Services guidelines call for a 50-foot SMZ measured from the top of the streambank. Within the SMZ, guidelines recommend:

- Minimize stream crossings. Go around if possible.
- Build no roads except those that cross the stream.
- Keep skidders away from streambanks. Place log landings outside the SMZ. Do not skid across stream channels.
- Avoid rutting during wet weather.
- Use **cable and chokers** to skid logs.
- Remove tops and large limbs from stream channels.

Forestry Services recommends always using a written contract when selling timber and including BMPs in the contract. Landowners should seek professional forestry advice. They may harvest only once in 20 years and proper marking/marketing is essential.

Roads and Stream Crossings

Roads and stream crossings are the principal concern in riparian protection and can be a major source of sediment to streams. The following guidelines will protect the riparian area, aquatic habitat, and water quality:

- Maintain a buffer of at least 50 feet between roads and the streambank.
- Plan your roads and minimize the number of stream crossings. Use **cross drains** and **turnouts** to get water off the road before reaching crossings.
- Cross in a straight section at right angles to the stream.
- Minimize disturbance to the streambank and channel during construction. Plan construction during low flows.

The pocket guide *Best Management Practices for Forest Road Construction and Harvesting Operations in Oklahoma* (FER-5) gives specifications for building roads and stream crossings.

Planting Recommendations for Riparian Areas

Forest management in bottomland areas is complex. Forestry Services foresters are located across the state and can assist with information and recommendations for planting riparian areas. They help landowners identify their objectives, develop a written plan, and implement practices designed to enhance the riparian area. Forestry Services also sells tree and shrub seedlings for conservation and reforestation purposes from their forest regeneration center. Contact Forestry Services for details.

Oklahoma Department of Agriculture Forestry Services

Oklahoma's Forestry Code requires that the *"...State Board of Agriculture shall institute a broad program of education and action in the protection, reforestation, harvesting, and wise use of forests..."* The code further provides for *"...needs in outdoor recreation, conservation, and environmental protection including the administration of forestry Best Management Practices (BMPs)."*

This overall mission is carried out through the forest resources protection, forest resource management, and NPS water quality management programs of the Oklahoma Department of Agriculture - Forestry Services in cooperation with other agencies, the forest industry, and individual landowners.

Under the Forest Stewardship program, Forestry Services can assist private, nonindustrial landowners with technical assistance and possibly cost-share funding to manage forest properties on a multiple-use basis. One of the objectives must be water quality protection.

Oklahoma Department of Agriculture - Forestry Services has offices located throughout the state. For the office located nearest you, contact the state office in Oklahoma City at (405) 521-3864.

Primary Resource:

Oklahoma Department of Agriculture - Forestry Services Division
2800 N. Lincoln Blvd.
Oklahoma City, OK 73105-4298
(405) 521-3864

Other Forestry Resources:

Oklahoma State University
Department of Forestry
Extension Forestry
008C Agriculture Hall
Stillwater, OK 74078
(405) 744-5438

U.S. Department of Agriculture
Natural Resources Conservation Service
Michael Barrick, Forester
Federal Building, Room 311
301 Carl Albert Parkway
McAlester, OK 74501-0301
(918) 423-5641

U.S. Department of Agriculture
Forest Service
Box 1270, Federal Office Building
Hot Springs, AR 71902
(501) 321-5202

Relevant Publications

Anderson, Steven, and Ron Masters. Riparian forest buffers. OSU Extension Facts F-5034. Oklahoma State University. 6p.

Baker, James B., and W.M. Broadfoot. Site evaluation for commercially important southern hardwoods. USDA-Forest Service Gen. Tech. Rpt. SO-26. 1979. 51p.

Belt, George, Jay O'Laughlin, and Troy Merrill. Design of forest riparian buffer strips for the protection of water quality: Analysis of scientific literature. Report No. 8. Idaho Forest, Wildlife and Range Experiment Station. University of Idaho. June 1992. 35p.

Goelz, J.C.G. A stocking guide for southern bottomland hardwoods. *Southern Journal of Applied Forestry.* 19(3). Aug. 1995. 2p.

Guide to regeneration of bottomland hardwoods. USDA-Forest Service SEFES. Gen. Tech. Rpt. SE-76.

Hodges, John D., and George L. Switzer. Some aspects of the ecology of southern bottomland hardwoods. Journal Paper No. 4087, Mississippi Agricultural and Forestry Experiment Station. 1978. 6p.

Keown, Malcom P., Streambank protection guidelines for landowners and local governments. U.S. Army Corps of Engineers, Waterways Experiment Station. Vicksburg, Miss. Oct. 1983. 60p.

Landowners guide to streambank management. Northern Vermont Conservation and Development Area in cooperation with the Vermont Agency of Environmental Conservation, Extension Service, University of Vermont. July 1979. 21p.

Manuel, Thomas M., Keith L. Belli, John D. Hodges, and Robert L. Johnson. A decision-making model to manage or regenerate southern bottomland hardwood stands. *Southern Journal of Applied Forestry.* 17(2). 1993. 5p.

Meadows, James S. Thinning guidelines for southern bottomland hardwood forests. USDA-Forest Service, Center for Bottomland Hardwood Research, Stoneville, Miss. 4p.

Oak regeneration: Serious problems, practical solutions. USDA-Forest Service SEFES Gen. Tech. Rpt. SE-84. 1993.

Perkey, Arlyn W., Brenda L. Wilkins, and H. Clay Smith. Crop tree management in eastern hardwoods. NA-TP-19-93. USDA-Forest Service.

Putnam, John A., George M. Furnival, and J.S. McKnight. Management and inventory of southern hardwoods. USDA Handbook No. 181. Nov. 1960. 102p.

Rast, Everett D., David L. Sonderman, and Glenn L. Gammon. A guide to hardwood log grading. USDA-Forest Service Gen. Tech. Rpt. NE-1. 1973. 31p.

Sykes, Karyn J., Arlyn W. Perkey, and Roxane S. Palone. Crop tree management in riparian zones. USDA-Forest Service Northeastern Area S&PF. July 1996 (revised).

United States Department of Agriculture. Southern hardwood management. Management Bulletin R8-MB-67. USDA-Forest Service. March 1994.

Margi Cooper, Oklahoma Coop. Extension Service

Key Points:

Because many of Oklahoma's stream channels are unstable and badly degrading, we recommend assessing channel stability before investing substantial effort into the design of riparian restoration, protection, and management systems.

- Examine aerial photography, soil surveys, and other sources for information on soils, geology, vegetation, and structures such as bridges and dams to assess stream morphology.
- Assess stream stability through field investigation of banks, bars, and the channel's meander pattern.
- Evaluate outside factors such as overgrazing, pavement, and sediment sources.

Information from the assessment will help determine if riparian management can restore the stream channel or if more aggressive measures are needed.

Assessing Stream Stability and Sensitivity

John Mueller, Natural Resources Conservation Service
Michael Smolen, Oklahoma State University
R. Daren Harmel, Oklahoma State University
Russell Dutnell, Oklahoma Conservation Commission

Introduction

Oklahoma is a very diverse state in terms of both rainfall and geology. Any plans for riparian management and/or restoration need to evaluate how climate, geology, and historical practices impact the specific area. Many streams underwent periods of **aggradation** from the time beginning with early statehood and extending through the Dust Bowl days. However, many of today's streams, particularly in central and western regions, appear to be degrading. A knowledge of the stream and its evo-

Mike Smolen, Okla. Coop. Extension Service

High banks and gravel bars are indicators of instability. Determine stream stability and sensitivity before designing riparian area protection systems.

lution will prove extremely helpful in making an accurate assessment of the long-term trends affecting the area.

This assessment is important because the long-term success of any riparian restoration project ultimately depends on the stability of the associated stream system. For the purposes of this assessment, a stable stream is defined as one that can carry flows and sediment through its system without significantly altering its basic dimensions or slope. This means the channel profile and form should allow high enough velocities to carry all the sediment that enters from its watershed, yet dissipate enough energy to minimize bank erosion.

In some cases, streams may be so badly degraded or choked with deposition that they will not heal without direct attention. Therefore, properly assessing a stream's current stability and sensitivity to factors such as grazing, vegetative condition, and land use changes is essential in riparian area design and management. The assessment involves two steps: 1) background information, and 2) field review.

Background Information

The first step in the assessment process is to review existing sources of information about the stream. Examine aerial photography and the county soil survey to gain a broad perspective. Look for information about the general stream pattern, vegetation, soils, geology, past and present land use, and structures such as bridges that may affect the stream.

Field Review

The next step consists of 1) determining the stability of the existing system, and 2) making an assessment of how sensitive the stream is to management practices. The field review includes examining upstream and downstream reaches to identify those items that could impact the area in future years. For example, an advancing head cut could quickly undermine a project, while log jams may cause flow to attack the banks as flow is diverted outward.

Stability Assessment

A number of visual indicators give clues concerning the stability of the stream. Healthy streams generally have a meandering pattern with an alternating riffle (an area of shallow water with rapid flow) and pool (an area of calmer, deeper water) system, vegetated banks, and an established flood plain. These characteristics allow the stream to dissipate flow energies while maintaining its basic configuration. Conversely, unstable systems undergo relatively rapid transition, and their appearance is often quite different. Document the presence or absence of the following indications of instability:

Head cutting and/or downcutting—A head cut is a discontinuity (or overfall) in the base of the stream. Downcutting is a general response to excessive grade often noted

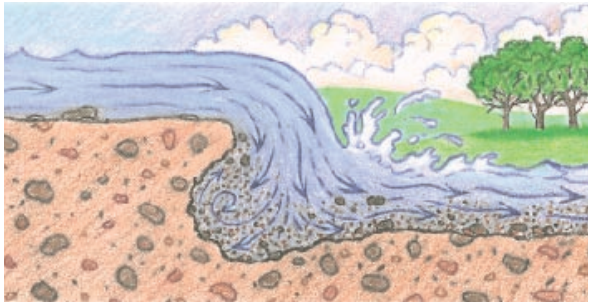


Figure 1. Headcutting results from erosion at an abrupt change of elevation.

by recent undercutting of the **bank toe** over a sustained length. These conditions may be the result of a change in the base grade of the controlling river or stream or a change in sediment regime of the stream (Figure 1).

Bank sloughing (localized bank collapse)—This indicates a bank stability problem. Bank sloughing may be caused by undercutting of the toe, bank seepage, or saturation of very loosely deposited material. Examine the area to determine the extent and cause of the sloughing (Figure 2).

Extremely steep or "blown out banks"—This indicates that the stream is attempting to adjust laterally or that the bank toe has been lost. This often occurs in channels that have down cut and are trying to reestablish a flood plain. It can also occur in channels with abrupt changes in alignment (Figure 3).

Seepage in the banks—This often affects incised channels. When water tables rise, the seepage exits through the streambank. Soil particles are dislodged if seepage forces are sufficient. Even if soil is not removed, the saturated area represents a weak point the next time high flows occur.

Mid-channel bars—The stream is probably aggrading in this reach. As the bar continues to grow, more of the flow is forced toward the bank. Bars (called "point bars") should form on the inside of stream bends (Figure 4).

Mike Smolen, Oklahoma Cooperative Extension Service

Figure 2. Bank sloughing is a dangerous form of instability that requires attention to the base or toe of the slope. Planting trees at the top of the bank would only worsen the condition.

Mitch Fram, Oklahoma Cooperative Extension Service

Figure 3. Steep banks are a sign of channel realignment or downcutting.

Lack of vegetation over the entire bank—This may indicate that the area was recently subject to scour or deposition or that the area has unfavorable moisture patterns for plant growth over the entire bank. Sparse vegetation or changes in species composition may be due to lack of moisture resulting from severe degradation or a dropping water table (Figure 5).

Straightened channel—To facilitate farming, many of Oklahoma's streams were altered. This increased the slope by reducing the length. Streams often down cut to try to return to the original slope or attempt to reestablish a natural meandering pattern (Figure 6).

Outside influences—Features such as large woody debris, beaver dams, or structures need to be evaluated carefully. In some instances, they have a positive impact, reducing localized velocities, providing habitat, or providing grade control. However, they can also cause localized scour, deposition, or even channel realignment.

The presence of these factors (with the possible exception of outside influences) generally indicates a problem that must be addressed before proceeding. Therefore, seek expert assistance, since the action needed will vary, depending upon the type and extent of the problem. Conversely, if these factors are not evident, the planned or present riparian area should perform as expected.

Sensitivity to Management Practices: A stream's sensitivity to management practices (such as overgrazing or land use change) is determined primarily by its dominant bank and bed material, the relative height and steepness of its banks, and its vegetative cover. Therefore, the field review should document these factors.

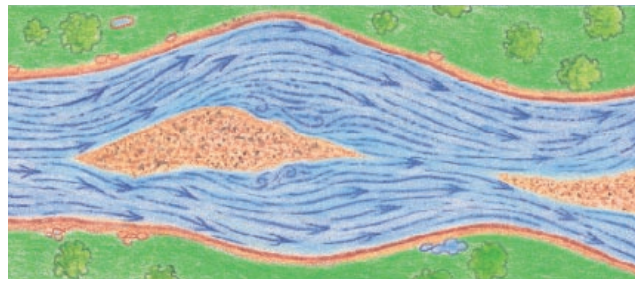


Figure 4. Obstruction in the middle of the channel causes erosion of the banks.

Richard Tapito, Oklahoma State University

Figure 5. The roots of vegetation act like reinforcing bars to stabilize banks. When vegetation is lost, banks become succeptable to erosion.

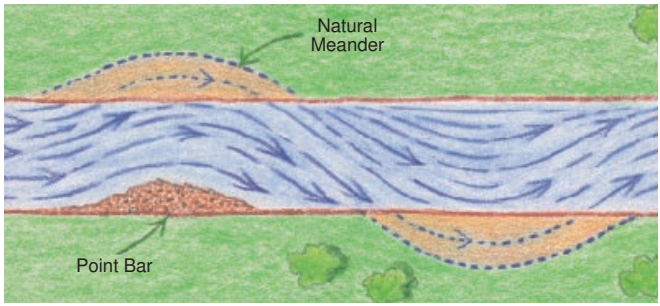


Figure 6. Channels have a natural meandering pattern. If straightened, they revert by cutting their banks and depositing point bars.

Streams composed primarily of gravel, sand, silt, or low plasticity clay are much more sensitive to outside influences than cobble, boulder, or bedrock dominated streams. Likewise, streams with low, relatively flat banks are not as subject to change as those with high, steep banks.

Vegetation also plays a critical role in streambank and riparian area protection, and its importance becomes even more pronounced in streams with easily disturbed soil materials. Vegetation protects and stabilizes banks by mechanically reinforcing the banks with roots, moderating the moisture regime, and physically protecting the banks from stream flows and the impact of rainfall. A dense mixture of vegetation over the entire bank is desired to reduce sensitivity. Various age classes and plant types should be represented with little or no exposed soil.

Summary

This chapter has concentrated on assessing the relative stability of a stream and its probable response to the condition of the riparian area. Because stream systems are inherently complex, it is beyond the scope of this chapter to discuss riparian restoration. However, this document can serve as a guide in determining when additional expertise is needed to solve problems associated with unstable stream systems. Furthermore, it shows the need to identify and correct serious stream stability problems before investing resources for riparian systems.

Anna Fallon, Oklahoma Cooperative Extension Service

Steep or blown-out banks are a sign of channel instability. Cropping up to the bank's edge only aggravates the problem.

A field determination that a stream is sensitive to change, however, does not preclude the development or enhancement of a riparian area. In fact, these streams will benefit most from a well-managed riparian area, and the influence of vegetation cannot be stressed enough in such systems.

Personnel at the USDA-NRCS and the Oklahoma Conservation Commission can provide guidance on assessing channel stability.

Key Points:

Management of grazing livestock can help maintain riparian areas in healthy and productive condition. Fencing is only one of many tools for protection and management of riparian pastures.

- Set clear objectives and develop a long-term plan.
- Maintain riparian vegetation in healthy condition through proper timing of grazing.
- Provide food, water, and desirable pasture in areas away from the riparian zone.
- Use fencing to separate management units and to limit access by livestock.
- Provide stable stream crossings and cattle access areas.

Grazing and Riparian Area Management

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R. Daren Harmel, Oklahoma State University
Reggie Blackwell, USDA – Forest Service, Black Kettle National Grasslands
Terry Bidwell, Oklahoma State University

Introduction

Riparian areas are important forage production areas and can be extremely productive parts of a grazing system. However, because riparian areas are also important areas for protecting water quality, they are very sensitive to unmanaged grazing. Riparian areas are usually more productive than the surrounding uplands because of the additional moisture available to plants. However, even if ample forage is available on upland areas, free-roaming livestock may congregate in and overuse riparian areas. Simply reducing the number of livestock

Grazing and healthy riparian areas can coexist with proper management.

is usually not the answer, because livestock with unrestricted access can still overuse the riparian area.

Grazing animals with unrestricted access to streams damage native vegetation and streambanks and create trails which cause erosion. Once this damage occurs, the integrity of streambanks can unravel. Typically, when riparian areas are overgrazed or trampled, they become even more vulnerable to damage. Not only do the remaining plants become widely spaced, but continuous grazing eliminates young plants and weakens established ones. Without the binding qualities of plant roots, accelerated bank erosion can occur, with valuable land falling into the river. Eroded material is then transported downstream and is deposited in channel bars or eventually lakes.

Historically, bison were observed to heavily impact streambank areas where they grazed. This adverse effect was minimized, however, because their migratory grazing allowed streambank areas enough time to rest and recover. Thus, vegetation types were not altered by heavy, intermittent grazing. Perhaps herein reveals a key to managing riparian areas.

Riparian Areas Need Time to Recover

Plants grow from food made in leaves and stored in crowns, lower stems, and roots. When grazing removes more than half the growing leaf of a plant, root growth slows due to lack of food. The more severely a plant is grazed, the longer it takes for root growth to recover.

Continued grazing defoliation, without a recovery period, does not allow time for the plant to restore its food supply. If defoliation continues, the plant may die and be replaced by a less-desirable species. The soil surface may also be left bare, leaving it more susceptible to erosion. The most effective grazing strategies provide a pruning of the

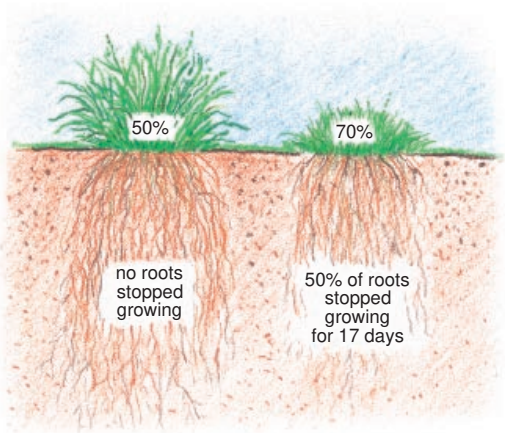

Figure 1. Longer recovery periods are needed for growing plants that have more than half their leaves removed.

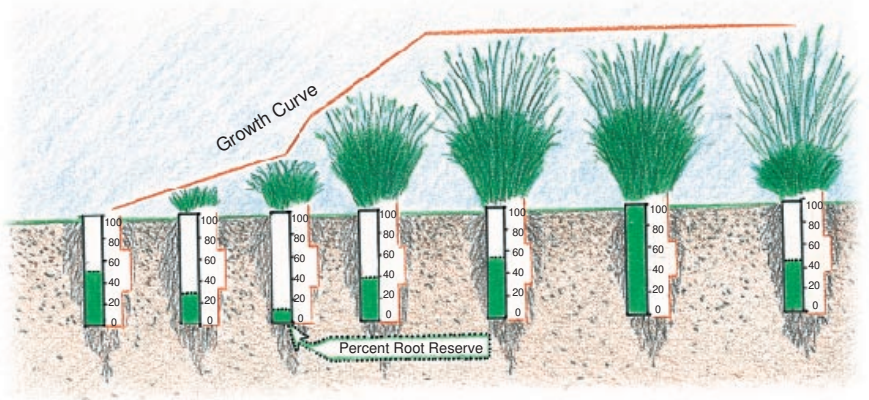

Figure 2. The amount of plant food available depends on plant growth stage. Just prior to seed set is the time most vulnerable to overgrazing.

plant followed by a recovery. This promotes strong, deep root systems that bind the riparian soils the way reinforcing bars strengthen concrete. This also maintains a healthy grass stand that lies down in flood flows and protects the soil in much the same way as shingles protect a roof.

Timing of grazing is also important. During various times of the year, certain species are more vulnerable to damage by grazing. Avoid grazing riparian species during vulnerable periods. Grazing during sustained wet periods should also be avoided because physical damage to riparian area soils limits vegetative growth and accelerates erosion. Managers may be surprised by the forage quality provided by well-managed riparian areas.

Riparian Areas Are Part of the Grazing System

To manage the riparian system effectively, grazing managers must consider the riparian area and the upland landscape as part of one grazing system. This is essential because a deteriorated upland vegetative community increases grazing pressure on the riparian zone. Deteriorated uplands also increase runoff and erosion and increase sediment delivery to streams. For these reasons, improvements in upland vegetation may be required to protect healthy riparian areas and/or to allow full recovery of deteriorated riparian areas.

Steps to Create a Successful Riparian Grazing Strategy

1. Set Objectives

Clearly defined objectives are important to a successful grazing strategy. Objectives should include 1) sustaining production and profitability of the land and the operation, 2) protecting and utilizing the riparian area, and 3) other personal objectives of the manager.

2. Know Your Area

Learn to identify the plants that grow in riparian areas and consider their special management needs. It is important to know the potential of the vegetative community. NRCS Ecological Site Guides and the information contained in the chapter on vegetation may be valuable references. Personnel trained in plant ecology can also help determine the expectations of riparian areas and offer tips on management.

3. Develop a Long-Term Plan

In the past, most management efforts have focused on the upland plant community and streams have been considered sacrifice areas. To provide long-lasting benefits to livestock production, management should include long-term plans for livestock management, financial considerations, and grazing management for the upland/riparian system. The perception that improved management of riparian areas has to come at the expense of livestock production is not necessarily true.

NRCS field office technical guides, specifically the Prescribed Grazing Standards and Specifications, and Oklahoma Cooperative Extension Service fact sheets are some of the resources available to help plan and monitor long-term grazing strategies.

4. Implement the Plan

Cross fencing, multiple pastures, planned grazing, cell grazing, and alternate water sources are part of the solution to restoring damaged riparian vegetation. Not only do these management activities reduce pressure on riparian areas, they also accomplish the goal of healing the upland vegetation, thus providing improved forage. If the total system is managed properly, improved livestock production will result.

5. Evaluate and Adjust the Plan

Monitor the vegetation. Record days of use, season of use, number of animals, and utilization heights to establish a history for the area. Future refinements can be predicted from this benchmark. Learn from mistakes!

Four Choices to Consider for Grazing Management

The merits of each of the following options should be determined after a close study of the specific site.

A. Encourage livestock to utilize upland areas.

Implement a planned grazing system to provide better grazing distribution. Provide alternate water sources and shade facilities. Move salt, mineral, and feeding locations, as well as oilers, dust bags, and shelters to attract livestock away from the riparian area.

B. Fence riparian areas into a separate pasture for special management.

Use the riparian areas for "special use" such as reserve forage or dormant season grazing. Grazing can be helpful to the riparian plant community. For example, graze to remove standing dead grass, so that vigorous new grass production can occur.

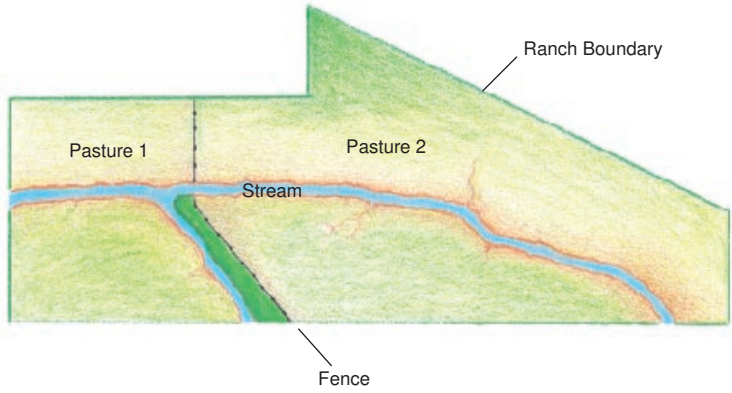

Figure 3. Example of poor fencing layout.

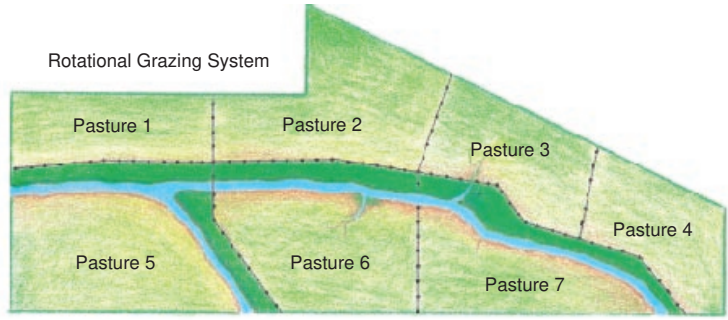

Figure 4. Pastures 1 through 4 will require an alternate water source or controlled access points for livestock. Pastures 5, 6, and 7 allow stream access. Proper management is critical to protecting the riparian area.

The fencing layout shown in Figure 3 ***does not*** allow effective management because of too few pastures and pastures of unequal size. Large pastures allow little opportunity to manage the riparian area because they allow unlimited access to the stream and make it difficult to ensure an effective rest and recovery period for riparian vegetation.

The fencing layout in Figure 4 creates pastures of equal carrying capacity that can be managed as a planned grazing system to benefit both the upland and riparian areas. The added pastures allow flexibility in controlling both the timing and intensity of grazing. Access to the stream is limited, but riparian areas are still part of the system.

With this fencing arrangement, several grazing strategies may be employed. These include 1) winter or spring grazing to allow rest during the growing period, 2) rest rotation to allow pastures to rest during certain years, and 3) deferred grazing to vary the time of year grazed. Selection of one or more of these strategies depends on the conditions present. No single strategy will work everywhere.

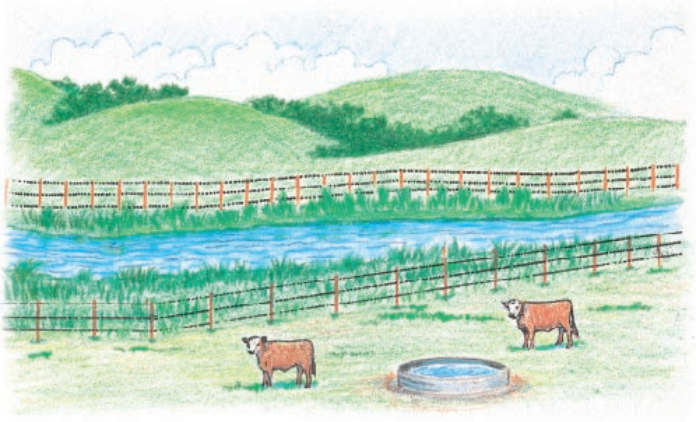

Figure 5. Excluding livestock from riparian areas and providing alternate watering sources.

Figure 6. Allowing cattle to cross streams at controlled access points.

C. Total exclusion with provisions for alternate livestock drinking water.

In this case, a fence is installed to exclude livestock from the riparian area and an alternate watering source is provided. Fences will require maintenance if damaged by floods (Figure 5).

D. Construct controlled access points.

Crushed rock or other suitable ramps prevent trampling damage to streams or water bodies, while allowing livestock to drink. To reduce debris from building up during floods and tearing out the fence, the wires must be widely spaced. Electric fence has been successfully used for this purpose. Information on floating electric fences can be obtained from your county Extension office.

Figure 6 shows a graveled stream crossing with fencing to limit stream access. A variation of this would be a graveled ramp to provide access to one side of the stream. The ramp can also be adapted to improve stock pond water quality.

Additional Tips for Managers

1. Allow plants to reach minimum grazing heights before introducing grazing animals into the riparian area. This is typically from four to 12 inches, depending upon the vegetation.
2. Select a key plant by which to judge the extent of grazing. The key plant should furnish a significant amount of grazing and be important to the riparian plant community. As the plant community changes, a different key plant will need to be selected. With experience, multiple plants give very precise management information.
3. Monitor the riparian area and, when predetermined stubble heights are reached, rotate livestock. Managers can set "height stakes" that become visible when the grasses are grazed to the proper height. This would be the signal to rotate the livestock.
4. Grazing management should provide time for the key perennial plants to recover. The rest period should be adjusted to maintain the desired plant community.
5. Move salt, mineral, and feeding locations, as well as oilers, dust bags, and shelters away from the riparian area.

The ultimate solution to restoring and maintaining the productivity and integrity of riparian areas in Oklahoma is to restore and maintain the upland and riparian areas of watersheds. This involves thoughtful planning and commitment. Improving riparian areas protects water quality, contributes to increased ranch productivity, and enhances wildlife habitat.

Relevant Publications

Krausman, P.R., Editor. 1996. Rangeland Wildlife. Society for Range Management. 440p.

Oklahoma Cooperative Extension Service grazing fact sheets.

Rosgen, D.L. 1996. Applied River Morphology. Wildland Hydrology, Pagosa Springs, Colo. 8:8-8:14.

USDA-NRCS Ecological Sites Guides.

United States Environmental Protection Agency. 1993. Managing Change: Livestock Grazing on Western Riparian Areas.

Key Points:

Riparian areas can be managed for wildlife. Both game and nongame species thrive in riparian areas. This chapter contains special considerations for wildlife.

- Fifty feet of buffer can provide wildlife benefits. Species diversity increases with buffer size.
- Tree stands of mixed age and species, with some dead trees interspersed, support the most wildlife diversity.
- Tree canopy enhances adjacent aquatic habitat and enhances the fishery.
- The presence of snags, den trees, and fallen logs improves reproduction success.
- Riparian buffers should be planted with trees native to the area.

Managing Riparian Areas for Wildlife

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Mark Howery – Oklahoma Department of Wildlife Conservation
Alan Stacey – Oklahoma Department of Wildlife Conservation
Rod Smith – Oklahoma Department of Wildlife Conservation
Steve Tully – Natural Resources Conservation Service
Ron Masters – Oklahoma State University
David Leslie, Jr. – Oklahoma State University
Scott Stoodley – Oklahoma State University

Riparian areas are the lands directly adjacent to water and serve as a transitional link between the aquatic and terrestrial ecosystem. These areas provide critical habitat for many of Oklahoma's wildlife species.

Managing riparian areas wisely can increase biodiversity and improve water quality in the adjacent water bodies.

Ron Masters, Oklahoma Coop. Extension Service

Riparian areas are used by many species for cover and feeding sites.

Aquatic Habitat

Permanent water sources, such as **perennial streams** and floodplain wetlands, are extremely beneficial in creating quality habitat for wildlife species within riparian zones. There are numerous values of riparian habitats to fish and wildlife species, aside from providing a physical place to live.

Riparian wetland vegetation helps regulate water temperature, which is important to fish species. Temperature regimes trigger spawning and control the solubility of oxygen.

Riparian vegetation supports the diversity of fish and wildlife within a lake, stream, or other body of water and provides food materials for invertebrates in streams, which are the basis of the food chain. Thus, preservation or establishment of riparian vegetation greatly enhances the aquatic habitat.

Retaining 50 percent or more of the existing tree canopy in naturally forested regions will enhance the aquatic habitat. In areas where fisheries are to be protected, the understory deciduous trees, shrubs, and herbaceous vegetation within 25 feet of the shoreline should be retained to provide optimal wildlife benefits (Herson-Jones et al. 1995).

To protect fisheries, ***do not:***

- Introduce sediment and debris into the water,
- Restrict natural water flow patterns associated with the area,
- Restrict fish travel to or from the area,
- Disrupt the streambed or channel, and
- Remove streambank vegetation.

Terrestrial Wildlife Habitat

Riparian areas provide important habitat for terrestrial wildlife. Riparian buffers preserve the natural breeding, foraging, and resting areas of native wildlife species. Due to their proximity to water and open areas, riparian forest buffers are extremely important habitat for numerous wildlife species (Zale et al. 1989). Riparian areas are critical wildlife habitats because they:

- Provide a permanent or seasonal water source,
- Provide structural diversity of habitat through diverse vegetation,
- Maximize wildlife diversity through interspersion of riparian and upland communities,
- Provide a variety of wildlife nesting and feeding sites,
- Provide important travel corridors that promote movement and dispersal of wildlife species (Zale et al. 1989).

The quality of the riparian corridor is also important for wildlife benefits. Riparian woodlands offer a larger and more structurally complex habitat than other manmade features, such as windbreaks and shelter belts. Structural and species variation in the

vegetation along riparian zones generally increases animal **species richness**, animal species diversity, and individual animal abundance for most wildlife (Zale et al. 1989).

For birds, riparian vegetation generally supports greater breeding bird density, species diversity, and species richness than adjacent uplands. Bird species diversity is directly related to the diversity of foliage height, percentage of vegetative cover, and width of the riparian zone. The greatest wildlife diversity in riparian areas can be found in areas that have a variety of mixed-age tree species interspersed with occasional dead trees (Zale et al. 1989).

Riparian Areas in Oklahoma

Riparian areas in Oklahoma offer highly valuable habitat for a large number of fish and wildlife species. For game species, food and cover are the riparian habitat components that dictate the relative abundance of these species in a given area. Hard mast (acorns, black walnuts, pecans, and hickory nuts) must be available for species such as turkeys and squirrels. It is also crucial in the distribution and relative abundance of other species. **Snags**, den trees, fallen logs, and other potential denning or nesting sites are essential for cover and reproductive success of many species, including **raptors** and small mammals (Brabander et al. 1985).

In western Oklahoma, the direct availability of water can be critical for wildlife. Thus, a change in riparian vegetation and floodplain land use can alter the community of wildlife inhabitants. Flooding, either natural or human induced, also influences the development of vegetation along **intermittent** and **ephemeral** waterways (Stinnett et al. 1987).

Grazing by livestock will change riparian vegetation. Grazing inhibits establishment of some plants, limits growth of others, and changes the character of the community. Wildlife biologists recommend limiting grazing to late fall and early winter. Grazing during these periods should not negatively affect birds that use the forest understory shrub and herbaceous layers for food and cover.

Numerous species of small and large mammals, birds, reptiles, and amphibians depend on riparian ecosystems for at least a portion of their life's requisites. Many riparian habitat components are important as wintering, feeding, and breeding sites. They also serve as staging grounds for migrant bird species. Favored game species, such as the wood duck, are greatly dependent on the riparian ecosystem throughout their life cycle (Brabander et al. 1985).

In western Oklahoma, 34 percent (103) of the bird species identified are dependent upon riparian vegetation. Additionally, 135 species of birds commonly reside, breed, or winter in Oklahoma Great Plains riparian habitats. In eastern Oklahoma, there are 148 bird species identified as dependent on riparian habitat. Some of these bird species are considered rare or endangered. There are also numerous game bird species that thrive in these habitats (Stinnett et al. 1987).

Riparian Buffer Size

For Birds

The size of a riparian forest stand can directly affect the species assemblage of migratory and breeding birds. Wildlife biologists believe that a minimum stand size of 12 to 15 acres is necessary to support high bird diversity.

Riparian woodlands along intermittent streams in the crosstimbers area of central Oklahoma are important as year-round habitats for birds. Intermittent streams, which tend to flow in spring and early summer, are important to migrants and other songbird species establishing breeding territories. Breeding species encounter optimum cover, nesting sites, food, and water availability in the spring along intermittent streams. Therefore, bird species richness along intermittent streams in central Oklahoma is highest in the spring.

In the crosstimbers, local bird species diversity is maximized when the width of the riparian zone is 100 to 300 feet and trees are six to 19 inches diameter at breast height (dbh). The variety of feeding sites is maximized at intermediate widths. Wider zones increase overall numbers of species by providing habitat for additional **forest interior species**. Similarly, bird species richness is directly related to the width of the riparian zone. Although waterfowl do not nest in large numbers in Oklahoma, intermittent streams provide important stopover sites for migrating waterfowl, particularly dabbling ducks such as mallards (Zale et al. 1989).

For Mammals

Unlike birds, few mammals are so restricted in their local distributions as to be considered exclusively riparian dependent. Riparian corridors can be important to mammals because such corridors typically provide food, shelter, cover, and water in greater abundance than upland areas (Zale et al. 1989).

Large, mobile species may regularly frequent or prefer riparian areas, but they also use upland sites with regularity. Small mammals, however, may occur in higher population densities in riparian habitats than in upland habitats (Zale et al. 1989).

Forty-six mammals are known to occur in riparian habitat in eastern Oklahoma. Eleven of these mammals are rare or endangered and 17 are game species. Some mammals, such as white-tailed deer, prefer the cover afforded by riparian habitat and use these areas for security and as travel corridors (Brabander et al. 1985).

Additionally, riparian habitats likely provide a greater variety of food resources for mammals. For example, raccoons prey on crayfish and other organisms along intermittent streams. Fox squirrels, eastern cottontails, and coyotes can be common in riparian areas, as well (Zale et al. 1989).

Trees in Riparian Areas

Trees provide shade to waterways beneath them, keeping them cool and thereby improving aquatic habitat. The lower water temperature increases dissolved oxygen content, and overhanging branches and roots provide cover for aquatic wildlife.

Leaves, twigs, flowers, animals, and insects from the streamside forest provide the fundamental food source in the aquatic food chain. Aquatic invertebrates shred large organic debris to smaller pieces, which move downstream to be used by larger species that feed by filtering or gathering. Such organic inputs dominate in small forest streams, providing food that supports many invertebrate animals, which in turn are the principal food source for fish.

By providing large stable debris to the streambed, streamside forests allow organic material to be held long enough to be processed by the invertebrate community.

Ninety-five percent (157 of 165) of the known fish species that occur in Oklahoma occur in eastern Oklahoma along bottomland hardwood riparian areas. These include eight game species and 33 species considered rare or endangered. Thirty-eight amphibians and 54 reptiles are also known to occur in riparian habitat in eastern Oklahoma. Of these, six amphibians and five reptiles are rare or endangered (Brabander et al. 1985).

Tables 1 and 2 in the Appendix list species found in Oklahoma riparian areas and suggest minimum widths for riparian buffers in regards to wildlife concerns. Table 3 lists shrubland/thicket-dependent wildlife species that may be attracted to a riparian buffer.

Considerations for Wildlife

When designed with upland wildlife habitat considerations in mind, riparian buffers incorporate the following factors:

- Wildlife species in the area,
- Species targeted for preservation, and
- The size of habitat required for targeted species.

The size of the habitat may determine whether a buffer will support small woodlot birds, forest interior birds, **edge species**, or large or small terrestrial vertebrates.

Species diversity increases with buffer size. In most cases, species diversity increases dramatically when habitat size increases from 10 to 20 acres. Furthermore, beyond the 20-acre mark, terrestrial vertebrate diversity continues to rise significantly with each 10- to 15-acre increase in habitat size.

The degree of habitat isolation is also important. In the interest of wildlife species diversity, habitat isolation should be minimized. The creation of narrow, connective corridors between habitat areas can generally reduce fragmentation, allowing species to use a broader range of areas. Finally, the density and type of vegetative cover should be considered (Herson-Jones et al. 1995).

Recommended Habitat Sizes (Herson-Jones et al. 1995)

Species	Habitat Size
Small and medium terrestrial vertebrates (e.g., mice, moles)	1.5 - 12.5 acres
Large terrestrial vertebrates (e.g., deer)	49.5 - 74 acres
Small woodlot birds (e.g., American robin, mockingbird, sparrow)	2.5 - 12.4 acres
Forest edge species	> 12. acres
Forest interior species	> 25 acres

Depending on site conditions, a riparian forest buffer as little as 50 feet wide (measured from the top of the streambank away from the stream) may provide wildlife habitat. For wildlife considerations, it is important to remember that habitat needs vary from species to species. Thus, when planning for specific species of wildlife, the individual needs of that species must be taken into account.

When planning for wildlife in a riparian area, wildlife tree management should be practiced. A wildlife tree is a standing live or dead tree with special characteristics that provide habitat for conservation or enhancement of wildlife. These characteristics include being:

- large in diameter and height for the site,
- currently used by wildlife,
- in a declining or dead state,
- in a suitable location,
- and relatively scarce.

High quality wildlife trees are frequently present in riparian areas and are used by a variety of species. The proximity of these trees to the edge of streams, wetlands, and lakes increases their value for some wildlife species. Landowners should consider establishing wildlife trees within the riparian management zones to meet wildlife objectives.

Ungrazed or unmowed areas may be utilized by ground-nesting birds such as bobwhite quail.

When cutting timber or thinning trees, fruit-producing trees such as sugarberry, black cherry, chittamwood, and mast-producing trees such as oaks and pecans should be left standing. Scattered individual trees should be cut rather than small groups of trees. This will mimic natural tree fall and encourage regrowth of woodland plants, while minimizing the potential for encroachment by weedy plant species and exotic plants.

To optimize benefits for wildlife, riparian areas should not be grazed during the growing season and should be left ungrazed every other year. Periodic winter grazing by cattle can stimulate new plant growth without damaging the structure of the vegetation.

When haying and/or mowing in a riparian area, grass should not be cut any shorter than 10 inches to leave some cover for wildlife. If the area is to be managed for wildlife, then haying and/or mowing should not take place before July 15 to avoid destroying the nests of ground-nesting birds and rabbits.

Riparian buffers should be planted primarily with tree and shrub species that are native to the area. Riparian tree and shrub species with relatively high value to wildlife are listed in Table 4 in the Appendix. The following tree and shrub species should be avoided when planting riparian buffers because they are either invasive (will crowd out native plants) or they have low value to wildlife: black locust (*Robinia pseudoacacia*), Siberian elm (*Ulmus pumila*), ailanthus (*Ailanthus altissima*), Russian olive (*Eleagnus angustifolia*), autumn olive (*E. umbellata*), pines (all species except loblolly in southeastern Oklahoma), and salt cedar (*Tamarix* spp.).

Financial Assistance

There are several programs that currently offer assistance to landowners interested in protecting riparian areas:

- Stewardship Incentive Program (SIP) - State Department of Agriculture-Forestry Services
- Environmental Quality Incentives Program (EQIP) - USDA
- Wildlife Habitat Incentives Program (WHIP) - USDA
- Partners For Wildlife (PFW) - USFWS
- Conservation Reserve Program - (CRP)

See the the section on incentive programs in the Appendix for further details.

Literature Cited

Zale, A.Z., D.M. Leslie, Jr., W.L. Fisher, S.G. Merrifield, and R.E. Kirby. 1989. The physicochemistry, flora, and fauna of intermittent prairie streams: A review of the literature. Biological Report 89(5):35-42.

Brabander, J.L., R.E. Masters, and R.M. Short. 1985. Bottomland hardwoods of eastern Oklahoma: A special study of their status, trends, and values. Oklahoma State Department of Wildlife Conservation, Oklahoma City.

Stinnett, D.P., R.W. Smith, and S.W. Conrady. 1987. Riparian areas of western Oklahoma: A special study of their status, trends, and values. Oklahoma Department of Wildlife Conservation, Oklahoma City.

Herson-Jones, L.M., M. Heraty, and B. Jordan. 1995. Riparian buffer strategies for urban watersheds. Metropolitan Washington Council of Governments. 112p.

Key Points:

- A riparian buffer system should be considered where 1) water quality is impaired and adjacent land use contributes to degradation, 2) wildlife habitat enhancement is desired, 3) protection from future water quality impairment is desired, 4) stream temperature and aquatic habitat are considerations, or 5) streambank erosion is a concern. In channels with severely eroding banks, bank protection measures should be used along with an RBS.
- The recommended RBS consists of one to three distinct zones. The complete three-zone RBS is recommended where conditions allow. Zone 1 is an undisturbed area of native trees, shrubs, or grasses with a suggested minimum horizontal width of 15 feet directly adjacent to the water body. Zone 2 is a managed zone of native trees, shrubs, forbs, or grasses with a minimum recommended width of 60 feet. Zone 3 is designed as a runoff control zone of dense, perennial grasses and forbs with a recommended minimum width of 20 feet.
- Riparian buffers are effective only when used in conjunction with sound upland erosion control and nutrient management.

Riparian Buffer Recommendations

A Guide for Establishing a Three-Zone Riparian Buffer System

R. Daren Harmel, Oklahoma State University

The proposed RBS is based largely on NRCS riparian buffer standards and D.J. Welsch, 1991, Riparian Forest Buffers: Function and Design for Protection and Enhancement of Water Resources, *USDA-FS Northeastern Area, Radnor, Pa. NA-PR-07-91.*

Robert Frazee, Univ. of Illinois Coop. Extension

Riparian buffer systems adjacent to cropland play an important role in protecting water resources from nutrients, pesticides, and eroded soil.

Introduction

This chapter details a three-zone RBS. The RBS is an engineered riparian buffer designed to protect water quality from adjacent agricultural activities, particularly cropping or grazing. These guidelines are intended for use by conservation district officials or other professionals working with landowners who are interested in installing a system to develop and enhance their riparian areas. Each of the three zones is detailed

in this chapter, including information on suggested minimum widths, general management, livestock management, and a requirement for upslope flow dispersal.

The RBS design is flexible so that the landowner can implement an acceptable buffer that fits his or her unique condition. These guidelines permit modification of zone widths, zone characteristics, and management objectives based on management needs. Width guidelines are all reported as minimum widths to accomplish the aim of protecting aquatic ecosystem health; therefore, widths can be expanded for individual objectives (such as wildlife) or site-specific conditions. Zone characteristics are also flexible within the riparian buffer. For example, existing high quality grassland or forestland meeting the purpose of a particular zone may be used unmodified as that zone. Also, zones need not have a clear delineation, but may differ only in management. For example, Zones 1 and 2 may contain the same vegetation and may not be noticeably different; harvest of timber or forage is allowed in Zone 2, but generally discouraged in Zone 1.

The RBS must be used in conjunction with sound upland management for it to be effective. It is not intended to mitigate the effects of poor nutrient management and erosion control practices above the RBS; rather, it should complement nutrient management and sediment control to enhance water protection. Although riparian buffers effectively aid in bank stabilization, they are not capable of correcting serious bank erosion conditions or watershed-scale problems. In channels with severely eroding banks, stream restoration and watershed planning measures should be used along with the RBS.

Riparian Buffer Specifications

For a general overview of riparian buffer specifications, refer to the RBS matrix beginning on page 70. Also see Figure 1, "Cross-sectional view of the three-zone riparian buffer matrix in a forested system," and Figure 2, "Cross-sectional view of the three-zone riparian buffer matrix in a non-forested system."

Scope: These specifications, modified for Oklahoma from Welsch (1991), establish guidelines for areas to be managed as RBSs.

Definition: ***Riparian areas*** are defined as geographically delineated areas with distinct resource values that occur adjacent to perennial or intermittent stream channels, lakes, ponds, or wetlands.[1] Stream channels are identified for the purposes of these guidelines by the dotted and solid blue lines on the USGS 7 1/2 minute quadrangle map. ***Riparian buffers*** are riparian areas that are designed or engineered to provide certain water quality functions.

[1]Karst formations, other small ground water recharge areas, and certain ephemeral and intermittent streams might also be included, but need further discussion. Some wetlands function as nutrient sinks and when they occur in fields or at field margins, they can be used for renovation of agricultural surface runoff and/or drainage. However, most wetlands associated with open water are subject to periodic flushing of nutrient laden sediments and, therefore, require riparian buffers to protect water quality.

Purpose: The purpose of the RBS is to protect and enhance surface and ground water quality and aquatic ecosystem health. Riparian buffers accomplish this by removing nutrients, sediment, organic matter, certain pesticides, and other pollutants from surface runoff and shallow subsurface flow[2] from upland sources prior to entry into surface water and ground water recharge areas by deposition, absorption, adsorption, plant uptake, and **denitrification**.

Riparian buffers also reduce flood heights and flood velocities, contribute to the stability of streambanks and lake shores, and provide important wildlife habitat. Forested riparian buffers shade streams, thus improving aquatic habitat, and support productive forests which can be harvested periodically. Grassed buffers provide productive livestock pasture.

Conditions where practice applies: RBSs are stable areas at the water body edge that provide a smooth transition from intensive upland land use. They are designed to form a buffer between cropland, pasture, hayland or rangeland, and water bodies, such as perennial or intermittent streams, lakes, ponds, rivers, or wetlands. For forestland, refer to the Oklahoma Department of Agriculture's Forestry Best Management Practices (BMPs) and the discussion of streamside management zones (SMZs).

The RBS will be effective only when used in conjunction with sound upland management practices for runoff and erosion control and for nutrient and pesticide management. In areas where erosion and sediment yield are high (erosion rate greater than 3-5 tons/acre/year), severe sheet, rill, and gully erosion must be controlled for this practice to function correctly. In areas with concentrated runoff, practices to disperse flow and promote infiltration and to impede concentrated flow are necessary for proper function. In areas with high nutrient loads and/or high pesticide rates, a nutrient and/or pesticide management plan is necessary to ensure the buffer's nutrient buffering/filtering capacity is not exceeded. Use of this practice without erosion and runoff control and nutrient and pesticide management can cause adverse impacts and result in high maintenance costs. These impacts include damage to buffer vegetation requiring periodic replanting and an increase in rill and channel development, causing dramatic reduction in the efficiency of the RBS.

The RBS should be considered where: 1) water quality is impaired and adjacent land use contributes to degradation, 2) wildlife habitat enhancement is desired, 3) protection against future water quality impairment is desired, 4) stream temperature reduction and improved aquatic habitat is a consideration, or 5) streambank erosion is a concern. In channels with severely eroding banks such as deeply entrenched channels, bank stability protection measures should be used along with an RBS.

Design criteria: Where conditions allow, the RBS should consist of three distinct

[2]Defined as flow in saturated conditions near or within the root zone of trees and other woody vegetation at depths where bacteria, oxygen, and soil temperature contribute to denitrification.

zones. An undisturbed zone directly adjacent to the water body is critical for maintenance of proper buffer function and is always recommended. Following this zone, a transition area of one to two zones is recommended in the direction of overland flow. Specific recommendations in regard to width, purpose, vegetation, management, livestock, and flow for each zone are given in the following section.

The three-zone RBS is designed to achieve the maximum benefits expressed in the Purpose section; however, other buffer arrangements can be expected to achieve some reduced level of benefits. Other acceptable buffer arrangements are 1) Zone 1[3] as a forested zone adjacent to the water body and Zone 3 as a grassed filter strip, and 2) Zone 1 only as a grassed buffer strip adjacent to the water body. Note that protection of the area directly adjacent to the water body, equivalent to Zone 1, is always recommended.

Maintenance guidelines: RBSs should be inspected annually (and immediately following severe storms) for evidence of buffer erosion or concentrated flow. Prompt corrective actions should be taken to stop erosion and restore sheet flow.

The following should be avoided within RBS areas: 1) excessive use of fertilizers, pesticides, and other chemicals; 2) vehicular traffic; and 3) removal or disturbance of vegetation and litter inconsistent with erosion control and buffering objectives. Fertilizers can be used in zones planted with grass only if determined necessary by a soil nutrient test to encourage vigorous growth.

As forested buffers mature, Zone 1 and Zone 2 will contribute large woody debris (LWD) to the water body. LWD in the aquatic ecosystem traps and holds detritus for processing by aquatic organisms, thus adding energy to the stream ecosystem, strengthening the food chain, and improving aquatic habitat. Where fallen trees obstruct flow and cause accelerated bank erosion, their removal may be necessary. When removing debris from streams, stable portions should be retained to provide storage of detritus. Removed debris should be placed a sufficient distance from the stream so that it will not be redeposited in the stream by high water.

Determining total minimum width of the buffer: In a three-zone RBS or other acceptable buffer arrangement, zones must have adequate widths to remove pollutants effectively from surface runoff and shallow subsurface flow to achieve the desired enhancement and protection of aquatic ecosystems and water quality. Zones 1, 2, and 3 are recommended to have minimum widths of 15, 60, and 20 feet, respectively.

In addition to the general minimum width requirements, the minimum width of RBSs can be fixed according to the following criteria, based generally on slope and soil permeability. Specific criteria such as buffer and upland slope, buffer soil permeability, buffer hydrologic soil group (HSG), source area, buffer soil capability class, or stream/water body class designation can be used to extend width recommendations above minimum levels.

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[3]The width of Zone 1 should be increased to 35 feet where Zone 2 is omitted. Note also that NRCS standards require both Zone 1 and Zone 2.

Zone 1

Of prime importance for protection is the region directly adjacent to the water body defined as Zone 1. An area equivalent to Zone 1 is recommended for all water bodies. Zone 1 should be left undisturbed for proper functioning condition. The purpose of Zone 1 is to create a stable ecosystem along the water's edge and provide soil/water contact to facilitate nutrient buffering processes. This area may also provide shade to lower water temperature and improve aquatic habitat. If trees are present, detritus and large woody debris may be contributed to the ecosystem.

Width: A minimum width of 15 feet is considered appropriate. All distances are measured horizontally on a line perpendicular to the streambank, beginning at the top of the bank. Note that this may be different from the direction of overland flow, as in a high bank.

Vegetation: The predominant vegetation in Zone 1 should consist of species selected for their ability to stabilize the riparian system. If the riparian system has historically been dominated by trees, then trees should be planted in Zone 1. Native tree species such as those suggested in the Appendix are preferred. In areas with severely eroded banks where native species are not suitable for stabilization, nonnative short-lived species may be used. However, use of nonnatives may alter successional patterns with time.

In riparian areas that have not historically been capable of supporting tree species, planting a mixture of native grasses, forbs, and shrubs may be preferred to planting trees. A list of native species is shown in the Appendix and can also be found in the vegetation chapter. Refer to the NRCS State Standard and Specifications for Tree Planting and for Streambank and Shoreline Protection for specific requirements to establish, manage, and maintain trees. For biodiversity considerations, refer to *Oklahoma's Biodiversity Plan: A Shared Vision for Conserving Our Natural Heritage*, which is available from the Oklahoma Department of Wildlife Conservation.

General management: It is critical for proper function that Zone 1 be undisturbed to the greatest extent possible. Inspect and manage for the sustainability of the stand. Activities within this zone should be limited to any necessary bank stabilization or removal of trees presenting possible hazards, such as blocking culverts or creating dangerous hydraulic obstructions. Overland equipment is prohibited except at designated stream crossings. Management for wildlife habitat and aesthetics are compatible secondary objectives, as long as their management does not jeopardize the primary function of the RBS. If other management objectives are desired, appropriate species adapted to site conditions may be selected. Consult with the NRCS, U.S. Forest Service, Oklahoma Biological Survey, or the U.S. Fish and Wildlife Service for species selection.

Logging should be limited to the removal of occasional high value trees where water quality values are not compromised.

Livestock management: Livestock presence is discouraged in Zone 1 except for designed stream crossings (allowed only on small streams) and for designed watering facilities

located outside the buffer or within the buffer if the watering facility is fenced. This recommendation is made because of probable negative impacts, such as streambank instability, livestock trails, and vegetative damage–all of which limit buffer effectiveness in this zone. If the decision is made to allow livestock, intensive management is necessary to protect the buffer. This might include controlled, short-term grazing when conditions are dry and firm and when vegetation is least vulnerable to damage.

Upslope flow dispersal: Flow should be limited to subsurface and shallow, uniform flow in this zone. Concentrated flow must be converted to subsurface or shallow, uniform flow prior to entering Zone 1, because buffering effectiveness would be short-circuited otherwise. Open ditches and subsurface drains crossing Zone 1 are discouraged. Grading and shaping should be used in Zone 3 (or the outermost zone) to ensure flow reaching Zone 1 is uniform and not concentrated. Care should be exercised when employing these techniques and devices to minimize disturbance.

Zone 2

Zone 2 is the intermediate zone where active management may take place. Its purpose is to provide the necessary contact time and carbon energy source for buffering to occur, as well as to provide long-term storage of nutrients in forest trees.

Width: A 60-foot minimum width is recommended, measured horizontally in the direction of overland flow. The minimum width requirement may be increased once the minimum width of the entire buffer is determined.

Vegetation: Predominant vegetation in Zone 2 should also consist of species selected for their ability to stabilize the riparian area. Refer to the NRCS, U.S. Forest Service, or U.S. Fish and Wildlife Service for species selection if other benefits are desired. Deciduous tree species are important for leaf litter carbon leachate production, which drives bacterial processes, and should be considered where possible. Evergreens are important for potential nutrient uptake in winter months. If the riparian system has been dominated by tree species historically, then trees should be planted in Zone 2. Native species such as those suggested in the Appendix are preferred. The NRCS State Standard and Specifications for Tree Planting and for Streambank and Shoreline Protection should be referred to for specific requirements to establish, manage, and maintain trees.

In riparian areas that have not historically been capable of supporting tree species, planting a mixture of shrubs, grasses, and forbs is recommended, rather than trees. Native species are preferred.

General management: Management for wildlife, aesthetics, and timber are compatible with proper buffer functions within Zone 2, as long as leaf litter, detritus, large woody debris production, and shade are maintained and their management does not impair the primary function of the buffer. Mechanical site preparation which exposes large amounts of bare soil, such as rootraking and windrowing, piling, disking, or bedding, is prohibited.

Periodic harvesting and timber stand improvement with appropriate recommenda-

tions from state and federal forestry agencies are allowed and encouraged to maintain vigorous growth and to remove nutrients and pollutants stored in the timber. All forest harvesting operations shall be in compliance with NRCS State Standard and Specifications for Improved Harvesting and with recognized BMPs. Stand density shall be maintained within 25 percent of forest density guidelines for forest type and size class.

Livestock management: The same recommendation for Zone 1 applies in Zone 2. However, on areas planted with grass, controlled, intensive grazing is allowed when conditions are dry and firm. Removal of vegetative growth may be accomplished with grazing or hay harvesting and is preferred to mowing.

Upslope flow dispersal: The same recommendations for Zone 1 apply for Zone 2.

Zone 3

Zone 3 is designed for runoff control and provides sediment filtering, nutrient uptake, and the space necessary to convert concentrated flow to uniform, shallow sheet flow through the use of techniques such as grading and shaping and devices such as diversions, basins, and level lip spreaders.

Width: A 20-foot minimum width is recommended for this zone, measured horizontally in the direction of overland flow, although additional width may be desired to accommodate land shaping and mowing equipment. Ungrazed grassland may meet Zone 3 requirements.

Vegetation: Dense, perennial grasses and forbs are recommended for this zone to maximize nutrient uptake. Vegetation should be maintained in vigorous growth condition, unless this conflicts with wildlife management objectives. Select species adapted to site conditions and with the ability to achieve other benefits, such as forage production and wildlife habitat improvement. Refer to the NRCS Filter Strip Standard for seeding mixtures. Improved grass species should be used with caution. Consult the NRCS standard for grass filter strips for species selection.

General management: Mow and remove clippings to recycle nutrients, promote vigorous sod growth, and control weeds. This zone should be inspected twice annually and may require periodic reshaping of earthen structures, removal of grading or accumulated sediment, and reestablishment of vegetation. Do not mow or harvest during nesting season.

Livestock management: Instead of mowing and removing clippings to remove vegetative growth, controlled, intensive grazing and hay harvesting are both allowed when conditions are dry and firm so that earth control structures and vegetation are not damaged. Designed watering facilities should be located outside the buffer; however, a location within the buffer is acceptable if the watering facility is fenced.

Upslope flow dispersal: Open ditches and subsurface drains crossing Zone 3 are discouraged; however, drains may outlet water within Zone 3 if the flow is converted to uniform flow upon outlet.

ZONE 1

Width	Purpose	Vegetation[1]	General Management[2]	Livestock Management[3]	Forestry Management[4]	Wildlife	Flow Requirements[5]
15 ft. minimum width (all distances are measured horizontally on a line perpendicular to the stream-bank) beginning at the bank top.	1) Create a stable ecosystem adjacent to the water's edge, 2) provide a soil/water contact area to facilitate the nutrient buffering process, 3) provide shade to lower water temperature and improve aquatic habitat, and 4) contribute detritus and LWD to the ecosystem.	Predominant vegetation composed of a variety of native riparian tree, forb, and shrub species suitable to soil and site and such plantings necessary for streambank stabilization during establishment period.	Bank stabilization and removal of trees presenting hazards, such as blocking culverts or creating dangerous hydraulic obstructions. Other overland equipment is prohibited except to cross the stream in designated stream crossings.	Livestock presence is discouraged except for designed stream crossings (allowed only on small streams) and for designed watering facilities located outside the buffer or within the buffer if the watering facility is fenced.	Logging limited to the removal of occasional high value trees where water quality values are not compromised.	Buffer width is a critical design parameter when attracting wildlife. Wildlife issues are addressed in the Appendix.	Limited to subsurface and shallow, uniform flow. Concentrated flow must be converted to subsurface or shallow, uniform flow prior to entering Zone 1. Open ditches and subsurface drains crossing Zone 1 are discouraged.

[1] Select species adapted to soil and site and for their ability to achieve other benefits such as wildlife habitat improvement. Consult with the NRCS, U.S. Forest Service, Oklahoma Biological Survey, or U.S. Fish and Wildlife Service for species selection. Plant native streamside species on HSG C and D and native upland species on HSG A and B. In riparian areas that have not historically been capable of supporting tree species, planting a mixture of native grasses, forbs, and shrubs may be preferred to planting trees. Refer to NRCS State Standard and Specifications for Tree Planting and for Streambank and Shoreline Protection or forestry reports recommendations to establish manage trees.

[2] Management for wildlife habitat and aesthetics are compatible secondary objectives, as long as their management does not jeopardize the primary function of the buffer.

[3] Livestock presence is discouraged because of probable negative impacts, such as streambank instability, livestock trails, and vegetative damage—all of which limit buffer effectiveness in Zone 1. If livestock are present in this zone, intensive management is necessary to prevent negative impacts. Lack of management or mismanagement will result in negative impacts. Intensive management might include controlled, short-term grazing when conditions are dry and firm and when vegetation is least vulnerable to damage.

[4] All forest harvesting operations shall be in compliance with State Standard and Specifications for Improved Harvesting and with recognized forestry BMPs for Oklahoma.

[5] Such concentrated flows are discouraged because they short-circuit buffering effectiveness. Grading and shaping should be used in Zone 3 (or the outermost zone) to ensure flow reaching Zone 1 is uniform and not concentrated. Care should be exercised when employing these techniques and devices to minimize disturbance.

ZONE 2

Width	Purpose	Vegetation[1]	General Management[2]	Livestock Management[3]	Forestry Management[4]	Wildlife	Flow Requirements[5]
60 ft. minimum width measured horizontally in the direction of flow. (Minimum width requirement may be increased based on "determining total minimum width of the buffer." (See discussion in the text.)	1) Provide necessary contact time and carbon energy sources for buffering to take place, and 2) provide for long-term storage of nutrients in forest trees.	Predominant vegetation composed of a variety of native riparian tree, forb, and shrub species suitable to soil and site and such plantings necessary for streambank stabilization during establishment period.	Management for wildlife, aesthetics, and timber are compatible objectives as long as leaf litter detritus production and shade levels are maintained.	Livestock presence discouraged except for designed stream crossings (allowed only on small streams) and for designed watering facilities located outside the buffer or within the buffer (if the watering facility is fenced).	Periodic harvesting and timber stand improvement with appropriate recommendations from state and federal forestry agencies are allowed and encouraged to maintain vigorous growth and to remove nutrients and pollutants stored in the timber.	Wildlife issues are addressed in the Appendix.	Limited to subsurface and shallow, uniform flow. Concentrated flow must be converted to subsurface or shallow, uniform flow prior to entering Zone 2. Open ditches and subsurface drains crossing Zone 2 are discouraged.

[1] Select species adapted to soil and site and for their ability to achieve other benefits, such as wildlife habitat improvement. Consult with the NRCS, U.S. Forest Service, Oklahoma Department of Wildlife Conservation, Oklahoma Biological Survey, or U.S. Fish and Wildlife Service for species selection. Plant native streamside species on HSG C and D and native upland species on HSG A and B. Deciduous trees are important for leaf litter carbon leachate production which drives bacterial processes and evergreens are important for potential nutrient uptake in winter months. In riparian areas that have not historically been capable of supporting trees, planting a mixture of native grasses, forbs, and shrubs may be preferred to planting trees. Refer to NRCS State Standard and Specifications for Tree Planting and for Streambank and Shoreline Protection or state forestry reports for recommendations to establish and manage trees.

[2] Management for wildlife habitat and aesthetics are compatible secondary objectives as long as their management does not jeopardize the primary function of the buffer. Mechanical site preparation which exposes large amounts of bare soil, such as root raking, windrowing, piling, disking, or bedding, is prohibited.

[3] Livestock presence is discouraged because of probable negative impacts such as streambank instability, livestock trails, and vegetative damage—all of which limit buffer effectiveness in this zone. If livestock are present in this zone, intensive management is necessary to prevent negative impacts. Lack of management or mismanagement will result in negative impacts. Intensive management might include controlled, intensive, short-term grazing when conditions are dry and firm and when vegetation is least vulnerable to damage. On areas planted with grass, grazing or hay harvesting can be used instead of mowing and removal of clippings to remove vegetative growth when conditions are dry and firm.

[4] All forest harvesting operations shall be in compliance with State Standard and Specifications for Improved Harvesting and with recognized forestry BMPs for Oklahoma.

[5] Such concentrated flows are discouraged because they short-circuit the buffering effectiveness. Grading and shaping should be used in Zone 3 (or the outermost zone) to ensure flow reaching Zone 1 is uniform and not concentrated. Care should be exercised when using these techniques and devices to minimize disturbance.

ZONE 3

Width	Purpose	Vegetation[1]	General Management	Livestock Management[2]	Forestry Management	Wildlife	Flow Requirements
20 ft. minimum width measured horizontally in the direction of overland flow (additional width may be desired to accommodate land shaping and mowing equipment). Ungrazed grassland meeting Zone 3 purpose may serve as Zone 3.	Provide sediment filtering, nutrient uptake, and space necessary to convert concentrated flow to uniform, shallow, sheet flow through the use of techniques such as grading and shaping and devices such as diversions, basins, and level lip spreaders.	Dense perennial grasses and forbs. Vegetation must be maintained in vigorous growth condition (may not be consistent with wildlife needs).	Mow and remove clippings to recycle nutrients, promote vigorous sod growth and control weeds. Inspect twice annually. May require periodic reshaping of earth structures, removal or grading of accumulated sediment and reestablishment of vegetation.	1) Controlled, intensive grazing, 2) grazing instead of mowing and removal of clippings to remove vegetative growth, and 3) hay harvesting are all allowed when conditions are dry and firm so that earth control structures and vegetation are not damaged.	Zone 3 is generally omitted in forestry areas.	Do not mow during nesting season. Additional wildlife issues are addressed in the Appendix.	Open ditches and subsurface drains crossing Zone 3 are discouraged; however, drains may outlet water within Zone 3 if the flow is converted to uniform flow upon outlet.

[1] Select species adapted to the soil and site and with ability to achieve other benefits, such as forage production and wildlife habitat improvement. Refer to Filter Strip Standard for seeding mixtures. Improved grass species are allowed.

[2] Designed watering facilities should be located outside the buffer or within the buffer (only if the watering facility is fenced).

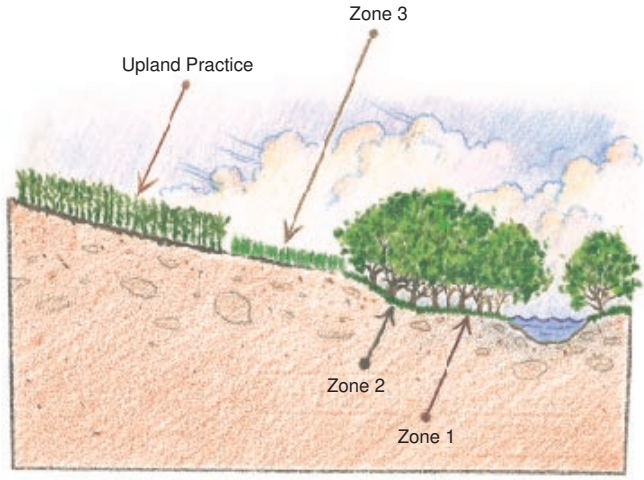

Figure 1. Cross-sectional view of the three-zone riparian buffer matrix in a forested area. (Modified from the NRCS, Riparian Forest Buffer Standard.)

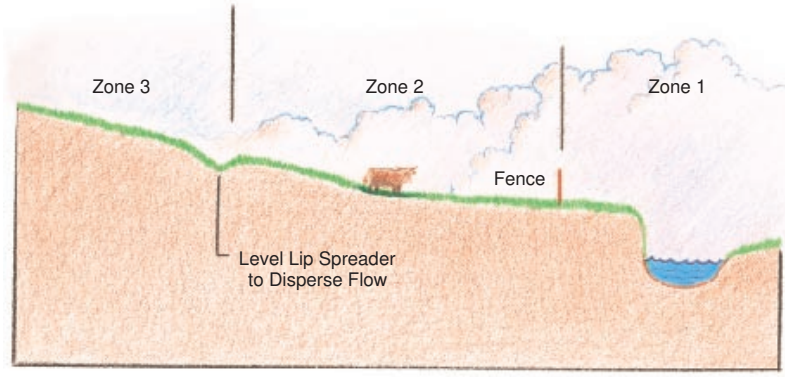

Figure 2. Cross-sectional view of the three-zone riparian buffer matrix in a non-forested region. (Modified from the NRCS, Riparian Forest Buffer Standard.)

Appendix

Table 1. Woodland-dependent wildlife bird species that may be attracted to an RBS. All cases assume the RBS exists in a landscape of pasture and/or cropland with Zone 1 undisturbed forest, Zone 2 managed forest, and Zone 3 hayed or burned. Zone 1 and 2 combined widths of 100 feet, 75 feet, and 50 feet, are listed for one bank; total buffer zone width is twice this figure.

Species	100 ft.	75 ft.	50 ft.	Species	100 ft.	75 ft.	50 ft.
Wood duck	●			Wood thrush	●		
Red-shouldered hawk	●			Eastern bluebird	●	●	●
Wild turkey	●			Blue-gray gnatcatcher	●	●	
Mourning dove	●	●	●	White-eyed vireo	●	●	
Screech owl	●	●		Yellow-throated vireo	●		
Barred owl	●			Red-eyed vireo	●		
Yellow-billed cuckoo	●	●		Warbling vireo	●	●	
Common nighthawk	●	●		Black and white warbler	●		
Chuck-wills-widow	●			Prothonotary warbler	●		
Ruby-throated hummingbird	●	●		Parula warbler	●		
Red-bellied woodpecker	●	●		Yellow warbler	●		
Redheaded woodpecker	●	●	●	Yellow-throated warbler	●		
Downy woodpecker	●	●	●	Louisiana waterthrush	●	●	
Northern flicker	●	●	●	Common yellowthroat	●	●	
Eastern kingbird	●	●	●	Kentucky warbler	●		
Great crested flycatcher	●	●		Orchard oriole	●		
Eastern phoebe	●	●	●	Northern oriole	●	●	
Acadian flycatcher	●			Summer tanager	●		
Rough-winged swallow	●	●	●	Northern cardinal	●	●	●
Blue jay	●	●	●	Blue grosbeak	●	●	●
Carolina chickadee	●	●	●	Indigo bunting	●	●	●
Tufted titmouse	●	●		Field sparrow	●	●	●
Carolina wren	●	●					
Northern mockingbird	●	●	●				
Brown thrasher	●	●	●				

Table 2. Woodland-dependent wildlife mammal, amphibian, and reptile species that may be attracted to an RBS. All cases assume the RBS exists in a landscape of pasture and/or cropland with Zone 1 undisturbed forest, Zone 2 managed forest, and Zone 3 hayed or burned. Zone 1 and 2 combined widths of 100 feet, 75 feet, and 50 feet, are listed for one bank; total buffer zone width is twice this figure.

Species	100 ft.	75 ft.	50 ft.
Mammals			
Opossum	●	●	●
Short-tailed shrew	●	●	
Eastern mole	●	●	●
Gray bat	●		
Keen's myotis	●		
Big-brown bat	●	●	
Eastern pipistrel	●	●	●
Red bat	●	●	●
Seminole bat	●	●	
Gray squirrel	●	●	
Fox squirrel	●	●	●
White-footed mouse	●	●	●
Eastern woodrat	●	●	●
Gray fox	●	●	
Raccoon	●	●	●
White-tailed deer	●	●	
Amphibians			
Ringed salamander	●		
Marbled salamander	●		
Spotted salamander	●		
Tiger salamander	●	●	
Smallmouth salamander	●		
Many-ribbed salamander	●		
Redbacked salamander	●		

Species	100 ft.	75 ft.	50 ft.
Amphibians (cont.)			
Slimy salamander	●		
American toad	●	●	●
Eastern narrowmouth toad	●	●	●
Gray treefrog	●	●	●
Green treefrog	●		
Crawfish frog	●	●	●
Reptiles			
Three-toed box turtle	●	●	
Ground skink	●	●	●
Southern coal skink	●	●	
Five-lined skink	●	●	●
Broad-headed skink	●	●	
Western worm snake	●	●	
Rough green snake	●	●	●
Scarlet snake	●	●	
Brown snake	●	●	●
Red-bellied snake	●	●	
Copperhead snake	●	●	

Table 3. Shrubland/thicket-dependent wildlife species that may be attracted to an RBS. Riparian areas dominated by shrubs rather than trees are common in western Oklahoma.

Birds	Mammals	Amphibians	Reptiles
Northern bobwhite quail	Short-tailed shrew	Tiger salamander	Three-toed box turtle
Mourning dove	Swamp rabbit	Woodhouse toad	Ground skink
Northern flicker	Eastern cottontail	Western chorus frog	Fence lizard
Scissor-tailed flycatcher	Fulvous harvest mouse	Strecker's chorus frog	Slender glass lizard
Eastern kingbird	Cotton mouse		Ringneck snake
Western kingbird	Woodland vole		Flathead snake
Bewick's wren	Cotton rat		Ground snake
Northern mockingbird			Racer
Brown thrasher			Speckled kingsnake
Eastern bluebird			Red-sided garter snake
Bell's vireo			
Common yellowthroat			
Eastern meadowlark			
Red-winged blackbird			
Northern cardinal			
Blue grosbeak			
Painted bunting			
Dickcissel			
Field sparrow			
Lark sparrow			

Table 4. Riparian tree and shrub species with relatively high value to wildlife for planting in Zones 1 and 2 of the riparian buffer system (RBS).

Species	Zone 1	Zone 2
Sugarberry (*Celtis laevigata*)	●	●
Water oak (*Quercus nigra*)	●	
Shumard oak (*Q. shumardii*)		●
Pecan (*Carya illinoensis*)	●	●
Green ash (*Fraxinus pennsylvanica*)	●	●
Black gum (*Nyssa sylvatica*)	●	●
Burr oak (*Q. macrocarpa*)	●	●
Black oak (*Q. velutina*)		●
Chinkapin oak (*Q. muehlenbergii*)		●
Black willow (*Salix nigra*)	●	
Hackberry (*Celtis occidentalis*)		●
Slippery or red elm (*Ulmus rubra*)	●	
American or white elm (*U. americanus*)		●
Red maple (*Acer rubrum*)	●	
Black walnut (*Juglans nigra*)		●
Red mulberry (*Morus rubra*)		●
Sassafras (*Sassafras albidum*)		●
Green hawthorn (*Crateagus viridis*)		●
American plum (*Prunus americana*)		●
Black cherry (*P. serotina*)		●
Deciduous holly (*Ilex decidua*)		●
Western soapberry (*Sapindus drummondii*)		●
Roughleaf dogwood (*Cornus drummondii*)		●
Chittamwood (*Bumelia lanuginosa*)		●
Rusty blackhaw (*Viburnum rufidulum*)		●

Table 5. A list of common woody species in Oklahoma riparian zones.

Tree Species (*Scientific name*)	Commercial Availability	Wildlife Value	Root Type	Growth Rate	Comments
Alder, Smooth (*Alnus serrulata*)	Uncommon	Intermediate	Shallow, spreading; produces suckers.	Slow	Common in southeastern Oklahoma and also Delaware County.
Ash, Green (*Fraxinus pennsylvanica*)	Common*	Low	Shallow, widespread, fibrous roots.	Fast	Common in bottomlands throughout Oklahoma, excluding the western quarter and Panhandle.
Ash, White (*Fraxinus americana*)	Common	Low	Shallow, widespread, fibrous roots.	Medium	Common in bottomlands throughout the eastern half of Oklahoma.
Bald Cypress (*Taxodium distichum*)	Common*	Very low	Shallow fibrous roots. Produces "knees."	Medium	Naturally occurring in the Little River drainage of McCurtain County. Function of the knees is unclear.
Basswood, American (*Tilia americana*)	Uncommon	Low	Deep, coarse lateral roots.	Medium	Naturally occurring in Adair, Cherokee, LeFlore, Delaware counties.
Birch, River (*Betula nigra*)	Common	Very high	Shallow.	Fast when young	Native to eastern Oklahoma.
Blackgum (*Nyssa sylvatica*)	Uncommon	Low	Sparse, fibrous, very long, descending.	Medium	Common in eastern Oklahoma.
Boxelder (*Acer negundo*)	Common	Excellent	Moderate, deep spreading.	Fast	Common throughout the eastern half of Oklahoma.
Buckeye, Ohio (*Aesculus glabra*)	Uncommon	Very low	Deep taproot.	Slow	Scattered to common in the eastern half of Oklahoma, extending west to the Witchita Mountains.
Cottonwood, Eastern (*Populus deltoides*)	Very common	Good	Shallow.	Fast	Common throughout Oklahoma.

Table 5. (Continued)

Tree Species (*Scientific name*)	Commercial Availability	Wildlife Value	Root Type	Growth Rate	Comments
Elm, American (*Ulmus americana*)	Very common	Intermediate	Taproot to shallow fibrous on moist sites.	Medium	Common throughout Oklahoma, excluding the Panhandle.
Elm, Red (*Ulmus rubra*)	Common	Intermediate	Taproot to shallow fibrous.	Medium	Common in eastern and much of central Oklahoma.
Elm, Winged (*Ulmus alata*)	Uncommon	Intermediate	Taproot to shallow fibrous on moist sites.	Medium	Common central, far northeastern, and southeastern Oklahoma. Also abundant in upland habits.
Hackberry (*Celtis occidentalis*)	Common*	Very high	Medium to deep, fibrous roots.	Medium to fast	Abundant along streams in the northern half of Oklahoma (excluding the Panhandle).
Hawthorn, Cockspur (*Crataegus crus-galli*)	Uncommon	Intermediate	Taproot.	Slow	Scattered throughout much of eastern and southern Oklahoma.
Hawthorn, Downy (*Crataegus mollis*)	Uncommon	Intermediate	Taproot.	Slow	Scattered throughout much of eastern and central Oklahoma.
Hawthorn, Green (*Crataegeus viridis*)	Uncommon	Intermediate	Taproot.	Slow	Scattered throughout much of eastern and southern Oklahoma. Forms thickets.
Hickory, Bitternut (*Carya cordiformis*)	Uncommon	Intermediate	Deep taproot and dense lateral roots.	Slow	Common in the northeast, extending from the southeast to the Arbuckle Mountains.
Hickory, Mockernut (*Carya tomentosa*)	Uncommon	Intermediate	Deep taproot.		Common in uplands and riparian zones in the Coastal Plain, Ouachita Mountains, and Ozark Plateau.
Holly, American (*Ilex opaca*)	Common	High	Shallow lateral roots.	Slow to medium	Restricted to the Coastal Plain section of McCurtain County.

Table 5. (Continued)

Tree Species (*Scientific name*)	Commercial Availability	Wildlife Value	Root Type	Growth Rate	Comments
Honeylocust (*Gleditsia triacanthos*)	Common	Very low	Taproots, deep to shallow lateral roots.	Fast	Scattered throughout the eastern half of Oklahoma.
Hornbeam, **American** *(Carpinus caroliniana*)	Rare	Very low	Deep, lateral roots.	Slow	Limited to portions of LeFlore, McCurtain, and Pushmataha counties.
Maple, Red (*Acer rubrum*)	Very common	Very high	Shallow to moderately deep; widespread fibrous.	Medium to fast	Common in southeastern Oklahoma and on the Ozark Plateau.
Maple, Silver (*Acer saccharinum*)	Common*	Very high	Shallow, fibrous.	Fast	Common in eastern Oklahoma (excluding the Coastal Plain), extending west to Osage County.
Maple, Sugar (*Acer saccharum*)	Very common	Very high	Shallow to moderately deep; widespread fibrous.	Slow	Common on the Ozark Plateau and LeFlore and McCurtain counties. Unique occurrences in the Witchita Mountains and in the canyons of Caddo and Canadian counties.
Mulberry, Red (*Morus rubra*)	Common*	High	Taproot or deep lateral roots.	Fast	Common throughout the main 4/5 of Oklahoma.
Oak, Bur (*Quercus macrocarpa*)	Common*	Very high	Deep taproot.	Slow to medium	Common throughout the eastern 4/5 of Oklahoma, excluding the Ouachita Mountains.
Oak, Chinkapin (*Quercus muehlenbergii*)	Infrequent	Very high	Deep coarse lateral roots.	Slow	Scattered to common throughout the eastern 3/4 of the state.
Oak, Overcup (*Quercus lyrata*)	Common*	Very high	Tap deteriorates to dense, shallow laterals.	Slow	Restricted to the Coastal Plain area of McCurtain County.

Table 5. (Continued)

Tree Species (*Scientific name*)	Commercial Availability	Wildlife Value	Root Type	Growth Rate	Comments
Oak, Red (*Quercus rubra*)	Common	Very high	Deep, spreading, lateral roots.	Medium	Eastern tier of Oklahoma counties, but follows the Arkansas River into Tulsa County.
Oak, Shumard (*Quercus shumardii*)	Common*	Very high	Shallow.	Medium	Throughout much of eastern and central Oklahoma.
Oak, Water (*Quercus nigra*)	Common	Very high	Shallow and spreading.	Fast on good sites	Eastern Oklahoma. Range extends along the Red River to Bryan County and the South Canadian River into McIntosh County.
Oak, White (*Quercus alba*)	Common	Very high	Tap to deep, well developed fibrous.	Slow	Eastern tier of Oklahoma counties, but extending west into Coal County to the south.
Oak, Willow (*Quercus phellos*)	Common*	Very high	Shallow, fibrous.	Fast	Common in LeFlore, McCurtain, Pushmataha, and eastern Choctaw counties.
Osage Orange *(Maclura pomifera*)	Common*	Very low	Shallow, fibrous.	Fast	Native range includes the Red River to Love County, north to the Arbuckle Mountains. Also east along the Arkansas River into Muskogee County.
Pecan (*Carya illinoensis*)	Common*	Intermediate	Taproot.	Slow	Southwest to northeast Oklahoma. Absent from the Ozark Plateau, Ouachita Mountains, and northwest Oklahoma.
Pine, Loblolly (*Pinus taeda*)	Uncommon*	Very high	Short tap changes to shallow spreading laterals.	Fast	Found only in the Coastal Plain section of McCurtain County. Often grown in plantations outside its natural range.
Possumhaw (*Ilex decidua*)	Uncommon	High	Shallow lateral roots.	Slow to medium	Limited to the eastern quarter of the state.

Table 5. (Continued)

Tree Species (*Scientific name*)	Commercial Availability	Wildlife Value	Root Type	Growth Rate	Comments
Redbud (*Cercis canadensis*)	Common*	Very low	Shallow, fibrous lateral roots.	Slow	Throughout much of the eastern three-quarters of Oklahoma. Also grows in uplands.
Soapberry (*Sapindus drummondii*)	Uncommon	High	Shallow fibrous.	Medium to fast	Western two-thirds of the state. Scattered in the Panhandle. Fruits are poisonous to livestock.
Sugarberry (*Celtis laevigata*)	Uncommon	Very high	Deep coarse lateral roots.	Medium	Common in 4/5 of the state, excluding the Panhandle. Often difficult to distinguish from hackberry.
Sweetgum (*Liquidambar styraciflua*)	Common	Low	Taproot.	Slow to medium	Primarily occurs in Choctaw, Latimer, LeFlore, McCurtain, and Pushmataha counties.
Sycamore (*Platanus occidentalis*)	Common*	Very low	Shallow, fibrous, widespread roots.	Very fast	Common throughout much of the eastern half of Oklahoma.
Walnut, Black (*Juglans nigra*)	Infrequent*	Low	Tap and deep and wide spread laterals.	Fair	Common to scattered throughout the eastern three-quarters of Oklahoma.
Willow, Black (*Salix nigra*)	Very common	Good	Shallow to deep.	Fast	Throughout Oklahoma, excluding the Panhandle.
Willow, Coyote (*Salix exigua*)	Fairly common	Good	Shallow suckering.	Fast	Common in western Oklahoma and along the Arkansas River from the Kansas border to Cherokee County.

** = Trees available from the Oklahoma Forestry Division.*

This section contains a list of agencies that deal with riparian management, protection, restoration, and education and a description of their field of expertise. Only those riparian areas that qualify as wetlands are under any current state or federal regulation. Wetland determination is based on 1) the presence of hydric soils, 2) hydrology, and 3) hydrophytic vegetation. Permits may be required for land disturbing activities in riparian wetlands.

Who to Contact

Federal Agencies:

- **U.S. Army Corps of Engineers** – The Corps is the principal federal regulatory agency for wetlands. Those riparian areas classified as wetlands fall under Section 404 of the Clean Water Act, to be regulated by the Corps. Determining if a riparian area is a wetland is a complicated matter that depends on factors such as soil, vegetation, and hydrology. Professionals at the Corps can provide guidance in wetlands determination. Contact the Corps before any land disturbing activity in riparian wetlands and if the potential to disturb wetlands or waterways exists. (Also see Natural Resources Conservation Service, the Environmental Protection Agency, and the Oklahoma Department of Environmental Quality.)
- **U.S. Environmental Protection Agency** – The EPA jointly administers and enforces the Section 404 permit program with the U.S. Army Corps of Engineers.
- **U.S. Fish and Wildlife Service** – The mission of the USFWS is to conserve, protect, and enhance fish and wildlife and their habitats for the continuing benefit of the American people. Through its Refuges, Fisheries, Law Enforcement, Ecological Services, and Federal Assistance programs, the USFWS fulfills a variety of responsibilities in conserving the nation's fish and wildlife resources. An important role of the USFWS is review and consultation on projects proposed or permitted by other federal agencies that may impact threatened or endangered species or wetlands resources. The USFWS has a continuing land acquisition program that is directed primarily to the benefit of wetlands-dependent wildlife and listed species. The USFWS also sponsors the Partners for Fish and Wildlife program. Funds may be available from Partners to restore/rehabilitate riparian areas to benefit fish and wildlife resources. Contact your local USFWS or the Oklahoma Department of Wildlife Conservation office for further information about this program.
- **Natural Resources Conservation Service** – The NRCS is a division of the U.S. Department of Agriculture which administers various voluntary incentive programs that were initiated by Congress. These include the Conservation Reserve Program (CRP), Environmental Quality Incentive Program (EQIP), Wildlife Habitat Incentive Program (WHIP), and the Wetlands Reserve Program (WRP).

These programs provide incentive to encourage the management and protection of environmentally sensitive lands. NRCS is responsible for making wetland determinations on agricultural lands, mapping, and acting as liaisons with landowners that participate in federal farm programs. Each of these programs can provide technical and financial assistance. In addition, NRCS is available to consult on total resource management plans that include needed treatment for riparian areas. They can also give planting recommendations for stream restoration projects. For more information, contact the local conservation district office.

State Agencies:

- **Oklahoma Conservation Commission** – The Commission is responsible for the distribution of Oklahoma's comprehensive Wetlands Conservation Plan. The Commission administers numerous Clean Water Act 319 Nonpoint Source and 104(b)(3) Wetland Grants through local units of government. These grants have established several riparian and wetland demonstration sites suitable for tours and education programs. The Commission has a network of 88 local conservation district offices that are responsible for conservation of renewable natural resources. Conservation district offices provide technical assistance in a variety of areas, including riparian management, land management, conservation planning, sediment and erosion control, and water quality issues, as well as conservation and environmental education. The offices maintain copies of the USFWS and NRCS wetlands inventory maps as well as county soil surveys.
- **Oklahoma Cooperative Extension Service** – Cooperative Extension represents a federal, state, and county partnership that helps bring the expertise of Oklahoma State University to the public. County Extension offices offer a wide variety of fact sheets, circulars, and videotapes. County Extension educators can assist in planning alternative management of riparian areas. They also provide educational materials for agriculture and science classes in the public schools.
- **Oklahoma Department of Agriculture - Forestry Services** – Forestry Services offers information on the protection, management, improvement, and use of Oklahoma's forests. Professional foresters offer assistance in all 77 counties. Wildfire control is a principal responsibility and the agency provides technical advice on forest management, utilization, and marketing. Special emphases include urban and community forest regeneration and tree improvement. Forestry Services also sells tree and shrub seedlings for conservation and reforestation purposes.
- **Oklahoma Department of Wildlife Conservation** – The primary mission of the ODWC is to protect and manage the state's wildlife resources. Because of the importance of riparian area habitat to many wildlife species, the ODWC has a keen interest in riparian area protection. Like the USFWS, the ODWC is involved with wetland mitigation on federal actions. They are also involved in implementing the North American Waterfowl Management Plan.

- **Oklahoma Water Resources Board** – The OWRB is responsible for at least three programs that affect riparian areas. They are responsible for the development of the state's water quality standards, they coordinate the National Flood Insurance Program, and they administer the management of water rights for both streams and ground water in Oklahoma. The OWRB also serves as the state repository for the USFWS national wetlands inventory maps.
- **Oklahoma Department of Environmental Quality** – The Oklahoma Department of Environmental Quality is responsible for reviewing the U.S. Army Corps of Engineers Section 404 dredge and fill permit applications and providing water quality certification to ensure state water quality standards are not violated. They also maintain copies of the USFWS national wetlands inventory maps.

Incentive Programs

There are several programs that currently offer assistance to landowners interested in protecting riparian areas. These programs are subject to change and additional programs could be added at a later date. Contact the appropriate agency for further information.

Stewardship Incentive Program (SIP) - Oklahoma Department of Agriculture-Forestry Services

Farmers, ranchers, and landowners across Oklahoma who have streamside forests or would like to establish a forested riparian buffer can get assistance from the Forest Stewardship Program. This program is administered by the Oklahoma Department of Agriculture-Forestry Services and is designed to help landowners develop multiple benefits from their forestland through good forest management. The program provides technical assistance and financial incentives and recognizes good forest stewards. Once a management plan is approved, a landowner can apply for financial assistance under the Stewardship Incentive Program (SIP). This program can assist with planting trees, establishing wildlife habitat, and installing fences to protect streamside forests. Through this program, neighbors working together can increase the length of the riparian zone, enhancing the benefit to wildlife across several landowners' properties.

Environmental Quality Incentives Program (EQIP) - USDA

The U.S. Department of Agriculture has a new Environmental Quality Incentives Program (EQIP), which makes long-term conservation contracts and funding available to farmers and ranchers to improve the environmental health of the nation's farm and ranch land. EQIP is USDA's largest conservation program and is designed to conserve and improve land while it remains in agricultural production.

EQIP provides cost-share assistance for up to 75 percent of the cost of certain conservation practices, such as grassed waterways, filter strips, and manure management facilities; capping abandoned wells; and wildlife habitat enhancement.

These incentive payments can be made for up to three years. The intention is to encourage producers to perform conservation-oriented land-use management practices, such as manure management systems, pest management, erosion control, wildlife management, and integrated pest management.

For this program, the total cost-share and incentive payments are limited to $10,000 per person per year and $50,000 for the length of the contract. A contract may run from five to 10 years. Contact your local NRCS office for further details.

Wildlife Habitat Incentives Program (WHIP) - USDA

WHIP offers technical and cost-share assistance to landowners to develop improved wildlife habitat. Under the 1996 Farm Bill, cost-share assistance may pay for up to 75 percent of the cost of installing wildlife habitat development practices on the land. To participate in WHIP, individuals must own or have control of the land being offered. Under the proposed rules, WHIP offers 10-year contracts. The total cost-share amount cannot exceed $10,000 per contract. USDA will work with state and local partners to establish wildlife habitat priorities in each state. Applications will be ranked at the county level and those that provide the greatest wildlife benefits will be funded. Contact your local NRCS office for further information.

Partners For Wildlife (PFW) - USFWS

These funds are available to benefit a broad array of diverse fish and wildlife species and to provide non-consumptive fish and wildlife recreation opportunities.

The purpose of the Partnerships for Wildlife Act is to establish a partnership among the United States Fish and Wildlife Service, the National Fish and Wildlife Foundation, designated state agencies, and private organizations and individuals to preserve and manage nongame fish and wildlife species. Contact your local NRCS, USFWS, or ODWC office for further information about this program.

Conservation Reserve Program - (CRP) - USDA

The CRP is a voluntary approach to improving the environment that utilizes partnerships between individuals and the government. The CRP protects highly erodible and environmentally sensitive lands with grass, trees, and other long-term cover. The 1996 Farm Bill allows for CRP continuous sign-up and provides farmers with the opportunity to enroll land in the program by devoting it to environmentally conscious conservation practices, such as riparian buffers and grassed waterways.

Landowners establish long-term conservation practices on highly erodible land or environmentally sensitive land in exchange for 10 to 15 years of annual rental payments. Cost-share assistance is available for adopting and maintaining these practices.

The contracts between USDA and landowners establish the rental rates and cost-share assistance to be paid over the 10 to 15 years covered by the contracts. Contact your local NRCS office for further information.

Glossary

Aggradation – an increase in the elevation of a streambed or slope due to the deposition of sediment. The opposite of degradation.

Best Management Practices (BMPs) – a collective term used to describe any practice or group of practices that are designed prevent or control nonpoint source pollution. BMPs can be structural in nature (e.g., a riparian buffer) or, alternately, a recommendation for management (e.g., don't spray pesticide on a windy day).

Biodiversity (or biological diversity) – a term that represents the variety of living organisms, their genetic differences, and the communities and ecosystems in which they occur.

Cable and choker – a rig consisting of a winch line (cable) and smaller diameter short line that is attached to logs to winch them to the back of a skidder (a logging vehicle) for transport to a landing (area where logs are stacked).

Cross drain – a drainage channel to get water from the upslope road ditch across the road (e.g., culverts, rolling dips).

Denitrification – a process by which bacteria convert dissolved nitrogen to nitrogen gas. This occurs when there is enough soil moisture and organic matter to create anaerobic conditions.

Ecosystem – the dynamic and interrelating complex of plant and animal communities and their associated physical environment.

Edge species – edge wildlife species live where two different landscape elements meet, such as the interface between a forest edge and a farm field.

Ephemeral stream – generally carries water or flows only for very short periods following precipitation events or snowmelt. Channels may not be clearly defined. Ephemeral stream channels are also referred to as draws, gullies, swales, arroyos, and gulches.

Forest interior species – interior wildlife species require large areas of undisturbed forest to live.

Intermittent stream – generally carries water or flows only during the wet season, which could be for only a few months each year.

Nonpoint source pollution – originates from undefined or diffuse sources such as fields or city streets. NPS pollutants include sediment, pesticides, and fertilizers.

Perennial stream – generally carries water over 90 percent of the time during the year in a well-defined channel.

Raptor – generally refers to owls and the group of birds known as *falconiformes*, which includes hawks, falcons, and vultures.

Rills and gullies – Small channels (rills) and large channels (gullies) formed by erosion.

Riparian – from the Latin "rip" meaning bank. Riparian areas are the geographically delineated areas with distinct resource values that occur adjacent to streams, lakes, ponds, wetlands, and other water bodies. The term "riparian species" refers to native species adapted to live near water.

Scour – Erosion of a channel due to high velocity water flow.

Snag – a freestanding dead or partially dead tree at least 10.2cm dbh (diameter at breast height) and 1.8m tall; important for cavity-nesting birds and mammals.

Species richness – the number of species in a given area.

Turnout – a channel constructed to carry water away from a road and onto the forest floor, commonly used in constructing forest roads.

Toe of bank – the base of a slope. If erosion occurs at this location, the result can be landslides and severe erosion.

References

Belt, G.H., J. O'Laughlin, and T. Merrill. 1992. Design of forest riparian buffer strips for the protection of water quality: Analysis of scientific literature. Report No. 8. Idaho Forest, Wildlife, and Range Policy Analysis Group.

Barclay, J.S. 1978. The effects of channelization on riparian vegetation and wildlife in south central Oklahoma. *In:* R.R. Johnson and J.F. McCormick (Eds.). Proceedings: Strategies for protection and management of floodplains and other riparian ecosystems. Callaway Gardens, Ga. Dec. 11-13. USDA Forest Service. General Technical Report WO-12. 129-138.

Barclay, J.S. 1980. Impact of stream alterations on riparian communities in southcentral Oklahoma. USDI Fish and Wildlife Service. FWS/OBS 80/17. 91p.

Behnke, R. Jard, and R.F. Raleigh. 1978. Grazing and the riparian zone: Impact and management perspectives. *In:* Strategies for protection and management of floodplain wetlands and other riparian ecosystems. USDA Forest Service. General Technical Report WO-12:263-267.

Brabander, J.J., R.E. Masters, and R.M. Short. 1985. Bottomland hardwoods of eastern Oklahoma. U.S. Fish and Wildlife Service, Tulsa, Okla.

Brinson, M.M., B. I. Swift, R.C. Plantico, and J.S. Barclay. 1981. Riparian ecosystems: Their ecology and status. U.S. Fish and Wildlife Service. Biological Services Program. FWS/OBS-81-17. 155p.

Carothers, S.W., R.R. Johnson, and S.W. Aitchison. 1974. Population structure and social organization of southwestern riparian birds. *American Zoology*. 14:97-100.

Castelle, A.J., A.W. Johnson, and C. Conolly. 1994. Wetland and stream buffer size requirement – A review. *J. of Environ. Quality*. 23:878-882.

Chesapeake Bay riparian handbook: A guide for establishing and maintaining riparian forest buffers. "Economics of Riparian Forest Buffers." 1997. Annapolis, Md.

Chescheir, G.M., J.W. Gillian, R.W. Skaggs, and R.G. Broadhead. 1991. Nutrient and sediment removal in forested wetlands receiving pumped agricultural drainage water. *Wetlands.* 11:87-103.

Claire, E.W. 1980. Stream habitat and riparian restoration techniques: Guidelines to consider in their use. *In:* Proceedings of a workshop for design of fish habitat and watershed restoration projects. County Squire, Ore.

Clary, W.P. 1987. Livestock effects on riparian vegetation and adjoining streambank. Forestry Sciences Laboratory. USDA Forest Service. Boise, Idaho. 26p.

Cooper, J.R., J.W. Gillam, and T.C. Jacobs. 1986. Riparian areas as a control of nonpoint pollutants. Watershed Research Perspectives. D.C. Correll (Ed.). Smithsonian Institute Press. Washington, D.C. 166-190.

Dickson, J.G., and M.L. Warren. 1993. Wildlife and fish communities of eastern riparian forests. *In:* Functions, values and management: Proceedings of riparian ecosystems in the humid U.S. March 15-18. Atlanta, Ga. National Association of Conservation Districts, Washington D.C. 1-31.

Dillaha, T.A., et al. 1986. Use of vegetated filter strips to minimize sediment and phosphorus losses from feedlots. Virginia Water Resources Research Center Bulletin 151. Blacksburg, Virginia.

Dillaha, T.A., R.B. Reneaux, S. Mostaghimi, and D. Lee. 1989. Vegetative filter strips for agricultural nonpoint source pollution control. *Transactions ASAE.* 32:513-519.

Elmore W., and R.L. Beschta. 1989. The fallacy of structures and the fortitude of vegetation. USDA Forest Service General Technical Report PSW-110. 116-119.

Elmore, W. 1992. Riparian responses to grazing practices. *In:* Watershed management: Balancing sustainability and environmental change. R.J. Naiman (Ed.). New York: Springer-Verlag, Inc. 442-457.

Forman, R. T. T. 1983. Corridors in a landscape: Their ecological structure and function. *Ekologia* (CSSR) 2:375-387.

Geier, A.R., and L.B Best. 1980. Habitat selection by small mammals of riparian communities: Evaluating effects of habitat alterations. *J. Wildlife Management.* 44(1):16-24.

Iowa State Agroforestry Research Team. 1994. Design and establishment of a multi-species riparian buffer strip.

Karr, J.R., and I.J. Schlosser. 1978. Water Resources and the Land Water Interface. *Science*. 201:229-224.

Karr, J.R., and I.J. Schlosser. 1977. Impact of near-stream vegetation and stream morphology on water quality and stream biota. U.S. Environmental Protection Agency Report 600/3-77-097.

Kauffman, J.B., and W.C. Krueger. 1984. Livestock impacts on riparian ecosystems and streamside management implications–A review. *J. of Range Management.* 37:430-438.

Keown, M.P. 1983. Streambank protection guidelines for landowners and local governments. U.S. Army Engineer Waterways Experiment Station. Vicksburg, Miss. 49p.

Keunzler, Edward J. 1988. Value of forested wetlands as filters for sediment and nutrients. The forested wetlands of the southern United States: Proceedings of the symposium: Orlando, Fla. July 12-14.

Little, E.L. 1985. Forest Trees of Oklahoma. Oklahoma Forestry Division, State Department of Agriculture. Oklahoma City, Oklahoma. 142p.

Lowrance L., R. Leonard, and J. Sheridan. 1985. Managing riparian ecosystems to control nonpoint source pollution. *J. of Soil and Water Conservation.* 40:87-91.

Miranowski, J.A., and R.L. Bender. 1982. Impact of erosion control policies on wildlife habitat on private lands. *J. Soil and Water Conservation*. 37(5):288-291.

Montana State University Extension Service. 1991. Montana forestry best management practices: Forest stewardship guidelines for water quality. EB0096.

Nieswand, G.H., R.M. Hordon, T.B. Shelton, B.B. Chavooshian, and S. Blarr. 1990. Buffer strips to protect water supply reservoirs: A model and recommendations. *Water Res. Bull.* 26:959-966.

Nutrient Subcommittee of the Chesapeake Bay Program. 1995. Water quality functions of riparian forest buffer systems in the Chesapeake Bay watershed. Chesapeake Bay Program Technology Transfer Report. U.S. Environmental Protection Agency. EPA 903-R-95-004. 67p.

Oklahoma Biodiversity Task Force. 1996. Oklahoma's biodiversity plan: A shared vision for conserving our natural heritage. Norman Murray (Ed.). Oklahoma Department of Wildlife Conservation, Oklahoma City, Okla.

Oklahoma Department of Agriculture-Forestry Services. 1995. Bareroot seedlings and species descriptions and uses. 2p.

Osborne, L.L., and D.A. Kovacic. 1993. Riparian vegetated buffer strips in water quality restoration and stream management. *Freshwater Biology.* 29:243-258.

Palone, Roxane S., and Albert H. Todd. 1997. "Economics of Riparian Forest Buffers." Chesapeake Bay riparian handbook: A guide for establishing and maintaining riparian forest buffers. Annapolis, Md.

Peterjohn, W.T., and D.L. Correll. 1984. Nutrient dynamics in an agricultural watershed: Observations on the role of a riparian forest. *Ecology.* 65:1466-1475.

Pfankuch, D.J. 1978. Stream reach inventory and channel stability evaluation: A watershed management procedure. Unpublished Report. USDA Forest Service, Northern Region. 25p.

Phillips, J.D. 1989a. An Evaluation of the factors determining the effectiveness of water quality buffer zones. *J. Hydrology.* 107:133-145.

Phillips, J.D. 1989b. Nonpoint source pollution control effectiveness of riparian forests along a Coastal Plain river. *J. Hydrology.* 110:221-237.

Platts, W.S. 1981. Effects of livestock grazing. USDA Forest Service. General Technical Report PNW-124. 25p.

Platts, W.S., and R.F. Raleigh. 1984. Impacts of grazing on wetlands and riparian habitat. *In:* Developing strategies for rangeland management. Boulder, Colo. Westview Press. 1105-1117.

Platts, W.S., C. Armour, C.G. Booth, et al. 1987. Methods for evaluating riparian habitats with applications to management. USDA Forest Service General Technical Report INT-221. Ogden, Utah. 177p.

Rinne, J. N., and T. Tharlson. 1986. Effects of domestic livestock grazing on mountain streams: Aquatic macroinvertebrates. Proceedings of the Western Association of Fish and Wildlife Agencies 65:91-98.

Rosgen, D.L. 1996. *Applied River Morphology*. Wildand Hydrology. Pagosa Springs, Colo. 343p.

Rudolph, D.C., and J.G. Dickson. 1990. Streamside zone width and amphibian and reptile abundance. *The Southwest Naturalist.* 35(4):472-476.

Skovlen, J.M. 1984. Impacts for grazing on wetlands and riparian habitat: A review of our knowledge. *In:* Developing strategies for rangeland management. Boulder, Colo. Westview Press. 1001-1103.

Stevens, L., B.T. Brown, J.M. Simpon, and R.R. Johnson. 1977. The importance, preservation and management of riparian habitat. USDA Forest Service General Technical Report RM-43:156-164.

Stinnett, D.P., R.D. Smith, and S.W. Conrady. 1987. Riparian Areas of Western Oklahoma. U.S. Fish and Wildlife Service, Tulsa, Okla.

Tubbs, A.A. 1980. Riparian bird communities of the Great Plains. *In:* Workshop proceedings–Management of western forests and grasslands for nongame birds. USDA Forest Service General Technical Report INT-86. 403-418.

Trimble, G.R., Jr., and R.S. Sartz. 1957. How far from a streambank should a logging road be located? *J. Forestry.* 55:339-341.

United States Department of Agriculture Soil Conservation Service. 1988. Filter Strip Specification 393-1. Field Office Technical Guide. Raleigh, N.C.

United States Department of Agriculture Soil Conservation Service a. South National Technical Center Interim Standard for Riparian Forest Buffers.

United States Department of Agriculture Soil Conservation Service b. Northeast National Technical Center Interim Standard for Riparian Forest Buffers.

United States Department of Agriculture, Natural Resources Conservation Service. 1995. Riparian forest buffer, conservation practice standard.

United States Department of Interior Bureau of Land Management. 1993. Riparian area management: Process for assessing proper functioning condition. USDI-BLM Tech. Ref. 1737-9.

U.S. Forest Service. 1969. Wildlife Habitat Improvement Handbook. FSH2609.11. U.S. Government Printing Office. Washington, D.C.

Welsch, D.J. 1991. Riparian Forest Buffers: Function and Design for Protection and Enhancement of Water Resources. USDA-FS. Northeastern Area. Radnor, Penn. NA-PR-07-91.

Xiang, W. 1993. A GIS method for riparian water quality buffer generation. *Int. J. Geographical Information Systems.* 7:57-70.

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