WF-010
AUGUST 2014

TEXAS A&M UNIVERSITY

Riparian Restoration on Farms and Ranches in Texas

Texas A&M AgriLife Extension
USDA United States Department of Agriculture
Texas Water Resources Institute
make every drop count

Photo by Blake Alldredge, Texas A&M AgriLife Extension Service.

The state of Texas has 191,000 miles of natural waterways with riparian areas—the green vegetation zones along streams, rivers and lakes—that collectively provide great economic, social, cultural and environmental value to the state.

Cover: Nelson Creek in Walker County. Photo by the Texas A&M Institute of Renewable Natural Resources.

Riparian Restoration on Farms and Ranches in Texas

Introduction

The state of Texas has 191,000 miles of natural waterways with riparian areas—the green vegetation zones along streams, rivers and lakes—that collectively provide great economic, social, cultural and environmental value to the state. These systems are the key connection between the upland grasslands and forests and the rivers and streams which are the lifeblood of the state providing water for urban and rural citizens. The main function of a river or creek is to transport water and sediment downstream. Riparian ecosystems play an important role in providing water for Texans today and in the future.

Healthy riparian areas ensure water for a variety of needs; however, those areas compromised by poor management of agricultural, industrial, commercial and residential activities result in significant direct and indirect impacts to water resources and the species which depend on them. The purpose of this publication is to describe the benefits of riparian areas and how they can be managed for better agricultural and wildlife production. Management described herein will focus on the Blackland Prairie and Post Oak Savannah ecoregions of central and eastern Texas, which cover most of the Middle Trinity River basin (Box 1). The recommendations given here should be viewed as a starting point for landowners who can then adapt the management plan to fit their specific property.

Box 1. Blackland Prairie and Post Oak Savannah Ecoregions

The gently rolling Blackland Prairie is named for the deep, fertile, black soils that once supported a vast area of native tallgrass prairie species such as little bluestem, big bluestem, switchgrass, sideoats grama, and indiangrass. The vast majority of this ecoregion has been replaced by crop farming, pastureland and cities. The Blackland Prairie covers 11,500,000 acres in bands running northeast to south in north central and central Texas, and is the southernmost extension of the true prairies that run from Canada to Texas.

The Post Oak Savannah contains patches of oak woodland within grasslands and is a transition zone between the tallgrass communities of the Blackland Prairie to the west and the pine forests of the Pineywoods to the east. This ecoregion covers approximately 12,500,000 acres and consists of gently rolling to hilly terrain. Dominant vegetation within the Post Oak Savannah includes oaks and hickories, with tallgrass species such as little bluestem, indiangrass, brownseed paspalum and switchgrass. Bottomland soils are clay to sandy loam, and upland soils are sandy loam to sand.

What is a Riparian Area?

Riparian areas are the transitional zones regularly influenced by fresh water, normally extending from the edges of waterbodies to the edges of upland communities (Naiman et al. 2005). Riparian habitats reflect interactions between aquatic and terrestrial components of a landscape, and are where hydrology, vegetation and soils come together on a stream to influence physical function. These functions include: dissipation of stream energy, stabilization of banks, trapping of sediment, building and enlarging of floodplains, storage of floodwater, recharge of groundwater, and sustenance of base flows. Proper functioning riparian areas are in a state of balance, or dynamic equilibrium. A stream can become out of equilibrium when the amount of water, sediment and vegetation is changed due to natural or man-made disturbances.

Riparian corridors are ecosystems that extend from both sides of a stream or river that serve as important habitat for many plants and animals. The easiest way to identify a riparian area is to know how high a normal flood reaches, and then to evaluate the differences in plant species found in the area. Plants that can tolerate and thrive in periodically flooded riparian areas will differ from those that cannot handle the stress of prolonged floodwater. Greater elevation and changes in soil profiles and plant species adapted to living in drier conditions mark the edges of upland areas.

Figure 1. If not managed properly, cattle traffic can lead to erosion of streambanks (left) and deposition of fecal matter in waterways (right). Photos by Blake Alldredge and Mark Tyson, Texas A&M AgriLife Extension Service.

What happens on the land is reflected in our creeks, which places a high level of stewardship responsibility on landowners. Society depends on many ecosystem services provided by riparian areas. Ecosystem services are the benefits that people obtain from the environment. Sometimes these are taken for granted and poor management will compromise ecosystem services, whereas sound management will enhance them. Properly functioning riparian areas are excellent buffer zones that provide ecosystem services such as:

- High quality habitat for both aquatic and terrestrial species
- Dissipation of flood energy and reduced downstream flood intensity and frequency
- Higher, longer-lasting and less variable baseflow between storm events
- Deposition of sediment in the floodplain, stabilizing it and maintaining downstream reservoir capacity longer
- Use and filtering of debris and nutrients to improve water quality and dissolved oxygen levels in the aquatic system
- Shade over streams from riparian vegetation canopies reduce temperatures, providing lasting habitat and a food base for aquatic and riparian animals
- Fewer exotic undesirable plant species
- Higher biodiversity than terrestrial uplands
- Stable banks, which reduce erosion and protect ownership boundaries
- Increased economic value through wildlife, livestock, timber and recreational enterprises
- Improved rural land aesthetics and real estate values

Management of the land, streams, and riparian zones affects not only individual landowners, but also livestock, wildlife, aquatic life and everyone downstream. By understanding the processes, key indicators, and impacts of disturbances (activities that hinder recovery), landowners and other citizen-stakeholders can evaluate these systems and improve their management to produce healthy stream conditions.

Grazing Impacts on Streams and Riparian Areas

In central and east Texas, several land use practices affect the condition of riparian areas, including livestock production, row crop farming, timber production, urbanization and oil and gas development. Cattle production is the primary agricultural activity in Texas and will be given the most attention in this publication. Cattle are naturally attracted to riparian areas due to the greater availability of water, shade, high quality forage and protection from harsh weather. Cattle can have significant impacts on riparian areas and stream systems if poorly managed. Some negative influences include:

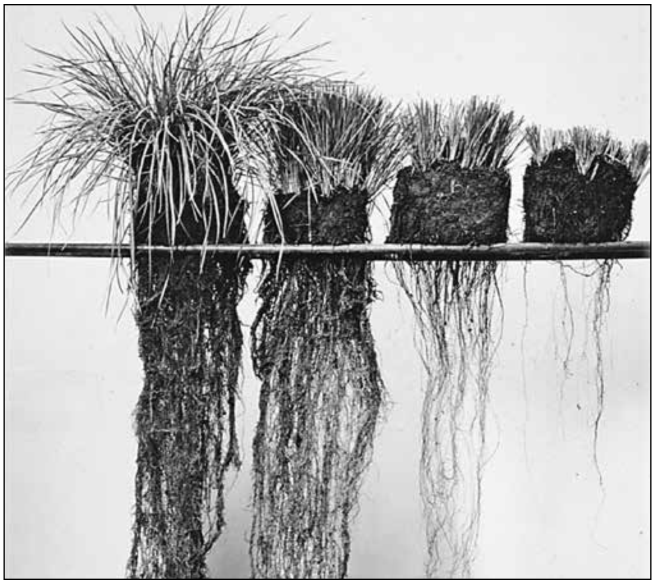

Figure 2. As grazing pressure increased, root biomass decreased. The second plant from left has 50% of the top growth removed with little effect on roots. An increase in grazing pressure results in dramatic loss of root development as seen in both plants on the right. From Crider (1955).

- Overgrazing that leads to a reduction in plant cover and vigor, and alteration of species composition and diversity (Kauffman and Krueger, 1984);
- Trampling of banks that results in accelerated stream bank erosion (Figure 1a);
- Soil compaction from livestock traffic that increases runoff and decreases infiltration and water available to plants; and
- Deposition of fecal matter in the stream leading to high levels of bacteria (Figure 1b; Wagner et al. 2013).

Overgrazing of riparian vegetation and plowing too close to the stream can affect bank stability because the removal of above-ground plant growth results in a decrease in root biomass, which physically binds the soil together and makes the soil up to 20,000 times more resistant to erosion (Figure 2; Crider, 1955; Thurow, 1991; Abernethy and Rutherford, 1998). Without the roots to hold soil in place, stream banks become vulnerable to erosion during flooding events. Overgrazing by cattle in the uplands can also impact riparian areas and streams, as decreased infiltration of rainfall into the ground results in greater volumes of runoff in streams and places additional pressure on the stream banks (Figure 3; Thurow, Blackburn, and Taylor, 1986; 1988). Riparian vegetation functions to slow down the overland flow and capture sediment, nutrients, and other pollutants and organic matter, and allow for increased infiltration in the flood plain/riparian area. Higher levels of runoff increase the chances for pesticides, fertilizers, and fecal matter to reach streams and worsen water quality.

Overgrazing and trampling by cattle in riparian areas and plowing of land to the bank edge for farming leaves very little or no vegetation, resulting in stream banks being more susceptible to incision and/or widening of the stream (Figure 4; Zygo, 1997). As a stream incises, it may become disconnected from its floodplain and thus flood the riparian area less frequently or not at all, greatly affecting the ability for water to infiltrate and deposit sediment and nutrients. This results in a loss of forage production, wildlife habitat and recreational value. In-stream habitat for fish and other aquatic species is also lost as these creeks downcut and widen. In addition, landowners may suffer as more and more land erodes and falls into the stream, ultimately causing acreage loss and affecting their property value and future economic opportunities.

Figure 3. Overgrazing in upland areas leads to less infiltration and greater runoff and erosion. Photo by Mark Tyson, Texas A&M AgriLife Extension Service.

Clean Water Act 303(d) List

As part of the Clean Water Act (CWA) that was passed in 1972 by the United States Congress, states must ensure that their streams and lakes meet their designated use and established water quality standards for that use. Examples of designated uses

Figure 4. Allowing livestock to overgraze riparian areas and trample banks is detrimental to bank stability and water quality. Proper grazing management improves both. Photo by Blake Alldredge, Texas A&M AgriLife Extension Service.

include public water supply, contact and non-contact recreation and aquatic life uses. Every two years, the Texas Commission on Environmental Quality (TCEQ) conducts a water quality inventory to evaluate the water quality in streams and lakes around the state. If a particular water source does not meet its designated use due to high pollutant levels, that waterbody is impaired and placed on the CWA 303(d) list. Once placed on this list, the state must take action to have that waterbody remediated and removed from the list within 13 years.

Excessive levels of bacteria are the leading cause of impairments in Texas, and livestock can be a significant source of bacteria, particularly in areas where livestock have direct access to waterbodies (Wagner et al. 2013). In addition, sediment and nutrients are significant pollutants in Texas, which can contribute to eutrophication problems and loss of aquatic habitats, as well as decreased aesthetic and recreational value. Proper management can help alleviate water impairments.

Poor management leads to high sediment loads carried by streams that reduce water storage capacity in reservoirs where the sediment is deposited. Studies have shown that poorly managed stream banks can account for as much as 85% of the sediment contributed in a watershed (Figure 5; Wynn and Mostaghimi, 2006). The Texas Water Development Board (2009) calculated that the Richland-Chambers Reservoir in Navarro County loses 2,065 acre-feet of water capacity every year for a total loss of 43,361 acre-feet in the 20-year period since 1987, when it was impounded. Consequently, enough sediment has accumulated during that 20-year period to cover the bottom of the 43,384-acre reservoir to an average depth of one foot (Figure 6). Texas A&M University researchers estimate that 84% of the sediment reaching the reservoir every year is from channel and stream bank erosion (Wang et al. 2010).

In Texas as a whole, it is estimated that major reservoirs lose 90,000 acre-feet of water storage capacity every year due to sedimentation, which is roughly equal to the amount of water that 180,000 families use in one year (TWDB, 2007). At this rate, the Texas Water Development Board (TWDB) estimates that by 2060, approximately 4.5 million acre-feet of reservoir capacity will be lost due to sedimentation, which is more than the capacity that would be gained through the construction of new major reservoirs (TWDB, 2007). The TWDB reported that dredging costs twice as much or more than constructing a new reservoir, making it impractical in many cases (TWDB, 2005). Therefore, focusing management efforts on quality land management to

Figure 5. Poor riparian management has led to extreme downcutting in this creek. For reference, the block of soil closest to the camera is the size of a refrigerator. Photo by Kenneth Mayben, Natural Resources Conservation Service.

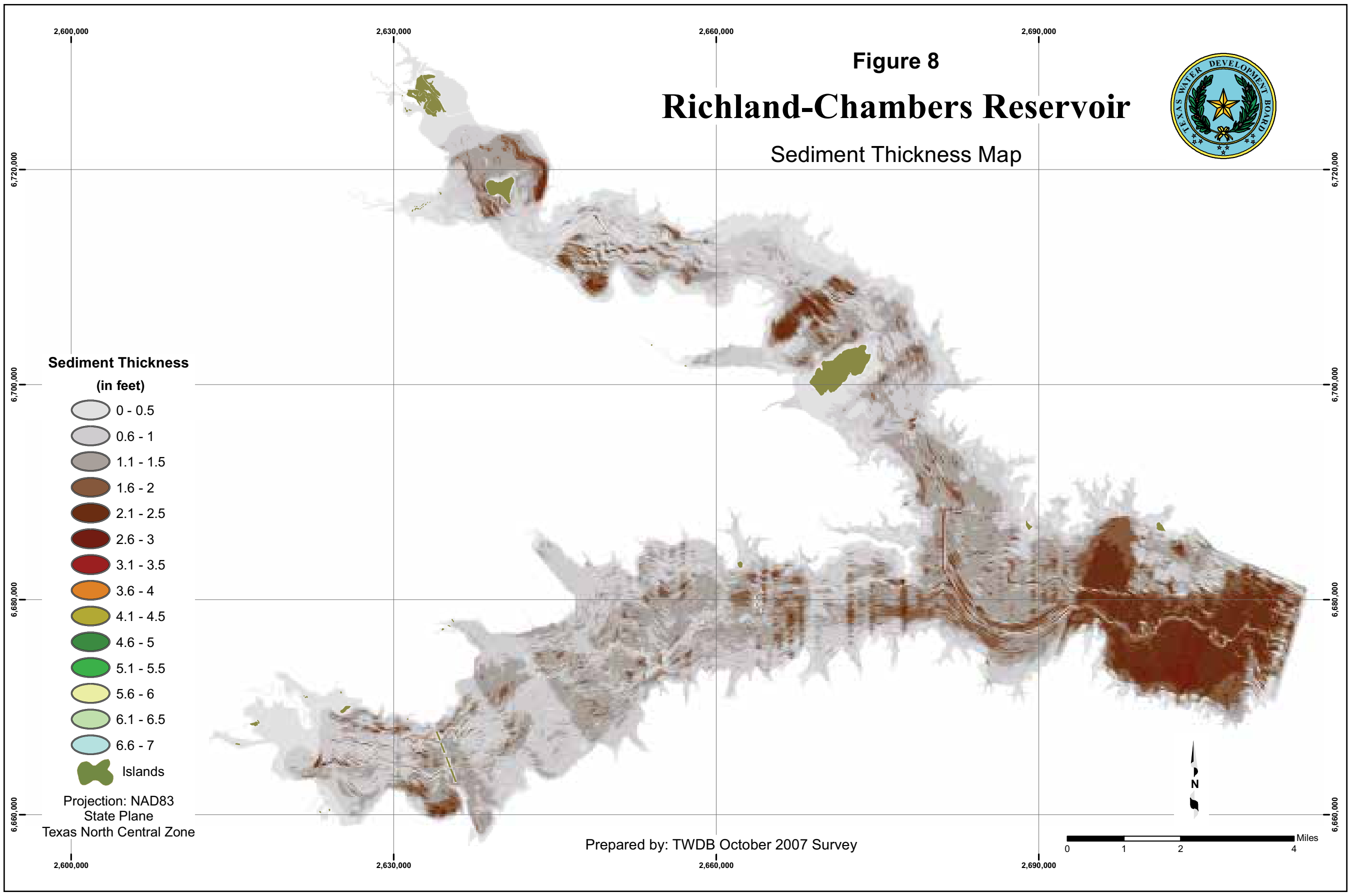

Figure 6. Eroded sediment is reducing water storage capacity in the Richland-Chambers Reservoir. From Texas Water Development Board (2009).

stabilize stream banks and riparian areas may be one of the most cost effective strategies for extending the operational life of the state's water supply reservoirs.

A riparian buffer is defined as a vegetated strip lying between agricultural land and a neighboring watercourse (Figure 7; Collins et al. 2009). Studies indicate that riparian buffers are an effective best management practice (BMP) for reducing nonpoint source pollution (NPS) in agricultural areas. These buffers and other agricultural BMPs can help prevent and/or minimize the effects of NPS by reducing erosion and pollutant loads that would otherwise reach the stream. In some cases, riparian buffers of only 32 feet in width can reduce phosphorus levels up to 95% (Vought et al. 1995), and nitrate levels up to 80% on row crop fields (Schultz et al. 1995). In addition, buffers as narrow as 20 feet can prevent up to 95% of the sediment eroded from uplands from reaching streams (Collins et al. 2009). Likewise, riparian buffers can benefit wildlife populations by providing corridors that connect habitats and allow safe movement between fragmented patches of natural areas (Lovell and Sullivan, 2006). Implementing BMPs on the land can improve profitability and sustainability of agricultural activities and increase property values, all while improving water quality.

Figure 7. Riparian buffers protect creeks by reducing water velocities and capturing sediment from croplands. Photo courtesy of USDA – Natural Resources Conservation Service.

Restoration of Riparian Areas

Before beginning a restoration project, it is important to identify existing problems and determine how current management practices might be altering or hindering the natural recovery of riparian areas. After completing this initial evaluation, a restoration plan that identifies the goals and objectives of the landowner, a course of action, and evaluation through monitoring should be developed (Naiman et al. 2005). Landowners can benefit from the expertise of Texas A&M AgriLife Extension Service, Texas A&M Forest Service, the U.S. Department of Agriculture - Natural Resources Conservation Service (NRCS) and Texas Parks and Wildlife Department (TPWD) personnel (hereafter natural resource professionals) when developing restoration plans.

Establishing goals is vital when restoring and managing riparian areas, as cattle production, wildlife habitat, stream bank stabilization and water quality could call for different actions. Knowing how these areas will be utilized will help identify what will be needed for restoration and management activities (cross fencing, prescribed grazing, alternative water sources, etc.) to maintain a productive riparian area in the future. Measureable indicators should be included in the restoration plan to help evaluate the project's success and guide monitoring activities, such as measuring the stubble height of riparian plants and conducting photo points. A budget for time and money are needed beforehand to determine how much can be spent on a project so that landowners can prioritize the restoration activities.

Economics

Some landowners may be reluctant to restore riparian areas because they feel that it is a lost opportunity cost, particularly for row crop production. A short-term loss of revenue could occur when land is taken out of crop production and replaced with a riparian buffer, but long-term benefits such as improved water quality, more pounds of forage grown or better wildlife habitat may outweigh those costs. Keep in mind that riparian buffers, which may only occupy a small area, can protect acres of land that are threatened by erosion (Brauman et al. 2007). Loss of acreage due to erosion directly impacts property value and reduces water quality – neither of which is desirable.

Landowners could pursue other economic opportunities after restoring riparian areas, including nature tourism (wildlife photography, bird watching, etc.), wildlife hunting and grazing. Landowners can work with a land trust or other organization to establish a conservation easement for the riparian area to ensure its protection from future development. In addition, landowners could earn revenue by selling stream mitigation credits to various groups by creating a stream mitigation bank. Stream and wetland mitigation banks are managed by the U.S. Army Corps of Engineers as part of the Clean Water Act section 404. Contact your local natural resource professionals to learn about these opportunities in your area.

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Because restoring native prairie plants may cost from $100 to $200 per acre, some landowners can take advantage of state and federal incentive programs aimed at reducing erosion and promoting wildlife habitat by re-establishing native riparian herbaceous and/or forested buffers. These programs include the Pastures for Upland Birds and Landowner Incentive Program (Texas Parks and Wildlife Department), and federal resources such as Partners for Fish and Wildlife (U.S. Fish and Wildlife Service), Conservation Reserve Program and Continuous Conservation Reserve Program (U.S. Department of Agriculture - Farm Service Agency), and Conservation Stewardship Program and Environmental Quality Incentive Program (NRCS).

Site Evaluation for Streams in the Blackland Prairie and Post Oak Savannah

The first step is to assess the condition of riparian areas on your property and what actions need to be taken. Determining what may be hindering the stream from functioning properly and why there may not be adequate vegetation is the first step. One example of a hindrance is overgrazing; therefore, rotationally grazing the riparian area for short periods of time may be the easiest way to recover this riparian area. Healthy riparian areas will be necessary along the entire length of the creek, river or wetland to protect banks from erosion. Identify if there has been a change in the amount of water, sediment or type of vegetation that may have the stream out of balance because of too much or too little of each. The stream will readjust itself to compensate for these changes and establish a new equilibrium. Land experiencing erosion due to an increase or decrease in the amount of water and sediment and a loss of vegetative cover is at greater risk of being lost and warrants special attention. This is due to the tendency of water to move in a channelized path instead of uniform sheet flow that is spread out across the landscape (Polyakov, Fares and Ryder, 2005). These areas of concern need to be identified early in the planning process. Examples include active headcuts, gullies, high slopes and areas downhill of land use activities that will contribute greater amounts of water and sediment (Figure 8). These areas will need a wider buffer to compensate for the greater amounts of water and sediment and to protect the stream bank from erosion. A Visual Assessment Checklist is provided in Appendix A to help evaluate streams and riparian areas.

It is also important to determine soil types on the land since the sediment trapping potential of a riparian buffer is related to particle size and smaller particles, such as the clay dominated soils of the Blackland Prairie, are harder to catch (Polyakov, Fares, and Ryder, 2005). Soil maps can be attained at no cost through the Natural Resource Conservation Service either by visiting the local service center or online at the Web Soil Survey website at <http://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm>. Matching the width of buffers to the soil and slope of the landscape is key to improving buffer effectiveness. Soils in the riparian areas of the Blackland Prairie and Post Oak Savannah ecoregions of the Middle Trinity River basin are cohesive, meaning they are more erosion-resistant since the soil has high clay content. These soils are less vulnerable to the direct pressure of water flow than soils dominated by sand or gravel, but will be affected more by repeated wetting and drying cycles during and after high flow events (Abernethy and Rutherford, 1998; Couper, 2003; Wynn et al. 2004; Wynn and Mostaghimi, 2006). Capello (2008) found that these cycles caused tension cracks in the soil that reduced the structural strength of the stream bank, making them more susceptible to erosion during floods for streams in the Cedar Creek Reservoir watershed in Kaufman, Van Zandt and Henderson counties. Here, stream banks typically erode in mass failure events as aggregates (blocks of soil) fall into the stream rather than individual soil particles being slowly eroded away (Abernethy and Rutherford, 1998; Wynn and Mostaghimi, 2006). A complete cover of riparian vegetation will mitigate the effects of the wetting

Figure 8. Active headcuts (left) and gullies (right) are a sign of active erosion and should be given special attention during planning. Photos by Blake Alldredge, Texas A&M AgriLife Extension Service.

and drying cycles as roots bind soil together to resist cracking, and grass and leaf litter will reduce drying from evaporation (Abernethy and Rutherford, 1998).

Species Selection

Healthy streams should access the floodplain every one to two years to maintain the shallow water table and deposit sediment and nutrients. Incision or widening can lower baseflow and cause streams to disconnect from the floodplain allowing it to "dry out" and no longer support water-loving plants, thereby transitioning to plants adapted to living in drier upland systems. It is important to inventory the current species and identify if they are wetland or upland species (Table 1). In some cases, where the water table has become disconnected the species selection may need to reflect that change during the planning process and utilize upland species when necessary to keep vegetative cover until those processes start to recover and riparian or water-loving vegetation can re-establish itself in the future (Stringham and Repp, 2010).

Healthy streams should access the floodplain every one to two years to maintain the shallow water table and deposit sediment and nutrients.

In general, native trees, shrubs, grasses and forbs of varying ages should all be present in a riparian area. Plant species selection is very important not only from a stream bank protection standpoint, but from a land operation perspective as well. When deciding which species to use, be sure to match the attributes of that species to how the riparian area will be utilized (Table 2). For example, if you want to provide forage for cattle, select native perennial grasses that are highly palatable and nutritious for cattle, such as switchgrass and indiangrass. Plant choice can be tailored to specific tasks such as stabilizing an eroding stream bank. Here, select plants that possess greater rooting depth and root area that provides strength to stabilize and hold the stream bank. For example, deer grass has 7.2 miles of roots per cubic foot, knotgrass has 18.8 miles of roots per cubic foot and spikerush has 22 miles of roots per cubic foot that equates to 67 feet of roots per cubic inch.

Table 1. Indicator categories for plant species and the percentage of time they occur in wetlands.

Indicator	Wetland Occurrence
Obligate (OBL)	>99%
Facultative Wetland (FACW)	66-99%
Facultative (FAC)	33-66%
Facultative Upland (FACU)	1-33%
Upland (UPL)	<1%

There has been debate as to whether trees or grasses are better for stabilizing stream banks and riparian areas (Lyons, Trimble, and Paine, 2000). Historically in prairie ecosystems such as the Blackland Prairie and Post Oak Savannah, the dominant riparian vegetation was likely grasses and forbs with a few trees along most small streams; nowadays, with wider and deeper channels resulting from degradation, trees are needed to help stabilize banks (Lyons, Trimble, and Paine, 2000). Therefore, a combination of trees, shrubs, grasses and forbs of varying ages are recommended for riparian areas to increase the physical structure (root mass) to stabilize stream banks and improve water quality. Trees and shrubs have larger diameter roots and deeper root systems that can provide significant strength for the stream bank, while the above ground parts of grasses and forbs can slow rainfall runoff and catch sediment from the uplands, protect the soil surface from eroding and provide forage for cattle. Restoring native riparian plants and allowing trees to establish naturally over time may be the best approach for landowners on a tight budget.

Clay soils have greater water holding capacity (Wynn and Mostaghimi, 2005) that can benefit forage production, but with the increased risk of erosion, it is essential to incorporate trees into your riparian restoration project. Tree roots not only enhance bank strength and reduce mass failure by physically binding the soil, but trees are better at mitigating the effects of wetting and drying cycles by pulling water up through the roots from greater depths and transpiring more water than grasses. This results in drier soils and lowers the erosion potential for mass failure (Abernethy and Rutherford, 1998; Lyons, Trimble, and Paine, 2000). For example, Whitted (1997) found that along Mill Creek in Ellis and Navarro counties, soil moisture was lowest under trees due to greater evapotranspiration, and that vegetation was found

Table 2. Attributes for recommended species for riparian restoration. 'X' indicates the species has that attribute. Obligate (OBL), Facultative Wetland (FACW), Facultative (FAC), Facultative Upland (FACU), and Upland (UPL).

Grasses	Bank Stabilization	Livestock Forage	Wildlife (food and/or cover)	Timber	Pollinator Value	Wetland Indicator
Indiangrass	X[1]	X[2]	X[2]			FACU
Switchgrass	X[1]	X[2]	X[2]			FAC
Eastern Gamagrass	X[1]	X[2]	X[2]			FAC
Big Bluestem	X[1]	X[2]	X[2]			FAC
Bushy Bluestem	X[1]					FACW
Little Bluestem		X[2]	X[2]			FACU
Texas Wintergrass		X[2]	X[2]			UPL
Side-Oats Grama	X[3]	X[2]	X[2]			
Broomsedge Bluestem		X[3]	X[2]			FAC
Virginia Wildrye	X[1]	X[2]	X[2]			FAC
Barnyardgrass	X[1]	X[2]	X[2]			FACW
Silver Bluestem		X[2]	X[2]			UPL
Florida Paspalum		X[2]	X[2]			FACW
Broad-Leaf Woodoats	X[1]	X[3]	X[2]			FAC
Southwestern Bristlegrass	X[1]		X[2]			UPL
Forbs	**Bank Stabilization**	**Livestock Forage**	**Wildlife (food and/or cover)**	**Timber**	**Pollinator Value**	**Wetland Indicator**
Illinois Bundleflower		X	X[3]		X[3]	FACU
Maximilian Sunflower	X[1]	X[3]	X[3]		X[3]	FACU
Purple Prairie Clover		X	X[3]		X[3]	UPL
Western Ragweed			X			UPL
Spiny Aster	X[1]					FACW
Goldenrod	X[1]				X[3]	FACU
Engelmann's Daisy	X[3]	X[3]	X[3]		X[3]	UPL
Shrubs	**Bank Stabilization**	**Livestock Forage**	**Wildlife (food and/or cover)**	**Timber**	**Pollinator Value**	**Wetland Indicator**
Buttonbush	X[1]		X[3]		X[3]	OBL
False Indigo Bush	X[1]				X[3]	OBL
American Beautyberry		X[3]	X[3]		X[3]	FACU
Flowering Dogwood	X[1]		X[3]		X	FAC
Rusty Blackhaw	X[1]		X[4]		X	FACU
Trees	**Bank Stabilization**	**Livestock Forage**	**Wildlife (food and/or cover)**	**Timber**	**Pollinator Value**	**Wetland Indicator**
Southern Red Oak	X[1]			X[3]		FACU
Water Oak	X[1]			X[3]		FAC
Live Oak	X[1]		X[3]			FACU
Bur Oak	X[1,3]		X[3]	X[3]		FAC
Overcup Oak	X[1]		X[3]			OBL
Sycamore	X[1]			X[3]		FAC
Pecan	X[1]		X[3]	X[3]		FAC
Black Willow	X[1]		X[3]	X[3]		FACW
Sugarberry	X[4]	X	X[3,4]	X[3]		FAC
Cedar Elm	X[1]	X	X	X[3]		FAC
American Elm	X[1]	X	X[4]	X[4]		FAC
Winged Elm	X[1]	X	X[4]	X[3]		FACU
Sweet Gum	X[1]		X[3]	X[3]		FAC
Box Elder	X[1]		X[3]			FACW
Black Walnut	X[1]		X[4]	X[4]		FACU
Eastern Cottonwood	X[1]		X[3,4]	X[4]		FAC
Possumhaw Holly	X[1]		X[4]			FACW
Green Ash	X[1]		X[4]	X[4]		FACW

[1] Linex, R. Common Plants of Riparian Areas – North Central Texas. U.S. Dept of Agriculture-Natural Resources Conservation Service.
[2] Shaw, R. 2012. Guide to Texas Grasses. Texas A&M University Press, College Station, Texas.
[3] U.S. Dept of Agriculture-Natural Resources Conservation Service. 2014. The PLANTS Database. Accessed 04/23/2014. http://plants.usda.gov/java/
[4] Cox, P.W., and P. Leslie. Texas Trees: A Friendly Guide. Corona Publishing Company, San Antonio, Texas.

to increase channel stability in three primary ways: mechanical reinforcement due to tree root tensile strength, decreased moisture content resulting from evapotranspiration of soil moisture through tree leaves, and bank armoring against channel scour by exposed tree roots (Figure 9).

Trees provide water quality benefits by shading the water, which lowers water temperature, and contributing large woody debris that acts as in-stream habitat (Lyons, Trimble, and Paine, 2000). When selecting trees or allowing tree regrowth, goals for the riparian area will influence which tree species should be present. For example, Whitted (1997) found that sugar hackberry offered greater root cohesion than American elm in the Mill Creek watershed in Ellis and Navarro counties. Several factors influence tree species value to the riparian area, such as stability from root systems, timber production, and wildlife value. Consult with your local Texas A&M Forest Service expert to determine which trees are right for you.

In situations where severe erosion has resulted in high, unstable banks, planting trees along the bank may worsen the condition, as the additional weight can lead to accelerated bank erosion (Figure 10; Oklahoma Cooperative Extension Service, 1998). Since the stream is unstable, it will require time to heal and reestablish equilibrium once the cause of the problem

Figure 9. Tree roots armor this bank and help to reduce erosion by protecting the soil from water flow. Photo by Blake Alldredge, Texas A&M AgriLife Extension Service.

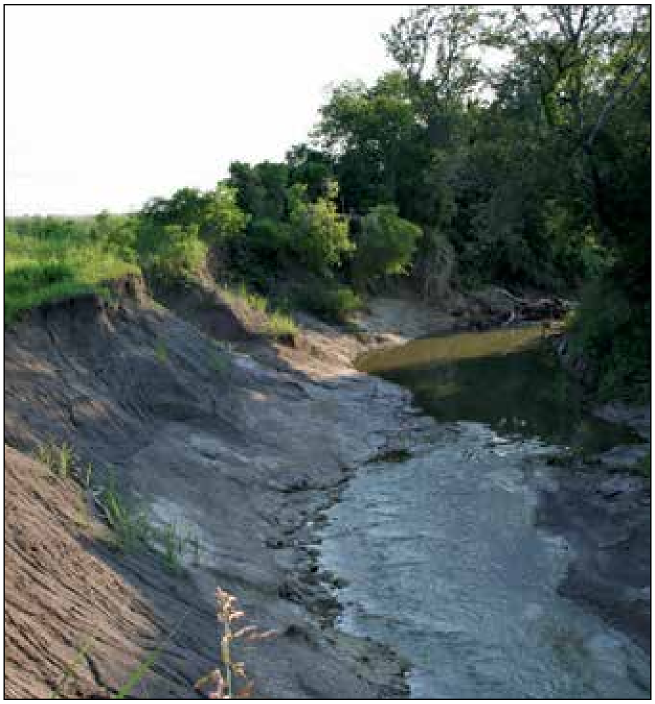

Figure 10. Grasses and forbs, not trees, should be planted along high, unstable banks as done here along Mill Creek in Navarro County. Photo by Dr. Jim Cathey, Texas A&M AgriLife Extension Service.

has been resolved. It is best to maintain/restore herbaceous riparian plants in the riparian area to stabilize the upper portion of the bank because some riparian plants can match trees in their stabilization ability due to the greater density of fine roots (Wynn et al. 2004). Consult with natural resource professionals or a private company about in-stream restoration techniques to address the in-stream erosion problem. Native riparian plants should be utilized to protect stream banks because they generally have greater rooting characteristics and height than introduced grass species, such as bermudagrass and bahiagrass. Height and stiffness of the vegetation is important to act as resistance during flooding, which slows water velocity and allows more water to infiltrate, and thus more sediment and other pollutants to be captured (Liu, Zhang, and Zhang, 2008). For landowners not wanting to restore native prairie plants, bermudagrass and other introduced grasses may provide some benefits, although not to the extent that native prairie plants will. Since these grasses require fertilizer periodically, there is greater risk for chemicals ending up in the stream and degrading water quality. Riparian areas provide numerous wildlife species with water, food, cover and travel routes. Native prairie

Figure 11. No-till seed drills (left) and cultipackers (right) are commonly used for restoring native prairies. Photos by Blake Alldredge, Texas A&M AgriLife Extension Service.

and riparian plants are preferred over introduced grass species for their wildlife value. Upland game birds, such as Northern bobwhite and wild turkey depend on native prairie plants throughout their lives. Bunchgrasses like little bluestem and switchgrass provide critical nesting and escape cover for upland game bird species, while many forbs, including Illinois bundleflower, Maximilian sunflower, and purple prairie clover produce seeds and attract insects that are a major component of game bird diets.

Conversion of native prairies to other uses has been so extensive that only 1% of historical prairies are believed to still exist in Texas (Allen, 2007). In areas where patches of habitat exist, they may be too disconnected to allow safe movement or be able to support populations of wildlife. Guthery (2006) theorizes that a minimum viable population of between 3,000 and 4,000 Northern bobwhites would require at least 30,000 acres of usable habitat. With fragmentation rates accelerating in Texas, restoring riparian areas can improve wildlife populations by providing corridors that connect wildlife habitats and allow safe movement between fragmented patches of natural area (Lovell and Sullivan, 2006). A study of cropland in North Carolina found that Northern bobwhite abundance increased 29% in a narrow buffer 10 feet wide and 91% in a buffer 30 feet wide (Riddle, Moorman, and Pollock, 2008). The wider a landowner can go the better; therefore, buffers 100 feet wide are recommended to ensure adequate habitat for Northern bobwhite and other upland game birds.

Native Prairie and Riparian Vegetation Restoration Techniques

There are two main ways to restore native prairie and riparian vegetation: passive or active restoration. In passive restoration, livestock are temporarily pulled off the land to discontinue grazing long enough to allow native seeds that may still be in the soil to germinate and grow. If the land in question still has natives growing or was only converted a few years prior, the remaining seedbank, given time, could lead to restored native pastures. This method may not be favorable to landowners who want to convert back to native species quickly, but may be more economical than active restoration. If there is a seed source and the natural vegetation is allowed to recover (i.e. is not grazed, plowed, mowed, trampled, etc.), the vegetation will grow and re-establish in an area by just removing these potential hindrances to the natural recovery. Some streams in Texas have dramatically recovered in just 5 to 10 years when the activity or management that was hindering the natural recovery was removed (see Appendix B).

Active restoration involves planting native seeds or plants. In prairie situations and sometimes in riparian areas, planting occurs after applying herbicide to eliminate the current introduced plant community. Along creeks, be very cautious to not create too much disturbance that can result in the loss of vegetation which is critical for stream equilibrium. The two most common planting techniques for reseeding native prairie plants are using no-till seed drills, or broadcasting seeds followed by using a cultipacker or other implement to firm the seedbed (Figure 11). This method typically costs from $100 to $200 per acre, depending mainly on seed prices, which are the greatest expense. Even though this method is more expensive than passive restoration, given the right conditions, a productive stand of native prairie plants can be established within two to three years. In contrast, if it is determined after two years of passive restoration that the native seedbank is not sufficient, then active restoration techniques would need to be used to establish a native prairie plant community which may take an additional two to three years.

For a complete discussion of these restoration techniques, as well as recommendations on site preparation, seeding rate, depth, and timing, refer to the Texas A&M AgriLife Extension publication *Native Grassland Restoration in the Middle Trinity River Basin* (SP-469) available at the AgriLife Bookstore.

Timing of riparian grazing is one of the most important factors when developing a management plan.

Grazing Management

Livestock grazing can greatly influence the quality of riparian areas throughout the state. Grazing can be done successfully to improve the structure and health of the plant community that will benefit future grazing, wildlife habitat and water quality. Stocking rate is the most important factor in any grazing management system. If the ranch is overstocked, the sophistication of the grazing system is irrelevant; it will fail given enough time. Beyond stocking rate, the key to sustainable grazing in riparian areas is the timing, duration, frequency and length of recovery (Mosley et al. 1997).

Timing of riparian grazing is one of the most important factors when developing a management plan. Riparian areas should be avoided when the stream banks are saturated as they are most sensitive and least stable. During these periods, livestock traffic can lead to greater compaction and have a detrimental effect on stream bank stability. Grazing during seasons of least rainfall helps to reduce loading of bacteria reaching the stream since there is less runoff (Wagner et al. 2012). Grazing while plants are dormant may be least damaging as long as proper stubble heights are maintained (3-4 inches for bermuda and other introduced shortgrasses; 12-14 inches for tallgrasses; 6-8 inches for midgrasses). Managers should also resist grazing the same riparian areas or pastures at the same time every year, as this will lead to plant community changes as some plants are continually utilized and others are completely deferred.

Duration of grazing refers to the grazing period and is defined as the period of time that animals are allowed to graze a specific area (SRM, 1989). Grazing duration is a very important factor in the success of any riparian grazing management system. By controlling grazing duration, managers can determine how much of the key forage species or riparian indicator plants are consumed. It is much easier to manage the duration of grazing in a specific pasture rather than manipulate stocking rates. More often than not, rangelands and riparian areas are overgrazed not because of over-stocking, but because the duration of grazing was too long for the given number of livestock.

Frequency of grazing refers to how often the riparian area is grazed. The optimum grazing frequency will be site specific to each riparian area and dependent upon the seasonality of the herbaceous vegetation. The frequency of the grazing periods should be determined by the season of use and managed to meet target end-of-year residual heights for the riparian key grazing species. A typical example would be to harvest 25% of the allowable forage in the growing season, 25% during the dormant season and allow 50% remaining to benefit root development, plant health and vigor.

Rotational grazing systems that allow recovery is one of the more practical means of restoring and maintaining riparian areas under light to moderate grazing (Holechek, Pieper, and Herbel, 2004). Length of recovery for the pasture is one of the most over-looked yet important factors of any grazing management system. Riparian and rangeland health are largely based on the health of the soils and plants that comprise them. Producers should give greater consideration to resting pastures. The rest or recovery period of a particular riparian pasture is much more important than the grazing period. As management plans are developed, care should be made to move the

Figure 12. This riparian fence could be moved back 200 to 300 yards to create a riparian pasture. Photo by Blake Alldredge, Texas A&M AgriLife Extension Service.

livestock before a plant is bitten twice. Since cattle may graze riparian areas more heavily than upland areas, producers should monitor stubble height of key riparian plant species that can be used as a trigger to rotate cattle to other pastures before they have opportunity to graze the regrowth.

Grazing management can be utilized to build healthy riparian systems; however, if not carefully managed it can also degrade them. Grazing duration is typically the culprit in most unhealthy riparian grazing management systems and is largely due to the fact that the pasture is under season-long or continuous grazing. Cattle tend to focus on riparian areas because they easily meet all of their requirements for food, water and shelter. Rotational grazing management allows the manager to be in control of the timing, duration, frequency and length of recovery for riparian systems.

One common practice to manage riparian systems with grazing management is to build a riparian pasture. In lieu of fencing off riparian areas and completely excluding grazing, many progressive producers are building riparian pastures by moving the fence away from the creek 200 to 300 yards and creating a specific riparian pasture (Figure 12). This allows the land manager, and not the livestock, to control grazed areas. Another important option to control grazing in riparian areas is to provide alternative water locations away from the riparian area, as well as moving supplemental feeding, mineral and salt stations (Wagner et al. 2013). Although excessive livestock grazing has historically been the cause of riparian degradation, the proper application of grazing management principles and practices has been proven to benefit and rehabilitate degraded riparian systems to a healthy and functioning riparian ecosystem.

For riparian areas severely damaged by improper grazing, temporary suspension of grazing may be as little as one growing season or as long as several years (particularly in low rainfall areas) to allow recovery before resuming grazing (TWDB, 2013). Recovery will vary from site to site and depends on productivity, grazing history and site conditions. If the riparian soils and channel are in good condition, there may be considerable resilience and rapid vegetation recovery with livestock removal, but where significant downcutting and gullying has occurred, the site may never recover to its initial state and will need to establish a new equilibrium (Sarr, 2002). Consider placing fences or exclosures at areas of special concern (active headcuts, deeply incised channels, re-vegetation projects, etc.) to ensure protection of these sensitive areas. Cattle exclusion typically results in rapid increases in plant height and vigor, increased leaf litter accumulation, and decreases in bare ground. Once plants have recovered, proper grazing can resume.

Grazing management can be utilized to build healthy riparian systems; however, if not carefully managed it can also degrade them.

For a complete discussion on riparian area BMPs and grazing management strategies, refer to the *Lone Star Healthy Streams* manuals (Beef Cattle, Dairy Cattle, Horses and Feral Hogs) available at the AgriLife Bookstore and *Riparian Area Management: Grazing Management Processes and Strategies for Riparian-Wetland Areas* from the U.S. Department of the Interior. For help determining an appropriate stocking rate for your land, download the smartphone app "Stocking Rate Calculator for Grazing Livestock" from the iTunes store. Consult with your local natural resource professionals for help developing a grazing management plan for your property.

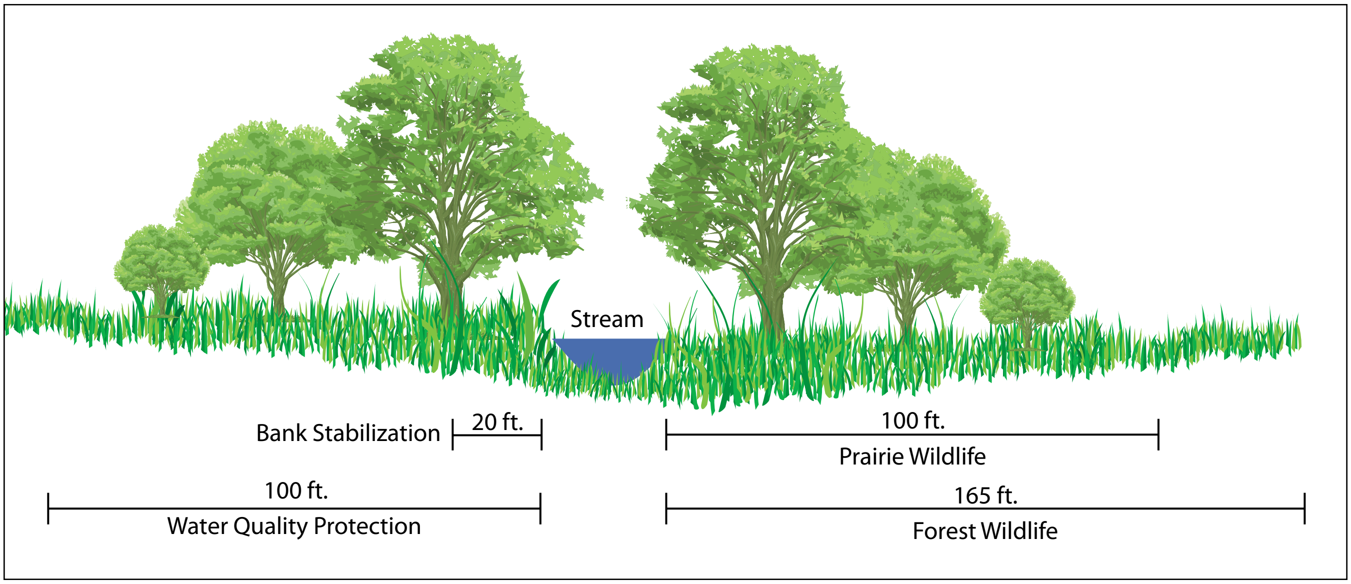

Figure 13. Recommendations for buffer width based on riparian management goal. Illustration by Jennifer Peterson, Texas A&M AgriLife Extension Service.

Cropland Management

Row crop farming is a major land use in the Blackland Prairie and can potentially impact riparian areas and streams even more than grazing since the land is cultivated for growing crops and is potentially bare for most of the year. Runoff and erosion is greater from crop fields than grazed pastures, therefore maintaining riparian buffers along crop fields are critical to ensure the integrity of stream banks and water quality. Riparian buffers are crucial for wildlife species, such as Northern bobwhite and other grassland birds, which require ground cover to provide food and shelter, and facilitate movement between habitat patches.

Width of the buffer is one important consideration when planning a riparian restoration project adjacent to cropland. There are many research-based recommendations for buffer widths, but the proper width for each property should be determined by the land use, soil type, existing riparian conditions and rainfall.

There are two main types of buffers promoted that would be most applicable on croplands: grassed filter strips and multi-species riparian buffer systems. These areas were historically dominated by prairie and may not have had many trees naturally occurring within riparian areas (Schultz et al. 1995). Grassed filter strips are the most simple and consist of permanent herbaceous vegetation of either a single species or a diversity of grasses, forbs and legumes, which have been shown to have greater benefits to soil health and pollutant removal (NRC, 2002). The minimum width required is 20 feet, but strips 50 to 150 feet are generally required to participate in USDA programs, such as the Conservation Reserve Program. The main purpose of grassed filter strips is to capture eroded sediment and pollutants before they reach the stream and, if plant species diversity is adequate, to provide habitat for wildlife.

Multi-species riparian buffer systems should be adapted to the conditions on each property. For example, if the stream bank and riparian area are in good condition, a landowner may decide to only establish native riparian plants in all zones to maximize forage production for cattle and provide wildlife habitat (Schultz et al. 1995). A recommended width of 20 feet for bank stabilization, 100 feet for water quality protection, 100 feet for prairie wildlife species and 165 feet for forest wildlife species should be followed (Figure 13; Fischer and Fischenich, 2000; Riddle, Moorman and Pollock, 2008). Landowners should work with their local natural resource professionals to design an appropriate buffer width for croplands. Once established, farmers should periodically maintain buffers to ensure they are functioning properly. Managed grazing or haying of buffers to remove top growth from riparian plants

Figure 14. Feral hogs cause $52 million in damages every year to the Texas agriculture industry and are implicated as a contributor to bacterial pollution in many Texas creeks and rivers. Photo by Texas Wildlife Services.

can be done to increase the nutrient uptake of grassy vegetation and limit woody growth, if desired (Lyons, Trimble and Paine, 2000).

There are several techniques that can be employed in crop fields to reduce runoff and erosion and prevent the problem at the source. Zhou et al. (2014) found that prairie filter strips interspersed in crop rows and at the bottom of the watershed reduced nitrogen and phosphorus losses by 67-90%. Other methods that have proven effective at reducing sediment and nutrient losses include no-till or conservation tillage, contour farming, terracing, cover crops and grassed waterways, just to name a few.

Invasive Species Management

Invasive plants and animals are detrimental to the natural processes occurring within riparian areas, and landowners may incur significant costs to remove these species and repair the damage. Feral hogs are a major threat to Texas riparian areas with an estimated population at 2.6 million inhabiting over 79% of Texas (Figure 14; Timmons et al. 2012). At current harvest levels of 29% of the population every year, the feral hog population is expected to double every 5 years and approach 5 million by 2015.

Research has shown that feral hog disturbance (rooting, wallowing, etc.) in riparian areas leads to less native tree establishment and more of the exotic, invasive Chinese tallow tree in the Big Thicket National Preserve in southeast Texas (Siemann et al. 2009). In addition, feral hogs are implicated as a contributor to bank erosion and bacterial pollution in Texas waterways. Therefore, it is essential to remove as many feral hogs from the landscape as possible to reduce damage to streams and agricultural operations and to improve water quality. The Texas A&M AgriLife Extension Service – Wildlife and Fisheries unit has many publications to help control efforts, as well as videos demonstrating control techniques on YouTube at https://www.youtube.com/user/WFSCAgriLife.

Monitoring

Riparian areas should be frequently monitored, especially when using the area to graze cattle. The easiest way to ensure that there is adequate plant material covering the ground is to measure plant stubble height (Figure 15; Clary and Leininger, 2000). The best way to do this is by using a grazing or yard stick to measure the height of the vegetation in several locations, within the same area, to obtain an average height. It is important to evaluate the grasses that cattle will graze. For bermudagrass and other introduced shortgrasses, the minimum average height should be 3 to 4 inches; 12 to 14 inches for native tallgrasses; and 6 to 8 inches for native midgrasses. Maintaining these minimum heights will ensure continued plant vigor in addition to erosion and stream bank stabilization. For a complete discussion of this technique and others with data recording

Figure 15. Measuring plant stubble height is easily done with a grazing stick or yard stick. Measure the height of standing vegetation in several locations within the same area. Photo by Blake Alldredge, Texas A&M AgriLife Extension Service.

sheets included, see *Native Grassland Monitoring and Management* (WF-001) at the AgriLife Bookstore. To make this assessment even quicker, consider using stakes with height marks on them throughout the area to visually estimate plant stubble heights rapidly. Use stakes only if it will not present a safety hazard to people and animals.

Another easy monitoring method for riparian areas and streams is the use of photo points (Dictson and White, 2004). Photo points are permanent locations that will help landowners see changes in the stream channel and riparian area over time and be able to adjust management accordingly. Photo points can be established by setting steel posts in the ground or by marking the GPS coordinates of the location. Photos should be taken from the point at least annually, and preferably after major storms, to document changes after high flow events. Four photographs should be taken at each point: 1) upstream, showing the nearest bank, stream channel and opposite bank, if possible; 2) directly across the stream of the opposite bank; 3) perpendicular to the stream with back towards the stream of the riparian area and/or upland; and 4) downstream, showing the channel and both banks, if possible (Figure 16). Be sure the camera is placing a time stamp on the photos, or include a sign in the photo to indicate the date and time. It is also a good idea to include a sign to identify the location and direction of the photo. Take detailed notes at each location of any evidence of erosion, vegetation changes and other indicators that will help evaluate the condition of the site. For an example of photo point monitoring, see Appendix B.

It may be necessary in severe situations to determine how quickly stream banks are eroding. This can be done by using erosion pins (steel rods) inserted perpendicularly into the stream bank face. There is no need to insert erosion pins along the entire stream length. Instead, focus on severely eroding areas that lack vegetation, have vegetated or non-vegetated overhanging banks, exposed tree roots and significant bank slumping (Zaimes et al. 2005). Insert erosion pins one-third and two-thirds of the bank height in five to seven vertical rows that are spaced three feet apart (Figure 17). After inserting the pins, measure the distance from the bank to the end of the pin for an initial measurement. Repeat the measurement for each

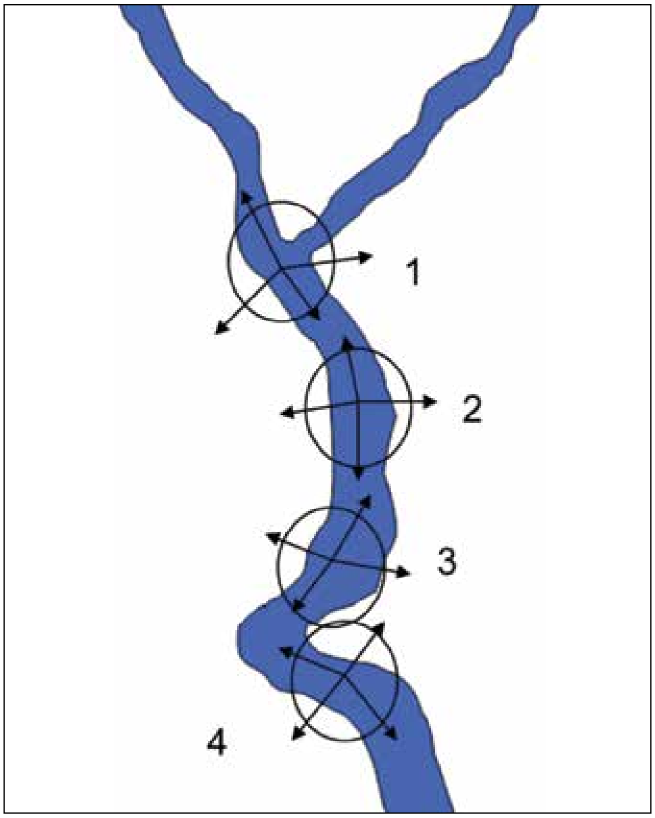

Figure 16. Physical locations for photo point monitoring stream-riparian areas should be located on either bank. Arrows show the direction of photographs. Illustration by Dr. Larry White (retired) and Nikki Dictson, Texas A&M AgriLife Extension Service.

erosion pin after flooding events to determine how much sediment was eroded.

Bank erosion can also be measured by placing erosion pins or a steel t-post in the riparian area along and next to the bank. Then measure the distance from the pin to the edge of the bank, as mentioned before. Also, marking the post with paint or tape at 10 to 12 inches above the ground may provide a way to monitor plant stubble height rapidly. This technique will be useful to determine the rate of erosion, which can provide critical information during the restoration planning process; however, determining the erosion rate at a single localized point along the bank may not provide all the information needed.

It will also be beneficial to find out how much bank erosion is occurring along the entire length of a stream reach, perhaps the entire reach along or within your property. This can be done by visually assessing the stream bank and looking for characteristics of erosion found in Appendix A. Assessing all of the stream banks on owned or managed property will

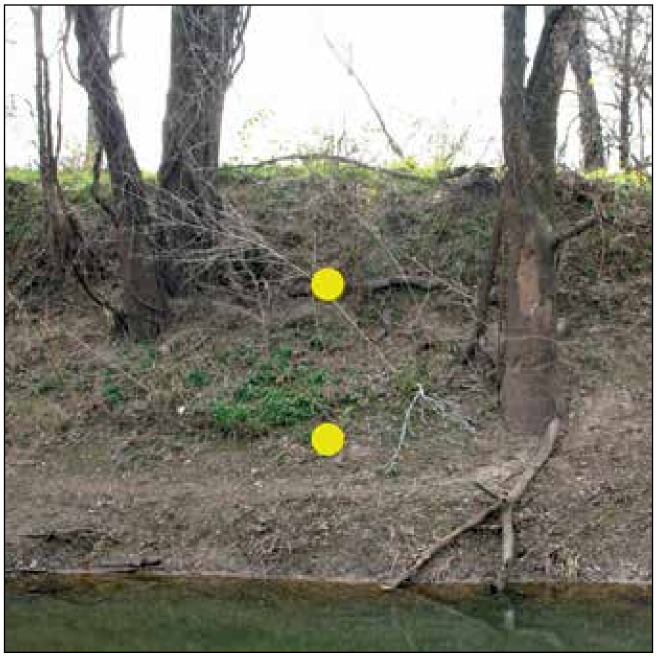

Figure 17. Erosion pins can be inserted into the bank face to measure erosion rates after floods. Yellow dots show placement of pins one-third and two-thirds of the height of the bank, and should be spaced three feet apart. Photo by Blake Alldredge, Texas A&M AgriLife Extension Service.

help identify the greatest areas of concern that can be addressed during the planning process.

Conclusion

Riparian management will increasingly be recognized as an effective and economical way to improve agricultural productivity, wildlife habitat and our state's water resources. Many watershed planners in rural and urban areas include riparian management as a key component to protecting water quality and vital infrastructure. Restoring riparian areas will require patience, as it may take time for vegetation to recover or to establish after planting. Monitor your riparian areas frequently, especially after floods, to evaluate how they are responding to certain management techniques and if needed, adjust your management accordingly. Work closely with your natural resource professionals to gain their insight.

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Glossary

Acre-foot - Amount of water needed to cover an acre of land to a depth of one foot, or 325,851 gallons, about the average annual use of two Texas families

Bank armoring – Protection of the bank to prevent or reduce erosion

Baseflow – Portion of streamflow derived from natural storage; average stream discharge during low flow conditions

Best Management Practice - Management activities that have been determined to be the most effective, practical means of preventing or reducing pollution from nonpoint sources to improve water quality in an area

Biodiversity – Variety of organisms within a particular habitat or ecoregion

Biomass – Amount of living matter in a given area or habitat

Cohesive – Soil that is dominated by high silt-clay content; stronger bonds between soil particles make it less vulnerable to individual soil particles eroding; rather, aggregate erosion occurs more often

Conservation tillage – Tillage practice that leaves the soil surface covered with plant residue for erosion control and moisture conservation

Cutbank – Area of bank that is actively eroding on a meander, or curve, of a creek opposite point bar

Dredging – Removing of sediment from a waterbody

Downcutting – Process whereby a stream cuts deeper into its streambed, thus moving away from its floodplain; see "Incision"

Equilibrium – State of physical balance in which opposing forces or influences are balanced

Eutrophication – Enrichment of an aquatic ecosystem with nutrients (nitrogen, phosphorus) that accelerates biological productivity (growth of algae and weeds) and the undesirable accumulation of algal biomass

Evapotranspiration – The process by which plants give off water vapor from leaf surfaces to cool itself

Exclosure – Fence or other barrier used to prohibit grazing animals from accessing area

Fragmentation – Dividing of large acreage properties into smaller ones

Gullies – Water-eroded ravine

Headcut – Sudden change in elevation or knickpoint at the leading edge of a gully; can range from less than an inch to several feet in height

Herbaceous – Non-woody vegetation such as grasses and forbs

Impaired (Impairment) – Waterbody that does not meet the water quality standards set for it; results in placement on Clean Water Act 303(d) list and state must take corrective action within 13 years

Incision – The process where a streambed erodes vertically and lowers the elevation of the streambed; usually occurs after change in the watershed alters hydrology. A stream is considered incised when its normal two-year high-water flow cannot reach its floodplain. Also known as downcutting

Light grazing – Degree of forage utilization that allows palatable species to maximize herbage-producing ability; utilization below 31%

Mass Failure – Erosion process where a section of bank moves downslope into the waterway; typical of cohesive soil dominated streams

Moderate grazing – Degree of forage utilization that allows palatable species to maintain themselves but usually does not permit them to improve their herbage-producing ability; utilization between 41% and 50%

Nonpoint Source Pollution (NPS) – Diffuse pollution source; a source without a single point of origin or not introduced into a receiving stream from a specific outlet. Pollutants are generally carried off the land by storm water runoff

Opportunity Cost – Cost of foregone rent or net revenue loss from agricultural production associated with land converted to more permanent uses, such as perennial prairie

Perennial – A plant that completes its life cycle in three or more growing seasons

Point bar – A gravel or sand deposit on the inside of a meander or curve; an actively mobile river feature

Pool – A point at which a creek is relatively deep, where stream energy is dissipated by increased volume of water; the pool surface is essentially level

Riffle – Shallow section in a creek where water breaks over rocks, wood or other partly submerged debris, producing surface agitation

Scour – Erosion occurring during a flood

Seedbank – Seeds that are present in the soil either from a previous plant community or deposited by wind or animals

Stream reach – Length of stream with uniform characteristics selected for study or observation; characteristics include land use, slope, soil type, vegetation, etc.

Stream Mitigation Bank – Restored, enhanced, or preserved stream corridor used to compensate for adverse impacts to streams and riparian areas within the same geographical area; banks are established under guidelines in Section 404 of the Clean Water Act

Stream Mitigation Credit – The "currency" of stream mitigation banking based on units of linear feet or functional assessment; can be purchased by third parties to compensate for damage to streams and riparian areas

Tension cracks – Fracturing of soil caused by repeated shrinking and swelling of clay coils during wetting and drying cycles

Watercourse – Stream, creek, river, waterway

Additional Resources

Texas Riparian and Stream Ecosystem Education <http://texasriparian.org/riparian-education-program/>

Lone Star Healthy Streams <http://lshs.tamu.edu>

Texas Watershed Stewards <http://tws.tamu.edu>

Feral Hog Community of Practice <http://extension.org/feral_hogs>

Texas A&M AgriLife Extension Service – Water Education Network <http://water.tamu.edu>

Appendix A. Visual Assessment Checklist: Rangeland Stream and Riparian Health Assessment for Texas Low-Gradient Streams. For examples on how to use this checklist, see Dictson and White (2004).

Location Observed: **Observer:** **Date:**

Indicator	Healthy	At-risk	Unhealthy
Channel condition	Natural channel, no evidence of active downcutting; cutbank erosion in balance with point bar deposition	Stream channelized or downcutting occurring; access to floodplain restricted; cutbank erosion exceeds point bar deposition	Channel actively downcutting or widening; floodplain access prevented; little if any deposition on point bars; if stream widening, deposition excessive
Access to floodplain	Flooding every 1-1⁄2 to 2 years—not incised	Flooding every 3 to 10 years—limited incision	No flooding; deeply incised
Bank stability (looking at left and right banks)	Banks stable; outside bends protected by roots with an erosion potential only on lower 1/3 of cutbank.	Moderately unstable; outside bends actively eroding; banks falling into channel from undercutting	Unstable; actively eroding, with bank slumping on inside bends and straight stretches; bare and unprotected banks
Riparian zone (looking at left and right banks)	Natural riparian vegetation (e.g., sedge, rush, willow, cottonwood, sycamore) at least 2 active-channel widths; point bars revegetating and all age classes of woody species present (seedling, young, mature, old); high sediment and debris capture with little scouring	Natural riparian vegetation extends1⁄2 active-channel width OR limited amount of sediment and debris capture with high flows and frequent scouring; upland vegetation intermixed with riparian species	Natural riparian vegetation extends less than 1⁄2 active-channel width OR lack of regeneration; infrequent debris capture and widespread scouring; upland vegetation dominates
Canopy Cover	70 to 90% of water surface shaded when sun is directly overhead	20 to 70% of water surface shaded	Less than 20% of water surface shaded
Pool variability and substrate	Even mix of large-shallow, large-deep, small-shallow and small-deep pools; mix of substrate (gravel, firm sand, etc.); roots and submerged vegetation common	Majority of pools large-deep or shallow pools more prevalent than deep pools; mix of soft sand, mud and clay; all mud, clay or sand; little to no root mats or submerged vegetation	Majority of pools small-shallow OR no pools; hard-pan clay or bedrock; no roots or submerged vegetation
Channel flow	Water reaches base of both lower banks; minimal substrate exposed	Water fills 25 to 75% of channel; riffle substrate mostly exposed	Very little water in channel and mostly present in standing pools
Macroinvertebrate habitat	More than five habitat types; score higher if good diversity	Two to four habitat types	Zero to one habitat type
Macroinvertebrates observed (optional)	Class I dominates or intolerant species with good diversity and numbers	Class II or III dominates or tolerant species	Very reduced number of species or near absence of macroinvertebrates
Fish habitat	More than seven habitat types	Two to six habitats present	Zero to one habitat present

Location Observed: **Observer:** **Date:**

Check the appropriate health category for each indicator; then total the number of checks per health rating for the location. Determine the overall health rating:

Health Category	Number of Checks	Percent of Total
Healthy*		
At-risk		
Unhealthy		
Total		

Overall Health Rating for Location – ______________________

*Note that hydrologic function must be healthy before a stream may be seen as healthy overall, regardless of the status of other indicators. If a stream's riparian and aquatic indicators are rated higher than its hydrologic indicators, the system is at greater risk and may lose its "desirable" characteristics with the next disturbance.

General Observations and Notes:

(Adapted from: NRCS and from Ward, T. A., K.W. Tate, and E. R. Atwell. 2003. Visual assessment of riparian health. Pub. 8089, Univ. of Calif., Division of Agriculture and Natural Resources, http://anrcatalog.ucdavis.edu.)

Appendix B. Example of photo point monitoring along the Nueces River after the prohibition of off-road vehicles in the riverbed. Photos by Sky Lewey, Nueces River Authority.

December 2007

October 2008

August 2009

September 2011

September 2012

June 2014

Acknowledgements:
This publication was developed as part of the Building Partnerships for Cooperative Conservation Initiative in the Trinity River Basin, with funding support from the U.S. Environmental Protection Agency through a Clean Water Act §319(h) grant administered by the Texas State Soil and Water Conservation Board and managed by the Texas Water Resources Institute.

We would like to thank Dr. Kevin Wagner (Associate Director, Texas Water Resources Institute) and Kent Ferguson (USDA – Natural Resources Conservation Service, retired) for their thoughtful review of this publication.

Photo by Blake Alldredge, Texas A&M AgriLife Extension Service

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