UNIVERSITY OF MISSOURI CENTER FOR AGROFORESTRY

ESTABLISHING & MANAGING RIPARIAN FOREST BUFFERS

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Riparian Forest Buffers: An Agroforestry Practice

Agroforestry is an integrated set of land management practices that helps land and forest owners to diversify products, markets and farm income, while simultaneously improving soil and water quality, enhancing wildlife habitat and sustaining land resources for long-term use. The five core practices of agroforestry — alley cropping, silvopasture, riparian forest buffers, forest farming and windbreaks — offer landowners opportunities for short-term income from areas that may not be currently utilized, like the alleyways between crops or stream side forests.

This Agroforestry in Action guide is intended to help you design and manage the interactive agroforestry practice of riparian forest buffers. Properly applied on a landscape, the riparian forest buffer can enhance and diversify farm income opportunities, improve the environment and create wildlife habitat. By developing an understanding of the interactions between the buffer (trees, shrubs and grasses), the stream or bank, and the adjacent upland area, its layout can effectively meet the goals for which it has been established. Riparian buffers improve the quality of the ground water by removing nutrients through uptake by deep rooted trees and microbial removal, a process called denitrification. This service is significantly important as close to 130 million people use groundwater for drinking in the US.

This well-established forested riparian buffer helps maintain water quality, creates a diverse habitat for wildlife, prevents streambank erosion and offers income opportunities.

Riparian buffers also serve as a defense for levee breaks and reduce sand deposition on fertile crop lands. Riparian buffers wider than 300 feet can minimize damages from climate change projected large rainfall amounts and intensities. By understanding the requirements of each of the components of the buffer, it can be managed to maintain effectiveness over time, and also sustain its contributions to the farm as an integrated agroforestry practice.

What is a Riparian Forest Buffer?

Riparian forest buffers are planned combinations of trees, shrubs, grasses, forbs and bioengineered structures adjacent to, or within, a stream designed to mitigate the impact of land use on the stream or creek. At the landscape level, riparian forest buffers link the land and aquatic environment, and perform vital ecological functions as a part of the network of watersheds that connect forest, agricultural and urban lands. By establishing, or managing, trees, shrubs and grasses in the zone adjacent to streams or creeks, water quality can be sustained or enhanced. However, to be effective, buffer management and design must include plants that are adapted to the specific riparian environment (flood regime, soils and topography), as well as management guidelines the landowner is willing to follow to keep the buffer healthy and effective.

A well-established and maintained riparian forest buffer can:

- Protect water quality
- Stabilize eroding banks
- Supply diverse food and cover for upland wildlife
- Improve aquatic habitats for fish and other organisms
- Generate farm income through products harvested from the buffer

When considering riparian forest buffer implementation, it is important to understand the benefits associated with riparian buffers, to think about planning and design considerations, to know the key management requirements necessary for successful riparian buffer use, and to understand the market opportunities and cost-share options.

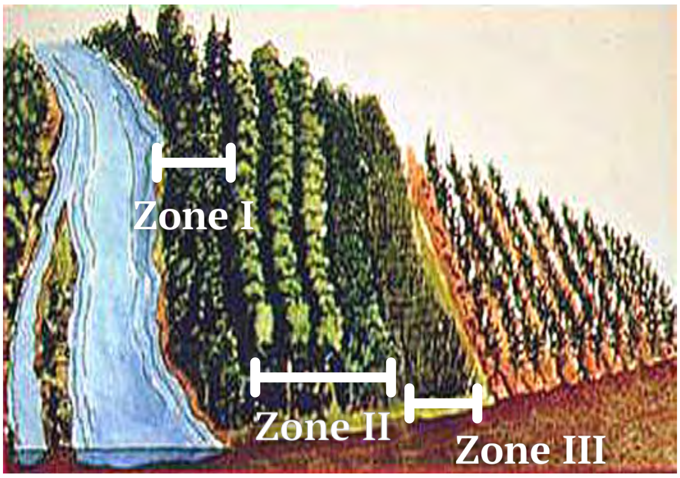

Figure 1: *The three distinct zones of a riparian buffer require individual management decisions to optimize their benefits. For Zone I, seek plants that help stabilize the bank and support aquatic habitat. For Zone II, decorative woody florals and fast-growing trees are an excellent choice for additional income. Zone III is well-suited for native grasses, forbs and wildflowers.*

Riparian Forest Buffer Zones: Benefits

A Riparian forest buffer is typically composed of three management Zones.

- ***Zone I*** – A narrow area closest to the stream bank that often includes a mixture of native trees, shrubs and forbs that are adapted to floodplain hydrology. The principle effect of Zone I is to stabilize the bank and provide woody debris for aquatic habitat.
- ***Zone II*** – A much wider area adjacent to Zone I consisting of fast-growing trees and shrubs that can tolerate periodic flooding. Their primary water quality purpose is nutrient uptake and storage. Woody stems also slow floodwater. This zone can be managed for additional income from nuts, berries or woody floral products.
- ***Zone III*** – Area adjacent to crop fields or grazing lands that provides high infiltration, sediment filtering, nutrient uptake and can help disperse concentrated runoff. Native grasses and forbs, such as wildflowers, are normally preferred for their multiple benefits and adaptability, but dense, stiff-stemmed introduced grasses may also be effective. (See Table 1, page 5)

In this guide:

- Riparian forest buffer zones: benefits
- Planning and design for riparian forest buffers
- Management and maintenance
- Marketing value-added products from buffers
- Financial considerations
- Frequently asked questions
- UMCA riparian forest buffers research

Riparian Forest Buffers and Market Opportunities In addition to slowing water runoff, enhancing infiltration of nutrients, reducing erosion and stabilizing stream banks, riparian forest buffers provide a landowner with value-added market opportunities and enhanced wildlife habitat.

Edible berries and decorative woody florals, such as Red Osier Dogwood and Curly Willow, may be planted in Zone II of the riparian buffer. These are valuable components of the floral and decorating industries. Nut bearing trees planted in Zone II also contribute to income opportunities from buffers. Wildlife habitat is significantly enhanced with the implementation of a riparian forest buffer (especially pheasant, quail and waterfowl), and lease hunting may be another economic opportunity gained through a riparian buffer system.

Planning for a Riparian Forest Buffer

Establishing a Buffer for Specific Goals The challenge to design and maintain a buffer system is to achieve your desired goals while also retaining the buffer's critical environmental benefits. For example, buffers established for reducing stream bank erosion require designs which incorporate plant materials both on, and adjacent to, the eroding bank that have deep and fibrous roots that better stabilize soil. Buffers created for the filtering of by-products from agricultural practices work best by filtering sediment and water as it moves through plant root zones, and before it can enter the adjacent body of water. This function of a buffer often utilizes stiff stem grasses and multi-stem shrubs to slow water moving over the soil surface, allowing it to infiltrate the soil. Once in the soil, plant roots are then able to capture, transform and store non-point source pollutants that would otherwise end up in aquatic systems.

Considering your desired outcomes for a buffer is an excellent first step in creating a design that is functional. Landowners are strongly encouraged to make a sketch of the buffer on an aerial photo and identify major problem areas, such as severe bank erosion, gullies, drainage tiles, etc., and then place trees, shrubs, and grasses in their appropriate zones to accommodate any unique problem areas

Dick Schultz, professor, Department of Natural Resource Ecology and Management, Iowa State University, offers suggestions for preparing to establish a buffer.

"Before you select the kind of buffer to install along your stream, think of what you would like the stream and riparian zone to look like, and what you would like the site to accomplish. Once you have identified your objectives, walk the site with natural resource professionals and explain your objectives and desires to them. They may use the Natural Resources Conservation Service 'Stream Visual Assessment Protocol' or a similar tool to help you identify the functional problems of the riparian zone. Once the site problems and objectives have been identified, select the buffer type that addresses your specific site's needs.

Keep in mind that riparian forest buffers and grass filter strips may not solve all of the identified problems along your stream corridor. They are primarily designed to reduce surface runoff of sediment and agricultural chemicals, bank erosion, subsurface movement of agricultural chemicals in the shallow groundwater, and degradation of aquatic or upland habitat. They are not designed to stop bank erosion along deep channels with vertical banks or stabilize the channel bed. They have no impact on groundwater moving through drainage tile networks, and they are not usually designed to accommodate livestock grazing.

To solve these problems, one or more other riparian management practices may be needed. These include stream bank stabilizing bioengineering techniques, small wetlands to intercept field drainage tiles, stream channel stabilizing boulder weirs, and controlled grazing practices."

according to your design. For example, trees, shrubs and deep-rooted native grasses should not be planted directly above field drainage tile lines. A list of the different plant species, their planting location and spacing are a critical part of the design sketch. In addition, identify the need for other riparian management practices such as stream bank bioengineering, in-stream boulder weirs or constructed wetlands to filter water from field drainage tiles. Remember, a totally functional riparian zone will require combinations of riparian and upland management practices.

Key areas for consideration:

In Stream – This involves an assessment of the stream bed and the stream banks. You may want to consider the channel bed material, and whether or not the stream is down-cutting. This can be addressed by in-stream structures. Consider points of erosion on the stream bank, such as sloughing or bank undercutting. These areas may need to have their bank mechanically regraded, and then proper stabilization implemented to deter future bank erosion.

Adjacent to the Stream – Plants growing on land in direct contact with the upper edge of the stream bank can both stabilize erosion and serve as a living filter. This area can also function to filter flood debris, slow flood waters and run-off from adjacent land activities. A landowner should consider the question, "what is the problem?" Species choice, and planting density, will be influenced by the problem being addressed and size of the stream. Trees, shrubs and grasses (even within a species) will likely vary in their tolerance to flooding. The establishment of trees/shrubs/grasses in this area should also take into account the soils and flood regimes. Choose species that are adapted to this environment. Trees and shrubs are often selected due to the deeper rooting structure and the shade they provide. Shade lowers water temperatures, reducing algal growth and improving the oxygen content of the water.

Outer Edge – This area provides the initial defense from direct runoff from adjacent land uses. Most often grasses are used in this area. Warm season grasses with stiff stems are desirable; however, it is again advisable to check soil types and flood frequencies/duration to ensure that the grass of choice will do well and persist. These grasses should provide good soil coverage that serves to slow water, allowing it to infiltrate the soil and for sediments to drop out of the flow. Warm-season grasses are often used because they have both stiff stems and deep roots.

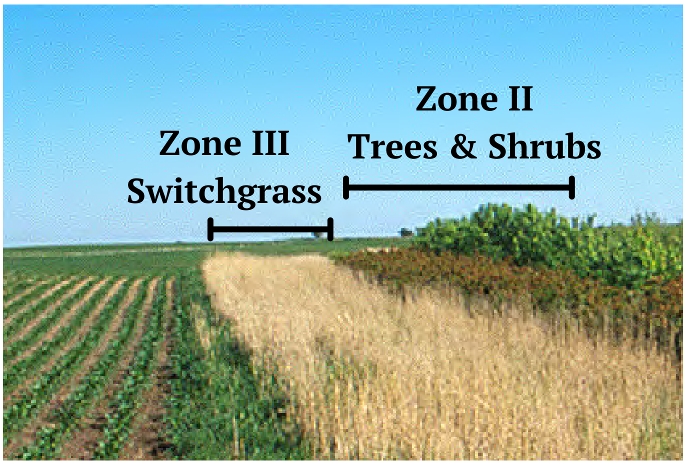

Figure 2: *Zones II and III of a riparian buffer*

All vegetation planted with the intended function to slow and filter water, and/or stabilize soil, should be kept actively growing and healthy. In many cases, especially with grasses, it is necessary to harvest, or otherwise remove, accumulated vegetative growth to prevent the build-up of a mat of dead material. This material results in areas of open ground where erosion may develop as water channels through.

Check out more Riparian Forest Buffer resources on the "Mizzou Agroforestry" YouTube channel!

Additional Considerations:

Width: When determining the width of your buffer, it is a good rule of thumb that "wider is better." For surface erosion control, buffers between 30 to 50 feet will work, but filtering subsurface flow may require significantly wider buffers. Keep in mind that the width of the buffer does not need to be the same throughout its length. Widths may vary to accommodate runoff hot spots or to smooth out field borders next to a meandering stream and create straight runs for operating equipment. (See Figure 3, next page.)

Length: Length of buffers will vary. However, it would be best if streams were protected along their full length. Is this practical or feasible? That is a decision each landowner must make.

One additional important consideration is that whatever the length, buffers must be designed and placed to prevent all sources of concentrated flow from entering streams or creeks.

Interaction between plant species: Recognize that buffers are constantly changing. Also, remember that buffer effectiveness is best maintained by keeping it healthy and growing vigorously. Over time, trees produce shade that causes a reduction in the density and vigor of neighboring grasses. By introducing a zone of shrubs between trees and grasses, for example, the impacts of competition for light on the growth and vigor of the grass zone are minimized.

Table 1: Understanding the Buffer Zone: Function and Management

Comprised of two or three zones, these zones become areas where specific plants and management are combined in order to create a forested riparian buffer that is highly effective at improving and maintaining water quality.

ZONE (Location, species choice)	FUNCTION	MANAGEMENT
Zone 1 (Beginning near the edge of the stream) (Fast growing trees/shrub species)	• Shade the stream and moderate water temperature • Provide bank stabilization • Enhance aquatic habitat with organic matter • Final filter of material moving through the buffer • Reduce velocity of over-the-bank flood waters	• Selective timber harvest, with replacement • Logging equipment excluded • Large woody debris should not be allowed to fall into the channel • Grazing is excluded, or limited to a specific point of access
Zone 2 (Beginning at the edge of Zone 1) (Fast and slower growing trees and shrub species)	• Provide maximum infiltration • Uptake of Non-Point Source (NPS) pollutants • Storage of NPS pollutants • Breakdown NPS pollutants • Provide forest-grown products • Enhanced wildlife habitat	• Active management encouraged • Harvest should stimulate new growth • Grazing excluded • Avoid soil compacting activities • Wildlife activities such as bird watching or lease hunting
Zone 3 (Beginning at the edge of Zone 2) (Grass and forb species)	• Converting concentrated flow to sheet flow • Filter sediment • Uptake of nutrients and chemicals	• Maintain vigorous vegetative growth • Remove biomass – mow • Remove biomass – graze carefully • Remove biomass – burn • Work accumulated sediments away from the buffer, back to the field

***Table 1**: On streams where damage to soils and banks is of little concern, Zones I and II are often combined, and management becomes more closely aligned to that of Zone II alone. In each of the zones it is important to recognize the role that buffer health plays in maintaining function. Healthy and actively growing vegetation provides the best uptake and utilization of problem nutrients and chemicals prior to their entering waterways.*

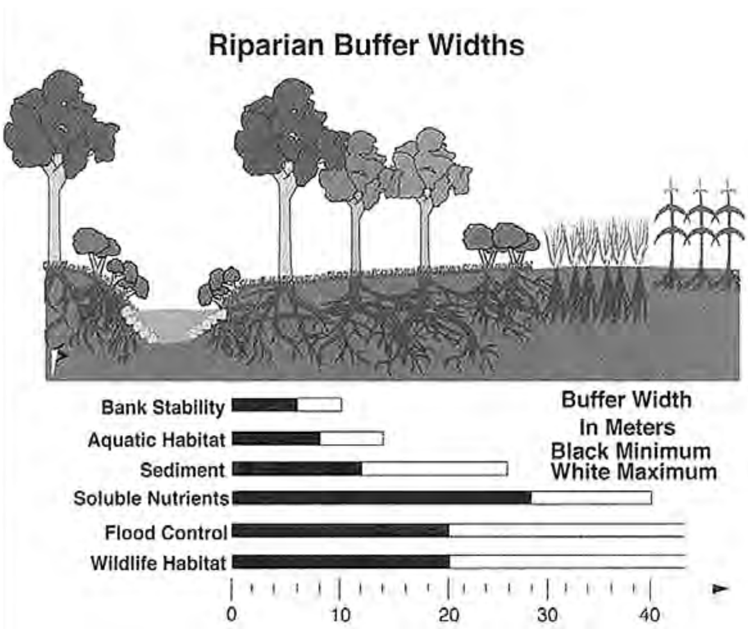

***Figure 3**: Riparian forest buffer widths by various sections. Source: North American Agroforestry, Third Edition. Edited by Garrett, Jose, and Gold. American Society of Agronomy, Inc. 2022. Chapter 8*

Impacts on wildlife habitat: Depending on the choice of plant materials used, wildlife may use buffers for food, cover and/or nesting and raising their young. Additionally, the buffer can serve to provide a connective corridor between various features on the landscape (to connect upland woods and bottomland fields, for example).

How to Design a Buffer Strip: General Requirements

(Adapted from Iowa State University Extension guide, "Stewards of our Streams: Buffer Strip Design, Establishment and Maintenance." Visit www.extension.iastate.edu/ for complete publication.) The most effective riparian buffer strip has three zones of vegetation, each planted parallel to the stream (see Table 1, page 5). Adjacent to streamside vegetation (Zone I) lies Zone II, a minimum 30 ft.-wide strip of trees (four to five rows). Upslope from the trees is an area that is a minimum 12 ft.-wide zone of shrubs (one or two rows). Farthest from the stream, next to cropland, Zone III is a minimum 20-24 ft.-wide strip of native warm-season grasses. This combination of trees, shrubs, and grasses helps protect the stream more than planting a single species. Trees and shrubs provide perennial root systems and long-term nutrient storage close to the stream. The warm season grass provides the highest density of stems to slow surface runoff from adjacent fields.

The design can be modified to fit the landscape and the landowner's needs, for example, by replacing shrubs with more trees, substituting some of the trees with shrubs, or expanding the grass zone. When the width of the tree zone is less than 30 ft., the buffer strip is less effective than one with a wide tree zone. The width of the buffer strip also can be adapted to straighten tillage boundaries along meandering streams or waterways.

A riparian buffer was installed at the Iowa State University Bear Creek demonstration area in Story County, Iowa, (top), and the difference in 5 years time (bottom) was dramatic.

Zone I: (Adjacent to the stream) Zone 1 contains a mixture of native trees, shrubs and forbs adapted to floodplains.

Zone II: (Fast growing riparian trees, higher-value hardwoods and shrubs) Four or five rows of trees are recommended in this zone. Trees nearest the stream in this zone (rows one and two and possibly three) are selected for their ability to quickly develop deep roots that can increase bank stability. The best choices are bottom land species adapted to the area that have a rapid growth rate such as silver maple, willow, cottonwood, green ash, and box elder. The species must be tolerant of wet conditions.

In the outer area of the tree zone (Zone II), hardwoods such as black walnut, red and white oak, and white ash can be planted to produce high-value timber. If the water table is at least three feet below ground for most of the growing season, plant hardwood species that require good drainage. If the site has poor drainage, select hardwood species more tolerant of wet conditions.

Shrubs also develop a perennial root system, add diversity and wildlife habitat to the ecosystem, and help slow floodwater when the stream leaves its channel. One or two rows of shrubs are recommended. Select species adapted to the soil site conditions in the area. Use a mix of species either by planting a different kind of shrub in each row or by block planting. A mixture also prevents loss of benefits if one species fails.

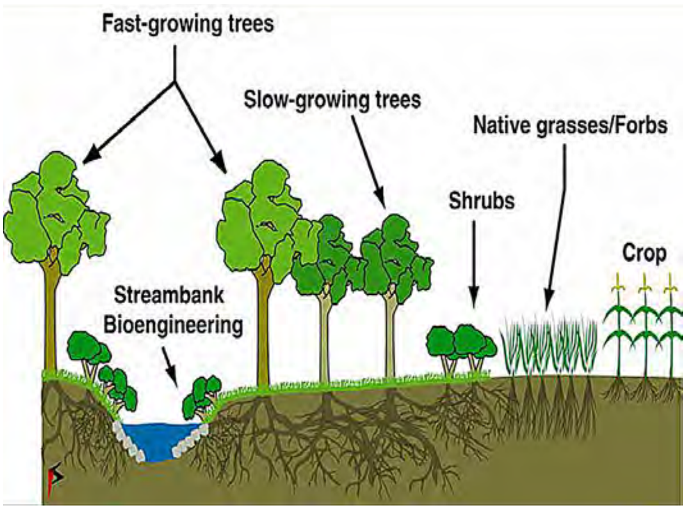

Figure 4: *Selecting the appropriate species for a riparian buffer will help ensure its success and longevity. Source: North American Agroforestry, Third Edition. Edited by Garrett, Jose, and Gold. American Society of Agronomy, Inc. 2022. Chapter 8*

Zone III: Grass zone (Next to cropland) The warm-season prairie grass zone is located on the outside of the buffer strip nearest the field crop. Where surface runoff is a problem, a minimum 20-24 ft. width is recommended. Switchgrass is often preferred because its dense, stiff stems slow the overland flow of water, allowing water to infiltrate and sediment carried by water to be deposited in the buffer area. In addition, switchgrass produces an extensive and deep root system, much of which is replaced annually, providing large amounts of organic matter to the soil. Organic matter improves soil quality by increasing infiltration rates and microbial activity.

Where surface runoff is not a major problem, other permanent native warm-season grasses such as Indian grass, big bluestem, and little bluestem can be used. Always maintain a 10-ft. switchgrass strip at the edge of a crop field. Black-eyed susan and purpleand gray-headed coneflower also might be planted with grass to intercept surface runoff that might occur. Mixing other warm-season grasses with switchgrass hybrids is not a good idea because the switchgrass will usually out-compete other grasses.

Native forbs also may be part of the mix, especially if they are seeded in clumps with other native grasses. Cool-season grasses, such as brome and fescue, are not appropriate for the grass zone because they do not tend to remain upright under the flow of water. They also produce only one-eighth of the root mass of native grasses and are not deeply rooted. Therefore, they do not improve soil quality as quickly or as much as the same planting of warm-season grasses.

Planting Tips and Species Selection

The selection of appropriate tree, shrub, forb and grass species is essential for the success of the buffer. When possible, select species of plants that are adapted to the site conditions. Often this is best accomplished by using native plants. With proper management, native plants will spread energetically through underground rhizomes, bulbs, or other vegetative means and are an excellent choice for the zones of a riparian forest buffer.

Compared with the roots of most non-native, cool-season grasses, warm-season grasses and flowers have a deep, extensive root system that helps absorb moisture and prevent erosion. The native plants can withstand long periods of dry weather, and do not require watering unless the buffer is established in a small residential or business park setting and is less than one year old.

The main considerations are: 1) selecting species that grow on potentially moist sites; 2) choosing species based on the severity of surface runoff from adjacent crop fields or grazed lands; and 3) making certain that seed of desired natives is both available and affordable. Most nursery information includes a description of sites suited for different species.

Many forest nurseries carry one to two-year old seedlings of most tree species for planting in Zone II of the buffer, the managed forest area. Use high quality stock with good root systems. Quality hardwood seedlings should have a minimum of four to five large lateral roots. Trees and shrubs should be planted in early spring, and make sure the planting holes are completely closed so the roots do not dry out.

Other Species Combinations

Combinations already described provide the most effective buffer strip, but they are not the only species that will provide water quality, habitat, and timber benefits. Site conditions, surrounding land use, owner objectives, and cost-share program requirements should be considered in determining combinations of species for a buffer strip. Here are other possibilities that could provide riparian buffer protection, although they have not been thoroughly tested throughout the region.

- Replace shrub rows with trees, or tree rows with shrubs, to increase timber or wildlife habitat. In either case, permanent woody roots are maintained, but use a mixture of species.
- Plant the entire buffer area to warm-season prairie grass. The area closest to the stream could include a mixture of grasses and forbs, but always maintain a 24-ft. strip of switchgrass along the edge of a crop field. Some bank stabilization may be needed (i.e., willow planted in the streambank) to provide long-term stability. This system will not provide as many benefits as a multispecies design and is best suited where stream banks are not very high or steep.
- Where grazing is desired and adjacent crop fields are more than several hundred feet from the stream, plant warm-season prairie grass in a 15- to 20-ft. strip along the stream and completely fence that area. Fencing regulates stream crossings; watering sites must be provided away from the stream. A portion of the buffer strip could be planted with a dense, cool-season grass such as fescue and orchard grass, which might be a more palatable forage and could be harvested.
- Broadcast or randomly plant a mixture of tree and shrub seeds in both tree and shrub zones to naturalize the planting and avoid rows. This might reduce the cost of planting seedlings.
- In urban areas, plant warm-season grasses over the entire area and small groups of shrubs and/or trees to provide a diverse, natural look. Recreational facilities such as hiking or bike trails can be incorporated into the system. Design with care to avoid erosion problems often associated with runoff from trails.

(Iowa State University Extension, "Stewards of our Streams" series, www.extension.iastate.edu/)

Consider as wide a variety of species as possible to develop diverse wildlife habitat and to reduce potential diseases and insect infestations. If you plan to sell products from your buffer, identify markets prior to purchasing seeds or plants. Non-natives may also have good market value, but take care to avoid establishing invasive exotics.

To determine the most suitable species for your design needs, ask the following:

1. What are my objectives?
2. What are the problems to be addressed?
3. Which species will do well on my site?
4. Which species are available from local nursery sources?

Resource professionals at your local NRCS, MDC or University Extension office can assist you with species selection.

Planting a Riparian Forest Buffer Most buffers are large enough to require seeding to be cost effective. Plants or plant plugs can be used, but add to the cost of the buffer. Prairie grasses and wildflowers (forbs) are usually started from seed, but wetlands are often planted with plugs. Trees and shrubs can be planted as 1-2 year old bare-root seedlings. If a buffer area is prone to flooding, additional measures will need to be taken (such as erosion control blankets, etc.) to ensure the success of the planting. Cover crops can be planted to help control weeds while the natives are becoming established.

Site preparation for planting the grasses and forbs in a filter strip can take numerous forms. If the site was previously in pasture, burning down the existing pasture vegetation with glyphosate in the fall and spring, and then using a prairie seed drill will result in a good stand of plants. If the site was previously in row crops, light tilling of the surface to kill early weed species, followed by surface packing with a cultipacker and then using a seed drill will provide a good stand. For woody plant establishment, site preparation should begin in the fall, followed by spring planting.

If the site has been in pasture, eliminate competing perennial vegetation in 3-foot or 4-foot wide strips or circles where trees or shrubs will be planted. Fall tillage and/or herbicide application (ex. glyphosate) can be used. If the area has been used for row crops, it is desirable to disk the ground in the spring and seed the area where trees and shrubs will be planted with a mixture of perennial rye and timothy grass. These cool-season grasses are less competitive with trees and shrubs than other species, such as tall fescue. Additional ground cover recommendations are available at your local NRCS or Missouri Department of Conservation office.

Management of Riparian Forest Buffers

Managing an Existing Streamside Forest for a Buffer System Buffer function should be a primary consideration in management.

Brad Riphagen is a Field Coordinator for Trees Forever, a non-profit organization founded in 1989 dedicated to planting and caring for trees and forests. He offers suggestions for planting trees, shrubs and grasses.

"When seeding grass and forbs, a firm seedbed is needed to ensure that the small seeds are in contact with the soil yet remain close to the surface. You can drill directly into soybean stubble and into sod that has been killed with glyphosate. When planting trees and shrubs into a crop field, it is a good idea to drill grasses, like timothy or perennial rye, which won't out compete the trees and help to prevent erosion during the first 5 years of buffer establishment.

Order trees and shrubs early, up to four months before scheduled planting time to assure receiving the desired species. For direct seeding of most trees or shrubs, collect or purchase seed and plant in the fall. Direct seeding in the spring is possible if you can purchase seed from a dealer. Plant tree and shrub seedlings as early in the spring as site conditions allow. Grasses and forbs should also be planted in the spring."

Therefore, management of existing buffers should focus on either maintaining or enhancing buffer function. Although plant materials may be alive and growing, they may not be growing vigorously and be in the best of health. Plants with vigorous growth will have enhanced uptake and use of nutrients. This also equals greater storage of materials that would otherwise travel into the water system. Management strategies need to look toward creating stronger plants, resulting in plants that are more likely to survive environmental stress, such as seasonal flood events.

Maintenance of Existing Streamside Forests Function is maintained when the buffer zones are maximizing their potential for plant growth. For grasses, this may mean mowing or selectively applying rotational grazing at appropriate times of the year (such as dry and not wet periods). This can assist in minimizing the accumulation of dead grass material, and enhance overall grass growth and vigor. However, it is crucial that access to the stream or creek be limited. One method of limiting access is to only have fenced access available in a small, planned area (Figure 5). Additionally, grass zones adjacent to crop fields may occasionally need to have accumulated soils pulled back into the field. This can be accomplished by directionally discing such that soil is moved away from the grasses edge.

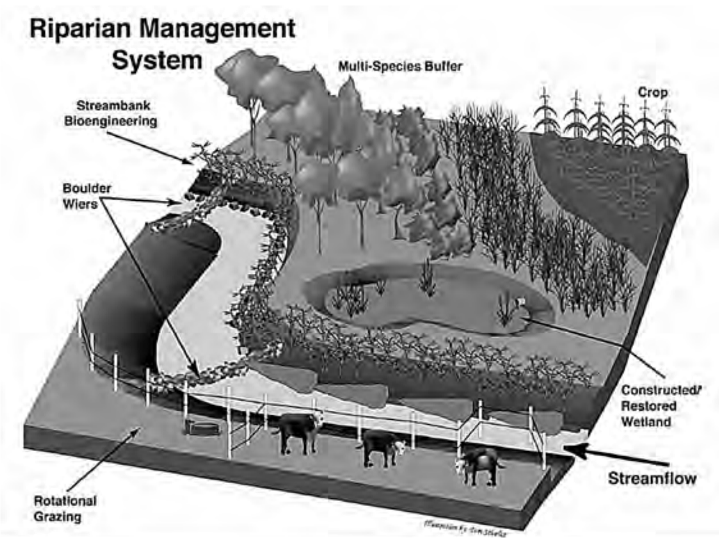

Figure 5: *Riparian management system with livestock access restricted by fencing. Source: Tom Schultz, Iowa State University.*

In the shrub zones, management may include such practices as cutting the shrub back, pruning and control of invading grasses (weed control). In the timbered zone, thinnings and selective harvest may be used to keep the remaining trees in a state of health and vigorous growth. Also, your management plan in the timbered zone should take into account the need for regeneration and the establishment of new seedlings. This can either be natural or artificial, such as when planting new seedlings. It is important to remember that as trees age, slower growth rates and death are natural. One management tool then, is to harvest mature trees prior to their death, degradation, or breakdown, when they may otherwise become debris in the waterway that inhibits proper flow.

Enhancement From time to time, in spite of any maintenance that may be completed, it may also be necessary to enhance or enrich the buffer to maintain the desired functionality. This may be as simple as planting additions (overseeding grass zones, putting in a new shrub, or planting trees in openings created by harvest or loss from flood damage). Remember, the goal is to have a healthy and vigorously growing buffer, and one without gaps that would allow water to channel through.

Maintenance of a Riparian Forest Buffer

The primary maintenance activities include mulching, mowing, herbicide application and weed control, until trees and shrubs are large enough to compete on their own. Mow the grass/prairie zone (Zone III) as high as possible to remove annual weed seed heads, but not young grasses and forbs. Prescribed burning during the first 4 to 5 years can also aid establishment. Once established, the grasses and forbs need to be hayed, grazed or burned regularly to maintain vigorous growth.

You can increase the filtering capacity and potential economic returns of Zones II and III by trimming, cutting back, mowing, or harvesting the shrub, grass, wildflower and forb species. By keeping the plants in a state of vigorous growth, they will actively filter more soluble nutrients from the water. Additional income can be generated by planting products to sell locally.

Replace significant losses of tree and shrub seedlings during the first three years to ensure the desired plant density of the mature buffer. Protecting young trees and shrubs from deer, rabbits and beaver can be expensive, but is necessary to the health and vitality of the buffer.

Finally, inspect the buffer annually and after significant storm events to determine the need to remove excess sediment at the cropland edge of the buffer that can prevent shallow runoff from flowing evenly through the buffer, or to repair concentrated-flow cuts through the buffer.

Replanting and Reseeding:

(Following replanting and prescribed burning sections reprinted with permission from Iowa State University Extension; "Stewards of our Streams: Maintenance of Riparian Buffers." For more information visit extension.iastate.edu)

Replanting and reseeding are important maintenance practices during the first few years following establishment of a riparian buffer and can be done in the spring or fall. Woody plants should be replanted within a row if more than three or four consecutive seedlings have died. Spot planting can be done quickly with just a bucket full of water, seedlings and a shovel.

Replanting in the native grass/forb zone may be a bit more involved, depending on the density and quality of grass and establishment. If there is poor establishment, a herbicide like Glyphosate can be used, followed by redrilling. If there is some establishment, but not as dense as desired, the site can be directly redrilled. If the areas needing reseeding are small, handspreading the seed and raking it into the ground is acceptable.

During the life of a riparian buffer, trees will begin to compete with each other as they do in a natural forest, and without pruning and thinning they will not maintain an optimal growth rate. Depending on spacing, fas-tgrowing trees such as cottonwoods and poplars will be competing with each other within 10 years of planting. After 8 to 9 years, every second or third tree may have to be harvested to increase water availability and growth space for remaining trees.

Prescribed Burning Fire is a good maintenance tool for native grasses and forb plantings in riparian buffers and filter strips. To reduce weed competition during the year, prescribed burns are usually performed early in the spring. During this time, many of the competing cool-season grasses, weeds and woody plants begin growing while the native prairie plants are still dormant. Always develop a prescribed burn plan prior to burning. (**Note:** Assistance is available through the Missouri Department of Conservation Private Lands Division).

While different burning frequencies may be used, an annual spring-burn for the first three or four years is recommended. Following establishment of a good stand of desired

Applying a chemical barrier helps seedlings get off to a good start.

grasses and forbs, a burning cycle of once every three to four years can be used. The burning cycle is usually defined by the accumulation of dead plant material on the ground, weed species invasion and general vigor of the plant community.

Fall burns also can be used to stimulate forb growth more than the grass growth. However, they may be problematic if adjacent crops are not harvested.

Burning the riparian grass/prairie component of a riparian buffer can be tricky due to the close proximity of shrubs and trees. Such a burn requires numerous people, careful planning, attention to fuel sources and amounts, and attention to wind. Using a small, slow backfire (a fire that burns into the wind) helps to keep the fire more controlled while it is close to neighboring shrubs and trees. A fire break is often mowed or raked between the shrubs and/or trees and the native prairie component. The fire break can be wetted if the fuel is dry.

A good strategy is to burn when steady wind (10-15 mph) is blowing into the buffer toward the stream. This way, a backfire can be started with a drip torch along the mowed break and allowed to burn into the prairie grass filter. The fire moves slowly because it is burning into a prevailing wind. Once the backfire has burned a strip of 10 - 15 feet in width, a head fire (burning with the wind) can be lit along the crop field and allowed to burn rapidly with the wind. If there is heavy corn stover left along the crop edge, care must be taken to keep the fire out of the field. This can be done by raking or wetting the stover just before the fire is lit. The crew, equipped with fire rakes, fire swatters, and backpack sprayers, should patrol the burn to keep it contained. Fires should be kept small and well controlled (start small to test the wind, moisture conditions, and train your crew). A water tank in a pickup truck fitted with a small pump and garden hose can be very useful for wetting down the fire break and corn stover. If you have not performed a controlled burn before, you should ask for assistance from a local natural resource professional with experience dealing with controlled burns. Consideration should be given to the influence of burning on nesting birds.

Ideally, you should burn in sections; burn only one side of the creek or break a prairie stand into three or four sections and burn one each year. Fall burns eliminate winter cover and late spring burns can destroy nests. However, fire helps to maintain native plant health. Most native prairie plants will grow more vigorously, produce more flowers and produce more seed after a fire. The active growing points of most prairie plants are below the soil surface, and are therefore unaffected as the fire rapidly passes over. After the fire, these plants are stimulated by warmth of the blackened ground and the nutrients that were released from burned plant material.

Considerations for Stability: Stream Bank Structures

In some cases, erosion caused by runoff and/or sloughing of stream banks is too excessive to be stabilized by a Forested Riparian Buffer alone. Therefore, to quickly stop erosion, it may be necessary to use bioengineering at the trouble spot.

Bioengineering can:

- Be used to change the steep angle on actively eroding banks to a more gradual slope upon which plants may then become established
- Slow water movement and reduce erosion by adding frictional material to stream banks
- Reduce undercutting
- Reduce stream sediment loads
- Improve water quality
- Improve aquatic habitat and wildlife habitat

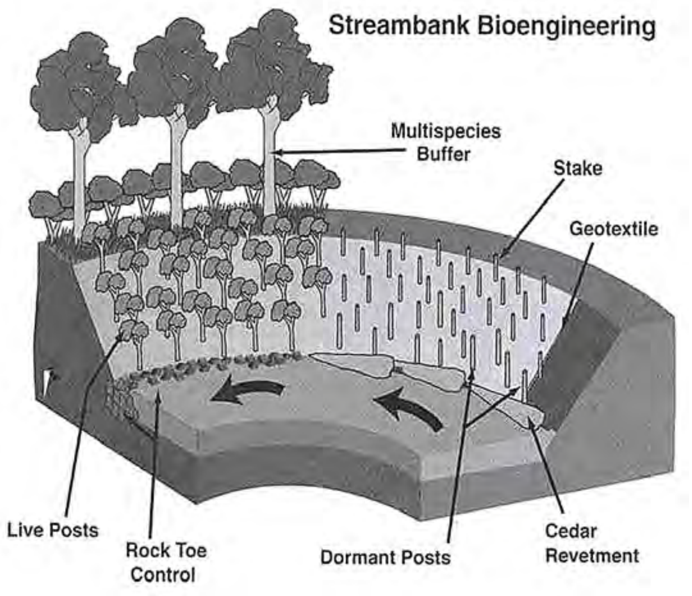

Figure 6: *A combination of live and dead materials used in the streambank bioengineering practice. Source: North American Agroforestry, Third Edition. Edited by Garrett, Jose, and Gold. American Society of Agronomy, Inc. 2022. Chapter 8*

The following bioengineering practices and structures can be used singly, or in combination, to create a more stable stream channel and bank.

Rock rip-rap — Rocks anchored to the stream bank. This type of stabilization is useful in areas of severe undercutting. Size of the rock is directly related to stream size, volume, and velocity. Larger streams with increased water velocity will require larger rock. In order to avoid undercutting of the anchored rock, the rip-rap should extend to stable material in the channel bottom. In some cases, it may be necessary to reshape the stream bank prior to rock placement.

Geotextile fabrics — Fabrics of jute, coconut, or other fibers may be used in conjunction with any of the living structures. This fiber mat will hold soil in place while the live plant material becomes established. The fabric can be held in place with stakes and/or placed in the trench with fascines and covered with a shallow layer of soil.

Tree revetments — By staking dead trees and logs along eroded stream banks, protection is provided and sedimentation allowed to collect, which in turn provides a medium for new vegetation to become established. Logs and branches can also serve as shade, creating better aquatic environments.

Live post and stakes — By using dormant plant material, stream banks can be quickly stabilized. Dormant material (cuttings) of a few selected tree and shrub species will quickly develop root structures below ground and produce live shoots above. Stakes of one-half inch and larger are driven into an eroding bank. The longer the stake, the better stability that is provided. Lengths may range from 2 to 3 feet for stakes, up to 10 feet for posts. Installation should begin with the larger stakes being placed at the base, along the water line, and the smaller stakes planted into the upper stream bank.

Live fascines — Also known as wattles, these are bundles of live, dormant branches (whips). Individual whips should be at least 4 feet in length. These branches are then overlapped, with all butts and buds pointed in the same direction, to form bundles of up to 8 inches diameter and 10 to 20 feet in length. As with live stakes it is desirable to use species which will quickly root. Place the fascines in shallow trenches, leaving the upper live buds exposed. Soil should be tamped into place around the bundles and a dead stake used to anchor them in place. By placing fascines along the contour, small branch dams are formed against soil movement. This will create a terraced effect on stream banks. Bundles should be spaced from 3 to 6 feet apart with narrower spacings used on steeper banks.

In-stream structures — Where channel incision is still actively occurring and stream banks are unstable, or where there is a lack of in-stream habitat, rock structures, such as boulder-weirs can be constructed. These structures are constructed of properly sized rock and no more than 1.5 to 2 ft high at their center. They are usually constructed with a slight V in the center to direct flow down the center of the channel. They have an upstream rock apron with a 4:1 slope and a down-stream apron with a 20:1 slope. These aprons reduce the turbulence of the water, while allowing enough to improve oxygenation. Use these structures in series, allowing enough distance between so that a pool develops. This placement reduces channel bed erosion. Providing pools that are 1.5 to 2 ft high reduces the critical bank height at low flow, thus reducing bank erosion. (See Figure 5, page 10).

Considerations for Wildlife:

One of the most notable benefits of using natives in a buffer is the creation of effective wildlife habitat. Native grasses and forbs provide different heights, densities, shapes of stems and leaves, different flowering times, and different flowers and fruits to attract several different species of wildlife. The key is to plant as wide a mix of species as possible to achieve the maximum wildlife benefit. Planting pure native warm-season grass strips with one or two species is more effective than just one species of low growing cool season grass, but planting 5 or 6 species of native grass and 25 forbs provides much more habitat potential. Similarly, planting mixtures of trees and shrubs will provide more diverse structural habitat, but if a landowner is mainly concerned with upland bird habitat, trees provide perches for predator raptors that may prey on the prairie birds.

Market Opportunities with Riparian Forest Buffers

Many products grown in the buffer have monetary value in addition to their conservation benefits. A trip to a local florist or craft store will give you an idea of the diverse uses of plants and plant stems. It may also be helpful to ask if local stores are interested in

Jim Wooley is a Regional Wildlife Biologist with Pheasants Forever, a non-profit organization dedicated to the protection and enhancement of pheasant and other upland wildlife population through habitat improvement.

"Pheasants Forever is interested in riparian buffers and other buffer systems because of the habitat that these types of practices provide for pheasants and other wildlife, including non-game wildlife. Beyond that, establishing a buffer offers an exceptionally good economic benefit for a landowner. He's taking ground that in a lot of cases is productive, but may have some problems associated with it. In some cases, we're looking at cash rentals and incentives that approach two hundred dollars per acre. That's an excellent return on the ground, and the buffer is providing many benefits, not only to the landowners, but to society in general."

Lease hunting is another opportunity for income from the wildlife habitat created by your riparian buffer. (MDC photo)

Improved wildlife habitat, such as ducks and quail, are another benefit of riparian buffers.

purchasing locally and sustainably grown materials. At that time, inquire how they would like to receive the material (condition and packaging).

Decorative woody florals and craft products: Decorative woody florals can be planted in Zone II of a riparian forest buffer for additional income. This category includes any woody plant species that has a colorful or unusually shaped stem, bud, flower, fruit or leaf. Common examples include pussy and curly willows and red- and yellow-stemmed dogwoods. These plants, and many others, are regularly used in the floral industry to add height and breadth, enhance line and form, and add a splash of color. They retain their bright colors for a long time, extending an arrangement's usable life. Woody florals accent cut-floral arrangements and enhance consumer perceptions of size and value, and can make a statement even when used alone in a vase design. They can be sold to retail or wholesale florists by the stem or the bundle at competitive prices.

Learn more about decorative woody florals through research conducted by the University of Nebraska Extension Forestry Program, including a list of additional species of woody plants commonly used in the floral industry and retail and wholesale nursery stock sources online at https://digitalcommons.unl.edu/cgi/viewcontent.cgi?article=1042&context=nebforestpubs

Willow and dogwood branches are bundled for sale to retail and wholesale florists, bringing as much as 50-75 cents per branch in some markets.

Berries and nursery stock: Various species of edible berries, including blackberries and raspberries, can be grown in the shrub zone of a riparian buffer for additional income. Markets for fresh berries can be found by contacting local farmers' markets, grocers and specialty health food stores.

Harvesting nut crops: Planting nut trees including pecan and black walnut in Zone II can provide income from nut harvests. Fresh pecans are readily sold at farmers' markets, roadside stands or to retail and wholesale grocers. The Center for Agroforestry is conducting extensive research to identify outstanding cultivars of pecan and black walnut. Informational guides and research updates are available at www.centerforagroforestry.org.

Markets for nut crops like black walnut (background) and pecan (inset) include farmers' markets and retail/specialty grocers.

Timber trees: Planting trees into Zone II of your riparian buffer for a future timber harvest requires a management plan and patience, but can be very profitable over the long-term. In Missouri, when the market is right, Silver Maple brings almost as much as oak species (price per board feet).

Integrating riparian buffers into your current land practices can maintain the integrity of stream channels, reduce the impact of upland sources of pollution, generate income and optimize performance for environmental protection and economic production.

Market Opportunities	
Examples of 'marketable' products	**Timeframe to reach market potential**
Floral & Craft Products	Beginning approximately 2 years after establishment, and if done correctly (i.e. plants re-sprout), continuing for many years
Berries & Nuts	From 2 to 15 years, depending on the crop
Biomass	10 to 20 year rotation, market dependent
Timber Trees	In most cases, 40+ years

Table 2: *Market opportunities for riparian buffers*

With thoughtful consideration to site characteristics, landowner goals, species selection and environmental and wildlife benefits, riparian buffers provide an additional source of sustainable production with multiple conservation benefits.

Financial Resources:

There are many agencies offering programs that can be used to establish and maintain agroforestry practices on private land. One of the most significant of these agencies is the USDA Farm Service Agency (FSA), offering three distinct programs that may be utilized toward agroforestry systems like riparian forest buffers: the Conservation Reserve Program (CRP), the Continuous Conservation Reserve Program (CCRP), and the Conservation Reserve Enhancement Program (CREP). Each of these programs is designed to take environmentally sensitive and highly erodible land out of production by offering a soil rental payment, a costshare for the establishment of various conservation practices and other financial incentives to landowners who offer to set aside their land.

Of these three programs, the CCRP program offers direct benefits to landowners establishing a forested riparian buffer. CCRP is a voluntary program that focuses on funding conservation practices (CP) protecting environmentally sensitive land, including wetlands and riparian areas. Landowners with eligible land who wish to enroll that land in the CCRP may sign-up at any time during the year.

Available funding through the CCRP can include:

- Annual soil rental rate payments that can be up to 120 percent of the average soil rental rate for the area.
- Annual maintenance payments of $5 to $10 per acre.
- Cost share payments up to 50 percent of the establishment cost.

Along with these three payments, CCRP also has two one-time incentive payments available for certain CP's, including:

- A signing incentive payment (SIP) equal to $10 per acre per number of contract years.
- A practice incentive payment (PIP) equal to 40 percent of the establishment costs.

Riparian Forest Buffer (CP22)

- 10- to 15-year contracts
- Continuous CRP
- Eligible for the following CRP financial incentives
  - -120 percent SRR
  - -50 percent regular cost share
  - -SIP
  - -PIP
  - -$7-$10 maintenance
- Width requirements (1st and 2nd order streams)
  - -Grass zone: 25 feet maximum
  - -Min. buffer width: 50 feet
  - -Max. buffer width: 180 feet
- Width requirements (3rd order streams)
  - -Grass zone: 25 feet maximum
  - -Min. buffer width: 100 feet
  - -Max. buffer width: 180 feet

There are 16 practices that are eligible for the CCRP. However, out of the 16, eight allow for tree planting, including:

- CP16A Shelterbelts
- CP22 Riparian buffers
- CP23 Wetland Restoration

Riparian buffers have become a priority for most USDA agencies. Under the requirements of the CCRP's riparian forest buffer practice (CP22), landowners must establish at least a two-zone buffer. The total width of the riparian forest buffer will vary depending on the size of the stream and landowner objectives. For first and second order streams, the buffer must be at least 50 feet wide and cannot exceed 180 feet. Buffers along third order streams must be at least 100 feet wide. Riparian forest buffers along the Missouri and Mississippi Rivers may be increased to 300 feet. Buffers may be extended beyond 180 feet or 300 feet for the purpose of improving water quality benefits.

NRCS Standard 391 identifies the guidelines for establishing a riparian forest buffer for the CCRP. For more information, contact your local USDA/FSA office. Additional USDA programs to establish and maintain riparian forest buffers are offered through the Natural Resources Conservation Service (NRCS); the Forest. Service (FS); and the Sustainable Agriculture Research and Education (SARE) program.

The United States Fish and Wildlife Service (USFWS) also offers assistance; see chart below for a listing of incentives offered by these federal agencies or consult the UMCA publication "Funding Incentives for Agroforestry in Missouri."

Summary

When incorporated on the farm landscape, forested riparian buffers can effectively improve water quality and limit soil loss. Buffers also can improve the quality of ground water, stabilize stream banks, minimize levee failure, and reduce sand deposition on land. A buffer can be established and become productive in a relatively short time period.

One of the keys to the successful buffer is the choice of materials and plant species that are suitable for the selected site. The next step is to understand the dynamics of the stream with respect to adjacent land use issues so that the buffer design will adequately address the problem. Finally, be clear on the management needed in order to maintain the effective functioning of the buffer over time.

Working from these three points of reference will best ensure the success of a riparian buffer for years to come.

Aerial image of a riparian buffer

Federal Funding Incentives for Riparian Forest Buffers

Federal Agency & Programs Offered	Programs Available for Riparian Forest Buffers	Key to Programs Available for Riparian Forest Buffers:
USDA/FSA		**CS** = Cost Share (ranges from 50% to 90%, based on a predetermined expected cost structure) **LE** = Land Easement (Rental payments based on an average rental rate per land use type; easements are typically 5, 10, 15, 30 years or permanent) **M** = Annual maintenance payments (range from \$5 - \$10 per acre) **IP** = Additional incentive payments (payments could include sign-up bonuses, additional cost-share, and/or increased land easement rates) **G** = Grants
Continuous Conservation Reserve Program (CCR)	CS, LE, IP, M	
Conservation Reserve Enhancement Program (CREP)	CS, LE, IP, M	
USDA/NRCS		
Environmental Quality Incentives Program (EQIP)	IP	
Wetland Reserve Program (WRP)	CS, LE	
Conservation Security Program (CSP)	CS, LE	
USDA/FS		
Forest Land Enhancement Program (FLEP)	CS	
SARE		
Producer Grants	G	
USFWS		
Partners for Fish and Wildlife (PFW)	CS	

Table 3: *Federal funding incentives and opportunities for riparian forest buffers*

Frequently Asked Questions

What will it cost me to put in a buffer?
There are many variables that may influence the cost of buffer establishment:

1. Size area to be established, including the length of stream and width of buffer;
2. Plant selection and nursery of choice;
3. Any work that needs to be done involving earth movement or rock along the stream bank;
4. and the availability of cost-share dollars for the buffer practices needed.

In buffer work performed at Iowa State University, Dr. Joe Colletti has calculated several cost estimates for multi-species riparian buffers. Here are some example cost estimates on a dollar-per-acre basis. Estimates are based on designs that vary the width of the buffer, including zone widths of both the woody and warm-season grass vegetations. (All costs are in 1999 dollars).

Design	Buffer Width:		
	66 ft.	100 ft.	150 ft.
2 tree rows	\$381/ac	\$310/ac	\$264/ac
4 tree rows	\$586/ac	\$447/ac	\$356/ac
5 tree rows	\$692/ac	\$516/ac	\$401/ac

[The cost estimates decrease with wider buffer width because the cost is on a unit area basis and the proportion of area planted to woody vegetation decreases. In many cases, grass costs less to install than trees and shrubs, so the unit area cost ($ per acre) decreases. As one widens a buffer with a fixed number of rows of trees and shrubs (2 or 4 or 5), the linear length required to have one acre planted in buffer decreases.]

Note the following assumptions: Trees and shrubs may be used in combination with the total number of rows. Planting will occur into previously cropped land. The costs per acre will be slightly higher if planting into pasture (Iowa experience based on tree/shrub costs $0.45 each).

First year maintenance activities and costs may include: pre-emergent chemicals and two mowings; warm-season grass $18 per pound with 8 lbs/acre seeding rate; planting cost for trees/shrubs is $0.27 each; and a mix of timothy (5 lbs/acre at $10/lb) and perennial rye (7 lbs/acre at $10/lb) as a cover crop (custom planting cost at $8.50 per acre). Tree/shrub planting density is 10 feet between rows and 5 feet between plants within row.

Also note that under the current CRP specs, the 100-ft and 150-ft, 2-row designs do not qualify for the program because there is not enough area in trees. Using Iowa custom rates and costs for comparison, a 66-ft wide buffer planted exclusively in switchgrass will cost $197/acre.

The Iowa costs may be slightly higher than Missouri costs.

UMCA Riparian Forest Buffers Research:

Ongoing USDA-ARS projects on riparian buffers and water quality are conducted at University of Missouri research farm sites and private landowner farm sites across the state. A primary goal is to determine the most suitable tree, shrub and grass species for removing agricultural chemicals from runoff water, as demonstrated in the following projects.

Success Stories

Lon Strum rotates corn and soybeans on his 1,000-acre operation in Story County, Iowa. Before installing a riparian buffer, his tractor would occasionally get stuck on the banks of Bear Creek. While he no longer produces corn or soybeans from the buffered land, he no longer loses his crops during wet years, doesn't have to worry about getting his tractor stuck, and enjoys the benefits of a healthy stream with a significant amount of habitat.

"When I was on the edges, I was constantly getting stuck as I was working close to the creek. It was just more hassle then what I wanted. Since putting in the riparian buffer, I don't notice any difference in the yields, but now I just go in straight rows.

The buffer has also added to our wildlife habitat. This is the hunting paradise of Story County right here, especially for pheasant hunting. People have come from Alaska, Michigan, and all over Iowa. The demand is very large."

Ron Risdal, another Story County, Iowa, landowner, has experienced similar success with the riparian buffer he installed more than 12 years ago. Risdal rotates corn, soybeans, and alfalfa on his farm.

"There's always something new. We can go fishing, or we can go out here and kick up a deer or pheasant or partridge. I don't think we've lost hardly any stream bank since 1993, but before we were moving fences almost every year. Yesterday morning when it was flooding, it stopped at the buffer strip instead of washing all over the bank. We don't have to haul rocks in the gullies like we used to do years ago."

Bioremediation of Herbicides in Grass and Agroforestry Buffers

Project Team: C.H. Lin, M.F. George, and H.E. Garrett, University of Missouri Center for Agroforestry; R.N. Lerch, USDA ARS, Columbia, Mo.

Herbicides are among the non-point source pollutants of greatest health concern in the Midwestern United States. More than 70% of the herbicides used in the U.S. are applied in the Midwest for corn and soybean production. Many herbicides, such as atrazine, are relatively persistent in soils with an average half-life ranging from 4 to 57 weeks. Not surprisingly, herbicides and their metabolites are commonly found in the wells, surface runoff, shallow aquifer, and surface drinking water supply throughout Missouri.

A well designed tree-shrub-grass riparian buffer strip is recognized as one of the most cost-effective approaches to alleviate non-point source pollution from adjacent crop lands. Current UMCA research involves four projects with the goals of optimizing riparian buffer designs in agroforestry systems to: 1) reduce herbicide transport to nearby agricultural lands before they reach riparian areas (streams and lakes) and 2) to enhance the degradation process of the herbicides trapped within the buffers.

This research will provide valuable tools for government agencies and landowners to optimize a cost-effective buffer strip design and improve the effectiveness of buffer strips for the bioremediation of herbicides derived from agricultural operations. A well-designed riparian forest buffer will not only minimize the amount of herbicide and their metabolites transported into the shallow aquifers or surface water, which are used for private and public drinking water sources, but also minimize the amount of land required to be taken out of crop production to reduce pollutants to acceptable levels. Other benefits may include significantly reduced operation and maintenance costs at local water treatment facilities. Findings from the research may also encourage local governments to implement more extensive cost-share, annual incentive or rental payment programs for landowners for the adoption of tree-shrub-grass riparian buffers.

Key Findings:

- Grass buffers significantly reduced herbicide transport in surface runoff.
- Grass buffers with native species displayed the best season-long effectiveness to reduce herbicide transport.
- An experimental filter strip of native warm season grasses approximately 27 feet wide removes about 75-80% of atrazine, metolochlor and glyphosate from surface runoff.
- The placement of switchgrass hedges situated at the beginning of the tall fescue buffers enhanced the reduction rates of atrazine and metolochlor transport by 13% and 9%, respectively, at a distance of approximately 3 feet from the herbicide application source.
- Warm-season switchgrass is shown to have the highest capacity to degrade and immobilize atrazine in soils, degrading more than 80% of applied atrazine to less toxic metabolites within 25 days of application.

Sources:

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Agroforestry Practices, Runoff, and Nutrient Loss: A Paired Watershed Comparison

Project Team: R.P. Udawatta, H.E. Garrett, and R.L. Kallenbach, University of Missouri Center for Agroforestry

Pollution of surface and ground waters linked to agricultural practices remains a serious concern in the United States. Excess nitrogen and phosphorus runoff have resulted in the "dead zone" in the Gulf of Mexico, and through water runoff and soil erosion, agrochemicals from herbicides and other soil amendments may generate millions of dollars in water treatment costs each year. States are required to implement water quality standards based on U.S. Environmental Protection Guidelines or other scientific methods, resulting in an increasing need for economically and environmentally suitable practices to reduce non-point source pollution from agricultural watersheds. UMCA researchers continue to investigate agroforestry practices, including alley cropping and riparian forest buffers, as environmentally beneficial solutions to non-point source pollution that also provide economic benefits to landowners.

Two long-term experiments of national significance in the science of agroforestry are the paired watershed at the University of Missouri Greenley Memorial Research Center Novelty, MO and replicated grazing study at the Horti Agroforestry Research Center, New Franklin, MO. The paired watershed project consists of:

1.) a corn-soybean/tree-grass buffer (agroforestry)
2.) a corn-soybean/ grass buffer, and
3.) a control treatment with a corn-soybean rotation

The replicated grazing project consists of: Two riparian buffer, two grass buffer, and two no-buffer control watersheds. These two long-term watersheds are being evaluated to determine the effects of upland and riparian buffers on sediment and nutrient losses from rowcrop and grazing management practices.

Key Findings:

- Incorporation of agroforestry practices into rowcrop agriculture has been shown to reduce runoff by 16% compared to a conservation-tilled, rowcropped watershed.
- Soil erosion was reduced by 30% and 48% by agroforestry buffers on rowcrop and grazing watersheds
- Treatments reduced total phosphorus loss by 48% on row crop and grazing watersheds
- Agroforestry buffers reduced total nitrogen loss by 43%

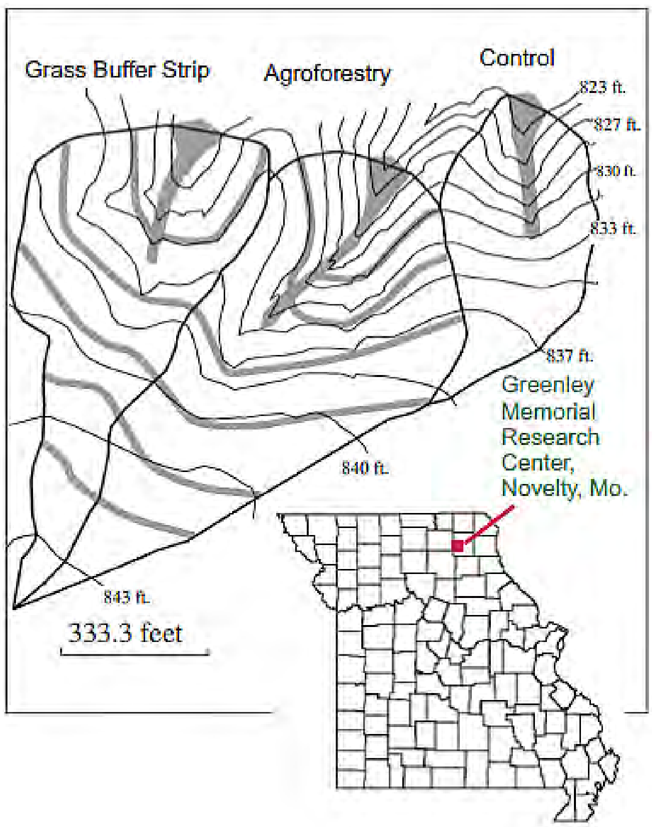

Figure 7: *Study site location and 1.5-foot interval topographic maps of grass buffer, agroforestry buffer and control watersheds. Broad gray areas represent grass strips (contour strip) and tree and grass strips (agroforestry). Grass waterways are visible from H Flumes in all watersheds.*

Aerial view of study site, 2015

Sources:
Udawatta, R.P., J.J. Krstansky, G.S. Henderson, and H.E. Garrett. 2002. Agroforestry practices, runoff, and nutrient loss: A paired watershed com.parison. Journal of Environmental Quality. 31:1214-1225

Udawatta, R.J., P.P. Motavalli and H.E. Garrett. 2004. Phosphorus loss and runoff characteristics in three adjacent agricultural watersheds with claypan soils. Journal of Environmental Quality. 33:1709-1719.

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Effectiveness of Riparian Forest Buffers in Headwater Watersheds of the Western Corn Belt Plains Ecoregion

Project Team: Tom Isenhart and Dick Schultz, Iowa State University (ISU) Dept. of Natural Resource Ecology & Management; Bill Simpkins, ISU Dept. of Geologic & Atm. Sciences; ISU Research Associates/Scientists Leigh Ann Long, Jin-Kie Yeo

The water quality - riparian project cluster, combining expertise from the ISU Agroecology Issue Team, MU and UMCA researchers and researchers at the National Agroforestry Center, Lincoln, Neb., and ARS Dale Bumpers Small Farm Research Center, Booneville, Ark., continues to work on the design, management and efficacy of the riparian forest buffer agroforestry practice in reducing the input of NPS pollution from upland practices into surface waters. A major goal of the cluster is to create flexible buffer designs that are maximally effective across the agricultural region of the Midwest. Researchers and natural resource managers generally agree that, given appropriate site conditions, a well-planned and properly maintained riparian forest buffer can have remarkable effects on sediment trapping and nutrient processing for overland and shallow ground water entering and within the riparian zone (Simpkins et al., 2002; Schultz et al., 2004). They not only provide buffer functions for surface and subsurface pollutants but also provide stream bank stabilization, diverse wildlife habitat and a potential income source for landowners (Schultz et al., 2000).

In collaboration with researchers at Iowa State University, UMCA is studying the impact of riparian forest buffers in the headwaters of the Crooked Creek watershed (in Missouri's Mark Twain Watershed) by monitoring associated groundwater wells. Results of these tests indicate that riparian forest buffers composed of combinations of warm or cool season grasses, shrubs and trees remove significant amounts of nitrates from the groundwater moving toward the stream.

Riparian forest buffer established near a stream

Key Findings:

- Groundwater moving below crop fields contains significantly higher levels of nitrates from fertilizers than groundwater moving below lightly used stream side pastures.
- Properly designed riparian buffers containing trees, shrubs and native warm or cool-season grasses can effectively intercept sediment and surface chemicals before they enter a stream.
- 42% of the forested strips along first order streams in the Crooked Creek watershed, and 10% of the higher order forested strips, are narrower than the NRCS recommended widths. Efforts to establish riparian buffers should be targeted toward first and second order headwater streams, as these are in closest contact with agricultural activities.

Sources:

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Informational Resources for Riparian Forest Buffers

University Resources

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(573) 884-2874
email: umca@missouri.edu
www.centerforagroforestry.org

Iowa State University Extension
www.extension.iastate.edu/
(See publications list for "Stewards of our Streams" series on riparian buffers. Listed under Water Resources and Water Quality section)

Healthy Land, Clean Water: Riparian Management Systems
www.buffer.forestry.iastate.edu/
(A resource web site from the Iowa State Agroecology Issue Team of the Leopold Center for Sustainable Agriculture)

University of Missouri Extension
http://extension.missouri.edu
(Use subject search for publications and links to newsletter articles for riparian buffers)

Five Practices of Agroforestry DVD
Produced by the University of Missouri Center for Agroforestry, available on YouTube via PublicResourceOrg

State-Based Resources

Missouri Department of Natural Resources
P. O. Box 176
Jefferson City, MO 65102
(573) 751-3443
https://dnr.mo.gov/
(Perform a search for "buffers" to see current bulletins and information.)

Missouri Department of Conservation,
Timber Management Assistance
https://mdc.mo.gov/trees-plants/forest-care/timber-management-assistance?msclkid=716583a3c71f11ec9f580f23d3a5a68f

Grow Native!
PO Box 180
Jefferson City, MO 65102
(573) 522-4115
www.grownative.org

Federal Resources

USDA Agricultural Research Service (ARS)
www.ars.usda.gov
(Search for "buffers" to find research projects and publications)

Natural Resources Conservation Service
www.nrcs.usda.gov/
(Use subject search to view nationwide guides and publications on riparian buffers.)

The USDA National Agroforestry Center
North 38th St. & East Campus Loop
UNL-East Campus
Lincoln, Nebraska 68583-0822
(402) 437-5178
https://www.fs.usda.gov/nac/

Non-Profit Organizations

Trees Forever
www.treesforever.org/

Mid-America Regional Council (MARC)
www.marc.org/

Follow UMCA on social media:

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Facebook: The Center for Agroforestry
YouTube: Mizzou Agroforestry
Instagram: @MUAgroforestry
LinkedIn: University of Missouri Center for Agroforestry

The Agroforestry Podcast
The UMCA's podcast series exploring a wide range of agroforestry topics.

Listen wherever you get your podcasts.

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