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Summary

The highly productive agricultural landscape of the midwestern United States yields substantial quantities of nonpoint source (NPS) pollutants which find their way into surface and groundwater. While upland conservation practices can reduce NPS pollution, it is the riparian zone immediately along the stream edge which may contribute the most to NPS pollution. If this zone is exploited by row crop agriculture or overgrazing, NPS pollutants can be generated immediately adjacent to the stream. If riparian zone best management practices (BMPs) are employed, that source of NPS pollution is eliminated and the riparian zone becomes a living filter of NPS pollutants generated in the upland. Increased use of such buffer zones has the potential to greatly improve the environmental performance of the agricultural landscape.

The Agroecology Issue Team of the Leopold Center for Sustainable Agriculture and the Iowa State Agroforestry Research Team (IStART) are conducting research on the design and establishment of multi-species riparian buffer strip systems (MSRBS). The objectives of such buffers are to intercept eroding soil and agricultural chemicals from adjacent crop fields, slow flood waters, stabilize streambanks and reduce channel movement, and improve in-stream environments, while also providing wildlife habitat and biomass for energy and high quality timber. The system includes soil bioengineering features to stabilize streambanks and small wetlands placed at the outlet of field tiles to process chemicals contained in tile flow before it enters the creek. The interdisciplinary teams began the research on a private farm, located along Bear Creek in a highly developed agricultural region of central Iowa, in 1990. The restored MSRBS systems have reduced sediment and chemicals moving with surface runoff by trapping over 90% of the material in the buffer zone where the plants and soil microbes can immobilize and metabolize them. NPS pollutants moving through the soil solution of the rooting zone or in the shallow groundwater also are reduced by over 90% to levels well below the maximum contaminant levels allowed by the U.S. Environmental Protection Agency. Similar improvements in water quality are seen in water passing through the tile wetland, and streambanks are stabilized by the living willow stems and associated grasses and forbes. The following design and establishment criteria are a result of the research and experiences gained by the interdisciplinary teams over the past five growing seasons.

General Design

The general MSRBS layout consists of three zones. Starting at the creek or stream bank edge, the first zone includes a 30-foot-wide strip of 4-5 rows of trees, the second zone is a 12-foot-wide strip of 1-2 rows of shrubs, and the third zone is a 24-foot-wide strip of native warm-season grass. This zonation design is important because the trees and shrubs provide perennial root systems and long-term nutrient storage close to the stream, while the grass provides the highest density of stems needed to dissipate the energy of surface runoff from the adjacent cropland. Modifications of this design are described later.

Plant Selections and Combinations

Fast growing trees are needed to develop a functioning MSRBS in the shortest possible time. It is especially important that rows 1-3 (row 1 is the closest to the streambank edge) in the tree zone (zone 1) should include fast-growing, riparian species such as willow, cottonwood, silver maple, hybrid poplars, green ash, and box elder. Other moderate-growth species include black ash, river birch, hackberry, shellbark hickory, swamp white oak, pin oak, Ohio buckeye, and sycamore. The key to tree species selection is to observe native species growing along existing natural riparian zones and select the faster growing species. If height from the top of the streambank to the water level at normal flow (summer non-flood stage) is more than 4 feet and soils are well drained, species such as black walnut, red oak, white oak, white ash or even selected conifers can be planted in rows 4 and 5. The slower-growing species will not begin to function as nutrient sinks as quickly as faster-growing species. Still other selections could be made based on species growing in neighboring uplands.

Shrubs are included in the design because of their permanent roots and because they add biodiversity and wildlife habitat. Their multiple stems also function to slow flood flows. The mixture of species that have been used by IStART include ninebark, red-osier and gray dogwood, chokecherry, Nanking cherry, and Nannyberry. Other shrubs can be used, especially if they are native species and provide the desired wildlife/aesthetic objectives. These other species could include speckled alder, serviceberry, silky dogwood, hawthorns, Eastern wahoo, wild plum, pin cherry, peachleaf willow, sandbar willow, buffalo berry, Nannyberry, viburnum, and blackhaw.

The grass functions to intercept and dissipate the energy of surface runoff, trap sediment and agricultural chemicals in the surface runoff, and provide a source of soil organic matter for improving soil quality and for microbes which decompose and metabolize the NPS pollutants. A minimum width of 20 feet of switchgrass is recommended because it produces a uniform cover and has dense, stiff stems which provide a highly frictional surface to intercept surface runoff. Other permanent warm season grasses, such as Indian grass and big bluestem and native perennial forbs, also may be part of the mix. Because of its structure, switchgrass should be used where surface runoff is most severe.

The MSRBS system that is presented here prescribes a zone of trees, a zone of shrubs, and a zone of prairie grass. Although these species combinations provide a very effective plant community, they are not the only combinations that can be effective. Site conditions, major buffer strip biological and physical function(s), owner objectives, and cost-share program requirements should be considered in specifying species combinations.

The following are given as examples of other possible plant combinations:

1) Shrub rows may be replaced by trees rows or vice versa, depending on whether wildlife habitat or wood fiber is the primary objective. In any case, a mixture of trees or shrubs species is beneficial for providing soil stability.

2) All zones could be planted to prairie grass instead of the shrubs and trees. If grasses are planted along the streambank, willow cuttings or other shrub species could be used in the streambank to provide long term streambank stability.

3) Prairie grass could be replaced by a dense, strong, cool-season grass such as fescue that might be more palatable forage, especially if surface runoff is not a major problem. Harvesting or controlled grazing and using fence to keep livestock out of the stream could be used to remove the biomass from the site.

4) A seeding of a mixture of trees and shrubs could be directly broadcast in the tree-shrub zone to naturalize the planting by avoiding rows.

5) In urban settings, warm season grasses could be planted over the whole zone along with groups of shrubs and/or trees to provide a diverse, naturalized look. This might provide a good setting for installing a well-designed bike or walking path within the buffer strip.

There are numerous other possible combinations. The keys to remember are that the plant community should be matched to the owners objectives, the important function(s) of the buffer strip, and cost-share program requirements.

MSRBS Establishment

If a proposed MSRBS site was a grazed pasture, it is recommended that 4-foot-wide strips in Zones 1 and 2, where trees and shrubs are to be planted, and all of Zone 3, the grass zone, be treated with glyphosate. Treatment should be done the fall before spring planting. If a proposed MSRBS site was in row crops the area should be disked and Zones 1 and 2 planted with a mixture of 5 lbs/ac of perennial rye and 7 lbs/ac timothy. After disking, Zone 3, the area where switchgrass will be planted, should be packed to provide a better seedbed for drilling. If perforated tile lines run through a proposed MSRBS site, they should be replaced with solid lines or a 30-foot-wide strip of grass or shallow-rooted shrubs planted over the tile across the MSRBS.

Tree rows should be planted 6-8 feet apart. Within rows, trees should be planted 4-8 feet apart, depending on product. For short-rotation biomass products, 4-foot spacing is adequate, however, for timber products use 8-foot spacing. Shrub rows should be 6 feet apart. Within rows, shrubs should be planted 3-6 feet apart, depending on the mature size of the shrubs. Immediately after planting, a pre-emergent herbicide should be applied in a 4-foot-wide band (ex. Goal & Surflan, Oust). A prairie seed drill should be used to plant switchgrass at 5-8 lbs/ac. Seed can be drilled into killed sod or into a disked and packed soil.

Weed control is of paramount importance during the first 2-3 years of establishment. The planting should be inspected frequently and appropriate herbicides or mowing used if needed. The tree and shrub rows should be mowed once or twice during the season to help identify the planting rows and to discourage rodent problems. The plantings should be inspected after every major storm event and areas repaired where surface runoff or flood flows have washed out plant material.

It costs about $350-$400 per acre to install the three-zone MSRBS. This includes plant purchases, site preparation, planting, and maintenance costs in the first year. About $20 per acre should be figured for annual maintenance for the first 3-4 years.

MSRBS Width

Although the model that IStART has developed is 66 feet wide on each side of the creek, stream, or river, a MSRBS system may have different widths that can be adapted to fit each site and land ownership. The total width of the buffer strip depends in large part on the major functions of the buffer strip and the slope and use of the adjacent land. If the major purpose of the buffer strip is sediment removal from surface runoff, a width of 50 feet may be sufficient on slopes of 0-5%. If excess nutrient removal also is an important function, a width of 66-100 feet would be necessary depending on the kind and quantity of agricultural chemicals applied and the soil and cultivation system used. If row crops are found adjacent to the buffer strip, both the sediment and chemical removal functions would be important.

In an urban setting where surface runoff is the major concern, a 50-foot-wide buffer strip should be effective. If wildlife habitat is an important objective of the buffer strip, widths of 100-300 feet would provide a more suitable wildlife corridor or transition zone between the upland agricultural land or urban/suburban areas and the aquatic ecosystem.

As the slope, intensity of land use, or total area of the land producing NPS pollutants increases, or as soil permeability decreases, a wider MSRBS is required. Some recommendations in the literature suggest: 1) 20% of the total NPS pollutant area should be in MSRBS; 2) land capability classes I, II, V = 95 ft, III & IV = 120 ft, VI & VII = 170 ft; and 3) USDA Forest Service and USDA Soil Conservation Service recommend a width of at least 95 feet.

Streambank Bioengineering and Constructed Wetland Options

An MSRBS system can provide additional streambank stability if soil bioengineering techniques are employed. On vertical or actively cutting streambanks, combinations of willow "posts" and/or anchored dead tree revetments can be used to slow bank collapse. These plant materials provide a frictional surface for absorbing stream energy and trapping sediment. The goal of these plantings is to change the streambank angle from vertical to about 50° to allow other vegetation to become established. Willow cuttings are collected during the dormant season, cut into 1-6 foot sections, and stored in a cooler until planting. Small cuttings with diameters between 1/4 and 2 inches can be manually installed. Large diameter cuttings should be hydraulically installed using an auger mounted on a backhoe.

One or two rows of the largest cuttings should be pounded into the stream bed at the base of the streambank at spacing of 2 ft x 2 ft between posts. An additional 2-4 rows of cuttings should be planted into the bank above the low water line. Small wing dams of willow posts can be extended into the stream by placing double rows of 3-4 posts at right angles or pointed slightly downstream. Where there is a concern for active undercutting of the bank, bundles of eastern red cedar or small hardwoods (5-6 year old) silver maples, willows, etc. can be tied together into 2-4 tree bundles. A row of these bundles is laid along the bottom-most row of willow posts with the bottoms pointed upstream and the bundles anchored into the bank.

In areas with extensive agricultural tile drainage, small wetlands can be constructed at the end of field tiles to interrupt and process NPS pollutants before they enter water bodies. A 2-3 foot deep depression is constructed at the ratio of 1:100 (1 acre of wetland for 100 acre drainage). The berm can be stabilized on the stream side with willow cuttings and the rest can be seeded to a mix of prairie grasses and forbs. If a coarse-textured soil is encountered, the bottom of the wetland can be sealed with clay. A gated control structure for controlling water level should be installed at the outflow into the stream. Cattail rhizomes can be planted at a spacing of 2 ft x 2 ft during early spring when shoots have just begun to elongate.

The above recommendations will provide a MSRBS system that effectively intercepts and treats NPS pollution from the uplands. However, a MSRBS system cannot replace upland conservation practices. In a properly functioning agricultural landscape both upland conservation practices and a MSRBS system should be in place.