1-1-1997

Agroforestry Systems: The Bear Creek Riparian Management Success Story

Richard C. Schultz
Iowa State University

Thomas M. Isenhart
Iowa State University

Joe P. Colletti
Iowa State University

Follow this and additional works at: https://lib.dr.iastate.edu/amesforester
Part of the Forest Sciences Commons

Recommended Citation
Available at: https://lib.dr.iastate.edu/amesforester/vol84/iss1/2

This Article is brought to you for free and open access by the Journals at Iowa State University Digital Repository. It has been accepted for inclusion in Ames Forester by an authorized editor of Iowa State University Digital Repository. For more information, please contact digirep@iastate.edu.
Agroforestry Systems: 
The Bear Creek Riparian Management Success Story

Richard C. Schultz - Professor
Thomas M. Isenhart - Research Associate
Joe P. Colletti - Associate Professor

Department of Forestry
Iowa State University

Introduction
The agricultural landscape has four major sources of non-point source (NPS) pollutants. These are: 1) surface and subsurface runoff which carry sediment and agricultural chemicals to streams; 2) eroding streambanks which can contribute more than fifty percent of the sediment load to the stream; 3) field tile drains which contribute the highest concentrations of soluble agricultural chemicals to streams; and 4) livestock grazing of streamside or riparian areas which contribute to bank instability and add animal waste and pathogens to the water.

Riparian Management Systems
To demonstrate the benefits of properly functioning riparian zones in the heavily row-cropped midwestern U.S., the Agroecology Issue Team (AIT) of the Leopold Center for Sustainable Agriculture and the Iowa State Agroforestry Research Team (IStART) are conducting research on the design and establishment of a Riparian Management System (RiMS) model. The purpose of this system is to restore the essential ecological functions that the riparian areas once provided. Specific objectives of this riparian management system are to intercept eroding soil and agricultural chemicals from adjacent crop fields, slow flood waters, stabilize streambanks, provide wildlife habitat, and improve the biological integrity of aquatic ecosystems.

The RiMS model consists of four components: 1) a constructed, multi-species riparian buffer strip, 2) soil bioengineering technologies for streambank stabilization, and 3) constructed wetlands to intercept and process NPS pollutants in agricultural drainage tile water and riparian zone rotational grazing systems with controlled access to the stream channel (Figure 1). The RiMS is being designed so the four components can be used individually or in combination depending on the NPS pollution problems that have been identified for a particular landscape. The research on this model was initiated in 1990 along a 1 km length of Bear Creek in a highly developed agricultural region of central Iowa. The buffer strip system has subsequently been planted along an additional 2.4 km of Bear Creek upstream from this original site.

Multi-Species Riparian Buffer Strip
The general multi-species riparian buffer strip layout consists of three zones (Figure 2). Starting at the creek or streambank edge, the first zone includes a 10 m wide strip of 4-5 rows of trees, the second zone is a 4 m wide strip of 1-2 rows of shrubs, and the third zone is a 7 m wide strip of native warm-season grass. This 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 high density of stems needed to dissipate the energy of surface runoff from the adjacent cropland.

Fast growing trees are recommended to provide a functioning multi-species riparian buffer strip in the shortest possible time. It is especially important that rows 1-2 (row 1 is closest to the streambank edge) in the tree zone include fast-growing, riparian species such as willow (Salix sp.), cottonwood (Populus deltoides), silver maple (Acer saccharinum), hybrid poplars (Populus sp.), green ash (Fraxinus pennsylvanica), and box elder (Acer negundo). Appropriate moderately-fast growing species include black ash (Fraxinus nigra), river birch (Betula nigra), hackberry (Celtis occidentalis), shellbark hickory (Carya laciniosa), swamp white oak (Quercus bicolor), Ohio buckeye (Aesculus glabra), and sycamore (Platanus occidentalis) can be grown in rows 3-5. 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 1 m and soils are well drained, species such as black walnut (Juglans nigra), red oak (Quercus rubra), white oak (Quercus alba), white ash (Fraxinus americana) or even selected conifers can be planted in rows 4-5 ft. apart. The slower growing species will not begin to function as significant nutrient sinks as quickly as faster growing species. 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 non-flood stage is more than 1 m and soils are well drained, based on species growing in neighboring uplands. (Viburnm lentago). Shrubs are included in the design because of their permanent tomentosa), a aesthetic objectives. These other species could include chokecherry (Prunus virginiana), Nanking cherry (Prunus tomentosa), hazel (Corylus americana), and nannyberry (Viburnm lentago). Other shrubs can be used, especially if they are native species and provide the desired wildlife/energy of surface runoff, trap sediment and agricultural organic matter for microbes which can metabolize the NPS pollutants. A minimum width of 7 m of switchgrass (Panicum virgatum) is recommended because it produces a uniform cover and has dense, stiff stems which provide a highly frictional surface to intercept surface runoff and facilitate infiltration. Other warm season grasses, such as Indian grass (Sorghastrum nutans) and big bluestem (Andropogon gerardii) 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. If the buffer strip is being planted on a recently abandoned crop field, a mixture of perennial rye and timothy grass should be sown before or at the time of planting. If the buffer strip is being established on an abandoned pasture, strips of grass should be killed prior to planting the trees and shrubs. The prairie seed mix can be drilled into a pasture sod that has been killed with a herbicide. Weed control is of paramount importance during the first 3-4 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 multi-species buffer strip. 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. Cost-share programs such as the Conservation Reserve Program (CRP) and the Stewardship Incentive Program (SIP) can provide assistance with establishment costs.

The multi-species riparian buffer strip model 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 (e.g. soils, slope), major buffer strip biological and physical function(s), owner objectives, and cost-share program requirements should be considered in specifying species combinations and placement.

Although the model that AIT and ISTART have developed is 20 m wide on each side of the creek, stream, or river, a multi-species riparian buffer strip 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 10 -15 m may be sufficient on slopes of 0-5%. If excess nutrient removal from the soil solution also is an important function, a width of 20 - 30 m 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. If increased wildlife habitat is an objective of the buffer strip, widths of 30 - 100 m would provide a more suitable wildlife corridor or transition zone between the upland agricultural land and the aquatic ecosystem (Castelle et al. 1994).

Streambank Bioengineering

Several authors have estimated that greater that 50% of the stream sediment load in small watersheds in the Midwest is the result of channel erosion (Roseboom and White 1990). This soil usually consists of small silt and clay particles which are ultimately deposited in rivers, lakes or backwater areas, choking these areas with sediment and diminishing their value as habitat for fish and aquatic macroinvertebrates (Frazee and Roseboom 1993). This problem has been exacerbated by the increased erosive power of streams as result of stream channelization and loss of riparian vegetation. The typical solution is to buttress blocks of concrete, wood or steel along the stretch of the bank which is eroding (Frazee and Roseboom 1993). Such solutions are costly to build and maintain, provide little aquatic habitat and often do not slow water movement because of their smooth surfaces. An alternative streambank stabilization technique is the use
of locally available natural materials such as willow posts or other live plant material, often in combination with revetments of rock, cut Eastern redcedar, or other woody material (Figures 3 and 4). These techniques are often referred to as soft engineering or soil bioengineering. The root systems of these plants provide strength to the streambank soils and their stems provide a frictional surface which slows flood flows reducing their erosive potential. If these stems are damaged by unusually large flood events, the roots and remaining stems will produce new stems. This dynamic system also can provide habitat for terrestrial and aquatic organisms.

Several different soil bioengineering techniques have been employed by AIT and ISTART (Figures 3 and 4). On vertical or actively cutting streambanks, combinations of willow ‘posts’ and/or anchored dead tree revetments are 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 (Salix sp.) cuttings with diameters ranging from 0.6 cm to 12 cm are collected during the dormant season, cut into 0.3 - 3 m sections, and stored in a cool place until planting. Small cuttings with diameters between 0.6 cm - 5 cm can be manually installed. Large diameter cuttings should be hydraulically installed using an auger mounted on a backhoe.

One or three rows of the largest cuttings (posts) are placed into the stream bed at the base of the streambank at a spacing of 0.6 x 1 m between posts. An additional 2 - 4 rows of small diameter cuttings (stakes) should be planted into the bank above the low water line.

Where there is a concern for active undercutting of the bank, the toe of the bank can be stabilized using bundles of Eastern redcedar (Juniperus virginiana) or small hardwoods (5-6 year old) such as silver maples, oaks, etc. can be tied together into 2 - 4 tree bundles. A row of these bundles is laid horizontally along the bottom most row of willow posts with the bottoms pointed upstream and the bundles anchored into the bank. Where potential undercutting may be severe, rock can be used along the toe. Where high, flashy flood flows are expected, grass can be seeded and natural fiber geo-textile mats can be stapled to the banks with willow cuttings planted through them. These bioengineering solutions are very effective and less expensive than traditional streambank stabilization techniques.

**Constructed Wetlands**

A characteristic of many parts of the upper midwest is the presence of an extensive network of subsurface tile drainage. Such tile drains provide a direct path to surface water for nitrate or other agricultural chemicals which move with the shallow groundwater. In such instances, constructed wetlands which are integrated into new or existing drainage systems may have considerable potential to remove nitrate from shallow subsurface drainage (Crumpton and Baker 1993, Crumpton et al. 1993).

Small wetlands can be constructed, at a ratio of 1 hectare (ha) of wetland to 100 ha of cropland, to process field drainage tile water from the cropped field. A shallow excavation of less than 1 m at the middle can be excavated within the multi-species buffer strip. A s drainage tile is rerouted into the wetland at a point furthest from the stream, maximizing the residence time of drainage tile water within the wetland. A simple gated water level control structure at the wetland outlet provides control of the water level maintained within the wetland. Cattail rhizomes (Typha glauca) can be collected from local marshes or road ditches and planted within the wetland and native grasses and forbs can be planted on the constructed berm.

Bacterial denitrification is the major process of nitrogen removal in constructed wetlands. Thus their removal rate improves over time as an organic substrate of plant remains forms on the bottom. Even initial water quality results are very encouraging with up to 80% of the nitrate-nitrogen being removed during the warmer times of the year. In addition, the wetland is also very attractive as wildlife habitat.

**Rotational Grazing**

Rotational grazing systems can improve streambank stability and forage production for livestock. Large pastures can be divided into 6-7 smaller ones and grazed for several days between 20 -30 day rest periods. This pattern concentrates the grazing pressure for a short time and gives both the streambanks and the forage crops time to recuperate. This method of grazing is more similar to the grazing of bison that once passed over the landscape impacting any one prairie or wetland area for only one or two days at a time. It is best to keep the livestock off of the streambank and out of the channel if sediment and organic chemical additions are to be minimized. This can be done by placing a fence 3 m from the bank edge. Access to the stream can be provided in areas where the bank is stable or pasture pumps can be used to keep the livestock completely out of the stream.

**System Effectiveness**

The components of the RiMS model can effectively intercept and treat NPS pollution from the uplands. However, it should be stressed that a riparian management system cannot replace upland conservation practices. In a properly functioning agricultural landscape, both upland conservation practices and an integrated riparian system contribute to achieving environmental goals and improved ecosystem functioning.
Long-term monitoring has demonstrated the significant capability of these systems to intercept eroding soil from adjacent crop land, intercept and process agricultural chemicals moving in shallow subsurface water, stabilize stream channel movement, and improve in-stream environments, while also providing wildlife habitat, biomass for energy, and high quality timber (Schultz et al. 1995). The buffer strip traps 70-90% of the sediment in surface runoff and has reduced nitrate and atrazine concentrations moving through the soil solution by over 90 percent, with resulting concentrations well below the maximum contaminant levels specified by the U.S. EPA. The constructed wetland has also proven to be very effective in processing nitrate and other NPS pollutants moving in the agricultural tile drainage water. Streambanks protected by bioengineered plant systems have stood up to the recent major floods of 1993 and 1996. Rotational grazing systems can result in revegetation of streambanks and reduced sediment loads. Wildlife benefits have also appeared in a very short time with a nearly five fold increase in bird species diversity observed within the buffer strip versus an adjacent, unprotected stream reach. The RiMS can be effectively used to improve the sustainability of the agricultural landscape.

Literature Cited


