# Sustainable tree-shrub-grass buffer strips along waterways

**Principal investigator**
Richard Schultz
Forestry

**Co-investigators**
Joe Colletti
Carl Mize
Steven Jungst
Paul Wray
Lita Rule
Richard Hall
Forestry

William Simpkins
Geology and Atmospheric Sciences

Micheal L. Thompson
Irvin C. Anderson
Agronomy
Iowa State University

Duane R. Buxton
Agronomy (ISU) and USDA/ARS

**Budget**
$21,950 for year one
$25,609 for year two
$25,609 for year three

## Background

The midwestern landscape, which formerly consisted of prairies, wetlands, and forests, is now primarily devoted to agricultural purposes. Unfortunately, the resulting large-scale agricultural production has also produced nonpoint source (NPS) pollution of water, alteration of waterways, and disruption of wildlife habitat. NPS pollution, whether by sediment, fertilizers, or pesticides, is a problem nationwide. The agricultural community has addressed this problem by increasing soil conservation efforts and improving chemical application practices. One Best Management Practice (BMP) is the use of riparian (streamside) vegetative filter strips on watersheds prone to such pollution. Most such filter strips to date consist primarily of cool-season grasses.

However, because the capacity of these grasses to develop above- and below-ground biomass—and trap sediment and remove agricultural chemicals—is limited, investigators in this ongoing project are studying the capacity of well-managed, multi-species, native riparian plant communities—including trees, shrubs, and grasses—to filter most of the sediment and agricultural chemicals from upland fields before they reach the stream.

Although long-term storage of nutrients and gaseous loss of nitrogen (N) are known to be high in diverse, vegetated riparian areas, little research-based information exists on the efficiency of native, vegetated buffer strips for nutrient uptake cycling compared to grass buffers. This project is unique in that the goal is to restore native vegetation in the form of *constructed multi-species riparian buffer strips* (CMRBS), to study their capacities, their optimal configuration(s), and the best approaches for managing them.

This goal includes determining the effectiveness and economic efficiency of CMRBS of short-rotation woody crop systems and prairie grass to intercept eroding soil and agricultural chemicals from adjacent crop fields, stabilize channels, and improve in-stream environments while providing wildlife habitat, biomass, and timber. Specific objectives were to measure

(1) changes in quality and quantity of surface and groundwater moving from up-slope through the CMRBS to the stream,
(2) quantity of up-slope sediment that is intercepted by the CMRBS,
(3) changes in soil and plant nutrients to determine their role in chemical uptake from water moving through the CMRBS,
(4) the effect of the CMRBS on stream bank stability and in-stream environments,
(5) impact of the CMRBS on wildlife populations,
(6) biomass and potential energy productivity of the CMRBS, and
(7) economic costs and benefits of the CMRBS.

This project was funded jointly by the Iowa Department of Natural Resources (319 funds), the U.S. Environmental Protection Agency, and Iowa State University. While the long-term nature of this project precluded meeting all objectives within this project's time frame, between 1990 and July 1993 the project has attracted more than $200,000 in additional funding from the USDA Cooperative States Research Service and the U.S. EPA Agriculture in Concert with the Environment Program.

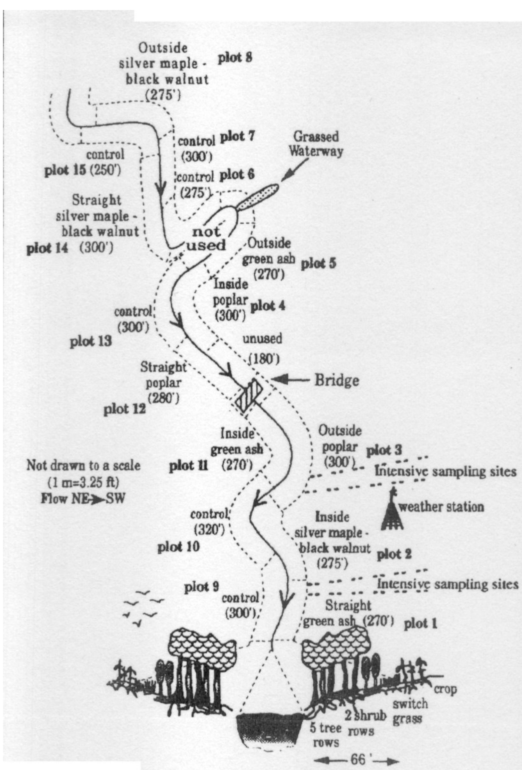
## Approach and methods

The project was conducted by the Iowa State Agroforestry Research Team (IStART), a group of specialists in forage crops, soils, hydrogeology, forest hydrology, forest ecology, wetland ecology, economics, biometrics, wildlife management, and extension.

At the Bear Creek watershed project site in Story County in north-central Iowa, concurrent, closely related research is also underway by the Leopold Center's interdisciplinary agroecology research issue team, led by this project's investigator. The team is developing a vulnerability map of critical reaches along the creek that need modified restoration or management to reduce the impact of NPS. The long-term goal of that project is to help landowners along the creek develop riparian zones that will intercept surface runoff and subsurface flow to prevent agricultural chemicals from reaching the creek.

Bear Creek runs 34.8 kilometers (21.6 miles) before emptying into the Skunk River. The watershed drains 17,180 acres of farmland, most of which have been tile-drained during the past 40 years at a density of up to 25 tiles per kilometer (40/mile). About 85% of the watershed is devoted to corn and soybeans.

***Fig. 1. Plot layout of the CMRBS project located In Story County, Iowa.***




The watershed topography is undulating to level; soils are well-drained to poorly drained. IStART is working on one farm to develop a model of CMRBS restoration. In compiling information on the soils, bedrock, climate, cropping and agricultural history of the site, the team has noted that its most unusual feature is its shallow bedrock, which complicates hydrogeology.

Investigators divided sections of the site as shown in Fig. 1. Treatments consisted of three combinations of planted trees, shrubs, grass, and two controls (pasture grasses). One treatment consisted of a poplar hybrid, another contained green ash, and the third mixed rows of silver maple with black walnut. A row of dogwood, one of ninebark, and a7.3-m (24 ft) wide strip of native prairie switchgrass were located up-slope. Trees are being grown in 6- to 10-year rotations depending on species. One willow post planting was also installed along the outside of the bend on plot 2 (Fig. 1). IStART also established permanent plots for measuring growth and biomass production.

The combined funding and project coordination has allowed maximum efficiency in establishing additional sampling instrumentation, parameters, and procedures, including analyses for nitrate, ammonia, pH, conductivity, alkalinity, temperature, hardness, and atrazine. Hydrology is being studied regionally, at the site scale, and within one section of the CMRBS to create the broadest possible context for interpreting the results. Water movement through the CMRBS is monitored with numerous strategically located piezometers, lysimeters, and collectors of various types in the unsaturated (vadose) zone of the soil above the water table, the unconfined shallow aquifer, the bedrock aquifers, the drainage tiles, and the stream channel. Tensiometers estimate soil-water tension in the vadose zone.

One important aspect of this project is determining whether the CMRBS affect groundwater flow and chemistry and whether they can retain nitrate-N (NO^-N) found in groundwater. Another is determining the contribution of groundwater to creek baseflow and which aquifer serves as the source. By developing N and atrazine mass balances that account for all the applied chemicals in this component of the watershed, the CMRBS ability to reduce NPS pollution can be evaluated.

Aerial photography is being used to identify sources of sediment that reaches the creek from the watershed. The agroecology issue team is using the Revised Universal Soil Loss Equation and another USDA model for measuring sedimentation; sediment traps originally installed at this site did not work because of insufficient slope and shifting of instrumentation. Other approaches are being devised to gather sediment data.

## Findings

Cultivation and intensive grazing in riparian zones aggravate NPS pollution in agricultural areas. Annual vegetation (crops) and cool-season grasses provide only minimal biomass and root systems to hold soil in place. A CMRBS consisting of native, non-bunch type prairie grasses, shrubs, and trees produces a plant community that provides resistance to surface runoff and aids soil infiltration; has a large transpiring surface to optimize water and agricultural chemical uptake; provides better below-ground root biomass; has a woody, perennial root mass that stabilizes stream banks; diversifies wildlife habitat; and offers economic diversification potential.

Switchgrass, ninebark, silver maple, poplar hybrids, and willow, which show the fastest above- and below-ground production of biomass (important for site stabilization) are examples of species that can be effectively interplanted in a CMRBS. Willow posts and cuttings provide additional stability to eroding streambanks; investigators estimated that willows planted in strategic locations along Bear Creek's entire length could reduce the suspended sediment flowing into the Skunk River by up to 50%. A CMRBS that incorporates willow posts and tile water remediation methods such as small constructed wetlands or another dispersing system would keep tile water from flowing directly into the stream. In addition, CMRBS can reduce creek storm flow by reducing—via infiltration and tile water remediation—the amount of surface runoff water entering the stream and by slowing the flow of flood waters through the dense vegetation. Along small streams where riparian soils are well drained and the water table is generally below one meter, slower growing hardwoods can be intermixed.

Investigators found that $NO_3$-N concentrations vary by aquifer system; the high concentrations in water moving through the agricultural landscape were found in field tiles that drain cultivated fields. These tiles pass under the CMRBS without plant-soil system interaction. Creek water N exceeds the U.S. EPA's maximum contaminant level (MCL) during late spring and summer after fertilizer application; headwater reaches of the creek produce the highest concentrations because baseflow comes mainly from field tiles, which occur at random spacing along Bear Creek with an average density of 25 per km in the intensively cultivated headwaters area. At the confluence of Bear Creek and the Skunk River, the Bear Creek watershed can deliver as high as 3.5 metric tons of N per day during high discharge events in the summer months. The effect of CMRBS on this loading, particularly the effect on water-table system N and tile water N, has not yet been clearly established.

The tiles were found to carry atrazine, but not in amounts that exceed the MCL; nevertheless, the cumulative effect of all the tiles combined keep atrazine concentrations high in creek water. It appears that the CMRBS provides a buffer zone of low $NO_3$-N and atrazine concentrations along the creek; it is not yet known whether these low concentrations are attributable to plant-soil processes working on agrichemicals moving through the CMRBS or to the fact that no chemicals have been applied to the CMRBS other than those in the infiltrated surface runoff that was trapped by the CMRBS. Mini-piezometers installed in the groundwater system just below the CMRBS will clarify this.

**Recommendations:** The findings from this study have allowed investigators to recommend that CMRBS be established along any perennial or intermittent stream, as well as around lakes and ponds in and near farming activities. These buffer strips should comprise trees, shrubs, and permanent non-bunch type native grasses (see Fig. 2); varying the tree and shrub species will reduce the likelihood that a disease or insect pest on a single species will significantly damage the CMRBS and will provide more diverse wildlife habitat. Species should be fast growing and well suited to the soils on the site. Willow, cottonwood, silver maple, and green ash meet these criteria. Slower growing species can be interplanted to further diversify habitat and provide biomass as well as traditional forest products.

Buffer strips 20 meters (22 yards) wide are effective and contribute optimally to wildlife habitat. They should run parallel to the stream on each side, following its curvature continuously. Although grassy ground cover within and between rows of trees slows production of biomass, it enhances the overall effectiveness of the CMRBS, and efforts to reduce its competition should be minimized while the CMRBS is getting established.

Finally, investigators have estimated that the CMRBS can be established at a cost of $358 per acre ($885/ha) with annual maintenance costs of $20/acre ($49/ha) during the first five years after establishment. *A CMRBS can be exempted from property taxes under the Iowa Forest Reserve Law; financial assistance with establishment is also available through various organizations.*

## Implications

The Soil Conservation Service published new riparian forest buffer guidelines in 1993 that could correspond well with the CMRBS approach. However, these guidelines, based on work by the U.S. Forest Service along wooded riparian zones, are geared to traditional forest management, whereas the CMRBS is designed to provide woody and perennial fiber products (traditional forest products and biomass for energy) as well as NPS pollution control.

The SCS has actually maintained recommendations for filter strips for some time, but the new buffer strip specifications reflect concerns for mitigating NPS along stream channels and lake and pond shores. Whereas the SCS filter strip recommendations have been aimed at up-slope, ephemeral drainage areas and problems, the recently released SCS buffer strip criteria will accelerate acceptance of riparian buffer strips. Although Iowa has yet to develop guidelines for riparian zone buffer strips, other states have developed BMPs for stream corridors. Over time, these project findings may also contribute to the development of site-specific buffer-strip BMPs.

Additional research is needed to quantify CMRBS sediment trapping ability and the fate of N and atrazine within them. The rate and extent of changes in soil characteristics after establishment of the CMRBS also remain to be determined. In addition, future work should quantify and verify initial samples of root distribution and infiltration capacities; identify and quantify wildlife use and biomass production potential over a full rotation of woody plants; refine economic benefits, costs, and social acceptance; assess impacts of changing governmental farm policies; and establish demonstrations around the state and region.

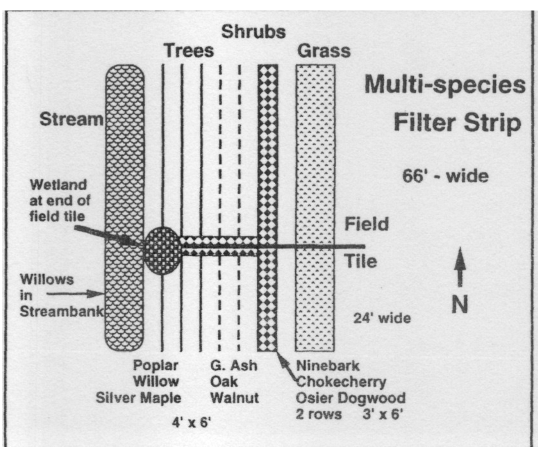



***Fig. 2. Layout for a multi-species buffer strip riparian zone management system that includes an in-stream willow planting and a small wetland at the end of a field tile.***

*For more information contact R, Schultz, Forestry, Iowa State University, Ames, Iowa, 50011, (515)294-7602.*

**Education and outreach:** This project has generated interest nationwide. Team members have made numerous invited presentations, prepared several posters, and authored papers and abstracts for technical meetings and scientific publications. More than 20 tours have been conducted for a wide variety of audiences, and requests for information and presentations about this project continue to increase. The project has attracted media coverage locally, regionally, and nationally.