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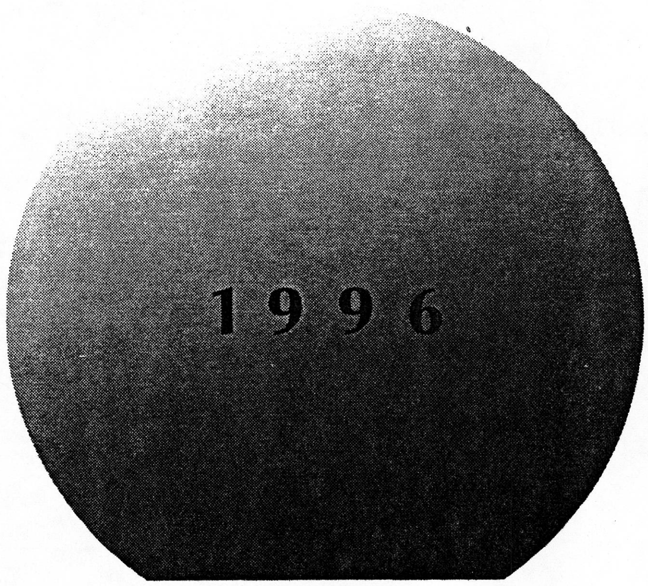

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RIPARIAN MANAGEMENT FOR WATER QUALITY: THE BEAR CREEK EXAMPLE

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To demonstrate the benefits of properly functioning riparian zones in the heavily row-cropped midwestern U.S., 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 integrated riparian management systems. The purpose of these systems is to restore the essential ecological functions that these riparian areas once provided. Specific objectives of such buffers are to intercept eroding soil and agricultural chemicals from adjacent crop fields, slow flood waters, stabilize streambanks, provide wildlife habitat, improve the biological integrity of aquatic ecosystems, and provide diversified marketable products (biomass, wood products, etc.)

The system consists of three components: 1) a constructed, multi-species riparian buffer strip, 2) soil bioengineering technologies for streambank stabilization, and 3) constructed wetlands to intercept and process nonpoint source pollutants in agricultural drainage tile water (Figure 1).

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. Fast growing native trees such as willow (*Salix spp*., poplar (*Populus spp*.), maple (*Acer saccharinum* L.), or ash (*Fraxinus pennsylvanica* Marsh.) are recommended nearest the stream to provide a functioning multi-species riparian buffer strip in the shortest possible time. Where site conditions permit, slower growing species such as oak (*Quercus spp*.) or walnut (*Juglans nigra* L.) can be planted in the outer rows. The trees provide perennial root systems to stabilize stream banks and long-term nutrient storage close to the stream. 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 grass zone 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 microbes which can metabolize nonpoint source pollutants.

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.

Streambank Bioengineering

Several authors have estimated that greater than 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 them with sediment and diminishing their value as habitat for fish and aquatic macroinvertebrates (Frazee and Roseboom 1993). This problem has been worsened by the increased erosive power of streams resulting from 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 and provide little aquatic habitat. 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 cedar, or other woody material. These techniques are often referred to as soft engineering or soil bioengineering. Several different soil bioengineering techniques have been employed by IStART in the Bear Creek watershed. These include the use of dormant willow posts and stakes driven into the bank, bundles of live willows partially buried along the slope (facines), and biodegradable fiber mat anchored with willow stakes on bare slopes. Alternatives used to stabilize the base of the streambank include rock and anchored dead plant material such as cedar or bundled maple. 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 et al. 1993). To initially demonstrate this technology, a small (500 m^2) wetland was constructed on the original project site to process field drainage tile water from a 4.9 ha cropped field. The wetland was constructed by excavating a depressional area near the creek and constructing a low berm. The subsurface drainage tile was rerouted to enter the wetland at a point furthest from the stream, maximizing 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* Godr.*)* collected from a local marsh or road ditch were planted within the wetland and native grasses and forbs planted on the constructed berm. Future plans include the construction of additional tile drainage wetlands within the Bear Creek watershed.

System Effectiveness

The above recommendations will provide an integrated riparian management system that effectively intercepts and treats nonpoint source 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 riparian management 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 instream environments, while also providing wildlife habitat, biomass for energy, and high quality timber (Schultz et al. 1995). The buffer strip traps much the sediment carried 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. Environmental Protection Agency. Streambank bioengineering systems have virtually stopped bank erosion along treated reaches and reversed the process by trapping channel sediment. The constructed wetland has also proven to be very effective in processing nonpoint source pollutants moving in the agricultural tile drainage water. In the case of nitrate-nitrogen, inflow concentrations have generally ranged between 8 and 15 mg L^{-1}. In contrast, outflow concentrations are substantially lower during most times. 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.

Project Development and Technology Transfer

The riparian management research was initiated in 1990 in the Bear Creek watershed in Central Iowa (Schultz et al. 1995). The Bear Creek watershed is typical of the region with over 85% of the land area devoted to row crop agriculture. Two levels of research activity are taking place in this watershed. First is a watershed scale assessment of land use, present condition of the riparian zones, and stream and ground water quality. Combined with geographic information systems and computer modeling, this information allows for the development of vulnerability maps for the watershed identifying critical stream reaches where modified management is expected to reduce the impact of nonpoint source pollution on Bear Creek.

Additionally, socio-economic data collected from landowners in the watershed have assisted in identifying acceptance of the riparian system, and quantifying the value placed on improvement in surface and ground water quality (Colletti et al. 1994). These perceptions are linked with farm-level research relating to the riparian system efficacy to guide watershed level, citizen driven, planning related to soil conservation and water quality improvement. These watershed scale assessments are being conducted primarily by the Agroecology Issue Team of the Leopold Center for Sustainable Agriculture.

The second level of the work, primarily being conducted be the IStART, is the actual establishment of the riparian management system along stretches of Bear Creek and the evaluation of its effectiveness in reducing nonpoint source pollution. This work was initiated in 1990 along a 1 km length of Bear Creek on the Ron and Sandy Risdal Farm. The buffer strip system has subsequently been planted along an additional 2.4 km of Bear Creek upstream from this original site. Buffer strip establishment in the Bear Creek watershed will continue as long as willing landowners and sufficient cost-share can be found.

The development of field research and demonstration sites has been influenced by the source of funding available for the project. Two major kinds of funding opportunities exist, those which support basic and applied research (e.g. US Department of Agriculture National Research Initiative) and those which support on-farm demonstrations (e.g. USDA/EPA Agriculture in Concert with the Environment and the Iowa Department of Natural Resources /US EPA 319 Water Quality Program). The latter funding sources support "real-world" demonstrations of new technologies with some simple monitoring for identifying results to landowners, while the former require replicated and rigorous research results that can be published in the scientific literature. The Bear Creek watershed project tries to incorporate both levels of these activities to meet the objectives of both types of funding programs.

The development of the riparian management system is an ongoing process incorporating several actions. These include:

- concept and design development
- experimental plot work with intensive process monitoring
- field testing of larger scale demonstrations in "real world" situations (e.g. three farms in the Bear Creek watershed)
- measurement of the reaction of landowners and professionals through the use of surveys, focus groups, and informal information exchange
- evaluation of the social acceptance and economic benefits and costs to landowners and society
- refinement of the model to integrate research results as well as social and economic considerations
- technology transfer in the form of:
  - on-site tours, field days, and self-guided walking tours
  - videos and extension bulletins
  - presentations at meetings of professionals, conservation groups, local civic organizations, etc.
  - articles in local newspapers and trade publications
  - publications in refereed journals
- encouragement of local "ownership" through the development of voluntary citizen "action teams" to assist in buffer strip establishment, water quality monitoring, construction of wildlife nesting boxes, etc.
- establishment of demonstration sites in other physiographic regions (Storm Lake, Buena Vista Co.; Volga River, Clayton Co.)
- development of a interdisciplinary network of professionals and practitioners
- training of agricultural and natural resource professionals to help disseminate the information and validate results

Experience gained from outreach and technology transfer activities associated with the Bear Creek watershed project has illustrated the importance of several less formal actions which may help "sell" a technology. A few of these considerations that may be important in other projects include:

- On-farm research and demonstration projects furnish credibility. Conducting demonstrations and research on privately owned farms lends credibility to the project and produces a network of neighbors and area landowners which facilitates technology transfer.
- Visitors or tours should not be hosted before a project site is ready. In most cases there will only be one opportunity to host a visitor at a project site. "First impressions" are therefore very important. Since many nonpoint source pollution reduction strategies utilize slower growing perennial vegetation, several growing seasons are required before the system becomes fully functional or makes a dramatic visual impact. As a result, it may be wise to delay hosting visitors or tours until a site makes the desired impact.
- Tour components should be located in close proximity to each other. If either guided or self-guided tours are to be hosted at a project site, demonstrations of the technologies that need to be seen should be located in close proximity to each other. Most tours will be limited in the amount of time that can be spent at a project site. If the demonstrations are spread out, time will be limiting, and it will be necessary to prioritize the sites to be visited.
- Visible details will have an impact. The visible presence of monitoring equipment, simple markers which indicate visible changes in a landscape, or "before" and "after" pictures will help to lend credibility to a project or technology.
- Local press coverage is very important. Articles written in the local daily or weekly newspapers will go a long way in informing the local population about a project. If a project goal is to gain acceptance for a practice within a specific watershed or area, these sources of information transfer will be invaluable.

An important consideration in encouraging the adoption of such management practices as the riparian model is the identification of landowner objectives. Initial conversations with landowners should focus on identifying their goals and recognizing concerns. The model design should then allow for the flexibility to incorporate these differing landowner objectives as well as site specific conditions. It is vitally important that conservation practices such as the riparian model be adapted to a farm and owner and should complement whole-farm management and planning.

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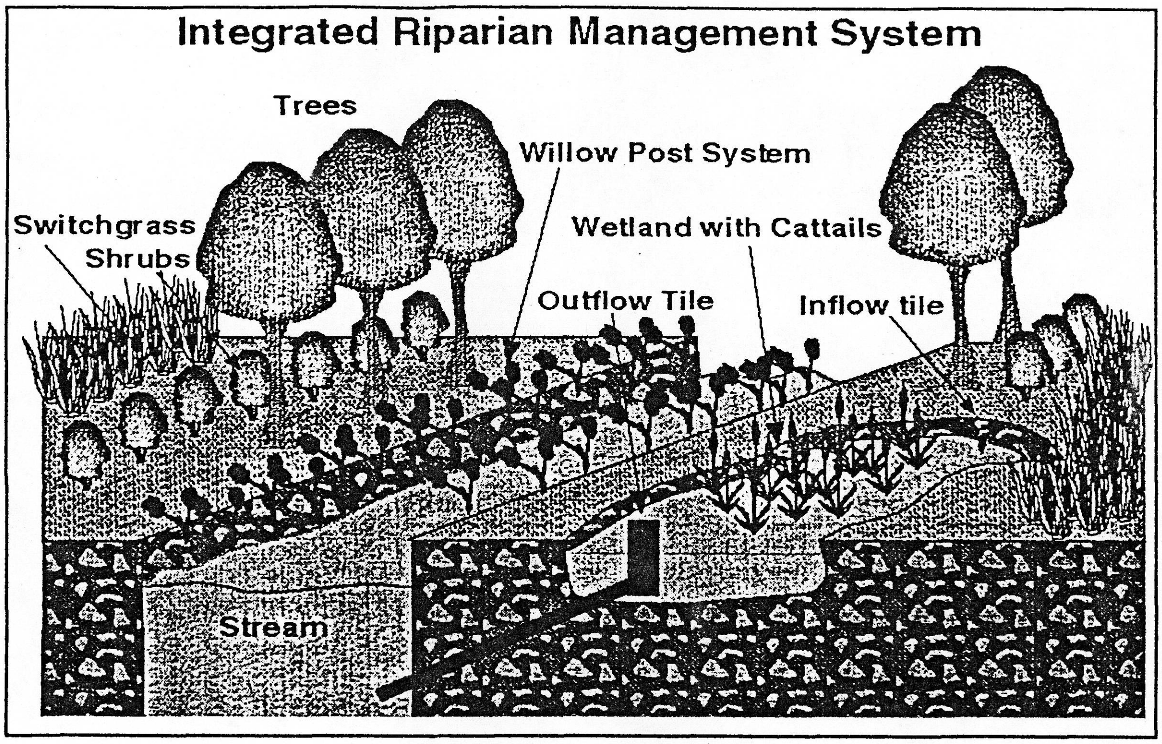

Figure 1. Riparian management system model which integrates a multi-species buffer strip, streambank stabilization technologies, and constructed wetlands.

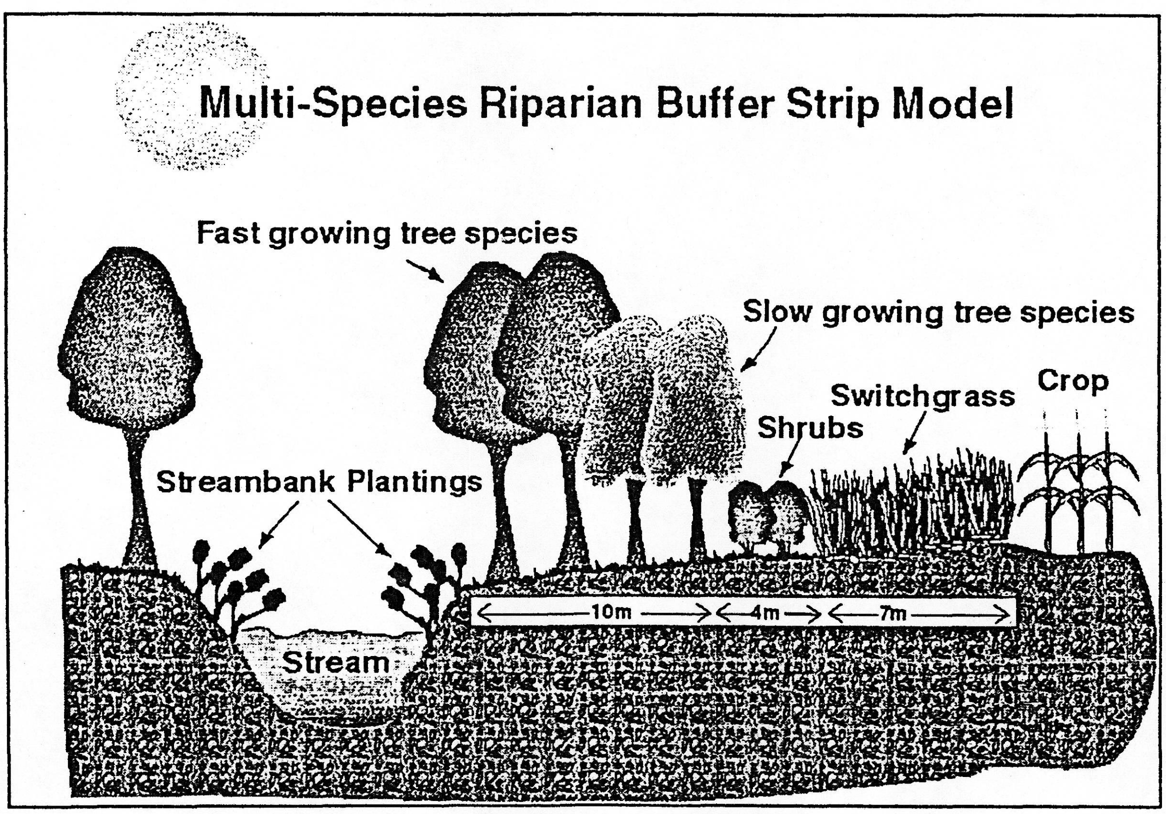

Figure 2. Multi-species riparian buffer strip model which includes tree rows closest to the stream, shrubs, and a strip of switchgrass adjacent to the cropland.