Bentrup, G., M. Schoeneberger, M. Dosskey, and G. Wells. 2003. **The fourth P: planning for multi-purpose riparian buffers.** In: *Proc. of the 8th North American Agroforestry Conference*. 23-25 June 2003. Corvallis, OR. pp. 26-37.

The Fourth P: Planning for Multi-Purpose Riparian Buffers

Gary Bentrup*
Michele Schoeneberger
Mike Dosskey
Gary Wells

USDA National Agroforestry Center
East Campus – UNL
Lincoln, NE, USA 68583-0822
**Corresponding Author: gbentrup@fs.fed.us*

ABSTRACT

Riparian buffers offer the potential to address many societal goals, such as water and soil quality, flood attenuation, wildlife habitat, carbon sequestration, along with providing additional economic and social returns to the landowner. Efforts to-date have focused on understanding how riparian buffers provide environmental ***protection,*** how they can help meet agricultural ***production*** goals, and what ***policy*** initiatives and programs are needed to meld these protection and production goals together. However, to achieve multiple protection and production goals from riparian buffer systems, we need to invoke the fourth "P" ~ ***planning***. Planning provides a process whereby riparian performance as a function of spatial scale can be incorporated into the design process to meet multiple goals. A planning framework that incorporates a regional reconnaissance, a landscape-scale assessment, and a site-scale design is presented, along with a discussion of several planning tools to guide the process. The application of the planning framework and associated tools is illustrated through a case study. Among the major advantages of this planning approach are it: (i) provides specific but flexible guidance for analyzing resources and developing riparian plans, (ii) increases the likelihood for a wider range of issues and resources to be considered upfront, and (iii) assists planners in the design of more comprehensive riparian buffers systems.

Keywords: GIS, Riparian buffers, Planning, Conservation Planning Atlas, Buffer Economic Analysis Tool, Landscape Assessments

Introduction

Riparian buffers offer the potential to address many environmental **protection** goals like water quality protection and enhancement, flood attenuation, wildlife habitat, and carbon sequestration (NRC 2002, Dosskey 2001, Naiman et al. 1993). Agricultural **production** goals can also be achieved with riparian buffers. Healthy, well-managed riparian buffers can minimize loss of productive land due to erosion, protect lands from flooding, provide refugia for natural enemies of crop pests, and can produce alternative, high-value products for commercial markets (Hill and Buck 2000, Pickett and Bugg 1998, FISRWG 1998). Recognizing the multiple purposes that can be accomplished with riparian buffers, **policy** initiatives and programs have been enacted to meld these goals together like the United States Department of Agriculture (USDA) Continuous Conservation Reserve Program and the USDA Forest Land Enhancement Program (NRC 2002).

To achieve multiple protection and production goals within current policy guidelines, we need to incorporate the fourth “P”, **planning**. Planning provides a framework to integrate and balance the variety of issues that riparian buffers can address at different spatial scales. Multi-scale planning is necessary because riparian functions vary at regional, landscape, and site scales and not all objectives can or should be achieved with riparian buffers at every location (NRC 2002). Watershed and individual site constraints and opportunities will dictate what goals are feasible, which in turn will be modified by community and landowner desires and needs (Nudbisi 2002).

Assumptions that one size or type of riparian buffer will fit all issues or locations are usually inappropriate. Critical factors like width, configuration, plant species, management practices, and watershed location require planning and design (NRC 2002). Rigid standards do not allow the flexibility to create workable buffers, however, a straightforward planning and design process can be used to develop science-based riparian buffer recommendations that are publicly supported.

At the USDA National Agroforestry Center (NAC), we are developing a riparian buffer planning process that integrates regional, landscape, and site-scale concerns through a question-driven framework. This planning process utilizes basic geographic information system (GIS) assessments as a foundation for the planning effort, allowing both landowner and community concerns to be addressed simultaneously. Additional science-based design tools for riparian buffers are also being created for the Western Corn Belt Ecoregion (WCBE). With some adjustment, the process and associated tools can be revised for other ecoregions.

Planning Framework: Overview

The planning framework incorporates three levels of consideration: region, landscape, and site (Figure 1). At the regional scale, a reconnaissance of existing spatial and temporal information provides a general overview of environmental conditions and resource issues. The reconnaissance is guided by a series of questions:

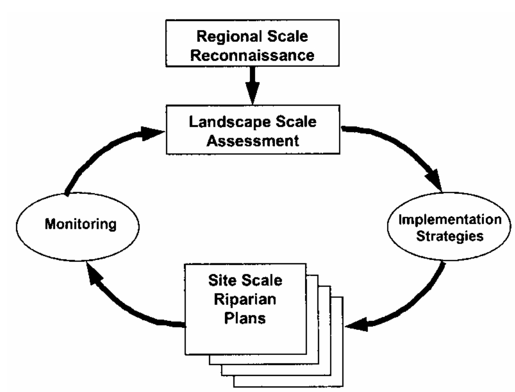

Figure 1. Riparian planning framework integrating multiple scales.

1. Based on public perception, what are the main conservation issues in the region?
2. Within the regional context, are these critical issues?
3. Are there other key issues that should be addressed?
4. What are the general linkages between these resource issues?

Answering the questions is facilitated by using a planning tool developed by NAC, the *Conservation Planning Atlas: Midwest Version* (Figure 2). This internet-based tool is a compilation of over one hundred assessment and resource maps from a variety of governmental and non-governmental organizations. The atlas covers a range of topics from soil and water resources to demographics. Examples of the national and regional-scale maps include:

- *Predicted Forest Composition Change based on Climate Change*
- *Regional Recreational Trails*
- *Percent Change in Total Population by County*
- *Watersheds with High Potential for Nitrogen and Pesticide Runoff*

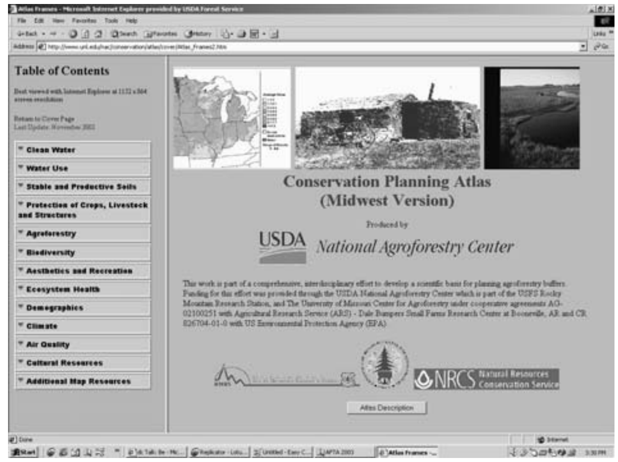

Figure 2. The *Conservation Planning Atlas: Midwest Version* consolidates a wide range of resource maps.

This quick reconnaissance gives a regional context that enables stakeholders to consider multiple resource concerns in their riparian planning effort and to capitalize on the capabilities of riparian areas to address several issues simultaneously.

Landscape-Scale Assessment

Based on the overview from the regional reconnaissance, a landscape-scale assessment is conducted to identify problem areas and general community-based goals for riparian buffers in the study area. The process is guided by series of questions modified from Steinitz (1990).

1. How should the riparian landscape be described?
2. Is the riparian landscape functioning well?
3. How might the riparian and upland landscape be altered?
4. What predictable changes might the scenarios cause?
5. How should the riparian and upland landscape change?

Through these questions, critical riparian functions, general locations for riparian restoration and enhancement, and basic design criteria can be determined. NAC has developed several individual assessment methodologies using GIS and publicly available datasets to assist with this process. Some of the assessments include:

- *Wildlife*: General assessments of landscape structure for biodiversity concerns.
- *Water Quality*: Suitability assessments for buffers to capture sediment and pollutants.
- *Economics*: Suitability assessments for growing agroforestry specialty products.

These assessments provide the landscape-scale context for developing site-based riparian buffer plans. Although the assessments can be used individually, combining the assessments in GIS allows the user to identify buffer locations where multiple objectives can be achieved.

Site-Scale Riparian Planning & Design

The site-scale planning and design process blends specific landowner objectives with community goals expressed in the landscape assessment. The site-scale design process is guided by the same questions used in the landscape-scale assessment. Additional, specific resource-based questions (not shown here) serve as a checklist to ensure that critical issues are not overlooked during the design phase. These questions are organized in seven resource-based categories: species and habitats, clean water, stable and productive soils, economic opportunities, crop, livestock, and structure protection, aesthetics and visual quality, and outdoor recreation. Several synthesis questions are also asked at each major step in the site-scale process, ensuring that the interrelationships between resources are considered. Guided by these questions, design alternatives are developed that address size, vegetation composition, and management of the riparian buffer. Because riparian buffers are intricately connected to upland areas, recommendations for managing uplands are also developed during this design process.

NAC has developed several tools to assist with the site-scale planning and design process. The *Conservation Buffers: Planning and Design Principles* synthesizes current buffer research into easy to understand and apply guidelines (Figure 3). This guide organizes buffer research from a diffuse body of literature ranging from landscape ecology, agricultural engineering, agronomy, economics, hydrology, to landscape perception studies. Other tools include the *Conservation Buffer Economic Analysis Tool,* a simple spreadsheet-based application used to calculate the cost-benefits of proposed alternatives, and the *Conservation Plant Database for the Northern Great Plains*, a database used to select plants based on desired ecological functions. The planning framework also promotes post-implementation monitoring to evaluate impacts and to indicate any need for making adjustments to achieve desired goals.

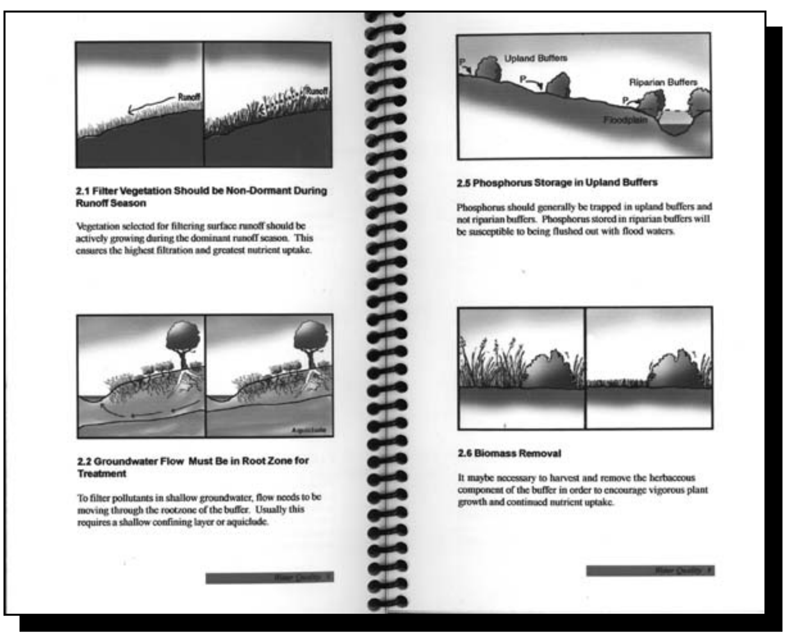

Figure 3. Conservation Buffers: Planning and Design Principles synthesizes the current research on buffers into easy-to-understand and apply guidelines.

The planning framework can be used by either stakeholder groups or individual planners. When a formal planning group is present, the planning framework can be used to facilitate stakeholder participation in the riparian planning process. If a planning group is not present, the process can still be used to guide individual site-scale riparian planning and design efforts. The planning framework can also be initiated at any scale, depending upon the needs of the users. For instance, a non-profit organization may conduct a landscape-scale assessment to assist local governments in land use planning decisions or state agency may use the regional reconnaissance to develop policy and conservation programs.

Nemaha NRD Case Study

To illustrate the planning process and the associated tools, a case study example is provided from the Nemaha Natural Resource District (NRD) in southeast Nebraska, a 7,200 km^2 region within the WCBE (Figure 4). The study area is characterized by extensive corn and soybean production on rolling hills of glacial till covered by deep loess. Valley floors are narrow except along several of the larger tributaries of the Missouri River and much of the riparian vegetation is highly fragmented into small remnants.

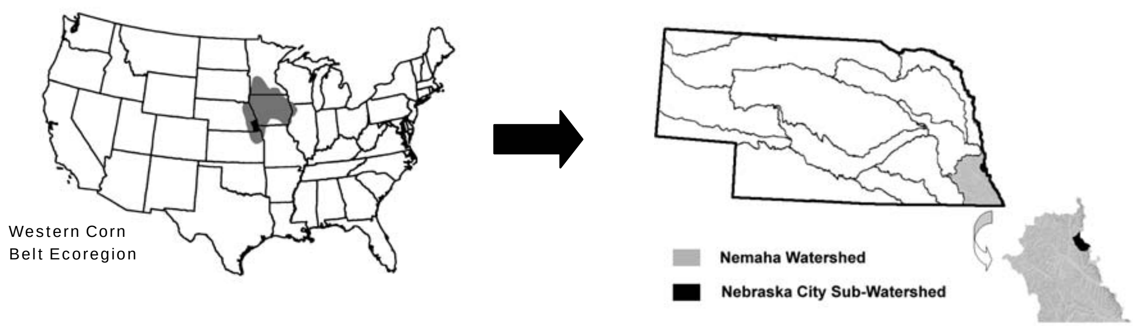

Figure 4. Study area within the Western Corn Belt Ecoregion.

Regional Reconnaissance Example

A primary driver for riparian planning in this area is water quality concerns from sediment entering streams, an issue the public readily identifies and understands. Rills and gullies in fields, brown water flowing in streams, and water supply reservoirs choked with sediment requiring expensive filtration are visual testimony of this problem. Other critical issues facing this region are less apparent. Through the regional reconnaissance and the *Conservation Planning Atlas*, other pressing issues in this region were revealed. These issues include:

- *Wildlife:* With less than 4% of native grassland, woodland, and wetland habitat remaining in the area, many species lack necessary habitat. Habitat remaining in the area is highly fragmented, creating barriers for species movement, particularly with patchy riparian corridors along low-order streams.

- *Water Quality:* Although sediment is a highly visible problem, other less apparent but potentially more serious water quality problems are present. Over 20 water bodies in the area are listed for excessive nitrogen and pesticides on the Environmental Protection

Agency's (EPA) 303d list of impaired waters. The Atlas also revealed that nitrogen from this basin is probably contributing to gulf hypoxia, an oxygen-depleted dead zone in the Gulf of Mexico.

- *Economics:* Crop production systems are generally limited to corn-soybean rotations, creating a low diversity enterprise that is highly vulnerable to climate, pest, and market variables. Consequently, 35 to 45% of the farmers in the area report off-farm income as a means of staying in the business of farming. This is also contributing to the removal of riparian remnants to maximize field size and production.

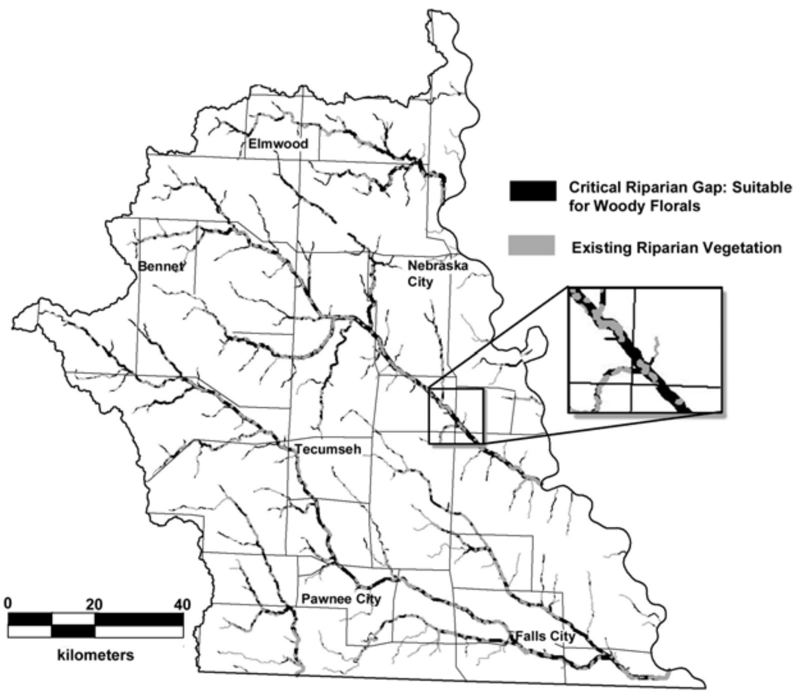

Figure 5. A landscape assessment indicating critical gaps in riparian corridors that could be restored with a mixture of native riparian species and woody florals.

Landscape-Scale Assessment Example

Based on the overview provided by the regional reconnaissance, general community-based goals for riparian buffers in the Nemaha NRD are: 1) restore and enhance riparian habitat and connectivity, 2) protect and enhance water quality from nitrogen, pesticide, and sediment pollution, 3) provide opportunities for landowners to derive economic benefits from riparian areas.

These broad goals were addressed using the GIS-guided landscape-scale assessments derived from publicly available datasets. A riparian connectivity assessment was completed to identify critical gaps in riparian corridors that should be restored with a buffer to provide habitat and to facilitate species movement. A suitability assessment was done to determine locations for growing woody florals used in the decorative floral industry, a viable alternative for landowners interested in diversifying production. By combining the results from these assessments, areas were identified where riparian buffers could be located to improve habitat connectivity while offering landowners the option of growing woody florals for profit (Figure 5). Water quality assessments to determine locations for buffers to capture and treat surface and sub-surface flow were also completed for the Nemaha NRD.

Site-Scale Buffer Planning and Design Example

These integrated assessments established a starting point to prioritize buffer planning projects in the Nemaha NRD. From the results of the landscape-scale assessments, the Nebraska City sub-watershed was selected for site-scale buffer planning and design (Figure 2). This 10,700 ha watershed, consisting of gentle to steep slopes, typifies many of the problems identified in the previous analyses. Using the landscape-scale assessment methodologies with finer resolution data, this watershed showed significant opportunities for utilizing riparian buffers to address water quality, wildlife habitat, and economic diversification issues.

Water quality assessments revealed that the Marshall-Monona-Ponca soil association in this watershed is conducive to capture and treatment of pollutants in surface flow in select areas where input flow does not exceed riparian buffer capability. However, this watershed is not suitable for significant reduction of pollutants via subsurface flow since there is no confining layer to maintain flow through the buffer root zone. Economic diversification assessments showed that the area is moderately suitable for growing a variety of agroforestry specialty products such as goldenseal and other medicinal herbs under existing forest canopy. The riparian connectivity analysis highlighted several critical gaps across the watershed that should be reconnected with buffers (Figure 6). Because these low-order streams flow directly into the Missouri River, these riparian areas in this watershed are particularly important for water quality and wildlife habitat. The combination of these various assessments illustrated key areas where several objectives could be addressed.

Based on these assessments, several landowners were contacted to determine their interest in having a riparian management plan developed for their property. The Arbor Day Farm and Conference Center in Nebraska City, a 90-ha facility that showcases conservation techniques, proved to be a willing participant.

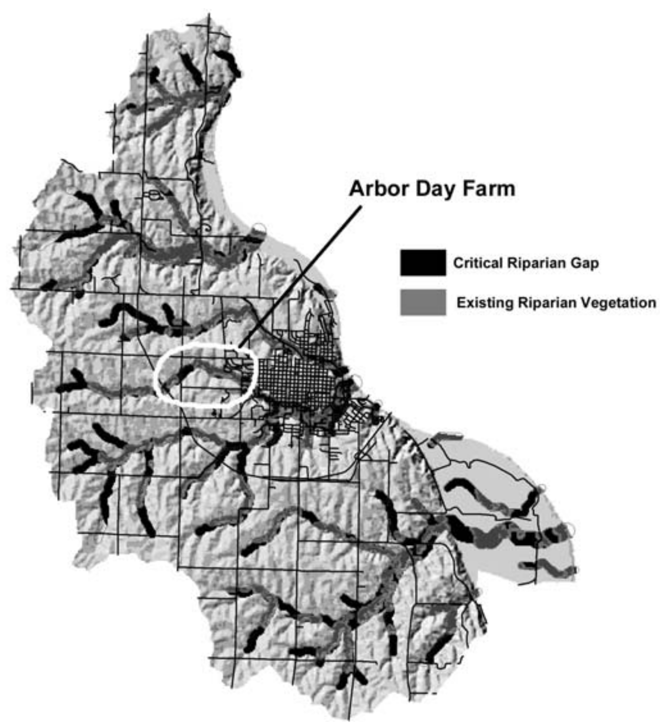

Figure 6. Riparian connectivity assessment for the Nebraska City watershed.

The riparian connectivity analysis revealed that South Table Creek flowing through the Farm has a critical riparian gap (Figure 6). Historical photos showed that sometime after 1970, this section of the Creek was cleared and channelized (Figure 7). Analysis showed that the adjacent 6- and 10-ha fields were contributing pollutants to the stream and that the channelized riparian area was suitable for a water quality buffer. On a positive note, the assessments revealed that this riparian area was favorable for growing woody florals.

Figure 7. Historical photos of South Table Creek at the Arbor Day Farm.

Using the question-based framework and the *Conservation Buffers: Planning and Design Principles*, upland field management recommendations were made to minimize pollutant loading to the proposed riparian buffer while increasing benefits for crop production and wildlife habitat. Field recommendations included spring application of fertilizer and conservation tillage to reduce runoff, improve soil structure, increase soil carbon, all which would minimize the need for chemical inputs.

A suitable buffer width for water quality based on site characteristics and the desired level of pollution reduction was estimated from a modeling tool currently under development at NAC (M.G. Dosskey, 2003, personal communication) (Figure 8). Each line in the graph, generated from this modeling exercise, reflects pollutant-trapping efficiency under different site conditions and pollutants. For instance, line c represents sediment trapping on previously wet silt loam soils with a field length of 350 meters and 2% slope. To estimate the width for nitrate removal with the same conditions, line e was used.

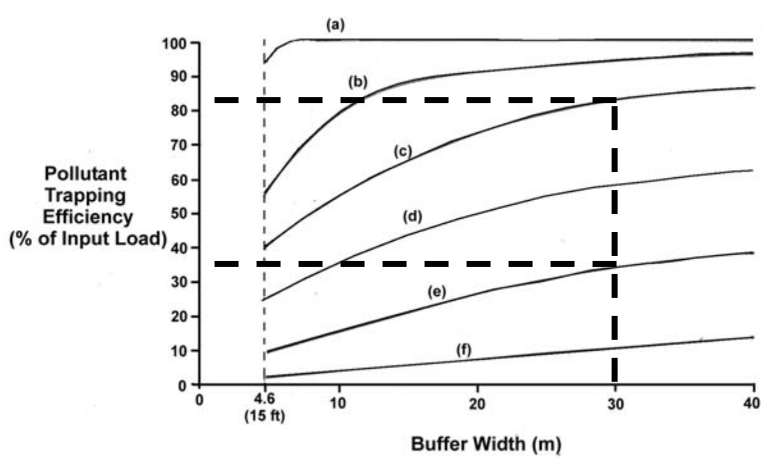

Figure 8. Buffer width estimated based on site conditions and desired level of pollution reduction. Lines a thru f represent specific site pollution scenarios. At the South Table Creek site, a 30 m buffer will provide an approximate input load reduction of 83% for sediment and 35% for nitrate (M.G. Dosskey, 2003, personal communication).

At the South Table Creek site, a minimum buffer width of 30 meters was selected, which should provide an approximate 83% reduction in sediment and a 35% reduction in nitrate. Pollution reduction may even be higher since appropriate upland management was also incorporated in the riparian buffer plan.

Wildlife habitat recommendations included linking the riparian buffer to existing shelterbelts and managing roadsides around the property for grassland birds by delaying mowing till after August 1st when nesting is completed. By incorporating certain herbaceous species in the buffer, pesticide applications for agricultural pests may be reduced, benefiting water quality and wildlife. Research synthesized in the *Conservation Buffers: Planning and Design Principles* showed that non-cropped areas planted with dill, yarrow, and fennel will support chalcid wasps and minute pirate bugs, which can control populations of corn borer, corn earworm, and spider mite. The guide also provided recommendations for existing riparian areas on the Farm, including managing the forest canopy to encourage understory growth for water quality enhancement.

The final plan called for establishing a variable width buffer of 30 to 50 meters to encompass the floodplain and provide adequate area for trapping pollutants. Arbor Day Farm also decided to realigned the creek along its' historic meander pattern, adding 200 meters to its' length, as a way showcasing different streambank bioengineering techniques.

Using the *Conservation Buffer Economic Analysis Tool,* different scenarios were quickly generated illustrating potential economic returns with and without conservation program funding. In a 15-year contract under Continuous Conservation Reserve Program (CCRP), the riparian buffer would yield a potential annual net return of $208 per ha compared to a loss of $79 per ha if the buffer area was planted in corn (Figure 9). Once the program contract was completed, another scenario showed a potential annual net return ranging from $245 to $345 per ha based on harvesting and selling cuttings from one row of woody florals established along a side of the buffer. (*Note: These scenarios do not include construction costs for remeandering the stream, a cost not covered by cost-share programs*). Although it was decided not to plant specialty products in the buffer, these species were established at other locations on the Arbor Day Farm.

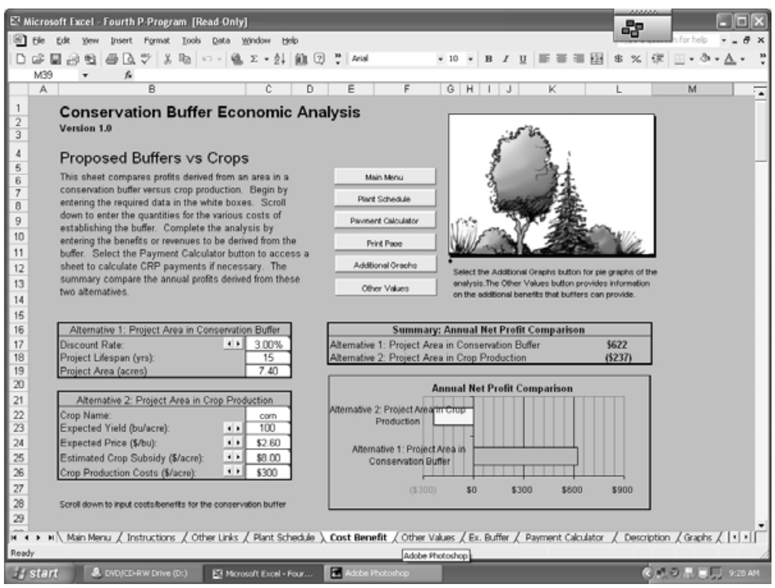

Figure 9. Using the *Conservation Buffer Economic Analysis Tool*, the riparian buffer was estimated to yield a net annual return of $622 for the project area ($208/ha) under the Continuous Conservation Reserve Program compared to a net loss of $237 ($79/ha) if the area was planted in corn.

In addition to the community-driven goals of water quality and wildlife habitat, the landowners may want a visually pleasing and diverse buffer. With landowner input, the *Conservation Plant Database for the Northern Great Plains* can be used to select plants that achieve the water quality and wildlife goals while providing seasonal textures and color for year-around interest. To help the landowners visualize various combinations of vegetation as it matures along the realigned stream channel, a visual simulation can then be prepared using inexpensive software (Figure 10). Of all the tools in this "4th P" process, visualization may prove to be one of the more powerful tools for influencing landowner understanding and adoption of agroforestry practices, especially riparian buffers.

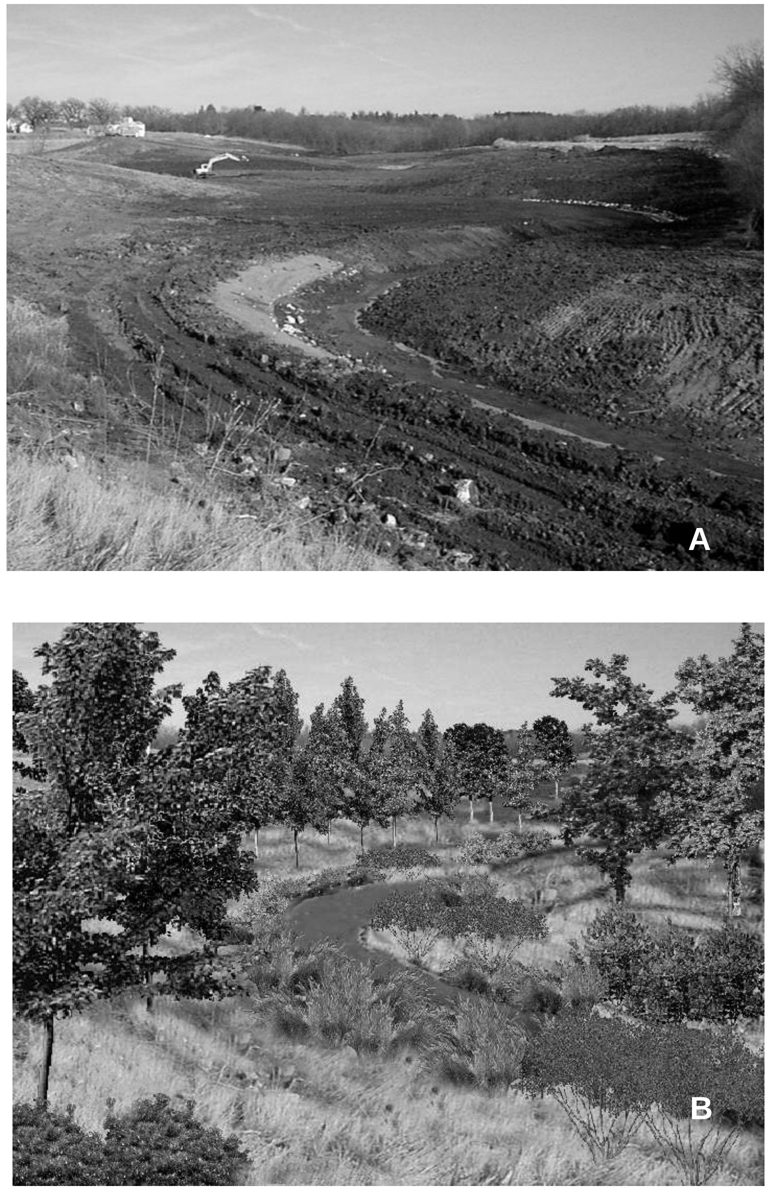

Figure 10. Image A shows the South Table Creek project after constructing the meander channel. Image B is a visual simulation of the proposed riparian plantings along the channel after 20 years of growth.

Conclusions

By using a multi-scale planning and design process, the ability to simultaneously achieve environmental protection and agricultural production goals can be greatly enhanced. The Arbor Day Farm is just one piece in the watershed puzzle but as additional landowners implement comprehensive riparian buffer management plans, the cumulative benefits will start to multiply. As the riparian vegetation matures over time, riparian corridors will be reconnected, benefiting many terrestrial and aquatic species. Using a multi-scale planning approach will result in better management of uplands and riparian areas, yielding positive benefits for water quality. The agricultural landscape may also become more diverse, economically stable, and visually pleasing as landowners integrate alternative specialty products into their riparian areas.

For more information on this planning process and the associated tools, please visit the project website at http://www.unl.edu/nac/conservation/

Acknowledgments

Funding and support for this project was provided through the USDA National Agroforestry Center, which is part of the U.S. Forest Service Rocky Mountain Research Station, and the University of Missouri Center for Agroforestry under cooperative agreements AG-02100251 with the Agricultural Research Service (ARS) and CR 826704-01-0 with the U.S. Environmental Protection Agency (EPA). The results presented are the sole responsibility of the authors and may not represent the policies or positions of the EPA or ARS.

References

Dosskey, M.G. 2001. Toward quantifying water pollution abatement in response to installing buffers on crop lands. Environmental Management 28(5):577-598.

FISRWG 1998. Stream Corridor Restoration: Principles, Processes, and Practices. Federal Interagency Stream Restoration Working Group (FISRWG) GPO Item No. 0120-A; SuDocs No. A 57.6/2:EN 3/PT.653.

Hill, D.B. and Buck, L.E. 2000. Forest farming practices. In: Garrett, H.E., Rietveld, W.J., and Fisher, R.F. (eds.) North American Agroforestry: An Integrated Science and Practice. American Society of Agronomy, Madison, WI, pp. 283-320.

Naiman, R.J., Decamps, H. M. Pollock. 1993. The role of riparian corridors in maintaining regional biodiversity. Ecological Applications 3(21):209-212.

National Research Council (NRC). 2002. Riparian Areas: Functions and Strategies for Management. National Academies Press, Washington, DC, 428 pp.

Ndubisi, F. 2002. Ecological Planning: A Historical and Comparative Synthesis. John Hopkins University: Baltimore, MD, 384 pp.

Pickett, C.H. and Bugg, R.L.1998. Enhancing Biological Control: Habitat Management To Promote Natural Enemies of Agricultural Pests. University of California Press, Berkeley, CA, 421 pp.

Steinitz, C. 1990. A framework for theory applicable to the education of landscape architects (and other design professionals). Landscape Journal 9(2):136-143.