ECONOMIC FEASIBILITY OF RIPARIAN BUFFER IMPLEMENTATION – CASE STUDY: SUGAR CREEK, CADDO COUNTY, OKLAHOMA

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Chapter 1

INTRODUCTION

Riparian areas in Oklahoma have diminished rapidly over the last several decades due to anthropogenic influences such as channelization/stream alteration, water resource development, agricultural production, silvicultural harvesting, mineral resource extraction and exploration, and urban development (Stinnet et al. 1987). These losses have been detrimental to water quality, recreational activities, streambank stability, agricultural productivity, and biodiversity. Without changes in riparian management practices, riparian destruction will continue to have a severe impact on the economy of the State of Oklahoma.

Riparian areas can been defined as: "The geographically delineated areas with distinct resource values that occur adjacent to streams, lakes, ponds, wetlands, and other specified water bodies (Smolen and Fallon 1998)." The root of the word riparian is derived from the Latin *ripa*, which means riverbank. It can be used as a noun when referring to a landowner whose property borders a stream. Or, the term can be used as an adjective to describe the location of a particular type of ecosystem (Hawkins 1994).

The Natural Resource Conservation Service (NRCS) and the Farm Service Agency (FSA) are responsible for implementing various federal programs, which are conservation-oriented. These programs often target highly erodible soils (HELs) in an attempt to bring soil erosion losses down to a minimum. One method of control is the implementation of best management practices (BMPs) in riparian areas to help reduce streambank erosion, overland erosion, biodiversity losses and water quality problems. Due to a variety of reasons, landowners in Oklahoma have been reluctant to take riparian areas out of production. Even with incentive programs, the overall perception from landowners appears to be that it would be economically harmful to them to take these lands out of production. A Turkey Creek Educational Assessment Project recently concluded that:

a) People are willing to adopt new practices to protect their water quality; however, they want more economic information about adoption of new practices for consideration.
b) If economic benefits cannot be directly correlated to the adoption of BMPs, there will be little adoption of these practices.
c) Farmers/ranchers believe that agricultural producers should adopt BMPs when feasible, and that adoption of those BMPs will improve water quality (Pierce and Key 1998).

The objective of this research is to provide a tool to show landowners and governmental agencies the costs versus benefits associated with implementation and maintenance of a designed riparian buffer system. The spatial/economic framework relies on interpretation of remotely sensed data, parameters of existing incentive programs, and quantification of secondary benefits. The framework can accommodate future changes in incentive programs and could be used for further modeling in a geographical information system (GIS) environment.

Specifically, this project provides a spatial framework for analyzing existing riparian conditions via aerial photography or satellite data. In addition, the project includes an economic model that analyzes the costs of implementing riparian buffer systems versus projected profits from continued farming in the riparian area. It will project erosion losses and factor in a value associated with these losses. Furthermore, it will directly compare costs associated with agricultural production based on Oklahoma Agricultural Statistics and project yields and profits, based on known soil types. Enterprise Budgets, created by OSU Department of Agricultural Economics, will be used to quantify production costs. Secondary benefits, such as enhanced recreation, improved biological diversity, improved water quality, and system stability are also addressed. Economic calculations are based on net present value.

For a case study, the Sugar Creek Watershed located in Caddo County has been chosen. It has been heavily farmed for decades. Due to morphological changes within the stream system caused by channelization and poor land management practices, the stream system has become extremely unstable. This has caused farmers to experience severe soil losses through overland and streambank erosion. In addition, terrestrial biodiversity has suffered dramatically due to habitat losses and agricultural productivity is down. Water quality is also poor in the watershed.

The NRCS plans to start a stream stabilization project in the near future. One management facet of this project would be for farmers to create riparian buffer strips. It is hoped that implementation of this type of BMP will help the system recover. Currently, landowners in Oklahoma have not enrolled any acreage in Conservation Reserve Program (CRP) Practice CP-22 - riparian buffers (USDA-FSA 1997a). This research will provide cost-benefit information for riparian buffer strip establishment. Outputs will include economic information on establishment of riparian buffer strips on a per acre basis, as well as a cost-benefit analysis of riparian buffer implementation.

The specific objectives of this research are to:

- Assess, classify and categorize existing land-use conditions in a watershed via remotely-sensed data,
- Transfer information to digital environment,
- Project idealized riparian buffer system in a GIS,
- Categorize and quantify existing land-use management practices within an idealized riparian buffer,
- Estimate profitability of farming in riparian areas based on Oklahoma Agricultural Statistics and Oklahoma Enterprise Budget figures,
- Estimate direct benefits of taking land out of production based on existing incentive programs,
- Estimate direct and indirect benefits associated with implementation of riparian buffer strips, and
- Frame economic analysis in net present value calculations to determine cost-effectiveness of current incentive programs,
- Derive conclusions from data about economic feasibility of taking riparian lands out of production.

Chapter 2

REVIEW OF LITERATURE

Riparian Areas – Importance

Riparian areas are important because they represent the interface between aquatic and upland ecosystems. Due to the fact that these areas contain sufficient water supplies and rich alluvial soils, the systems are very productive and provide for many different functions. Riparian areas can: 1) store water and help reduce floods; 2) stabilize stream banks and improve water quality by trapping sediment and nutrients; 3) shade streams and help maintain temperature for fish habitat; 4) provide shelter and food for birds and other animals; 5) support productive forests which can then be periodically harvested, 6) be used as recreational sites; 7) provide productive pasture lands for livestock, and 8) serve as repositories of biological diversity (Anderson and Masters, 1995).

The use of riparian buffers as a best management practice (BMP) is well established as a forestry practice (Comerford et al. 1992). It has not been applied as often in an agricultural or urban setting (Lowrance et al. 1997). However, its use in agricultural settings is increasing dramatically. The Chesapeake Bay Task Force has mandated use of riparian BMPs to achieve a reduction of 40 percent of nutrient loadings to the Chesapeake Bay by the year 2000 (Palone and Todd 1997). Furthermore, the 1996 Farm Bill allows for continuous, non-competitive enrollment of riparian buffers in the

CRP program. This enrollment protocol is a direct result of governmental recognition of riparian buffers as a practice that yields highly desirable environmental benefits (FSA 1997a).

Flooding

The detrimental effects of riparian losses can be measured in many ways. The decrease in water storage capability can increase flooding potential. Riparian vegetation reduces the energy of water flow, thus reducing damage to riverbanks and the effects of downstream flooding (Palone and Todd 1997). The decreased flow results in sediment deposition (Welsch 1991). The streamside forest acts as a filter by allowing sediment to settle out from flood waters (Forman and Godron 1986). Stormwater costs in Fairfax County, Va., have been reduced by $57 million due to retention of forested riparian buffers (Palone and Todd 1997). The floods of 1993 in the Midwest created more damage in areas where there was no riparian forest protection (Palone and Todd 1997). These observations were also made in Virginia during the floods of 1994-1995 (Palone and Todd 1997).

Water Quality

Riparian losses also contribute to decreases in water quality and biodiversity. Riparian areas can be important for the control of non-point sources of pollution from land management practices. Riparian buffer zones have been shown to decrease NPS pollution (Lowrance et al. 1984; Peterjohn and Correll 1984; Jacobs and Gilliam 1985; Dillaha et al. 1989). The EPA has estimated that non-point source pollution (NPS) contributes over 65 percent of the total pollution load to surface waters in the United States (EPA 1989).

Non-point source pollutants include sediment, nutrients, pesticides, animal wastes, and other substances that enter water supplies as part of runoff and ground water flow (Anderson and Masters 1995). Riparian buffers contain intrinsic chemical and biological processes, which are activated in the riparian ecosystem for transforming pollutants (Narumalani et al. 1997). Filter zones contain bacteria and fungi that convert N in runoff and decaying organic debris into mineral forms. The mineral forms can be synthesized into proteins by plants or bacteria. Denitrifying bacteria can also convert dissolved N into its gaseous form, which returns it to the atmosphere (Welsch 1991). Riparian vegetation also acts as a nutrient sink. Certain types of vegetation have a high rate of N uptake, so the nutrients stored in the litter can be converted into peat and stored for a long time in the ecosystem (Narumalani et al. 1997).

Sediment is the most common non-point source pollutant. Erosion from cropland accounts for about 38 percent of the sediment that reaches our nation's waters each year (Welsch 1991). Pasture and range erosion accounts for another 26 percent (Welsch 1991). Suspended sediment in the water blocks sunlight, limiting the growth and reproduction of aquatic plants. Sediment on the bottom of the stream interferes with the feeding and reproduction of benthic fish and aquatic insects, thus weakening the food chain and diminishing biodiversity. Sizable deposits of sediment can clog stream channels and floodplains, thus increasing the potential of flooding (Anderson and Masters 1995). The amount of sediment filtered by a riparian buffer strip varies due to a variety of factors including rainfall intensity, slope, soils, upland land use practices, and width and vegetational composition of buffer (Xiang 1996).

Riparian buffers are also effective at removing nutrients from overland flow. Riparian forest buffers can provide effective control of nutrients from non-point sources. Reduction in nutrient runoff is most likely in areas where the flow moves closely to the root zone of the buffer system (Lowrance et al. 1997). Lowrance et al. (1997) found a retention of 50-90 percent of the total loading of nitrate in shallow groundwater, sediment in surface runoff, and total N in surface runoff and groundwater. Lowrance et al. (1985) found that denitrification removal of N and storage by woody vegetation was 6 times as much as N output to streamflow. They also found that half of the P outflow was taken up by the vegetation and the remainder was exported in streamflow (Lowrance et al. 1985). The USDA Forest Service found that riparian buffers significantly reduced P through filtering action due to the fact that 85 percent of available P is transported by small soil particles in sediment (Welsch 1991).

Wildlife Habitat

Due to their proximity to water and open areas, riparian buffers are extremely important habitat for numerous wildlife species and thus act as repositories of biological diversity. They also serve as travel corridors between different habitat types (Stinnet et al. 1987). In addition, these areas serve as strips of habitat for vertebrates to move across landscapes (Forman 1983). Management practices currently promote the protection of corridors in landscape networks (Forman and Godron 1981, Hudson 1991). Trees in these areas shade and cool the water systems which run beneath them. As a result, trees improve aquatic habitat by lowering water temperatures and increasing dissolved oxygen levels. Branches and roots also provide cover for wildlife. Organic matter from the streamside forest provides the fundamental food source in the aquatic food chain (Stinnet et al. 1987).

These organic inputs are most dominant in small streams that flow through forests. They act as a food supply that supports many invertebrate animals, which in turn are the principal food source for fish (Anderson and Masters 1995). Aquatic invertebrates shred large organic debris to smaller pieces that move downstream to be used by larger animals that feed by filtering or gathering. By providing large stable debris to the streambed, streamside forests allow organic materials to be held long enough to be processed by the invertebrate community (Anderson and Masters 1995).

Riparian bottomland hardwood forests are important as habitat for both resident and migratory species. Many small and large mammals, birds, reptiles, and amphibians depend on bottomland hardwood forests for at least a portion of their life needs. These forests serve as wintering, feeding, and breeding grounds for migrant species (Stinnet et al. 1987). Many animals use food in the form of hard mast found in bottomlands. This is especially true for game species such as turkey, deer, and squirrel. Insects produced in the bottomland hardwood forest are an important food source for many bats. Snags, den trees, fallen logs, and other nesting sites provide essential cover and help reproductive success of many different wildlife species (Stinnet et al. 1987).

Riparian Wildlife in Oklahoma

Bottomland hardwood forests in eastern Oklahoma support at least 20 species of mammals, 160 species of fish, 38 species of amphibians, 54 species of reptiles, and 150 species of birds. Some of these are considered threatened and/or endangered (Stinnet et al. 1987). Riparian areas in central and western Oklahoma support at least 49 species of mammals, 28 species of fish, 13 species of amphibians, 43 species of reptiles, and 134 species of birds (Anderson and Masters 1995). In western Oklahoma, the endangered bald eagle relies heavily on trees, such as cottonwoods, for perch and roost sites. The endangered whooping crane, piping plover, and interior least tern utilize the broad sandbars of major western Oklahoma rivers or salt flats for nesting, feeding, or roosting (Stinnet et al. 1987). As is evident, maintaining, protecting and restoring riparian areas is critical to protecting biodiversity in Oklahoma.

Riparian Area Status in Oklahoma

National Wetland Inventory (NWI) maps show that only 328,700 acres or 15 percent of the original Bottomland Hardwood (BLH) forest remain today in eastern Oklahoma (Brabander et al. 1985). Less than half of this would be considered good quality mature BLH forest (Brabander et al. 1985). It has been projected by the United States Fish and Wildlife Service (USFWS) that without significant state and/or federal initiatives, only 217,937 acres, less than 10 percent of the pre-settlement total, will remain by the year 2015 (Brabander et al. 1985).

Western Oklahoma has also experienced severe riparian area losses. The USFWS estimates a total potential riparian acreage of 621,025 for the western 30 counties in Oklahoma (Stinnet et al. 1987). Recent figures indicate a best-case scenario of 251,098 acres remaining, or a 60 percent decrease in potential riparian areas (Stinnet et al. 1987). The worst-case scenario data reflect up to 73 percent decrease in riparian areas in western Oklahoma (Stinnet et al. 1987). The differences in these figures is attributable to source variation and differences in sampling methodology (Stinnet et al. 1987).

Riparian Buffer Design

The location, layout and density of a riparian buffer strip will vary based on management objectives (NRCS 1998). A 3-zone concept has been described by Welsch (1991) and is commonly utilized around the country. The concept is described in Table 1.

The width of a buffer strip will vary depending on management objectives. There are no steadfast rules in determining the optimum width. Widths must take into account many different variables including slope, soils, native vegetation, land form and land use (Xiang 1996). If wildlife is a major consideration, the general rule of thumb is that wildlife benefits increase with an increase in buffer width (Smolen and Fallon 1998).

The efficiency of a riparian buffer strip for removal of NPS pollutants will vary depending on the dimensions of the buffer zone, composition of vegetation species within the zone, land use, soil types, topography, hydrology, microclimate, and other characteristics of the agrosystem (Narumalani et al. 1997). Buffer zones reduce the connection between the source of the pollution and the aquatic resource. Peterjohn and

Correll (1984) found that N concentrations were significantly reduced in surface runoff flowing from agricultural fields through a 19-m buffer of riparian forest. Castelle et al. (1994) found that buffer widths ranging from 3 to 200 m can be effective. Narumalani et al. (1997) found that methods used to determine proper buffer widths by water resource scientists, researchers, and various U.S. government agencies can be broadly classified into 3 categories:

Table 1: 3-Zone Riparian Buffer System

Zone - Width	Vegetation	Management
Zone 1: 15 ft. minimum – measured horizontally on a line perpendicular to the water body from the bank top	Native trees and shrubs that are suited to site and intended purpose	Livestock must be controlled or excluded as necessary to achieve and maintain the intended purpose. Some removal of trees may be acceptable, provided that there is no deterioration in the functionality of the zone.
Zone 2: 20 ft. minimum – begins at the edge and upgradient of Zone 1. Measured horizontally on a line perpendicular to the water body	Native trees, shrubs, and forbs that are suited to site and intended purpose	The management criteria is the same as in zone 1, however; removal of tree and shrub products such as timber, nuts and fruit is permitted on a more regular basis as long as the intended purpose of the buffer is not compromised.
Zone 3: 20 ft minimum - begins at the edge and upgradient of Zone 2. Measured horizontally on a line perpendicular to the water body	Perennial grasses and forbs, maintained in vigorous growth condition	Mow and remove clip-pings to control weeds and promote growth. May require shaping or grading.

Source: NRCS 1998

1. Application of a constant buffer width for the entire area under consideration;
2. Determination of a minimum buffer width based on soil capability, extent of source area, and slope (Trimble and Sartz 1957; Welsch 1991);
3. Spatial modeling methods which take into consideration the regional variations in physical ecological, and socio-economic conditions (Delong and Brusven 1991; Xiang 1993)

The first strategy makes implementation much more manageable than the other alternatives. It does not take into consideration regional differences, which can be unique. The second method is more complex, taking into account regional variation in soils and slope. However, it is more readily applied than a complicated model. The third method utilizes a complex set of variables and provides a systematic and scientific foundation for the establishment of riparian buffers. It is difficult to implement due to spatially dynamic and variable buffer widths. It is also less feasible due to the dependence on data availability and the rigorous nature of the computations (Narumalani et al. 1997).

Change Detection Analysis - Assessing Riparian Areas

Satellite Data

A synoptic view of the terrestrial landscape is provided via remote sensing (Narumalani et al. 1997). It can be used for inventorying, monitoring, and change detection analysis of environmental and natural resources (Narumalani et al. 1997). There are many studies which have demonstrated the utility of remote sensing for examining non-point source pollution (Pelletier 1985, Hewitt and Mace, 1988). Hewitt

(1990) used Landsat TM data to map riparian areas associated with the river, lakes, and wetlands along the Yakima River in Washington. They achieved a classification accuracy of 80 percent in the detection of riparian areas (Hewitt 1990). Narumalani et al. (1997) used Landsat TM data to assess existing riparian conditions along the Iowa River. Jensen et al. (1995), utilized multi-sensor remotely sensed data including Landsat Multispectral Scanner (MSS) and SPOT High Resolution Visible (HRV) images for a change detection study of aquatic macrophyte distribution and composition within the Florida Everglades Water Conservation Area from 1973 to 1991.

The major problem with utilizing satellite data is the coarse spatial resolution (TM= 30x30m; SPOT HRV = 20x20m). These types of resolutions are often inadequate for detection and analysis or riparian areas since the resolution can exceed the physical dimensions of the zone (Narumalani et al. 1997). In the future, it is expected that satellite spatial resolutions such as 3x3m and 1x1m, will be readily available. These types of resolutions will provide data that will be a source for detailed and temporally frequent studies of the impact of NPS pollution on water resources (Narumalani et al. 1997).

Aerial Photos

Aerial photography has long been used as a remote sensing method for inventorying lands and natural resources (Clemmer 1994). This method of remote sensing can be used not only to obtain inventory data, but also as a valuable tool for making management decisions. This is especially true in the case of managing riparian areas (Clemmer 1994). There are several benefits to utilizing this technology. The use of aerial photos can accelerate and enhance collection of ground data. It is also possible to calculate percent of canopy and ground cover, bare soil, and land-use by acreage. In addition, riparian communities can be delineated for mapping purposes and generalized vegetation/soil correlations can be made (Clemmer 1994). Aerial photos provide a historical record of the condition of an area at a specific point in time, thus changes in riparian areas can be assessed by comparing aerial photos taken at a later date (Clemmer 1994). It is also possible to link aerial photo data geographically, thus allowing detailed vegetation maps to be transferred to a GIS system for spatial modeling purposes (Clemmer 1994).

As the Bureau of Land Management (BLM) moves towards an ecosystem approach to management, resources in the future will be managed across jurisdictional boundaries. Small-scale aerial photos (<1:40,000) can provide a broad ecosystem perspective of a watershed. Preliminary analysis of photos can identify specific problem areas in the management of riparian areas (Clemmer 1994). When problem areas are identified, larger scale imagery (1:12,000, 1:6,000, or 1:4,800) can be used to focus in on site-specific areas of interest (Clemmer 1994). It is imperative to create baseline data when managing riparian areas. Aerial photos allow for analysis of a large area of interest at a high resolution, with minimum costs, in less time per hectare than conventional on-the-ground methods (Keating 1993). Baseline data can support or disprove management decisions.

The Bureau of Land Management uses aerial photos for their riparian assessment needs (Clemmer 1994). Harris et al. (1997) also utilized aerial photos in their riparian assessment of the San Luis Rey River in northern San Diego County, CA. Others to utilize the use of aerial photos in riparian assessment include state agencies in Oregon and California (Bach 1994) and by the United States Forest Service (Harris et al. 1997).

Geographic Information Systems (GIS)

GIS systems can be useful for the analyses of temporal and spatial biophysical parameters detected by various remote sensing applications (Narumalani et al. 1997). Spatial data on soil, topography, rainfall, and pollution load measures, can be compiled in a GIS and used in conjunction with remotely sensed data for the development of various water resource management models (Narumalani et al. 1997).

Scientists have used many different models within a GIS environment for the estimation of soil loss and sediment yield, including USLE (Universal Soil Loss Equation), CREAMS (Chemical, Runoff, and Erosion from Agricultural Management Systems), and ANSWER (Area Non-point-Source Watershed Environment Response Simulation, Narumalani et al. 1997). Land cover characteristic information that has been derived from remotely sensed data has been used synergistically in these models to enable an analysis of aquatic conditions (Pelletier 1985, Sivertun et al. 1988).

Arguments for Manual versus Digital

GIS systems are becoming a widely used tool in natural resource management due to their ability to store, organize, and manipulate mapped data (Allen 1994; Chou 1992; Delong and Brusven 1991; James and Hewitt 1990). Resource agencies have adopted GIS due to the speed and flexibility of the systems and the assumption that they will have higher productivity, easier to use data, and will be more cost-effective (Harris et al.

1997). Few doubt that GIS can be a powerful tool in mapping, spatial data base management, spatial statistics analysis, and modeling (Berry 1986). However, there has been little evaluation of the superiority of GIS for activities that previously have been accomplished manually (Lowell 1990; Warwick and Hannes 1994). Through 1997, there were no published studies comparing cost and time-effectiveness of computerized GIS versus manual techniques for analysis of mapped land cover data in riparian-related applications (Harris et al. 1997). In an era of budgetary constraints, the expenses associated with utilization of GIS require some thought as to its cost-effectiveness (McCrary et al. 1993; Smith and Tomlinson 1992).

Agencies and other organizations with limited budgets must determine the value of the system over the long-term against the costs associated with the investment in equipment, software, training, personnel hours, and data base maintenance (Allen 1994). Harris et al. (1997) conducted such a study to compare the personnel time-costs for using manual versus GIS computer techniques to obtain information needed for riparian restoration planning from maps. Their results are summarized in Table 2.

The accuracy of results derived from manual versus digital methods of map interpretation were relatively similar (Harris et al. 1997). The results indicate that GIS may be more useful when dealing with complex data sets over large geographic area. If the interested parties want to do any modeling or repeat functions, GIS is the more effective option (Harris et al. 1997). If the project is small and discrete, it might be better to utilize manual techniques for obtaining information from maps. The long and short of it are that GIS modeling is a tool for use in riparian areas, but it should be adopted with caution (Harris et al. 1997). It is expensive because it requires experienced analysts.

However, if modeling is an intended use, the modeling capabilities of the GIS should be an important criterion for system selection (Berry 1996). When considering the use of

Table 2: Analysis of Manual versus GIS Techniques for Natural Resource Projects

Resources Needed	Manual Techniques	GIS
Budget	Equipment and training costs minimal	High front-end training costs.
Personnel	No computer skills needed; minimal maintenance time-costs	High-level computer skills necessary; high time-costs for system operation and maintenance.
Recommended project characteristics		
Project Scale	Project area relatively small; map themes simple	Large geographic area, multiple and/or complex themes.
Information needs	Best used with unstable landscape features (e.g. land cover in flood areas)	Best used with permanent landscape features (e.g. watershed boundaries, stable vegetation types, topography).
	Best for easily measured data (polygon area, perimeters, etc.)	More versatile when repeat data retrieval, data manipulation, and/or modeling capabilities are required).

Source: Harris et al. 1997

GIS for modeling, the complexity and scale of the project are important factors (Harris et al. 1997). For large-scale projects that have intricate data management requirements, utilization of a GIS system may be the most cost-effective and practical method (James and Hewitt 1992).

Riparian Economics

The economics of riparian area protection and restoration are a complicated issue. The term value, as associated with riparian areas, can have several different meanings based on individual perception. Services or products only have value if humans assign them either directly or indirectly. Sometimes values cannot accurately be assigned a dollar value due to intrinsic qualities or environmental services that are not easily quantified. Individual values must be additive to take into account the value of something to society as a whole (Palone and Todd 1997).

Economic value can be broken up into many elements, that fall into two broad categories, defined as use and non-use values. A use (direct) value represents a resource that can either be used or consumed today or in the future. Non-use (indirect) or existence values represent intrinsic benefits (van Kooten 1993). It is the value of simply knowing that something exists such as an endangered whooping crane or the Grand Canyon. Examples of direct use benefits include recreational, industrial, or agricultural activities. Water quality, an example of an indirect or non-use value, results in an aesthetically pleasing environment or one that will be preserved for future generations.

Use Values & Incentives

The use values associated with riparian areas include recreational benefits, specialty products, and agricultural productivity. In order to implement riparian buffer strips, some direct benefit must result from implementation of the BMP. A central element of riparian forest policy involves incentives, which include cost-share programs, fee payments for land taken out of production, and subsidized seedlings. Currently, the protection of riparian land relies heavily on voluntary and contractual programs. A variety of agencies including the Natural Resource Conservation Service (NRCS), the Consolidated Farm Service Agency (CFSA), and the U.S. Department of Agriculture Forest Service administer these incentive programs.

In the state of Oklahoma, there are currently no programs specifically addressing riparian protection and restoration. However, other states utilize local natural resource agencies, private industry, and citizen groups to assist in riparian protection. The state of Pennsylvania has a Streambank Fencing Program that has proven to be a model for other states to follow. It provides fencing to restrict livestock access to streams at no charge to farmers. This program has resulted in the installation of over 100 miles of fencing (CBC 1995). In the Chesapeake Bay Area, corporations such as Westvaco, Chesapeake, and Glatfelter have provided subsidized seedlings to landowners for reforestation. Also, there are many private businesses that are involved in community forest buffer replanting programs (CBC 1995). However, these issues don't offer any insight into how effective the current incentive programs are to Oklahoma farmers in meeting the economic needs of landowners.

It is obvious that the financial benefit a landowner receives will have an impact on his/her willingness to participate in a riparian conservation program. A good example of this principle has been Maryland's Buffer Incentive Program. This program had a backlog of applicants when it offered landowners a one-time $500-per-acre payment to establish and maintain a minimum 50-foot forested buffer strip. Then, there was a legislative modification to the program that lowered the payment to $300 per acre (CBC

1995). The end-result was a significant decline in the number of applicants. If they would have had the foresight, they could have conducted a more detailed analysis of the economic incentives. This would have helped them to determine what levels of cost-share are economical to landowners in differing land-use scenarios (CBC 1995).

Federal Programs - Financial Assistance Overview

There are several programs that offer assistance to landowners interested in protecting riparian areas:

Stewardship Incentive Program (SIP) - State Department of Agriculture-Forestry Services :

Farmers, ranchers and landowners across Oklahoma who have streamside forests or would like to establish a forested riparian buffer may be interested in the Forest Stewardship Program. This program is administered by the State Department of Agriculture-Forestry Services and is designed to help landowners receive more benefits from their forestland through good forest management.

The program provides technical assistance and recognizes good forest stewards. Once a management plan is approved, a landowner can apply for financial assistance under the Stewardship Incentive Program (SIP). This program can assist with planting trees, establishing wildlife habitat, and installing fences to protect streamside forests. Neighbors working together can increase the length of the riparian zone, enhancing the RBS benefit to wildlife across several landowners' properties (USDA 1996c).

Environmental Quality Incentives Program (EQIP) – USDA:

The USDA has an Environmental Quality Incentives Program (EQIP), that makes long-term conservation contracts and funding available to farmers and ranchers to improve the environmental health of the nation's farm and ranch land. EQIP is USDA's largest conservation program and it is designed to conserve and improve land, while it remains in agricultural productions. The EQIP program provides cost-share assistance for up to 75 percent of the cost of certain conservation practices, such as grassed waterways, filter strips, manure management facilities, capping abandoned wells, and wildlife habitat enhancement (USDA 1996b).

Incentive payments can be made for up to three years. The intention is to encourage producers to adopt conservation-oriented land-use management practices such as manure management systems, pest management, erosion control, wildlife and integrated pest management. For this program, the total cost-share and incentive payments are limited to $10,000 per person per year and $50,000 for the length of the contract. A contract may run from 5 to 10 years (USDA 1996b).

Partners For Wildlife (PFW) – USFWS:

These funds may be used to provide grants to States to benefit a broad array of diverse fish and wildlife species and to provide non-consumptive fish and wildlife recreation opportunities.

The purpose of the Partnerships for Wildlife Act is to establish a partnership among the United States Fish and Wildlife Service (Service), the National Fish and Wildlife Foundation (Foundation), designated State agencies, and private organizations and individuals to preserve and manage all non-game fish and wildlife species (Palone and Todd 1997).

Wildlife Habitat Incentives Program (WHIP) – USDA:

WHIP offers technical and cost-share assistance to landowners to develop improved wildlife habitat. Under the 1996 Farm Bill, cost-share assistance may pay for up to 75 percent of the cost of installing wildlife habitat development practices on the land. To participate in WHIP, individuals must own or have control of the land being offered. Under the proposed rules, WHIP offers 10-year contracts. The total cost-share amount cannot exceed $10,000 per contract. USDA will work with state and local partners to establish wildlife habitat priorities in each state. Applications will be ranked at the county level and those that provide the greatest wildlife benefits will be funded (USDA 1996e).

Conservation Reserve Program - (CRP):

The CRP is a voluntary approach to improving the environment utilizing partnerships between individuals and the government. The CRP protects highly erodible and environmentally sensitive lands with grass, trees and other long-term cover. The 1996 Farm Bill allows for CRP continuous sign-up and provides farmers with the opportunity to enroll land in the program by devoting it to environmentally conscious conservation practices, such as riparian buffers and grass waterways (USDA 1996a).

The premise behind the 'New CRP' is to achieve the fullest potential of government-farmer conservation partnerships. Thus, the goal is to enroll the most environmentally sensitive lands that will yield the greatest environmental benefits. Though erosion control remains a priority, water quality and wildlife habitat improvement are also emphasized. To this end, an Environmental Benefits Index (EBI) has been developed. The EBI will be used to select areas and acreages that offer the best environmental benefits. The deciding factors include wildlife habitat improvements, water quality increases, on-farm benefits from reduced erosion, air quality benefits, and costs of enrollment per acre.

Landowners establish long-term conservation practices on highly erodible land or environmentally sensitive land in exchange for 10-15 years of annual rental and incentive payments. Cost-share assistance is available for adopting and maintaining these practices. The contracts between USDA and landowners establish the rental rates and cost-share assistance to be paid over the 10-15 years covered by the contracts. Annual rental rates are based on intrinsic soil qualities and land-form. The main office in Washington determines appropriate rental rates and passes them down to each individual state office (USDA 1996a).

Disincentives

There are certain aspects of regulatory programs that can hinder participation in a riparian protection program. There is an example from Maryland where a farmer reportedly wanted to participate in a riparian protection program, but became disenfranchised due to complications in federal permitting. If the farmer were to allow his cattle unrestricted access to his stream, he fell under no permitting guidelines. However, if the landowner wanted to construct a regulated stream crossing, then he had to comply with federal and state wetland-permitting requirements. In this particular case, the regulatory process actually made it more difficult for a landowner to participate in a riparian protection project (CBC 1995).

There are also disincentives due to conditions in other landowner assistance programs. Some federal subsidy programs make payments to farmers based on the number of acres in or available to production. The USDA Commodity Set-Aside program operates in this fashion. The landowner risks losing some subsidies when they permanently remove part of their land from production for uses such as riparian forest buffers. Legislators need to comprehensively examine all resource-use assistance programs to identify disincentives to riparian forest implementation. Then, it will be possible to make adjustments that will benefit both the landowner and the riparian area (CBC 1995).

Riparian buffer restoration also has the potential to present perceptual disincentives to landowners. The restoration of riparian areas can take time and be influenced by high rainfall events. In some instances, the landowner may experience a precipitation event that washes away valuable land and planted trees. Although this is a natural occurrence, it can be perceived by the landowner to be a policy or land-use management failure. In addition, many landowners view riparian forest establishment efforts as preservationist. In reality, successful riparian forest programs encourage active forest management and other resource-use activities within the riparian zone. Thus, education and communication with landowners and managers is key to addressing disincentives and developing effective riparian management strategies (CBC 1995).

Externalities and Secondary Benefits of Riparian Buffer Implementation

There are numerous secondary values and externalities associated with the implementation of riparian buffer strips. Riparian forest buffers help ensure clean rivers and provide many ancillary benefits. The benefits provided by riparian areas are functional benefits that are basically provided for free, based on voluntary implementation of Best Management Practices. Also, they assist the land and resource manager in avoiding externalities such as costs to repair damaged and degraded natural systems (van Kooten 1993). The following list of externalities and benefits is taken from the Chesapeake Bay Riparian Handbook (Palone and Todd 1997):

Externalities

1) Stream Stability – Costs associated with urban retrofits and stormwater management technologies are expensive. If the watershed is at 15 percent or greater impervious surface, studies indicate that urban stream systems may fail to function, resulting in "blown-out" streams that silt downstream areas and increase flood potential. It is believed that forests help retain stream integrity.

2) Nutrient Removal – Riparian buffers can reduce costly water treatment.

- Riparian forest buffers are a low maintenance and long-term solution. It is estimated that forest buffers can remove 21 pounds of nitrogen per acre each year for $.30 per pound, and about 4 pounds of phosphorous per acre every year for $1.65 a pound.

- The Interstate Commission for the Potomac River Basin (ICPRB) estimates that urban retrofit of BMPs to remove 20 percent of current nutrient runoff will cost approximately $200/acre, or $643,172,600 for the Bay basin.
- In the same study, estimated costs of reducing runoff from highly erodible agricultural land are $130 per acre, or $68,758,430 for the basin.
- Wastewater treatment facilities in the Washington, D.C. area have annual costs of $2 to $10 million per year per facility, which equates to $3 to $5 per pound of nitrogen removed.
- Maryland's Tributary Strategies show that to reach a 40 percent reduction of nutrients by the year 2000, forest buffers and non-structural controls are significantly more cost-effective than engineered approaches. Where forest buffers are estimated to cost $617,000 and nonstructural shore erosion prevention/control $1.6 million per year, comparable structural techniques could cost $3.7 million to $4.3 million per year.

3) Pollution Prevention – Trees and riparian buffers act as natural pollution prevention technology by trapping and filtering atmospheric pollution. Air pollution and deposition of airborne pollutants are a multi-billion dollar problem nationally that affect human health, damage vegetation, and reduce visibility.

4) Stream Temperature – Removal of streamside vegetation has an adverse effect on aquatic life by increasing water temperature. Where cold water trout streams were once common in the Mid-Atlantic States, they have been greatly reduced due to the loss of riparian trees.

5) Erosion Control – Erosion and sediment control produces significant costs during development and in maintenance to communities down the road. Buffers mitigate some of these costs for free and add quantifiable and non-quantified benefits (Palone and Todd 1997).

Secondary Benefits

1) Flooding – Riparian vegetation diffuses the energy associated with the flow of water during flooding, thus reducing damage to riverbanks and the effects of downstream flooding. Also, forests reduce the quantity of water for stormwater.

2) Increased Property Values – Forests and riparian buffers have been found to increase the value of property, and to provide important environmental and recreational benefits.

3) Recreational Greenways – Riparian corridors attract revenue and are an important recreational resource to communities.

4) Wildlife Habitat – Riparian buffers provide valuable wildlife habitat. Many species use riparian areas at various stages of their life cycles and as travel corridors. Riparian trees produce organic matter, which is the foundation of the food web in most stream environments (Anderson and Masters 1995).

5) Timber Production – In 1992, timber products composed the largest portion of the total agricultural crop value in the United States. The total value is listed at $23.8 billion, passing corn and soybeans as the leading agricultural commodity.

6) Crop Alternatives and Specialty Forest Products – Trees and other alternative products grown in the streamside forest can bring big rewards. Examples include aromatics, cooking wood, nuts, wildlife recreation, weaving and dyeing materials, shiitake mushroom or ginseng production, and decorative cones (Palone and Todd 1997).

These types of externalities and secondary benefits must be taken into account when analyzing the cost benefit ratio of implementing riparian buffer strips and analyzing the maximum net present value for individual landowners.

Methods of Resource Valuation

There are three main techniques for estimating or valuing commodities that are not traded on the market and do not have directly observable prices. These types of commodities could include wildlife habitat, wildlife, recreation, etc., etc. The three methods of evaluation are travel-cost, contingent valuation, and land value. There is a fourth method for evaluating non-commodity benefits, which looks at associated expenditures (van Kooten 1993).

Travel-cost Method

The travel-cost method separates the site from the rest of the recreational experience. The method is based on costs associated with transportation and other costs of travel. It is assumed that the cost of travel and the time to visit a recreational area is a proxy for the site experience. This is a survey-based method of analysis (van Kooten 1993).

The recreation approach includes 5 phases:

1) Anticipation and trip preparation,
2) Travel to the site,
3) The on-site experience,
4) The travel back from the site
5) The recollection of the experience.

The expected relationship for the travel-cost method is that the number of site uses will decrease as user fees, travel-cost, and travel time increases. Rings are drawn around the recreational site and average travel-costs from each zone are determined. It is also necessary to determine the populations of each concentric zone. Then, it is possible to derive demand curves due to the fact that those who travel farther are willing to pay more to use the recreational site. It is expected that a smaller proportion of the population travel to the site as the distance from the site increases (van Kooten 1993).

This method is good for estimating uses of recreational areas in the absence of other data. However, it does rely on surveys, which have many sources of bias. Travel-cost methodology also does not account for the tourist traveling through or for special uses such as family reunions. It also fails to value what an individual's time is worth. In addition, it does not account for non-use or existence values (van Kooten 1993).

Land Value Method or Hedonic Pricing

This method is an indirect method for valuing a non-market commodity. This method presumes that the value of lake sites or other environmental features is reflected in the difference between the price consumers are willing to pay for property with the attribute as opposed to property without the attribute. For example, it is obvious that an individual would be willing to pay much more for a lakefront house on Lake Travis, than a house that had a scenic view of the local landfill. This method is good for measuring something that normally does not lend itself to being analyzed quantitatively. However, it does not account for existence or non-use values (van Kooten 1993).

Contingent Valuation Method

The contingent valuation method relies on individual responses to the contingent circumstances that are posed in an artificially construed market. The market is characterized by contingent payments. Payments are contingent upon the existence of hypothetical changes. The individual valuation of the non-market commodity is directly assessed by experimentation. Value is defined in terms of an individual's willingness to pay or accept compensation (van Kooten 1993).

The major benefit of this method is that it provides a way to analyze what people are willing to pay for existence value of non-market goods. However, there are some major problems with this method. One problem is that the survey and responses are completely hypothetical. There are also problems with several different types of survey bias. It is possible to try and minimize bias through setting of the survey and providing a contingent market that is credible. It is possible to reduce bias by ensuring that the people surveyed have enough information to provide an informed response. This requires a level of familiarity with the non-market goods in question. The contingent valuation method is commonly used, but the results are questionable (van Kooten 1993).

Expenditures Method

One last method of evaluating the benefits of a non-market good is to take a look at expenditures with or without a particular feature. For instance, it is possible to assign some value for wildlife habitat and wildlife through analysis of current hunting trends. Though this does not capture all of the value of the resource, it does provide a basis for economic worth. In the case of water quality, it is possible to analyze water treatment costs and assign value based on reducing the load to the system (van Kooten 1993).

Water Quality Research

The majority of papers written about the economic benefits of water quality utilize either the travel-cost or contingent valuation approach for valuation. As noted previously, these are survey-based methods based on willingness to pay for the resources. However, water quality benefits from riparian buffer implementation also come from stream stability, nutrient removal, erosion control, and flood damage averted. It is hard to directly value these benefits because riparian buffers provide them for free. However, it is possible to look at direct expenditures to provide the same service (Palone and Todd 1997).

The CBRH (1997) gives many economic examples of the quantitative benefits of riparian areas. From a streambank stability perspective, they show that:

1) *Stormwater treatment options that integrate riparian buffers are less expensive to construct than stormdrain systems and provide better environmental results. The costs of engineered stormwater BMPs range from $500 to $10,000 per acre and will have easily these amounts in maintenance costs over 20 years.*
2) *Montgomery Co., MD spends $20,000 to $50,000 per housing lot in some areas to repaired damaged streams and restore riparian areas.*
3) *Fairfax Co., VA – provided $1.5 million through a local bond issue to restore two miles of degraded stream and riparian area.*

From a nutrient removal perspective, riparian buffers can reduce water treatment costs.

1) *It has been estimated that riparian forest buffers can remove 21 pounds of nitrogen per acre each year for $.30 per pound and about 4 pounds of phosphorous per acre every year for $1.65 a pound*
2) *The Interstate Commission for the Potomac River Basin estimates that urban retrofit of BMPs to remove 20 percent of current nutrient runoff will cost approximately $200/acre or $643,172,600 for the Bay basin*
3) *In the same study, estimated costs of reducing runoff from highly erodible agricultural land are $130 per acre or $68,758,430 for the basin*
4) *Wastewater treatment facilities in the Washington D.C. area have annual costs of $2 to $10 million per year per facility, which equates to $3 to $5 per pound of nitrogen removed*

5) *Maryland's Tributary Strategies show that to reach a 40 percent reduction of nutrients by the year 2000, forest buffers and non-structural controls are significantly more cost effective than engineered approaches. Where forest buffers are estimated to cost $617,000, and nonstructural shore erosion prevention/control $1.6 million per year, comparable structural techniques could cost $3.7 million to $4.3 million per year.*

Agricultural sources are the largest contributor to the surface water quality problem in the United States (Crutchfield et al. 1993). From an erosion control perspective, riparian buffers provide a trap for dropping out sediment prior to its entering the waterway. Erosion harms water quality and decreases net fertility and productivity on farms (van Kooten 1993).

Water Quality Policy

Historically, policy efforts to protect water quality have been focused on municipal and industrial point sources of pollution. The effect of focusing on point sources for more than 20 years that non-point source pollution is the single remaining water quality problem in the United States (EPA 1992). From a policy perspective, it is important that water quality policies be designed to account for all costs and benefits of such policies in order to make the most effective use of resources. The costs of agricultural policies related to water quality can be estimated using conventional micro- and macroeconomic models of farm production. The benefits of improved water quality are difficult to assess. The benefits from improved water quality are environmental services not necessarily sold in conventional markets, so valuation techniques that are not reliant on market prices must be used to estimate benefits (Crutchfield et al. 1995).

Water quality and agricultural conflicts cannot be resolved without consideration of both private and public costs (Crutchfield et al. 1995). Farmers base their production decisions on a balance of their expected private costs of production options with returns from crops produced. These decisions may have unintended long-range effects and the consumer bears the cost of the externalities (Crutchfield et al. 1995). Economic losses from impaired environmental quality reflect the value of the services the resources provide. Examples of this are listed in Table 3.

Table 3: Use and Non-Use Values of Improved Water Quality

Benefit Class	Benefit Category	Examples
Use Value	In-stream Services	Recreational uses such as swimming, boating, and fishing. Commercial/municipal uses such as fishing, navigation, and water storage facilities.
	Consumptive Services	Drinking water from municipal water systems and private wells. Irrigation and other agricultural uses.
	Aesthetic Value	Near-water recreation such as picnicking and sightseeing. Property value enhancement.
	Ecosystem Value	Preservation of wildlife habitat and promotion of ecosystem diversity.
Nonuse Value	Vicarious Consumption	Value placed on enhanced use of clean water by others.
	Option Value	Desire to preserve opportunity to enjoy clean water at some time in future.
	Stewardship Value	Protection of environmental quality and desire to improve water quality for future generations.

Source: Crutchfield et al. 1995

Over 287 studies have been conducted on the value of recreation, over half of which dealt with some form of water-based recreation (Walsh, Johnson, and McKean 1992). The EPA has identified several hundred studies of water-quality benefits. The preponderance of these studies were for specific sites of local water-quality issues (Crutchfield et al. 1995). They are of nominal use in evaluating the national benefits of changes in water quality policies. There have not been many studies that have presented a comprehensive look at the cost of water pollution and the benefits of pollution reduction on a nationwide scale (Crutchfield et al. 1995).

Freeman (1982) completed one of the first comprehensive assessments of the benefits of pollution control. His studies relied on secondary studies of the costs of water pollution. Freeman estimated four types of benefits associated with removal of water pollutants: recreational benefits, nonuser benefits, commercial fishing, and consumptive uses. Total benefits were estimated to be between \$3.8 and \$18.4 billion (1978 dollars), with a point estimate of \$9.4 billion (Crutchfield et al. 1995). The largest category of benefits was recreation. It had a point estimate of \$4.6 billion (Crutchfield et al. 1995). The recreation benefits were derived from travel cost studies. The other estimated benefits were drawn from a synthesis of various non-market benefit studies, including averting expenditures and surveys of willingness to pay (Crutchfield et al. 1995).

Clark, Haverkamp, and Chapman (1985) conducted the first real analysis of water quality issues related to agriculture. They identified and quantified damages associated with soil erosion from cropland. Their work was based on existing studies and prorated them to account for the amount of pollution thought to be related to soil erosion from all sources and from cropland (Crutchfield et al. 1995). The studies they conducted reported the total economic cost from impairments of surface waters related to soil erosion to be around $6.1 billion in 1980 dollars (Clark et al. 1985) It was estimated that croplands contributed a share of erosion-related damages amounting to $2.2 billion (Clark et al. 1985).

The Clark et al. (1985) study only identified the total damages from soil erosion. They did not address the related issue of the marginal benefits of reducing these damages by reducing erosion (Crutchfield et al. 1995). In 1986, Ribaudo used the Clark study estimates in a study of the benefits of reducing soil erosion. Ribaudo disaggregated the total damage estimates by farm production region. Then, he created estimates of water-quality benefits by joining damage estimates along with regional water-quality changes created by reducing soil erosion. Based on conservation programs in place in 1983, he estimated off-farm benefits at $340 million (Ribaudo 1986). In 1989, he updated his work by adding on a travel cost and recreation participation model. This improved the estimated recreational fishing components of water-quality benefits (Ribaudo 1989). Ribaudo reported that off-farm damages of soil erosion varied regionally. His estimates varied from $0.57 per ton of erosion in the Northern Plains to over $7 per ton in the Northeast (Ribaudo 1989). The conclusion to be drawn from this work is that the economic efficiency of conservation programs could be improved by targeting programs in regions where the benefits would be the greatest (Ribaudo 1989).

Carson and Mitchell (1993) published one of the only comprehensive, nationwide estimates of the benefits of freshwater pollution control based on direct estimation of water-quality benefits (Crutchfield et al. 1995). They used a contingent valuation survey to ask respondents to indicate their willingness to pay for various levels of water-quality improvements (Carson and Mitchell 1993). They concluded that the national benefits of surface water quality improvement from non-boatable to swimmable quality would be approximately $29 billion per year in 1990 dollars (Carson and Mitchell 1993). This equates to around $240 per household (Carson and Mitchell 1993).

Modeling Erosion and Predicting Yield

The Universal Soil Loss Equation or USLE (Wischmeier and Smith 1965) approximates erosion reduction benefits from implementing riparian buffer strips as a BMP. The USLE is represented as:

[1] $$A=RKLSCP$$

Where A is computed soil loss (t/a), R is the rainfall-runoff erosivity factor, K is a soil erodibility factor, L is the slope length factor, S is the slope steepness factor, C is a cover-management factor, and P is a supporting practices factor. This equation is empirically based and derived from field data. It computes sheet and rill erosion using values that represent four major factors affecting erosion:

1) Climate erosivity – represented by R
2) Soil erodibility – represented by K
3) Topography – represented by LS
4) Land-use and management – represented by CP

RUSLE (Renard et al. 1993) is the Revised Universal Soil Loss Equation. The aforementioned values are retained by RUSLE. RUSLE was developed to further refine the USLE. These refinements include:

R-factor – increased sampling points were used for input data to create a new isoerodent map that is much more detailed and precise than the original USLE isoerodent maps.

K-factor – readily available from NRCS via major soil mapping units. However, the site-specific K values can be quite different than those represented by the soil survey. The updated K values represent developed values where a typical nomograph does not apply. Erodibility data from around the world were reviewed and an equation was developed that gives a K value estimate as a function of average diameter of soil particles. RUSLE also varies K seasonally. K is not a constant value, but one that changes with season. The seasonal variability is addressed by weighting the instantaneous estimate of K in proportion to the EI (the percent of annual R) for 15-day intervals. Instantaneous K estimates are made from equations relating K to the frost-free period and the annual R factor. An additional change incorporated into RUSLE is to account for rock fragments on and in the soil.

LS – factors – RUSLE includes improved guides for choosing slope length values to give greater consistency to users. However, it should be noted that soil loss is less sensitive to slope length than to any other USLE factor. The RUSLE uses three separate slope length relationships. They include a) a function of slope steepness (as in USLE), b) a function of the susceptibility of the soil to rill erosion relative to interrill erosion, and c) a slope length relationship for the Pacific Northwest.

The RUSLE has a more linear slope steepness relationship than the USLE. Computed soil loss for slopes less than 20 percent are similar in the USLE and RUSLE. However, on steep slopes, computed soil loss is reduced almost by half with the RUSLE. Data do not support the USLE quadratic relationship when extended to steep slopes.

C-factor – The C factor is perhaps the most important USLE factor because it represents conditions that can be managed most easily to reduce erosion.

EPIC (Erosion/Productivity Impact Calculator) is considered to be one of the most sophisticated and versatile models for simulating short and long-term biophysical processes in agrosystems (Moulin and Beckie 1993). The potential crop growth and development are determined by the amount of light intercepted and heat units accumulated. This is a daily time-step model that simulates potential growth daily and is constrained by resource limitations and erosion (Moulin and Beckie 1993). This model has been tested in diverse environments and has been found to be accurate in simulated grain yields, though calibration may be required on local sites (Ritchie and Otter 1985; Steiner et al. 1987).

The EPIC model utilizes a weather submodel that generates daily weather data over years for any given location. The data set includes of long-term monthly averages for air temperature, amount and number of days of precipitation, relative humidity, and wind velocity. Wind and precipitation are generated independent of other variables

(Moulin and Beckie 1993). Values generated for other variables are dependent on whether the day was wet or dry. The weather generator has been tested and found to be adequate for the weather generating task required by EPIC (Nicks et al. 1990).

Insufficient Data

A significant amount of data have been collected in regards to riparian forest buffers. However, programmatic data (data quantifying acreage in restoration and costs associated with restoration) are lacking. The agencies responsible for the various riparian programs do not maintain readily available data on riparian forest implementation. It is possible that this type of data are contained within program files, but limited personnel resources prevent this information from being easily obtained (Palone and Todd 1997).

In other cases, agencies have not designed their data collection methods to differentiate between riparian buffer information and other general data. These examples clearly illustrate the importance of integrating a riparian buffer policy into the current framework of resource assistance programs. As agency programs become more riparian-oriented, it is imperative that a forest buffer tracking system be developed so that this kind of data can be maintained in the future (Palone and Todd 1997). This type of data will allow for direct analysis of the cost-effectiveness of current incentive programs.

Data also need to be collected on the externalities associated with current land-use practices. These externalities include stream and streambank stability, nutrient removal, pollution prevention, stream temperature, and erosion. All of these externalities would need to be factored into a comprehensive model for analyzing the benefit/cost ratio of riparian buffer implementation.

It is also important for collection of data on secondary benefits of riparian buffer implementation. It is possible for the individual landowner in Oklahoma to receive ancillary benefits from riparian buffers such as erosion control, reduced flooding, increased property values, recreational greenways, wildlife habitat, timber production, cropping alternatives, and specialty forest products. However, there is currently little or no documentation on these benefits in Oklahoma.

Chapter 3

METHODS

Research for this project was conducted at Sugar Creek, Caddo County, Oklahoma. Riparian areas were assessed through interpretation of aerial photographs. The data were then transferred to a digital environment. Land-use by soil type was characterized and summarized. The data were then exported for economic analysis in a spreadsheet model. Erosion figures were calculated using the Revised Universal Soil Loss Equation (RUSLE). Productivity was calculated using the Erosion Productivity Impact Calculator or Environmental Policy Integrated Climate (EPIC) model (USDA-TAES 1996). These figures were integrated into an economic model to account for productivity losses due to net productivity decreases caused by erosion. Externality data was provided by the Oklahoma Federal Emergency Management Agency and the NRCS Office in Stillwater.

Sugar Creek Watershed - Background Information

The Sugar Creek Watershed is located in Caddo County, Oklahoma. It drains approximately 233 square miles (148,748 acres) into the Washita River. Sugar Creek's headwaters are located approximately three miles west of Hinton, Oklahoma. The water flows in a south-southeasterly direction for approximately 31miles. The elevation drops from a maximum of 1680 feet above mean sea level to a minimum 1150 feet (NRCS 1998).

Caddo County is located in southwestern Oklahoma, approximately 30 miles southwest of Oklahoma City. It has a warm, temperate climate. Caddo County has an average annual temperature of 61.2 degrees Fahrenheit. The average annual precipitation is 29.8 inches (NRCS 1998).

In the early 1900's, Sugar Creek's stability was governed by a wide, shallow floodplain with well-developed riparian areas. After settlement, the land-use changed and croplands replaced established riparian areas. The response of the watershed system was an increase of runoff and erosion. As a result, the lower reaches and floodplains of the system aggraded and flooding became prevalent (NRCS 1998).

The NRCS estimates that 87 percent of the county is in farm land usage (crop and rangeland). The 1997 county estimates show 70 percent of the cultivated land in wheat, 15 percent of the land in all types of hay, 8 percent in peanuts, 3 percent in sorghum, and approximately 1 percent each for oats, corn, cotton, and soybeans (NRCS 1998).

In the late 1950's, the Soil Conservation Service initiated a watershed protection project to reduce flooding and sedimentation. Sugar Creek Watershed was one of eleven watershed projects authorized under the authority of PL 78-534, the Flood Control Act of 1944. The SCS built 43 flood retarding structures, channelized approximately 21.3 miles of the main stem, and provided several grade stabilization structures and other land treatment measures (NRCS 1998). There are four primary problems that still exist in the watershed today:

1) Sedimentation in the Washita River downstream from the confluence with Sugar Creek,
2) Bank instability along Sugar Creek's main channel and tributaries,
3) Degrading side lateral channels,
4) Excessive sedimentation in some of the floodwater retarding structures (NRCS 1998).

Sugar Creek's drainage network is not functioning as designed due to excessive erosion and stabilization problems. One method of stabilization for the system is development of riparian buffers. This watershed was chosen for research due to the degraded state of its riparian areas and the fact that the NRCS is interested in increasing stability through implementation of riparian buffers as a BMP.

Remotely-sensed Data – Geographic Information System (GIS)

Due to resolution problems with satellite data, aerial photos were chosen as the data source for riparian assessment in Sugar Creek. Specific GIS methodology is listed in Appendix A. Aerial photographs were obtained from the Anadarko Field Office of the NRCS. The aerial photographs have a resolution of 1:7920.

The desired features of hydrology and land-use were traced onto transparent Mylar sheets from the aerial photographs. The hydrologic features were based on visual interpretation of the photos and cross-referenced with a United States Geologic Survey (USGS) 7.5-minute quadrangle map. All perennial channels and intermittent channels, denoted by blue lines on the USGS 7.5-minute quadrangle maps, were included in the assessment. Ephemeral channels are not depicted on USGS 7.5-minute quadrangles maps and were not included in the analysis.

The land-use features adjacent to the hydrologic features were also captured on the Mylar sheets. These land features included crops, pastures, urban areas, and forested riparian areas. The local NRCS field office personnel aided in interpretation of land-uses. Riparian areas were captured if the presence of trees could be interpreted from the photos to be 1/10" perpendicular to a stream feature for 1/10" or approximately 66 feet in length.

The Mylar sheets were then scanned into a digital environment. After the Mylar features were scanned, they were edited in Line Trace Plus (LTP) software version 4.13 (USDA-FS 1992). The purpose of the editing was to remove superfluous data, dangles, and spurs. Once editing was completed the files were exported. Registration points for each geographical coverage were noted on USGS 7.5' Quadrangle Maps. These maps were registered in GRASS 4.0 (USACE 1989) and the Universal Transverse Mercator (UTM) Coordinates for the registration points were written down. The coverages were imported and registered in ARC/INFO (ESRI 1996). The data were edited to create a land-use layer and a hydrology layer. Attribute values were added to these layers to define the polygons.

An idealized riparian buffer of 30 meters was extended from all water features in the hydrologic layer. This created a new polygon coverage. The land-use and hydrologic layers were then overlayed (Map 2, see insert). This operation overlays polygons on polygons, but keeps only those portions of the input coverage features falling within the overlay coverage features. Thus, the result was a layer detailing what land-uses occur within the idealized riparian buffer strip. This layer was then overlayed with a soils layer. The resulting layer contained information about land-use and soils within an idealized riparian buffer strip. The statistics were exported using the EXPORT command in an ASCII format. The statistics were imported into EXCEL for economic analysis. Maps for the area were generated in ARCVIEW 3.0 (ESRI 1997).

Economic Analysis

Statistics regarding Land-use and Soil Type were imported from ARC/INFO. Conservation Reserve Program (CRP) Rental Rates were obtained from the local FSA and NRCS offices (Table 4). Other federal incentive programs were not analyzed in this

Table 4: CRP Rental Rates by Soil Type

Soil Map Unit Symbols	CRP Soil Rental Rates (dollars)
None	18
AGD, COD, COD2, CRD3, DAD3, DND, DNE, KSD3, LUD, LUE, RO TAE	21
EFD, LM, QWD, VED	24
BK, DUD, EUC, KOC2, MOE	27
COB, COC, DOB, EUB, SHC, TLC, TLC2, WUC, YA	30
FOA, GRC2, GRD, ME, NOD, SHB, TLB	33
CS, CY, GRB, GRC, GWC, HOA, NOB, NRC, PU, RHA	37
MOD, MSC, NRB, PCA, PCB, PKB2, PO, REB	40
PKA, PKB, REA	43
MC	46

Source: NRCS 1998

project. This is due to the fact that they would not be economical to the individual landowner because there are no state programs to supplement the cost-share payments. Without a supplementation of 100 percent in the cost-share arrangement, it will not be directly economically beneficial for the landowner to take their land out of production, as these other federal programs do not offer a rental payment.

Establishment costs associated with implementing riparian buffer strips were determined through cost-share incentive payment information provided by the NRCS. The number of treatments required per year were multiplied by the (cost/units x # of units). The total was divided by the cost-share incentive payment provided for by the CRP Program. The total CRP Rental Rate was determined by:

[2] [Total acreage of land-use category by soil type X {CRP Rental Rate + $5.00 maintenance fee + .20 percent riparian incentive fee}]

This information was plugged into a net present value equation:

[3] $NPV = \sum_{t=0}^{T} [R_t - C_t/(1 + i)^t]$, where R_t = Receipts total, C_t = Costs total, T= total years, and i = interest rate

All calculations were derived using the ten-year contract length for CRP contracts. Figures for costs and receipts for farming operations were derived from the Oklahoma Enterprise Budgets for each farming practice (OSU Dept. of Agricultural Economics 1998). Budgets for each farming practice are listed for 1997 (Appendix B). The following is an example of the wheat budget:

Table 5: Sample Wheat Budget

WHEAT				76374004	
LOAM SOILS				09/15/97	
OWNED EQUIPMENT				SOUTHWEST	
OPERATING INPUTS	UNITS	PRICE	QUANTITY	VALUE	YOUR VALUE
WHEAT SEED	BU.	6.000	1.250	7.50	
NITROGEN (N)	LBS.	0.250	50.000	12.50	
18-46-0 FERT	CWT.	12.000	1.000	12.00	
CUSTOM SPRAY INS	ACRE	5.000	1.000	5.00	
ANHYDROUS AMMON.	LBS.	0.150	100.000	15.00	
ANNUAL OPERATING CAPITAL	DOL.	0.095	29.496	2.80	
MACHINERY LABOR	HR.	6.50	2.534	16.47	
MACHINERY FUEL, LUBE, REPAIRS	DOL.			24.33	
TOTAL OPERATING COSTS				95.60	
FIXED COSTS		AMOUNT	VALUE		YOUR VALUE
MACHINERY					
INTEREST AT	9.500%	207.87	19.75		
DEPR, TAXES, INSURANCE			26.81		
TOTAL FIXED COSTS				46.56	
PRODUCTION	UNITS	PRICE	QUANTITY	VALUE	YOUR VALUE
WHEAT	BU.	3.75	30.00	112.50	
SM GR PASTURE	AUMS	27.50	1.30	35.75	
TOTAL RECEIPTS				148.25	
RETURNS ABOVE TOTAL OPERATING COST				52.65	
RETURNS ABOVE ALL SPECIFIED COSTS				6.09	
N, P & K ARE IN POUNDS OF ACTUAL MATERIAL				SELLERS,KRENZER,HUTS	
CUSTOM SPRAY INCLUDES INSECTICIDE				04-Nov-97	
				0030	

Source: OSU Dept. of Agricultural Economics 1998

This project assumed that fixed costs will remain fixed. Thus, the values used in the calculations are for operating costs only (Total Receipts – Total Operating Costs). Establishment costs are included in the annual crop budgets for some of the crop types (see budget tables). For perennial grasses, the establishment costs were prorated over a ten-year period. It is expected that these types of fields will be productive for that length of time. For alfalfa, it assumed that the field will only yield productively for 5 years, thus a second establishment cost was included at year 5. For native grass pasture, the calculations were run with and without establishment costs. Depending on the quality of pasture, it may behoove the individual landowner to re-establish the native grasses to maximize productivity.

The calculations for CRP values also include a fencing option, where grazing is desired. CRP requires no grazing within the riparian buffer strip. The fencing calculations were estimated for a 1-acre plot of riparian land. It was assumed that the water body would act as one side and that there would already be two boundary fences in place. Thus, the estimate for fencing only includes a connection fence between boundaries. Wildlife lease values are included in the CRP valuation. The wildlife leasing value per acre was obtained from the Noble Research Center. It is assumed that this is a riparian leased-land value only. It does not reflect average lease values, which include marginal upland habitat. This figure represents the marginal value of the riparian area, not the property value as a whole.

Based on initial results, it was determined that land-use types were either more economical in production or in CRP. However, wheat production was on the bubble. Thus, it was decided that EPIC (USDA-TAES 1992) should be run for specific soil types based on wheat production. The EPIC model was used to predict erosion and net productivity decreases on specific wheat production soils. NPV estimates utilized average yield values for the entire county. Many of the soils that are currently being wheat farmed are marginal, erosive, and have a relatively low net productivity.

The six soils that had the highest acreage in wheat production and had the highest percentages of slopes were analyzed in this model. It was assumed that the soils with very high productivity and low slope would not alter the economic value formulas greatly. Thus, we only looked at the soils where it appeared there was a chance that the economic viability of farming would be lower than the economic average based on countywide figures.

An EPIC input file was created for each soil type from the MUUF directory. These contain all the intrinsic parameters for the soil type. The soils that were analyzed included Binger and Grant, Darnell-Noble Association, Gracemont and Ezell Soils, Ironmound-Nash Complex, Minco Very Fine Sandy Loam, and Noble Fine Sandy Loam. Soil hydrologic group, curve number, P factor, and average slope were calculated and added into file. The Oklahoma City (OKC) weather and wind files were generated by the model and utilized for Caddo County. In addition, the OKC elevation and latitudes were utilized for the model runs. For these model runs, we assumed a watershed area of 16 hectares.

For each model run, the soil type to be analyzed was loaded into the software. For each input file the slope, slope length, P factor and Runoff Curve Number were altered. In addition, the fertilizer level application rate was changed to 89lbs/ac. The EPIC program runs through 100 years or until the soil layer erodes to 0.1 meters, whichever occurs first. The output file from EPIC contains data in calendar year form. Wheat, for instance, is planted in September and harvested in June. A summary program was created that reads the output and summarizes the data on a crop year basis. The summary program creates a file *.PRN, which can then be read into EXCEL for data analysis.

EXCEL

In EXCEL, the files were opened as text files, parse with equal spaces. The two parameters of concern for these runs were soil depth losses and net productivity. The output results assume Y is yield in mt/ha, and D is depth in meters. These were converted to bu/ac and depth in feet. Simple linear regressions were run on the data by regressing the yield (y variable) on depth (x variable). The form is:

[4] $$Y = a + bD$$

Projected yields were then put into a ratio with known productivity yields from the Caddo County Soil Survey. Projected soil loss in depth then was subtracted from known soil depths over a 10-year period. The intercept and x variable were then added and multiplied by the actual soil depth, and then the result was multiplied by the productivity projection to determine productivity on a yearly basis. The results from the predicted yearly productivity were then factored into a 10-year NPV equation to determine the profitability of farming on these soils in riparian areas versus entry into the CRP program.

Secondary Benefits

In addition to using EPIC for direct benefits analysis, the RUSLE equation was applied to riparian areas in the entire watershed to approximate erosion reduction benefits from implementing riparian buffer strips as a BMP. RUSLE is the Revised Universal Soil Loss Equation. The Universal Soil Loss Equation (USLE) is represented as:

[5] $$A=RKLSCP$$

Where A is computed soil loss (t/a), R is the rainfall-runoff erosivity factor, K is a soil erodibility factor, L is the slope length factor, S is the slope steepness factor, C is a cover-management factor, and P is a supporting practices factor. This equation is empirically based and derived from field data. It computes sheet and rill erosion using values that represent four major factors affecting erosion:

1) Climate erosivity – represented by R
2) Soil erodibility – represented by K
3) Topography – represented by LS
4) Land-use and management – represented by CP

RUSLE utilizes the same equation, but relies on more detailed information for the R, K, and C factors. For this application, all factor values were obtained from NRCS (NRCS 1998a). Adjusted R factor was taken directly from isoerodent map (NRCS 1998a). Adjusted K factor was taken from tables(NRCS 1998a). If there were two soil components, the numbers were averaged. LS was calculated based on the 30 meter buffer length and an average soil steepness for each soil type. The C factor (Table 6) was based on land-use and parameter values listed in the State Program Handbook (NRCS 1998a).

Table 6: C Factors

Land-Use	Parameters	C Factor
Pasture	50% Canopy, 50% Ground-cover	.002
Wheat	10-15% Cover residues, Conventional tillage, Grazed, 30 bu/ac yield	.2
Peanuts	No cover crop, Conventional tillage, 2000 lbs. nuts/ac	.26
Alfalfa	Conventional tillage, Grazing	.05

The P factor was based on land-use and parameter values listed in the State Program Handbook (NRCS 1998a).

Table 7: P Factors

Land-use	Parameter	P Factor
Wheat	Code 5 – Light cover, Moderate roughness, Condition 5, Low ridges	0.83
All Pastures & Alfalfa	Code 1 – Established meadow for all pastures and alfalfa, no ridges	1
Peanuts	Code 7 – 4-6" Ridges, 4% slope	0.31

Values were adjusted for contouring, but not terracing. These figures were used to project soil loss for the entire watershed.

An annuity equation was applied to the CRP values for each land-use to determine the annual cost of implementing the riparian buffer practice.

[6] Annuity Payment (A) = NPV CRP $[i/1-(1/1+i^{10})]$, where i =interest rate

The annual payments were then divided by erosion from each particular land-use to determine the cost per ton of erosion reduced by implementation of the practice.

Additional Data on Externalities and Secondary Benefits

Additional data regarding flood damages was collected from the Oklahoma Federal Emergency Management Agency. They provided countywide figures on federal disaster aid from 1990-1995. In addition, transportation infrastructure damages due to stream instability figures were collected from the Caddo County Commissioners Office. In stream and streambank erosion figures were supplied by the NRCS.

Spatial/Economic Framework

The methodological framework used in this research was designed to assist policy makers in determining the cost-effectiveness and desirability of implementing riparian buffers as a best management practice. It can be used as a decision-making tool that will help land-use managers assess and spatially display existing riparian conditions within their respective water planning units. It also provides them with an economic and spatial basis for targeting potentially critical areas of riparian degradation for further analysis. The conclusions to be drawn include determination of areas deficient in riparian habitat and the economics of implementing riparian buffers for the watershed and the individual landowner. In addition, the externality information provides the decision-maker with further economic information regarding the costs to society of an unstable watershed system.

Framework - GIS

The framework requires decisions to be made based on individual circumstances. Flow charts (Figures 1 & 2) delineate the potential decision making paths that the potential user will follow.

The first decision that needs to be made is in regards to the data format. The choices include either utilizing aerial photographs or satellite data. Once this decision has been made, the data needs to be processed to assess existing riparian conditions. This requires conversion to a digital format (scanning or digitizing) for aerial photos or post-processing and classification for satellite data. In addition, satellite data will need to be ground-truthed to verify accuracy of classification. The purpose of putting this information into a digital format is so that it can be imported into a GIS system for analysis. The type of data required includes existing riparian areas, land-use, hydrologic features, and soils. Riparian areas and land-use layers are interpreted and created by the individual utilizing the framework. A hydrology layer may or may not be readily available to the user from governmental or academic resources. It will require research to determine if a layer is already in existence. Otherwise, hydrology can be interpreted from either aerial photos and referenced against USGS 7.5-minute Quadrangle maps, or can be processed from satellite data. Soils layers should be available in digital format from a local NRCS office.

Once the data are in a GIS system, then analysis may begin. Refer to flowcharts for types of analysis and specific information. The general idea is to quantify existing

Figure 1: Economic Framework Flow Chart

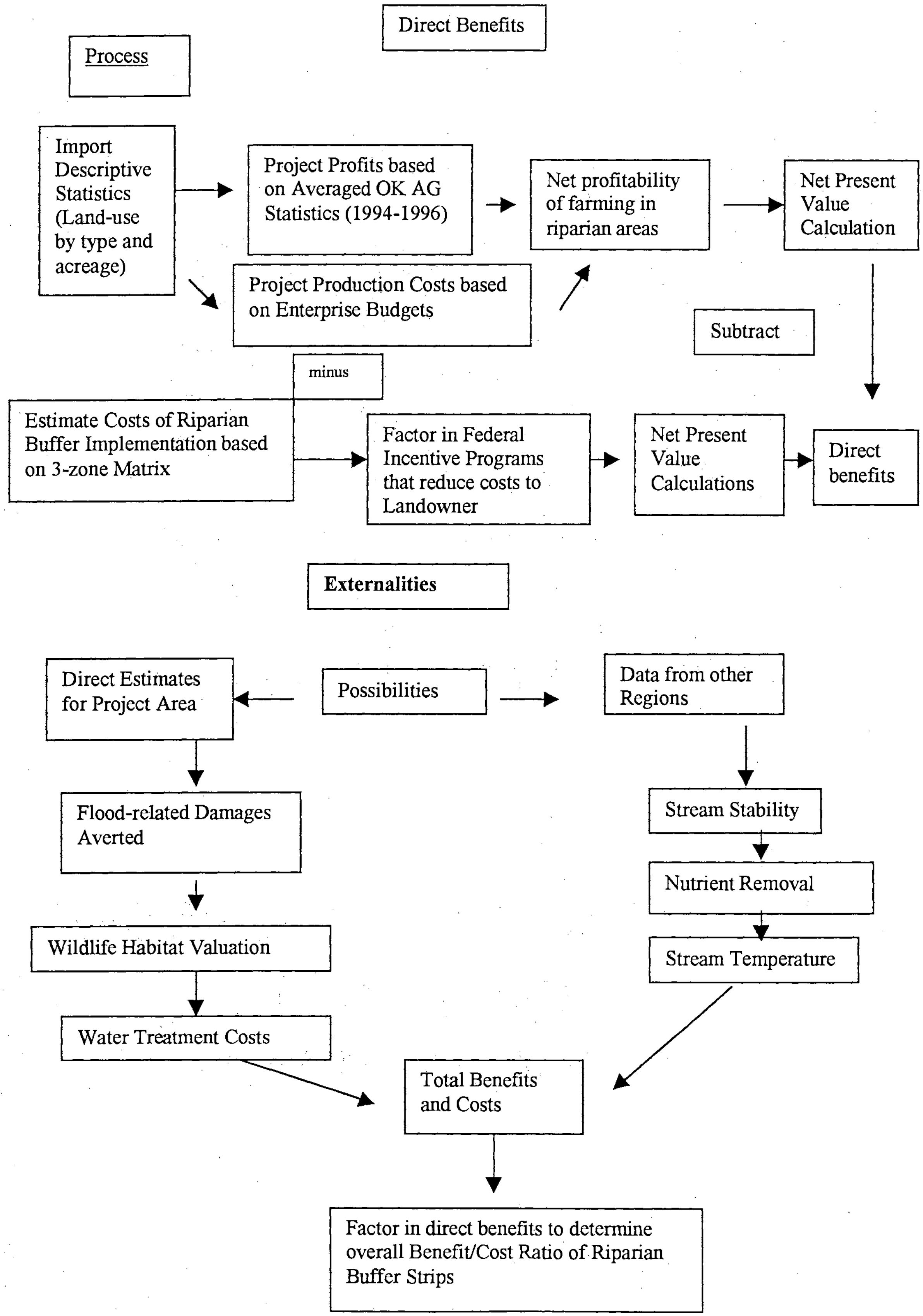
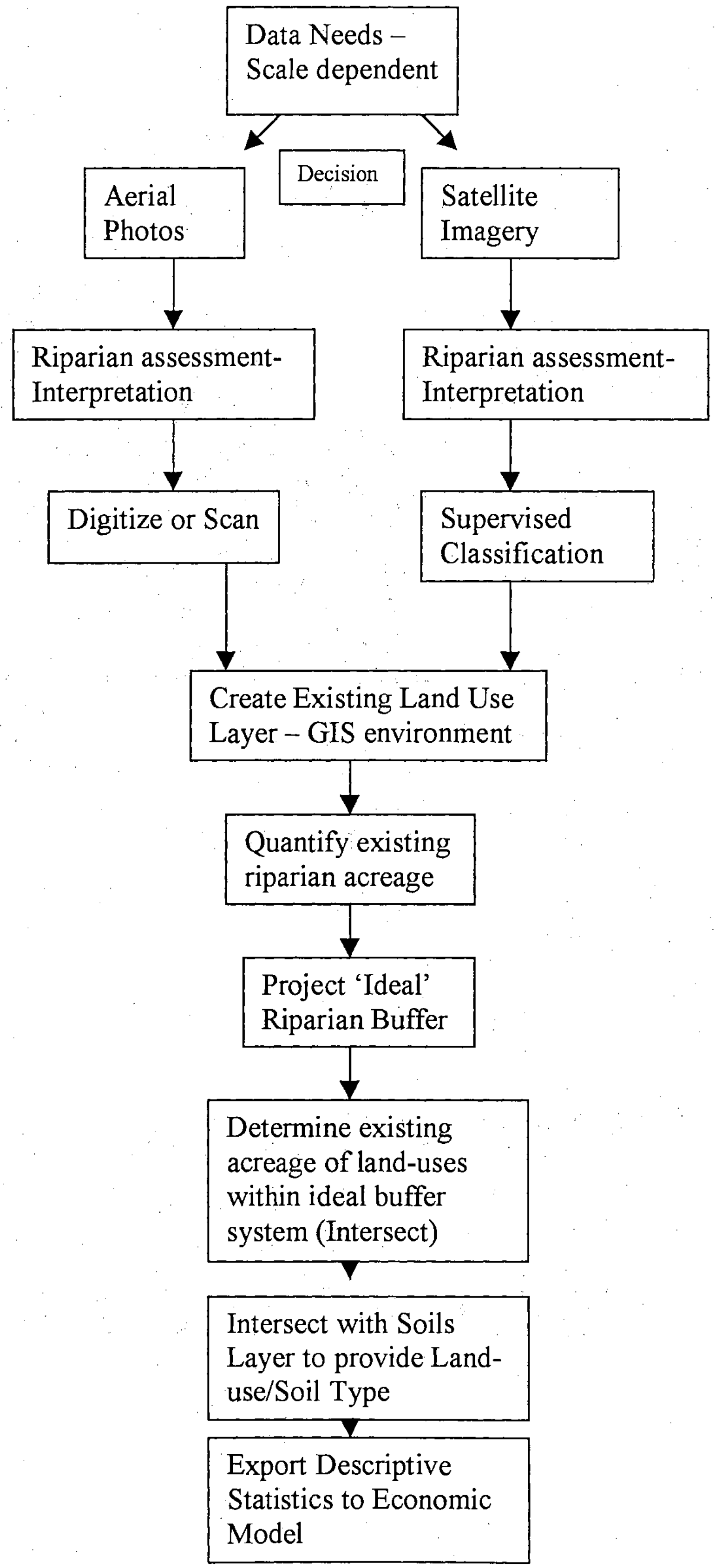


Figure 2: Spatial Framework Flow Chart



acreage of riparian areas and to then project an 'idealized' riparian buffer in a GIS environment. This projection, based on an INTERSECT command, will tell the user what land-uses, based on soil types, are currently taking place in the riparian areas within the idealized projected buffer. These statistics will be exported for economic analysis.

Framework - Economics

The next step in utilizing this framework starts with importing the land-use/soil statistics from the GIS system. First, profits can be projected based on averaged Oklahoma Agricultural Statistics, published by the Oklahoma Department of Agriculture (ODA 1996). The production figures are then entered into the Oklahoma Enterprise Budgets (OSU Dept. of Agricultural Economics 1998). These budgets provide the user with production costs and expected profits associated with each land-use, based on geographic location. These figures can then be entered into a net present value formula to determine profitability of farming in riparian areas, through time. The budget information should be available regardless of the state in question.

In improperly managed agricultural areas, one must account for the effects of soil erosion on productivity. Soil erosion can decrease farming productivity by removing nutrients and organic matter. It changes the physical and chemical properties of the soil. Often, it removes the most fertile topsoil and plowing mixes the less fertile lower soil layers into the growing zone. The increases in farming costs and the sum of the yield losses caused by erosion is a measure for productivity loss (USDA 1989).

The EPIC model can be used to account for these specific losses on a field by field basis. EPIC stands for Erosion Productivity Impact Calculator or Environmental

Policy Integrated Climate. The model objectives are to assess the effect of soil erosion on productivity. It also predicts the effects of management decisions on soil, water, nutrient, and pesticide movements and their impact on soil loss, water quality, and crop yields for areas with homogenous soils and management (USDA 1996). The reduced production yields can then be factored into the NPV equation to account for productivity losses through erosion.

The next step in utilizing the framework is to calculate the costs of implementing a riparian buffer strip. The costs include labor, materials, plants, fencing, and possible gradation work. In addition, maintenance costs need to be accounted for over the life of the potential contract or buffer. These data are factored into an NPV equation in coalition with the incentive programs available to landowners. The NPV equation includes establishment costs for the buffer in addition to the types of direct benefits received from federal and state programs. These benefits include incentive payments, rental payments, and cost-sharing payments. Once the direct benefits have been calculated through time, one can simply subtract the net profitability of farming in riparian areas to determine which is more cost effective, continued farming or participation in an incentive program.

Secondary benefits and externalities also factor into a cost/benefit analysis. However, these factors are usually added in as additional considerations and not factored directly into a NPV equation. This is due to the difficulty in attributing precise values to the individual, when society might be receiving the benefits or footing the bill. The individual or agency utilizing this framework will determine these additional factors. They include such things as water quality benefits, terrestrial and aquatic biodiversity increases, flood damages averted, streambank stability.

Chapter 4

RESULTS

The land-uses for the Sugar Creek watershed are shown in Map 1 (see insert) and the summary of existing land-use conditions in riparian areas are in Table 8. These land-uses occur within a 30 meter buffer from the stream system.

Table 8: Existing Land-Use Area in Riparian Areas of the Sugar Creek Watershed

Land-use	Acreage	Percent of Total Land-Use
Native Pasture	3016.55	32.71
Bermudagrass	751.76	8.15
Fescue Grass	77.43	0.84
Love Grass	45.23	0.49
Wheat	1292.69	14.02
Alfalfa	234.87	2.55
Peanuts	29.34	0.32
Forest	1662.36	18.02
Riparian Forest	2105.15	22.82
Urban	7.072	0.08
Total	9223.09	100

Approximately 42 percent of existing land-use is in some type of pasture land. Production crops account for 17 percent, with 14 percent in wheat production. Forty-one percent of land-use in riparian areas is forested. Urban areas comprise 0.08 percent of land-use in riparian areas. Land-use in riparian areas is displayed in Map 2 (see insert).

Table 9 lists the predominant riparian land uses by soil types. Complete figures for all land-uses and soil types are listed in Appendix C.

Table 9: Predominant Riparian Land-Use (over 20 acres) by Soil Type

Soil Type	Land-Use	Acreage
Binger and Grant	Native Grass	87
Binger and Grant	Wheat	20
Binger Fine Sandy Loam	Native Grass	53
Binger Fine Sandy Loam	Bermuda	25
Darnell-Noble Association	Native Grass	506
Darnell-Noble Association	Wheat	112
Darnell-Noble Association	Bermudagrass	84
Dougherty and Eufaula Loamy Fine Sands	Native Grass	81
Dougherty and Eufaula Loamy Fine Sands	Wheat	31
Eufaula Fine Sand	Native Grass	21
Gracemont and Ezell	Native Grass	400
Gracemont and Ezell	Wheat	194
Gracemont and Ezell	Bermudagrass	188
Gracemont and Ezell	Alfalfa	45
Ironmound-Nash Complex	Native Grass	209
Ironmound-Nash Complex	Wheat	48
Ironmound-Nash Complex	Bermudagrass	43
Minco Very Fine Sandy Loam	Native Grass	278
Minco Very Fine Sandy Loam	Bermudagrass	30
Noble Fine Sandy Loam	Native Grass	823
Noble Fine Sandy Loam	Wheat	190
Noble Fine Sandy Loam	Bermudagrass	157
Noble Fine Sandy Loam	Fescue Grass	23
Noble Fine Sandy Loam	Love Grass	20
Pond Creek Silt Loam	Native Grass	35
Port Silt Loam	Wheat	263
Port Silt Loam	Native Grass	127
Port Silt Loam	Bermudagrass	111
Port Silt Loam	Alfalfa	96
Pulaski Fine Sandy Loam	Native Grass	235

Soil Type	Land-Use	Acreage
Pulaski Fine Sandy Loam	Wheat	234
Pulaski Fine Sandy Loam	Bermudagrass	61
Pulaski Fine Sandy Loam	Alfalfa	47
Reinach Silt Loam	Native Grass	27

The Conservation Reserve Program incentive payment potential for implementing riparian buffers is located in Table 10. This has been calculated based on area, soil type, and CRP rental rates, incentive payments, and maintenance fees. CRP rental rates are based on the average county cash rental rates and intrinsic characteristics of the land including landscape, soil properties, and climate (R. Sinclair, NRCS, personal communication, Lincoln, NE., 13 September 1998).

Table 10: CRP Incentive Payment Potential

Land-Use	Soil Type	Area (ac)	CRP Rental Rate($)	Main-tenance Fee ($)	Incentive Payment ($)	Total Payment ($/ac)	Total payment ($)
Native Grass	Binger and Grant	86.98	21	5	4.2	30.20	2627
Bermuda-grass	Binger and Grant	14.15	21	5	4.2	30.20	427
Fescue Grass	Binger and Grant	0.84	21	5	4.2	30.20	25
Love Grass	Binger and Grant	0.23	21	5	4.2	30.20	7
Wheat	Binger and Grant	20.71	21	5	4.2	30.20	625
Peanuts	Binger and Grant	4.43	21	5	4.2	30.20	134
Native Grass	Binger Fine Sandy Loam	53.12	30	5	6	41.00	2178
Bermuda-grass	Binger Fine Sandy Loam	25.93	30	5	6	41.00	1063
Fescue Grass	Binger Fine Sandy Loam	4.71	30	5	6	41.00	193

Land-Use	Soil Type	Area (ac)	CRP Rental Rate($)	Main-tenance Fee ($)	Incentive Payment ($)	Total Payment ($/ac)	Total payment ($)
Wheat	Binger Fine Sandy Loam	17.02	30	5	6	41.00	698
Alfalfa	Binger Fine Sandy Loam	0.01	30	5	6	41.00	1
Peanuts	Binger Fine Sandy Loam	2.05	30	5	6	41.00	84
Native Grass	Cyril Fine Sandy Loam	12.46	37	5	7.4	49.40	615
Wheat	Cyril Fine Sandy Loam	6.35	37	5	7.4	49.40	314
Native Grass	Darnell Fine Sandy Loam	10.86	21	5	4.2	30.20	328
Bermuda-grass	Darnell Fine Sandy Loam	1.17	21	5	4.2	30.20	35
Fescue Grass	Darnell Fine Sandy Loam	0.13	21	5	4.2	30.20	4
Wheat	Darnell Fine Sandy Loam	0.19	21	5	4.2	30.20	6
Native Grass	Darnell-Noble Association	506.90	21	5	4.2	30.20	15308
Bermuda-grass	Darnell-Noble Association	84.60	21	5	4.2	30.20	2555
Fescue Grass	Darnell-Noble Association	14.15	21	5	4.2	30.20	427
Love Grass	Darnell-Noble Association	6.90	21	5	4.2	30.20	208
Wheat	Darnell-Noble Association	112.06	21	5	4.2	30.20	3384
Alfalfa	Darnell-Noble Association	3.09	21	5	4.2	30.20	93
Native Grass	Darnell-Rock Outcrop Complex	18.86	21	5	4.2	30.20	570
Wheat	Darnell-Rock Outcrop Complex	4.16	21	5	4.2	30.20	126
Peanuts	Darnell-Rock Outcrop Complex	2.72	21	5	4.2	30.20	82

Land-Use	Soil Type	Area (ac)	CRP Rental Rate($)	Main-tenance Fee ($)	Incentive Payment ($)	Total Payment ($/ac)	Total payment ($)
Native Grass	Dougherty and Eufaula Loamy Fine Sands	81.00	27	5	5.4	37.40	3030
Bermuda-grass	Dougherty and Eufaula Loamy Fine Sands	1.99	27	5	5.4	37.40	74
Love Grass	Dougherty and Eufaula Loamy Fine Sands	3.12	27	5	5.4	37.40	117
Wheat	Dougherty and Eufaula Loamy Fine Sands	31.22	27	5	5.4	37.40	1168
Alfalfa	Dougherty and Eufaula Loamy Fine	5.87	27	5	5.4	37.40	220
Peanuts	Dougherty and Eufaula Loamy Fine Sands	0.27	27	5	5.4	37.40	10
Native Grass	Eufaula Fine Sand	21.15	24	5	4.8	33.80	715
Wheat	Eufaula Fine Sand	3.83	24	5	4.8	33.80	130
Alfalfa	Eufaula Fine Sand	1.87	24	5	4.8	33.80	63
Native Grass	Eufaula Loamy Fine Sand	6.83	30	5	6	41.00	280
Love Grass	Eufaula Loamy Fine Sand	4.42	30	5	6	41.00	181
Wheat	Eufaula Loamy Fine Sand	1.60	30	5	6	41.00	65
Native Grass	Grant Loam	7.97	37	5	7.4	49.40	394
Bermuda-grass	Grant Loam	2.61	37	5	7.4	49.40	129
Wheat	Grant Loam	0.90	37	5	7.4	49.40	44
Native Grass	Grant-Port Complex	6.53	27	5	5.4	37.40	244

Land-Use	Soil Type	Area (ac)	CRP Rental Rate($)	Main-tenance Fee ($)	Incentive Payment ($)	Total Payment ($/ac)	Total payment ($)
Native Grass	Ironmound-Dill Complex	7.64	21	5	4.2	30.20	231
Bermuda-grass	Ironmound-Dill Complex	11.24	21	5	4.2	30.20	339
Wheat	Ironmound-Dill Complex	12.09	21	5	4.2	30.20	365
Native Grass	Ironmound-Nash Complex	209.07	24	5	4.8	33.80	7066
Bermuda-grass	Ironmound-Nash Complex	42.60	24	5	4.8	33.80	1440
Fescue Grass	Ironmound-Nash Complex	2.97	24	5	4.8	33.80	100
Wheat	Ironmound-Nash Complex	48.22	24	5	4.8	33.80	1630
Alfalfa	Ironmound-Nash	6.26	24	5	4.8	33.80	212
Native Grass	Konawa Loamy Fine Sand	11.51	27	5	5.4	37.40	431
Wheat	Konawa Loamy Fine Sand	9.10	27	5	5.4	37.40	341
Alfalfa	Konawa Loamy Fine Sand	1.01	27	5	5.4	37.40	38
Native Grass	Miller Silty Clay Loam	6.62	33	5	6.6	44.60	295
Native Grass	Minco Silt Loam	2.41	40	5	8	53.00	128
Wheat	Minco Silt Loam	6.78	40	5	8	53.00	359
Native Grass	Minco Very Fine Sandy Loam	278.25	40	5	8	53.00	14747
Bermuda-grass	Minco Very Fine Sandy Loam	29.89	40	5	8	53.00	1584
Fescue Grass	Minco Very Fine Sandy Loam	7.30	40	5	8	53.00	387
Wheat	Minco Very Fine Sandy Loam	70.41	40	5	8	53.00	3732
Peanuts	Minco Very Fine Sandy Loam	1.95	40	5	8	53.00	103

Land-Use	Soil Type	Area (ac)	CRP Rental Rate($)	Main-tenance Fee ($)	Incentive Payment ($)	Total Payment ($/ac)	Total payment ($)
Native Grass	Noble Fine Sandy Loam	823.46	37	5	7.4	49.40	40679
Bermuda-grass	Noble Fine Sandy Loam	156.84	37	5	7.4	49.40	7748
Fescue Grass	Noble Fine Sandy Loam	23.03	37	5	7.4	49.40	1138
Love Grass	Noble Fine Sandy Loam	19.98	37	5	7.4	49.40	987
Wheat	Noble Fine Sandy Loam	190.21	37	5	7.4	49.40	9396
Alfalfa	Noble Fine Sandy Loam	13.99	37	5	7.4	49.40	691
Peanuts	Noble Fine Sandy Loam	5.19	37	5	7.4	49.40	256
Native Grass	Pond Creek Fine Sandy Loam	1.06	40	5	8	53.00	56
Bermuda-grass	Pond Creek Fine Sandy Loam	2.10	40	5	8	53.00	111
Wheat	Pond Creek Fine Sandy Loam	8.00	40	5	8	53.00	424
Native Grass	Pond Creek Silt Loam	35.36	43	5	8.6	56.60	2001
Wheat	Pond Creek Silt Loam	30.63	43	5	8.6	56.60	1734
Native Grass	Port Silt Loam	127.45	40	5	8	53.00	6755
Bermuda-grass	Port Silt Loam	111.16	40	5	8	53.00	5892
Fescue Grass	Port Silt Loam	11.35	40	5	8	53.00	602
Wheat	Port Silt Loam	263.68	40	5	8	53.00	13975
Alfalfa	Port Silt Loam	95.90	40	5	8	53.00	5083
Peanuts	Port Silt Loam	10.41	40	5	8	53.00	552
Native Grass	Pulaski Fine Sandy Loam	235.15	37	5	7.4	49.40	11616
Bermuda-grass	Pulaski Fine Sandy Loam	60.78	37	5	7.4	49.40	3003
Fescue	Pulaski Fine	1.09	37	5	7.4	49.40	54

Land-Use	Soil Type	Area (ac)	CRP Rental Rate($)	Main-tenance Fee ($)	Incentive Payment ($)	Total Payment ($/ac)	Total payment ($)
Grass	Sandy Loam						
Love Grass	Pulaski Fine Sandy Loam	3.42	37	5	7.4	49.40	169
Wheat	Pulaski Fine Sandy Loam	234.11	37	5	7.4	49.40	11565
Alfalfa	Pulaski Fine Sandy Loam	46.63	37	5	7.4	49.40	2303
Native Grass	Reinach Silt Loam	27.37	40	5	8	53.00	1450
Bermuda-grass	Reinach Silt Loam	2.55	40	5	8	53.00	135
Wheat	Reinach Silt Loam	7.58	40	5	8	53.00	402
Alfalfa	Reinach Silt Loam	1.08	40	5	8	53.00	57
Native Grass	Yahola Fine Sandy Loam	5.27	30	5	6	41.00	216
Bermuda-grass	Yahola Fine Sandy Loam	0.12	30	5	6	41.00	5
Wheat	Yahola Fine Sandy Loam	0.75	30	5	6	41.00	31

Cost share figures for implementing riparian buffers are located in Table 11. The costs for implementing a riparian buffer without fencing are $191.59 per acre of riparian area. The costs for implementing a riparian buffer with fencing are $345.00 per acre of riparian area.

CRP values by soil type are listed in Table 12. The estimated value of continued farming in riparian areas are broken down by land-use and listed in Table 13 and Table 14.

Table 11: Estimated Cost of Riparian Buffer Implementation for 1-acre Plot with Cost-Share

Practice	Type	Unit	Applied	# of treatment	Cost/ unit	Units	Total cost	50 percent CS
Riparian Forest Buffer	Seedbed Prep	ac	1st year	1	30	0.77	23.10	11.55
	Trees/ shrubs	t/s	1st year	1	0.49	681	333.69	166.84
Filter Strip	Native mixture	ac	1st year	1	80	0.33	26.40	13.20
Fencing	4 Wire	Rod/ac	1st year	1	11.44	26.82	306.82	153.41

Table 12: CRP Values Based on Soil Types

Soil Type	Value/ac
Binger and Grant	48.73
Binger Fine Sandy Loam	136.54
Cyril Fine Sandy Loam	204.84
Darnell Soils	48.73
Dougherty and Eufaula Loamy Fine Sands	107.27
Eufaula Fine Sandy Loam	78.00
Eufaula Loamy Fine Sand	136.54
Grant Loam	204.84
Grant-Port Complex	107.27
Ironmound-Dill Complex	48.73
Ironmound-Nash Complex	78.00
Konawa Loamy Fine Sand	107.27
Miller Silty Clay Loam	165.81
Minco Silt Loam	234.11
Minco Very Fine Sandy Loam	234.11
Noble Fine Sandy Loam	204.84
Pond Creek Fine Sandy Loam	234.11
Pond Creek Silt Loam	263.39
Port Silt Loam	234.11
Pulaski Fine Sandy Loam	204.84
Reinach Silt Loam	234.11
Yahola Fine Sandy Loam	136.54

The value to the producer of taking land out of production and putting it into CRP is listed in Appendix D. The results from Appendix D include measuring the value of CRP payments per acre versus the value of farming per acre. It analyzes scenarios with and without establishment costs, as some types of farming do not require annual establishment costs. In addition, these equations reflect the increase or decrease in value associated with wildlife leasing, fencing, and erosion. The calculated erosion loss figures from RUSLE are located in Appendix E. The losses of productivity figures are located in Appendix F.

Tables 13-14 summarize the results from Appendix D. These tables list the range in values for the producer to either continue current farming practices or to put land into CRP. The estimates are based on a 10-year CRP contract.

Table 13: Estimated Net Present Value of Farming by Pasture Type

Land-use	Farming ($)	Farming w/o establishment ($)	Value/ac CRP – Range ($)
Native Grasses	-30.70	55.37	73.50 – 288.16
Bermuda-grass	8.45	8.45	73.50 – 288.16
Fescue	-69.67	-48.42	73.50 – 288.16
Love Grass	36.73	36.73	73.50 – 288.16

Table 14: Estimated Net Present Value of Farming by Crop Type

Land-use	Farming Value ($)	Value/ac CRP Range ($)
Wheat	332.49	73.50 – 288.16
Alfalfa	971.07	73.50 – 288.16
Peanuts	2307.14	73.50 – 288.16

The findings indicate that when all values are factored in, it is more profitable in each pasture scenario, regardless of soil type, to put land into CRP (Table 13). They also indicate that, in the absence of erosion, it is more economical for all production crops to remain in production (Table 14).

When erosion was considered for five soil types that had relatively high slope percentages, the results were mixed (Table 15). These estimates indicate that it would be more economical to continue farming wheat in the Minco Very Fine Sandy Loam soil.

Table 15: CRP Value with Erosion Factored in for Selected Soils

Wheat Production - SOIL TYPE	Value/ac Farming ($)	Value/ac Farming w/ erosion ($)	Value/ac CRP ($)
Binger and Grant	332.49	-211.92	73.50
Darnell-Noble Association	332.49	-369.76	73.50
Ironmound-Nash Complex	332.49	-351.72	102.77
Minco Very Fine Sandy Loam	332.49	942.293	258.89
Noble Fine Sandy Loam	332.49	107.04	229.62

However, it would be more profitable for the producer to take wheat out of production and put it into CRP for the Binger and Grant, Darnell-Noble Association, Ironmound-Nash Complex, and the Noble Fine Sandy Loam soils.

Chapter 5

DISCUSSION

This study utilized a conceptual framework to assess existing riparian conditions and to project the economics of implementing riparian buffers as a best management practice. Aerial photographs were used to assess existing riparian conditions. These data were transferred to a digital environment for further analysis in a GIS system. The statistics generated from existing land-use within an idealized riparian buffer were then utilized to analyze the cost-effectiveness of putting land into riparian buffers, based on existing incentive programs.

These estimates determine the direct benefits to the landowner of taking land out of production. Externality data were also collected as further economic evidence of an unstable system. These data include calculation of soil erosion losses, the damages associated with soil erosion losses, net fertility decreases and the effect on production yields, and flood damages. This information can be used to help look at the costs to society of continuing current land-use practices. This information assists decision-makers in formulating plans to manage systems from a broader perspective.

GIS

Aerial photos were used for this assessment. For larger scale projects, it may be more effective to utilize satellite data. The user of the framework must make the decision. Aerial photos can be more accurate, but transferring the data to Mylar and then to a digital environment, can be time and labor-intensive. However, there are accuracy gains to be made by using the aerial photos and ground-truthing the data can be less time intensive than ground-truthing a satellite scene. In time, as satellite data improves in resolution, it may become easier and more efficient to utilize satellite data as a primary data resource in this type of research. It should be noted that personnel trained in remote sensing and GIS are required for this type of project.

Determining the ideal buffer width will require a subjective interpretation from the user. As noted previously, there are several methods for determining buffer widths. There is no one correct method. The width will vary based on intrinsic factors, as well as management objectives. The width for this research was based on the NRCS requirements for minimum buffer widths in a 3-zone matrix.

The GIS findings indicate that 41 percent of land-use in Sugar Creek is already in riparian forest. However, the spatial display of these data show it is located primarily in the northern one-third of the watershed. Moving south through the watershed, there is very little contiguous riparian protection (Map 2, see insert). The results also indicate that production crops account for 17 percent of land area in riparian areas. Pasturelands of varying types account for another 42 percent of land-use in riparian areas. This research and the utilization of this framework give the decision-maker the opportunity to target critical areas for riparian protection.

Economics – Direct Benefits

The economic framework utilized for this project was based on net present value calculations. The results for this study analyzed the value of the land based on CRP values, existing land-uses with and without establishment costs, wildlife values, fencing costs, and erosion losses. Other federal incentive programs were not analyzed in this research. This was due to the fact that Oklahoma does not currently have any cost-share programs to supplement the federal programs. Thus, only the CRP program currently shows promise for being economically viable to the individual landowner due to the fact that it offers an annual rental payment, incentive payment, maintenance payment, and a cost-share incentive. However, this framework allows for analysis of any type of program and can be modified for utilization in other states or in Oklahoma, if cost-share programs become a reality in the future.

Sugar Creek - Direct Benefits

The results indicate that for every soil type, it is more economical to put pastureland in CRP than to continue utilizing it as pasture. This result was indicated for every scenario analyzed. CRP rental values do fluctuate, so the user will have to take that into account when conducting the direct benefit analysis.

The problem with taking pasturelands out of production is that the CRP does not currently accept pastureland in the program, unless it is "marginal pastureland." The definition of marginal pastureland is not clear in Oklahoma and thus CRP is not effectively being used. If the CRP were to accept pastureland into the program, it would be possible to put 42 percent of the total riparian land area into protection. Combined with the 41 percent already in riparian forest, this would achieve 83 percent protection for the Sugar Creek watershed, without even addressing production crops.

The analysis for production crops shows that for every scenario regarding peanut production, it is more economical to continue farming peanuts. However, it should be noted that peanut farming is heavily subsidized and does not necessarily reflect true market costs and values. The analysis for alfalfa shows that it is more economical to continue farming alfalfa in every scenario presented. The analysis for wheat production shows that it is more profitable to continue farming wheat in every scenario, except when soil erosion is considered. Soil erosion can reduce profits by cutting productivity. In some cases, it is only more profitable by a few dollars per acres, but it is still more profitable. However, when soil erosion is considered, it may be more profitable to take the land out of production in 4 out of the 5 soils analyzed. It is critical to include the net fertility losses due to erosion, when analyzing the viability of continued farming in a riparian area.

This framework relies on budgets developed by the OSU Department of Agricultural Economics. Variations in market values can affect the outcome of the economic model. For wheat production, fluctuations in the market could influence the decision made by the individual landowner. Table 16 shows how market fluctuations affect the value of wheat. The data show that as wheat prices drop, a greater amount of land would be more profitable in CRP than in production. As wheat prices increase, the possibility of CRP being more profitable becomes further removed.

Table 16: Effects of Wheat Market Fluctuations on NPV of Cropland, Value/acre CRP Range $73.50 - $258.16

Price of Wheat ($/bu)	Change from Current Market Value	Total Value (Receipts $)	Net Present Value (10 years, 4 % discount, $)	Value/ac CRP – Range ($)
5.25	+ $1.50	193.25	698.40	73.50 – 288.16
4.75	+ $1.00	178.25	576.43	73.50 – 288.16
4.25	+ $0.50	163.25	454.47	73.50 – 288.16
3.75	Current Value	148.25	332.49	73.50 – 288.16
3.25	- $0.50	133.25	210.54	73.50 – 288.16
2.75	- $1.00	118.25	88.57	73.50 – 288.16
2.25	- $1.50	103.25	-33.40	73.50 – 288.16

The direct benefits analysis provided in this research allows for a direct comparison of benefits farmers receive from farming versus those that they would receive from federal incentive programs. This research did not account for every contingency and possible variable within a farming operation. The framework allows for integration of case-specific information such as alteration of production variables in the agricultural budgets, market value fluctuation, and individual needs which may vary such as watering considerations for livestock. The user of the framework can easily adjust these factors.

It should be noted that Gracemont soils are not accepted into the CRP program. They have been determined to be ‘unarable’ by the FSA manual on CRP Rental Rates (K. Matlock, NRCS, personal communication, Stillwater, OK., September 5, 1998). However, this research indicates that Gracemont soils include over 607 acres of pastureland, 194 acres of wheat, 45 acres of alfalfa, and 2 acres of peanuts. These soils consist of deep, nearly level soils that occur on flood plains and are frequently flooded. They are poorly drained and characterized as a fine sandy loam. They are listed as a Capability unit Vw-2, dryland soil that is suited for pasture, range, and woodland (USDA-SCS 1973).

Economics – Externalities

Although externalities were not directly factored into the NPV equation in this research, they can still be revealing and should be considered. For this particular research, the stream system is unstable and damages have been estimated based on calculations of erosion-related damages, federal disaster aid, and county commissioner's budget information.

The individual user of this framework can choose to include any externality data desired, assuming data are available. The decision-maker will want to include as much hard data as possible, when evaluating the cost-effectiveness of implementing riparian buffers as a BMP.

Sugar Creek - Externalities

A significant amount of money has been spent improving the channel system of Sugar Creek. The NRCS spent $5,220,199 on watershed improvement projects on Sugar Creek from 1961-1974. These projects include building flood control impoundments and other stream stabilization structures. Channelization of the stream from 1967-1968 cost an additional $1,054,933. Also, drop structures were put in on several of the laterals at a cost of approximately $609,600. Operation and maintenance costs exceed $20,000 annually and it is projected that the NRCS will spend over $500,000 in the next 2-3 years on in-stream stabilization projects. An additional $1,000,000 in long-term stabilization projects will also be spent over the next 5 years (J. Mueller, NRCS, personal communication, Stillwater, OK., 13 September 1998).

In-stream erosion for Sugar Creek, which includes undercutting and bank sloughing, has been estimated by the NRCS (Appendix G). In-stream erosion for the main stem of Sugar Creek is estimated to be 141,810 tons/year over a 10-year period. In-stream erosion for the lateral tributaries of Sugar Creek is estimated to be 29,600 tons/year over the same 10-year period (J. Mueller, NRCS, personal communication, Stillwater, OK., 13 September 1998). Using Ribaudo's (1989) rates for damages associated with erosion for the Southern Plains Region ($2.02/ton), I conclude that in-stream erosion damages from the main stem are approximately $286,000 annually. Damage estimates for the contributing tributaries are about $60,000 annually. This sums to around $346,000 in annual erosion damages from in-stream erosion. The $20,000 operation and maintenance figure probably substantially underestimates the monetary needs of the system. The estimated $286,000 in annual in-stream erosion damages are a reflection on the instability of the system. There is no guarantee that simply increasing the amount of money spent annually on operation and maintenance will solve the problem.

The NRCS estimates that 550,000 tons of eroded soil is delivered to the watershed outlet annually. This figure includes over 170,000 tons from in-stream erosion and 380,000 tons from sheet, rill and gully erosion (J. Mueller, NRCS, personal communication, Stillwater, OK, September 25, 1998). Applying Ribaudo's (1989) rate of damages suggests that another $767,000 in erosion damages would occur from sheet, rill, and gully erosion for the watershed. A summary of expenditures and damages is provided in Table 17.

Table 17: Summary of Expenditures and Damages in Sugar Creek

Money Spent to Date 1998	Project	Annual Operation and Maintenance Costs
$6,880,000	Stream Improvements	
$1,500,000		$20,000
Total – 8,380,000		
Erosion		
In-Stream	Overland	
171,400 tons	380,000 tons	
Damages Due to Erosion		
$350,000	$760,000	
Flooding Damages in 1990s		
$2,560,000		
Cost to Implement Riparian Buffer	**Benefits**	**Value**
$95,000 annually	8,700 ton Erosion Reduction	$17,600
	Wildlife ($24/acre)	$108,000

Estimates of erosion via the RUSLE equation are located in Appendix E. The C and P factors were varied from existing land-use to predict erosion under a riparian buffer system. My findings suggest erosion under existing land-use to be more than 9000 tons per year within a projected riparian buffer area 30 meters wide on each side of all channels and tributaries. With implementation of a 3-zone forested riparian buffer, this would be reduced to 370 tons per year or by 96 percent.

It is important to target riparian areas for protection due to the increased percentages of erosion actually delivered to the stream system. Table 18 breaks down the erosion figures for cropland and pastureland. Pastureland represents over 70 percent of the land-area in production, but is responsible for only 30 percent of erosion in riparian areas. Cropland represents close to 30 percent of land-area in production, yet is responsible for

Table 18: Erosion on Cropland versus Pasture in Riparian Areas

Land-Use	Acreage	Erosion – No buffer (tons)	Acreage	Erosion – With Buffer (tons)
Pasture	3200	3000	3200	300
Cropland	1300	6000	1300	75

70 percent of erosion within riparian areas. Table 19 lists the associated costs to achieve the reduction in erosion in riparian areas. Complete findings are listed in Appendix E.

Table 19: Compensation Required to Achieve Erosion Reduction

Land-Use	Total Cost ($)	Total Tons Erosion Reduced	Dollars/Ton ($)
Pastureland	17,800	2700	6.60
Cropland	77,800	6000	13.00
Total	95,600	8700	10.98

These costs reflect the amount of money needed to implement riparian buffers from a federal incentive program and the reduction in erosion expected. The total cost for riparian buffer implementation in this system would be $95,600 annually. This would result in a reduction in erosion of 8700 tons annually. It should be noted there are other secondary benefits. Using Ribaudo's (1989) rates for damages associated with erosion the 8700 tons of erosion prevented would equate to a minimum savings of approximately $17,600 in annual damages.

Soils Erosion and Land-Use

This assessment indicates that a small group of soil types and land-use practices on these soils contribute most of the erosion in riparian areas. The greatest source of erosion in riparian areas is from the Darnell-Noble Association soils. Complete findings are listed in Appendix E. This soil type accounts for over 4,400 tons of annual erosion within riparian areas (Table 20). This represents approximately 50 percent of the total estimated erosion within riparian areas in the watershed. These soils have slopes ranging from 3-12 to 12-30 percent. They are a shallow, sandy loam and are on gently sloping to hilly areas. The soils are well drained, have a low water capacity and high water intake rate. They are best suited for native rangeland, but have been cultivated frequently throughout history (USDA 1973). Over 500 acres of this group of soils are in native grasses, 110 acres in wheat production, and 85 acres in Bermudagrass. Wheat production accounts for the largest share of erosion at 2,916 tons/year. Targeting these soils for BMPs would reduce erosion within the watershed.

The next greatest source of erosion in riparian areas is from the Ironmound-Nash Complex soils. This soil type accounts for over 1,113 tons of annual erosion. This accounts for another 12 percent of the total erosion occurring within riparian areas.

These soils have 5-12 percent slopes. They are shallow to moderately deep, well-drained, with low

Table 20: Descending Rates of Total Erosion by Soil Type and Land-Use

Soil Type	Land-use	Acres	Total Erosion
Darnell-Noble Association	Wheat	112.0582	2916.337
Darnell-Noble Association	Native Grass	506.8977	1319.212
Ironmound-Nash Complex	Wheat	48.21995	649.1817
Noble Fine Sandy Loam	Wheat	155.4736	635.1593
Minco Very Fine Sandy Loam	Wheat	70.40996	539.3386
Noble Fine Sandy Loam	Native Grass	733.1116	360.8429
Ironmound-Nash Complex	Native Grass	209.0653	281.4631
Minco Very Fine Sandy Loam	Native Grass	278.2465	256.7905
Port Silt Loam	Wheat	263.6771	251.8415
Darnell-Noble Association	Bermudagrass	84.60239	220.1795
Ironmound-Nash Complex	Alfalfa	54.63568	183.889

available water capacity. Due to depth of soils to bedrock and strong slopes, these soils are not desirable for crop production and are better suited to pasture or range (USDA-SCS 1973). However, 48 acres were in wheat, 54 in alfalfa, and 209 in native pasture. The area in wheat production represents the largest contribution of erosion at 649 tons/year.

The third greatest source of erosion in riparian areas is found on Noble Fine Sandy Loam soils. This soil type accounts for over 995 tons of annual erosion within riparian areas. This accounts for approximately 11 percent of the total erosion within riparian areas. The slope on this soil type ranges from 3-8 percent. The soils are well-drained with a high available water capacity. Most of these soils are in cultivation or pasture (USDA-SCS 1973). Wheat production on this soil accounts for 635 tons/year of soil erosion.

The fourth greatest source of erosion in riparian areas is found on Minco Very Fine Sandy Loam. This soil type accounts for over 795 tons of annual erosion within riparian areas. This accounts for approximately 9 percent of the total erosion within riparian areas. The slope on this soil type ranges from 3-8 percent. The soils are well-drained with a high available water capacity. Most of these soils are in cultivation or pasture (USDA-SCS 1973). Wheat production on this soil accounts for 539 tons/year of soil erosion.

The common factor in all of these erodible lands is the production of wheat on soils that have relatively high slopes. Table 15 in the results chapter reflects that continued farming in the presence of erosion is not profitable on Darnell-Noble Association, Ironmound-Nash Complex, or on Noble Fine Sandy Loam soils. It would be more profitable to take these lands out of production and put them into CRP. Results for the Minco Very Fine Sandy Loam indicate that it would be more profitable for the landowner to continue production within these soils. However, by targeting the first three soil types, 73 percent of erosion within riparian areas would be addressed.

Table 21 shows the amount of expenditure required to achieve the greatest erosion benefits. By targeting the soil types and land-uses listed in the table, the decision-maker could reduce erosion in riparian areas by 73 percent and only spend $24,300 annually. This is approximately $70,000 less than it would cost to implement riparian buffers throughout the watershed that would result in only 27 percent reduction in erosion. A full ranking of erosion benefits versus costs is listed in Appendix I.

Table 21: Amount of Money Required to Achieve Greatest Erosion Reduction in Riparian Areas

Soil Type	Land Use	Net Gain Erosion	NPV of Land Use	Acres	Annuity Payment	Cost ($)	Total Tons Erosion	$/ton
Darnell-Noble Association	Wheat	2887	332	112	41	4594	2887	1.60
Darnell Fine Sandy Loam	Native Grass	1187	55	507	7	3461	1187	2.90
Ironmound-Nash Complex	Wheat	643	332	48	41	1977	643	3.00
Noble Fine Sandy Loam	Wheat	628	332	155	41	6374	628	10.10
Minco Very Fine Sandy Loam	Wheat	533	332	70	41	2887	533	5.40
Noble Fine Sandy Loam	Native Grass	325	55	733	7	5005	325	15.40
					Total	24297	6202	

Map 3 (see insert) shows the spatial distribution of these lands and allows the decision-maker to target prospective lands visually to be taken out of production.

Flood damages

Flood damages are another type of externality commonly used to identify costs to society of an unstable watershed. Table 22 shows flood damage estimates for Caddo County, where the Sugar Creek watershed is located. Since 1990, Caddo County has the 4th highest per capita losses due to flooding in the state. These figures are based on a countywide population of 29,550 people (FEMA 1998).

Table 22: Federal Flood Disaster Aid since 1990, Caddo County

Caddo Co.	1993 ($)	1995 ($)	1995 ($)	Total ($)
Caddo	569,499	651,262	58,819	1,279,580
Anadarko	32,245	209,901	0	242,146
Binger	36,659	0	0	36,659
Caddo Co. RWD #1	20,373	0	0	20,373
Caddo Co. RWD #3	22,761	36,851	0	59,612
Caddo Elec. Coop.	14,750	31,159	0	45,909
Carnegie	12,453	19,571	0	32,024
Eakly	8,783	0	0	8,783
Ft. Cobb	7,632	0	0	7,632
Ft. Cobb-Broxton Sch.	16,845	0	0	16,845
Ft. Cobb Mst Con. Dist.	165,420	9,094	0	174,514
Gracemont	2,956	0	0	2,956
Hydro	10,547	4,713	0	15,260
Lookeba	3,296	0	0	3,296
Western Farmers Elec.	471,296	79,795	65,100	616,191
Grand Total	1,395,515	1,042,346	123,919	2,561,780
Per Capita Loss				86.70

Source: FEMA 1998

These figures include damages to roads and bridges. It also includes some structures that were put in place to help stabilize areas near bridges. According to the 3 District Commissioners Offices, any other costs associated with flood damage are not kept in records in such a way that they can be gleaned. In most situations, they attempt to get federal funding through NRCS to assist in stream stabilization projects and highway projects where damage has resulted from stream instability. However, District 1 has provided some figures regarding the amount of their budget spent on road and bridge maintenance in the Sugar Creek portion of the district. The annual budget for the district is $1,080,000. The district commissioner estimates that 40 percent or $432,000 of the annual budget is spent on repairing damages caused by stream instability (D. Recker, District 1 Commissioner, personal communication, Anadarko, OK., 21 August 1998).

Spatial/Economic Framework

The objective of this research was to provide a spatial/economic framework for decision-making that will show landowners and governmental agencies the costs versus benefits associated with implementation and maintenance of a designed riparian buffer system. The purpose of the framework is delineated in Table 23.

Table 23: Spatial/Economic Framework

Framework Element	Data Source/Function
Assess existing riparian conditions	Remotely sensed data -satellite or aerial photos. Spatial Analysis.
Direct and Indirect Benefits	Agricultural Statistics and Enterprise Budgets. Determines profitability of existing practices based on NPV calculations.
Alternative Land-Use	Incentive Programs. Examines profitability of taking land out of production and putting into incentive programs. Based on NPV calculations. Landowner point of view.
Costs/Benefits for Implementing Practice	Direct Benefits and Externality Data. Recommendations based on findings. Government perspective.

The spatial framework relies on interpretation of remotely sensed data. Agencies responsible for management of our natural resources have access to remotely-sensed data. This framework suggests a methodology for using this data to assess existing riparian conditions. This type of information provides land-use managers and decision-makers with a visual display to assist them in determining the status of riparian areas within their jurisdictional or management boundaries.

Having land-use and soil layers available in a GIS environment provides the user with many different types of modeling options. These options include modeling erosion, which would allow the user to identify critical areas of concern. The land-use layer can also be utilized by wildlife managers for habitat analysis and predictive modeling of wildlife population distributions. Crop production specialists may use this type of data to predict decreases in yields due to erosion. There are many alternative uses for this data.

The economic framework is based on quantifying the direct benefits to the landowner based on existing incentive programs and quantification of secondary benefits or externalities to society. The purpose of analyzing the direct benefits to the landowner is to provide some quantifiable economic data that a field technician or agricultural extension agent can use to show landowners the economic alternatives in utilizing riparian buffer zones as a BMP. Applying the framework may indicate that specific types of land-use on specific types of soils are more profitable than existing incentive programs. On the other hand, it may also show that profitability to the individual landowner is greater when lands are taken out of production and put into long-term incentive programs. The data may also reflect that there is adequate riparian protection and that restoration or implementation of riparian buffers is unnecessary.

The purpose of including externality data within this type of analysis is to provide the decision-maker with further economic evidence of the viability of riparian areas as a BMP. This type of information can be used by the decision-maker to prioritize areas of critical concern or to determine whether it is economically necessary or viable to restore riparian areas. It is not uncommon for economic data to be segmented in terms of availability to various agencies. Often, one agency holds economic information about a system that another agency may never see. Utilization of this framework and collection of externality data may reveal facts previously unknown to the individuals responsible for making decisions about the allocation of resources in the watershed in terms of management activities.

The application of this framework provides the decision-maker with information regarding the existing state of riparian areas within their management area. The economic data reflects the viability of riparian buffers as a BMP based on existing incentive programs and externalities. This type of information allows the decision-maker to make more informed decisions on the future land-use management practices within their watersheds.

Chapter 6

CONCLUSIONS

Riparian degradation in Oklahoma is a serious concern that has been detrimental to water quality, recreational activities, streambank stability, agricultural productivity, and biodiversity. Without changes in riparian management practices, riparian destruction will continue to have a severe impact on the economy of the State of Oklahoma.

The objective of this research was to provide a tool to show landowners and governmental agencies the costs versus benefits associated with implementation and maintenance of a designed riparian buffer system. The spatial/economic framework relied on interpretation of remotely sensed data, parameters of existing incentive programs, and quantification of secondary benefits. The maps created from the remotely-sensed data provide a means of visualizing what is occurring within a watershed in terms of land-use management and existing riparian areas. This type of visual information will assist decision-makers in their application of land-use management plans. It allows them to see areas that have no riparian protection versus other areas that may have adequate protection. In cases where the decision-maker does not have much time to spend out in the field, this type of information will provide them with the next best alternative.

The findings from this research concluded that:

1) In every crop production scenario, it was more profitable to continue farming in riparian areas than to put the land into CRP. However, this result changed when erosion was considered for wheat production. In 4 out of 5 soils modeled for decreases in yield due to erosion, it was more profitable to take wheat out of production and put it into CRP.
2) In every pasture scenario, it was more profitable to take land out of production and put it into CRP. However, due to the vague definition of 'marginal pastureland,' the majority of these lands are not eligible for inclusion in the program. If pastureland were eligible for inclusion in the CRP program, it would be possible to achieve 83 percent riparian protection throughout the watershed without addressing production crops.
3) Pastureland represents over 70 percent of riparian land-area in production, but is responsible for only 30 percent of erosion in riparian areas. Cropland represents close to 30 percent of riparian land-area in production, yet is responsible for 70 percent of erosion within these areas.
4) The total cost for riparian buffer implementation in this system would be $95,600 annually. This would result in a reduction in erosion of 8700 tons annually.
5) Four soil types were shown responsible for 82 percent of erosion in riparian areas. The common factor in all of these erodible lands is the production of wheat on soils that have relatively high slopes. Table 15 in Chapter 4 shows that continued farming would not be profitable on Darnell-Noble Association, Ironmound-Nash Complex, or on Noble Fine Sandy Loam soils due to

erosion. It would be more profitable to take these lands out of production and put them into CRP. Results for the Minco Very Fine Sandy Loam indicate that it would be more profitable for the landowner to continue production within these soils. However, by targeting the first three soil types, 73 percent of erosion within riparian areas would be addressed.

The spatial/economic framework presented here gives the decision-maker a tool to target critical areas for riparian protection. It further shows that in the absence of programs that are economically viable to both the landowner and the government, riparian protection is not likely to occur rapidly. Incentive programs also need to be more flexible in management options available to the landowner, as some programs allow for no management activity within the riparian buffer zone. Management options include limited access to water for livestock, hay production in Zone 3, and selective removal of valuable tree species in Zones 1 and 2. In addition, it is possible that current programs could be more economical if the State of Oklahoma had some supplemental cost-sharing programs.

Even with strong economic evidence showing the economic viability of utilizing riparian buffers as a BMP, there are still cultural and educational boundaries that will need to be addressed. Simply showing the economics is a first step, but it will ultimately be the job of field personnel to get the word out. There needs to be some flexibility in the management of these areas, in terms of fencing and watering livestock. Education about external benefits such as biodiversity gains and water quality enhancement needs to be addressed. Also, leadership from the federal, state, and local governments in this arena needs to occur. Currently, there is little direction in riparian protection, though legislation has been introduced in the Oklahoma Legislature which would offer some state cost-sharing from riparian buffer implementation. At the federal level, greater emphasis needs to be placed on protecting riparian areas in an economically viable way for farmers to participate in the programs offered.

Existing programs, in the absence of cost-sharing, simply do not equate economically for the individual land-owner in many cases. The CRP does work in some situations, but there are restrictions and inflexibility in the program that may cause landowners to be ineligible or to perceive that it is not in their best economic interests to participate. This type of research will assist both policy-makers and decision-makers in their efforts to effectively protect riparian areas in the future.

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Appendix A

Methods for Geographical Information System

Aerial photographs were obtained from the Anadarko Field Office of the NRCS. The aerial photographs have a resolution of 1:7920. The desired features of hydrology and land-use were traced onto transparent Mylar sheets from the aerial photographs. The hydrologic features were based on visual interpretation of the photos and cross-referenced with a United States Geologic Survey (USGS) 7.5-minute quadrangle map. Ephemeral channels were not included in the analysis. The land-use features adjacent to the hydrologic features were also captured on the Mylar sheets. These land features included crops, pastures, urban areas, and forested riparian areas. The local NRCS field office personnel aided in interpretation of land-uses. Riparian areas were captured if the presence of trees could be interpreted from the photos to be 1/10" perpendicular to a stream feature for 1/10" in length or approximately 66 feet.

The Mylar sheets were then scanned utilizing ASCAN version 7.2. Settings are shown in Table A-1.

Table A-1: ASCAN Settings for Scanning Mylar Sheets into Digital Environment

Software Parameter	Desired Setting
Density	200 pixels/inch
X (inches)	0.00 – 24.00
Y (inches)	0.00 – 24.00
Output File X Pixel Limits	1 – 4800
Output File Y Pixel Limits	1 – 4800
Speed	100 percent

Software Parameter	Desired Setting
Scan Line Orientation	4 (top left horizontal)
Image System	Bi-level
Sensitivity	135, 5, 0
Invert	No Invert
Mirror	No Mirror

After the Mylar features were scanned, they were then edited in Line Trace Plus (LTP) software (USDA 1992). The purpose of the editing was to remove superfluous data, dangles, and spurs. Once editing was completed, the files were exported in a DLG3 format.

Registration points for each geographical coverage were noted on USGS 7.5' Quadrangle Maps. These maps were registered in GRASS 4.0 (USACE 1989) and the UTM Coordinates for the registration points were written down. For the purposes of registration, a RMS of less than 6 was required.

The coverages were imported into ARC/INFO (ESRI 1996) using the DLGARC command and Optional Data Format. Once imported, the coverages were copied. The copied coverages were then opened in ARC/EDIT (AE), where all lines were removed, thus leaving only the registration tic marks. After exiting AE, INFO was opened. In INFO, the *.TIC file was opened and the records were UPDATED to reflect accurate UTM Coordinates for registration points. Then, the PROJECTDEFINE command was used to give the projection information listed in Table A-1.

Table A-2: Project Definitions in ARC/INFO

Project Definition	Parameter Input
Projection	UTM
Zone	14
Units	Meters
Datum	NAD27
Parameters	Parameters

Once the project was defined, the original coverage and the copied coverage were TRANSFORMED to merge the existing line file with the newly registered tic coverage. The CLEAN command was used to recreate the topology in the final coverage.

Two copies were made of the final coverage. The first coverage was edited in ARCEDIT to create a LANDUSE polygon layer. Using the CREATELABEL command, labels were added to all polygons. In the ARC environment, ADDITEM was used to add a LUCODE attribute to the *.PAT file. Then, attribute information was added to the layer in ARCEDIT by selecting labels and identifying LUCODEs. LUCODEs are listed in Table A-3. The layer was then rebuilt using the BUILD <POLY> command. The second layer was edited to select out the hydrologic features from the original layer (WATCOV). This layer is a line coverage and required no labeling, as all features are the same for this project. After editing, the WATCOV coverage was built using the BUILD <LINE> command.

Table A-3: Land-use Codes for GIS Project

Land-use Type	LUCODE
Unmaintained Pasture	100
Maintained Pasture – Bermuda	110
Maintained Pasture – Fescue	120
Maintained Pasture – Love Grass	130
Wheat	200
Alfalfa	300
Peanuts	400
Forest	500
Riparian Forest	600
Water	700
Urban	800
Corn	900

An idealized riparian buffer of 30 meters was extended from all features in the WATCOV hydrologic layer. This created a polygon coverage KK, which was built using the BUILD <POLY> command. The LANDUSE layer and WATCOV layer were overlayed using the INTERSECT command. This command overlays polygons on polygons, but keeps only those portions of the input coverage features falling within the overly coverage features. Thus, the result is a layer detailing what land-uses occur within the idealized riparian buffer strip.

This layer was overlayed with a SOILS layer, utilizing the INTERSECT command. The SOILS layer was obtained from the NRCS. It was exported as an ARCVIEW 3.0 (ESRI 1997) Shapefile. It was converted into an ARC coverage using the SHAPEARC command for a Type 5 (polygon) conversion with a subclass. The resulting layer contained information about land-use and soils within the idealized riparian buffer strip. The statistics were exported from the software using the EXPORT command in an ASCII format. The statistics were imported into EXCEL for statistical analysis.

Appendix B

Budgets for Farming Practices

BERMUDA PASTURE, DRYLAND
100# NITROGEN

83360301
09/15/97
SOUTHWEST

OPERATING INPUTS	UNITS	PRICE	QUANTITY	VALUE	YOUR VALUE
1/10 EST. COST	ACRE	106.680	0.100	10.67	________
NITROGEN (N)	LBS.	0.250	100.000	25.00	________
PHOSPH (P2O5)	LBS.	0.160	20.000	3.20	________
RNTFERTSPRD/ACRE	ACRE	2.500	2.000	5.00	________
ANNUAL OPERATING CAPITAL	DOL.	0.095	2.368	0.22	________
MACHINERY LABOR	HR.	6.50	0.225	1.46	________
MACHINERY FUEL, LUBE, REPAIRS	DOL.			1.61	________
TOTAL OPERATING COSTS				47.16	

FIXED COSTS		AMOUNT	VALUE		YOUR VALUE
MACHINERY					
INTEREST AT	9.500%	12.49	1.19		________
DEPR, TAXES, INSURANCE			1.30		________
TOTAL FIXED COSTS				2.48	________

PRODUCTION	UNITS	PRICE	QUANTITY	VALUE	YOUR VALUE
PASTURE	AUMS	12.00	4.50	54.00	________
TOTAL RECEIPTS				54.00	________

RETURNS ABOVE TOTAL OPERATING COST	6.84	________
RETURNS ABOVE ALL SPECIFIED COSTS	4.35	________

EST. COST IS PRORATED OVER 10 YR. PERIOD

REDMON, HUTSON

ALFALFA HAY, DRYLAND				81360004	
LOAM SOIL				09/15/97	
OWN EQUIPMENT				SOUTHWEST	
OPERATING INPUTS	UNITS	PRICE	QUANTITY	VALUE	YOUR VALUE
ESTAB PRORATE	ACRE	120.170	0.200	24.03	
PHOSPH (P2O5)	LBS.	0.160	60.000	9.60	
INSECTICIDE-PARATHION*	ACRE	7.500	2.000	15.00	
BALING WIRE	BL.	0.120	107.000	12.84	
RNTFERTSPRD/ACRE	ACRE	2.500	1.000	2.50	
CUSTOM HAULING	BL.	0.420	107.000	44.94	
ANNUAL OPERATING CAPITAL	DOL.	0.095	13.166	1.25	
MACHINERY LABOR	HR.	6.50	1.447	9.40	
OTHER LABOR	HR.	6.50	0.30	1.95	
MACHINERY FUEL, LUBE, REPAIRS	DOL.			15.84	
TOTAL OPERATING COSTS				137.36	

FIXED COSTS		AMOUNT	VALUE		YOUR VALUE
MACHINERY					
INTEREST AT	9.500%	170.80	16.23		
DEPR, TAXES, INSURANCE			21.57		
TOTAL FIXED COSTS				37.79	

PRODUCTION	UNITS	PRICE	QUANTITY	VALUE	YOUR VALUE
ALFALFA HAY	TONS	80.00	3.75	300.00	
TOTAL RECEIPTS				300.00	

RETURNS ABOVE TOTAL OPERATING COST	162.64	
RETURNS ABOVE ALL SPECIFIED COSTS	124.85	

EST. COST IS PRORATED OVER FIVE YEARS — REDMON, HUTSON

*INSECTICIDE HAS RESTRICTIONS ON APPLICATION — 22-Oct-97

FESCUE MAINTENANCE HIGH OPT CA-LA SOILS

84480401
09/15/97
SOUTHEAST

OPERATING INPUTS	UNITS	PRICE	QUANTITY	VALUE	YOUR VALUE
NITROGEN (N)	LBS.	0.250	115.000	28.75	
PHOSPH (P2O5)	LBS.	0.190	40.000	7.60	
POTASH (K2O)	LBS.	0.130	40.000	5.20	
RNTFERTSPRD/ACRE	ACRE	2.500	2.000	5.00	
ANNUAL OPERATING CAPITAL	DOL.	0.088	11.011	0.96	
MACHINERY LABOR	HR.	6.50	0.346	2.25	
MACHINERY FUEL, LUBE, REPAIRS	DOL.			2.29	
TOTAL OPERATING COSTS				52.05	

FIXED COSTS		AMOUNT	VALUE		YOUR VALUE
MACHINERY					
INTEREST AT	9.100%	13.49	1.23		
DEPR, TAXES, INSURANCE			1.51		
TOTAL FIXED COSTS				2.73	

PRODUCTION	UNITS	PRICE	QUANTITY	VALUE	YOUR VALUE
FESCUE PASTURE	AUMS	8.75	6.00	52.50	
TOTAL RECEIPTS				52.50	

RETURNS ABOVE TOTAL OPERATING COST	0.45	
RETURNS ABOVE ALL SPECIFIED COSTS	-2.29	

TAKE A HAY CROP FROM SURPLUS GROWTH
ROTATION GRAZING

REDMON, LLOYD
24-Oct-97

LOVEGRASS PASTURE, DRYLAND | 84360202
60# N. | 09/15/97
SOUTHWEST

OPERATING INPUTS	UNITS	PRICE	QUANTITY	VALUE	YOUR VALUE
1/10 EST. COST	ACRE	52.870	0.100	5.29	________
NITROGEN (N)	LBS.	0.250	60.000	15.00	________
PHOSPH (P2O5)	LBS.	0.160	20.000	3.20	________
RNTFERTSPRD/ACRE	ACRE	2.500	2.000	5.00	________
ANNUAL OPERATING CAPITAL	DOL.	0.095	2.318	0.22	________
MACHINERY LABOR	HR.	6.50	0.225	1.46	________
MACHINERY FUEL, LUBE, REPAIRS	DOL.			1.61	________
TOTAL OPERATING COSTS				31.78	

FIXED COSTS		AMOUNT	VALUE		YOUR VALUE
MACHINERY					
INTEREST AT	9.500%	12.49	1.19		________
DEPR, TAXES, INSURANCE			1.30		________
TOTAL FIXED COSTS				2.48	________

PRODUCTION	UNITS	PRICE	QUANTITY	VALUE	YOUR VALUE
PASTURE	AUMS	12.00	3.35	40.20	________
TOTAL RECEIPTS				40.20	________

RETURNS ABOVE TOTAL OPERATING COST	8.42	________
RETURNS ABOVE ALL SPECIFIED COSTS	5.94	________

LOVEGRASS PASTURE, SOUTHWEST OKLAHOMA | REDMON, HUTSON
40-40-40 STARTER, 60# N. ANNUALLY | 24-Oct-97
ESTABLISHMENT COST PRORATED OVER 10 YEAR LIFE | 0030

NATIVE GRASS PASTURE — 85000102
DEFERRED GRAZING, GOOD TO EXCELLENT RANGE CONDITION — 09/15/97
ANNUAL BURNING FOR FORAGE ENHANCEMENT — STATE

OPERATING INPUTS	UNITS	PRICE	QUANTITY	VALUE	YOUR VALUE
PRESCRIBED FIRE	ACRE	2.000	1.000	2.00	______
ANNUAL OPERATING CAPITAL	DOL.	0.088	0.563	0.05	______
MACHINERY LABOR	HR.	6.50	0.242	1.57	______
MACHINERY FUEL, LUBE, REPAIRS	DOL.			1.69	______
TOTAL OPERATING COSTS				5.31	

FIXED COSTS		AMOUNT	VALUE		YOUR VALUE
MACHINERY					
INTEREST AT	9.100%	2.51	0.23		______
DEPR, TAXES, INSURANCE			0.52		______
TOTAL FIXED COSTS				0.75	______

PRODUCTION	UNITS	PRICE	QUANTITY	VALUE	YOUR VALUE
PASTURE	AUMS	8.75	1.30	11.38	______
TOTAL RECEIPTS				11.38	______

RETURNS ABOVE TOTAL OPERATING COST	6.06	______
RETURNS ABOVE ALL SPECIFIED COSTS	5.31	______

GRAZING DEFERRED FROM JULY 10 UNTIL FIRST KILLING FROST NOV 1 — BIDWELL, BURTON
BERMUDA, LOVEGRASS, OR OLD WLD. BLUESTEMS UTILIZED. PRESCRIBED — 24-Oct-97
FIRE APPLIED LATE SPRING EVERY 3 YRS. — 1234

PEANUTS DRYLAND

95370007
09/15/97
SOUTHWEST

OPERATING INPUTS	UNITS	PRICE	QUANTITY	VALUE	YOUR VALUE
PEANUT SEED	LBS.	0.850	80.000	68.00	
NITROGEN (N)	LBS.	0.250	20.000	5.00	
PHOSPH (P2O5)	LBS.	0.160	40.000	6.40	
POTASH (K2O)	LBS.	0.130	75.000	9.75	
HERBICIDE	ACRE	8.000	1.000	8.00	
FUNGICIDE PROGRAM	ACRE	50.000	1.000	50.00	
RNTFERTSPRD/ACRE	ACRE	2.500	1.000	2.50	
ANNUAL OPERATING CAPITAL	DOL.	0.095	62.888	5.97	
MACHINERY LABOR	HR.	6.50	5.109	33.21	
MACHINERY FUEL, LUBE, REPAIRS	DOL.			47.37	
TOTAL OPERATING COSTS				236.21	

FIXED COSTS		AMOUNT	VALUE		YOUR VALUE
MACHINERY					
INTEREST AT	9.500%	418.77	39.78		
DEPR, TAXES, INSURANCE			48.12		
TOTAL FIXED COSTS				87.90	

PRODUCTION	UNITS	PRICE	QUANTITY	VALUE	YOUR VALUE
PEANUTS	CWT.	30.50	18.00	549.00	
TOTAL RECEIPTS				549.00	

RETURNS ABOVE TOTAL OPERATING COST	312.79	
RETURNS ABOVE ALL SPECIFIED COSTS	224.89	

N, P, & K AMOUNTS ARE ACTUAL POUNDS OF MATERIAL.
HERBICIDE IS PROWL

SHOLAR, HUTSON
24-Oct-97

Appendix C

Land-use area by soil type

Table C-1: Land Use Area by Soil Type

Area (ac)	LU Code	Soil_name	Soil Symbol
86.9806	100	BINGER AND GRANT SOILS	CRD3
14.1535	110	BINGER AND GRANT SOILS	CRD3
0.84364	120	BINGER AND GRANT SOILS	CRD3
0.22919	130	BINGER AND GRANT SOILS	CRD3
20.7075	200	BINGER AND GRANT SOILS	CRD3
4.43235	400	BINGER AND GRANT SOILS	CRD3
53.1218	100	BINGER FINE SANDY LOAM	CoC
25.9327	110	BINGER FINE SANDY LOAM	CoC
4.71019	120	BINGER FINE SANDY LOAM	CoC
17.0174	200	BINGER FINE SANDY LOAM	CoC
0.0122	300	BINGER FINE SANDY LOAM	CoC
2.05253	400	BINGER FINE SANDY LOAM	CoC
12.4583	100	CYRIL FINE SANDY LOAM	CS, CY
6.34911	200	CYRIL FINE SANDY LOAM	CS, CY
10.8617	100	DARNELL FINE SANDY LOAM	DaD3, DnE, DNd
1.17441	110	DARNELL FINE SANDY LOAM	DaD3, DnE, DNd
0.13396	120	DARNELL FINE SANDY LOAM	DaD3, DnE, DNd
0.18588	200	DARNELL FINE SANDY LOAM	DaD3, DnE, DNd
506.898	100	DARNELL-NOBLE ASSOCIATION	DaD3, DnD, DNe
84.6024	110	DARNELL-NOBLE ASSOCIATION	DaD3, DnD, DNe
14.1532	120	DARNELL-NOBLE ASSOCIATION	DaD3, DnD, DNe
6.90314	130	DARNELL-NOBLE ASSOCIATION	DaD3, DnD, DNe
112.058	200	DARNELL-NOBLE ASSOCIATION	DaD3, DnD, DNe
3.09207	300	DARNELL-NOBLE ASSOCIATION	DaD3, DnD, DNe
18.8632	100	DARNELL-ROCK OUTCROP COMPLEX	DaD3, DnD, DnE

Area (ac)	LU Code	Soil_name	Soil Symbol
4.15717	200	DARNELL-ROCK OUTCROP COMPLEX	DaD3, DnD, DnE
2.72412	400	DARNELL-ROCK OUTCROP COMPLEX	DaD3, DnD, DnE
81.005	100	DOUGHERTY AND EUFAULA LOAMY FINE SANDS	DuD
1.9914	110	DOUGHERTY AND EUFAULA LOAMY FINE SANDS	DuD
3.11815	130	DOUGHERTY AND EUFAULA LOAMY FINE SANDS	DuD
31.2228	200	DOUGHERTY AND EUFAULA LOAMY FINE SANDS	DuD
5.87048	300	DOUGHERTY AND EUFAULA LOAMY FINE SANDS	DuD
0.27259	400	DOUGHERTY AND EUFAULA LOAMY FINE SANDS	DuD
21.1536	100	EUFAULA FINE SAND	EfD
3.83175	200	EUFAULA FINE SAND	EfD
1.86559	300	EUFAULA FINE SAND	EfD
6.83497	100	EUFAULA LOAMY FINE SAND	EuB
4.41599	130	EUFAULA LOAMY FINE SAND	EuB
1.5954	200	EUFAULA LOAMY FINE SAND	EuB
400.438	100	GRACEMONT AND EZELL SOILS	Gm
187.895	110	GRACEMONT AND EZELL SOILS	Gm
11.8101	120	GRACEMONT AND EZELL SOILS	Gm
7.18719	130	GRACEMONT AND EZELL SOILS	Gm
194.912	200	GRACEMONT AND EZELL SOILS	Gm
45.1969	300	GRACEMONT AND EZELL SOILS	Gm
2.32024	400	GRACEMONT AND EZELL SOILS	Gm
7.974	100	GRANT LOAM	GrC
2.60782	110	GRANT LOAM	GrC
0.89559	200	GRANT LOAM	GrC
6.52763	100	GRANT-PORT COMPLEX	Bk
7.63504	100	IRONMOUND-DILL COMPLEX	LuD
11.2392	110	IRONMOUND-DILL COMPLEX	LuD
12.094	200	IRONMOUND-DILL COMPLEX	LuD

Area (ac)	LU Code	Soil_name	Soil Symbol
209.065	100	IRONMOUND-NASH COMPLEX	QwD
42.5997	110	IRONMOUND-NASH COMPLEX	QwD
2.97237	120	IRONMOUND-NASH COMPLEX	QwD
48.22	200	IRONMOUND-NASH COMPLEX	QwD
6.25845	300	IRONMOUND-NASH COMPLEX	QwD
11.5121	100	KONAWA LOAMY FINE SAND	KoC3
9.10461	200	KONAWA LOAMY FINE SAND	KoC3
1.00602	300	KONAWA LOAMY FINE SAND	KoC3
6.61727	100	MILLER SILTY CLAY LOAM	Me
2.41364	100	MINCO SILT LOAM	MsC
6.77988	200	MINCO SILT LOAM	MsC
278.246	100	MINCO VERY FINE SANDY LOAM	MoD
29.8915	110	MINCO VERY FINE SANDY LOAM	MoD
7.30012	120	MINCO VERY FINE SANDY LOAM	MoD
70.41	200	MINCO VERY FINE SANDY LOAM	MoD
1.94798	400	MINCO VERY FINE SANDY LOAM	MoD
823.46	100	NOBLE FINE SANDY LOAM	NoB
156.841	110	NOBLE FINE SANDY LOAM	NoB
23.0315	120	NOBLE FINE SANDY LOAM	NoB
19.9766	130	NOBLE FINE SANDY LOAM	NoB
190.209	200	NOBLE FINE SANDY LOAM	NoB
13.986	300	NOBLE FINE SANDY LOAM	NoB
5.19149	400	NOBLE FINE SANDY LOAM	NoB
1.05874	100	POND CREEK FINE SANDY LOAM	PcB
2.10194	110	POND CREEK FINE SANDY LOAM	PcB
8.00279	200	POND CREEK FINE SANDY LOAM	PcB
35.3615	100	POND CREEK SILT LOAM	PkB
30.632	200	POND CREEK SILT LOAM	PkB
127.454	100	PORT SILT LOAM	Po
111.163	110	PORT SILT LOAM	Po
11.3545	120	PORT SILT LOAM	Po
263.677	200	PORT SILT LOAM	Po
95.8998	300	PORT SILT LOAM	Po
10.4089	400	PORT SILT LOAM	Po

Area (ac)	LU Code	Soil_name	Soil Symbol
235.151	100	PULASKI FINE SANDY LOAM	Pu
60.7807	110	PULASKI FINE SANDY LOAM	Pu
1.09478	120	PULASKI FINE SANDY LOAM	Pu
3.41892	130	PULASKI FINE SANDY LOAM	Pu
234.108	200	PULASKI FINE SANDY LOAM	Pu
46.6267	300	PULASKI FINE SANDY LOAM	Pu
27.3668	100	REINACH SILT LOAM	ReB
2.5483	110	REINACH SILT LOAM	ReB
7.5802	200	REINACH SILT LOAM	ReB
1.07728	300	REINACH SILT LOAM	ReB
5.27131	100	YAHOLA FINE SANDY LOAM	Ya
0.11625	110	YAHOLA FINE SANDY LOAM	Ya
0.74833	200	YAHOLA FINE SANDY LOAM	Ya

Appendix D

Value of taking land out of production and putting it into CRP

Table D-1: Value of taking land out of production and putting it into CRP

Value Of Taking Land Out of Production							
		Value/ac	Value/ac	Value/ac	Value/ac	Value/ac	Value/ ac
LU Code	Soil Type	NPV in CRP	NPV of Farming	NPV(w/o est. cost) Farming	NPV CRP with wild-life values	NPV CRP(fen-cing)	NPV w/Ero-sion
100	CRD3	48.73	-30.70	55.37	243.87	73.50	
110	CRD3	48.73	8.45	8.45	243.87	73.50	
120	CRD3	48.73	-69.67	-48.42	243.87	73.50	
130	CRD3	48.73	36.73	36.73	243.87	73.50	
200	CRD3	48.73	332.49	332.49	243.87	73.50	-211.92
400	CRD3	48.73	2307.14	2307.14	243.87	73.50	
100	CoC	136.54	-30.70	55.37	331.69	161.32	
110	CoC	136.54	8.45	8.45	331.69	161.32	
120	CoC	136.54	-69.67	-48.42	331.69	161.32	
200	CoC	136.54	332.49	332.49	331.69	161.32	
300	CoC	136.54	971.07	971.07	331.69	161.32	
400	CoC	136.54	2307.14	2307.14	331.69	161.32	
100	CS, CY	204.84	-30.70	55.37	399.99	229.62	
200	CS, CY	204.84	332.49	332.49	399.99	229.62	
100	DnD,DnE, DaD3	48.73	-30.70	55.37	243.87	73.50	
110	DnD,DnE, DaD3	48.73	8.45	8.45	243.87	73.50	
130	DnD,DnE, DaD4	48.73	36.73	36.73	243.87	73.50	
120	DnD,DnE, DaD3	48.73	-69.67	-48.42	243.87	73.50	
200	DnD,DnE, DaD3	48.73	332.49	332.49	243.87	73.50	-369.76
300	DnD,DnE, DaD4	48.73	971.07	971.07	243.87	73.50	
400	DnD,DnE, DaD5	48.73	2307.14	2307.14	243.87	73.50	
100	DuD	107.27	-30.70	55.37	302.41	132.05	
110	DuD	107.27	8.45	8.45	302.41	132.05	
130	DuD	107.27	36.73	36.73	302.41	132.05	
200	DuD	107.27	332.49	332.49	302.41	132.05	
300	DuD	107.27	971.07	971.07	302.41	132.05	
400	DuD	107.27	2307.14	2307.14	302.41	132.05	

Value Of Taking Land Out of Production

LU Code	Soil Type	Value/ac NPV in CRP	Value/ac NPV of Farming	Value/ac NPV(w/o est. cost) Farming	Value/ac NPV CRP with wild-life values	Value/ac NPV CRP(fen-cing)	Value/ac NPV w/Ero-sion
100	EfD	78.00	-30.70	55.37	273.14	102.77	
200	EfD	78.00	332.49	332.49	273.14	102.77	
300	EfD	78.00	971.07	971.07	273.14	102.77	
100	EuB	136.54	-30.70	55.37	331.69	161.32	
130	EuB	136.54	36.73	36.73	331.69	161.32	
200	EuB	136.54	332.49	332.49	331.69	161.32	
100	GrC	204.84	-30.70	55.37	399.99	229.62	
110	GrC	204.84	8.45	8.45	399.99	229.62	
200	GrC	204.84	332.49	332.49	399.99	229.62	
100	Bk	107.27	-30.70	55.37	302.41	132.05	
100	LuD	48.73	-30.70	55.37	243.87	73.50	
110	LuD	48.73	8.45	8.45	243.87	73.50	
200	LuD	48.73	332.49	332.49	243.87	73.50	
100	QwD	78.00	-30.70	55.37	273.14	102.77	
110	QwD	78.00	8.45	8.45	273.14	102.77	
120	QwD	78.00	-69.67	-48.42	273.14	102.77	
200	QwD	78.00	332.49	332.49	273.14	102.77	-351.72
300	QwD	78.00	971.07	971.07	273.14	102.77	
100	KoC3	107.27	-30.70	55.37	302.41	132.05	
200	KoC3	107.27	332.49	332.49	302.41	132.05	
300	KoC3	107.27	971.07	971.07	302.41	132.05	
100	Me	165.81	-30.70	55.37	360.96	190.59	
100	MsC	234.11	-30.70	55.37	429.26	258.89	
200	MsC	234.11	332.49	332.49	429.26	258.89	
100	MoD	234.11	-30.70	55.37	429.26	258.89	
110	MoD	234.11	8.45	8.45	429.26	258.89	

Value Of Taking Land Out of Production

LU Code	Soil Type	Value/ac NPV in CRP	Value/ac NPV of Farming	Value/ac NPV(w/o est. cost) Farming	Value/ac NPV CRP with wild-life values	Value/ac NPV CRP(fen-cing)	Value/ac NPV w/Ero-sion
120	MoD	234.11	-69.67	-48.42	429.26	258.89	
200	MoD	234.11	332.49	332.49	429.26	258.89	942.29
400	MoD	234.11	2307.14	2307.14	429.26	258.89	
100	NoB	204.84	-30.70	55.37	399.99	229.62	
110	NoB	204.84	8.45	8.45	399.99	229.62	
120	NoB	204.84	-69.67	-48.42	399.99	229.62	
130	NoB	204.84	36.73	36.73	399.99	229.62	
200	NoB	204.84	332.49	332.49	399.99	229.62	107.04
300	NoB	204.84	971.07	971.07	399.99	229.62	
400	NoB	204.84	2307.14	2307.14	399.99	229.62	
100	PcB	234.11	-30.70	55.37	429.26	258.89	
110	PcB	234.11	8.45	8.45	429.26	258.89	
200	PcB	234.11	332.49	332.49	429.26	258.89	
100	PkB	263.39	-30.70	55.37	458.53	288.16	
200	PkB	263.39	332.49	332.49	458.53	288.16	
100	Po	234.11	-30.70	55.37	429.26	258.89	
110	Po	234.11	8.45	8.45	429.26	258.89	
120	Po	234.11	-69.67	-48.42	429.26	258.89	
200	Po	234.11	332.49	332.49	429.26	258.89	
300	Po	234.11	971.07	971.07	429.26	258.89	
400	Po	234.11	2307.14	2307.14	429.26	258.89	
100	Pu	204.84	-30.70	55.37	399.99	229.62	
110	Pu	204.84	8.45	8.45	399.99	229.62	
120	Pu	204.84	-69.67	-48.42	399.99	229.62	
130	Pu	204.84	36.73	36.73	399.99	229.62	
200	Pu	204.84	332.49	332.49	399.99	229.62	
300	Pu	204.84	971.07	971.07	399.99	229.62	
100	ReB	234.11	-30.70	55.37	429.26	258.89	
110	ReB	234.11	8.45	8.45	429.26	258.89	

Value Of Taking Land Out of Production

LU Code	Soil Type	Value/ac NPV in CRP	Value/ac NPV of Farming	Value/ac NPV(w/o est. cost) Farming	Value/ac NPV CRP with wild-life values	Value/ac NPV CRP(fen-cing)	Value/ac NPV w/Ero-sion
200	ReB	234.11	332.49	332.49	429.26	258.89	
300	ReB	234.11	971.07	971.07	429.26	258.89	
100	Ya	136.54	-30.70	55.37	331.69	161.32	
110	Ya	136.54	8.45	8.45	331.69	161.32	
200	Ya	136.54	332.49	332.49	331.69	161.32	

Appendix E

Calculated Erosion Loss Figures for Existing Land-Use and Riparian Buffer Implementation

Table E-1: Erosion With Existing Land-Use

Soil Symbol	Lu-code	R factor	K factor	LS	C	P	A Erosion	Acres	At Total Erosion
CRD3	100	190	0.25	0.809551	0.02	1	0.769074	86.98063	66.8945
CoC2	100	190	0.2	0.574771	0.02	1	0.436826	9.373798	4.09471
CoC3	100	190	0.2	0.809551	0.02	1	0.615259	38.40156	23.6269
CoC4	100	190	0.2	0.949112	0.02	1	0.721325	5.346462	3.85656
CS, CY	100	190	0.2	0.088192	0.02	1	0.067026	12.45833	0.83502
DaD3, DnE, DNd 1	100	190	0.16	1.122039	0.02	1	0.6822	10.86175	7.40984
DaD3, DnE, DNd 2	100	190	0.16	4.280462	0.02	1	2.602521	506.8977	1319.12
DuD	100	190	0.15	0.809551	0.02	1	0.461444	81.00497	37.3728
EfD	100	190	0.12	1.607981	0.02	1	0.73324	21.15362	15.5167
EuB	100	190	0.16	0.28465	0.02	1	0.173067	6.834972	1.18208
GrC 1	100	190	0.3	0.574771	0.02	1	0.655239	7.974003	5.22477
Bk	100	190	0.3	0.879363	0.02	1	1.002474	6.527628	6.54375
LuD 1	100	190	0.16	1.122039	0.02	1	0.6822	7.63504	5.20823
QwD	100	190	0.28	1.265313	0.02	1	1.346293	209.0653	281.431
KoC3 1	100	190	0.16	0.427349	0.02	1	0.259828	8.938255	2.32211
KOC3 2	100	190	0.16	0.726296	0.02	1	0.441588	2.573801	1.1356
Me	100	190	0.35	0.088191	0.02	1	0.117295	6.617269	0.7717
MsC	100	190	0.3	0.574771	0.02	1	0.655239	2.413636	1.58108
MoD	100	190	0.3	0.809551	0.02	1	0.922889	278.2465	256.705
NoB 1	100	190	0.16	0.28465	0.02	1	0.173067	90.34802	15.6325
NoB 2	100	190	0.16	0.809551	0.02	1	0.492207	733.1116	360.829
PcB	100	190	0.2	0.28465	0.02	1	0.216334	1.058736	0.2204
PkB	100	190	0.3	0.28465	0.02	1	0.3245	35.3615	11.4782
Po	100	190	0.3	0.088191	0.02	1	0.100538	127.4543	12.8102
Pu	100	190	0.16	0.088191	0.02	1	0.05362	235.1515	12.6091
ReB	100	190	0.3	0.28465	0.02	1	0.3245	27.36684	8.88053
Ya	100	190	0.16	0.088191	0.02	1	0.05362	5.271314	0.2865
CRD3	110	190	0.25	0.809551	0.02	1	0.769074	14.15349	10.8808
CoC1	110	190	0.2	0.28465	0.02	1	0.216334	0.018096	0.00315
CoC2	110	190	0.2	0.574771	0.02	1	0.436826	18.12611	7.91755
CoC3	110	190	0.2	0.809551	0.02	1	0.615259	6.771837	4.16634
CoC4	110	190	0.2	0.949112	0.02	1	0.721325	1.016665	0.73346
DaD3, DnE, DNd 1	110	190	0.16	1.122039	0.02	1	0.6822	1.17441	0.80182
DaD3, DnE, DNd 2	110	190	0.16	4.280462	0.02	1	2.602521	84.60239	220.195

Soil Symbol	Lu-code	R factor	K factor	LS	C	P	A Erosion	Acres	At Total Erosion
DuD	110	190	0.15	0.809551	0.02	1	0.461444	1.991398	0.91819
GrC1	110	190	0.3	0.574771	0.02	1	0.655239	2.607819	1.70844
LuD 1	110	190	0.16	1.122039	0.02	1	0.6822	8.704385	5.93831
LuD 2	110	190	0.16	4.280462	0.02	1	2.602521	2.534831	6.59651
QwD	110	190	0.28	1.265313	0.02	1	1.346293	42.59966	57.3561
MoD	110	190	0.3	0.809551	0.02	1	0.922889	29.89146	27.5848
NoB 1	110	190	0.16	0.28465	0.02	1	0.173067	18.62284	3.22298
NoB2	110	190	0.16	0.809551	0.02	1	0.492207	138.2186	68.0321
PcB	110	190	0.2	0.28465	0.02	1	0.216334	2.101937	0.4572
Po	110	190	0.3	0.088191	0.02	1	0.100538	111.163	11.1713
Pu	110	190	0.16	0.088191	0.02	1	0.05362	60.78072	3.25985
ReB	110	190	0.3	0.28465	0.02	1	0.3245	2.548296	0.82623
Ya	110	190	0.16	0.088191	0.02	1	0.05362	0.116251	0.00633
CRD3	120	190	0.25	0.809551	0.02	1	0.769074	0.843644	0.64824
CoC3	120	190	0.2	0.809551	0.02	1	0.615259	4.710194	2.8999
DaD3, DnE, DNd 1	120	190	0.16	1.122039	0.02	1	0.6822	0.133965	0.09191
DaD3, DnE, DNd 2	120	190	0.16	4.280462	0.02	1	2.602521	14.15316	36.839
QwD	120	190	0.28	1.265313	0.02	1	1.346293	2.972369	4.00179
MoD	120	190	0.3	0.809551	0.02	1	0.922889	7.300116	6.73794
NoB 1	120	190	0.16	0.28465	0.02	1	0.173067	15.48402	2.67972
NoB2	120	190	0.16	0.809551	0.02	1	0.492207	7.547489	3.71429
Po	120	190	0.3	0.088191	0.02	1	0.100538	11.35445	1.14156
Pu	120	190	0.16	0.088191	0.02	1	0.05362	1.094779	0.05802
CRD3	130	190	0.25	0.809551	0.01	1	0.384537	0.229186	0.0813
DaD3, DnE, DNd 2	130	190	0.16	4.280462	0.01	1	1.30126	6.903142	8.98286
DuD	130	190	0.15	0.809551	0.01	1	0.230722	3.118145	0.71925
EuB	130	190	0.16	0.28465	0.01	1	0.086533	4.415991	0.38231
NoB 1	130	190	0.16	0.28465	0.01	1	0.086533	4.547533	0.39314
NoB2	130	190	0.16	0.809551	0.01	1	0.246104	15.42902	3.79737
Pu	130	190	0.16	0.088191	0.01	1	0.02681	3.41892	0.09162
CRD3	200	190	0.25	0.809551	0.2	0.83	6.383313	20.70752	132.126
CoC2	200	190	0.2	0.574771	0.2	0.83	3.625655	5.665607	20.5454
CoC3	200	190	0.2	0.809551	0.2	0.83	5.10665	7.479769	38.1956
CoC4	200	190	0.2	0.949112	0.2	0.85	6.131261	3.872033	23.7444
CS, CY	200	190	0.2	0.088192	0.2	0.95	0.636747	6.349115	4.04281
DaD3, DnE, DNd 1	200	190	0.16	1.122039	0.2	1	6.821999	0.185878	1.26862
DaD3, DnE, DNd 2	200	190	0.16	4.280462	0.2	1	26.02521	112.0582	2916.37

Soil Symbol	Lu-code	R factor	K factor	LS	C	P	A Erosion	Acres	At Total Erosion
DuD	200	190	0.15	0.809551	0.2	0.52	2.39951	31.22281	74.9145
EfD	200	190	0.12	1.607981	0.2	0.66	4.839381	3.831748	18.5429
EuB	200	190	0.16	0.28465	0.2	0.58	1.003788	1.595402	1.60146
GrC 1	200	190	0.3	0.574771	0.2	0.83	5.438482	0.895594	4.87072
LuD 1	200	190	0.16	1.122039	0.2	1	6.821999	12.09399	82.5018
QwD	200	190	0.28	1.265313	0.2	1	13.46293	48.21995	649.117
KoC3 1	200	190	0.16	0.427349	0.2	0.83	2.156575	5.179967	11.1799
KoC3 2	200	190	0.16	0.726296	0.2	0.83	3.665182	3.924641	14.3853
MsC	200	190	0.3	0.574771	0.2	0.83	5.438482	6.779881	36.8727
MoD	200	190	0.3	0.809551	0.2	0.83	7.659975	70.40996	539.386
NoB 1	200	190	0.16	0.28465	0.2	0.83	1.436455	34.7352	49.8956
NoB2	200	190	0.16	0.809551	0.2	0.83	4.08532	155.4736	635.193
PcB	200	190	0.2	0.28465	0.2	0.83	1.795569	8.00279	14.3656
PkB	200	190	0.3	0.28465	0.2	0.83	2.693354	30.632	82.5081
Po	200	190	0.3	0.088191	0.2	0.95	0.955113	263.6771	251.815
Pu	200	190	0.16	0.088191	0.2	0.95	0.509394	234.1078	119.53
ReB	200	190	0.3	0.28465	0.2	0.83	2.693354	7.580196	20.4115
Ya	200	190	0.16	0.088191	0.2	0.95	0.509394	0.748334	0.38197
CoC4	300	190	0.2	0.949112	0.05	1	1.803312	0.012202	0.02205
DaD3, DnE, DNd 2	300	190	0.16	4.280462	0.05	1	6.506302	3.09207	20.1194
DuD	300	190	0.15	0.809551	0.05	1	1.153611	5.870477	6.77245
EfD	300	190	0.12	1.607981	0.05	1	1.833099	1.865589	3.41909
QwD	300	190	0.28	1.265313	0.05	1	3.365732	54.63568	183.89
KoC3 1	300	190	0.16	0.427349	0.05	1	0.649571	1.006023	0.6583
NoB 1	300	190	0.16	0.28465	0.05	1	0.432667	4.295902	1.85896
NoB2	300	190	0.16	0.809551	0.05	1	1.230518	9.69011	11.9286
Po	300	190	0.3	0.088191	0.05	1	0.251346	95.89979	24.1098
Pu	300	190	0.16	0.088191	0.05	1	0.134051	46.62666	6.25048
ReB	300	190	0.3	0.28465	0.05	1	0.811251	1.077279	0.87344
CRD3	400	190	0.25	0.809551	0.26	0.31	3.099367	4.432352	13.7349
CoC3	400	190	0.2	0.809551	0.26	0.31	2.479494	2.052531	5.08939
DuD	400	190	0.15	0.809551	0.26	0.31	1.85962	0.272592	0.50618
MoD	400	190	0.3	0.809551	0.26	0.31	3.719241	1.947977	7.24494
NoB 1	400	190	0.16	0.28465	0.26	0.31	0.69746	3.040717	2.12077
NoB 2	400	190	0.16	0.809551	0.26	0.31	1.983595	2.150771	4.2626
Po	400	190	0.3	0.088191	0.26	0.31	0.405169	10.40893	4.21777
							194.0421	4539.636	9009.31

Table E-2: Erosion With Riparian Buffer Implementation

Soil Symbol	Lucode	C	P	A Erosion	Acres	At Total Erosion	Difference In Practices
CRD3	100	0.002	1	0.076907	86.98063	6.689452	60.20507
CoC2	100	0.002	1	0.043683	9.373798	0.409472	3.685246
CoC3	100	0.002	1	0.061526	38.40156	2.362691	21.26422
CoC4	100	0.002	1	0.072132	5.346462	0.385654	3.470882
CS, CY	100	0.002	1	0.006703	12.45833	0.083503	0.751529
DaD3, DnE, DNd 1	100	0.002	1	0.06822	10.86175	0.740988	6.668895
DaD3, DnE, DNd 2	100	0.002	1	0.260252	506.8977	131.9212	1187.291
DuD	100	0.002	1	0.046144	81.00497	3.737928	33.64135
EfD	100	0.002	1	0.073324	21.15362	1.551067	13.9596
EuB	100	0.002	1	0.017307	6.834972	0.118291	1.064617
GrC 1	100	0.002	1	0.065524	7.974003	0.522488	4.702389
Bk	100	0.002	1	0.100247	6.527628	0.654377	5.889397
LuD 1	100	0.002	1	0.06822	7.63504	0.520862	4.687761
QwD	100	0.002	1	0.134629	209.0653	28.14631	253.3168
KoC3 1	100	0.002	1	0.025983	8.938255	0.232241	2.09017
KOC3 2	100	0.002	1	0.044159	2.573801	0.113656	1.022904
Me	100	0.002	1	0.011729	6.617269	0.077617	0.698553
MsC	100	0.002	1	0.065524	2.413636	0.158151	1.423357
MoD	100	0.002	1	0.092289	278.2465	25.67905	231.1114
NoB 1	100	0.002	1	0.017307	90.34802	1.563625	14.07263
NoB 2	100	0.002	1	0.049221	733.1116	36.08429	324.7586
PcB	100	0.002	1	0.021633	1.058736	0.022904	0.206136
PkB	100	0.002	1	0.03245	35.3615	1.147482	10.32734
Po	100	0.002	1	0.010054	127.4543	1.281402	11.53262
Pu	100	0.002	1	0.005362	235.1515	1.260891	11.34802
ReB	100	0.002	1	0.03245	27.36684	0.888055	7.992498
Ya	100	0.002	1	0.005362	5.271314	0.028265	0.254385
CRD3	110	0.002	1	0.076907	14.15349	1.088508	9.796569
CoC1	110	0.002	1	0.021633	0.018096	0.000391	0.003523
CoC2	110	0.002	1	0.043683	18.12611	0.791796	7.12616
CoC3	110	0.002	1	0.061526	6.771837	0.416643	3.749791
CoC4	110	0.002	1	0.072132	1.016665	0.073335	0.660011
DaD3, DnE, DNd 1	110	0.002	1	0.06822	1.17441	0.080118	0.721064
DaD3, DnE, DNd 2	110	0.002	1	0.260252	84.60239	22.01795	198.1615
DuD	110	0.002	1	0.046144	1.991398	0.091892	0.827027
GrC1	110	0.002	1	0.065524	2.607819	0.170874	1.53787
LuD 1	110	0.002	1	0.06822	8.704385	0.593813	5.344317

Soil Symbol	Lucode	C	P	A Erosion	Acres	At Total Erosion	Difference In Practices
ReB	100	0.002	1	0.03245	27.36684	0.888055	7.992498
Ya	100	0.002	1	0.005362	5.271314	0.028265	0.254385
CRD3	110	0.002	1	0.076907	14.15349	1.088508	9.796569
CoC1	110	0.002	1	0.021633	0.018096	0.000391	0.003523
CoC2	110	0.002	1	0.043683	18.12611	0.791796	7.12616
CoC3	110	0.002	1	0.061526	6.771837	0.416643	3.749791
CoC4	110	0.002	1	0.072132	1.016665	0.073335	0.660011
DaD3, DnE, DNd 1	110	0.002	1	0.06822	1.17441	0.080118	0.721064
DaD3, DnE, DNd 2	110	0.002	1	0.260252	84.60239	22.01795	198.1615
DuD	110	0.002	1	0.046144	1.991398	0.091892	0.827027
GrC1	110	0.002	1	0.065524	2.607819	0.170874	1.53787
LuD 1	110	0.002	1	0.06822	8.704385	0.593813	5.344317
LuD 2	110	0.002	1	0.260252	2.534831	0.659695	5.937255
QwD	110	0.002	1	0.134629	42.59966	5.735161	51.61645
MoD	110	0.002	1	0.092289	29.89146	2.758648	24.82784
NoB 1	110	0.002	1	0.017307	18.62284	0.3223	2.900698
NoB2	110	0.002	1	0.049221	138.2186	6.803221	61.22899
PcB	110	0.002	1	0.021633	2.101937	0.045472	0.409248
Po	110	0.002	1	0.010054	111.163	1.117613	10.05852
Pu	110	0.002	1	0.005362	60.78072	0.325909	2.933177
ReB	110	0.002	1	0.03245	2.548296	0.082692	0.744231
Ya	110	0.002	1	0.005362	0.116251	0.000623	0.00561
CRD3	120	0.002	1	0.076907	0.843644	0.064882	0.583942
CoC3	120	0.002	1	0.061526	4.710194	0.289799	2.608191
DaD3, DnE, DNd 1	120	0.002	1	0.06822	0.133965	0.009139	0.082252
DaD3, DnE, DNd 2	120	0.002	1	0.260252	14.15316	3.68339	33.15051
QwD	120	0.002	1	0.134629	2.972369	0.400168	3.601511
MoD	120	0.002	1	0.092289	7.300116	0.673719	6.063474
NoB 1	120	0.002	1	0.017307	15.48402	0.267977	2.411795
NoB2	120	0.002	1	0.049221	7.547489	0.371493	3.343436
Po	120	0.002	1	0.010054	11.35445	0.114156	1.027401
Pu	120	0.002	1	0.005362	1.094779	0.00587	0.052832
CRD3	130	0.002	1	0.076907	0.229186	0.017626	0.070504
DaD3, DnE, DNd 2	130	0.002	1	0.260252	6.903142	1.796557	7.186228
DuD	130	0.002	1	0.046144	3.118145	0.143885	0.57554
EuB	130	0.002	1	0.017307	4.415991	0.076426	0.305705
NoB 1	130	0.002	1	0.017307	4.547533	0.078703	0.314811
NoB2	130	0.002	1	0.049221	15.42902	0.759427	3.03771

Soil Symbol	Lucode	C	P	A Erosion	Acres	At Total Erosion	Difference In Practices
Pu	130	0.002	1	0.005362	3.41892	0.018332	0.07333
CRD3	200	0.002	1	0.076907	20.70752	1.592561	130.59
CoC2	200	0.002	1	0.043683	5.665607	0.247488	20.29405
CoC3	200	0.002	1	0.061526	7.479769	0.4602	37.73636
CoC4	200	0.002	1	0.072132	3.872033	0.279299	23.46114
CS, CY	200	0.002	1	0.006703	6.349115	0.042556	4.000225
DaD3, DnE, DNd 1	200	0.002	1	0.06822	0.185878	0.012681	1.255382
DaD3, DnE, DNd 2	200	0.002	1	0.260252	112.0582	29.16337	2887.174
DuD	200	0.002	1	0.046144	31.22281	1.440759	73.47869
EfD	200	0.002	1	0.073324	3.831748	0.280959	18.26233
EuB	200	0.002	1	0.017307	1.595402	0.027611	1.573835
GrC 1	200	0.002	1	0.065524	0.895594	0.058683	4.81199
LuD 1	200	0.002	1	0.06822	12.09399	0.825052	81.68012
QwD	200	0.002	1	0.134629	48.21995	6.491817	642.6899
KoC3 1	200	0.002	1	0.025983	5.179967	0.13459	11.0364
KoC3 2	200	0.002	1	0.044159	3.924641	0.173308	14.21122
MsC	200	0.002	1	0.065524	6.779881	0.444244	36.42802
MoD	200	0.002	1	0.092289	70.40996	6.498055	532.8405
NoB 1	200	0.002	1	0.017307	34.7352	0.601151	49.29441
NoB2	200	0.002	1	0.049221	155.4736	7.652522	627.5068
PcB	200	0.002	1	0.021633	8.00279	0.173127	14.19644
PkB	200	0.002	1	0.03245	30.632	0.99401	81.5088
Po	200	0.002	1	0.010054	263.6771	2.650963	249.1905
Pu	200	0.002	1	0.005362	234.1078	1.255295	117.9978
ReB	200	0.002	1	0.03245	7.580196	0.245978	20.17017
Ya	200	0.002	1	0.005362	0.748334	0.004013	0.377184
CoC4	300	0.002	1	0.072132	0.012202	0.00088	0.021124
DaD3, DnE, DNd 2	300	0.002	1	0.260252	3.09207	0.804718	19.31323
DuD	300	0.002	1	0.046144	5.870477	0.27089	6.501355
EfD	300	0.002	1	0.073324	1.865589	0.136792	3.283017
QwD	300	0.002	1	0.134629	54.63568	7.355562	176.5335
KoC3 1	300	0.002	1	0.025983	1.006023	0.026139	0.627344
NoB 1	300	0.002	1	0.017307	4.295902	0.074348	1.784348
NoB2	300	0.002	1	0.049221	9.69011	0.476954	11.4469
Po	300	0.002	1	0.010054	95.89979	0.964159	23.13983
Pu	300	0.002	1	0.005362	46.62666	0.250014	6.000334
ReB	300	0.002	1	0.03245	1.077279	0.034958	0.838986
CRD3	400	0.002	1	0.076907	4.432352	0.340881	13.39661
CoC3	400	0.002	1	0.061526	2.052531	0.126284	4.962955
DuD	400	0.002	1	0.046144	0.272592	0.012579	0.494339

Soil Symbol	Lucode	C	P	A Erosion	Acres	At Total Erosion	Difference In Practices
MoD	400	0.002	1	0.092289	1.947977	0.179777	7.065217
NoB 1	400	0.002	1	0.017307	3.040717	0.052625	2.068153
NoB 2	400	0.002	1	0.049221	2.150771	0.105863	4.160397
Po	400	0.002	1	0.010054	10.40893	0.10465	4.112728
				9.854023		371.3984	8638.032

Appendix F

Erosion and Loss of Productivity - Results from EPIC Model

EPIC Predictions for			
Wheat Production			
on Cobb Soils			
Actual		Actual	Predicted Yield (bu/ac)
Yield (bu/ac)		9	33.7035
Depth(m)		4	9.82959
	2	3.975	9.752
	3	3.95	9.6744
	4	3.925	9.59681
	5	3.9	9.51921
	6	3.875	9.44162
	7	3.85	9.36402
	8	3.825	9.28643
	9	3.8	9.20883
	10	3.775	9.13124

Wheat Production			
on Darnell Soils			
Actual		Actual	Predicted yield (bu/ac)
Yield (bu/ac)		14	20.14
Depth (m)		1.66667	14.1207
	2	1.50667	12.4103
	3	1.34667	10.6998
	4	1.18667	8.98932
	5	1.02667	7.27884
	6	0.86667	5.56837
	7	0.70667	3.8579
	8	0.54667	2.14743
	9	0.38667	0.43695
	10	0.22667	-1.2735

EPIC Predictions for
Wheat Production
on Gracemont Soils

Actual		Actual	Predicted yield (bu/ac)
Yield (bu/ac)		15	38.28
Depth(m)		10	33.478025
	2	9.975	33.401515
	3	9.95	33.325005
	4	9.925	33.248495
	5	9.9	33.171985
	6	9.875	33.095475
	7	9.85	33.018965
	8	9.825	32.942455
	9	9.8	32.865945
	10	9.775	32.789435

EPIC Predictions for
Wheat Production
on Ironmound Soils

Actual		Actual	Predicted yield (bu/ac)
Yield (bu/ac)		19.5	24.76
Depth(m)		1.66667	10.3633
	2	1.61267	9.69294
	3	1.55867	9.02259
	4	1.50467	8.35225
	5	1.45067	7.6819
	6	1.39667	7.01155
	7	1.34267	6.34121
	8	1.28867	5.67086
	9	1.23467	5.00051
	10	1.18067	4.33017

EPIC Predictions for Wheat Production on Minco Soils

Actual Yield (bu/ac) Depth(m)		Actual	Predicted yield (bu/ac)
		25	51.3893
		10	50.5399
	2	9.9722	50.4106
	3	9.9444	50.2812
	4	9.9166	50.1518
	5	9.8888	50.0224
	6	9.861	49.8931
	7	9.8332	49.7637
	8	9.8054	49.6343
	9	9.7776	49.5049
	10	9.7498	49.3756

EPIC Predictions for Wheat Production on Noble Soils

Actual Yield (bu/ac) Depth(m)		Actual	Predicted yield (bu/ac)
		12	47.6328
		4	11.1215
	2	3.969	11.0568
	3	3.938	10.9921
	4	3.907	10.9274
	5	3.876	10.8626
	6	3.845	10.7979
	7	3.814	10.7332
	8	3.783	10.6685
	9	3.752	10.6037
	10	3.721	10.539

Appendix G

Summary of erosion expected to occur on Sugar Creek within 10 years.

Table G-1: Summary of erosion expected to occur on Sugar Creek main stem within 10 years.

Station	Tons Lost Degradation	Tons Lost Widening	Total Tons Lost	Major Mode
43+80		22978	22978	Meandering
288+80	110202		110202	Overfall progressing
354+19		60120	60120	
477+32			106259	Combination degradation and meandering
534+46	62664	63272	125936	
613+89	62664	122639	185303	
652+14		542450	542450	Primarily widening in S curve and above
794+89		20960	20960	
984+19		104073	104073	
1010+10	17100		17100	Impact of overfall on main stem
1020+10		42370	42370	
1131+50	79344		79344	
1189+50			10000	
Total			1418095	
Tons/year			141,810	

Source: NRCS 1998

Table G-2: Summary of erosion expected to occur on Sugar Creek tributaries within 10 years.

Tributary	Total tons lost
Whitebread	5518
Keechi	22793
Wildcat	55400
Medicine	5848
Kickapoo	54133
Hunt	102600
Var. unnamed	50000
Total	296292
Tons/year	29,629

Source: NRCS 1998

Appendix I

Expenditure Required to Achieve Erosion Reduction in Riparian Areas

Soil Type	Land Use	Net Gain - Erosion	NPV of Land Use	Acres	Annuity Payment	Cost	Total Tons Erosion	$/ton
Sandy Loam								
Pulaski Fine Sandy Loam	Wheat	118.00	332.49	234.11	41.00	9597.49	118.00	81.34
Minco Very Fine Sandy Loam	Peanuts	7.07	2307.14	1.95	284.47	554.14	7.07	78.43
Port Silt Loam	Native Grass	11.53	55.37	127.45	6.83	870.15	11.53	75.45
Binger Fine Sandy Loam	Alfalfa	0.02	971.07	0.01	119.73	1.46	0.02	69.16
Eufaula Fine Sand	Alfalfa	3.28	971.07	1.87	119.73	223.37	3.28	68.04
Eufaula Loamy Fine Sand	Love Grass	0.31	36.73	4.42	4.53	20.00	0.31	65.42
Noble Fine Sandy Loam	Love Grass	0.31	36.73	4.55	4.53	20.59	0.31	65.42
Cyril Fine Sandy Loam	Wheat	4.00	332.49	6.35	41.00	260.29	4.00	65.07
Miller Silty Clay Loam	Native Grass	0.70	55.37	6.62	6.83	45.18	0.70	64.67
Eufaula Loamy Fine Sand	Native Grass	1.06	55.37	6.83	6.83	46.66	1.06	43.83
Noble Fine Sandy Loam	Native Grass	14.07	55.37	90.35	6.83	616.82	14.07	43.83
Port Silt Loam	Wheat	249.19	332.49	263.68	41.00	10809.71	249.19	43.38
Eufaula Loamy Fine Sand	Wheat	1.57	332.49	1.60	41.00	65.41	1.57	41.56
Ironmound-Nash Complex	Alfalfa	176.53	971.07	54.64	119.73	6541.69	176.53	37.06
Pond Creek Fine Sandy Loam	Native Grass	0.21	55.37	1.06	6.83	7.23	0.21	35.06
Konowa Loamy Fine Sand	Native Grass	2.09	55.37	8.94	6.83	61.02	2.09	29.20
Noble Fine Sandy Loam	Wheat	49.29	332.49	34.74	41.00	1424.00	49.29	28.89
Dougherty	Love	0.58	36.73	3.12	4.53	14.12	0.58	24.54

Soil Type	Land Use	Net Gain - Erosion	NPV of Land Use	Acres	Annuity Payment	Cost	Total Tons Erosion	$/ton
and Eufaula Loamy Fine Sands	Grass							
Reinach Silt Loam	Native Grass	7.99	55.37	27.37	6.83	186.84	7.99	23.38
Pond Creek Silt Loam	Native Grass	10.33	55.37	35.36	6.83	241.42	10.33	23.38
Pond Creek Fine Sandy Loam	Wheat	14.20	332.49	8.00	41.00	328.08	14.20	23.11
Noble Fine Sandy Loam	Love Grass	3.04	36.73	15.43	4.53	69.88	3.04	23.00
Pulaski Fine Sandy Loam	Bermud agrass	2.93	8.45	60.78	1.04	63.33	2.93	21.59
Yahola Fine Sandy Loam	Bermud agrass	0.01	8.45	0.12	1.04	0.12	0.01	21.59
Konowa Loamy Fine Sand	Wheat	11.04	332.49	5.18	41.00	212.36	11.04	19.24
Darnell-Noble Association	Alfalfa	19.31	971.07	3.09	119.73	370.22	19.31	19.17
Dougherty and Eufaula Loamy Fine Sands	Wheat	73.48	332.49	31.22	41.00	1280.01	73.48	17.42
Binger Fine Sandy Loam	Native Grass	3.69	55.37	9.37	6.83	64.00	3.69	17.37
Konowa Loamy Fine Sand	Native Grass	1.02	55.37	2.57	6.83	17.57	1.02	17.18
Dougherty and Eufaula Loamy Fine Sands	Native Grass	33.64	55.37	81.00	6.83	553.03	33.64	16.44
Noble Fine Sandy Loam	Native Grass	324.76	55.37	733.11	6.83	5005.04	324.76	15.41
Reinach Silt Loam	Wheat	20.17	332.49	7.58	41.00	310.76	20.17	15.41
Pond Creek Silt Loam	Wheat	81.51	332.49	30.63	41.00	1255.79	81.51	15.41
Binger and Grant Soils	Love Grass	0.07	36.73	0.23	4.53	1.04	0.07	14.72

Soil Type	Land Use	Net Gain - Erosion	NPV of Land Use	Acres	Annuity Payment	Cost	Total Tons Erosion	$/ton
Binger Fine Sandy Loam	Native Grass	21.26	55.37	38.40	6.83	262.17	21.26	12.33
Grant Loam	Native Grass	4.70	55.37	7.97	6.83	54.44	4.70	11.58
Minco Silt Loam	Native Grass	1.42	55.37	2.41	6.83	16.48	1.42	11.58
Port Silt Loam	Bermudagrass	10.06	8.45	111.16	1.04	115.82	10.06	11.51
Binger Fine Sandy Loam	Wheat	20.29	332.49	5.67	41.00	232.27	20.29	11.45
Konowa Loamy Fine Sand	Wheat	14.21	332.49	3.92	41.00	160.89	14.21	11.32
Ironmound-Dill Complex	Native Grass	4.69	55.37	7.64	6.83	52.13	4.69	11.12
Darnell Fine Sandy Loam	Native Grass	6.67	55.37	10.86	6.83	74.15	6.67	11.12
Binger Fine Sandy Loam	Native Grass	3.47	55.37	5.35	6.83	36.50	3.47	10.52
Eufaula Fine Sand	Native Grass	13.96	55.37	21.15	6.83	144.42	13.96	10.35
Noble Fine Sandy Loam	Wheat	627.51	332.49	155.47	41.00	6373.80	627.51	10.16
Binger and Grant Soils	Native Grass	60.21	55.37	86.98	6.83	593.83	60.21	9.86
Eufaula Fine Sand	Wheat	18.26	332.49	3.83	41.00	157.09	18.26	8.60
Minco Very Fine Sandy Loam	Native Grass	231.11	55.37	278.25	6.83	1899.62	231.11	8.22
Binger Fine Sandy Loam	Wheat	37.74	332.49	7.48	41.00	306.64	37.74	8.13
Grant Loam	Wheat	4.81	332.49	0.90	41.00	36.72	4.81	7.63
Minco Silt Loam	Wheat	36.43	332.49	6.78	41.00	277.95	36.43	7.63
Grant Port Complex	Native Grass	5.89	55.37	6.53	6.83	44.56	5.89	7.57
Binger Fine Sandy Loam	Wheat	23.46	332.49	3.87	41.00	158.74	23.46	6.77
Noble Fine Sandy Loam	Bermudagrass	2.90	8.45	18.62	1.04	19.40	2.90	6.69
Binger and	Wheat	130.59	332.49	20.71	41.00	848.93	130.59	6.50

Soil Type	Land Use	Net Gain - Erosion	NPV of Land Use	Acres	Annuity Payment	Cost	Total Tons Erosion	$/ton
Grant Soils								
Darnell Fine Sandy Loam	Wheat	1.26	332.49	0.19	41.00	7.62	1.26	6.07
Ironmound-Dill Complex	Wheat	81.68	332.49	12.09	41.00	495.81	81.68	6.07
Ironmound-Nash Complex	Native Grass	253.32	55.37	209.07	6.83	1427.31	253.32	5.63
Minco Very Fine Sandy Loam	Wheat	532.84	332.49	70.41	41.00	2886.53	532.84	5.42
Binger Fine Sandy Loam	Bermudagrass	0.00	8.45	0.02	1.04	0.02	0.00	5.35
Pond Creek Fine Sandy Loam	Bermudagrass	0.41	8.45	2.10	1.04	2.19	0.41	5.35
Darnell-Noble Association	Love Grass	7.19	36.73	6.90	4.53	31.26	7.19	4.35
Reinach Silt Loam	Bermudagrass	0.74	8.45	2.55	1.04	2.66	0.74	3.57
Ironmound-Nash Complex	Wheat	642.69	332.49	48.22	41.00	1976.83	642.69	3.08
Darnell Fine Sandy Loam	Native Grass	1187.29	55.37	506.90	6.83	3460.65	1187.29	2.91
Binger Fine Sandy Loam	Bermudagrass	7.13	8.45	18.13	1.04	18.89	7.13	2.65
Dougherty and Eufaula Loamy Fine Sands	Bermudagrass	0.83	8.45	1.99	1.04	2.07	0.83	2.51
Noble Fine Sandy Loam	Bermudagrass	61.23	8.45	138.22	1.04	144.01	61.23	2.35
Binger Fine Sandy Loam	Bermudagrass	3.75	8.45	6.77	1.04	7.06	3.75	1.88
Grant Loam	Bermudagrass	1.54	8.45	2.61	1.04	2.72	1.54	1.77
Darnell Fine Sandy Loam	Bermudagrass	0.72	8.45	1.17	1.04	1.22	0.72	1.70
Ironmound-Dill	Bermudagrass	5.34	8.45	8.70	1.04	9.07	5.34	1.70

Soil Type	Land Use	Net Gain - Erosion	NPV of Land Use	Acres	Annuity Payment	Cost	Total Tons Erosion	$/ton
Complex								
Binger Fine Sandy Loam	Bermud agrass	0.66	8.45	1.02	1.04	1.06	0.66	1.60
Darnell-Noble Association	Wheat	2887.17	332.49	112.06	41.00	4593.94	2887.17	1.59
Binger and Grant Soils	Bermud agrass	9.80	8.45	14.15	1.04	14.75	9.80	1.51
Minco Very Fine Sandy Loam	Bermud agrass	24.83	8.45	29.89	1.04	31.14	24.83	1.25
Ironmound-Nash Complex	Bermud agrass	51.62	8.45	42.60	1.04	44.38	51.62	0.86
Ironmound-Dill Complex	Bermud agrass	5.94	8.45	2.53	1.04	2.64	5.94	0.44
Darnell-Noble Association	Bermud agrass	198.16	8.45	84.60	1.04	88.15	198.16	0.44
Darnell-Noble Association	Fescue Grass	33.15	-48.42	14.15	-5.97	-84.50	33.15	-2.55
Ironmound-Nash Complex	Fescue Grass	3.60	-48.42	2.97	-5.97	-17.75	3.60	-4.93
Minco Very Fine Sandy Loam	Fescue Grass	6.06	-48.42	7.30	-5.97	-43.58	6.06	-7.19
Binger and Grant Soils	Fescue Grass	0.58	-48.42	0.84	-5.97	-5.04	0.58	-8.63
Darnell Fine Sandy Loam	Fescue Grass	0.08	-48.42	0.13	-5.97	-0.80	0.08	-9.72
Binger Fine Sandy Loam	Fescue Grass	2.61	-48.42	4.71	-5.97	-28.12	2.61	-10.78
Noble Fine Sandy Loam	Fescue Grass	3.34	-48.42	7.55	-5.97	-45.06	3.34	-13.48
Noble Fine Sandy Loam	Fescue Grass	2.41	-48.42	15.48	-5.97	-92.44	2.41	-38.33
Port Silt Loam	Fescue Grass	1.03	-48.42	11.35	-5.97	-67.79	1.03	-65.98
Pulaski Fine Sandy Loam	Fescue Grass	0.05	-48.42	1.09	-5.97	-6.54	0.05	-123.7

VITA

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