CONSERVATION DECISIONS OF AGRICULTURAL PRODUCERS IN EASTERN NORTH CAROLINA

by

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ABSTRACT

MORRIS, JAMES THEODORE. Conservation Decisions of Agricultural Producers in Eastern North Carolina. (Under the direction of Peter Tyson Bromley.)

The purpose of this research has been to assess the role of economic incentives in producers' decisions to adopt naturally-vegetated field borders in eastern North Carolina. This work has identified barriers to producer adoption of field borders on farms, quantified the opportunity costs of field borders in two distinct agronomic regions, determined hunter willingness-to-pay for wild quail hunting opportunities, and conducted a qualitative evaluation of the necessity and sufficiency of these findings as economic incentives to motivate producer adoption of field borders on their farms. Major barriers to producer adoption included uncertainty regarding field border generation of environmental benefits, the opportunity costs in foregone crop production and the impact of field border vegetation on adjacent crop yields. The opportunity costs of field borders in foregone corn and soybeans were lowest on corn field edges in Wilson County, in the upper coastal plain, especially those next to wooded areas where corn production was often unprofitable. Hunters' willingness-to-pay for wild quail hunting opportunities were sufficient to make field borders economically viable on some profitably farmed areas as well. Qualitative evaluation of these findings as economic incentives for producer adoption of field borders found the adoption decision process of producers to be more complex in the upper than in the lower coastal plain. Increased competition for farmland and recreational hunting opportunities in upper coastal plain communities accounted for these differences.

DEDICATION

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BIOGRAPHY

James Theodore Morris was born and raised in Tucson, Arizona to Mr. James F. Morris and Mrs. Sheryle F. Morris. Ted graduated from St. Gregory Preparatory School in 1985 and then attended the University of Arizona from 1985 to 1987 pursing a finance degree. Ted moved to Raleigh, North Carolina in 1987 to attend North Carolina State University graduating summa cum laude in 1989 with a double major in business and economics. After graduation, he worked for three years as a financial analyst for Branch Banking & Trust Company. Ted returned to NC State and received a Master of Economics in Agricultural and Resource Economics in 1994. After completing the necessary course work for a Ph.D. in economics, Ted switched to the Forestry Department to study the conservation decisions of private landowners in eastern North Carolina. During this project Ted married Ms. Jane Stith Childs, 19 October, 1996. Ted received his Ph.D. in Forestry from NC State University in May, 1998.

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INTRODUCTION

Agricultural lands provide food and fiber as well as social, economic, ecological and aesthetic benefits. Global demand, however, has increased production on existing farms (Weiss 1996) this at a time when agricultural lands continue to be converted for urban uses (Lopez et al. 1994). From an economic perspective, government intervention may be justified to adjust land markets which inadequately allocate land by not fully considering the open space and environmental amenity benefits from agricultural areas (Gardner 1977). It follows that natural resource managers work to influence land management decisions, especially in conjunction with non-industrial private landowners, to enhance production of farm commodities and other benefits from agricultural lands. Concern goes beyond the current generation and includes consideration of "intergenerational equity", "social capital" and "safe minimum standards" to form part of the current sustainable agriculture movement (Toman 1994).

Due to its broad public appeal, farm wildlife receives considerable attention from resource managers. Wildlife agencies, however, have been frustrated by their inability to increase investment in wildlife habitat on farms, especially when the enhancement of endangered and threatened species requires changes in land management on a landscape scale (Morris et al. 1996).

In eastern North Carolina and other southern states, natural resource professionals are working to understand and address recent declines in bobwhite quail populations

(Brennan 1991). As part of this effort, three meter wide field borders of mixed, naturally-occurring vegetation were established on crop lands as part of landscape-scale experiments focused on improving wildlife habitat (Bromley 1997). It is "a particular challenge to economic thought to devise systems based on conventional economic incentives to remedy the depletion of fugitive wildlife resources" (Davis 1985). This raises several questions including 1) what are the economic incentives and disincentives to field border establishment for bobwhite quail in eastern North Carolina, 2) what are the magnitudes of these factors, and 3) to what extent will incentives be necessary and sufficient in motivating producer adoption of field borders on farms? It can be argued that producer adoption of field borders will depend upon the availability and reliability of information describing agronomic tradeoffs and environmental benefits of these areas (Morris et al. 1996). This study has: 1) identified barriers to producer adoption of field borders in eastern North Carolina; 2) quantified the opportunity costs of field borders in two crops across two distinct geographical regions; 3) determined hunter willingness-to-pay for wild quail hunting opportunities; and 4) conducted a qualitative evaluation of the necessity and sufficiency of these findings as economic incentives to motivate producer adoption of field borders on their farms.

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Chapter One: **Investments in Wildlife Enhancement through Widespread Implementation of Sustainable Agriculture for Social and Economic Benefits**

Morris, James Theodore, Peter T. Bromley, John R. Anderson, Jr., Robert C. Abt and William E. Palmer

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Investments in Wildlife Enhancement through Widespread Implementation of Sustainable Agriculture for Social and Economic Benefits

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Farming in the North Carolina coastal plain is intensive and profitable. Clearing and drainage efforts in past decades have produced large tracts of tillable land from forests and swamps. Using modern farming technology, producers seek to maximize production on these hard-won areas by cultivating all available acreage (Robinson 1991, Doering 1992, Johnson et al. 1993). As a result, early successional habitats available to wildlife on these and other grain farms are greatly limited and wildlife associated with these habitats have declined over the last 30 years (Graber et al. 1983, Berner 1988, Brennan 1991, Rodenhouse 1992, Warner 1994, Knopf 1995). Survey data for Wilson County, North Carolina show that early successional habitats comprise less than 2.5 percent of the farm landscape (Palmer 1995). Economic and social barriers exist to increasing investment in wildlife habitats on farms.

Current land-use practices are culturally, technologically and economically based (Gerard 1995). How individuals farm their land reflects their personal values, as well as the values of their rural community. Landowner decisions to invest in long-term conservation improvements appear dependent on farm size, income and type of farming practice (Featherstone et al. 1993, Miller et al. 1990). Farm-management practices are governed partly by the technical expertise and abilities of the individual producer. The production potential of a farm is further constrained by current economic realities in the marketplace, government incentives and regulations, and by a producer's ability to acquire and utilize new information. Knowledge about the costs of enhancing habitat is an expected key determinant in the level of habitat investment (Williams 1994). In this environment, wildlife agencies are frustrated by an inability to impact investment in wildlife habitat on individual farms. This frustration is exacerbated when significant improvement in wildlife populations requires landscape-scale changes in habitat. Traditional wildlife enhancement programs have not recognized the economic and cultural incentives for clean farming practices. Consequently, these programs provide insufficient information to landowners evaluating habitat-investment decisions. Wildlife management efforts also are made difficult by conflicts between economic and environmental policies and between environmental policies concerned with different resources (Lakshminarayan et al. 1995). To be effective at the landscape scale, wildlife polices cannot be piecemeal attempts to effect change on isolated and shifting locations. Rather, these policies must include consideration of other environmental resources as well as the technical, economic and cultural realities of modern farming and rural life. The farm wildlife issue is a special case of the larger social problem of integrating farming, the rural community and urban interests within progressive social policy (Wimberley 1993). Current sustainable agriculture ideology provides an environment where policies resolving these problems can be developed.

In the 1990 Farm Bill, Congress defined sustainable agriculture as "an integrated system of plant and animal production practices having site-specific application that will, over the long-term: satisfy human food and fiber needs; enhance environmental quality, and the natural resource base upon which the agriculture economy depends; make the most efficient use of non-renewable resources and integrate, where appropriate, natural biological cycles and controls; sustain the economic viability of farm/ranch operations; and enhance the quality of life for farmers/ranchers and society as a whole." This definition recognizes the interaction of economic, ecological and cultural factors in the production and conservation of resources. It emphasizes the use of integrated, site-specific approaches to enhance human and environmental well-being over long-term planning horizons; precisely the things lacking from past wildlife policies. The sustainable agriculture movement promotes research and information transfer, and emphasizes interagency cooperation in addressing complex issues and reducing policy conflicts. Specifically, this movement is an opportunity for the development of influential and far-reaching wildlife habitat and environmental conservation policies. Why, then, does landowner incorporation of wildlife habitat on production areas remain a problem?

This question was asked to a group of producers attending a focus group meeting. They responded that, without adequate information and motivation, landowners will persist in currently profitable farming patterns. For these producers, farming methodologies which maintain production levels and annual profitability represent sustainable agricultural practices. Participants stated that investments in wildlife habitat may not occur on farms even when growers would like (have no objections) to increase wildlife, such as bobwhite quail. The reasons for this are financial risk and outcome uncertainty.

Ecological and Financial Risk Assessment

Responses from focus group participants indicate that landowners perceive various types of risk when evaluating and implementing investments in wildlife habitat. One group of risks is ecologically based. These result from uncertainty about how particular practices will benefit various species and to what degree. Food plots, protective cover and nesting structures, for example, do not guarantee results of a certain magnitude. This package of risks can be described as outcome uncertainty. The second group of risks faced is economically based and can be termed financial risk. Often, there is uncertainty about the costs of establishing and maintaining habitat areas. There also may be uncertainty associated with the value of the commodities a landowner may be trying to produce, such as quality quail hunting opportunities. Taken together, outcome uncertainty and financial risk represent a formidable roadblock to producer investment in habitat enhancement projects. This problem is further magnified when such projects are to be established on land already under cultivation. While producers may be willing to enhance habitat on unused areas in meeting their stewardship obligations, the land ethic alone is insufficient to ensure such investments on production areas. To encourage establishment of wildlife habitat on production areas, research and management recommendations must reduce outcome uncertainty and financial risk. We are working to resolve these problems.

Eastern North Carolina is a productive crop and livestock region. Poultry, swine, tobacco, corn, wheat, cotton, peanuts and soybeans are produced on family farms and large corporate farming operations. This also is the most productive area in North Carolina for bobwhite quail, although even here the same decline is seen as in other southeastern states (Sharpe unpublished data). We have been researching northern bobwhite quail on production farms in the coastal region to test the wildlife benefits of field border systems and no-till farming techniques. Use of filter strips between tilled fields and drainage ditches was shown to generate and enhance habitats utilized by quail during the growing season. Flush-count surveys found 4.3 times the number of quail on farms with field border systems as on those without (Puckett 1995). The costs to establish and maintain such areas under various vegetative and maintenance regimes have been quantified (J.T. Morris unpublished data, J.R. Anderson unpublished data). Fields planted to no-till soybeans after winter wheat where found to provide insects to quail chicks at rates equal to insect availability in fallow fields (Palmer 1995). Integrated pest management practices are capable of reducing the direct and indirect impacts of pesticides on wildlife (Palmer et al. 1992). Furthermore, many conservation practices, particularly no-till and field border systems, can reduce sediment and nutrient loading of waterways. These reductions in non-point source pollutants benefit humans and wildlife both on-site and downstream (Allen 1993).

Eastern North Carolina Research Design

Currently, in eastern North Carolina, 15 cooperators volunteering 12,000 treatment and control acres are participating in a study of the wildlife and water quality benefits of both naturally vegetated and fescue field border systems. Our work is focused in four subregions, each of which is characterized by its own combination of crops and rotations. These experiments will allow assessment of reductions in nutrient and sediment loading of field ditch and canal networks and insights into the response of quail populations, as well as the benefits for other wildlife species in the farm landscape. Monitoring of the installation and maintenance of the field borders under various regimes will provide precise cost estimates. These estimates will be combined with calculations of the lost crop production from land removed from cultivation in each subregion. These costs will be compared with financial incentives available under current government-sponsored programs. These comparisons will contribute to determining the net costs of establishing habitat and highlight conflicting incentives between agriculture, conservation and wildlife policies. When provided to producers in a usable form, this information will reduce the financial risk associated with investments in field border systems. To reduce financial risk further, we will characterize the demand for high-quality, wild quail hunting on private lands in eastern North Carolina. This will provide producers with information on possible income opportunities from quail hunting leases. Income from such leases is another important factor in determining the net cost of establishing wildlife habitat on production areas.

The economic benefits from enhancing quail habitat and leasing hunting rights are difficult to determine due to a lack of price and market signals. There is a lack of information on how such factors as habitat extent and quality influence hunter demand. To quantify the benefits of habitat enhancement, the demand for high-quality, wild quail hunting must be examined in conjunction with the willingness of landowners to enhance wildlife populations and lease hunting rights. It is essential that the results of these analyses be useful to the individual landowner. Past data on demand for wildlife resources have been produced to meet state and regional policy needs. These data do not satisfy the site-specific planning requirements of individual producers.

Value of Nonmarket Goods and Characteristics of Hunter Demand

Enhanced quail populations generally are considered a positive economic good. Prices for such a good, however, cannot be determined simply by observation in the market place. In addition, recreational amenities, such as quail hunting, are composite in nature and, thus, are goods produced by combining other goods. To understand the value a quail hunter will derive from enhanced hunting opportunities produced through landowner adoption of sustainable agricultural practices requires an understanding of the various attributes desired in a hunt and the marginal rates of substitution between these attributes. We will characterize hunter demand by identifying the various hunt attributes desired, as well as the relative importance of these attributes in determining the overall value of a hunt. These attributes include the type of cover on the land, the ability to hunt with dogs, the distance to the site, the number of birds harvested and others.

Past efforts to value recreational amenities have utilized nonmarket, primarily contingent valuation methods (CVM), and related-market approaches, such as the travel cost, hedonic and household production methods. Problems with respondent biases, nonresponse and inconsistent estimators, however, have limited the value of these results. In addition, the travel cost model traditionally has assumed that an appropriate value for travel time is the foregone wage rate. Rigidities in the labor market, however, likely distort such valuations of leisure time (Bockstael et al. 1987), causing the travel cost model to underestimate the value (cost) of travel time.

The conjoint analysis method builds on the closed-end CVM (MacKenzie 1992). In the closed-end CVM, respondents are asked if they would be willing-to-pay or willing-to-accept some dollar value for a given increase or decrease in environmental quality, respectively. The conjoint method breaks down a composite good into its various attributes and then surveys respondents regarding their preferences for different attribute bundles when several attributes are varied simultaneously. Unlike the CVM, the conjoint method does not directly ask respondents for a dollar valuation, rather the price of a recreational outing is included as an attribute. This helps to reduce the confusion of respondents generated when they are asked to value goods which they do not normally purchase directly or at all. The conjoint approach differs from the travel cost method in that travel time is valued as lost time at the site rather than time foregone at work (MacKenzie 1992). This is intuitively appealing when one imagines a recreationist who finds he/she has available a fixed block of time for a recreational trip. In this scenario, all of this block is to be spent away from work, thus, each hour of travel time to and from the site directly reduces the on-site time available.

We will use conjoint analysis to investigate the potential recreational income opportunities available to landowners enhancing wild quail populations in eastern North Carolina. North Carolina Quail Unlimited members and participants in the North Carolina Wildlife Resources Commission's *Avid Quail Hunter Survey* will be surveyed to determine the marginal values held for various trip attributes and the marginal rates of substitution between these attributes. When price is included as an attribute, hunter demand for various quail hunting opportunities can be estimated. Cooperating farmers will be surveyed using conjoint analysis and focus group meetings to understand how they will respond to this demand. We will investigate what attributes landowners desire from leasees of hunting rights and what types of hunting opportunities those landowners will be able or willing to supply.

Conclusion

The economic and social factors that will determine the creation and availability of habitat on private lands in eastern North Carolina can only be understood by focusing on the decisions made by private landowners. We believe that wildlife habitat has not been created or maintained by farmers because of their reluctance to accept unknown levels of ecological and financial risk. Our work seeks to reduce these uncertainties by simultaneously demonstrating the environmental benefits, and the economic costs and benefits, of early successional wildlife habitat within four agronomic regions. On a farm-by-farm basis, the landowner will be able to add the economic values from recreational use to funds available from government conservation programs to make informed decisions on establishing early successional wildlife habitat.

Wildlife managers traditionally have been good practical ecologists who had strong ties to the agricultural community. In recent decades, however, agriculture has become a highly intensive and technologically advanced industry. Simultaneously, demand for environmental quality and recreational access from urban and rural communities has increased, creating challenges for policy makers at the state and federal levels (Wimberley 1993). Implementation of these policies ultimately resides in the hands of the private landowner. To effectively represent the wildlife resource, wildlife managers must be prepared to show how investments in wildlife habitat simultaneously achieve environmental, social and economic objectives.

We believe the information age will equip the field biologist better to handle complex issues. Geographic information systems, government data bases, and production, wildlife population and recreational demand models all will be used to forecast the costs and benefits of establishing field borders and other conservation agriculture and forestry practices to yield desired wildlife benefits. The wildlife biologist will become a site-specific wildlife investment analyst.

Our work will help identify conflicts between existing agriculture, environmental and wildlife policies. The interactive effects of these policies may provide unclear or conflicting incentives to producers. These effects are likely to increase the levels of risk and uncertainty producers perceive and, hence, impact farm-management decisions toward the status quo. To encourage incorporation of early successional habitats on production areas, wildlife programs must overcome both outcome uncertainty and financial risks by providing adequate information for site-specific management planning. To do this, wildlife programs must work within the cultural and economic realities of modern farming.

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Chapter Two: Agronomic Analysis of Experimental Field Borders in Eastern North Carolina

Morris, James Theodore, John R. Anderson, Jr. And Peter T. Bromley

This chapter is intended for submission to the Journal of Soil and Water Conservation, Soil and Water Conservation Society. To the extent reasonable, guidelines for submission to this journal have been followed in the preparation of this document.

Abstract: Differences in corn and soybean yields were measured at field edges and field interiors to quantify the agronomic tradeoffs of fields borders established in crop fields in eastern North Carolina. Yields were sampled using a combine equipped with a GPS and yield monitoring system and a traditional combine and weigh wagon in Carteret and Wilson Counties, respectively. The opportunity cost of foregone corn production from establishment of naturally-vegetated field borders ranged from 7,531 kg ha^{-1} (120 bu ac^{-1}) in Carteret County to 6,213 kg ha^{-1} (99 bu ac^{-1}) in Wilson County. In Wilson County, the opportunity cost of foregone soybean production was 2,085 kg ha^{-1} (31 bu ac^{-1}). A general decline in crop yields at field edges was observed in both counties. In Wilson County, no significant effect of field border vegetation on adjacent crops was found. While drainage ditches had no significant effect on crops yields at field edges, the presence of trees was found to significantly reduce yields in nearby crops. Information on the opportunity cost of field borders is expected to reduce producer uncertainty and encourage adoption of these practices.

INTRODUCTION

Increasing emphasis is being placed upon reduction of non-point source pollution from crop fields via conservation tillage and vegetated buffer systems (Pritchard et al. 1993, Misra et al. 1996, Daniels and Gilliam 1996, Patty et al. 1997). It can be argued that landowner adoption of field borders (FB) will depend upon the availability and reliability of information describing agronomic tradeoffs and environmental benefits of these areas (Morris et al. 1996). However, at this time, economic evaluations of FB are absent from the agronomic literature. To better understand the economics of field borders, this investigation examined the opportunity cost of forgone crop production generated by establishment of FB along corn and soybean field edges in two agronomic regions of eastern North Carolina. Yield distributions at field edges were quantified and possible effects from FB vegetation, trees and drainage ditches were investigated.

Geographically-positioned corn yield data was obtained from a farming operation in Carteret County, NC. Data for 1995 was obtained from eight fields each approximately 19 ha (47 ac) in size. This effort was undertaken to: 1) investigate the distribution of yields across entire fields and develop a representative corn yield surface using geo-referenced farming technology (Weiss 1996); and 2) calculate FB opportunity costs in foregone corn production on lower coastal plain soils. In 1997, corn and soybean yields were measured using a combine, weigh wagon, and moisture meter, on field border treatment and control areas, in Wilson County in the upper coastal plain. These efforts focused on crop yields within the first three combine passes at the edges of fields to: 1) determine field border opportunity costs in forgone corn and soybean production in this region of the State; 2) investigate effects of field border vegetation on crop yields at field edges; and 3) investigate effects of woods and ditches on crop yields at field edges.

METHODS

In Carteret County, NC extensive areas of pocossin wetlands were cleared and drained in the 1970's, creating landscapes dominated by rectangular fields approaching 20 ha (49 acres). Typically, drainage ditches run lengthwise along both sides of fields and drain into headland canals. Deloss fine sandy loam and Wasda, Ponzer and Belhaven muck soils, all with at least ten percent organic matter, were the predominant soil types on the farm fields sampled in this study. In 1996, experimental FB were established on upper coastal plain soils in Wilson County, North Carolina. The landscape in Wilson

County featured numerous crop fields approximately five hectares in size interspersed with blocks of forested land. Many field edges were bordered by woods and/or drainage ditches. Raines, Goldsboro and Norfolk sandy loam mineral soils were the predominant soil types.

Corn and soybeans are major crops in both areas. In 1996, Carteret County ranked 19th in both corn and soybean production out of 100 counties in North Carolina. In comparison, Wilson County ranked 21st in corn production and 12th in soybean production (NCDA NCAS 1997).

Carteret County

In 1995, geographically-positioned no-till corn yield data was collected from eight adjacent fields using a John Deere 9600 combine equipped with an AgLeader 2000 yield monitoring system. Measurements were taken in Dekalb 657 corn no-till planted in .75 m (30 in) rows. The combine was equipped with a 12-row corn header, cutting a 9.14 m (30 ft) swath. Yield and moisture readings were taken approximately every 5 m (16.5 ft) as the combined traveled through the field. Raw data was transferred into Agris Corporation's Aglink for Windows software to generate yield maps (Agris Corp., Roswell GA. 1996) (**Figure One**).

To analyze yields within and across the eight fields, a layer of vectors spaced 168 m (550 ft) apart, and running perpendicular to the direction of the combine passes, was superimposed over the eight fields resulting in 10 vectors numbered west to east crossing each field. Vectors one and ten each fell approximately 206 m (675 ft) in from their respective ends of the fields (**Figure Two**). Field ends were not sampled to avoid potential biases from compacted areas on turn rows. A yield surface was developed by aggregating yield and moisture data where each combine pass crossed vectors one through ten in each field (**Figure Three**). Tests of means significance and mean differences were conducted using SAS computer programs for the two outermost passes along each field edge and the two center most passes over the eight fields sampled (SAS Inst., Cary, NC) (**Figure Four**). The projected opportunity costs in foregone corn production from establishing FB on these fields was then calculated from the average yields found in the first combine passes (9.14 m) (30 ft) at field edges.

Wilson County

In 1997, corn and soybean yields at field edges were sampled using a Case model 1660 combine. Six rows of Pioneer #3163 no-till planted corn in .75 m (30 in) rows were sampled with each combine pass. A 5.18 m (17 ft) cut was taken in Haerts #6686 Round-up Ready® soybeans minimum-tilled in .381 m (15 in) rows. After each sampling pass along field edges, the contents of the combine were weighed with portable scales and moisture readings taken with a portable moisture meter. Distance measurements were recorded and yield calculations were made for each pass. When sampling in both crops, the combine pass at the outermost edge of the field was designated pass zero, the next pass into the field as pass one and likewise the next pass in as pass two. This system allowed field borders to occupy pass zero on fields with borders (**Figure Five**). Yields from passes zero on fields without borders, therefore, provided opportunity cost estimates in foregone corn and soybean production from installing field borders approximately one combine head in width (4.57 m and 5.18 m) (15 feet and 17 feet respectively).

Corn and soybean yields from passes one were compared to those from passes two over all the fields sampled to gain a general understanding of yield distributions at field edges. In addition, yields from passes one and two in corn and soybean fields with borders were compared with yields from passes one and two in corn and soybean fields without borders, to test for effects of field border vegetation on yields in adjacent crops. It was suspected that competition from trees for moisture, nutrients, light, or other factors could impact yields of nearby crops. Similarly, ditches might impact soil moisture or some other factors which could also effect adjacent crop yields. Tests were therefore conducted to verify the presence or absence of such effects. SAS statistical software was used to run the regressions and significance tests.

Sixty combine passes were taken along 25 field edges in nine corn fields. In addition, two center passes were taken from each of these fields and averaged together for a total of nine interior field measurements. Forty six combine passes were taken in soybeans along 19 field edges in 13 fields. On these fields, time constraints prevented collection of data from center passes.

RESULTS

Carteret County

Vector sampling of geo-referenced corn yield data illustrated that even across four predominant soil types, while the relative shape and magnitude of the ten yield-by-pass profiles varied, yields were consistently lower at field edges than at field centers (**Figure Three**). Least-square mean significance and least-square mean difference tests indicated mean yields were lowest at each outside pass, increased slightly going into the next two passes and increased sizably going into the centers of the fields (**Table One**). Each of these means was significantly different from zero at the α=.0001 level. While mean yields did not differ significantly within or between the northern or southern field edges, yields from each of the outer four passes were significantly different from yields in the middle of the field at the α=.0162 to α=.0001 level. The potential opportunity cost in foregone corn production from establishment of FB on these fields was estimated at 7,531 kg ha^{-1} (120 bu ac^{-1}) calculated as the average of the Northern Edge-1 and Southern Edge-1 mean yields.

Wilson County

Thirteen pass zero samples taken in corn indicated a mean yield of 6,213 kg ha^{-1} (99 bu ac^{-1}) within the first combine pass at field edges. Similarly, eight pass zero samples taken in soybeans indicated a mean yield of 2,085 kg ha^{-1} (31 bu ac^{-1}) (**Table Two**). These values, 6,213 kg ha^{-1} (99 bu ac^{-1}) and 2,085 kg ha^{-1} (31 bu ac^{-1}), represented the opportunity cost of field border establishment on these fields in foregone corn and soybean production respectively.

Field border vegetation ("Border") was found to have no significant impact on yields of adjacent corn plants occupying passes one and two (α=.8561) (**Table Three**). The effect of passes one ("Pass") on corn yields was found to be negative and significant at the α=.0643 level when compared to passes two. Thus, in general, corn yields in pass one were lower than yields in pass two. No significant interaction effects ("Border*Pass") were found between the impacts of borders and passes. While the presence of drainage ditches ("Ditch") was found to have no significant effect upon adjacent crop yields, the impact of trees ("Trees") was negative and significant at the α=.0112 level.

Analysis of soybean yields again showed no significant impact of field border vegetation on adjacent crop yields at the α=.05, .10 or .15 level (**Table Four**). The effect of pass one on bean yields was, as with corn, found to be negative compared to pass two and significant at the α=.0225 level. As before, no interaction appeared to exist between the effects of border and pass. The presence of ditches had no significant impact upon adjacent soybean yields while the impact of trees was again negative and significant at α=.0056.

DISCUSSION

Opportunity Costs of FB in Foregone Corn and Soybean Production at Field Edges:

Carteret County

Climate data for 1995 indicated the Carteret County site received approximately 1.32 m (52.01 in) of precipitation, slightly less than the 30-year average of 1.39 m (54.77 in). The average temperature of 62 degrees Fahrenheit was equal to the 30-year average. Analysis of 1995 geo-referenced no-till corn data indicated that yields did not differ significantly within the outside two passes of fields, but they were higher in the center than at the edges of fields (**Figure Four**). Generation of a representative yield surface indicated these trends continued across entire fields over four predominating soils types (**Figure Three**).

The estimated opportunity cost in foregone corn production from potential establishment of FB in each outside pass of the fields studied was estimated at 7,594 kg ha^{-1} (121 bu ac^{-1}). This comes to \$812.93 ha^{-1} (\$329.12 ac^{-1}) using the average 1997 market price of \$.11 kg^{-1} (\$2.72 bu^{-1})(USDA NCDA 1997). North Carolina Cooperative Extension Service 1997 crop enterprise budgets for no-till corn in this region indicated a break-even level of production of 7,280 kg ha^{-1} (116 bu ac^{-1}) assuming \$.11 kg^{-1} (\$2.72 bu^{-1}). Therefore, on the eight fields surveyed, corn production within the first combine pass 9.14 m (30 ft) of the field made producers 313.8 kg (5 bu) or \$33.60 ha^{-1} (\$13.60 ac^{-1}) (**Table Five**).

Wilson County

Nineteen ninety seven was a near normal year with annual rainfall on the Wilson site of approximately 1.27 m (49.83 in) compared to the 1961-1990 30-year average of 1.19 m (46.83 in). The average temperature matched the 30-year average of 59 degrees. The opportunity cost of foregone corn production from field border establishment in each outside pass of the fields studied was estimated at 6,213 kg ha^{-1} (99 bu ac^{-1}) or \$665.12 ha^{-1} (\$269.28 ac^{-1}) at the same 1997 market price of \$.11 kg^{-1} (\$2.72 bu^{-1}). The estimated opportunity cost of foregone soybeans on these areas was estimated at 2,085 kg ha^{-1} (31 bu ac^{-1}) or \$537.52 ha^{-1} (\$217.62 ac^{-1}) at a 1997 market price of \$.28 kg^{-1} (\$7.02 bu^{-1}) (USDA NCDA 1997). North Carolina Cooperative Extension Service 1997 crop enterprise budgets for no-till corn in this region indicated a 7,719 kg ha^{-1} (123 bu ac^{-1}) break-even level of production for corn assuming the \$.11 kg^{-1} (\$2.72 bu^{-1}). On the surveyed areas, therefore, corn production within the first combine pass (4.57 m) (15 feet) at field edges cost producers \$161.24 ha^{-1} (\$65.28 ac^{-1}). These same budgets provided a break-even level of soybean production of 1,412 kg ha^{-1} (21 bu ac^{-1}) at the \$.28 kg^{-1} (\$7.02 bu^{-1}). Thus on the surveyed areas, soybean production within the first combine pass (5.18 m) (17 ft) at field edges made \$173.40 ha^{-1} (\$70.20 ac^{-1}) (**Table Four**).

Impacts of FB Vegetation, Ditches and Trees on Adjacent Crop Yields at Field Edges:

Wilson County

Sampling of corn and soybean fields in Wilson County found no significant impacts of field border vegetation on crop yields within the nearest two combine passes at field edges. The presence of trees was found to have a significant negative impact upon corn and soybean yields in passes one and two while the presence of ditches had no effect. This may result from competition between trees and crops for light, nutrients, moisture or some other factors (Ottman 1985, Ottman and Welch 1988). These effects, however, are likely to vary with annual climatic conditions as well as the moisture and nutrient requirements of specific tree and crop species (personal communications with M.J. Ottman and L.F. Welch 1998). Where trees were present, their effects strengthened the general findings of lower yields in passes one than passes two.

Summary Discussion:

Carteret and Wilson Counties

In terms of corn production, yield measurements in both Carteret and Wilson Counties, NC indicated production in the first combine pass along field edges was near or below break-even. Conversely, edge-of-field soybean production in Wilson County exceeded projected break-even bushels by 47.6 percent. In Wilson County, evidence was also found that yields from passes one in the edges of fields were consistently lower than yields from passes two. The presence of woods along field edges exacerbated these effects. These combined findings indicate that corn field edges in Wilson County, especially those next to woods, may produce below break-even and therefore provide an economically viable area for FB establishment in eastern North Carolina.