ECONOMIC AND ENVIRONMENTAL IMPACT OF THE INTEGRATED CROP MANAGEMENT PROGRAM

By

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If you are ever in Clarinda, Iowa and need the assistance of a Farm Management Specialist, look me up.

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CHAPTER I

INTRODUCTION

Background

Use of public policy to reduce negative externalities of agricultural production has a long history in the United States. For example, federal policy to provide incentives for farmers to implement soil conservation measures began in 1933 (Griffin and Stoll). Cost sharing has been used to provide incentives for farmers to invest in soil conservation by building grass waterways, terraces, and shelter belts. Cost sharing has also been used as an incentive for farmers to adopt or experiment with soil conserving production practices such as strip cropping and no-till planting.

Federal funds for these programs have been provided to the states via the Agricultural Conservation Program (ACP). ACP was established in 1936 with an amendment to the Soil Conservation and Domestic Allotment Act of 1935 (US Congress). Historically, United States Department of Agriculture - Agricultural Stabilization and Conservation Service (USDA-ASCS) state committees, composed of farmers, have had input into the type of programs funded at the local level (Strohbehn et al.). In 1989, the ASCS provided state committees with the option to use ACP funds to cost-share with a limited number of farmers electing to implement an Integrated Crop Management (ICM) program.

ICM is a cost-share program that encourages producers to modify their production practices. Cost-sharing of production practices is not unique to the ICM program. However, ACP cost-sharing has traditionally been used to implement construction of soil conserving structures (terraces, grassed waterways, retention dams). Funds applied to a one-time construction practice (terraces) with a measurable benefit (reduced erosion as measured by the Universal Soil Loss Equation (USLE)) may have a relatively low net present value to the producer, but a relatively high net present value to society. Funds applied to production practices (soil nutrient testing) can have relatively high net present values to both producers and society. ACP funds used to encourage annual production practices are generally thought of as having less measurable benefits than ACP funds used for long-term construction practices (Griffin and Stoll).

ICM is described as "A total crop management system that promotes the efficient use of pesticide and nutrients in an environmentally sound and economically efficient manner" (ASCS p. 7). ICM represents a more comprehensive view of external consequences of agricultural production than the traditional cost-share soil conservation programs. However, ICM is much less precise than traditional ACP funded cost-share programs and hence, more difficult to evaluate. ICM practices and activities are listed in Table I.

The ICM pilot program was established without a legislative mandate as Special Cost-Share Practice 53 (SP-53) by the ASCS. ASCS gave producers the option of participating in the SP-53 cost-share practice for up to three years. The Food, Agriculture, Conservation, and Trade Act of 1990 (FACTA 1990) included

This study analyzes 1991 ICM participants. Participation in ICM in 1991 was possible through both the pilot program and WQIP. The implicit objective of the ICM program was to encourage a producer to adopt more "sustainable" production systems. Cost-share funds under WQIP were limited to $10/acre for row crops and $20/acre for specialty crops. Under SP-53, payments were limited to $7/acre for row crops and $14/acre for specialty crops. Participating farmers were required to obtain the assistance of a qualified technician (either Cooperative Extension Service, Soil Conservation Service, or certified private consultant) to develop an ICM plan. The plan was to be designed and implemented to ensure that pesticides and nutrients were used in an "environmentally sound and economically efficient" manner (ASCS).

Enrollment in ICM under WQIP was limited to producers whose current management system was impacting, or had the potential to impact, a water source, and had a potential to achieve a source reduction of agricultural pollutants through participation in the program. At least two-thirds of the land that qualified had to be in a designated project area, and the owner or operator receiving the cost-share must have control of the land for the contract period. Approved designated project areas included existing Water Quality Demonstration Projects (DEMO's), Hydrologic Unit Areas (HUA's), or 1991 ACP Water Quality Special Projects (WQSP's). A DEMO is a project with the objectives of demonstrating the effectiveness of selected conservation practices in treating specific nonpoint source pollution problems and promoting the use of those practices in other areas. A HUA is an area where the impairment of water quality by agricultural nonpoint sources is significant. A WQSP may be identified as a local situation where agricultural nonpoint source pollution has significantly impaired water quality. In 1991 there were 24 DEMO projects, 35 HUA's and an uspecified number of WQSP's (Bjerke, Johnsrud, and Scaling).

Problem Statement

The economic and environmental impact of the ICM program has not been determined. This research has the objective of determining if the Integrated Crop Management (ICM) option as implemented on farms in 1991 met its stated goal as a total crop management system that promoted the efficient use of pesticides and nutrients in an environmentally sound and economically efficient manner. The specific objectives are a) to determine if costs and returns of ICM fields differed from costs and returns of non-ICM fields (both Pre-ICM and Farm Costs and Returns Survey (FCRS) results) and b) to determine if the environmental quality, as measured by a suitable index, differed between ICM and Pre-ICM fields.

Assumptions

It is assumed that the technology encouraged by the ICM program was also available to both participants and non-participants in ICM prior to participation in the program. Thus, it is not clear whether ICM practices would have been applied if the cost-share assistance were not available, or whether they were being applied prior to the cost-share. It is assumed that the cost-share of the ICM program influenced the participants in the ICM program to adopt the ICM practices.

Production agriculture is assumed to operate under competitive commodity markets. That is, producers enrolled in ICM and those surveyed for the Farm Costs and Returns Survey (FCRS) are assumed to have paid the same prices for their inputs and received the same prices for their production. FCRS values, and their use in this research, are explained in Chapters III and IV. Production conditions, weather and pest infestation are assumed to be comparable for ICM, Pre-ICM and non-ICM fields.

Scope and Limitations

This study analyzes Nebraska corn growers who received cost-share funds to use ICM practices to produce corn. The farmers selected for this study produced corn in both 1990 and 1991. Fertilizer and pesticide application levels and yield data were provided by 84% of the participants (217 out of 257). Nebraska corn producers were chosen because of their high number (first) and proportion of participants providing complete data and high acreage (second). ICM was made available to producers for the first time in 1989-90. An unspecified number of those 1989-90 participants were enrolled in the program for the 1990-91 and 1991-92 crop years. Data limitations did not allow positive identification of specific fields enrolled in both 1989-90 and 1990-91.

Cost-share recipients who produced under ICM used a variety of chemicals with varying environmental impacts. Reducing the study of ICM to one state and one crop was necessary because of the varying production situations in different states. Corn is not produced in Rhode Island with the same practices as corn produced in Oklahoma, and comparison of pesticide or nutrient applications on apples, cotton, and hay would yield misleading results.

Although ICM is offered as two separate programs, SP-53 and WQIP, the production practice data source, form ACP-313 (Figure I), does not differentiate between recipients enrolled under SP-53 and those enrolled under WQIP. Data on application of specific cost-share practices are not available. It was not possible to determine which specific practice was supposed to influence a particular producers' actions. It is also not possible to determine what proportion of participants responded to any particular practice. Data on ICM cost-share payments to individual participants and ICM cost-share expenditures at the county level are not available. Early in the research of this issue, it was assumed that the Conservation Reporting and Evaluation System (CRES) data, that contain information on federal cost-sharing across all USDA agencies at the individual level, could be used to determine the cost-share amounts for ICM at the county level. This was an erroneous assumption. Each of the five practices included in the WQIP implementation of ICM has a corresponding code included in the data, but the codes are not specific to the ICM practice. Conservation cropping sequence as a specific practice under the WQIP has an SCS technical practice code of 328, and the note on its application says "Not available with ICM" (ASCS). Conservation cropping sequence as a practice under the specific practice of ICM under WQIP also has the SCS technical practice code of 328. The four other ICM practices also have cost-share codes used by other programs. The result is that ICM cost share data cannot be separated from other cost share data. Thus, no economic data specific to this analysis of the ICM program can be obtained from the CRES data or from any other source.

CHAPTER II

THEORY, MEASURES, AND LITERATURE

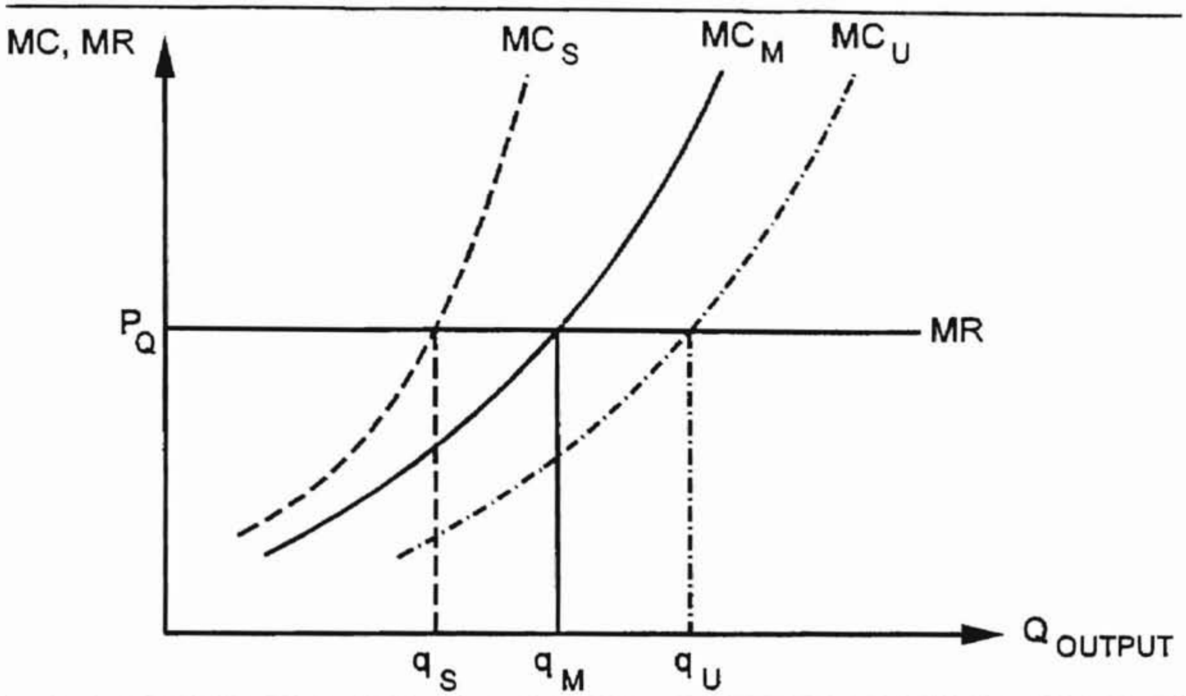
Theoretical Basis

ICM is a total crop management system that promotes the efficient use of pesticide and nutrients in an environmentally sound and economically efficient manner (ASCS). Economic efficiency is a comprehensive concept for theoretical economists and a specific practical concept for applied economists. To a theoretical economist, an economically efficient outcome is one that makes people as well off as possible, taking into account all factors that influence their well being (Browning and Browning). To an applied economist, economic efficiency is made up of "technical" efficiency and "pricing" efficiency (Cramer and Jensen). ICM did not attempt to discover 'the' efficient allocation of inputs. There are many efficient economic states and, therefore many efficient policies (Griffin). For that reason, in this chapter, theory, measures, and literature relevant to exploring ICM's economic and environmental impacts are discussed. The normative concept of efficiency, Pareto Optimality, is not discussed, and positive efficiency concepts are only discussed with regard to reduction of negative externalitites. The market is not efficient when there are externalities.

ICM is concerned with the efficient use of pesticides and nutrients because excess nutrients, pesticides, or soil lost from a producer's field (nonpoint source pollution) into the environment (ground water, surface water, non-target specimens) represent a negative externality to society. An example of a positive externality to society associated with agriculture would be the scenic views provided by producers. Cost-shares as incentives for producers to reduce nonpoint pollution has precedence. Environmental legislation designed to encourage adoption of technologies aimed at reduction of nonpoint source pollution has traditionally provided cost-share assistance to producers (Browne et al.). ICM was implemented in response to the perception that nonpoint source pollution can be controlled at the source with cost-share incentives to encourage adoption of the practices listed in Table I.

Figure I is a graphic representation of how an individual producer can be affected by externalities in the marketplace. Figure I has three marginal cost curves and a marginal revenue line. Marginal revenue and cost are on the Y-axis and quantity of output is on the X-axis. Marginal revenue (MR) is linear and without slope, because each additional unit of output is equal in value to the previous level of output. Marginal cost curves shows the additional costs incurred by the producer with each additional unit of output. Marginal costs, as reflected by the market, are represented by MC_M. Marginal costs reflecting society's cost of each additional unit of output are represented by MC_S if there are negative externalities, or MC_U if there are positive externalities. MC_U could also be the result of an unexpected level of marginal costs resulting from either a cost-share (reduction in production costs) or a change to a new production practice with lower marginal costs.

FIGURE I. POSSIBLE CHANGES IN MARGINAL COSTS



MC_S is to the left of MC_M, and both are to the left of MC_U . Placement of these marginal cost curves shows the relative costs of production at each level of output. Optimal quantities of output are produced where MR and MC intersect (q_S , q_M , and q_U) with the optimum depending on the cost curve faced by the producer.

The purpose of nonpoint source pollution control is primarily to protect the public from the negative external costs resulting from agricultural practices (Griffin and Stoll). Externalities exist when the welfare of some agent depends not only on their own activities, but also on another's activities (Tietenberg). Externalities are costs or benefits that are external to the decision maker and are imposed on others (Cramer and Jensen). Externalities are benefits or costs accruing to some individuals or groups who are apart from a market transaction. They create market failure (Knutson et al.). There are two traditional solutions to market externalities, taxation and internalization of costs (Nicholson).

Studies of alternative policies to reduce agricultural nonpoint source pollution have shown that cost-sharing is the most popular approach (Kerns and Kramer). ICM cost-shares were intended to help the producer adopt practices that would reduce the external cost to society of their agricultural production. Cost-sharing alternatives have been shown to be effective at reducing pollutant loadings, and have the political advantage of raising net farm income (Kramer et al.). Cost-sharing to encourage desired nonpoint source pollution control was shown to be significantly less effective than either taxes or regulations (Walker and Timmons; Seale et al).

History of ACP Expenditures and Evaluations

Federal cost-sharing funds were first made available through the ACP in 1936. ACP was created as a replacement for the Agricultural Adjustment Program (AAP) when the AAP was declared unconstitutional (Rasmussen and Baker). ACP cost-shares were initially provided to reduce production and provide income supports (Baker et al.). ACP also provided cost-sharing for lime and fertilizer applications, and acreage reduction (USDA). With the advent of World War II (WW II), ACP was used to encourage greater production of food and fiber. After WW II the emphasis began to gradually shift from short-term projects, like countour plowing, to longer lasting practices, like terraces and grass waterways (Rasmussen). When ACP shifted torward primarily providing cost-sharing for construction activities under the Soil Conservation Service (SCS) it was still accused of providing income supplement payments under the guise of conservation payments (Simms).

Federal studies of ACP expenditures have determined that program costs outweigh benefits in part because ACP funds were not sufficiently targeted. The Government Accounting Office (GAO) reviewed ACP and concluded that funds were not used in a cost effective manner (USGAO). A study published by the USDA also concluded that, due to insufficient targeting, the costs of the ACP are greater than the benefits (Strohbehn). Three problems with the ACP have been recognized as the most significant: a) lack of a concerted effort to direct funding to specific problem areas, b) district committees often approve cost-sharing requests for whomever applies as long as funds are available, and c) the voluntary nature of ACP means that producers managing the most erosive lands may never participate (Cook). However, targeting of ACP funds through application of Variable Cost-Share Levels (VCSL) in West Tennessee were not shown to reduce the cost per ton of soil saved from erosion, because the Best Management Practices (BMP) used in those counties were more expensive (Park and Montieth). A reason frequently reported for ACP expenditures lack of cost-effectiveness is the difficulty of measuring benefits associated with conservation measures (Cook; Strohbehn; USGAO).

Economic Impact Measures

Alternative measures of farm-level economic impacts include whole-farm budgets, enterprise budgets, and partial budgets. Whole-farm budgets require data on every income and expense activity that occurs on the farm. Enterprise budgets require data on every income and expense item connected with a particular enterprise. Partial budgets only require data on the items expected to change due to an actual or proposed change in production activity. As the following discussions show, partial budgets are well documented in literature and applications are straightforward.

Partial budgets have four components as illustrated in Table II. Ease of measuring economic impacts of marginal changes in production practices makes partial budgeting a popular and commonly used tool. Partial budget analysis is a key part of the farmer's decision making process (CIMMYT), and it is particularly useful in analyzing marginal changes in production (Boelje and Eidman).

TABLE II. PARTIAL BUDGET COMPONENTS

	Change in Income	Additional Income - Reduced Income
-	Change in Expenses	Additional Expenses - Reduced Expenses
	Difference	Change in Income - Change in Expenses

Partial budgeting has been used to measure the potential benefits of herbicide use for wheat production in Ethiopia (Sahile and Dejene). Partial budget analysis was used to measure the economic impact of alternative Integrated Pest Management (IPM) strategies for control of apple scab and codling moth in an Iowa apple orchard (Gleason et al.). Researchers in Maine used partial budget analysis to test the profitability of alternative levels of hexazinone applications for weed control strategies in lowbush blueberry production (Hanchar et al.). A survey of Texas dairy producers showed that adoption of bovine somatotroptin (bST) as a production technology depended only upon the producers perceptions of changes in yields and costs (Saha et al.). A study of alternative cropping systems in the Eastern corn belt evaluated economic returns and environmental impacts of systems designed to minimize soil and water degradation (Foltz et al.).

Environmental Impact Measures

The universal soil loss equation has long been used as a standard to measure differences in soil erosion potential across soil types and production practices. However, no generally accepted standard measure is available for quantifying the relative differences in environmental consequences across production systems that use different types and levels of chemical pesticides. Several measures have been proposed including the Environmental Impact Quotient (EIQ) (Kovach et al.), the Chemical Environmental Index (CINDEX) (Teague et al.), the Chemical Concentration Index (CONC) (Teague et al.), the Environmental Impact Points (EIP) (Reus and Pak), and the Cost-Groundwater Hazard (C-GH) frontier method (Hoag and Hornsby). Science has a role in ordering risks. Individuals evaluate risks based on many priorities, and science must determine which of these are public priorities: eg. public values and opinions, economic constraints (Bretthauer). Thus, an attempt was made to determine if one of these measures could be used to determine if the relative potential hazard from pesticide use was reduced by the ICM program. Discussion of each measures' emphasis: eg. surface water quality, ground water quality, beneficial insect toxicity, arthropod toxicity, human toxicity, water organism toxicity, soil organism toxicity, or cost, and the suitability of it as a measure of the environmental impact of ICM follows.

Environmental Impact Quotient

The Environmental Impact Quotient (EIQ) measure for evaluating the relative environmental impact of pesticides is unique in that it attempts to reduce all effects of a pesticide to a single index number. Knowledge of the pesticide's common name, application rate, and percentage of active ingredient is necessary to calculate an EIQ field rating. EIQ values for common pesticides have been calculated by Kovach et al.

EIQ has three impact components: farm worker, consumer, and ecology. Each of these impact components is weighted equally, but within each component individual factors are assigned various weights. In all cases, the impact potential of a specific pesticide on any specific environmental factor is equal to the toxicity of the chemical times the potential for exposure. The Environmental Impact Quotient (EIQ) is calculated as follows:

(1)

EIQ= { [C*((DT*5)+(DT*P))] — farm worker risk

+ [(C*(S+P)/2*SY)+(L)] — consumer component

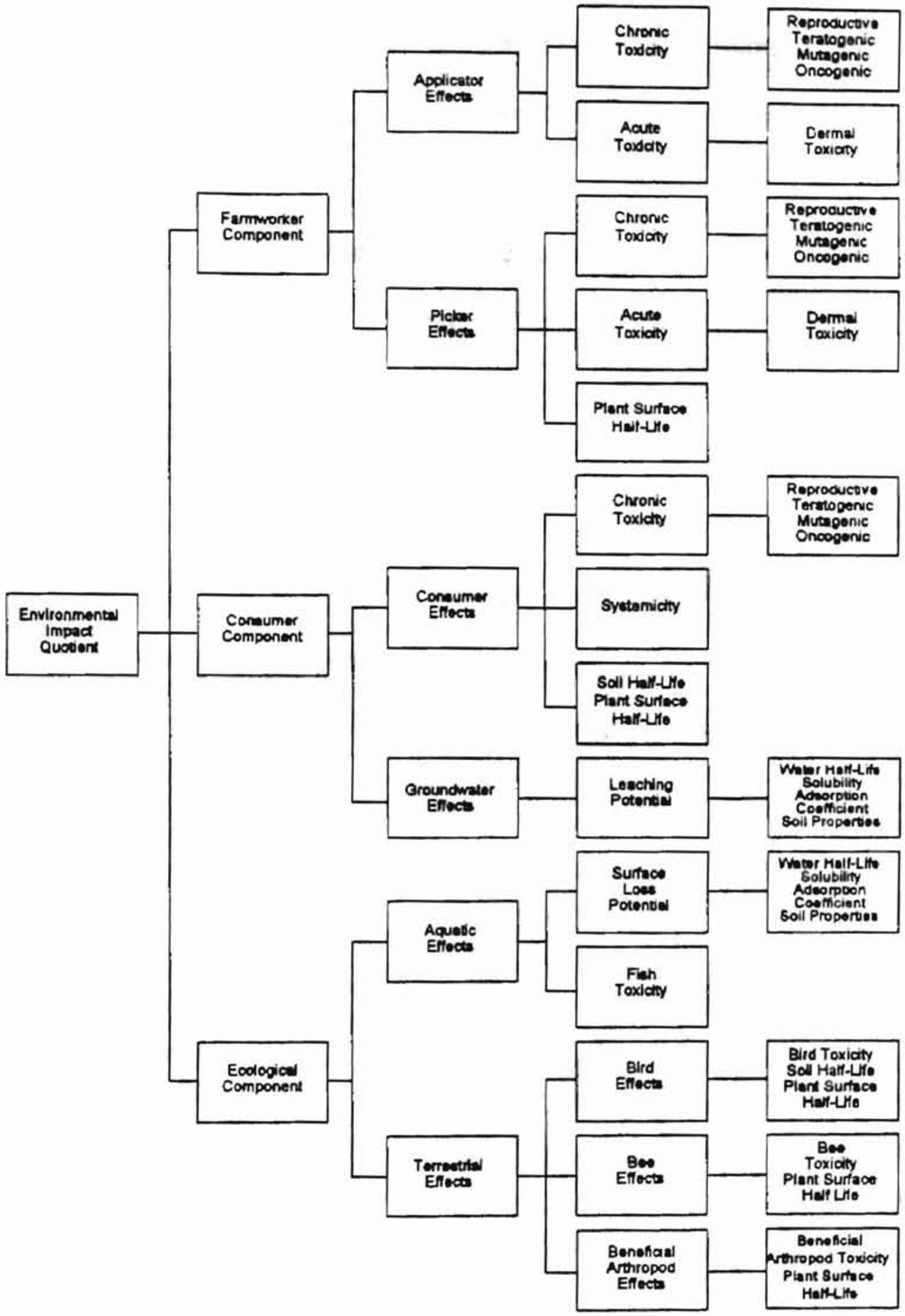
+ [(F*R)+(D*(S+P)/2*3)+(Z*P*3)+(B*P*5)] } — ecological component

/3

where C is chronic toxicity, DT is the dermal toxicity, P is the plant surface half life, S is the soil half life, SY is systemicity, L is leaching potential, F is the fish toxicity, R is the surface loss potential, D is bird toxicity, Z is bee toxicity, and B is the beneficial arthropod toxicity. Figure II graphically depicts the relationships of each component of the EIQ calculation.

The first component, farm worker risk, is defined as the sum of applicator and picker exposure times the long term health effect or chronic toxicity (C). Applicator exposure is determined as the dermal toxicity weighted by a factor of five to account for the increased risk associated with handling concentrated pesticides (DT*5).

FIGURE II. ENVIRONMENTAL IMPACT QUOTIENT COMPONENTS



Source: A Method to Measure the Environmental Impact of Pesticides

Picker exposure is determined as the dermal toxicity multiplied by plant surface half life (DT*P).

The consumer component is defined as the sum of consumer exposure and ground water effects. Consumer exposure is calculated as the product of chronic toxicity, one-half the sum of soil and plant surface half-life, and systemicity (C*((S+P)/2)*SY). Groundwater effects are captured as leaching potential (L).

The ecological component is composed of the aquatic and terrestrial effects and is the sum of the effects of the pesticide on fish, birds, bees, and beneficial arthropods. Fish effect is calculated as the product of fish toxicity and surface loss potential (F*R). Bird effect is calculated as the product of dermal toxicity and one-half the sum of soil and plant surface half-life it is given a weight of three (D* ((S+P)/2) *3). Bee effect is calculated as the product of bee toxicity and plant surface half-life, it is given a weight of three (Z*P*3). Beneficial arthropod effect is calculated as the product of beneficial arthropod and plant surface half-life, it is given a weight of five (B*P*5). Reasoning for the above weights is that birds and bees are less likely to be harmed by pesticides than beneficial arthropods, but more likely than fish. Birds and bee effect is weighted by 3 while the beneficial arthropod effect is weighted by 5.

EIQ is a desirable method of measuring environmental impacts of pesticide strategies because it reduces a pesticide's environmental impact to one index number. However, this introduces several problems. Scaling of impacts, weighting of effects, omission of factors, no accounting for application conditions, and value judgements are considered significant shortcomings (Dushoff et al.). Dushoff et al. suggest that pesticide data be reported, with both quantitative and qualitative descriptors, in a tabular form for one or two fixed application levels and that the Tables be unique for "different regions" of the country. The intractability of this suggestion is not lost to Dushoff et al., policymakers, on the other hand, may prefer the simplicity of a single number, especially as an input to complex decisions. EIQ was developed for impact analysis of alternative IPM measures.

Chemical Environmental Index

The CINDEX system models surface and ground water environmental impacts of pesticides. CINDEX does not have a farm worker component and hence ignores the applicator or picker effects. The CINDEX model also ignores consumer effects related to the consumption of the crop to which the pesticide is applied. Bird, bee, and beneficial arthropod effects (terrestrial effects) are not considered by CINDEX. This means that the only effect measured by CINDEX is the groundwater component of the consumer effect. CINDEX is calculated as:

(2)

$$CINDEX_{ij} = \frac{(PERC_{ij} * HA_i) + (RUNOFF_{ij} * LC_i)}{2}$$

where $CINDEX_{ij}$ is the CINDEX for chemical i of pesticide strategy j, $PERC_{ij}$ is the quantity of chemical i of pesticide strategy j lost in percolation (grams/acre), HA_i is an index based on the Health Advisory Level (HAL) of pesticide i, $RUNOFF_{ij}$ is the quantity of chemical i of pesticide j lost in runoff (grams/acre), and LC_i is an index based on the LC_{50} of pesticide i. $PERC_{ij}$ and $RUNOFF_{ij}$ are based on average annual estimates of percolation and runoff water from twenty-year simulation obtained from the Erosion-Productivity Impact Simulator (EPIC) (Sharpley, 1990), Groundwater Loading Effects of Agricultural Monitoring Systems (GLEAMS) (Leonard, 1987) Pesticide Sub-routine (PST) (EPIC-PST) simulations. The HA_i uses a combination of the HAL and EPA carcinogenic risk rating. This measure uses the Kovach et al. breakdown for the LC_i.

CINDEX has the strength of being a specific measure of surface and ground water impacts of pesticides. CINDEX has the weakness of not being a comprehensive measure of environmental impact. CINDEX was developed as a general water quality impact measure. CINDEX could not be applied to analysis of the environmental impacts of ICM because of its data requirements.

Chemical Concentration Index

The CONC system is only slightly different from the CINDEX system. It also models the surface and ground water environmental impacts of pesticides. As a result it has the same criticisms as the CINDEX relating to the ignored pesticide effects and incompatibilty with ICM data. CONC is calculated as:

(3)

$$CONC_{ij} = \frac{RCONC_{ij} + PCONC_{ij}}{2}$$

where $CONC_{ij}$ is the CONC for chemical i of pesticide strategy j, $RCONC_{ij}$ is the concentration of chemical i of pesticide strategy j in runoff (ppm) divided by the LC_{50} of chemical i, and $PCONC_{ij}$ is the concentration of chemical i of pesticide strategy j in percolate (ppb) divided by the lifetime HAL of chemical i (ppb). As with the CINDEX model percolation and runoff concentrations are based on EPIC-PST simulations. CONC and CINDEX have the same strengths, weaknesses, and applications.

Environmental Impact Points

Environmental Impact Points (EIP) is a measure developed by Reus et al. in response to the Dutch government's Multi-Year Crop Protection Plan (MYCPP) (Reus). This method is designed to address the three environmental effects given highest priority in Dutch environmental policy: leaching into groundwater, effects on water organisms, and effect on soil organisms. The measurement of the effect on soil organisms is a feature that the EIQ does not have. However, the EIP shares the criticisms of the CINDEX and CONC in that it ignores applicator, picker, consumer, bird, bee, and beneficial arthropod effects, and that it cannot be estimated with the available data. The EIP requires more information than the EIQ. Soil organic matter content, season of application, and method of application are necessary inputs.

The EIP relies heavily on ratios of chemical properties and Pesticide Leaching and Accumulation Model (PESTLA) results. The PESTLA model is used in the Netherlands to determine those active ingredients and metabolites for which additional field experiments will be required to determine the actual risk of leaching (Brouwer).

A strength of the EIP is that it has a base of 100. At 100 EIP the proposed Dutch standards are not exceeded, thus the environmental burden is considered to be acceptable. This is comparable a soil loss level (T) of 5 (tons/acre/year) as estimated by the USLE. A weakness of the EIP is data requirements. EIP is being applied in the Netherlands.

Cost-Groundwater Hazard

Hoag and Hornsby's cost-groundwater hazard (C-GH) frontier is a decision aid that presents the economic and environmental impacts simultaneously. The C-GH frontier model is represented graphically with cost on the vertical axis and groundwater hazard on the horizontal axis, the space is then divided into quadrants. Strategies which fall in the first quadrant are clearly undesirable (high cost and high hazard). Strategies which fall into the third quadrant are clearly desirable (low cost and low hazard). Strategies falling into quadrants two and four are undesirable. Quadrant two strategies have low costs and high hazard, and quadrant four strategies have high costs and low hazards. Cost for each treatment strategy is calculated as: the cost of the chemical treatment plus the "opportunity cost" of yield losses that the strategy fails to prevent. The groundwater hazard index (GHI) is calculated as:

(4)

$$GHI = \frac{C_{gw}}{HAL}$$

where HAL is the Environmental Protection Agency's (EPA) health advisory level and C_{gw} is the concentration (μg/l) in the groundwater calculated as:

(5)

$$C_{gw} = \frac{A.I.\ leached\ per\ unit\ area}{(unit\ area)\ (depth\ of\ mixing)\ (aquifer\ porosity)}$$

where the A.I. leached per unit area is determined by Gustafson's Groundwater Ubiquity Score (GUS) (Gustafson). Depth of mixing (meters) and aquifer porosity (percentage) are site specific data.

C-GH is a good field-level environmental impact measure. It is a relatively simple decision aid. A drawback of the C-GH is the site specific data necessary for its calculation, it cannot be applied to ICM because of the site specific data requirements. C-GH has been applied at North Carolina experiment stations.

Selection of an environmental impact measure

Table III shows environmental determinants and management opportunities that influence nonpoint source pollution. Some alternative measures of environmental impact discussed above used not only variables that fell under management opportunities, but also the variables that fell under environmental determinants. Arguably, methods using site specific data could better model environmental impact than methods not using site specific data. However, site specific data were not available.

TABLE III. NONPOINT SOURCE POLLUTION FACTORS

Environmental Determinants	Management Opportunities
Soil Characteristics	Pest Management Strategy
Field Slope, Length	Nutrient Management Strategy
Rainfall	Cultivation Practices
.	.
Temperature	Crop Rotations

ICM was designed as a holistic practice. It did not have a directive of strictly reducing the impact on water quality, but on the environment. Figure III shows the comprehensiveness of EIQ as an environmental impact measure. ICM's broad directive implies that the EIQ would be a preferable method for analyzing the environmental impact of ICM. In addition, data limitations do not allow the other methods to be applied.

ICM Studies

Two studies of the first year of ICM implementation have been published. A 1994 study by Osborn et al. compared ICM production practices with those of a control group. A 1992 study by Dicks et al. compared ICM production practices with historical production practices. Both Osborn et al. and Dicks et al. were concerned with the change in input levels. Dicks et al. also applied an environmental impact measure. Neither Osborn et al. nor Dicks et al. studied the economic effect on participants. This study is concerned with the unanswered question, "Did the ICM program meet its goals?"

Dicks et al. produced a cooperative extension service circular, *Analysis of the 1990 Integrated Crop Management Practice* to fulfill a contract between the Department of Agricultural Economics at Oklahoma State University and the USDA-ES. Dicks et al. summarized and reported input use and yields at the state and county level. Historical use of pesticides, nitrogen, phosphorous, potassium, and yields for each crop, and environmental impacts were compared to ICM levels to determine if participation had any effect. ICM levels were based on the recommendations of the technicians responsible for program administration. Yields were analyzed to determine if the difference between historic and ICM levels were significant. Dicks et al. made no report of the economic impact of the ICM program. Comparison of ICM yields to county-level average yields showed that only two crops in three states had significantly different yields under ICM practices. Dicks et al. used the EIQ to measure the environmental impact of participants in the ICM program.

Osborn et al. produced *A Preliminary Assessment of the Integrated Crop Management Practice*. Osborn et al. conducted an analysis of the ICM program by comparing the 1990 ICM (SP-53) cost-share fields to a control group. Objective Yield Survey (OYS) data were used to construct the control group. Osborn et al. focused on three questions:

1. Did fertilizer use change as a result of ICM, and if so by how much?
2. Did pesticide use change as a result of ICM, and if so by how much?
3. Did ICM have any effect on crop yields, and if so by how much?

Two additional questions were posed, but not answered :

4. What was the effect of ICM on the environment?
5. What was the effect of ICM on farm profitability?

Osborn et al. used a nested hypothesis testing procedure to determine the answers to one, two, and three. Osborn et al. did not answer four or five. Osborn et al. had limited discussion on the difficulty of analyzing questions four and five.

Osborn et al. first tested the hypothesis that there was a non-ICM effect on the variable in question by determining if there was a change in input use or yield for the OYS fields. If no non-ICM effect was found, Osborn et al. assumed that there was no significant difference (in the yields or applications) for the two years, and there was no significant change in weather and/or pest pressures for the two years. If there was not a significant difference in 1989 and 1990 OYS data, then only the differences (in the yields or applications) for ICM participants for the two years are considered. But, if there was a significant difference in 1989 and 1990 OYS data, then the difference in OYS levels is used to index the ICM participants' responses.

Osborn et al.'s analysis has the inherent weakness of not considering absolute values, only the changes in values. This was shown to be significant by the reporting of results of all hypothesis tests. A footnote on page 7 of Osborn et al. reads

> "The analysis indicates a net 21-percent increase in the total use of herbicides on Nebraska corn on ICM farms relative to the control group. [Control group herbicide use, measured as total pounds of active ingredients, fell significantly (-36 percent) for Nebraska corn acres according to the OYS. Average herbicide use also fell significantly for ICM participants, but at a lesser rate (-23 percent). Therefore the net effect of ICM was ((1-.23)-(1-.36))/(1-.36), for a net increase of about 21 percent.]"

What Osborn et al. do not mention is that the levels of application for the control group were greater (75-percent more for 1989 and 45-percent more for 1990). Thus, Osborn et al.'s conclusions about the effect of the ICM practices on input use are both correct and misleading. No discussion of the relatively low chemical input levels on ICM fields in pre-ICM or ICM periods is made by Osborn et al.

CHAPTER III

DATA AND METHODS

Chapter Overview

In this chapter both the data and the methods used to analyze the data are discussed. Production practices used by participants on ICM fields were recorded on form ACP-313. Form ACP-313 provided quantity data (yields, fertilizer and pesticide applications). No expenses were recorded on this form. To analyze the economics of this program, fertilizer and chemical price data were obtained and applied to the quantity data. All costs and returns were calculated at the farm level on a per acre basis. There were 217 producers which fit the criteria outlined in Chapter I, and many producers had multiple fields. As the summation notation in the following equations show, data were aggregated to the producer (farm) level. Thus, the ICM data used for this study had 217 observations. Fertilizer price data were obtained from USDA sources, and chemical price data were obtained from a chemical wholesale company. Whenever nitrogen, phosphorous, and or potassium are mentioned in this paper, it can be assumed that these are the commercial terms. A fertilizer application of 10-20-10 contains 10% elemental N, 20% K_2O_5, and 10% K_2O.

ICM promoted the efficient use of pesticides and nutrients in an economically efficient and environmentally sound manner. However, the data limitations discussed in Chapter I do not allow tests of relative efficiency. Chapter II developed the reasoning behind the tests described in this chapter. Two separate methods were used to analyze the data and fulfill the objectives of the study. Partial budgeting was used to determine if the costs and returns from ICM fields differed from their pre-ICM levels and FCRS levels. Environmental impact analysis based on a method developed at Cornell University, Ithaca, New York by Kovach et al. was used to determine if the environmental quality differed on ICM fields from their pre-ICM levels.

Data

ICM Participant Data

Production practices used by ICM participants on ICM fields were obtained from form ACP-313 (Figure III). Form ACP-313 has nine sections:

1) Identification
2) Crop/Yield
3) Acreage
4) Fertilizer Applied
5) Fertilizer Application Rate
6) Pesticide Applied
7) Pesticide Application Rate
8) Remarks
9) Cover/Green Manure Crops

FIGURE III. FORM ACP-313

REPRODUCE LOCALLY. Include form number and date on reproductions.

ACP-313 (10-1989) U.S. DEPARTMENT OF AGRICULTURE Agricultural Stabilization and Conservation Service	1. State	2. County
INTEGRATED CROP MANAGEMENT EVALUATION SHEET	3. Farm No.	4. Page __ of __

SECTION I - PRE-PLAN USE (Acres Covered by ICM Plan)

CROP/YIELD A	ACREAGE B	FERTILIZER APPLIED C	FERTILIZER APPLICATION RATE (lbs/acre) D	PESTICIDE APPLIED E	PESTICIDE APPLICATION RATE (pt,qt,lbs/acre) F

SECTION II - ACTUAL USE (Based on ICM Plan)

CROP/YIELD A	ACREAGE B	FERTILIZER APPLIED C	FERTILIZER APPLICATION RATE (lbs/acre) D	PESTICIDE APPLIED E	PESTICIDE APPLICATION RATE (pt,qt,lbs/acre) F

5. REMARKS

	BEFORE A	AFTER B
6. ACRES IN COVER CROPS		
7. ACRES IN GREEN MANURE CROPS		

Section one has four identifiers: state, county, farm number, and page __ of __. Sections two through seven, and nine, have both pre-plan use (based on past practices) and actual use sections. Data in the pre-ICM section are used for comparison of ICM practices to conventional practices. The pre-ICM data are used as a proxy for a control group. To that end, only information obtained from Nebraska corn producers who included data on corn production practices in both the pre-plan and actual use sections is used. A problem encountered in the analysis of ICM data was the incomplete ACP-313 forms. Not all participants provided yield data. No information was included in section nine for most participants. Section five was completed on most forms. Section six provided for a great deal of leeway as to the data to be provided by the participant/consultant. The name of the chemical(s) applied were in several forms: trade-name, common-name, chemical (formulation) descriptions, and in some cases local vernacular. The form did not specifically request that the pesticide application rate be the amount of formulation applied. As a result, participants reported in several manners. Some reported pounds of active ingredient per acre, some reported amount of formulation per acre, and some reported total spray volume per acre. Misspellings of pesticide names were common. For example, Terbufos was mistaken for Tribufos. Terbufos is an insecticide used on corn. Tribufos is a defoliant used on cotton. Information that could have allowed better analysis of the program such as soil type, timing of application, method of application, and cropping method was not obtained.

USDA Data

State Level Farm Costs and Returns Survey (FCRS) data provided a state-level budget for corn production in Nebraska (Ali, 1994). The FCRS budget allowed comparison of ICM participants costs and returns to the USDA estimated average costs and returns. The FCRS survey is designed to estimate national- and regional-level costs and returns. State-level costs and return estimates are to be used for general discussion only, because statistical reliability diminishes for estimates below the regional and U.S. levels due to sample size. The data are available both in printed and electronic form. The electronic form was used because additional statistical information was provided. FCRS data were retrieved from Cornell University's USDA data and report repository via the Internet at gopher:\\usda.mannlib.cornell.edu\. FCRS data are collected for all major field crops, and production costs and returns are annually estimated. FCRS estimates are based on comprehensive data collected every fourth year for each of the major field crops. Estimates for the interval years are based on base year estimates and estimated annual changes. Data for the 1991 corn FCRS budget were collected from 49 Nebraska corn producers in February and March 1992. Characteristics of the producers surveyed for FCRS are listed in Table IV. Table IV includes coefficients of variation as indicators of statistical variability.

TABLE IV. CHARACTERISTICS OF PRODUCERS EVALUATED FOR FCRS

Total Operation Size	1,323 acres
Corn Planted	265 acres
Corn Harvested for Grain	257 acres
Corn Yield	132 bu/acre
Corn for Farm Use	15%
Fertilizer Use (any fertilizer)	90%
Nitrogen	142 lbs/acre
Phosphorous	23 lbs/acre
Potassium	3 lbs/acre
Chemical Use (any chemicals)	86%
Herbicides	75%
Insecticides	54%
Production Method	
Irrigated	76%
Dryland	24%
No-till	22%
Previous Crop	
Corn	61%
Soybeans	18%
Wheat	6%
Alfalfa	6%
Other Crops	9%
Livestock Inventory	
Beef Cattle	78%
Hogs	28%
Sheep	12%
Other Livestock	11%

Source: Corn: State-level Production, Costs, Characteristics, Inputs, and Machine Use Data, 1991

TABLE V .NEBRASKA CORN PRODUCTION COSTS AND RETURNS, 1991

	Cost ($/acre)	Coefficient of Variation (%)
Gross value of production:		
Corn grain	302.85	NA
Cash Expenses:		
Seed	24.32	7.59
Fertilizer (142# N, 23# P, 3# K)	29.30	16.51
Chemicals	22.78	11.29
Custom Operations	5.75	27.60
Fuel, lube, and electricity	38.56	13.70
Repairs	17.37	7.51
Hired Labor	8.42	37.59
Purchased irrigation water	1.80	38.34
Commercial drying	1.94	75.04
Total variable cash expenses	150.24	9.57
General farm overhead	14.01	26.28
Taxes and insurance	21.53	12.00
Interest	26.28	31.64
Total fixed cash expenses	61.82	16.50
Total cash expenses	212.06	9.00
Gross value of production less cash expenses	90.79	NA
Harvest-period price	2.29/bu.	NA
Yield	132.25 bu.	4.23

Source: Corn: State-level Production, Costs, Characteristics, Inputs, and Machine UseData, 1991 (fertilizer cost, total expenses, and gross value of production less cash expenses changed)

The fertilizer cost shown in Table V is not the cost published in the FCRS report. A revised method of gathering fertilizer cost was implemented in 1991. Instead of using a price times quantity approach, a total cost approach was used. Enumerators asked, "How much did it cost you to fertilize this year?", not "How many pounds of nitrogen, phosphorous and potassium did you apply this year." The result was an inflated value for fertilizer cost. For the sake of comparability, FCRS participant fertilizer costs were recalculated. The method used to assign fertilizer cost to ICM participants was used to calculate the fertilizer cost item in the FCRS budget with the reported quantities of fertilizer applied by FCRS producers.

Research Methods

Partial budgets are used to estimate the change that will occur in farm profit or loss from some change in the farm plan by considering only those items of income and expense that change (Boehlje and Eidman). Partial budgeting methods allow the economic impact of the ICM program to be measured with available data. Form ACP-313 provides data for the physical amounts of two inputs, fertilizer and pesticide applications. These inputs are treated as the only expense items that change. The data limitations do not allow comparisons of expenses related to each individual ICM practice. Fertilizer expenditures for ICM program participants were calculated by applying USDA fertilizer price data to the algorithm described below. Chemical expenditures were calculated using pesticide price data from Estes Inc. Other expenditures are assumed to be fixed for ICM participants both before and after adopting ICM practices, and producers in the rest of the state as represented by the

FCRS. Yields were reported on ACP-313, so the change in income can be calculated. ICM participants' actions under the program are compared both to their previous actions and to those represented by the FCRS.

Fertilizer Cost Determination

The FCRS fertilizer cost data were used to determine the source of nutrients applied. This was possible because FCRS provides both fertilizer application levels and costs. With fertilizer costs obtained from the USDA (Table VI), the sources can be determined. The sources found to be used by the FCRS were the same used by ICM participants. This allowed a simple least-cost method to be developed.

TABLE VI. FERTILIZER PRICES ($/ton)

Year	Di-Ammonium Phosphate 18-46-0	Anhydrous Ammonia 82-0-0	Super-Phosphate 0-46-0	Potassium-Dichloride 0-0-60
1990	$219	$199	$201	$155
1991	$235	$210	$217	$156

Source: USDA Fertilizer Use and Price Statistics

The method was tested, and found to be accurate in estimating 1987-91 FCRS fertilizer costs. It is based on the following assumptions:

1) Nitrogen and phosphate are applied to corn in the form of di-ammonium phosphate (DAP) (18-46-0), and DAP is the primary phosphorous carrier used.

2) Nitrogen is applied in the form of anhydrous ammonia (NH_3) (82-0-0).

3) Phosphorous is occasionally applied in the form of super-phosphate (0-46-0).

4) The sole source of potassium is potassium chloride (KCL) (0-0-60).

Fertilizer costs were aggregated to the farm-level using the following equation:

(6)

$$Farm\text{-}level\ Fertilizer\ Cost_{ICM} = \frac{\sum_{f=1}^{n} \sum_{n=1}^{n} (Price_n * Rate_{nfiICM} * Acres_{nfiICM})}{\sum_{f=1}^{n} \sum_{n=1}^{n} Acres_{nfiICM}}$$

where: $Price_n$ is the per-pound price of nutrient n; $Rate_{nfiICM}$ is the indicated application rate of nutrient n per acre of field f, on farm i, in the ICM period; $Acres_{nfiICM}$ is the acreage of field f, on farm i, that nutrient n was applied to in the ICM period. Pre-ICM period fertilizer expenses were calculated in the same manner. Per acre nutrient costs were estimated as a weighted average. The cost per ton of nutrients are shown in Table VI. Per acre pre-ICM, ICM, and difference fertilizer costs and ICM acreage for each farm are listed in Appendix I by county.

Pesticide Cost Determination

The farm-level chemical cost was determined by multiplying the chemical's per unit price by the units applied by the acres the pesticide was applied to then dividing that total amount by the number of acres that received the pesticide application. This is done to achieve a weighted average value for the per acre chemical cost. Per acre pesticide costs were determined as shown in equation 7:

(7)

$$Farm\text{-}level\ Pesticide\ Cost_{ICM} = \frac{\sum_{f=1}^{n} \sum_{p=1}^{n} (Price_p * Rate_{pfiICM} * Acres_{pfiICM})}{\sum_{f=1}^{n} \sum_{p=1}^{n} Acres_{pfiICM}}$$

where: $Price_p$ is the per-unit price of pesticide p; $Rate_{pfiICM}$ is the indicated application rate of pesticide p per acre of field f, on farm i, in the ICM period; $Acres_{pfiICM}$ is the acreage of field f, on farm i, treated with pesticide p in the ICM period. Pre-ICM period pesticide expenses were calculated in the same manner. Pesticide costs, like the nutrient costs, were estimated as a weighted average. Per acre pre-ICM, ICM, and difference in pesticide costs and ICM acreage for each farm are listed in Appendix II by county.

Revenue Determination

The farm-level revenue was determined by multiplying each ICM field's average yield by the number of acres in the field, summing that for all fields a producer had in ICM, then dividing that by the number of acres the producer had in ICM. This is done to achieve a weighted average value for per acre revenue. The following equation shows how acre revenue levels were determined:

(8)

$$Farm\text{-}level\ Revenue_{ICM} = \frac{\sum_{f=1}^{n} (Price_C * Yield_{CfiICM} * Acres_{CfiICM})}{\sum_{f=1}^{n} Acres_{CfiICM}}$$

where: $Price_c$ is the per-bushel price of corn (2.29/bushel, average 1991 Nebraska harvest price) period; $Yield_{cfiICM}$ is the indicated yield of field f, on farm i, in the ICM period; and $Acres_{cfiICM}$ is the acreage of field f, on farm i, producing corn in the ICM period. Pre-ICM period revenue levels were calculated in the same manner. Revenue levels, like the nutrient and pesticide costs, were estimated as a weighted average. The per acre pre-ICM, ICM, and difference in revenue levels and ICM acreage for each farm are listed in Appendix III by county.

Economic Impact Determination

The differences in profitability of ICM practices as compared to pre-ICM and FCRS profitability are calculated as:

(9)

	Change in Revenue	(ICM revenue - pre-ICM revenue)
-	Change in Costs	(ICM fertilizer cost - pre-ICM fertilizer cost)
	+	(ICM pesticide cost - pre-ICM pesticide cost)
	Economic Impact of ICM (ICM and Pre-ICM)	

(10)

	Change in Revenue	(ICM revenue - FCRS revenue)
-	Change in Costs	(ICM fertilizer cost - FCRS fertilizer cost)
	+	(ICM pesticide cost - FCRS pesticide cost)
	Economic Impact of ICM (ICM and FCRS)	

Per acre ICM - pre-ICM and ICM - FCRS economic impacts and ICM acreage for each farm are listed in Appendix IV by county.

Environmental Impact Determination

Kovach et al. EIQ's were used to calculate field ratings for the pesticides used by the ICM participants. The EIQ field ratings were determined as shown in equation 11:

(11)

$$Farm\text{-}level\ EIQ\ Rating_{ICM} = \frac{\sum_{f=1}^{n} \sum_{p=1}^{n} (Rate_{pifICM} * Acres_{pifICM} * EIQ_p)}{\sum_{j=1}^{n} \sum_{i=1}^{n} \sum_{p=1}^{n} Acres_{pifICM}}$$

where: EIQ $Rating_{ICM}$ is the EIQ for producer i in the ICM period; $Rate_{p\,ifICM}$ is the indicated application rate in pounds of active ingredient of pesticide p, per acre of field f, on farm i, in the ICM period; $Acres_{pf\,iICM}$ is the acreage of field f, on farm i, treated with pesticide p in the ICM period; and EIQ_p is the EIQ rating of pesticide p. The pre-ICM ratings were calculated with the same formula using pre-ICM year data. EIQ values were calculated using the indices determined by Kovach et al. In the cases where EIQ_p was unknown the mean value for that type of pesticide (herbicide, insecticide, etc.) was used. The per acre pre-ICM, ICM, and difference in EIQ values and ICM acreage for each farm are listed in Appendix V by county.

Hypotheses Tests

ICM participants' fertilizer and pesticide expenses and revenue were compared first to pre-ICM expenses and revenue, then to FCRS data. Tests for equality (ICM to Pre-ICM and ICM to FCRS) of each expense and income item were done separately, then the economic impact of ICM, difference in profitability, was tested. Control group pesticide application levels data were not available. Environmental impact of ICM was tested by testing for equality of pre-ICM and ICM EIQ levels.

The null hypotheses to test for equality of ICM participants' expense, income, economic impact, and environmental impact levels to pre-ICM levels are:

$$H_{0\ ICM\ EXP} : \overline{EXPENSE}_{ICM} = \overline{EXPENSE}_{PRE\text{-}ICM}$$

$$H_{0\ ICM\ REV} : \overline{REVENUE}_{ICM} = \overline{REVENUE}_{PRE\text{-}ICM}$$

$$H_{0\ ICM\ ECO} : \overline{ECONOMIC\ IMPACT}_{ICM} = \overline{ECONOMIC\ IMPACT}_{PRE\text{-}ICM}$$

$$H_{0\ ICM\ ENV} : \overline{ENVIRONMENTAL\ IMPACT}_{ICM} = \overline{ENVIRONMENTAL\ IMPACT}_{PRE\text{-}ICM}$$

These tests are matched-pair difference tests. Data for these tests were obtained from Nebraska ICM participants who produced corn on the same fields in both the pre-ICM period and the ICM period. This allows data obtained from the difference in the pre-ICM and ICM periods to be used. The test statistic associated with a matched-pairs difference test is:

(12)

$$t_{n_D-1} = \frac{\bar{x}_D}{s_D / \sqrt{n_D}}$$

where: t with $n_D - 1$ degrees of freedom is the test statistic value; $\overline{x}_D$ is the mean value of the difference; s_D is the standard deviation of the difference; and n_D is the number of differences (McClave and Benson).

The null hypotheses to test for equality of ICM participants' income, expense, and environmental impact levels to the mean values for all Nebraska corn producers as estimated by the FCRS are:

$$H_{0\ FCRS\ EXP} : \overline{EXPENSE}_{ICM} = \overline{EXPENSE}_{FCRS}$$

$$H_{0\ FCRS\ REV} : \overline{REVENUE}_{ICM} = \overline{REVENUE}_{FCRS}$$

$$H_{0\ FCRS\ ECO} : \overline{ECONOMIC\ IMPACT}_{ICM} = \overline{ECONOMIC\ IMPACT}_{FCRS}$$

Tests for equality of ICM and FCRS expenses and incomes are not matched-pair difference tests. ICM data were obtained from Nebraska ICM participants who produced corn on the same fields in both the pre-ICM period and the ICM period. FCRS data were obtained from the 49 producers surveyed by the USDA for the

FCRS. This means that a test for the equality of two sample means must be used. The test statistic:

(13)

$$t_{n_{ICM} + n_{FCRS} - 2} = \frac{(\bar{x}_{ICM} - \bar{x}_{FCRS})}{\sqrt{s_p^2 \left(\frac{1}{n_{ICM}} + \frac{1}{n_{FCRS}}\right)}}$$

where: t with $n_{ICM} + n_{FCRS} - 2$ degrees of freedom is the test statistic value; $\bar{x}_{ICM}$ is the mean value of the ICM estimate; $\bar{x}_{FCRS}$ is the mean value of the FCRS estimate; s^2_p is pooled variance estimator; n_{ICM} is the number of ICM observations; and n_{FCRS} is the number of FCRS observations (McClave and Benson). The pooled variance estimator needed for calculation of the test statistic is calculated as:

(14)

$$s_p^2 = \frac{(n_{ICM} - 1)\, s_{ICM}^2 + (n_{FCRS} - 1)\, s_{FCRS}^2}{n_{ICM} + n_{FCRS} - 2}$$

where: s^2_{ICM} is the variance of the ICM observations; s^2_{FCRS} is the variance of the FCRS observations; and all other variables are explained above. (McClave and Benson).

Data and Methods Summary

This chapter discussed the sources of data used for analysis of the economic and environmental impacts of the ICM program, and the methods used to analyze that data. Both economic impact tests and the environmental impact test are treated as matched pairs difference tests. Conversion of the physical quantity data provided on form ACP-313 to costs and revenues allowed rather simple hypothesis tests to be performed. With Kovach's index, environmental impact anlysis was done in a much more analytical manner than it could be done with other measures. Chapter IV includes a discussion of the results of applying these methods to the appropriate data.

CHAPTER IV

FINDINGS

Introduction

Chapter I included discussion of the assumption that cost-sharing influenced adoption of ICM. Information provided in chapter II outlined that ICM was a program designed to encourage adoption of technologies that would reduce negative externalities of agricultural production. Chapter II also emphasized that cost-share programs, like ICM, are popular and effective at influencing technology adoption. These points, along with the fact that economic benefits of changes in environmental impacts are difficult to measure, encourage the analysis of economic and environmental impacts separately.

Values discussed in this chapter are farm-level per acre means. Values used in the economic analysis are dollars per acre, and values used in the environmental analysis are EIQ points per acre. The tests used to determine significance of economic and environmental impacts are described in Chapter III and results of those tests are presented in this chapter. Differences in fertilizer and pesticide costs, revenue, and economic impact are presented, both ICM - pre-ICM and ICM - FCRS, and the difference in environmental impact is then presented, ICM - pre-ICM.

Chapter I related the lack of adequate control data. It would have been desirable to have data on the production practices of ICM producers for the same time period on adjacent fields, but the data were not available. Two alternative sources of data are used for the economic analysis. Pre-ICM data reflects historical input levels for ICM fields. Pre-ICM data were provided by ICM participants on form ACP-313. FCRS data used in this analysis are estimates obtained from the 1991 Farm Costs and Returns Survey. FCRS estimates had less dispersion, lower coefficients of variation, than ICM estimates.

FCRS is a complex list and area frame survey designed and maintained by the National Agricultural Statistics Service (NASS). FCRS was designed to generate accurate costs and returns estimates at the regional and national levels, and there were a limited number of states for which the FCRS provided reliable state level costs and returns estimates. Nebraska was one of those states.

Chapter I discussed that ICM practices could only be applied in watershed areas designated as at risk. These watersheds, and the ICM fields, were in counties with greater proportions of land under irrigation than the statewide average. ICM fields were in counties with greater than 90% of production under irrigation, and 76% of the FCRS fields were irrigated (Table IV). That could explain a significant difference in costs and returns, because 1991 was a drought year. In this study, comparison of ICM costs and returns to FCRS costs and returns was much like comparing apples and oranges. The methods used to compare FCRS data with North Dakota Farm Management Association data and the similar methods used to compare FCRS data with Illinois Farm Business Farm Management data could not be applied to this analysis because of ICM participant data limitations (Gustafson, Nielsen, and Mitchell; Koenigsten and Lins). However, the results of comparing ICM values with FCRS values are included in this chapter for discussion purposes.

Economic Impact

Fertilizer costs

Fertilizer cost estimates for ICM participants, both pre-ICM and in the year of application of ICM practices, are listed in Table VII. Fertilizer cost data used to calculate these statistics are in Appendix I. Participants' mean ICM fertilizer cost is close to the pre-ICM mean, and the standard deviations of these estimates are also close. It follows that the coefficients of variation, ratios of mean to standard deviation, are close. Coefficients of variation are used as a measure of the relative reliability of the mean estimates.

TABLE VII. FERTILIZER COSTS

	PRE-ICM	ICM	FCRS
Fertilizer Cost ($/acre)	22.25	22.49	29.3
Standard Deviation	8.3	8.48	4.84
Coefficient of Variation (%)	37.29	37.71	16.51
Number of Observations	217	217	49

Difference between participants' ICM and historic fertilizer cost levels are shown in Table VIII. Equality of pre-ICM and ICM fertilizer costs are being tested.

This, like all of the following pre-ICM to ICM tests, is a matched pairs difference test. An acceptable rejection region for this test would be 5%. If equality of the means were not rejected, then the student's t test statistic (a ratio of the mean value to its standard deviation) would have to fall within the range of -1.96 to 1.96. These values are the same for the z (standard normal) and t distributions for sample sizes greater than 30. The difference test statistic is 0.51 with 216 degrees of freedom. This shows the null hypothesis that ICM fertilizer costs are equal to pre-ICM fertilizer costs cannot be rejected, and fertilizer costs under ICM were equal to pre-ICM fertilizer costs.

TABLE VIII. FERTILIZER COST DIFFERENCES

	ICM - PRE-ICM	ICM - FCRS
Difference ($/acre)	0.24	-6.81
Standard Deviation of Difference	0.46	1.25
Test Statistic	0.51	-5.42
Degrees of freedom	216	264

Descriptive statistics of the FCRS fertilizer cost estimate are listed in Table VII. FCRS mean fertilizer cost is greater than participants' mean ICM fertilizer cost, and the standard deviation is less. The coefficient of variation of the FCRS estimate is also lower than ICM coefficient of variation indicating that the FCRS estimate is from a sample with less dispersion. The difference between FCRS and participant's ICM fertilizer cost levels is shown in Table VIII. The difference test statistic is -5.42 with 264 degrees of freedom. This t value exceeds the critical value of -1.96. Thus, the null hypothesis that ICM costs are equal to FCRS historic levels must be rejected. Fertilizer costs were significantly less for ICM participants than they were for producers surveyed by the FCRS.

This set of test results shows that ICM participants' fertilizer costs were not significantly different from pre-ICM. It would be expected that the fertilizer costs would be less under ICM because of the implication that fertilizer applications of producers not participating in ICM are excessive. However, the comparison of ICM participants' program fertilizer application costs to historic levels show there was not a significant change.

The opposite is true when the difference between ICM participants' fertilizer costs and FCRS budget values are used. This difference is shown to be significant, and it does show that participants' costs of fertilizer were less under ICM than the budgeted mean values for the state. This implies that ICM participants were already applying significantly lower levels of nutrients than nonparticipants

Pesticide costs

ICM participants' mean pesticide costs are listed in Table IX. Appendix II lists the pre-ICM, ICM, and difference in pesticide costs for each ICM producer. Mean pesticide costs under ICM were $2.62 greater than pre-ICM. The standard deviations of the ICM and historical estimates are close, and the coefficients of variation for both estimates show the standard deviation is greater than 50% of the mean value. The coefficients of variation indicate that pesticide costs were widely dispersed around the mean value.

TABLE IX. PESTICIDE COSTS

	PRE-ICM	ICM	FCRS
Pesticide Cost ($/acre)	26.39	29.01	22.78
Standard Deviation	14.04	15.14	2.57
Coefficient of Variation (%)	53.22	52.18	11.29
Number of Observations	217	217	49

The difference between ICM and historic pesticide cost levels are shown in Table X. The difference test statistic is 2.85 with 216 degrees of freedom, and this indicates that the hypothesis that pesticide costs under ICM are equal to pesticide costs under conventional methods can be rejected. The probability of rejecting a true null hypothesis with this test statistic is less than 1%. Pesticide costs for ICM fields were greater under ICM than their pre-ICM levels.

TABLE X. PESTICIDE COST DIFFERENCES

	ICM - PRE-ICM	ICM - FCRS
Difference ($/acre)	2.62	6.23
Standard Deviation of Difference	0.92	2.18
Test Statistic	2.85	2.86
Degrees of freedom	216	264

Pesticide cost statistics from the FCRS data are listed in Table IX. The FCRS mean pesticide cost is $6.23 less than participants' mean ICM pesticide cost, and the standard deviation of the FCRS estimate is less than the standard deviation of the ICM estimate. The coefficient of variation of the FCRS estimate is much lower than the ICM estimates coefficient of variation. These statistics show that the FCRS estimate has less variability.

The difference between FCRS and ICM pesticide cost levels are shown in Table X. The difference test statistic is 2.18 with 264 degrees of freedom. This is greater than 1.96 and it shows that the null hypothesis that ICM costs are equal to FCRS historic levels can be rejected. The probability of rejecting a true null hypothesis with this test statistic is less than 1%. Pesticide costs were greater on ICM fields than those reported on fields surveyed for the FCRS.

Tests on the significance of the differences between ICM and historical pesticide costs and ICM and FCRS costs showed that costs significantly greater on ICM fields. ICM practices do not dictate a decrease in pesticide application levels. ICM practices have the goal of encouraging environmentally sound and economically efficient pesticide strategies. One explanation for higher pesticide cost under ICM could be that a practice encouraged by ICM is the substitution of low cost, highly environmentally damaging pesticides with those that may be more expensive but less environmentally damaging (Table I). It cannot be determined whether this practice caused the higher pesticide costs because of data limitations.
No data on specific practices used by individual ICM participants were available (Chapter I).

Revenue

Revenue statistics for ICM participants are listed in Table XI. Appendix III lists the pre-ICM, ICM, and difference in the revenue levels for all 217 Nebraska farmers participating in ICM. ICM participant revenue does not include the cost-share payments, because it is assumed that the cost-share payments were used to offset costs associated with the practices adopted. Participants' mean ICM revenue is $17.64 less than mean historical levels. The standard deviation of the ICM estimate is greater than that of the historical estimates. Coefficients of variation in the mean ICM revenue show that the standard deviation of the estimate is 19 percent of the estimate. This is five percent greater than the pre-ICM coefficient of variation, but less than coefficients of variation for the cost estimates.

TABLE XI. REVENUE

	PRE-ICM	ICM	FCRS
Grain Revenue ($/acre)	383.38	365.74	302.85
Standard Deviation	55.24	68.53	12.81
Coefficient of Variation (%)	14.41	18.74	4.23
Number of Participants	217	217	49

Statistics on the difference between participants' ICM and pre-ICM pesticide cost levels are shown in Table XII. The difference test statistic is -4.98 with 216 degrees of freedom. The hypothesis that revenue under ICM is equal to revenue under conventional methods can be rejected, -4.98 is less than -1.96 and the probability of rejecting a true null hypothesis with this test statistic is less than 1%. ICM participants had lower levels of revenue.

Revenue statistics derived from the FCRS data are listed in Table XII. The

FCRS mean revenue is $62.89 less than mean ICM revenue. As with the cost estimates, both the standard deviation and coefficient of variation of the FCRS revenue estimate are less than the ICM values. The coefficient of variation of the FCRS estimate is much lower than the ICM estimate's coefficient of variation. This shows that the FCRS return value, like the costs values, has less variability than the ICM or pre-ICM values.

TABLE XII. REVENUE DIFFERENCES

	ICM - PRE-ICM	ICM - FCRS
Difference ($/acre)	-17.63	62.89
Standard Deviation of Difference	3.54	9.84
Test Statistic	-4.98	6.39
Degrees of freedom	216	264

Statistics on the difference between FCRS and participant's ICM revenue levels are shown in Table XII. The difference test statistic is 6.39 with 264 degrees of freedom, and this shows that the null hypothesis that ICM revenue is equal to FCRS levels must be rejected. The probability of rejecting a false null hypothesis with this test statistic is less than 1%. This test shows that fields of ICM participants generated significantly higher revenue than fields surveyed for the FCRS.

Tests on the significance of the differences between ICM and pre-ICM revenue showed that ICM practices resulted in a significant decrease in revenue. Tests on ICM and FCRS revenue showed a significant difference in revenue. The difference between ICM and FCRS revenue levels are partially explained by the fact that ICM participants were in counties with greater proportions of land under irrigation than the statewide average and irrigated corn generally has higher yields than non-irrigated corn.

Economic Impact

Economic impact statistics are listed in Table XIII. This table shows the change that occurred in farm returns net of fertilizer and pesticide costs on ICM fields, and it estimates the difference in returns between ICM and FCRS. The first column depicts the differences when partial budgeting is applied to ICM fields with the historical expenses and revenue as a base. The second column depicts the change when partial budgeting is applied to ICM fields with FCRS budget expenses and revenue as a base. The differences are both significant, but ICM practices are shown to have lower returns than pre-ICM practices and greater returns than practices of producers involved in the FCRS.

ICM is shown to affect revenue net of fertilizer and pesticide costs by comparing ICM to pre-ICM. Producers' revenue net of fertilizer and pesticide costs, on the average, were $20.54 per acre lower in the ICM year. This difference is significant with a t test statistic value of -5.56. That t value is less than the lower bound of the confidence interval (-1.96). The null hypothesis that ICM revenue net of fertilizer and pesticide costs was equal to that of conventional practices is rejected. The significance of the test statistic is such that the probability of rejecting a true null is less than 1 percent. ICM practices, on the average, had lower levels of revenue net of fertilizer and pesticide costs than did pre-ICM practices.

TABLE XIII. ECONOMIC IMPACT OF ICM

	ICM - PRE-ICM	ICM - FCRS
Difference ($/acre)	-20.54	85.67
Standard Deviation of Difference	3.64	4.57
Test Statistic	-5.64	18.75
Degrees of freedom	216	216

ICM revenue net of fertilizer and pesticide costs was greater than FCRS revenue net of fertilizer and pesticide costs. ICM fields are shown to have $85.67 per acre greater revenue net of fertilizer and pesticide costs levels. This difference is highly significant. As discussed in the revenue section, these results are driven by lower revenue levels on FCRS fields.

Environmental Impact

Environmental impacts of ICM are measured in EIQ per acre. The results of analysis of the ICM and pre-ICM pesticide applications impact on the environment are shown in Table XIV. ICM fields were 3.42 EIQ points worse off per acre. Standard deviations and coefficients of variation of the estimates show that the impacts were widely dispersed.

TABLE XIV. ENVIRONMENTAL IMPACTS

	PRE-ICM	ICM
Environmental Impact Quotient	99.31	102.73
Standard Deviation	50	53.39
Coefficient of Variation	50.35	51.97
Number of observations	217	217

The difference in environmental impacts is shown in Table XIV. The test statistic, 1.12, shows the hypothesis that ICM had no environmental impact cannot be rejected. Significance of this finding is uncertain. If the assumptions outlined in Chapter I hold, and the weaknesses of the EIQ outlined in Chapter II are discounted, then this finding indicates ICM did not affect environmental quality. The implications of this finding and alternative ways of examining the effects of ICM are discussed in Chapter V.

TABLE XV. ENVIRONMENTAL IMPACT OF ICM

	ICM - PRE-ICM
Difference (EIQ)	3.42
Standard Deviation of Difference	3.04
Test Statistic	1.12
Degrees of freedom	216

CHAPTER V

SUMMARY, CONCLUSIONS, SUGGESTIONS FOR FUTURE RESEARCH

Introduction

Each of the previous four chapters has contributed to the discussion contained in this chapter. Chapter I described the ICM program and the problems this research addressed. Chapter II explained the necessity of ICM, the history of ACP cost-share payments, attempts at resolving the appropriateness of cost-sharing of production practices, theoretically correct ways to analyze the impacts of ICM, and the attempts of other authors to analyze ICM. Chapter III described the methods used to analyze ICM, and Chapter IV described the results. This chapter summarizes those results and presents results that provide for more quantitative discussion, and provides suggestions for future research in economic/environmental analysis of Federal cost-share programs. Impacts discussed in this chapter are measured on a per acre basis. Environmental impacts are measured in EIQ. Economic impacts, revenue net of fertilizer and pesticide expenses, are measured in dollars. Methods used to calculate these values for each farm are discussed in chapter III. Due to reasons outlined in chapter IV, the results of comparisons of ICM and FCRS are not discussed in this chapter.

Summary

Summary of Chapter IV Findings

Tables XIV and XV, in chapter IV, show that ICM had a negative impact on revenue net of fertilizer and pesticide expense and no impact on environmental quality. Those results indicate that ICM was both ineffective at reducing the externalities of targeted producers, and detrimental to producers economically. If the methods are sound and the results accurate, then two conclusions could be reached. ICM was either ineffective or unnecessary with regard to encouraging producers to adopt nutrient and pesticide technologies that were environmentally sound, or ICM was not successful at increasing economic efficiency.

If producers were exerting a negative externality through nonpoint source pollution, ICM should have reduced that externality. A reduction in nonpoint source pollution would have resulted in a decreased environmental impact. However, there was no change in environmental impact. Thus, ICM did not have the effect of increasing environmental soundness on producers' fields. Alternatively, no change in environmental impact could indicate that producers were already using practices that minimized environmental impacts. In that case, ICM was not necessary.

An increase in economic efficiency would have resulted in an increase in revenue net of fertilizer and pesticide expenses, but there was a decrease in revenue net of fertilizer and pesticide expenses. Economically, producers were worse off. This indicates that ICM practices were less profitable than the conventional practices used on the ICM fields. Again, this suggests that ICM was not effective.

Summary of Field-Level Impacts

The methods outlined in chapter III are statistically reliable, but they limit qualitative discussion of the impacts on individual participants' fields. More qualitative discussion is needed due to the apparent ineffectiveness of the program. The number of producers experiencing differences in economic or environmental impacts were not discussed in chapter IV, and increased discussion of the effects of ICM on individual producers could provide insights into the reasons for the apparent ineffectiveness.

Graphs showing the economic (revenue net of fertilizer and pesticide costs) and environmental (EIQ) impacts for each of the 217 Nebraska corn growing participants provide a basis for discussion of those effects. In this section, economic and environmental impacts in both the pre-ICM and ICM periods are discussed. Then the differences attributed to ICM are discussed.

Figure IV shows the economic and environmental impacts of producers in the pre-ICM period. This figure has economic impact on the vertical axis and environmental impact on the horizontal axis. The relationship between economic and environmental impacts is not immediately obvious, but when a line is fitted to the data the relationship is shown to be negative. This line's slope is both negative and significant at the 99% confidence level. This figure shows that practices with lesser effects on the environment had greater levels of revenue net of fertilizer and pesticide costs, and practices with greater levels of environmental impact had lower levels of revenue net of fertilizer and pesticide costs. This is an unexpected relationship.

TABLE XV. LINES FITTED TO FIGURES IV, V AND VI.

Parameter	Pre-Icm	ICM	Difference
Intercept	359.70***	332.89**	-19.35***
Slope	-0.259***	-0.189***	-0.349***
R^2	0.05	0.02	.09

** 95% confidence level
***99% confidence level

FIGURE IV. PRE-ICM ECONOMIC AND ENVIRONMENTAL IMPACTS

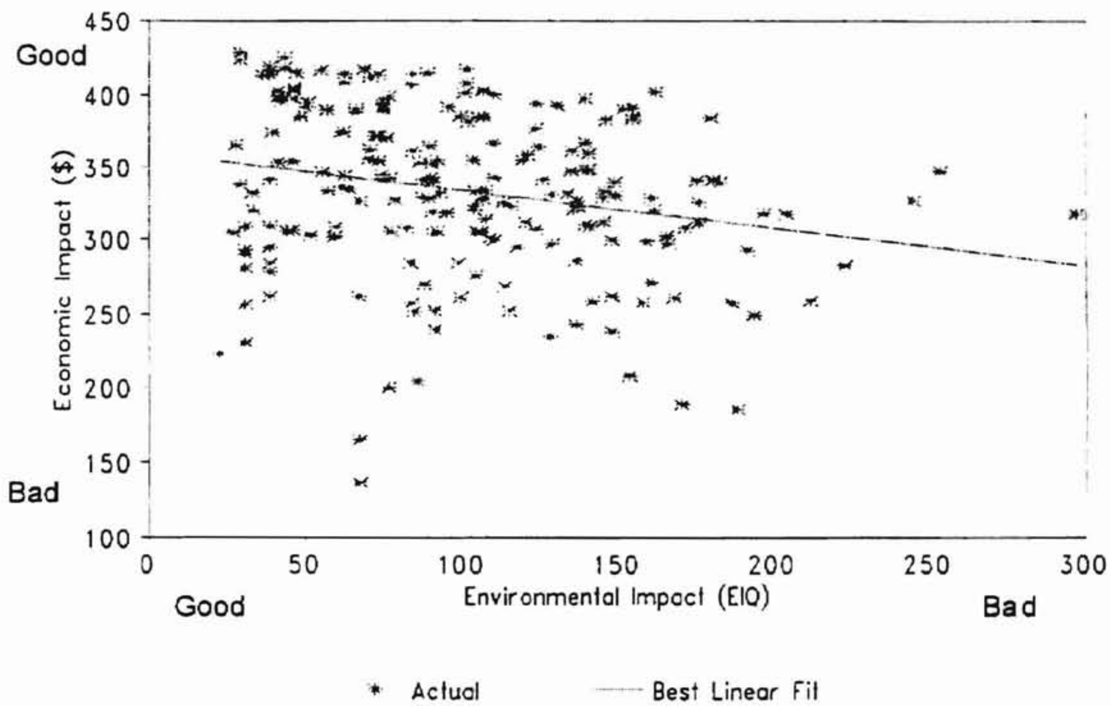


Figure V shows the economic and environmental impacts on ICM fields under ICM practices. Impacts of producers under ICM show greater variation than pre-ICM levels. The relationship shown in figure IV again emerges. ICM participants with greater levels of revenue net of fertilizer and pesticide expenses have lower levels of EIQ. However, the inverse relationship is not as strong as shown by the flatter slope in table XVI. Figure V suggests that producers using ICM practices had less of an income penalty for greater environmental impact. The differences between pre-ICM and ICM economic and environmental impacts are not readily obvious. Figure VI shows the differences.

FIGURE V. ICM ECONOMIC AND ENVIRONMENTAL IMPACTS

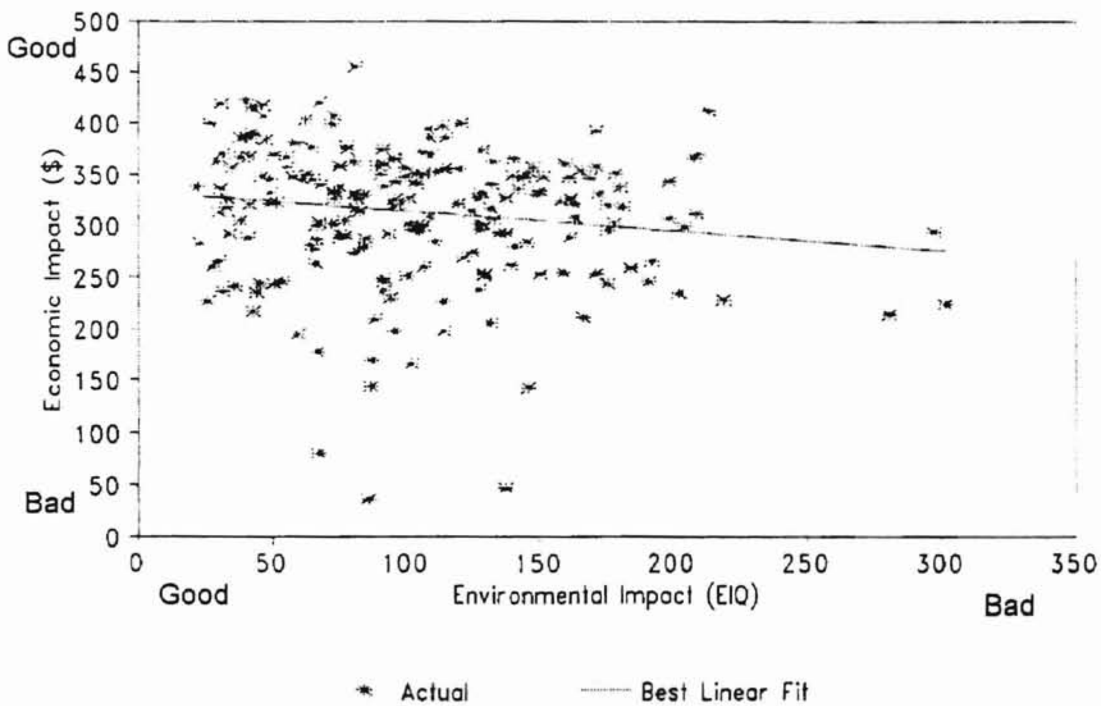
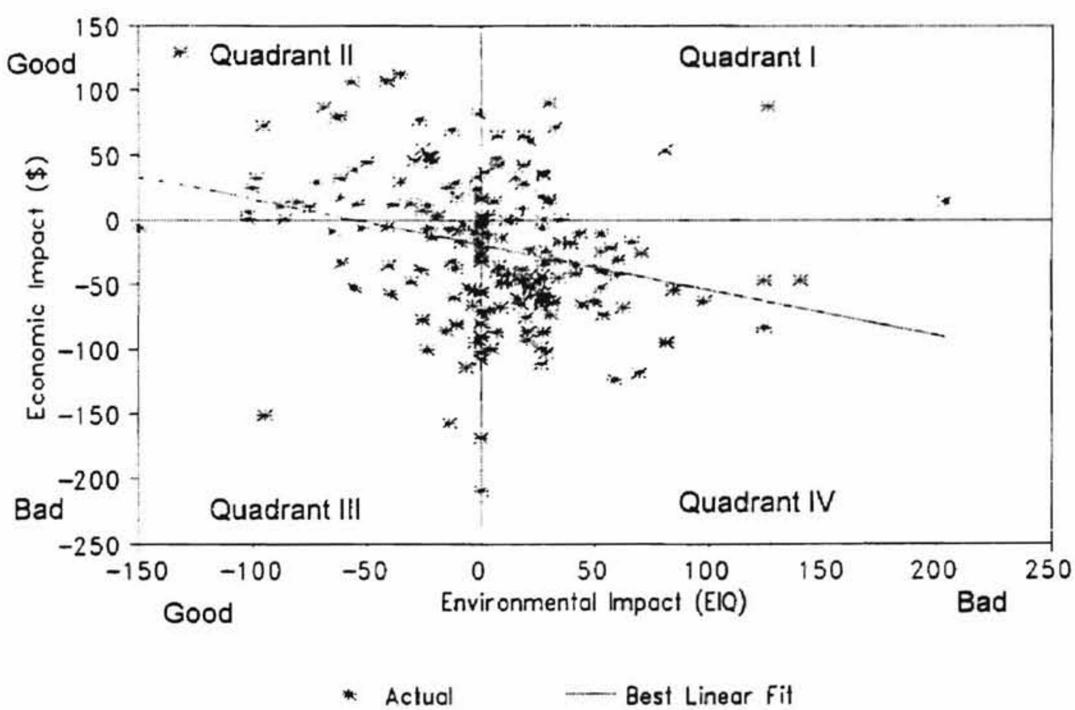


Figure VI shows the difference in economic and environmental impacts between pre-ICM and ICM practices. Table XVII lists the number and percentage of producers by their placement on this graph. Bad economic impact means lower revenue net of fertilizer and pesticide costs, and bad environmental impact means lower environmental quality (higher EIQ). Participants in quadrant IV make up the largest proportion (35%). This shows that, in the ICM year, producers had lower levels of revenue net of fertilizer and pesticide expense and greater environmental impacts. When all producers with negative environmental impacts are grouped, quadrants I and IV and those on the horizontal axis with no economic impact, 46% or nearly one half of all ICM participants are shown to have had a negative environmental impact on fields under ICM. When all producers with reduced levels of revenue net of fertilizer and pesticide costs are grouped, quadrants III and IV and those on the vertical axis with no environmental impact, 62% or well over half of all ICM participants are shown to have a negative impact on fields under ICM.

FIGURE VI. DIFFERENCE IN IMPACTS



Quadrant two contains participants experiencing both greater revenues net of fertilizer and pesticide costs and lower levels of environmental impact (16%). Figure VII and table XVII show that ICM resulted in a decreased environmental impact on only 28% of producers' fields under ICM.

TABLE XVI. IMPACTS OF ICM

Quadrant	Difference		Number	Percentage
	Economic	Environmental		
I	Good	Bad	19	9%
II	Good	Good	35	16%
III	Bad	Good	25	12%
IV	Bad	Bad	75	35%
Horizontal Axis	No Change	Good	6	3%
Horizontal Axis	No Change	Bad	4	2%
Vertical Axis	Good	No Change	8	3%
Vertical Axis	Bad	No Change	33	15%
Origin	No Change	No Change	12	5%

ICM reduced the environmental impacts of 66 (30%) producers, increased the environmental impacts of 98 (45%) producers, and had no effect on the environmental impact of 53 (24%). ICM increased the revenue net of fertilizer and pesticide costs of 62 (29%) producers, reduced the revenue net of fertilizer and pesticide costs of 133 (61%), and had no effect on the revenue net of fertilizer and pesticide costs of 22 (10%) producers.

Quadrants I and II contain producers who benefitted economically from ICM. ICM failed with regard to the 19 (9%) producers in quadrant I, profitability increased, but environmental impacts on these producers' fields also increased. ICM was successful with regard to the 35 (16%) producers in quadrant II, these producers experienced increased revenue net of fertilizer and pesticide costs and decreased environmental impact.

Summary

This analysis has shown that ICM had a negative impact on the level of revenue net of fertilizer and pesticide costs and no impact on the environmental quality on producers' fields under ICM. It has also shown that when the changes in individual producers' field level impacts are analyzed, a large proportion of producers had both negative impacts upon revenue net of fertilizer and pesticide costs and environmental quality. Thus, it has been shown in this thesis that ICM did not meet its goals in 1991 on a large proportion of Nebraska corn growers' fields.

These findings suggest that ICM was not effective as administered in 1991. They also suggest that with better targeting producers with higher levels of environmental impact could have been targeted and the program could have been more effective. As indicated by Figure IV, several producers had both high levels of revenue net of fertilizer and pesticide costs and low levels of environmental impact in the pre-ICM period. If those producers were not allowed to participate in ICM, the results would indicate that ICM was moderately successful.

As mentioned in Chapters I and III, an undetermined number of the producers participating in ICM in 1991 may have also participated in ICM in 1990. Producers who participated in 1990 could have provided data on their 1990 input levels on form ACP-313 (Figure III) in the pre-ICM section. If that were the case, then it would be expected that the change in pesticide and nutrient use levels would be insignificant. Alternatively, producers may have had to adjust input levels to compensate for the impacts of ICM participation in 1990. Either way, the inability to separately analyze producers who may have participated in ICM in 1990 from those who participated for the first time in 1991 may have had a profound impact on the accuracy of the results of this research.

Suggestions for Future Research

A shortcoming that has arisen in each analysis of ICM participants is a lack of data. Three types of data are not available: control group data, environmental data, and socioeconomic data. Without an adequate control group, there is no way to separate the effects of ICM from the independent effects of weather and pest pressure. Without adequate environmental data (soil type and field slope and length) for ICM fields, analysis of environmental impacts of ICM is limited. And without socioeconomic data, factors influencing adoption of ICM participants cannot be analyzed. The following sections addresses each of these data concerns.

Control Group Data

Dicks et al. compared ICM participants' yield levels to county averages, but the usefulness of the results were somewhat limited. Osborn et al. used the OYS data set as a control group for input use and yield level comparisons, but that was only marginally adequate. This research used the FCRS budgets for costs and returns level comparisons, but they were inadequate. All three analyses used pre-ICM to ICM comparisons. However, as discussed in Chapter III, year to year variability can invalidate these results.

Optimum control group data would come from fields adjacent to ICM fields producing the same crops produced in the ICM fields in the same year. Those fields would have identical weather conditions and pest pressures as ICM fields, and allow the effects of ICM practices to be analyzed. Data needed from adjacent fields includes: input levels, yield, practices, environmental data, and socioeconomic data.

Environmental Data

ICM producers were not asked to provide environmental data. Data on soil type, field size, slope, and length, and cropping practices would be desirable. With that data, more accurate measures of environmental impact could be used. Data on practices used by the control group mentioned in the previous section would enhance the analysis considerably. With data provided on the specific ICM practices applied to ICM fields, a comparison of the environmental impacts of various practices could be better estimated.

The environmental impact measure used for this analysis did not consider nutrient application levels. In addition to that discrepancy, Dushoff et al. found several problems with the EIQ as a measure of environmental impact. The shortcomings of EIQ were overlooked for the purposes of this analysis due to the data limitations. Increased data on the environmental characteristics of ICM fields would allow comparison of the results with various alternative environmental impact measures.

Socioeconomic Data

Traditionally, technology adoption impact studies have included analysis of the socioeconomic characteristics of producers adopting the technologies. However, no socioeconomic data on ICM participants were available. ICM cost-sharing is only available to producers with farms in the areas mentioned in Chapter I, but not every producer who is eligible needs to participate. The results discussed at the beginning of this chapter emphasize that. With socioeconomic data on participants in both ICM and the control group, both the factors influencing adoption and the characteristics of participants could be determined. Without that data, no discussions of factors leading to adoption of ICM practices can be expressed. Desirable socioeconomic data on participants would include at the minimum: age, sex, tenure, education, exposure to university extension programs, debt to asset ratio, and farm size. These data would allow better targeting of program funds.

Implications for the Future of the ICM Program

Integrated Crop Management has admirable goals, and as far as ACP programs go, it was well targeted. However, for it to achieve its goals consistently, it must be even more targeted. The methods used in this analysis were not complex, and they did not take into account the total impacts of ICM. But the results were conclusive. ICM had a negative economic impact and no environmental impact on producers' fields.

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APPENDIX I. FERTILIZER COSTS

COUNTY	ICM ACRES	PRE-ICM COST ($/ACRE)	ICM COST ($/ACRE)	COST DIFFERENCE ($/ACRE)
ADAMS	145	23.42	21.77	-1.65
ADAMS	36	24.80	19.46	-5.33
ADAMS	118	38.83	14.18	-24.70
ADAMS	43	18.91	19.01	0.11
ANTELOPE	116	24.20	27.19	2.99
ANTELOPE	115	28.15	20.67	-7.49
ANTELOPE	560	19.29	25.08	5.79
ANTELOPE	130	23.23	20.52	-2.71
ANTELOPE	185	21.62	20.86	-0.76
ANTELOPE	441	25.35	25.45	0.10
ANTELOPE	129	18.54	42.70	24.16
ANTELOPE	68	23.30	40.13	16.84
ANTELOPE	260	22.63	28.68	6.05
ANTELOPE	67	26.44	30.45	4.02
ANTELOPE	130	16.85	19.54	2.69
ANTELOPE	130	12.64	13.93	1.30
BUFFALO	105	32.42	34.44	2.02
BUFFALO	39	20.16	12.60	-7.56
BUFFALO	241	26.94	28.60	1.66
BUFFALO	77	20.04	21.15	1.11
BUFFALO	90	26.96	28.68	1.71
BUFFALO	63	32.78	34.75	1.97
BUFFALO	140	23.88	25.37	1.49
BUFFALO	40	23.91	25.40	1.49
BUFFALO	68	22.70	24.12	1.42
BUFFALO	119	25.31	26.76	1.46
BUFFALO	70	20.16	21.46	1.30
BUFFALO	118	17.40	18.48	1.08
BUFFALO	200	32.37	32.03	-0.34
BUFFALO	97	21.26	22.61	1.34
BUFFALO	301	24.96	26.49	1.53
BUFFALO	541	20.20	21.47	1.28
BUFFALO	269	25.25	26.81	1.56
BUFFALO	115	24.52	26.10	1.57

APPENDIX I. FERTILIZER COSTS (Continued)

COUNTY	ICM ACRES	PRE-ICM COST ($/ACRE)	ICM COST ($/ACRE)	COST DIFFERENCE ($/ACRE)
BUFFALO	93	29.95	32.00	2.04
BUFFALO	46	24.52	26.04	1.52
BUFFALO	214	20.54	21.83	1.29
BUFFALO	104	17.45	17.28	-0.17
BUFFALO	502	15.51	16.50	0.99
BUFFALO	510	15.76	16.69	0.93
BUFFALO	127	29.37	31.16	1.79
BUFFALO	138	24.97	17.07	-7.89
BUFFALO	101	19.87	21.05	1.18
BUFFALO	173	28.76	30.52	1.76
BUFFALO	492	24.62	26.15	1.53
BUFFALO	49	14.00	14.85	0.86
BUFFALO	285	12.62	13.36	0.74
BUFFALO	68	25.73	27.32	1.59
BUFFALO	104	30.31	27.84	-2.46
BUFFALO	187	28.16	29.88	1.72
BUFFALO	402	12.28	12.15	-0.13
BUFFALO	72	25.09	19.64	-5.45
BUFFALO	201	18.37	19.44	1.07
BUFFALO	126	26.94	27.27	0.33
BUFFALO	67	24.52	26.04	1.52
BUFFALO	84	28.76	30.52	1.76
BUFFALO	220	25.84	27.43	1.59
BUFFALO	59	22.09	23.48	1.39
BUFFALO	58	27.37	29.13	1.77
BUFFALO	99	22.09	23.48	1.39
BUFFALO	82	22.78	24.12	1.33
BUFFALO	137	20.02	21.29	1.27
BUFFALO	139	20.02	21.29	1.27
BUFFALO	67	15.94	16.98	1.05
BUFFALO	78	33.01	35.00	1.99
BUFFALO	153	24.37	25.85	1.48
BUFFALO	109	28.47	30.27	1.80
BUFFALO	72	16.34	17.41	1.07

APPENDIX I. FERTILIZER COSTS (Continued)

COUNTY	ICM ACRES	PRE-ICM COST ($/ACRE)	ICM COST ($/ACRE)	COST DIFFERENCE ($/ACRE)
BUFFALO	150	29.85	31.67	1.82
BUFFALO	84	16.15	17.14	0.99
CHEYENNE	65	51.93	54.80	2.87
CLAY	128	26.09	27.53	1.44
FILLMORE	142	25.87	23.10	-2.77
GAGE	58	19.40	19.22	-0.19
HALL	217	39.35	16.46	-22.90
HALL	205	17.39	19.60	2.21
HALL	113	25.26	25.26	0.00
HALL	129	21.84	36.86	15.02
HALL	210	21.73	22.30	0.57
HALL	184	37.40	21.86	-15.50
HALL	67	35.03	21.76	-13.30
HALL	75	24.15	20.71	-3.44
HALL	62	30.50	31.69	1.19
HALL	464	17.18	21.99	4.81
HALL	810	33.96	18.41	-15.60
HALL	143	41.04	31.39	-9.66
HALL	45	22.94	22.40	-0.54
HALL	37	29.25	18.90	-10.40
HALL	50	33.61	22.40	-11.20
HALL	52	18.93	17.98	-0.95
HALL	202	37.52	31.02	-6.50
HALL	117	36.36	24.38	-12.00
HALL	237	23.34	23.65	0.30
HALL	74	26.13	26.57	0.44
HALL	69	27.94	29.04	1.10
HALL	72	27.82	23.54	-4.28
HALL	140	14.56	27.64	13.08
HALL	116	29.72	36.57	6.85
HALL	134	27.70	28.53	0.83
HALL	72	27.34	31.22	3.88
HALL	68	23.46	17.18	-6.28
HALL	117	25.08	27.97	2.90

APPENDIX I. FERTILIZER COSTS (Continued)

COUNTY	ICM ACRES	PRE-ICM COST ($/ACRE)	ICM COST ($/ACRE)	COST DIFFERENCE ($/ACRE)
HALL	50	23.05	21.13	-1.93
HALL	79	16.39	27.55	11.15
HALL	133	20.16	35.24	15.08
HALL	75	31.11	25.56	-5.55
HALL	104	25.97	21.62	-4.36
HALL	90	21.12	21.61	0.49
HALL	75	25.20	28.15	2.94
HALL	341	27.94	28.57	0.63
HALL	183	32.95	31.62	-1.33
HALL	153	41.04	32.67	-8.37
HALL	620	19.42	30.56	11.14
HALL	185	33.90	9.79	-24.10
HALL	533	25.48	22.87	-2.61
HALL	42	30.22	25.60	-4.62
HALL	153	35.21	32.67	-2.55
HALL	67	12.13	21.20	9.07
HALL	107	28.15	35.92	7.77
HALL	342	31.84	28.02	-3.82
HALL	72	14.56	20.46	5.90
HALL	160	15.04	30.78	15.75
HALL	195	16.02	36.57	20.55
HALL	140	31.42	36.05	4.64
HALL	178	20.58	22.18	1.60
HALL	80	26.61	24.32	-2.29
HAMILTON	108	19.41	17.00	-2.41
HAMILTON	226	23.34	28.47	5.13
HARLAN	40	25.48	26.89	1.41
KEARNEY	120	23.77	25.19	1.42
KEARNEY	211	19.29	25.91	6.62
KNOX	67	21.68	21.05	-0.63
KNOX	120	9.10	8.00	-1.10
KNOX	66	19.77	15.52	-4.26
KNOX	119	0.00	10.24	10.24
KNOX	271	17.41	18.42	1.01

APPENDIX I. FERTILIZER COSTS (Continued)

COUNTY	ICM ACRES	PRE-ICM COST ($/ACRE)	ICM COST ($/ACRE)	COST DIFFERENCE ($/ACRE)
KNOX	90	19.80	5.13	-14.70
MERRICK	171	23.56	18.79	-4.76
MERRICK	132	17.59	25.58	7.98
MERRICK	22	33.22	17.63	-15.60
MERRICK	193	30.60	22.06	-8.53
MERRICK	38	31.74	21.12	-10.60
MERRICK	83	36.22	11.78	-24.40
MERRICK	127	31.48	27.88	-3.60
MERRICK	128	35.62	25.22	-10.40
MERRICK	44	32.13	25.19	-6.93
MERRICK	153	23.62	22.74	-0.89
MERRICK	65	23.84	17.28	-6.56
MERRICK	62	33.61	20.48	-13.10
MERRICK	118	23.56	15.05	-8.50
MERRICK	55	23.05	23.99	0.93
MERRICK	84	27.64	24.49	-3.14
MERRICK	73	28.09	23.68	-4.41
MERRICK	149	31.22	27.82	-3.39
MERRICK	120	36.67	27.08	-9.58
NANCE	256	33.95	45.66	11.71
NANCE	259	36.66	52.36	15.70
NANCE	98	24.14	30.87	6.73
NANCE	115	30.96	51.34	20.38
NANCE	311	17.21	47.57	30.36
NUCKOLLS	83	15.67	16.32	0.66
NUCKOLLS	139	10.45	10.79	0.34
NUCKOLLS	139	5.47	25.09	19.62
NUCKOLLS	92	12.24	12.91	0.68
NUCKOLLS	80	1.21	1.28	0.07
NUCKOLLS	193	25.44	26.89	1.44
NUCKOLLS	64	8.49	8.96	0.47
NUCKOLLS	72	13.56	14.31	0.75
NUCKOLLS	185	18.94	13.88	-5.05
NUCKOLLS	61	17.71	18.38	0.66

APPENDIX I. FERTILIZER COSTS (Continued)

COUNTY	ICM ACRES	PRE-ICM COST ($/ACRE)	ICM COST ($/ACRE)	COST DIFFERENCE ($/ACRE)
NUCKOLLS	33	14.93	13.65	-1.28
NUCKOLLS	88	17.40	17.61	0.21
NUCKOLLS	98	12.34	13.02	0.68
NUCKOLLS	112	16.38	17.36	0.98
NUCKOLLS	238	25.88	28.06	2.18
NUCKOLLS	33	7.28	7.68	0.40
NUCKOLLS	96	16.61	19.71	3.11
NUCKOLLS	63	15.03	15.92	0.89
NUCKOLLS	490	19.42	21.82	2.41
NUCKOLLS	44	14.63	13.13	-1.50
NUCKOLLS	200	16.19	18.25	2.06
NUCKOLLS	40	14.57	14.46	-0.11
NUCKOLLS	94	17.36	18.36	1.00
NUCKOLLS	20	13.88	14.69	0.80
NUCKOLLS	19	12.24	10.50	-1.74
NUCKOLLS	45	12.44	12.60	0.16
NUCKOLLS	270	12.77	13.77	1.00
NUCKOLLS	253	4.38	4.31	-0.07
NUCKOLLS	110	12.44	13.13	0.69
NUCKOLLS	42	4.98	4.04	-0.94
NUCKOLLS	52	18.94	16.59	-2.35
NUCKOLLS	33	13.93	20.07	6.14
PHELPS	79	21.84	23.05	1.21
PHELPS	44	23.51	25.03	1.52
PIERCE	130	23.05	27.27	4.22
PIERCE	161	18.64	19.75	1.12
PIERCE	120	21.41	22.68	1.27
PIERCE	263	8.69	9.77	1.08
PIERCE	187	30.06	33.27	3.21
PIERCE	172	25.07	26.58	1.51
PIERCE	130	18.13	22.01	3.88
PIERCE	65	33.51	35.47	1.97
PIERCE	40	34.20	30.70	-3.50
PIERCE	73	21.41	22.64	1.23

APPENDIX I. FERTILIZER COSTS (Continued)

COUNTY	ICM ACRES	PRE-ICM COST ($/ACRE)	ICM COST ($/ACRE)	COST DIFFERENCE ($/ACRE)
PIERCE	33	13.66	16.92	3.25
PIERCE	130	15.79	16.79	1.00
PIERCE	35	0.40	4.70	4.30
SALINE	157	17.91	22.61	4.70
SALINE	132	35.37	37.08	1.71
SALINE	53	27.86	28.94	1.08
SALINE	62	24.57	23.97	-0.59
SEWARD	50	20.87	21.51	0.64
SEWARD	204	23.08	16.12	-6.97
THAYER	347	30.14	32.04	1.91
THAYER	209	18.63	21.63	2.99
YORK	75	17.57	19.59	2.01
YORK	230	23.00	24.34	1.34

APPENDIX II. PESTICIDE COSTS

COUNTY	ICM ACRES	PRE-ICM COST ($/ACRE)	ICM COST ($/ACRE)	COST DIFFERENCE ($/ACRE)
ADAMS	145	31.63	35.68	4.05
ADAMS	36	48.87	43.78	-5.09
ADAMS	118	43.12	43.12	0.00
ADAMS	43	27.25	11.35	-15.90
ANTELOPE	116	19.80	44.91	25.11
ANTELOPE	115	19.93	41.33	21.41
ANTELOPE	560	51.28	50.03	-1.25
ANTELOPE	130	38.57	38.57	0.00
ANTELOPE	185	16.75	21.10	4.35
ANTELOPE	441	15.12	19.29	4.17
ANTELOPE	129	13.84	26.68	12.85
ANTELOPE	68	10.45	10.45	0.00
ANTELOPE	260	17.05	17.05	0.00
ANTELOPE	67	18.67	40.54	21.87
ANTELOPE	130	36.28	34.63	-1.65
ANTELOPE	130	38.57	38.57	0.00
BUFFALO	105	10.17	28.51	18.35
BUFFALO	39	27.88	28.75	0.87
BUFFALO	241	5.72	14.90	9.17
BUFFALO	77	49.91	49.91	0.00
BUFFALO	90	10.17	19.34	9.17
BUFFALO	63	22.88	32.05	9.17
BUFFALO	140	15.08	35.90	20.82
BUFFALO	40	20.05	69.45	49.40
BUFFALO	68	20.05	69.45	49.40
BUFFALO	119	23.02	32.19	9.17
BUFFALO	70	20.05	60.28	40.23
BUFFALO	118	20.05	27.90	7.85
BUFFALO	200	28.00	28.00	0.00
BUFFALO	97	20.90	32.71	11.81
BUFFALO	301	33.20	36.26	3.06
BUFFALO	541	18.72	18.72	0.00
BUFFALO	269	40.98	62.66	21.68
BUFFALO	115	38.99	38.33	-0.66

APPENDIX II. PESTICIDE COSTS (Continued)

COUNTY	ICM ACRES	PRE-ICM COST ($/ACRE)	ICM COST ($/ACRE)	COST DIFFERENCE ($/ACRE)
BUFFALO	93	17.65	35.99	18.34
BUFFALO	46	6.59	20.40	13.81
BUFFALO	214	26.73	26.73	0.00
BUFFALO	104	29.05	50.74	21.69
BUFFALO	502	43.40	26.90	-16.50
BUFFALO	510	32.86	31.36	-1.49
BUFFALO	127	43.47	52.64	9.17
BUFFALO	138	18.31	27.48	9.17
BUFFALO	101	16.43	5.02	-11.40
BUFFALO	173	12.96	34.33	21.38
BUFFALO	492	17.65	34.59	16.94
BUFFALO	49	16.43	13.38	-3.06
BUFFALO	285	16.43	16.43	0.00
BUFFALO	68	33.30	42.47	9.17
BUFFALO	104	10.13	24.80	14.67
BUFFALO	187	12.11	35.95	23.85
BUFFALO	402	18.95	13.92	-5.02
BUFFALO	72	25.92	27.93	2.01
BUFFALO	201	26.18	26.18	0.00
BUFFALO	126	43.69	80.21	36.51
BUFFALO	67	30.38	30.56	0.18
BUFFALO	84	12.96	22.13	9.17
BUFFALO	220	11.97	11.97	0.00
BUFFALO	59	43.47	61.81	18.35
BUFFALO	58	29.86	8.28	-21.60
BUFFALO	99	5.72	14.90	9.17
BUFFALO	82	44.72	47.77	3.06
BUFFALO	137	17.68	11.76	-5.92
BUFFALO	139	17.68	25.32	7.64
BUFFALO	67	18.95	18.95	0.00
BUFFALO	78	40.64	55.31	14.67
BUFFALO	153	18.76	33.30	14.54
BUFFALO	109	16.00	24.84	8.84
BUFFALO	72	17.68	17.68	0.00

APPENDIX II. PESTICIDE COSTS (Continued)

COUNTY	ICM ACRES	PRE-ICM COST ($/ACRE)	ICM COST ($/ACRE)	COST DIFFERENCE ($/ACRE)
BUFFALO	150	26.02	26.02	0.00
BUFFALO	84	23.02	36.97	13.96
CHEYENNE	65	8.05	20.23	12.18
CLAY	128	10.60	8.48	-2.12
FILLMORE	142	10.99	10.96	-0.03
GAGE	58	25.16	48.70	23.54
HALL	217	18.53	15.00	-3.53
HALL	205	46.73	40.00	-6.73
HALL	113	31.47	29.15	-2.33
HALL	129	23.30	11.46	-11.80
HALL	210	43.26	34.91	-8.34
HALL	184	33.64	6.25	-27.40
HALL	67	45.32	44.77	-0.55
HALL	75	9.90	19.13	9.23
HALL	62	10.99	23.45	12.46
HALL	464	14.92	21.81	6.89
HALL	810	20.96	11.77	-9.19
HALL	143	26.75	5.94	-20.80
HALL	45	9.90	19.46	9.56
HALL	37	18.94	16.44	-2.49
HALL	50	59.11	26.93	-32.20
HALL	52	11.88	48.58	36.70
HALL	202	23.52	48.58	25.07
HALL	117	12.91	21.00	8.09
HALL	237	30.93	25.28	-5.65
HALL	74	47.56	17.80	-29.80
HALL	69	7.92	14.94	7.02
HALL	72	7.92	14.94	7.02
HALL	140	27.79	21.15	-6.64
HALL	116	24.17	19.58	-4.59
HALL	134	7.92	26.99	19.07
HALL	72	7.92	29.63	21.71
HALL	68	36.54	31.66	-4.88
HALL	117	7.92	3.66	-4.26

APPENDIX II. PESTICIDE COSTS (Continued)

COUNTY	ICM ACRES	PRE-ICM COST ($/ACRE)	ICM COST ($/ACRE)	COST DIFFERENCE ($/ACRE)
HALL	50	26.88	18.19	-8.68
HALL	79	42.29	33.37	-8.92
HALL	133	27.79	53.16	25.37
HALL	75	30.66	39.64	8.98
HALL	104	24.29	7.64	-16.60
HALL	90	44.57	7.64	-36.90
HALL	75	7.92	8.82	0.90
HALL	341	7.92	26.81	18.89
HALL	183	23.76	9.90	-13.90
HALL	153	25.86	3.66	-22.20
HALL	620	6.59	9.16	2.57
HALL	185	56.86	32.89	-24.00
HALL	533	23.78	12.21	-11.60
HALL	42	9.90	20.31	10.41
HALL	153	15.84	9.90	-5.94
HALL	67	18.94	10.19	-8.75
HALL	107	24.47	11.46	-13.00
HALL	342	9.90	7.19	-2.71
HALL	72	18.94	8.15	-10.80
HALL	160	40.59	21.37	-19.20
HALL	195	27.88	33.67	5.79
HALL	140	34.05	27.57	-6.49
HALL	178	11.81	17.93	6.12
HALL	80	46.81	41.81	-5.00
HAMILTON	108	17.29	23.25	5.95
HAMILTON	226	32.63	31.98	-0.65
HARLAN	40	46.34	34.61	-11.70
KEARNEY	120	20.44	20.44	0.00
KEARNEY	211	17.07	15.23	-1.84
KNOX	67	19.66	18.79	-0.87
KNOX	120	23.87	23.87	0.00
KNOX	66	7.91	11.51	3.61
KNOX	119	44.29	25.64	-18.70
KNOX	271	26.55	16.66	-9.89

APPENDIX II. PESTICIDE COSTS (Continued)

COUNTY	ICM ACRES	PRE-ICM COST ($/ACRE)	ICM COST ($/ACRE)	COST DIFFERENCE ($/ACRE)
KNOX	90	25.25	41.11	15.85
MERRICK	171	15.56	20.41	4.85
MERRICK	132	38.30	56.12	17.82
MERRICK	22	28.11	31.01	2.89
MERRICK	193	25.57	33.20	7.63
MERRICK	38	45.32	44.77	-0.55
MERRICK	83	45.32	37.64	-7.68
MERRICK	127	63.94	29.80	-34.10
MERRICK	128	59.72	38.05	-21.70
MERRICK	44	14.61	55.77	41.16
MERRICK	153	32.03	22.06	-9.97
MERRICK	65	39.62	23.78	-15.80
MERRICK	62	60.60	39.73	-20.90
MERRICK	118	11.63	15.95	4.32
MERRICK	55	23.21	22.92	-0.29
MERRICK	84	42.56	18.25	-24.30
MERRICK	73	43.23	23.78	-19.40
MERRICK	149	20.41	31.16	10.75
MERRICK	120	25.77	35.46	9.68
NANCE	256	12.58	16.92	4.33
NANCE	259	8.32	15.75	7.43
NANCE	98	13.63	21.83	8.20
NANCE	115	6.72	12.12	5.40
NANCE	311	21.92	36.83	14.91
NUCKOLLS	83	27.20	36.46	9.26
NUCKOLLS	139	22.49	21.13	-1.36
NUCKOLLS	139	39.14	46.89	7.75
NUCKOLLS	92	34.24	34.53	0.29
NUCKOLLS	80	22.18	22.18	0.00
NUCKOLLS	193	20.61	33.31	12.71
NUCKOLLS	64	48.07	60.41	12.34
NUCKOLLS	72	53.25	52.28	-0.97
NUCKOLLS	185	43.68	34.60	-9.07
NUCKOLLS	61	24.11	24.11	0.00

APPENDIX II. PESTICIDE COSTS (Continued)

COUNTY	ICM ACRES	PRE-ICM COST ($/ACRE)	ICM COST ($/ACRE)	COST DIFFERENCE ($/ACRE)
NUCKOLLS	33	25.13	27.13	2.00
NUCKOLLS	88	4.07	24.04	19.97
NUCKOLLS	98	6.37	16.35	9.97
NUCKOLLS	112	32.38	33.73	1.35
NUCKOLLS	238	8.91	8.91	0.00
NUCKOLLS	33	25.11	35.11	10.00
NUCKOLLS	96	48.34	73.16	24.82
NUCKOLLS	63	60.39	64.80	4.41
NUCKOLLS	490	36.74	39.78	3.04
NUCKOLLS	44	39.96	50.74	10.78
NUCKOLLS	200	32.76	34.03	1.27
NUCKOLLS	40	8.14	8.28	0.14
NUCKOLLS	94	17.35	26.34	8.99
NUCKOLLS	20	19.94	21.68	1.73
NUCKOLLS	19	22.31	22.44	0.14
NUCKOLLS	45	8.14	8.28	0.14
NUCKOLLS	270	12.44	14.92	2.48
NUCKOLLS	253	31.13	31.13	0.00
NUCKOLLS	110	26.05	37.35	11.30
NUCKOLLS	42	18.11	18.11	0.00
NUCKOLLS	52	54.20	40.45	-13.80
NUCKOLLS	33	9.90	6.00	-3.90
PHELPS	79	32.27	25.14	-7.13
PHELPS	44	18.11	17.22	-0.89
PIERCE	130	12.95	12.95	0.00
PIERCE	161	30.04	30.04	0.00
PIERCE	120	16.81	18.12	1.31
PIERCE	263	46.51	40.53	-5.98
PIERCE	187	41.84	43.72	1.88
PIERCE	172	22.93	22.93	0.00
PIERCE	130	32.30	23.13	-9.17
PIERCE	65	33.54	33.54	0.00
PIERCE	40	47.73	47.73	0.00
PIERCE	73	16.81	9.97	-6.84

APPENDIX II. PESTICIDE COSTS (Continued)

COUNTY	ICM ACRES	PRE-ICM COST ($/ACRE)	ICM COST ($/ACRE)	COST DIFFERENCE ($/ACRE)
PIERCE	33	32.59	32.59	0.00
PIERCE	130	41.25	41.25	0.00
PIERCE	35	32.59	32.59	0.00
SALINE	157	29.35	32.53	3.17
SALINE	132	73.80	73.10	-0.70
SALINE	53	5.60	23.53	17.93
SALINE	62	20.24	28.86	8.62
SEWARD	50	60.75	62.67	1.92
SEWARD	204	30.97	24.23	-6.74
THAYER	347	40.45	35.40	-5.04
THAYER	209	42.79	37.84	-4.95
YORK	75	24.26	46.25	21.99
YORK	230	28.76	55.09	26.32

APPENDIX III. REVENUE

COUNTY	ICM ACRES	PRE-ICM IMPACT ($/ACRE)	ICM IMPACT ($/ACRE)	IMPACT DIFFERENCE ($/ACRE)
ADAMS	145	305.20	313.50	8.34
ADAMS	36	339.00	326.10	-13.00
ADAMS	118	328.50	345.70	17.29
ADAMS	43	284.40	391.00	106.60
ANTELOPE	116	200.00	214.10	14.19
ANTELOPE	115	271.10	224.20	-46.90
ANTELOPE	560	317.70	264.90	-52.80
ANTELOPE	130	348.60	364.60	15.96
ANTELOPE	185	262.10	168.80	-93.30
ANTELOPE	441	334.50	274.10	-60.40
ANTELOPE	129	355.20	319.90	-35.30
ANTELOPE	68	353.90	347.90	-5.98
ANTELOPE	260	302.30	194.10	-108.00
ANTELOPE	67	342.50	288.50	-54.00
ANTELOPE	130	311.70	197.70	-114.00
ANTELOPE	130	359.20	279.50	-79.60
BUFFALO	105	413.40	374.40	-39.00
BUFFALO	39	362.40	313.60	-48.80
BUFFALO	241	423.30	357.30	-66.10
BUFFALO	77	340.40	320.50	-19.90
BUFFALO	90	418.90	375.60	-43.20
BUFFALO	63	400.30	301.90	-98.50
BUFFALO	140	417.00	373.80	-43.20
BUFFALO	40	389.20	342.50	-46.70
BUFFALO	68	390.50	307.20	-83.30
BUFFALO	119	407.70	296.00	-112.00
BUFFALO	70	393.00	330.50	-62.50
BUFFALO	118	395.80	342.90	-52.80
BUFFALO	200	353.80	325.80	-28.00
BUFFALO	97	413.80	355.00	-58.90
BUFFALO	301	340.80	292.20	-48.60
BUFFALO	541	394.30	367.80	-26.50
BUFFALO	269	389.80	368.90	-20.90
BUFFALO	115	346.90	339.20	-7.64

APPENDIX III. REVENUE (Continued)

COUNTY	ICM ACRES	PRE-ICM IMPACT ($/ACRE)	ICM IMPACT ($/ACRE)	IMPACT DIFFERENCE ($/ACRE)
BUFFALO	93	408.40	355.70	-52.70
BUFFALO	46	424.90	349.70	-75.20
BUFFALO	214	351.70	349.90	-1.83
BUFFALO	104	331.90	306.70	-25.20
BUFFALO	502	374.30	422.60	48.32
BUFFALO	510	384.60	417.60	33.04
BUFFALO	127	383.20	319.20	-63.90
BUFFALO	138	412.70	355.70	-57.00
BUFFALO	101	396.90	399.80	2.93
BUFFALO	173	414.30	397.70	-16.50
BUFFALO	492	413.70	351.50	-62.30
BUFFALO	49	402.80	385.60	-17.20
BUFFALO	285	404.10	407.20	3.04
BUFFALO	68	397.00	353.90	-43.10
BUFFALO	104	415.60	398.50	-17.10
BUFFALO	187	415.70	385.30	-30.40
BUFFALO	402	402.00	419.80	17.79
BUFFALO	72	389.00	403.60	14.61
BUFFALO	201	320.30	300.20	-20.10
BUFFALO	126	385.40	311.60	-73.80
BUFFALO	67	401.10	321.30	-79.90
BUFFALO	84	414.30	407.60	-6.64
BUFFALO	220	418.20	413.70	-4.47
BUFFALO	59	390.40	365.80	-24.60
BUFFALO	58	319.00	356.50	37.49
BUFFALO	99	428.20	367.00	-61.20
BUFFALO	82	377.10	363.20	-13.90
BUFFALO	137	395.50	363.10	-32.40
BUFFALO	139	395.50	335.80	-59.70
BUFFALO	67	398.30	367.10	-31.20
BUFFALO	78	382.40	337.90	-44.40
BUFFALO	153	412.90	377.70	-35.10
BUFFALO	109	411.50	364.40	-47.10
BUFFALO	72	399.20	416.00	16.86

APPENDIX III. REVENUE (Continued)

COUNTY	ICM ACRES	PRE-ICM IMPACT ($/ACRE)	ICM IMPACT ($/ACRE)	IMPACT DIFFERENCE ($/ACRE)
BUFFALO	150	354.50	343.10	-11.50
BUFFALO	84	416.80	351.50	-65.40
CHEYENNE	65	304.80	305.10	0.29
CLAY	128	373.70	370.20	-3.48
FILLMORE	142	327.90	229.30	-98.60
GAGE	58	251.80	252.70	0.85
HALL	217	329.70	357.80	28.12
HALL	205	312.10	357.60	45.55
HALL	113	342.30	366.30	24.05
HALL	129	342.50	386.80	44.32
HALL	210	258.90	371.00	112.00
HALL	184	391.80	241.00	-151.00
HALL	67	261.70	295.30	33.64
HALL	75	262.30	280.80	18.42
HALL	62	364.40	357.10	-7.29
HALL	464	380.50	373.20	-7.23
HALL	810	366.90	380.80	13.92
HALL	143	251.40	283.30	31.86
HALL	45	309.20	345.20	35.99
HALL	37	339.40	331.10	-8.35
HALL	50	249.30	259.80	10.54
HALL	52	306.60	393.70	87.10
HALL	202	304.10	357.80	53.70
HALL	117	343.70	359.50	15.80
HALL	237	325.30	277.90	-47.40
HALL	74	261.50	333.50	72.01
HALL	69	281.10	345.30	64.26
HALL	72	290.30	332.50	42.21
HALL	140	328.00	351.10	23.13
HALL	116	276.70	383.50	106.80
HALL	134	281.30	317.80	36.45
HALL	72	256.60	216.20	-40.30
HALL	68	331.90	400.00	68.07
HALL	117	230.60	311.90	81.29

APPENDIX III. REVENUE (Continued)

COUNTY	ICM ACRES	PRE-ICM IMPACT ($/ACRE)	ICM IMPACT ($/ACRE)	IMPACT DIFFERENCE ($/ACRE)
HALL	50	269.30	345.40	76.13
HALL	79	328.90	294.00	-34.90
HALL	133	305.50	305.50	0.03
HALL	75	282.50	360.70	78.22
HALL	104	257.50	337.10	79.60
HALL	90	207.90	337.10	129.20
HALL	75	308.90	235.50	-73.30
HALL	341	293.30	320.80	27.45
HALL	183	354.30	366.70	12.34
HALL	153	234.10	265.90	31.89
HALL	620	337.40	326.00	-11.50
HALL	185	257.20	204.90	-52.30
HALL	533	305.90	347.50	41.60
HALL	42	295.00	263.20	-31.80
HALL	153	336.50	385.70	49.12
HALL	67	242.50	243.40	0.88
HALL	107	300.80	387.70	86.95
HALL	342	371.60	384.90	13.25
HALL	72	285.70	292.00	6.29
HALL	160	310.40	339.20	28.77
HALL	195	284.40	349.10	64.64
HALL	140	301.90	362.30	60.42
HALL	178	360.80	296.10	-64.70
HALL	80	302.80	346.10	43.29
HAMILTON	108	305.30	394.90	89.55
HAMILTON	226	400.00	386.00	-14.00
HARLAN	40	327.20	339.30	12.08
KEARNEY	120	354.80	332.20	-22.60
KEARNEY	211	374.00	421.20	47.18
KNOX	67	323.50	166.30	-157.00
KNOX	120	366.00	368.90	2.85
KNOX	66	223.10	227.00	3.88
KNOX	119	188.30	197.70	9.43
KNOX	271	333.60	276.30	-57.20

APPENDIX III. REVENUE (Continued)

COUNTY	ICM ACRES	PRE-ICM IMPACT ($/ACRE)	ICM IMPACT ($/ACRE)	IMPACT DIFFERENCE ($/ACRE)
KNOX	90	164.50	46.54	-118.00
MERRICK	171	302.90	304.00	1.10
MERRICK	132	308.90	245.50	-63.50
MERRICK	22	326.30	226.20	-100.00
MERRICK	193	371.70	326.70	-45.00
MERRICK	38	299.10	243.30	-55.90
MERRICK	83	237.70	143.30	-94.40
MERRICK	127	326.40	320.20	-6.21
MERRICK	128	292.30	321.50	29.19
MERRICK	44	340.90	411.40	70.52
MERRICK	153	320.60	337.60	17.08
MERRICK	65	312.70	279.50	-33.20
MERRICK	62	259.20	253.50	-5.68
MERRICK	118	284.00	243.80	-40.20
MERRICK	55	261.50	250.80	-10.70
MERRICK	84	185.20	209.20	23.99
MERRICK	73	339.10	330.40	-8.69
MERRICK	149	406.10	338.60	-67.50
MERRICK	120	313.80	326.80	13.00
NANCE	256	333.30	286.90	-46.40
NANCE	259	278.80	176.40	-102.00
NANCE	98	308.80	245.00	-63.80
NANCE	115	331.90	245.70	-86.20
NANCE	311	334.00	210.20	-124.00
NUCKOLLS	83	344.70	302.20	-42.60
NUCKOLLS	139	340.90	286.90	-54.00
NUCKOLLS	139	297.40	258.60	-38.80
NUCKOLLS	92	306.90	237.50	-69.50
NUCKOLLS	80	204.60	36.08	-169.00
NUCKOLLS	193	341.50	291.10	-50.40
NUCKOLLS	64	294.60	251.20	-43.30
NUCKOLLS	72	320.80	254.60	-66.20
NUCKOLLS	185	299.40	253.50	-45.80
NUCKOLLS	61	414.20	358.30	-55.90

APPENDIX III. REVENUE (Continued)

COUNTY	ICM ACRES	PRE-ICM IMPACT ($/ACRE)	ICM IMPACT ($/ACRE)	IMPACT DIFFERENCE ($/ACRE)
NUCKOLLS	33	370.30	325.60	-44.70
NUCKOLLS	88	320.50	301.90	-18.70
NUCKOLLS	98	391.70	305.00	-86.70
NUCKOLLS	112	384.40	326.80	-57.70
NUCKOLLS	238	352.80	320.20	-32.60
NUCKOLLS	33	323.30	282.40	-40.90
NUCKOLLS	96	322.70	227.90	-94.80
NUCKOLLS	63	307.60	234.80	-72.80
NUCKOLLS	490	326.80	316.20	-10.50
NUCKOLLS	44	333.00	302.50	-30.50
NUCKOLLS	200	384.30	332.40	-51.80
NUCKOLLS	40	387.70	286.40	-101.00
NUCKOLLS	94	398.50	321.70	-76.80
NUCKOLLS	20	308.20	284.20	-23.90
NUCKOLLS	19	353.10	143.40	-210.00
NUCKOLLS	45	389.80	299.70	-90.10
NUCKOLLS	270	385.20	298.80	-86.40
NUCKOLLS	253	363.50	273.70	-89.80
NUCKOLLS	110	360.50	350.30	-10.20
NUCKOLLS	42	136.50	80.90	-55.60
NUCKOLLS	52	268.90	301.70	32.84
NUCKOLLS	33	341.00	260.20	-80.80
PHELPS	79	401.90	455.60	53.72
PHELPS	44	346.00	347.10	1.07
PIERCE	130	306.00	234.60	-71.40
PIERCE	161	347.60	348.20	0.62
PIERCE	120	326.60	291.20	-35.30
PIERCE	263	298.60	292.30	-6.25
PIERCE	187	384.10	346.70	-37.40
PIERCE	172	330.20	330.30	0.15
PIERCE	130	325.80	332.70	6.94
PIERCE	65	354.80	354.60	-0.12
PIERCE	40	317.10	299.40	-17.70
PIERCE	73	326.60	288.00	-38.60

APPENDIX III. REVENUE (Continued)

COUNTY	ICM ACRES	PRE-ICM IMPACT ($/ACRE)	ICM IMPACT ($/ACRE)	IMPACT DIFFERENCE ($/ACRE)
PIERCE	33	238.70	236.70	-2.00
PIERCE	130	330.60	331.30	0.70
PIERCE	35	252.00	249.00	-3.05
SALINE	157	317.50	268.60	-48.90
SALINE	132	346.80	347.80	0.99
SALINE	53	365.50	325.40	-40.20
SALINE	62	297.20	290.70	-6.53
SEWARD	50	317.40	293.70	-23.70
SEWARD	204	393.60	307.60	-86.00
THAYER	347	305.60	317.30	11.66
THAYER	209	257.80	261.10	3.36
YORK	75	391.40	323.50	-67.90
YORK	230	358.60	335.80	-22.90

APPENDIX V. ENVIRONMENTAL IMPACT

COUNTY	ICM ACRES	PRE-ICM IMPACT (EIQ)	ICM IMPACT (EIQ)	IMPACT DIFFERENCE (EIQ)
ADAMS	145	106	124	18
ADAMS	36	183	162	-21
ADAMS	118	161	161	0
ADAMS	43	84	42	-41
ANTELOPE	116	77	280	203
ANTELOPE	115	161	302	140
ANTELOPE	560	197	192	-5
ANTELOPE	130	141	141	0
ANTELOPE	185	67	87	20
ANTELOPE	441	64	80	16
ANTELOPE	129	71	98	27
ANTELOPE	68	46	46	0
ANTELOPE	260	60	60	0
ANTELOPE	67	77	162	84
ANTELOPE	130	121	114	-6
ANTELOPE	130	141	141	0
BUFFALO	105	38	91	53
BUFFALO	39	71	83	12
BUFFALO	241	29	56	26
BUFFALO	77	176	176	0
BUFFALO	90	38	65	26
BUFFALO	63	101	127	26
BUFFALO	140	69	129	60
BUFFALO	40	75	199	124
BUFFALO	68	75	199	124
BUFFALO	119	102	128	26
BUFFALO	70	75	173	98
BUFFALO	118	75	96	21
BUFFALO	200	73	73	0
BUFFALO	97	84	114	30
BUFFALO	301	126	135	9
BUFFALO	541	51	51	0
BUFFALO	269	152	209	57
BUFFALO	115	135	132	-3

APPENDIX V. ENVIRONMENTAL IMPACT (Continued)

COUNTY	ICM ACRES	PRE-ICM IMPACT (EIQ)	ICM IMPACT (EIQ)	IMPACT DIFFERENCE (EIQ)
BUFFALO	93	62	115	53
BUFFALO	46	43	63	20
BUFFALO	214	90	90	0
BUFFALO	104	93	164	70
BUFFALO	502	62	40	-22
BUFFALO	510	48	46	-2
BUFFALO	127	155	182	26
BUFFALO	138	74	100	26
BUFFALO	101	47	27	-20
BUFFALO	173	47	114	66
BUFFALO	492	62	111	49
BUFFALO	49	47	38	-9
BUFFALO	285	47	47	0
BUFFALO	68	140	166	26
BUFFALO	104	38	72	34
BUFFALO	187	55	115	60
BUFFALO	402	41	31	-11
BUFFALO	72	57	63	6
BUFFALO	201	104	104	0
BUFFALO	126	155	209	54
BUFFALO	67	163	163	0
BUFFALO	84	47	74	26
BUFFALO	220	43	43	0
BUFFALO	59	155	208	53
BUFFALO	58	91	35	-56
BUFFALO	99	29	56	26
BUFFALO	82	124	133	9
BUFFALO	137	42	30	-13
BUFFALO	139	42	30	-12
BUFFALO	67	41	41	0
BUFFALO	78	146	180	34
BUFFALO	153	36	78	42
BUFFALO	109	71	96	25
BUFFALO	72	42	42	0

APPENDIX V. ENVIRONMENTAL IMPACT (Continued)

COUNTY	ICM ACRES	PRE-ICM IMPACT (EIQ)	ICM IMPACT (EIQ)	IMPACT DIFFERENCE (EIQ)
BUFFALO	150	104	104	0
BUFFALO	84	102	146	44
CHEYENNE	65	27	38	11
CLAY	128	39	31	-8
FILLMORE	142	90	94	4
GAGE	58	115	150	35
HALL	217	87	75	-12
HALL	205	176	147	-29
HALL	113	110	95	-15
HALL	129	90	40	-50
HALL	210	142	107	-35
HALL	184	130	36	-95
HALL	67	148	176	27
HALL	75	38	65	26
HALL	62	90	75	-14
HALL	464	102	78	-24
HALL	810	140	59	-81
HALL	143	85	23	-62
HALL	45	38	65	27
HALL	37	91	81	-10
HALL	50	194	107	-88
HALL	52	46	172	126
HALL	202	91	172	81
HALL	117	63	92	29
HALL	237	113	83	-31
HALL	74	169	73	-96
HALL	69	31	49	18
HALL	72	31	49	18
HALL	140	106	104	-2
HALL	116	104	48	-57
HALL	134	31	32	2
HALL	72	31	43	12
HALL	68	134	121	-13
HALL	117	31	30	-1

APPENDIX V. ENVIRONMENTAL IMPACT (Continued)

COUNTY	ICM ACRES	PRE-ICM IMPACT (EIQ)	ICM IMPACT (EIQ)	IMPACT DIFFERENCE (EIQ)
HALL	50	88	61	-27
HALL	79	145	105	-40
HALL	133	106	133	27
HALL	75	223	160	-63
HALL	104	84	22	-62
HALL	90	154	22	-132
HALL	75	31	32	1
HALL	341	31	49	18
HALL	183	92	38	-54
HALL	153	128	30	-99
HALL	620	29	33	4
HALL	185	187	132	-55
HALL	533	92	100	7
HALL	42	38	66	28
HALL	153	61	38	-23
HALL	67	136	51	-86
HALL	107	109	40	-69
HALL	342	72	42	-31
HALL	72	136	34	-102
HALL	160	140	104	-35
HALL	195	99	106	7
HALL	140	59	80	21
HALL	178	84	102	18
HALL	80	166	144	-22
HAMILTON	108	78	108	30
HAMILTON	226	110	108	-2
HARLAN	40	107	68	-39
KEARNEY	120	74	74	0
KEARNEY	211	61	68	6
KNOX	67	116	102	-14
KNOX	120	110	110	0
KNOX	66	22	26	3
KNOX	119	171	95	-75
KNOX	271	104	65	-39

APPENDIX V. ENVIRONMENTAL IMPACT (Continued)

COUNTY	ICM ACRES	PRE-ICM IMPACT (EIQ)	ICM IMPACT (EIQ)	IMPACT DIFFERENCE (EIQ)
KNOX	90	68	137	70
MERRICK	171	52	67	15
MERRICK	132	141	191	50
MERRICK	22	137	114	-24
MERRICK	193	73	101	28
MERRICK	38	148	176	27
MERRICK	83	148	146	-3
MERRICK	127	245	96	-149
MERRICK	128	192	120	-72
MERRICK	44	181	214	33
MERRICK	153	136	75	-61
MERRICK	65	146	84	-61
MERRICK	62	212	171	-41
MERRICK	118	39	46	7
MERRICK	55	100	100	0
MERRICK	84	189	88	-100
MERRICK	73	149	84	-65
MERRICK	149	84	92	8
MERRICK	120	108	137	30
NANCE	256	57	75	18
NANCE	259	39	67	28
NANCE	98	60	91	32
NANCE	115	33	54	21
NANCE	311	108	166	59
NUCKOLLS	83	74	101	26
NUCKOLLS	139	88	85	-3
NUCKOLLS	139	167	184	18
NUCKOLLS	92	124	127	4
NUCKOLLS	80	86	86	0
NUCKOLLS	193	75	94	19
NUCKOLLS	64	118	129	11
NUCKOLLS	72	162	159	-3
NUCKOLLS	185	110	130	19
NUCKOLLS	61	89	89	0

APPENDIX V. ENVIRONMENTAL IMPACT (Continued)

COUNTY	ICM ACRES	PRE-ICM IMPACT (EIQ)	ICM IMPACT (EIQ)	IMPACT DIFFERENCE (EIQ)
NUCKOLLS	33	76	96	20
NUCKOLLS	88	33	72	39
NUCKOLLS	98	50	77	27
NUCKOLLS	112	106	127	22
NUCKOLLS	238	41	41	0
NUCKOLLS	33	104	146	41
NUCKOLLS	96	137	219	81
NUCKOLLS	63	172	203	30
NUCKOLLS	490	79	132	53
NUCKOLLS	44	146	178	32
NUCKOLLS	200	107	128	21
NUCKOLLS	40	66	67	0
NUCKOLLS	94	77	51	-25
NUCKOLLS	20	82	111	28
NUCKOLLS	19	87	87	0
NUCKOLLS	45	66	67	0
NUCKOLLS	270	100	106	7
NUCKOLLS	253	125	125	0
NUCKOLLS	110	136	179	43
NUCKOLLS	42	68	68	0
NUCKOLLS	52	114	129	15
NUCKOLLS	33	38	28	-11
PHELPS	79	107	81	-26
PHELPS	44	55	58	2
PIERCE	130	44	44	0
PIERCE	161	140	140	0
PIERCE	120	68	75	8
PIERCE	263	160	137	-22
PIERCE	187	180	169	-11
PIERCE	172	149	149	0
PIERCE	130	177	150	-26
PIERCE	65	120	120	0
PIERCE	40	205	205	0
PIERCE	73	68	41	-26

APPENDIX V. ENVIRONMENTAL IMPACT (Continued)

COUNTY	ICM ACRES	PRE-ICM IMPACT (EIQ)	ICM IMPACT (EIQ)	IMPACT DIFFERENCE (EIQ)
PIERCE	33	92	92	0
PIERCE	130	129	129	0
PIERCE	35	92	92	0
SALINE	157	95	121	26
SALINE	132	254	151	-102
SALINE	53	28	82	54
SALINE	62	129	77	-52
SEWARD	50	297	297	0
SEWARD	204	124	109	-16
THAYER	347	105	81	-24
THAYER	209	159	139	-19
YORK	75	96	158	63
YORK	230	121	142	21

VITA

Candidate for the Degree of

Master of Science

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