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Malheur County is located in the southeast corner of Oregon and consists of about 6.4 million acres of which 260,000 acres is irrigated. Groundwater contamination has been found in a 115,000 acre area in Northeastern Malheur County. The main source of the groundwater contamination is agricultural practices. The overall objective of this research is to design and evaluate environmentally sound and economically feasible alternative row crop and dairy farming systems for Northern Malheur County. Previous research has commonly used linear programming and growth and physical simulation models for environmental and economic analysis. This research takes a different approach in that the baseline farming system and each alternative farming system for row crop and dairy farms had a detailed whole-farm budget completed and evaluated using Planetor. NLEAP was used to evaluate nitrogen leaching for the row crop alternatives. The row crop analysis results indicated that implementing best management practices (BMPs) to reduce soil erosion, water use, and nutrient runoff and leaching, can increase profits. The dairy farm analysis results indicated

that storing and applying dairy barn runoff was cost effective because of the savings in nutrients from storage.

Economic and Environmental Evaluation of Alternative Farming Systems for Row Crop and Dairy Farms in Northern Malheur County

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CHAPTER ONE

INTRODUCTION

The Problem

Malheur County is located in the southeast corner of Oregon and consists of about 6.4 million acres of which 260,000 acres is irrigated (Water Quality Plan Ontario Hydrologic Unit, 1991). The remaining acreage is rangeland. The county's population of 26,000 is primarily supported by agriculture (Oregon State University Extension Service, Malheur County Office, 1991). The majority of the crop land is located in northeast Malheur County where the Malheur, Owyhee, and Snake River valleys meet. This area is commonly known as Treasure Valley. Onions, potatoes, and sugar beets are the major crops grown and contributed $40, $17, and $14 million respectively to the county's agricultural income in 1992 (Oregon State University Extension Service, Malheur County Office, 1992).

These crops also contribute heavily to the county's economy in terms of the jobs created from field production and processing and handling. Onions, for example, while considered the most important cash crop, can have a large impact on the overall county economy because of a volatile onion market (Oregon State University Extension Service, Malheur County Office, 1991). Wheat, of the soft white varieties, is another cash crop and is the major cereal crop produced, while field corn raised for grain is mostly consumed by the local dairy and beef industries (Water Quality Plan Ontario Hydrologic Unit, 1991). Other crops grown in the county include alfalfa seed, red clover, flower and vegetable seed, alfalfa hay, dry beans, sweet corn, and mint.

Malheur County is best described as having hot summers, cold winters, and low annual precipitation. The average annual precipitation is 10 inches with a mean temperature of 50.2 degrees and a frost free season of 158 days (Oregon State University Extension Service, Malheur County Office, 1991). The soils consist mainly of alluvial flood plains and terraces from which the lower river valleys form the fertile land which supports the intensive diverse agriculture (Water Quality Plan Ontario Hydrologic Unit, 1991). The majority of the 260,000 acres is irrigated from stored water projects (Water Quality Plan Ontario Hydrologic Unit, 1991). Control and distribution of water is done by both private irrigation companies and the Federal Bureau of Reclamation. Water is distributed in specific amounts (feet per acre per season) and to specific acres of land. Each project allocates the feet per acre per season and the total cost per acre with conditions for distributing excess water allocations, if water is available, at additional cost (Oregon State University Extension Service, Malheur County Office, 1991). There are many different cropping rotations used, but there is no set system since rotations seem to be dependent upon markets and water availability.

The main method of water application is surface irrigation with furrow irrigation being the most widely used. Many of the surface systems have irrigation pipelines, gated pipe or concrete ditches to increase the efficiency of the system (Water Quality Plan Ontario Hydrologic Unit, 1991). In addition, many fields have undergone some land leveling. All of these practices help to maintain an adequate surface system.

Most Malheur County dairy farms are located within the Owyhee and Malheur drainage systems. Dairying has contributed approximately $12 million annually to the Malheur County agricultural economy (Oregon State University Extension Service, Malheur County Office, 1991). The 70 dairies in the county are all family operated and have an average herd size of 86 cows (Schneider, 1993). Since no milk processors are located in Malheur County all milk must be processed and marketed in Idaho. The majority of dairies produce a large portion of their feed in the form of hay, silage, and pasture with the typical ration consisting of alfalfa hay, silage, and commercially mixed grain (Schneider, 1993). Manure handling systems commonly consist of scraping manure from alleys, storing in a dry stack, and then spreading on fields at appropriate times (Schneider, 1993). A confined animal feeding operations (CAFO) permit is required of all dairies through a cooperative agreement of the Oregon State Department of Agriculture (ODA) and Department of Environmental Quality (DEQ).

Groundwater contamination (nitrate and the herbicide Dacthal) has been found in a 115,000 acre area in Northeastern Malheur County and because of this problem the area has been designated by the DEQ as a Groundwater Management Area under the provisions of the Groundwater Protection Act of 1989 (ORS 468.698) (Malheur County Groundwater Management Committee, 1991). The goal and strategy of the Groundwater Protection Act of 1989 is to protect groundwater from contamination and to restore groundwater quality when it is contaminated from nonpoint sources (Malheur County Groundwater Management Committee, 1991). The Malheur County Groundwater Management Committee (1991) has adopted this goal for the Northern Malheur County Groundwater Management Action Plan since it applies to the nonpoint source groundwater contamination in the area.

The specific goal of the action plan is to reduce nitrate/nitrite-nitrogen contamination in the groundwater to a level below that which caused the designation of the Groundwater Management Area (Malheur County Groundwater Management Committee, 1991). The action plan was developed to coordinate the activities undertaken by the Malheur County agricultural community, State of Oregon, and Federal Government. In cooperation with ODA and the Soil Conservation Service (SCS), Oregon State University (OSU) will identify and develop alternative management practices, as well as conduct field studies on the alternatives to verify and complement the formal research (Malheur County Groundwater Management Committee, 1991).

In addition to being a Groundwater Management Area, Northern Malheur County has been designated by the United States Department of Agriculture (USDA) as a Hydrologic Unit Area (HUA). The HUA and Groundwater Management Area encompass the same area. Like the action plan, HUA is a major effort of USDA to coordinate federal, state, and local agencies' efforts to solve water quality problems. The Ontario HUA is concerned with both surface and groundwater quality. The Water Quality Plan Ontario Hydrologic Unit (1991) has two objectives. Objective one is to improve surface water quality to meet basin standards, with the goals being: (a) reduce sediment entering the HUA waters by 25 percent, and (b) reduce nitrogen application by 20 percent. Objective two is to improve groundwater quality to meet drinking water standards, with the goals being: (a) reduce Dacthal use in the HUA by 30 percent, and (b) reduce nitrogen leaching by 20 percent.

The main source of surface and groundwater contamination is agricultural practices (Water Quality Plan Ontario Hydrologic Unit, 1991). Furrow irrigation is a major cause of erosion in surface water because the inflow rates cause excessive erosion and contribute to both on-site and off-site sediment (Water Quality Plan Ontario Hydrologic Unit, 1991). Too much tail water also moves large amounts of sediment, nutrients, and pesticides that contribute to the water quality problem. A major contributor to groundwater contamination is the combination of irrigation and use of fertilizers that have nitrates and ammonium in them (Water Quality Plan Ontario Hydrologic Unit, 1991). Inadequate manure storage and handling systems are also a concern because of the large amounts of nitrogen in run-off that ends up in both surface and groundwater.

The Objectives

Past activities in the area have primarily focused on applied crop research of various alternative farming practices. It is now necessary to perform economic analyses on these alternatives to determine their feasibility.

The overall objective of this research project is to design and evaluate environmentally sound and economically feasible farming systems suitable for Northern Malheur County, based on results of prior research of alternative farming practices. Specifically:

a) Design alternative farming systems which require the use of fewer potential contaminants or which reduce potential contaminants entering groundwater;

b) Assess the economic viability of candidate systems where costs of the alternative systems and profitability over time are taken into account; and

c) Evaluate selected environmental impacts from alternative farming systems.

The Procedures

The objectives listed above will be accomplished using the following procedures:

a) A conceptual framework for evaluating economic and environmental viability over time will be constructed. After selecting an appropriate technique for analysis, a base farm with detailed production and economic information for baseline farming practices will be defined for both a row crop and dairy farm. Alternative farming practices with expected superior environmental and economic results will be identified. These alternative practices will be identified in cooperation with area farmers and scientists from other disciplines.

b) Using the analytical model and data developed under procedure (a), whole-farm budget(s) will be prepared. This evaluation will include the impacts of a shift to an alternative practice on profitability over time, change in net worth, soil erosion, and water use.

c) The whole farm budget(s) developed under procedure(b) will form the basis for evaluating the environmental effects of alternative practices. This evaluation will include nitrogen leaching potential. Sensitivity analysis will be performed on parameters such as profitability and nitrogen management.

Organization of the Thesis

Chapter two consists of a literature review of previous work and how this work will contribute to that knowledge. Also included in chapter two is the theoretical framework of the theory of the firm. Chapter three is the specific model of the farm firm and how it relates to the row crop analysis. The row crop farm analysis which is also in chapter three consists of the enterprise budgets, baseline farming practices, alternative practices that were evaluated and other practices that were not evaluated at this time, and the sensitivity analysis performed on the laser leveling alternative. It also discusses the nitrogen management evaluation performed by NLEAP. Chapter four consists of the dairy farm analysis and how the specific model of the farm firm relates to the dairy farm analysis. The dairy farm analysis is similar to chapter three in that it contains the enterprise budgets, baseline farming practices, alternative practices that were evaluated, and other practices that were not evaluated. Chapter five contains a summary, conclusions drawn from this research, and a brief discussion of future research possibilities.

CHAPTER TWO

LITERATURE REVIEW

A major environmental concern that has been growing in recent years is water quality. Surface water was the main focus initially, but attention has been turned to the more serious groundwater pollution. Groundwater pollution is a nonpoint source of pollution of which agriculture and agriculture chemicals in particular are a major contributor. Rather than deal with the costs and implications of mandatory measures to reduce groundwater pollution, many regions have undertaken an effort to determine which best management practices (BMPs) and crop rotations will be most cost effective on a voluntary basis. Most previous research focused on erosion and chemicals. Recently, attention has been turned to nutrients, such as nitrogen and phosphorus, in addition to chemicals and erosion. This allows for a more complete picture of the problem being solved.

Economic, production, and water quality components pertaining to agriculture make up the linear programming model that Wade, Nicol, and Heady (1976) used to evaluate changes in national and regional gross farm income. They evaluated farm income changes based on public and environmental policies that allowed unlimited soil loss (base year) per acre per year, five tons of soil loss per acre per year, and three tons of soil loss per acre per year. Overall, national farm income increased from the base year to five tons and base year to three tons. On a regional basis they found that some regions' farm incomes increased while others decreased. The Pacific Northwest farm income decreased from the base year to five tons and increased from base year to three tons.

McSweeney and Shortle (1990) used activity analysis to evaluate the cost effectiveness of whole-farm pollution plans from a probabilistic effectiveness standpoint rather than average cost of control because it's a more practical and well developed device for screening farm plans. Nitrogen (N) was assumed as the single pollutant, but a multiple pollutant analysis could be performed. Nutrient reduction targets for nitrogen were set at 20, 40, and 60 percent of the baseline with nutrient reduction target probabilities of 50, 75, and 95 percent. Several rotation possibilities with alternative tillage options defined the cropping practices. They found that changes in cropping practices to meet the probabilistic nutrient reduction targets at least cost involved complex combination changes in rotation, tillage practices, and the addition of cover crops and\or sod filter strips instead of additions of best management practices.

Johnson, Adams, and Perry (1991) combined a plant simulation model (biophysical - CERES), dynamic optimization model (hydrological), and linear programming model to analyze the on-farm effects of various alternatives for reducing nitrate groundwater pollution in the Columbia Basin of Oregon. They found that some crops' profits increased when water and nitrogen rates and timing were changed.

CREAMS (Chemicals, Runoff, and Erosion from Agricultural Management Systems), a computer simulation model, has been used in several different situations. CREAMS compares field soil and nutrient losses between management practices. Some of these results were used in a representative farm linear programming model by Young, Crowder, Shortle, and Alwang (1985) to evaluate manure storage and handling facilities. They listed application, reduction of manure produced, structural practices, and manure disposal on other farms as ways to reduce nutrient runoff. Their economic model found that the savings in nutrients from manure storage would cover all or most of the cost of a structure. CREAMS found that field BMPs may reduce soil and nutrient loss.

Crowder, Pionke, Epp, and Young (1985) used CREAMS to estimate soil and chemical losses from crops for a typical dairy farm in Pennsylvania. This was done for three soils and conventional, reduced, and no-till tillage practices. A linear programming model was then used to maximize profits subject to economic and environmental constraints. Under these constraints, no-till with a rotation of corn-alfalfa and continuous corn had the highest net returns, while reduced tillage and the same rotation as no-till had slightly lower returns. They found that soil loss is almost identical for the two tillage practices, but reduced tillage has much less N and Phosphorus (P) loss.

Using CREAMS, Crowder and Young (1987) combined cost information for BMPs to compare cost effectiveness of the practices. They compared eleven practices of which three were combinations of single practices. The single practices that were most cost effective for controlling soil and nutrient losses were contour tillage, conservation tillage, and sod waterways. Permanent vegetative cover and terrace systems were not cost effective due to their high implementation costs. The combination practices were also cost ineffective.

Heatwole, Bottcher, and Baldwin (1987) combined CREAMS-WT and BASIN for their cost effectiveness analysis of two Florida basins. CREAMS-WT predicts nutrient and water yield for field size areas. The CREAMS-WT nutrient yields are then put into BASIN, a computer simulation model, which estimates nutrient delivery to the nearest stream and sub-watershed outlets in the basin. They evaluated BMPs for dairy farms, beef cattle operations, and row crops. Of the fifteen BMPs evaluated, the four most cost effective were (1) fence dairy cows from streams and wetlands, (2) fence intensively managed beef and dry cow pasture from streams and wetlands, (3) store dairy barn runoff and apply to pasture or crop land, and (4) fence beef cattle on improved unirrigated pasture from streams and wetlands.

Foltz, Lee, and Martin (1993) evaluated the farm level environmental and economic impacts of alternative farming systems with a crop rotation of alfalfa and other row crops. They used Repfarm, a farm level linear programming model, for the economic evaluation. The environmental evaluation used EPIC (Erosion Productivity Impact Calculator), a growth simulation model, and GLEAMS (Groundwater Loading Effects of Agricultural Management Systems), a physical simulation model. Three scenarios were evaluated for a high productivity and low productivity soil for the representative farm: (1) a government program (participation in the 1989 government program with a 10 percent corn set-aside);

(2) observed crop market prices; and (3) policy option (one-fourth of the farm is required to produce alfalfa). Scenario one, for the high productivity soil had the highest net return. The reason for the high return was that less productive acreage was put in set-aside and the remaining acreage produced higher average yields. The low productivity soil had a return of $61.60 an acre with estimated N leaving the field at 36.72 lb/acre.

Based on this literature review, it is apparent that the common approaches to environmental and economic analysis are linear programming and growth and physical simulation models. Comparison of baseline and alternative scenarios is also common. The problems encountered in previous studies were mostly with the growth and physical simulation models. Johnson, Adams, and Perry (1991) did not have a CERES model for alfalfa while Heatwole, Bottcher, and Baldwin (1987) did not have subdivision data on "dairy" land in pasture or hayland. McSweeney and Shortle (1990) had problems with their hydrological model of nonpoint pollution because although it had good estimates of mean losses it neglected other parameters. Similarly, Foltz, Lee, and Martin (1993) used actual weather data for a ten year period because a typical year wasn't available due to large year to year variability. The most interesting problem was that Wade, Nicol, and Heady (1976), in a sense, double counted regional income for some commodities. This is caused by counting grain grown for feed and the livestock that the grain was fed to.

A common result was apparent for both dairy and crop producers. In reducing nutrient runoff, storing and applying dairy barn runoff is cost effective because of the savings in nutrients from storage. For crop producers, profits can be increased by changing cropping practices and implementing best management practices to reduce water use, soil erosion, chemical and nutrient runoff and leaching. However, the complexity of these changes depends on climate and resources of the area being analyzed.

While this analysis is also concerned with the economic and environmental factors of erosion and nutrients, it takes a different approach in that the economic section is accomplished through budgeting a complete crop rotation and the environmental section analyzes erosion, water use, and nitrogen leaching as a whole rather than as single factors. In addition, this analysis focuses on the Pacific Northwest, where most previous work has concentrated on the East and Midwest. The results are presented in chapters three and four. The remainder of this chapter develops the theoretical framework upon which the economic analysis is based.

THEORETICAL FRAMEWORK

Describing the relationship between a firm and its workers and capital investors can become quite complicated as Nicholson (1992) points out. Complications arise with the negotiating of workers contracts that specify wage, hours worked, working conditions, and benefits among other things. Capital investors have conditions for the use of their investment, and compensation requirements as well as what portion of retained earnings or losses they can expect to receive. Even with contracts, there is still the problem of who makes the production decisions. In studying firms' behavior, some economists have chosen a "behavioral" approach, but most found it too complex for general cases and have chosen a "holistic" approach that treats the firm as a single decision maker and avoids the complications of firm, worker, and capital investor mentioned previously (Nicholson, 1992).

Henderson and Quandt (1980) define a firm as "a technical unit in which commodities are produced." The firm's entrepreneur (owner and/or manager) decides how many commodities to produce and the quantity of each commodity to produce. The entrepreneur transforms inputs into outputs subject to their production function. Profit is received if the difference between the sale of outputs (revenue) and costs of input (expense) are positive and a loss is incurred if the difference is negative.

The production function is essentially the relationship between inputs and outputs. This relationship can be written as

$$q = f\,(x_1 \,|\, x_2,\ \ldots,\ x_n) \tag{1}$$

where q is the output, x_1 is the variable input, and x_2 through x_n are the fixed inputs (Boehlje and Eidman, 1984). The number of factors that are fixed and variable depends on the length of the planning period. The production function can be generalized for a firm producing s outputs and using n inputs over multiple production periods. Henderson and Quandt (1980) express this in implicit form as

$$F\ (\ q_{12},\ ...,\ q_{s,L+1};\ x_1,\ ...,\ x_{nL}\ ) = 0 \qquad (2)$$

where

q_{it} = the quantity of the i^{th} output secured during the (t-1)st period and sold on the t^{th} marketing date, i = 1, ..., s; t = 2, ..., L+1

x_{jt} = the quantity of the j^{th} input purchased on the t^{th} marketing date and applied to the production process during the t^{th} period, j = 1, ..., n; t = 1, ..., L

t = time

assuming the function has continuous first and second order partial derivatives which are different from zero for all its nontrivial solutions. It is assumed to be an increasing function of outputs, decreasing function of inputs, and regular strictly quasi-convex over a relevant domain.

The objective of the firm that sells their products in a perfectly competitive market is profit maximization, the difference between revenue from outputs and expenditure on inputs. Profit maximization becomes (Henderson and Quandt, 1980)

$$\Pi = \sum_{i=1}^{s} p_{it}\ q_{it} - \sum_{j=1}^{n} r_{jt}\ x_{jt} \qquad (3)$$

where

Π = profit

p_{it} = price of q_{it}

r_{jt} = price of x_{jt}

and q_{it} and x_{jt} are defined above.

The entrepreneur maximizes profits subject to the production function. This forms the function

$$J = \sum_{i=1}^{s} p_{it}\, q_{it} - \sum_{j=1}^{n} r_{jt}\, x_{jt} + \lambda F\,(\,q_{12}, \ldots, x_{nL}\,) \tag{4}$$

where

J = profit constrained by the production function

Setting each of the (s + n + 1) partial derivatives equal to zero, gives the following:

$$\begin{aligned} \frac{\partial J}{\partial q_{it}} &= p_{it} + \lambda F_{it} = 0 \qquad i = 1, \ldots, s;\ t = 2, \ldots, L+1 \\ \frac{\partial J}{\partial x_{jt}} &= r_{jt} + \lambda F_{s+jt} = 0 \qquad j = 1, \ldots, n;\ t = 1, \ldots, L \\ \frac{\partial J}{\partial \lambda} &= F\,(q_{12}, \ldots, x_{nL}) = 0 \end{aligned} \tag{5}$$

where F_{it} (i = 1, ..., s + n = m) is the partial derivative of (2) with respect to the i^{th} argument.

Select any two of the first s equations in (5) and move the second terms to the right hand side and divide one by the other:

$$\frac{p_{jt}}{p_{kt}} = \frac{F_{jt}}{F_{kt}} = -\frac{\partial q_{kt}}{\partial q_{jt}} \qquad j, k = 1, \ldots, s;\ t = 2, \ldots, L+1 \tag{6}$$

First order conditions require: holding all other inputs and outputs constant, (a) the rate of product transformation (RPT) for any two outputs must equal the ratio of their prices; (b) the rate of technical substitution (RTS) for any two inputs must equal the ratio of their prices; and (c) each input's value of marginal product with respect to each output is equal to its input price.

The firm that sells products in a perfectly competitive market has profit (Π) equal to the fixed unit price (p_{it}) received times the number of units sold (q_{it}) minus the total cost (C)

$$\Pi = p_{it}q_{it} - C \tag{7}$$

where Π, p_{it}, and q_{it} are defined above

and total cost is given by the linear equation

$$C = r_{jt}x_{jt} + b \tag{8}$$

where

b = cost of any fixed inputs

and r_{jt} and x_{jt} are defined as above (Henderson and Quandt, 1980).

The cost of fixed inputs (fixed costs) must be paid regardless of how much the firm produces or whether it produces at all. Joint costs, such as tractors used in the production of more than one product, can be allocated to the entire farm and/or allocated by enterprise. For example, fuel used by tractors can be considered a variable cost and be allocated by enterprise, while tractor depreciation can be considered a fixed cost and be allocated to the entire farm.

In this study the firm is a farm, and thus the assumption that the firm operates in a perfectly competitive market. In order for perfect competition to exist the following assumptions must be satisfied: 1) there are numerous firms producing homogeneous products; 2) each firm maximizes profits; 3) each firm is a price taker; 4) perfect information exists; and 5) transactions between buyers and sellers are costless (Nicholson, 1992). Perfect information doesn't exist in the real world, so this assumption is violated. It takes time and money to collect information, and even when the firm has the information it may not be accurate. There will also be firms that are better at collecting this information than others.

Agriculture is truly a dynamic environment. Everything is constantly changing and thus involves risk and uncertainty. Each firm is very different in its risk taking ability and thus, changes in this dynamic environment may come at a much slower pace for some firms. For example, changing farming practices from the traditional practices to today's more environmentally aware practices may come about in a very painful manner.

Therefore, the theory of the firm discussed above is only an approximation of conditions governing a "real world" farm firm. However, this approximation is useful in understanding "real world" relationships and can, therefore, be used as the basis for the empirical economic analysis that follows.

CHAPTER THREE

SPECIFIC MODEL OF THE FARM FIRM

To study the impact of alternative farming systems, a theory of the farm firm was outlined in the previous chapter. This chapter will outline the specific model used.

In choosing alternative farming systems, economic and environmental implications are a major limitation. The baseline farming system and each alternative farming system has a detailed whole-farm budget completed and evaluated. The alternatives are evaluated based on change in net return, total return, soil loss, total water use (acre feet and inches per irrigated acre), and nitrogen leaching.

Planetor is a whole farm planning system for SMART (Sustaining and Managing Agricultural Resources for Tomorrow), a farm decision support system. Planetor is a software package designed to be used by agriculture specialists to help farmers evaluate the economic and environmental aspects of their farming practices (Planetor Overview, 1990). Planetor comes with a soils database (county soil surveys) for the area of its use. Crop budgets for an entire rotation, of up to 12 years in length rather than single years, are entered in Planetor. Each crop rotation can be budgeted for several alternative fertility, pest management, and tillage systems (Planetor Overview, 1990). Nitrogen requirements are specified and chemicals are explicitly identified so that water quality and human toxicity effects can be identified. Risk factors within enterprises and those relating to diversification are also specified (Planter Overview, 1990). If data is not available for entry in Planetor, then applied research must be used to make an informed judgement.

Planetor's three main components are: data entry, environment, and economic. Data entry is where the farmer enters information on their fields, crop and livestock plans, overhead costs for the farm, and risk (subjective opinion for degree that net returns from one enterprise are correlated with each of the others) (Planetor Overview, 1990). Planetor reports the consequences of the farming system in an economic and environmental section. The economics section reports return over direct costs, net return, and change in net worth, as well as the use of water, labor, feed, and energy. The environment section shows water quality, soil erosion, and pesticide toxicity effects.

In using Planetor, limitations occurred in the environment section. In this version (1.1) of Planetor, erosion is water erosion only. Water erosion is calculated using the Universal Soil Loss Equation and is discussed in the Environmental Analysis section later in this chapter. Wind erosion potential of a field is only in the data entry section and is determined by the wind erodibility group in the soil data file.

Water quality consists of three factors: excess nitrogen, pesticide leaching, and pesticide runoff effects. Excess nitrogen is estimated by calculating the average difference between the amount of N available and the amount removed by crop production over the length of the rotation (Planetor Technical Notes, 1990). N available and N removed are defined by Planetor Technical Notes (1990) as follows:

N Available = Credit from Previous Crop + Credit from Other Sources + Applied Nitrogen

N Removed = Removal Per Unit of Production * Yield.

Planetor reports excess nitrogen in pounds at expected and optimistic yields for each year in the rotation (see Appendix A, Summary Data, pg. 77).

Pesticide leaching is determined in Planetor by a three-step process suggested by the Soil Conservation Service (Planetor Demonstration Program User's Manual, 1990). The three-step process is:

1) Take the leaching rating for the field's soil type from the soil data file.

2) Take the leaching rating for the chemical from the chemical data file.

3) Combine the two ratings according to Table 1 to determine the pesticide leaching potential:

Table 1. Pesticide Leaching Indicator

Soil Leaching Rating	Pesticide Leaching Ratings		
	Large	Medium	Small
High	High	High	Medium
Intermediate	High	Medium	Low
Nominal	Medium	Low	Low

Pesticide runoff is determined the same way as pesticide leaching.

1) Take the runoff rating for the field's soil type from the soil data file.

2) Take the runoff rating for the chemical from the chemical data file.

3) Combine the two ratings to determine the pesticide runoff potential according to Table 2:

Table 2. Pesticide Runoff Indicator

Soil Surface Loss Rating	Pesticide Surface Loss Ratings		
	Large	Medium	Small
High	High	High	Medium
Intermediate	High	Medium	Low
Nominal	Medium	Low	Low

Pesticide toxicity rating for individual chemicals is taken from the chemical data file. Planetor reports the highest chemical rating for toxicity, leaching potential, and runoff potential for each year of the rotation (see Appendix A, Summary Data, pg. 77). This is the first version of Planetor and as the authors of Planetor have also indicated, the chemical runoff and leaching models need to be more fully developed.

This model (planning system) is consistent with the theory of the firm discussed in chapter two. In relating Planetor to equation three, the inputs (x_{jt}'s) are the following: seed, fertilizer, crop chemicals, and water. The outputs (q_{it}'s) are expected yields for the following: bushels of wheat, hundred weight of potatoes, tons of sugarbeets, tons of sweet corn, and hundred weight of onions. The price coefficients (p_{it}'s and r_{jt}'s) are expected prices of the outputs and prices of the inputs respectively. Chemical, nitrogen, and water application rates are entered as transformation coefficients for each crop. In addition, the C-factor (the Cover and Management Factor is discussed in the Environmental Analysis section later in this chapter), which is available from the Soil Conservation Service, is entered for each farming system.

In Planetor, each enterprise's cultural operations rate (acres per hour) and time of year completed were used to allocate labor to the appropriate month and to calculate total labor required (hrs/acre) by crop.

Materials (fertilizer and chemicals) and their rate of application (units/acre) were then entered in Planetor. The pounds of applied nitrogen were entered for each crop. Chemicals were entered as either herbicides or pesticides by name, units, and units per acre for each crop. Water applied (inches/year) was also entered for each crop.

Cash operating costs of seed (with the exception of onions), crop insurance, water assessment, and direct crop labor were taken directly from Oregon State University Extension Service enterprise budgets. Onion seed, fertilizer, crop chemicals, custom hire, fuel, repairs and operating interest expense were calculated based on O.S.U. Extension Service enterprise budgets and cultural operations breakdown. Baseline farming practices cash operating costs are shown in Table 3 and overhead expenses (fixed costs) are shown in Table 4.

Expected yields and prices were based on eleven years of Malheur County Agricultural Statistics (Oregon State University Department of Agricultural and Resource Economics, 1980-1991). Baseline farming practices crop yield and prices are shown in Table 5.

Table 3. Baseline Farming Practices Cash Operating Costs Per Acre

Cash Operating Costs	Wheat	Potatoes	Beets	Corn	Onions
Seed	12.00	253.00	27.00	25.00	103.00
Fertilizer	42.16	103.40	68.65	63.24	159.40
Crop Chemicals	10.23	115.45	91.14	20.25	472.67
Crop Insurance					21.00
Water assessment	26.00	26.00	26.00	26.00	26.00
Custom hire	18.50	49.50	49.50	14.50	64.50
Direct crop labor	12.00	56.00	137.00	24.00	267.50
Fuel	19.92	34.79	30.31	21.16	33.75
Repairs	44.34	82.16	56.94	42.49	63.73
Operating interest	9.26	36.02	24.33	11.83	60.58
Total $	194.41	756.32	510.87	248.47	1272.13

Table 4. Baseline Farming Practices Overhead Expenses

Overhead Expenses	
Farm taxes	12,500.00
Farm insurance	22,339.00
Crop marketing & storage	53,890.00
Miscellaneous	8,946.00
Interest on overhead expense	204,830.00
Depreciation	59,475.00
Total $	361,980.00

Table 5. Baseline Farming Practices Crop Yields and Prices

	Wheat	Potatoes	Beets	Corn	Onions
Unit of yield	Bu.	Cwt.	Tons	Tons	Cwt.
Expected yield	110.0	400.0	30.0	8.6	550.0
Expected price ($)	3.50	4.35	37.20	59.75	7.35

NLEAP (Nitrate Leaching and Economic Analysis Package) is a software package designed to be used by farmers, extension personnel, and agencies that require site-specific estimates of Nitrate-N leaching potential under agricultural crops along with potential Nitrate-N leaching on associated aquifers (Shaffer, Halvorson and Pierce, 1991). Farm management practices, soils, climate and economic information are entered by the user. NLEAP then reports this information as projected N budgets, potential Nitrate-N leaching below the root zone, economic impacts, and potential off-site effects of Nitrate-N leaching (Shaffer, Halvorson, and Pierce, 1991). These results are the automated version of simple hand calculations that estimate the potential for NO_3-N leaching. Smida Abdelli (OSU Department of Bioresource Engineering) and Jeff Connor (OSU Department of Agricultural and Resource Economics) modified NLEAP to run several crop scenarios at once rather than by single crop. Site-specific crop, soil, and precipitation information are entered just as in NLEAP. The results are site-specific by crop and present applied N fertilizer, Nitrogen Available for Leaching (NALy), Nitrogen Leached from Root Zone (NLy), standard deviation for NLy, and Leaching Index (LI). In Managing Nitrogen for Groundwater Quality and Farm Profitability (Follett, Keeney, and Cruse, 1991), Pierce, Shaffer, and Halvorson (1991) present worksheets for calculating LI and NALy in chapter 12 and equations for calculating NLy in chapter 13 (Shaffer, Halvorson, and Pierce, 1991).

The information that is entered includes the following:

crops: identification (ID) number; crop names; crop yield; yield units (ton, cwt etc.); N harvested (lb. of Nitrogen/Unit of yield harvested); portion of crop not harvested; fraction of crop mineralized each year; and applied fertilizer N totals. Table 6 shows baseline farming practices NLEAP crop data.

soils: ID number; soil name; root zone depth; soil bulk density; soil organic matter; residual soil nitrate; drainage class of soil; tile drain; soil slope; topographic position; and hydrological group. Table 7 shows baseline farming practices NLEAP soils data.

precipitation: year and the monthly precipitation (monthly precipitation plus monthly irrigation water for each crop).

Table 6. Baseline Farming Practices NLEAP Crop Data

Description	Wheat	Potatoes	Beets	Corn	Onions
Identification number	1	2	3	4	5
Crop yield	3.30	20	30	8.6	27.5
Yield units	Ton	Ton	Ton	Ton	Ton
N harvested [1]	31.67	8	3.7	8.6	4.4
Portion of crop not harvested	0.33	0.33	0.33	0.33	0.33
Fraction of crop residue mineralized each year	0.90	0.90	0.90	0.90	0.90
Applied fertilizer N totals	136	200	175	204	300

[1] lb. of Nitrogen/unit of yield harvested

Table 7. Baseline Farming Practices NLEAP Soils Data

Description	Owyhee	Greenleaf
Identification number	1	2
Root zone depth (ft.)	5	5
Soil bulk density (g/cm^3)	1.59	1.59
Soil organic matter (%)	1.30	1.50
Residual soil nitrate (lbs. N/acre)	75	75
Drainage class of soil (1=excessively drained...5=poorly drained)	2	2
Tile drain (1=Yes and 0=No)	0	0
Soil slope (%)	1	1
Topographic position (TP=1 for summit or side slope and TP=2 for all others)	2	2
Hydrologic group (A, B, C, or D)	B	B

All of this information is available from farmer's records, soil survey (Lovell, 1980), and Shaffer, Halvorson, and Pierce (1991). Residual soil nitrate is best estimated by a soil test, but in this case, the average of the Planetor crop budgets (see Appendix A, Summary Data, pg. 77) excess nitrogen (lbs/acre) with expected yield from the five year crop rotation was used. To add monthly irrigation water to monthly precipitation note that total irrigation = consumptive use + runoff + deep percolation. In this case consumptive use is added to precipitation. Monthly irrigation water for each crop was calculated as follows:

Total irrigation applied to a crop, say wheat, is 30 inches.

Assume a runoff percentage, say 35 percent, thus 65 percent stays on the field.

Thus consumptive use plus deep percolation:

$$30\ inches \times 65\% = 19.5\ inches \tag{9}$$

Consumptive use for wheat is 16 inches (U.S.D.A., Soil Conservation Service, 1988). Thus total irrigation minus consumptive use equals deep percolation:

$$19.5\ inches - 16\ inches = 3.5\ inches \tag{10}$$

The efficiency of the application after runoff is:

$$\frac{16}{19.5} = .82 = 82\% \tag{11}$$

Therefore, it is necessary to deliver 1/0.82 inches of water for every inch of consumptive use.

Looking at the consumptive use sheet, wheat's consumptive use by month is:

	April	May	June	July
inches	2	5	6	3

consumptive use plus deep percolation =

$$\frac{1}{0.82} \times \mathit{consumptive\ use} \tag{12}$$

	April	May	June	July
inches	2.44	6.10	7.32	3.66

Thus, to calculate monthly precipitation, add these monthly irrigation water amounts to monthly precipitation amounts. Table 8 shows the baseline farming practices inches of monthly precipitation.

The baseline farming practices, alternative farming practices, and sensitivity analysis results from the simulations are presented in the row crop results and discussion section that follows.

Table 8. Baseline Farming Practices Inches of Monthly Precipitation[1]

Crop	Month Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Wheat	0.81	0.92	1.29	3.15	7.09	8.16	3.89	0.37	0.46	0.51	1.26	1.07
Potatoes	0.81	0.92	1.29	0.71	2.29	6.03	11.92	10.76	3.06	0.51	1.26	1.07
Beets	0.81	0.92	1.29	1.75	3.07	6.05	8.56	8.70	5.67	1.55	1.26	1.07
Corn	0.81	0.92	1.29	0.71	3.81	7.88	11.50	4.60	0.46	0.51	1.26	1.07
Onions	0.81	0.92	1.29	2.27	6.35	8.65	8.04	8.18	2.02	0.51	1.26	1.07

[1] monthly precipitation plus irrigation water for each crop

ROW CROP RESULTS AND DISCUSSION

This section discusses the use of enterprise and whole-farm budgets to calculate the economics of baseline and alternative management practices; baseline results; the basis for choosing the alternative practices and their results; and the reasoning why other alternative practices were not evaluated.

Baseline farming practices were constructed based on Oregon State University Extension Service enterprise budgets and input from a panel of local farmers, agency staff, researchers, and extension staff. The panel identified a five year crop rotation with equal acreage of wheat, potatoes, sugarbeets, sweet corn or dry beans, and onions. They decided on a 500 acre farm and the quantity and size of the tractors and trucks. The model farm assumes the producer maximizes profits subject to irrigation, fertilizer, and chemical constraints. The crop rotation was furrow irrigated and grown on Owyhee and Greenleaf silt loam soils with zero to two percent slopes.

Baseline Economic Analysis

Enterprise selection and the order of rotation was based on the local farmers' own crop rotations. Although each varied slightly, deep rooted crops like wheat, sugarbeets, and corn typically followed shallow rooted crops like potatoes and onions (Shock, Miller, Saunders, and Stieber, 1993).

Enterprise budgets were constructed based on the cultural operations performed for each crop. Rate (acres per hour); time of year completed;

machinery and implements used; materials (custom work, seed, fertilizer, chemicals); and rate of materials application (units/acre) were identified for each operation. Appendix A shows the enterprise nitrogen application rates on page 78; herbicide application rates, pesticide application rates, and water, fuel, and energy requirements on page 79; and the labor requirements and cash operating costs are on page 80.

A machinery complement appropriate for this size farm was constructed based on the cultural operations breakdown and panel recommendations. The machinery and implements for each cultural operation, by crop, were then entered into a machinery cost model to calculate total cost per acre for fuel and repairs. Total annual costs for insurance, depreciation, and interest were also calculated. The machinery cost model was based on the following information: size (hp or ft); fuel type (1 = gas; 2 = diesel); purchase price; salvage value; life (hrs); annual use by crop (hrs); total annual use (hrs); capacity (acres\hour); interest rate; labor ($/hr); gas and diesel cost ($/gal); and repair factors (RC1 and RC2).

The machinery are shown in Table 9. Purchase prices were obtained from local dealerships and the North American Equipment Dealers Association, Official Guide Tractors and Farm Equipment (1992). Salvage value assumptions were: machine = 30 percent of purchase price; implement = 20 percent of purchase price. Willett and Smathers (1992) provide a table of repair factors and life (hrs) for tractors and farm equipment in the Pacific Northwest. Total annual use was the total hours the machine and implement were used for the entire farm.

Total annual use =

$$\Sigma \textit{ machine and implement annual use by crop} \tag{13}$$

Annual use by crop was the number of hours the machine and implement were used for that crop only. Annual use by crop =

$$\frac{\textit{Total acres of crop}}{\textit{acres per hour for each operation}} \tag{14}$$

This was necessary in order to allocate annual costs to individual enterprises. Willett and Smathers (1992) annual interest calculation was modified by calculating interest cost per hour for each machine and implement, then calculating total interest cost per year.

Interest cost per hour =

$$\frac{\frac{\textit{Purchase price} + \textit{Salvage value}}{2} \times \textit{interest rate}}{\textit{Total annual use}} \tag{15}$$

Interest cost per year =

$$\textit{Interest cost per hour} \times \textit{Annual use by crop} \tag{16}$$

Straight-line depreciation and insurance were also modified in order to allocate annual costs to individual enterprise.

Depreciation cost per year =

$$\frac{\textit{Annual use by crop}}{\textit{Remaining life}} \times (\textit{Current Value} \times [1 - (\frac{\textit{Salvage value}}{\textit{Current value}})]) \quad (17)$$

Insurance cost per year =

$$\textit{Insurance multiplier} \times \textit{Current value} \quad (18)$$

Total interest, depreciation, and insurance costs per year for the rotation were arrived at by summing each crop's machine and implement interest, depreciation, and insurance costs per year. A 10 percent interest rate was assumed. The wage rate was set at $9.50/hr for both owner-operator and hired labor, including all payroll overhead and taxes. Gas and diesel prices, $1.159 and $0.819 respectively, were quoted from a local wholesaler in January 1993. Fuel and repair costs were also modified from those given by Willett and Smathers (1992). Fuel cost per hour was calculated as:

$$\textit{Diesel cost} \times \textit{horsepower} \times \textit{fuel multiplier} \quad (19)$$

Fuel cost per acre =

$$(\frac{1}{\textit{acres per hour}}) \times \textit{fuel cost per hour} \quad (20)$$

Repairs cost per hour was modified to be calculated as:

$$\frac{\textit{Purchase price} \times \textit{RC1} \times (\frac{\textit{Remaining life} + \textit{Annual use by crop}}{1000})^{RC2} - (\frac{\text{Remaining life}}{1000})^{RC2}}{\textit{Annual use by crop}} \quad (21)$$

Repair cost per acre =

$$\left(\frac{1}{\textit{acres per hour}}\right) \times \textit{Repair cost per hour} \tag{22}$$

Total fuel and repair cost per acre per crop was the sum of the fuel and repair costs per acre by crop plus the sum of the miscellaneous equipments repair and fuel costs per acre. The miscellaneous equipment consists of a blade, ditcher, pickup, and trucks that were used by the entire farm. Fuel cost per year for pickups and trucks was calculated as:

$$\textit{Diesel cost} \times \left(\frac{\textit{Total annual miles}}{\textit{miles per gallon}}\right) \tag{23}$$

then fuel cost per acre was calculated as:

$$\frac{\textit{Total - machine and implement fuel cost per year}}{500 \textit{ acres}} \tag{24}$$

Repair costs per year on the pickup and trucks were assumed at 2% of purchase price. Repair cost per acre was calculated as:

$$\frac{\textit{Total - machine and implement repair cost per year}}{500 \textit{ acres}} \tag{25}$$

The fuel and repair cost per acre per crop and annual fixed costs of insurance, depreciation and interest were then entered into Planetor to calculate whole-farm economic results.

Table 9. Machinery and Implement Values, Calculated Annual Use, and Capacity

Description	Units	Tractor	Tractor	Tractor	Tractor	Tractor	Plow	Disk	Groundhog	Grain Drill
Size	hp/ft	140	105	95	75	65	4-16	18		12
Fuel type	1 or 2	2	2	2	2	2				
Purchase price	$	60,875	52,162	42,910	43,692	38,833	4,500	12,000	7,900	8,000
Life	hrs	10,000	10,000	10,000	10,000	10,000	2,000	2,000	2,000	1,200
Total Annual use	hrs	451	437	211	354	40	165	75	92	17
Capacity	ac/hr						3	6	6	6

Table 9. Machinery and Implement Values Continued

Description	Units	Fertilizer Spreader	Sprayer (Boom)	Combine	Flail Chopper	Ripper	Corrugator/ Chisel	Corrugator	Roller-Harrow	Potato Planter
Size	hp/ft		50	190						4-row
Fuel type	1 or 2			2						
Purchase price	$	450	3,500	110,000	7,800	3,400	3,500	2,000	6,000	22,875
Life	hrs	1,200	1,500	2,000	2,500	2,000	2,000	2,000	2,000	1,200
Total Annual use	hrs	20	53	33	20	33	13	70	17	33
Capacity	ac/hr	10	10	3	5	3	8	6	6	3

Table 9. Machinery and Implement Values Continued

Description	Units	Lilliston Cultivator	Tire Roller	Potato Digger	Chisel	Harrow	Float	Beet Planter	Allway Cultivator	Beet Topper
Size	hp\ft	6-row			17	5	10	6-row		6-row
Fuel type	1 or 2									
Purchase price	$	4,500	2,500	42,000	4,500	300	6,750	4,580	6,000	17,000
Life	hrs	2,000	2,000	2,500	2,000	2,000	2,000	1,200	2,000	2,500
Total Annual Use	hrs	64	13	200	66	66	20	33	47	33
Capacity	ac/hr	7	8	0.5	3	6	5	3	7	3

Table 9. Machinery and Implement Values Continued

Description	Units	Beet Digger	Corn Planter	Sidedress Injector	Bed Harrow	Onion Planter	Crust Buster	Onion Topper	Onion Lifter	Onion Loader
Size	hp/ft		6-row		6-row	6-row			3-bed	
Fuel type	1 or 2									
Purchase price	$	43,000	11,000	4,500	4,700	6,230	300	34,500	3,700	41,000
Life	hrs	2,500	1,200	1,200	2,000	1,200	2,000	2,000	2,000	2,000
Total Annual Use	hrs	50	25	25	20	50	25	25	25	63
Capacity	ac/hr	2	4	4	5	2	4	4	4	1.6

Table 9. Machinery and Implement Values Continued

Description	Units	Bean Planter	Bean Windrower	Bean Combine	Ditcher	Blade	Pickup	8 Trucks	Mulch Machine
Size	hp/ft	6-row					3/4 Ton		3-row
Fuel type	1 or 2						2	2	
Purchase price	$	11,000	16,500	40,000	1,500	3,000	19,000	616,000	6,228
Life	hrs	1,200	2,000	2,000	2,000	2,000	100,000 mi	400,000 mi	2,500
Total Annual Use	hrs	20	20	50	10	40	20,000 mi	40,000 mi	200
Capacity	ac/hr	5	5	2					2

Alternative Practices

Alternative management practices which require the use of fewer potential contaminants or which reduce potential contaminants entering groundwater were identified by the expert panel. The five alternatives analyzed include surge irrigation, laser leveling, straw mulching, sampling (soil and petiole tissue testing), and sprinklers. Each alternative farming practice was analyzed by modifying baseline parameters and assumptions used in the analysis discussed in the previous section. It was assumed that sufficient capital was available to fully implement an alternative. It does not account for the costs of adjustment and change in net worth which occurs when an alternative is adopted. Thus, new equilibrium results are analyzed and transition results are ignored.

The first alternative to be discussed is surge irrigation. This irrigation practice uses an intermittent application of water to each side of a field during an irrigation set, as opposed to conventional furrow irrigation where water is applied continuously. This allows the furrow to be wet and then dry a little, thereby compacting the soil and slowing down infiltration. This allows water to reach the end of the field in less time, decreasing irrigation water requirements (Yonts, Eisenhauer, and Cahoon, 1991). Adoption of surge irrigation requires gated pipe, a surge valve, and a surge controller. The surge valve is the switch valve that applies the water to each side of the field, and the surge controller is programmed to switch the surge valve at the desired time. The surge valve and surge controller are known as a surge unit. The surge irrigation alternative assumed all fields were irrigated with ten inch gated pipe and eight surge units. With a field size of twenty acres, it was assumed that one surge unit was used for every three fields; thus eight surge units were required for 25 fields. Gated pipe laying across the tops of 25, 20 acre fields with a width of 933 feet each, required 23,330 feet of ten inch gated pipe. Surge irrigation also assumed that yields would stay the same while cutting water use in half (Miller and Shock, 1993; Miller, Shock, Stieber, and Saunders, 1992) and labor cost was reduced by 2O percent. Overall, cash costs decreased with a decrease in direct crop labor, operating interest expense and miscellaneous general overhead, and a slight increase in repairs occurred. The purchase of 23,330 feet of gated pipe at $2.27 a foot and eight surge units at $1,898 increased depreciation and interest. Total capital required to adopt surge irrigation was $ 68,143.

Laser leveling is the leveling of a field with the aid of a laser. This is a more efficient practice than leveling by eye. This allows uniform irrigation of a field so that water reaches the end of the field more quickly and uniformly, thereby preventing ponding and dry spots. This results in reduced soil erosion (U.S.D.A. Soil Conservation Service, 1988). Laser leveling was assumed to be performed on all acreage at a cost of $225 per acre with $0 salvage value and a life of 20 years(U.S.D.A. Soil Conservation Service, 1988). Total capital required to implement laser leveling was $112,500. Based on the expert panel input, it was assumed that yield increased by 15 percent and that water use was reduced by 20 percent. Onions crop marketing ($0.136 a pound, net packout) and commodity storage costs ($13 a bin, gross packout) increased due to their dependence on yield. Depreciation and interest from laser leveling increased due to the 15 percent increase in land value that resulted from a 15 percent increase in yields. It was assumed that property tax remained unchanged because laser leveling would increase land value only if the land was sold.

Straw mulching is the application of straw to the soil surface between rows to help maintain soil moisture, reduce soil erosion, and control weeds (U.S.D.A. Soil Conservation Service, 1988). Straw mulching is completed for the entire row of all row crops. This requires 800 pounds of straw per acre, with potatoes requiring slightly more (Shock, Hobson, Banner, Saunders, and Stieber, 1993; Shock, Hobson, Banner, Saunders, and Townley, 1993). Mulching involved the purchase of a three-row, one bale chamber mulch machine and additional labor to operate the machine, which was pulled by a 65 horsepower tractor. The purchase price of a three-row, one bale chamber mulch machine was $6,228. Straw mulching increased fuel, repairs, miscellaneous crop expense (straw use) and operating interest expense. It also increased insurance, miscellaneous general overhead, interest, and depreciation.

Sampling involves testing the soil for nitrogen and other nutrients as well as tissue testing for nitrogen (U.S.D.A. Soil Conservation Service, 1988). This practice balances crop nutrient requirements with fertilizer applications. Perry, Fleming, and Conway (1992) note that on average only 39 percent of the fields had samples taken in any given year. They also mention that less than two-thirds of the more commonly tested sugarbeet and potato fields were actually tested. Sampling (soil and petiole tissue tests) was done on all crops and assumed that less applied nitrogen in the rotation would be needed. However, the reduction amount will depend on site specific soil tests. All crops except wheat had a complete soil test ($32 per field) and six petiole tissue tests ($18 per test = $108 per field). Wheat had a complete soil test and no applied nitrogen, assuming it would have the same yield while recovering the nitrogen left in the soil from the previous onion crop in the rotation (Simko, Jensen, and Supkis, 1993; Miller, Stieber, Shock, and Saunders, 1991). Thus for wheat, fertilizer, custom hire, operating interest expense, and miscellaneous general overhead decreased because the reduction in fertilizer cost offset the increase in miscellaneous crop expense (soil test at $0.32 an acre). The remaining crops of potatoes, sugarbeets, sweet corn, and onions had miscellaneous crop expense (soil and petiole tissue tests at $1.40 an acre or $140 a field) and operating interest expense increase and miscellaneous general overhead decrease.

Sprinklers are a water application practice that allows for more efficient water use. Sprinklers were used only on potatoes and a 30 percent reduction in water use was assumed. Thirty percent may be slightly conservative, as Shock, Stieber, and Eldredge (1993) have a 40 percent reduction in water use when comparing sprinklers with furrow irrigation. Sprinklers are used primarily on potatoes because yield and grade quality does not seem to be as high when they are used on other crops such as onions. Feibert, Shock, and Saunders (1993) have found that onion yield is less with sprinklers than with furrow irrigation, but noted that some adjustments need to be made with sprinklers for an accurate comparison. Sprinklers are not used on wheat, sugarbeets, and sweet corn because of the high cost of conversion and the questionable economic justification. Forty acres of sprinklers were rented at a cost of $9,000 ($225 an acre) and one pump was rented for five months at a cost of $5,000 ($1,000 a month). Additional labor was needed to set out, move, and retrieve the pipe. The cash costs of irrigation energy ($2 ac/in * 48 in/yr = $96 ac/yr), direct crop labor, miscellaneous crop expense (pipe and pump), and operating interest expense increased. Miscellaneous general overhead also increased.

Environmental Analysis

This section will discuss the environmental components analyzed and how they were calculated. The baseline and alternative farming systems environmental analysis includes soil erosion (tons per acre), total water use (acre feet used and inches per irrigated acre), and nitrogen leached from the root zone (lb N/acre). Soil erosion and total water use was calculated by Planetor while nitrogen leached from the root zone was calculated by NLEAP. A few environment assumptions of the baseline and alternative farming systems were mentioned in the previous section, but the assumptions for calculating nitrogen leached from the root zone are discussed here. The baseline system assumed 35 percent of the irrigation water applied runs off the field. The residual soil nitrate was assumed to be 75 lbs. N/acre for the baseline, surge, sprinklers, and mulching; 56 lbs. N/acre for laser leveling; and 48 lbs. N/acre for sampling. Surge assumed 15 percent runoff (Miller and Shock, 1993) as did straw mulching (Shock, Hobson, Banner, Saunders, and Townley, 1993).

Planetor technical notes (1990) calculated the annual soil loss in tons per acre based on the Universal Soil Loss Equation (USLE)

$$A = R\ K\ LS\ C\ P \tag{26}$$

where

A = Estimated Average Annual Soil Loss (tons per acre)

R = Rainfall factor

K = Soil-Erodibility factor (stored in the soils data base)

LS = Combined Effect of Slope Length and Steepness (calculated)

C = Cover and Management Factor (0.001 to 1.0)

P = Practice (contouring, contour strip, ridge till, terracing, or other)

The estimated average annual soil loss (A) for the baseline and each alternative is shown under resources in Table 10. The rainfall factor (R) was determined by a map that predicts rainfall erosion losses (Planetor Technical Notes, 1990). The soil-erodibility factor (K) varied with the soil type selected. The combined effect of slope length and steepness (LS) was stored in the soils database and also varied with the soil type selected. The cover and management factor (C-factor) depended on the crops grown on the soil type selected. The C-factor was entered for the baseline and each alternative: baseline, surge irrigation, laser leveling, sampling, and sprinklers = 0.430 and straw mulching = 0.06. The baseline and alternatives practice (P) used was "other". The results of the environmental and economic analysis follow in the next section.

Results

In comparing the alternatives with the baseline (see Table 10: Whole Farm Environmental and Economic Comparison) laser leveling and sampling are the only two with positive changes in net returns of $97,649 and $5,216 respectively. Surge irrigation, straw mulching and sprinklers have negative changes in net returns of ($3,580), ($10,230), and ($28,605) respectively.

Surge irrigation has a zero percent increase in total return and a one percent decrease in cash costs from the reduction in labor, which results in a one percent increase in return over cash costs. The 2.7 percent increase in depreciation and interest is from the purchase of gated pipe and surge units. Thus, a three percent decrease in net return and a 3.7 percent decrease in change in net worth results. Soil loss has a zero percent change and total water use has a 50 percent reduction, just as previously mentioned in the alternative practices section. The nitrogen lb N/acre, is nitrogen leached from the root zone in pounds of nitrogen per acre, has a 54 percent decrease compared with the baseline.

Table 10. Whole Farm Environmental and Economic Comparison

	Baseline	Surge	Surge %Δ[1]	Laser	Laser %Δ[1]	Mulch	Mulch %Δ[1]	Sampling	Sample %Δ[1]	Sprinklers	Sprinkle %Δ1
Economics ($)											
Total Return	779,735	779,735	+0.0	896,695	+15.0	779,735	+0.0	779,735	+0.0	779,735	+0.0
Cash Costs	381,693	377,743	-1.0	389,754	+2.1	388,705	+1.8	376,718	-1.3	408,976	+7.2
Return Over Cash Costs	398,042	401,992	+1.0	506,941	+27.4	391,030	-1.8	403,017	+1.3	370,759	-6.9
Depreciation & Interest	278,507	286,037	+2.7	289,757	+4.0	281,725	+1.2	278,266	-0.1	279,829	+0.5
Net Return	119,535	115,955	-3.0	217,184	+81.7	109,305	-8.6	124,751	+4.4	90,930	-23.9
Δ in Net Worth	70,682	68,105	-3.7	138,603	+96.1	63,317	-10.4	74,438	+5.3	52,195	-26.2
Δ in Net Return		(3,580)		97,649		(10,230)		5,216		(28,605)	
Resources											
Soil Loss	1.7	1.7	+0.0	0.9	-47.1	0.2	-88.2	1.7	+0.0	1.7	+0.0
Total Water Use											
tot. ac. ft.	1775.0	887.5	-50.0	1420.0	-20.0	1775.0	+0.0	1775.0	+0.0	1655.0	-6.8
in./irrg. ac.	42.6	21.3	-50.0	34.1	-20.0	42.6	+0.0	42.6	+0.0	39.7	-6.8
Nitrogen[2]											
lb N/acre	52.30	24.03	-54.0	29.56	-43.5	72.15	+38.0	42.71	-18.3	48.30	-7.7

[1] The percentage change relative to the baseline results.

[2] Nitrogen leached from the root zone.

Laser leveling has the only increase in total return at 15 percent. The 15 percent increase in yield results in a 2.1 percent increase in cash costs. Return over cash costs increase by 27.4 percent. The cost of laser leveling increases depreciation and interest by four percent. Laser leveling net return increases 81.7 percent and change in net worth increases 96.1 percent. Soil loss decreases by 47.1 percent and total water use decreases by 20 percent. Nitrogen leached from the root zone is 43.5 percent less.

Straw mulching has no percentage change in total return, a 1.8 percent increase in cash costs from additional labor and straw use, thereby resulting in a 1.8 percent decrease in return over cash costs. The purchase of the mulch machine increases depreciation and interest 1.2 percent and reduces net return and change in net worth by 8.6 and 10.4 percents respectively. Soil loss is reduced by 88.2 percent while there is no change in total water use. Straw mulching results in a 38 percent increase in nitrogen leached from the root zone and is the only alternative with a positive change.

Sampling has no change in total returns, but the 1.3 percent decrease in cash costs that results from not applying nitrogen to wheat leads to a 1.3 percent increase in return over cash costs. Depreciation and interest decrease 0.1 percent due to the small decrease in operating interest expense. Net return increases 4.4 percent and change in net worth increases 5.3 percent. Sampling has no changes in soil loss or total water use and an 18.3 percent decrease in nitrogen leached from the root zone.

Sprinklers have no change in total return and a 7.2 percent increase in cash costs from irrigation energy and renting a pump and pipe that results in a 6.9 percent decrease in return over cash costs. The 0.5 percent increase in depreciation and interest is caused by an increase in operating interest expense. Net return decreases 23.9 percent and change in net worth decreases 26.2 percent. There are no changes in soil loss with sprinklers, but a 6.8 percent decrease in total water use. Sprinklers have 7.7 percent reduction in nitrogen leached from the root zone.

Based on the economic and environmental analysis results for each of the alternatives relative to the baseline, a sensitivity analysis was performed on laser leveling since the assumed increases in yield and decreases in water use had such large effects on net return and nitrogen leached from the root zone. Table 11 shows the effects on net return and nitrogen leached given yield increases of zero, five, ten, fifteen, and twenty percent and water use reductions of zero, six, thirteen, twenty, and twenty-six percent. This two-way table allows any yield increase and water decrease combination to be chosen and then reports the net return and nitrogen leached from the root zone given that combination.

Table 11. Laser Leveling Net Returns and Nitrogen Leached from the Root Zone given Yield Increases and Water Use Reductions.

Increase In Yield		Reduction In Water Use Zero %	Six %	Thirteen %	Twenty %	Twenty-Six %
Zero %	Net Returns	108,285	108,285	108,285	108,285	108,285
	Nitrogen [1]	52.30	46.98	41.22	35.73	30.83
Five %	Net Returns	144,595	144,595	144,595	144,595	144,595
	Nitrogen [1]	49.37	44.35	38.90	33.72	29.10
Ten %	Net Returns	180,896	180,896	180,896	180,896	180,896
	Nitrogen [1]	46.45	41.72	36.59	31.73	27.37
Fifteen %	Net Returns	217,184	217,184	217,184	217,184	217,184
	Nitrogen [1]	43.29	38.37	34.09	29.56	25.50
Twenty %	Net Returns	253,486	253,486	253,486	253,486	253,486
	Nitrogen [1]	40.38	36.24	31.78	27.56	23.77

[1]Nitrogen leached from the root zone in pounds N per acre.

Other Practices

This section will describe the other alternative practices that the expert panel identified and the reasons why they were not evaluated at this time. The alternatives that were identified but not evaluated are deep ripping, recovery ponds, filter strips, alfalfa/grass crops, and water mark sensors.

Deep ripping is the loosening of the soil below plow depth to increase infiltration and root growth (U.S.D.A. Soil Conservation Service, 1988). Deep ripping breaks up the hard pan and improves the soil's ability to hold water. With increased infiltration, surface runoff and soil erosion is reduced. In addition, the potential for denitrification is reduced by deep ripping (U.S.D.A. Soil

Conservation Service, 1988). Deep ripping was not analyzed because the farmers that have needed to use this alternative have already done so. Deep ripping also requires the field to go into permanent cover for three years to prevent compaction and establish normal root growth. Permanent cover is a deep rooted crop such as pasture or alfalfa, and was not felt to be economically feasible by the expert panel.

Recovery ponds are essentially return flow systems and consist of two ponds (U.S.D.A. Soil Conservation Service, 1988). The first pond is long and shallow and catches sediment. The second pond is deep and the water which drains into it from the first pond is pumped back onto the field from here. Recovery ponds let the water be reused as well as any fertilizer or chemicals in the water. Some farmers are irritated by the use of recovery ponds by the farmer above them on the irrigation ditch line because the farmer below is no longer able to use that water to irrigate fields. An additional complaint is that some farmers over-irrigate in order to fill their ponds. Despite these arguments, recovery ponds may be useful in drought periods in that one or more irrigation sets can be applied. Recovery ponds were not evaluated even though they have zero sediment loss. The reason they weren't evaluated involves water right laws that require farmers to use all their water allocation or lose their right. It's difficult to determine the water savings when a farmer pays for a certain amount of acre feet and then has to use all the water even if it's not needed.

Filter strips are a strip of vegetation cover at the beginning and/or end of a field to reduce soil erosion and remove other runoff matter (U.S.D.A. Soil Conservation Service, 1988). Filter strips are economical in that most are wheat and they can be planted easily with the grain drill. There is no value in the wheat because it does not reach maturity; its only purpose is vegetation. There are several farmers using filter strips already and they will reduce soil erosion, but it's very difficult to place numbers on; thus they weren't evaluated.

An alfalfa/grass crop could be planted into the rotation to remove nitrogen and other nutrients from the soil. The harvested hay crop that could be sold to local dairy and beef cattle producers would be additional farm income. However, an alfalfa/grass crop was not felt to be economically feasible given the high value of land in the area.

Watermark sensors are modified gypsum blocks that provide a means to determine soil water potential (Shock and Barnum, 1992). They increase water use efficiency and thus aid in nitrogen management. Water mark sensors were not evaluated because not enough information was available. The water mark sensors appear to be a good alternative, but it will depend on the farmer's management skills.

The success of any of the alternatives will depend on the farmer's management skills. Future research possibilities include evaluation of watermark sensors and drip irrigation. When additional applied crop research is available, economic and environmental evaluation of the practices will be possible.

CHAPTER FOUR

This chapter will begin by discussing how the specific model of the farm firm relates to the dairy farm analysis. It will discuss the use of enterprise and whole farm budgets to calculate the economics of baseline and alternative management practices; baseline results; alternative practice selection criteria and results; why other alternatives were not evaluated; and why additional environmental analysis is not performed.

SPECIFIC MODEL OF THE FARM FIRM

The model, Planetor (planning system), is consistent with the theory of the firm discussed in chapter two. In relating Planetor to equation three, the inputs (x_{jt}'s) are the following: purchased feed and artificial insemination. The outputs (q_{it}'s) are the following: milk and calves. The price coefficients (p_{it}'s and r_{jt}'s) are expected prices of the outputs and prices of the inputs respectively.

Expected sale quantity (Oregon State University Extension Service, Malheur County Office, 1992) and price per hundred weight (cwt.) (Schneider, 1993) were based on historical data. Baseline dairy farming practices sale quantity and price per hundred weight are shown in Table 12.

Table 12. Baseline Dairy Farming Practices Sale Quantity and Price Per Cwt.

	Per Cow
Expected annual sale quantity (cwt.)	180.00
Expected price per cwt	12.00

The cash operating costs and overhead expenses were taken directly from the Oregon State University Extension Service enterprise budget. The following items were grouped as miscellaneous livestock expense: DHIA - Dairy Herd Improvement Association (production testing), bedding, dairy vehicle costs (fuel), and herd replacement. Baseline dairy farming practices cash operating costs are shown in Table 13 and overhead expenses in Table 14.

The baseline farming practices and alternative farming practices results from the simulation are presented in the next section.

Table 13. Baseline Dairy Farming Practices Cash Operating Costs

Cash Operating Costs	$ Per Cow
Purchased feed	948.00
Artificial insemination	30.00
Health	40.00
Supplies	40.00
Direct livestock labor	210.00
Repairs	40.00
Marketing	120.00
Miscellaneous livestock expense	352.00
Interest expense	43.00
Total	1823.00

Table 14. Baseline Dairy Farming Practices Overhead Expenses

Overhead Expenses	$ Per Year
Taxes	2000.00
Insurance	1000.00
Utilities	4000.00
Miscellaneous	4000.00
Interest on overhead expense	10,500.00
Depreciation	7,000.00
Total	28,500.00

DAIRY FARM RESULTS AND DISCUSSION

Baseline farming practices were constructed based on Oregon State University Extension Service enterprise budgets and input from a panel of four local farmers, extension staff, and agency staff. The panel identified a dry lot dairy farm with 100 Holstein cows each producing 18,000 pounds a year. They decided on a 200 acre farm that produced equal acreage of alfalfa hay, corn for silage, and barley. These feed crops were grown on Virtue, Nyssa, and Frohman soils with zero to two percent slopes. The model farm assumed the producer maximizes profits subject to feed and reproductive constraints.

Baseline Economic Analysis

Enterprise budgets were constructed based on dairy farm operations. The crops that were grown for feed were valued at market price, therefore they were not budgeted in the farm plan. Appendix B shows the dairy farm income and labor allocation on page 82 and the cash operating costs and feed requirements on pg 83.

Alternative Practices

Alternative management practices which reduce dairy barn runoff and conserve manure nutrients were discussed by the expert panel and the most promising alternative was identified. The alternative analyzed was a combination manure push wall and evaporation basin. The alternative management practice was analyzed by modifying baseline parameters and assumptions used in the analysis discussed in the previous section. It was assumed that sufficient capital was available to fully implement the alternative. It does not account for the costs of adjustment and change in net worth when switching to an alternative. Thus, new equilibrium results are analyzed and transition results are ignored.

The manure push wall was located 60 feet directly behind the dairy barn and ran the full 108 foot length of the barn. It was assumed that this 60 foot by 108 foot area was a concrete slab and that the push wall was built at the edge of the slab. This allows the manure to be scraped from the barn and stacked against the wall, which creates easier stacking, larger stacks, and reduces the number of times manure needs to be spread on fields, thereby conserving manure nutrients. The evaporation basin is an earth pond for storage of milk house and milking parlor waste water. The basin was located directly behind the push wall so that any seepage from the manure stack would run into the basin. This evaporation basin eliminates runoff getting into nearby streams and allows the liquid to evaporate.

The volume of manure to be stored, the size of the storage area, and height of the push wall were based on the Oregon Department of Agriculture's, Oregon Animal Waste Installation Guide Book (1989) as follows:

The volume of manure production for a 180-day storage period given

$$V_{\text{milk cows}} = (no.\ of\ cows)(\frac{wt.\ of\ cow}{1000})(manure\ produced\ daily)(days)(\%\ conf) \qquad (27)$$

equals 32,760 ft^3, assuming 100 cows, 1,400 wt./cow, 1.3 ft^3 manure/day/1000 pounds, 180 days, and confined 100 percent of time.

The volume of bedding given

$$Bedding\ Volume = \frac{(lbs.\ used/day)(days)}{straw\ density} \qquad (28)$$

equals 9,720 ft^3, assuming 378 lbs. of straw used/day, 180 days, and seven lbs./ft^3 straw density. However, in use the volume of bedding will be reduced by one-half, which results in 4,860 ft^3. This is due to only a portion of the straw becoming wet and/or dirty.

The total volume to be stored dry

$$Volume = V_{\text{milk cows}} + Bedding\ Volume \qquad (29)$$

is 37,620 ft^3. Assuming that the 60 foot by 108 foot concrete slab was already in existence, a six foot high push wall would need to be built.

Given the following storage component volumes:

Cow Prep (Manual: 5 gal/milker/day)

Bulk Tank (Auto: 85 gal/wash) times every other day

Pipeline (90 gal/wash) times twice a day

Contributing Drainage Area, three acres

the Malheur County Soil Conservation Service determined an evaporation basin size of:

Bottom Width: 100 feet

Bottom Length: 200 feet

Top Length: 225 feet

Depth: four feet

The push wall was made of 8 foot rail road ties and 20 foot, two inch by 12 inch boards, with the rail road ties set vertically in a concrete curb. With rail road ties set three feet in the ground a five foot wall was constructed, with the two inch by 12 inch boards placed horizontally at three inches apart four rails result. Given 108 foot wall, 20 foot boards, four rails, and rail road ties set six feet apart, 22 boards and 18 rail road ties were needed. In constructing the wall assume one-half yard of cement was required for each rail road tie, resulting in nine yards. Assuming that the milking facilities were flush with the edge of the barn, 60 feet of six inch PVC pipe was needed to pipe the milk house and milking parlor waste water to the evaporation basin.

The purchase of 22 boards at $28 each, 18 rail road ties at $9.99 each, and nine yards of cement at $44.75 a yard resulted in a total push wall cost of $2,800.75. Given the dimensions of the evaporation basin mentioned previously, 3,200 cubic yards of earth at $2 a cubic yard to build and 60 feet of six inch PVC pipe at $0.91 a foot resulted in a total evaporation basin cost of $6,454.60. Total capital required for the combination push wall and evaporation basin was

$9,293.35. The push wall has a useful life of 20 years and the evaporation basin has a useful life of 50 years (United States Department of Agriculture, Soil Conservation Service, 1988). An interest rate of 10 percent was assumed. In addition, repairs were assumed to be two percent of total cost. Overall, depreciation, interest, and repairs increased. Operating interest expense does not increase since it was based on feed costs.

Results

In comparing the alternative with the baseline (see Table 15: Whole Farm Economic Comparison) the push wall and evaporation basin have a negative change in Net Return of $918. The push wall and evaporation basin have no change in total return and a 0.1 percent increase in cash costs from increased repairs, which results in 0.4 percent decrease in return over cash costs. Depreciation and interest increase by 4.2 percent due to the total cost of the structures. Net return and change in Net Worth decrease by 2.6 and 4.4 percent respectively. The push wall and evaporation basin prevent any dairy barn runoff from entering nearby streams or ditches.

Table 15. Whole Farm Economic Comparison

	Baseline	Push Wall & Evaporation Basin	Push Wall & Evaporation Basin %Δ[1]
Economics			
Total Return	238,550	238,550	+0.0
Cash Costs	186,030	186,216	+0.1
Return Over Cash Costs	52,520	52,334	-0.4
Depreciation & Interest	17,500	18,232	+4.2
Net Return	35,020	34,102	-2.6
Δ in Net Worth	15,184	14,523	-4.4
Δ in Net Return		(918)	

[1]The percentage change relative to the baseline results.

The following waste utilization of the manure produced by the 100 Holstein cows was based on the Oregon Department of Agriculture's, Oregon Animal Waste Installation Guide Book (1989). First, determine the nutrients in the excreted manure for the year.

$$lbs. = (no.\ of\ animals)\left(\frac{avg.\ wt.\ of\ animal}{1000}\right)(daily\ production\ of\ nutrient)(days) \qquad (30)$$

assuming, 0.45 lb. N/day/1000 pounds, 0.07 lb. Phosphorus (P)/day/1000 pounds, 0.26 lb. Potassium (K)/day/1000 pounds, 365 days, and number of animals and average weight of animals given previously. There were 22,995 pounds of nitrogen, 3,577 pounds of phosphorus, and 13,286 pounds of potassium produced. Secondly, determine nutrients remaining after storage.

$$lbs.\ retained = (lbs.\ of\ nutrient\ produced)(\%\ retained) \tag{31}$$

assuming, open lot storage, 60 percent of N retained, 70 percent of P retained, and 65 percent of K retained. There were 13,797 pounds of nitrogen, 2,504 pounds of phosphorus, and 8,636 pounds of potassium retained after storage. Thirdly, determine nutrients remaining after application.

$$lbs.\ retained = (lbs.\ after\ storage)(\%\ retained) \tag{32}$$

assuming, broadcast application, 80 percent of N retained, and 100 percent of P and K. There were 11,038 pounds of nitrogen, 2,504 pounds of phosphorus, and 8,636 pounds of potassium retained after application. Fourth, determine nitrogen remaining after denitrification.

$$lbs.\ retained = (lbs.\ after\ application)(\%\ retained\ by\ soil\ type) \tag{33}$$

assuming, well drained soils with 90 percent of inorganic nitrogen retained. Thus, for the well drained Virtue, Nyssa, and Frohman soils there were 9,934 pounds of nitrogen, 2,504 pounds of phosphorus, and 8,636 pounds of potassium remaining after denitrification. Fifth, determine nutrients remaining after recalcitrant losses.

$$lbs.\ retained = (lbs.\ after\ denitrification)(\%\ retained) \tag{34}$$

assuming, 90 percent of N, P, and K are retained after recalcitrant losses. There were 8,941 pounds of nitrogen, 2,254 pounds of phosphorus, and 7,772 pounds of potassium remaining after recalcitrant losses. Lastly, determine the acres required to recycle nutrients.

$$Acres\ required = \frac{nutrients\ available}{(lbs.\ of\ nutrients\ removed\ by\ crop)(crop\ yield)} \qquad (35)$$

assuming the crops, yields (Oregon State University Department of Agricultural and Resource Economics, 1980-1991), and pounds of nutrients removed by the crop shown in Table 16.

Table 16. Crops, Yields, and Pounds of Nutrients Removed by the Crop

			lbs. of nutrients removed		
	Yield	Unit	N	P	K
Crop					
Corn Silage	21.5	Tons	7.0	1.3	6.6
Alfalfa	4.4	Tons	76.8	7.7	61.4
Barley	81	Bu.	41.6	5.0	7.2

It was assumed that manure would be spread on corn silage acreage first followed by alfalfa then barley. Manure was applied to the crop acreage until the limiting nutrient required the number of acres that the crop was grown on. Then the percentage of the nutrient used was calculated. The percentage was then used to calculate the pounds of the other nutrients used by the crop. The remaining percentage of nutrients available were then spread on the next crop acreage. This same procedure was continued until all the nutrients were used. For example: corn silage's limiting nutrient is P, thus manure was applied until the acres required to recycle P was 65. The pounds of P used was 80 percent of the total available. Corn silage also used 80 percent of the total available N and K. The remaining 20 percent of the nutrients was spread on alfalfa. Table 17 shows the pounds of nutrients used and acres used to recycle the nutrients for each crop.

Table 17. Pounds of Nutrients Used and Acres Used to Recycle Nutrients by Crop

Nutrients		Corn Silage	Alfalfa	Barley
N	acres used	47.88	5.13	0
	lbs. of nutrients used	7206.45	1734.55	0
P	acres used	65	12.91	0
	lbs. of nutrients used	1816.75	437.25	0
K	acres used	44.15	5.58	0
	lbs. of nutrients used	6264.23	1507.77	0

Each crop was short the required nutrients and thus required supplemental commercial fertilizer. To determine supplemental commercial fertilizer.

$$\textit{lbs. nutrient required} = (\textit{acres available} - \textit{acres used})(\textit{lbs. utilized per acre}) \qquad (36)$$

assuming, 65 acres available for each crop and lbs. utilized per acre = lbs. of nutrients removed by crop * crop yield. Since commercial fertilizer formulations and recommendations are expressed as N, P_2O_5, and K_2O, P must be multiplied by 2.288 and K must be multiplied by 1.205. The pounds of supplemental fertilizer required for each crop are shown in Table 18.

Table 18. Supplemental Commercial Fertilizer Required

Nutrients	Corn Silage	Alfalfa	Barley
N lbs.	2,577	20,231	6,544
P lbs.	0	4,038	1,800
K lbs.	2,959	19,344	1,364

The costs of supplemental fertilizer for each crop are shown in Table 19. Nitrogen was \$0.31/lb., Phosphorus (P_2O_5) was \$0.12/lb., and Potash (K_2O) was \$0.23/lb. There was no cost for N for alfalfa as it was assumed that alfalfa fixed its own nitrogen.

Table 19. Cost of Supplemental Fertilizer

Nutrients	Corn Silage	Alfalfa	Barley	Total $
N	798.73	0	2,028.50	2,827.23
P	0	484.55	215.94	700.49
K	819.98	4,449.06	313.82	5,582.86
Total $	1,618.71	4,933.61	2,558.26	9,110.58

The fertilizer savings from manure application are shown in Table 20.

Table 20. Fertilizer Savings from Manure Application

Nutrients	Corn Silage	Alfalfa	Barley	Total $
N	2,234.00	537.71	0	2,771.71
P	218.01	52.47	0	270.48
K	1,440.77	346.79	0	1,787.56
Total $	3,892.78	936.97	0	4,829.75

By comparing Table 19 with Table 20 it is evident that corn will have an overall savings in nutrients of $2,274.07, while alfalfa and barley will have costs of $3,996.64 and $2,558.26 respectively. Application of commercial fertilizer will still be necessary for the farm and will cost $4,280.83. The $4,829.75 total fertilizer savings from manure application offsets the negative change in net return of $918 in Table 15 by $3,911.75.

CHAPTER FIVE

SUMMARY AND CONCLUSIONS

Malheur County is located in the southeast corner of Oregon and consists of about 6.4 million acres (Water Quality Plan Ontario Hydrologic Unit, 1991). The area where the Malheur, Owyhee, and Snake River Valleys meet in Northern Malheur County is more commonly known as the Treasure Valley. The high value crops of onions, potatoes, sugarbeets, alfalfa seed, and sweet corn among others are typical of the area and are largely irrigated with furrow irrigation. Most of the dairy farms in Malheur County are located between the Owyhee and Malheur River drainage systems and have an average herd size of 86 cows (Schneider, 1993).

Groundwater contamination has been found in a 115,000 acre in Northeastern Malheur County and as a consequence, the DEQ designated it as a Groundwater Management Area (Malheur County Groundwater Management Committee, 1991). This same area has also been designated a HUA by the USDA. The main source of the surface and groundwater contamination is agricultural practices (Water Quality Plan Ontario Hydrologic Unit, 1991).

The overall objective of this research project was to design and evaluate environmentally sound and economically feasible alternative row crop and dairy farming systems for Northern Malheur County. This objective was accomplished using whole-farm budgets to evaluate the performance of alternative practices.

Based on the literature review, it is apparent that the common approaches to environmental and economic analysis are linear programming and growth and physical simulation models. Comparison of baseline and alternative scenarios is also common. Most of the previous research focused on erosion and chemicals as single environmental factors.

The theory of the firm is used as the basis for the empirical economic analysis as it provides a useful approximation in understanding the "real world" relationships. The firm owner and/or manager transforms inputs into outputs subject to their production function. The objective of the firm that sells their products in a perfectly competitive market is profit maximization, the difference between revenue from outputs and expenditure on inputs.

In choosing alternative farming systems, economic and environmental implications are a major limitation. The baseline farming system and each alternative farming system for row crop and dairy farms had a detailed whole-farm budget completed and evaluated using Planetor, a whole farm planning system for SMART. In addition, NLEAP was used to evaluate nitrogen leached from the root zone for the row crop alternatives.

While previous studies have accomplished the economics and environmental evaluation of alternative farming systems using optimization models, this research used whole-farm budgeting. Although the results of this research may not be optimal, they are feasible. They also arrived at the same conclusions as previous studies. As indicated by the results of this research and previous research, implementing best management practices to reduce soil erosion, water use, and nutrient runoff and leaching, can increase profits. Specificly, this research shows that by implementing the BMP, laser leveling, profits will increase while reducing soil loss, water use, and nitrogen leaching. Another practice that increases profits and reduces nitrogen leaching is sampling. Sampling appears to be a good alternative, but without knowing what will happen to nitrogen in both the baseline and alternative practices no conclusions can be drawn. The effects of sampling really depend on the farmers ability to manage. In other words there may be little or no improvement or there could be a large improvement. However, sampling has the potential to become a BMP for wheat (Simko, Jensen, and Supkis, 1993).

Straw mulching reduces soil erosion and total return just like Wade, Nicol, and Heady (1976) found in evaluating income changes based on public and environmental policies that allowed unlimited soil loss (base year), five tons per year, and three tons per year. Just as Crowder, Pionke, Epp, and Young (1985) found that permanent vegetative cover was not cost effective, this research did not evaluate an alfalfa/grass crop alternative because of the high land values typical of the area.

In reducing nutrient runoff from dairy farms, this research and previous research have found that storing and applying dairy barn runoff is cost effective because of the savings in nutrients from storage. Although this research shows a small negative change in net return from storing manure, this can be offset by the savings in nutrients from storage because of the commercial fertilizer that will not have to be purchased and applied to the crop fields.

Several future research possibilities exist for both row crop and dairy farms. The water mark sensors appear to be a good alternative, but additional crop research is necessary for a complete economic and environmental analysis. Other irrigation alternatives that look promising but need additional crop research are drip irrigation and alternate furrow irrigation. The laser leveling and surge irrigation alternatives that have yield changes as a function of management practice changes need further analysis to be able to predict yield impacts. In addition, to perform a more accurate nitrogen leaching analysis, more site-specific data such as the actual residual soil nitrate results of a soil test, and the percentage of water runoff based on specific field parameters (length of furrow, crops grown, slope of field, management practices, etc.) are needed. For dairy farms the analysis could be extended to include heifer raising facilities and the practices used in growing crops for feed. When additional applied research is available for new and current alternative farming systems for both row crop and dairy farms, an economic and environmental evaluation of the systems will be possible.

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APPENDICES

Appendix A

PLANETOR CROP ROTATION BUDGET

Field Name: 1a
Description: Wheat-Potatoes-Beets-Corn-Onions

Farm: W,P,B,C,O
Date: August 1, 1993

**** RESOURCE MANAGEMENT STRATEGIES ****

C-Factor for this rotation	0.430
Irrigation system used	Flood
Tillage system	Unrestricted
Input level	Unrestricted
Length of the rotation (yrs)	5

**** COMMENTS ****

Baseline system. 500 acres - 20 acre fields. Furrow irrigation - all dirt ditches.

**** CROP PLAN ****

Year	Primary Crop	Second Crop
1	Wheat Winter	
2	Potato Sum.	
3	Sugarbeets	
4	Sweet Corn	
5	Onions Summr	

**** SUMMARY DATA ****

	Year 1	Year 2	Year 3	Year 4	Year 5
Excess nitrogen (lbs)					
With expected yield	-3	48	55	131	146
With optimistic yield	-28	10	43	126	132
Highest chemical rating					
Toxicity	Medium	High	High	High	High
Leaching potential	Low	High	Medium	Medium	Low
Run-off potential	Medium	High	High	Medium	High
Diesel equivalents (gallons)	22.78	33.50	29.31	34.17	50.25
BTU equivalents (millions)	3.19	4.69	4.10	4.78	7.04
Value of exp. yield - Crop 1 ($)	385	1740	1116	514	4043
Value of exp. yield - Crop 2 ($)	-	540	-	-	-

		Year 1	Year 2	Year 3	Year 4	Year 5
Total return/benefit	($)	385.00	2280.00	1116.00	513.85	4042.50
Total cash operating costs	($)	194.41	756.32	510.87	248.47	1272.13
Return over direct costs	($)	190.59	1523.68	605.13	265.38	2770.37
Total return risk factor	(+/-)	130	553	178	66	841
Labor requirement	(hours)	2	4	3	2	5
Barley equivalents prod.	(cwt)	73	-	-	-	-
Hay equivalents produced	(ton)	-	-	-	-	-
Silage equiv. produced	(ton)	-	-	-	-	-
Animal Unit Month prod.	(AUM)	-	-	-	-	-

**** YIELD AND PRICE ****	Year 1 Wheat Winter	Year 2 Potato Sum.	Year 3 Sugarbeets	Year 4 Sweet Corn	Year 5 Onions Summr
Unit of yield	Bu.	Cwt	Tons	Tons	Cwt
Expected yield	110.0	400.0	30.0	8.6	550.0
Optimistic yield	130.0	500.0	33.0	9.2	600.0
Pessimistic yield	90.0	300.0	25.0	7.4	500.0
Expected price	3.50	4.35	37.20	59.75	7.35
Optimistic price	4.00	5.00	40.70	63.00	8.50
Pessimistic price	2.00	3.50	34.20	54.00	5.75
Price/yield correlation	Negligible	Negligible	Negligible	Negligible	Negligible
Value other product/acre	-	-	-	-	-

**** NITROGEN ****		Wheat Winter	Potato Sum.	Sugarbeets	Sweet Corn	Onions Summr
Credit green manure	(lbs)	-	-	-	-	-
Credit other sources	(lbs)	-	-	-	-	-
Applied nitrogen	(lbs)	136	200	175	204	300

		Wheat Winter	Potato Sum.	Sugarbeets	Sweet Corn	Onions Summr
**** HERBICIDES ****						
Prowl	QT	-	1.00	-	-	-
Sencor	PT	-	1.00	-	-	-
Treflan	PT	-	-	1.00	-	1.00
Ro-Neet	GAL	-	-	0.50	-	-
Eptam	QT	-	-	2.00	-	-
Betamix	OZ	-	-	30.00	-	-
Dacthal	LBS	-	-	-	-	6.00
Roundup	PT	-	-	-	-	1.00
Goal	OZ	-	-	-	-	24.00
Buctril	OZ	-	-	-	-	16.00
Lasso EC	QTS	-	-	-	3.00	-
Bronate	PT	1.50	-	-	-	-
MH-30	LBS	-	-	-	-	3.33
Prefar	QT	-	-	-	-	3.00
**** PESTICIDES ****						
Bravo	QT	-	1.00	-	-	6.00
Mocap	LBS	-	30.00	-	-	-
Thimet	LBS	-	15.00	-	-	-
Counter	LBS	-	-	10.00	-	-
Lorsban	LBS	-	-	-	-	6.70
Super Six	LBS	-	10.00	60.00	-	-
Comite	LBS	-	2.00	-	-	-
Ammo	OZ	-	-	-	-	12.00
Telone C-17	GAL	-	-	-	-	20.00
**** WATER, FUEL & ENERGY ****						
Water applied (inches/year)		30.0	48.0	48.0	39.0	48.0
Irrigation energy:						
Diesel equivalents	(gal)	-	-	-	-	-
Electricity	(KWH)	-	-	-	-	-
Drying:						
LP Gas	(gal)	-	-	-	-	-
Electricity	(KWH)	-	-	-	-	-
All Other:						
Diesel equivalents	(gal)	-	-	-	-	-

	Wheat Winter	Potato Sum.	Sugarbeets	Sweet Corn	Onions Summr
**** LABOR ****					
Total labor required (hrs/A)	1.5	3.9	3.0	2.0	4.6
Labor allocation in:					
January	-	-	-	-	-
February	-	-	-	-	-
March	-	0.3	0.5	-	0.9
April	0.1	0.5	0.3	0.2	0.3
May	-	-	0.2	0.9	0.7
June	-	-	-	0.2	0.7
July	-	-	-	-	-
August	0.7	-	-	-	-
September	0.5	2.4	0.4	-	0.9
October	0.3	0.7	1.6	0.7	1.1
November	-	-	-	-	-
December	-	-	-	-	-
**** CASH OPERATING COSTS $ ****					
Seed	12.00	253.00	27.00	25.00	103.00
Fertilizer	42.16	103.40	68.65	63.24	159.40
Crop chemicals	10.23	115.45	91.14	20.25	472.67
Crop insurance	-	-	-	-	21.00
Drying fuel	-	-	-	-	-
Irrigation energy	-	-	-	-	-
Water assessment	26.00	26.00	26.00	26.00	26.00
Custom hire	18.50	49.50	49.50	14.50	64.50
Direct crop labor	12.00	56.00	137.00	24.00	267.50
Fuel	19.92	34.79	30.31	21.16	33.75
Repairs	44.34	82.16	56.94	42.49	63.73
Packaging	-	-	-	-	-
Supplies	-	-	-	-	-
Miscellaneous	-	-	-	-	-
Operating interest expense	9.26	36.02	24.33	11.83	60.58
Total cash operating expense	194.41	756.32	510.87	248.47	1272.13

Appendix B

PLANETOR LIVESTOCK BUDGET

Enterprise: Dairy Cows
Description: Dairy Cows, 18000 lbs, 3.7% fat

Farm: DAIRY
Date: August 2, 1993

**** COMMENTS ****

Baseline system - Dairy Cows, 100 cows, 18000 lbs, 3.7% fat.

**** INCOME ****

	Per Cow
Expected sale quantity (Cwt)	180.00
Optimistic sale quantity	200.00
Pessimistic sale quantity	160.00
Expected price per Cwt	12.00
Optimistic price	13.00
Pessimistic price	11.00
Price/prod. correlation	Negligible
Cull income	175.50
Other sales	50.00
Total return/benefit	2385.50

**** LABOR ****

Labor (hrs./unit)	30.0
Labor allocation in:	
January	3.0
February	3.0
March	3.0
April	2.0
May	2.0
June	2.0
July	2.0
August	2.0
September	2.0
October	3.0
November	3.0
December	3.0

**** CASH OPERATING COSTS ****

Purchased feed	948.00
Artificial insemination	30.00
Health	40.00
Supplies	40.00
Direct livestock labor	210.00
Fuel	-
Repairs	40.00
Marketing	120.00
Miscellaneous expense	352.00
Interest expense	43.00
Total operating expense	1823.00
Value of feed equivalents	-
Return over direct costs	562.50
Total return risk factor (+/-)	300

**** FEED REQUIREMENTS ****

		Quantity	Value
Barley equivalents	(cwt)	-	-
Hay equivalents	(tons)	-	-
Silage equivalents	(tons)	-	-
AUMs required	(AUMs)	-	-
Value of feed equivalents			-

**** MANURE ****

Total manure production (lbs)	25800
Nitrogen produced (lbs)	155