EXTENSION AND EDUCATION
MATERIALS FOR
SUSTAINABLE AGRICULTURE:
VOLUME 8

Procedures for Evaluating Alternative Farming Systems: A Case Study for Eastern Nebraska

North Central Region Sustainable Agriculture Research and Education Program

Richard K. Olson

July 1998

Prepared with the support of a grant from the Sustainable Agriculture Research and Education (SARE) program through the U.S. Department of Agriculture Cooperative State Research Service under Cooperative Agreement No. 92-COOP-1-7266. Any opinions, findings, conclusions or recommendations expressed herein are those of the author and do not necessarily reflect the views of the U.S. Department of Agriculture.

EXTENSION AND EDUCATION
MATERIALS FOR
SUSTAINABLE AGRICULTURE:
VOLUME 8

Procedures for Evaluating Alternative Farming Systems: A Case Study for Eastern Nebraska

North Central Region Sustainable Agriculture Research and Education Program

Richard K. Olson

July 1998

Prepared with the support of a grant from the Sustainable Agriculture Research and Education (SARE) program through the U.S. Department of Agriculture Cooperative State Research Service under Cooperative Agreement No. 92-COOP-1-7266. Any opinions, findings, conclusions or recommendations expressed herein are those of the author and do not necessarily reflect the views of the U.S. Department of Agriculture.

EVALUATING ALTERNATIVE FARMING SYSTEMS: A CASE STUDY FOR EASTERN NEBRASKA

U.S. agriculture is characterized by trends toward fewer and larger farms, fewer farmers, and a shift in economic power from the farm sector to the inputs and marketing sectors. Reversing these trends will require the development of viable alternatives to conventional cash grain farms and other large-scale farming enterprises. Toward this end, the USDA National Commission on Small Farms has called for the development of farm management models emphasizing lower capital investment, more intensive management, and increased income through high value crops and creative marketing.

The best information on alternative farming systems comes from those farmers who actually take approaches outside of the mainstream. Unfortunately, these unconventional farmers are often few in number, and many of the alternative systems that could potentially work in various regions have not been tried. Adoption of new systems without preliminary evaluation is risky.

Economic and environmental models of farming systems offer a means of evaluating a wide range of alternative farming systems at low cost and no risk. While there are many computer models of farming systems, other approaches can also serve for preliminary assessments and as teaching tools.

This report demonstrates a low-cost procedure for conducting economic, energy, and environmental analyses of farming systems, and for synthesizing the results into a qualitative assessment of relative sustainability. The approach uses data from readily available sources, and can be tailored to meet the particular questions of a specific region or type of agriculture. It is designed to serve as both an educational and a research tool.

The approach is demonstrated by evaluating five alternative farming systems for eastern Nebraska — conventional corn/soybean, modified conventional, agroforestry, organic, and pasture-based beef. Parameters used to evaluate the five systems include net income, income variability, per acre production costs and returns for each crop, weekly labor requirements, energy budgets, soil erosion, and nutrient budgets. The results suggest that farming systems can be developed that allow smaller farms to be economically and environmentally competitive with larger conventional farms.

Extension and Education Materials for Sustainable Agriculture—

- Volume 1: Information from Regional Workshops, 1994, 212 p.
- Volume 2: Curricula for Undergraduate and Graduate Courses, 1994, 178 p.
- Volume 3: Alternative Approaches to On-Farm Research and Technology Exchange, 1995, 174 p
- Volume 4: Everyone a Teacher, Everyone a Learner, 1995, 245 p.
- Volume 5: Shared Leadership, Shared Responsibility, 1996, 276 p.
- Volume 6: Future Horizons: Recent Literature in Sustainable Agriculture, 1997, 222 p.
- Volume 7: Linking People, Purpose, and Place: An Ecological Approach to Agriculture, 1998, 266 p.
- Volume 8: Procedures for Evaluating Alternative Farming Systems: A Case Study for Eastern Nebraska, 1998, 310 p.

All volumes are available from:

Center for Sustainable Agricultural Systems
University of Nebraska-Lincoln
225 Keim Hall
Lincoln, NE 68583-0949
Phone: 402-472-2056
Fax: 402-472-4104
Email: csas003@unlvm.unl.edu

Richard Olson
Center for Sustainable Agricultural Systems
University of Nebraska-Lincoln
219 Keim Hall
Lincoln, NE 68503-0949
Phone: 402-472-0917
Fax: 402-472-4104
Email: csas005@unlvm.unl.edu

ACKNOWLEDGMENTS

Chuck Francis, Department of Agronomy, University of Nebraska-Lincoln was Principal Investigator for this project, and a critical source of information. Many other people generously contributed their time and expertise in helping me to develop realistic models of eastern Nebraska farming systems. I sincerely thank Dennis Adams, Bruce Anderson, Kevin Bernhardt, Bruce Bolander, Jim Brandle, Laurie Hodges, Bruce Johnson, Terry Klopfenstein, and Alex Martin for their contributions. Heidi Carter provided unceasing advice and support.

This study was funded in part by a grant from the North Central Sustainable Agriculture Research and Education (SARE) program through the U.S. Department of Agriculture Cooperative State Research Service under Cooperative Agreement No. 92-COOP-1-7266.

Table of Contents

List of Tables

List of Figures

Disclaimer

Any opinions, findings, conclusions or recommendations expressed herein are those of the author and do not necessarily reflect the views of the U.S. Department of Agriculture, University of Nebraska, or the Center for Sustainable Agricultural Systems.

I. Introduction

The Changing Structure of U.S. Agriculture

Agriculture in the United States is undergoing a radical and rapid transformation as it adopts a corporate or industrial mode of production (Friedland 1994). Agricultural industrialization involves the concentration, increased technical advancement, and ongoing integration with input and marketing sectors of larger-sized agricultural interests (Hamilton 1993). Table I-1 documents some of the more obvious effects of this process. Since 1950, the number of farms has decreased by 64%, average farm size has increased 127%, and the farm population has declined to less than 2% of the U.S. total. The U.S. Bureau of the Census no longer tracks farm families as a separate demographic category.

Average farm size masks an important aspect of this restructuring. The size distribution of farms is skewed toward many small farms and a relatively few very large farms (Table I-2). Two-thirds of all farms are less than 260 acres in size, while the largest 9% of farms control two-thirds of the land. In terms of gross sales, 90% of U.S. agricultural output is produced by only 522,000 farms (Lyson et al. 1998). Accompanying this concentration of production is a high level of absentee ownership with 43% of U.S. farmland rented (Rogers 1993).

Table I-1. Structural changes in U.S. agriculture since 1950 (Albrecht and Murdoch 1990, Bureau of the Census 1983, 1984, 1992, 1994).

Characteristic	1950	1982	1992
Number of farms	5,388,000	2,240,976	1,925,300
Average farm size (acres)	216	440	491
Farm population	23,048,000	5,620,000	4,632,000*
Farm population as percent of U.S. total	15.3	2.4	1.9

*Farm population data from 1991.

Table I-2. Percent distribution of farms — number and acreage, by size of farm, 1992 (Bureau of the Census 1994).

Size of farm	Percent distribution		
	Number of farms	All land in farms	Cropland harvested
Less than 10 acres	8.6	0.1	0.1
10 to 259 acres	59.3	11.5	14.0
260 to 999 acres	23.0	23.4	37.9
1,000 to 1,999 acres	5.3	14.7	23.4
2000 acres or more	3.7	50.4	24.5

A less obvious, but equally important aspect of industrialization is the shifting of economic activity from the farming sector to the inputs and marketing sectors, and within the latter two sectors, the concentration of control with a small number of giant multinational corporations. The farmer's share of total agricultural economic activity has declined from 21% in 1910 to 5% in 1990 (Smith 1992). The marketing sector now has a 65% share, and the inputs sector the balance.

Six multinational corporations account for half of all retail food purchases in the United States (Standard and Poors 1994). Three packers controlled the slaughter of 80% of U.S. beef in 1994 (Lehman and Krebs 1996), and similar oligopolies exist in grain exports, pork packing, poultry and egg production, and flour milling (Heffernan et al. 1996). In the inputs sector, mergers and acquisitions have greatly reduced the number of suppliers of seed (Raeburn 1995), chemicals (PANUPS 1998), and equipment (Krebs 1992). The ongoing acquisition by corporations such as DuPont of seed companies and food processing technology companies increases the vertical integration within agriculture (Kilman 1998).

So What?

The loss of small farms and the restructuring of agriculture is of more than academic interest. Walter Goldschmidt's (1946) now classic comparison of the California communities of Arvin and Dinuba illustrated the importance of farm size and land tenure. In the early 1940s, average farm size in Arvin was 497 acres, only 35% of the farmers were full owners of their farms, and less than one-third of the landowners lived in the community. In Dinuba, the average farm size was 57 acres, more than 75% of the farmers owned all their land, and 70% of the landowners lived in the community.

In all measures of community well-being including quality of social services, living conditions, stability of the population, and retail trade, Dinuba scored far higher than Arvin. Goldschmidt concluded that "The study of Arvin and Dinuba shows, therefore, that quality of social conditions is associated with scale of operations; that farm size is in fact an important causal factor in the creation of such differences and that it is reasonable to believe that farm size is the most important cause of these differences."

More recently Lobao (1990) and the National Commission on Small Farms (USDA 1998) have reiterated the benefits and importance of small farms to local economies, food security, and community well-being. Advantages cited for the preservation of small farms include maintenance of a population with knowledge of farming and the land; a greater population base for rural schools and communities; an important foundation for local retail activity through the purchase of farm inputs and household consumer goods; protection against concentrated control of farmland and the means of production; and a lower capitalization that makes it easier to finance a transfer of the farm to the next generation.

An analysis by the Center for Rural Affairs in Walthill, Nebraska provides an example of the potential economic benefits of small farms. Their study indicates that 23 farms of 150 sows each would create 21 more jobs and produce almost $35,000 more in revenues to local governments than one farm with 3,400 sows, if all produced at the same rate. In addition to creating more jobs and local tax revenue, the smaller operations would create 20% more net revenue for the state and pay 7% more property taxes than one large operation of equal output (Anderson 1998).

The biological and social implications of the restructuring of agriculture from many small farms to fewer, larger farms with lower crop diversity have been described for rural Minnesota by a state task force (University of Minnesota Extension 1998). "Our current agricultural cropping systems have less biological diversity than at any time in history," the task force report says. "The cause is continued simplification of farming leading to production of a few crops over large acreages. It is increasingly clear that simplified farming is causing a crisis in rural Minnesota. This crisis is felt in rural communities that have lost population, businesses, churches, schools and social institutions as smaller diversified farms have been replaced by larger operations focused on a single commodity. Production of single, low value commodities does not add substantially to the economic base of the community and creates a high level of biological and environmental risk for farmers and society."

A basic tenet of sustainable agriculture is that knowledge of place is essential to efficient and sound use of the land (Jackson 1994), and large farms make the acquisition of an intimate knowledge of the land difficult. David Orr (1992) writes "The ecological knowledge and level of attention necessary to good farming limits the size of farms. Beyond that limit, the 'eyes to acres' ratio is insufficient for land husbandry. At some larger scale it becomes harder to detect subtle differences in soil types, changes in plant communities and wildlife habitat, and variations in topography and microclimate. The memory of past events like floods and droughts fades. As scale increases, the farmer becomes a manager who must simplify complexity and homogenize differences in order to control."

The transition to larger farms is part of the industrialization of agriculture. Industrial operations require large amounts of cheap, standardized raw materials, and large corporations are more likely to contract with large farms (Lyson et al. 1998). Limited competition in the marketing sector lowers prices for agricultural commodities, forcing farmers to expand in order to increase net income through greater volume, which ironically often reduces prices further due to oversupply.

Why is this happening?

The restructuring of agriculture is viewed by many economists as an inevitable economic trend (Urban 1991), the consequence of larger, more efficient production units winning on the playing field of capitalism. However, the National Commission on Small Farms (USDA 1998), citing a study by Dr. W.L. Peterson, suggests that there may be limits to economies of size in agriculture. "After accounting for the quality of land and farm management, subtracting the contribution of the farmhouse to farm output, and considering the effect of opportunity costs related to off-farm employment on farm output and production costs, Peterson asserts 'that small family and part-time farms are at least as efficient as larger commercial operations. In fact, there is evidence of diseconomies of scale as farm size increases.'" An economic study of Iowa agriculture demonstrates that farms reach full economies of size at 600 acres (Hassebrook 1998).

A key point is that the reduction of the role of small farms in the agricultural economy has not occurred in a vacuum. It has been facilitated, perhaps even forced, by federal research priorities and agricultural policies. The playing field has not been level. "...government policies and practices have discriminated against small farm operations and poor farmers. In some cases, such as commodity program policies, the discrimination was explicit. In other cases, the bias was less intentional and reflected simple ignorance of the specific needs of small farms" (USDA 1998).

An important bias lies in the federal research agenda, which favors large farms rather than small farms, and the input and marketing sectors rather than the farm sector. A report by the Agribusiness Accountability Project concludes that research by land-grant universities helps mainly "the largest-scale growers, the farm machinery and chemicals input companies and the processors.... Mechanization research by land-grant colleges is either irrelevant or only incidentally adaptable to the needs of 87 to 99 percent of America's farmers. The public subsidy for mechanization actually has weakened the competitive position of the family farmer" (Berry 1977).

As corporate influence increases, University research is further directed toward technologies that will increase the share of agricultural activity in the input and marketing sectors to the detriment of the farming sector (Hamilton 1994). Monsanto can make money selling bST to dairy farmers, but cannot profit from rotational grazing strategies. DuPont profits from selling pesticides to monoculture corn farmers, but not from the use of crop rotations for pest control.

Yet, some research suggests that smaller farms can increase their productivity and economic competitiveness without growing larger. For example:

- Management intensive grazing systems in Louisiana have increased utilization of forage from 30% to 70%, allowing an increase in livestock units without an increase in land (SARE 1998).
- Management intensive grazing also provides small dairies with an alternative to bST for increasing milk production, thus increasing the intensity of land use rather than increasing purchased inputs (Liebhardt 1993).
- Direct marketing of vegetables to consumers or retailers rather than to wholesalers can increase net income (SARE 1998).

The common denominator of much of the research that benefits small farms is a focus on the farming system rather than particular inputs or practices. In addition to agronomic factors, economic, environmental, and social aspects are often considered. Still, a complete farming systems analysis is beyond the scope of most research.

Objectives

The objectives of this report are:

- to demonstrate a method for deriving production, economic, energy, and environmental measures for comparing different farming systems, and to do so by
- designing and evaluating two conventional and three smaller alternative farming systems for eastern Nebraska.

The evaluation procedures include low-cost, relatively simple accounting methods that measure economic, energy, and environmental impacts of farming systems, as well as a method for synthesizing the results into a qualitative assessment of relative sustainability. The approach uses data from readily available sources, and can be tailored to meet the particular questions of a specific region or type of agriculture. It can serve as both an educational and a research tool.

Alternative Approaches to Farming Systems Analysis

Traditional agricultural research is highly controlled and replicated, both of which are impossible conditions to meet if the experimental unit is a full-sized working farm. As a result, two different approaches are commonly used in analyzing agricultural systems (Ball et al. 1991). *Statistical analysis* uses data from representative samples of the farming systems of interest to derive estimates of the variables that will be used to compare the farms. An *engineering* approach develops models of the farming systems of interest, and uses output from the models to evaluate the farms.

Statistical analysis only works if adequate numbers of the farming systems of interest exist and have been adequately characterized. By definition, there are many conventional farms, and USDA and others collect much data on them. Alternative farming systems such as organic production, rotational grazing, and agroforestry are much less common, and in some regions will not provide enough of a base for statistical analysis. Often, a farmer may wish to evaluate an idea for a system that does not exist anywhere. A preliminary evaluation is essential before most people will consider adopting a new system.

An engineering approach provides the flexibility to evaluate a wide range of existing and potential farming systems. A model of the system is developed, and the parameters in the model are given values based on data from many different sources. When data are not available, assumptions and best estimates are used until further research provides more precise data. The method can be tailored to make use of existing data and estimates and to match the time and resources available to the analyst, producing anything from a preliminary assessment to a rigorous analysis. The main concern is whether the models are realistic. Do they accurately portray not only the functioning of the system components, but also the emergent properties of the system that make it more than the sum of its parts (O'Neil et al. 1986)?

Despite uncertainties inherent in the engineering approach to farming systems analysis, it is a widely applicable method, and an essential tool for the sustainable agriculture community to evaluate unconventional systems without the risk of actually adopting them. For these reasons, an engineering approach is used in the case study of alternative farming systems for eastern Nebraska.

The general methods shown should be applicable to any region of the United States, and the basic questions are certainly germane to any location — can we design alternative farming systems (USDA 1998) that:

- increase the farmer's share of the agricultural dollar
- reverse the trend toward fewer, larger farms
- reduce the negative environmental impacts of agriculture
- increase the sustainability of farming systems?

An Eastern Nebraska Case Study

Eastern Nebraska lies within the western portion of the Western Cornbelt ecoregion (Omernik 1987). Terrain is flat to rolling glaciated soils of Loess parent material. It has a continental climate with approximately 25 to 32 inches annual precipitation, highly variable from year to year and showing a spring and early summer maximum.

The dominant farm type in eastern Nebraska is a conventional corn-soybean cash crop system. More than 80% of the cropland in the region is devoted to corn or soybean each year (NASS 1995). The case study involved the design of a modified conventional and three smaller farming systems that might serve as viable alternatives to the conventional corn-soybean system, and the application of a variety of procedures to evaluate their relative performance. In defining the alternatives, I was guided by four premises or working hypotheses that are commonly touted in debates regarding sustainable agriculture, although not necessarily proven:

- Increasing the diversity of crops and economic enterprises on a farm can improve economic performance (Olson and Francis 1995).
- Increasing the intensity of management can substitute for additional land to increase net income (Dansingburg et al. 1995).
- Increased use of perennial crops can reduce negative environmental impacts while maintaining economic performance (Olson et al. 1998).
- Livestock are an important mechanism for adding value to crop residues and forages, and for reducing erosion through the use of permanent pastures (Bender 1994).

Working from these premises, I defined four alternatives to the corn-soybean system (Table I-3). The modified conventional, agroforestry, and organic farming systems represent increasing diversity, intensity of management, and use of perennials. The pasture-based beef system relies totally on perennial grasses, harvested primarily by livestock. The remainder of this report shows how these basic definitions were fully developed, and how the relative performance of the systems was evaluated.

Table I-3. Basic definition of the five farming systems.

Farming system	Crops
Conventional	corn, soybean
Modified conventional	corn, soybean plus two other crops
Agroforestry	same as modified conventional plus windbreaks and tree crops
Organic	organic production; greater diversity than agroforestry including intensive vegetable production
Pasture-based beef	warm- and cool-season pastures

Outlining the Approach

Figure I-1 outlines the basic steps in the economic, energy, and environmental analyses of five farming systems for eastern Nebraska. It also describes the structure of this report. The first part of this volume consists of *eight sections* that present the main results of the analyses along with some discussion. The second part, which makes up the bulk of the volume, includes *eight appendices* that present in full detail the data sets used in each analysis, the calculations from which the results are derived, and references for all data and methods. Many readers will be satisfied to read Part 1 with only occasional reference to the appendices to determine how a particular result was derived. For readers interested in using this approach to evaluate other systems or to change assumptions or parameters, the appendices provide a step-by-step guide, and a rich source of data and supporting information.

Beginning with the general definition of the five farm types (Section I), I asked *What would a typical farm of each type, located in eastern Nebraska, look like?* Starting with a database of the characteristics of 381 Nebraska farms (Bernhardt et al. 1994; Appendix 1), and a catalog of operational characteristics of standard farm machinery (Powell et al. 1992; Appendix 2), I derived baseline descriptions of the size, land tenure, and equipment complement of each farm type (Section II). These baseline descriptions were then transformed into detailed descriptions of farm operations in a process that drew upon published crop budgets for eastern Nebraska (Selley 1996); general information on crop rotations, organic production, and rotational grazing; and information on alternative tree and vegetable crops (Appendix 3). The resulting farm operations descriptions (Section

III) included crop acreage, rotations, field operations schedules, amounts of fertilizers and other inputs, and a modified equipment list tailored to each system. References to specific data sources are provided throughout the appendices.

An economic model using data on crop and input prices for 1996 (Appendix 4) was used to estimate gross and net income for each farm (Section IV). Historical yields and prices for the period 1985 through 1994 (Appendix 5) were used to compare income variability among the five farms (Section V).

Inputs and outputs for each farming system were expressed in energy units using data on energy content of fuels as well as the embodied energy of machinery, fertilizers and other inputs (Appendix 6). The result was an energy budget and an estimate of the energy efficiency (output/input ratio) of each farm (Section VI). A commercially available farming systems model (PLANETOR) and data on nitrogen and phosphorus content of crops (Appendix 7) were used to estimate erosion and nutrient budgets (Section VII).

Finally, the results of the economic, energy, and environmental analyses were summarized in a preliminary evaluation of the relative sustainability of the five farms (Section VIII) using a suite of indicators of sustainability of farming systems (Appendix 8).

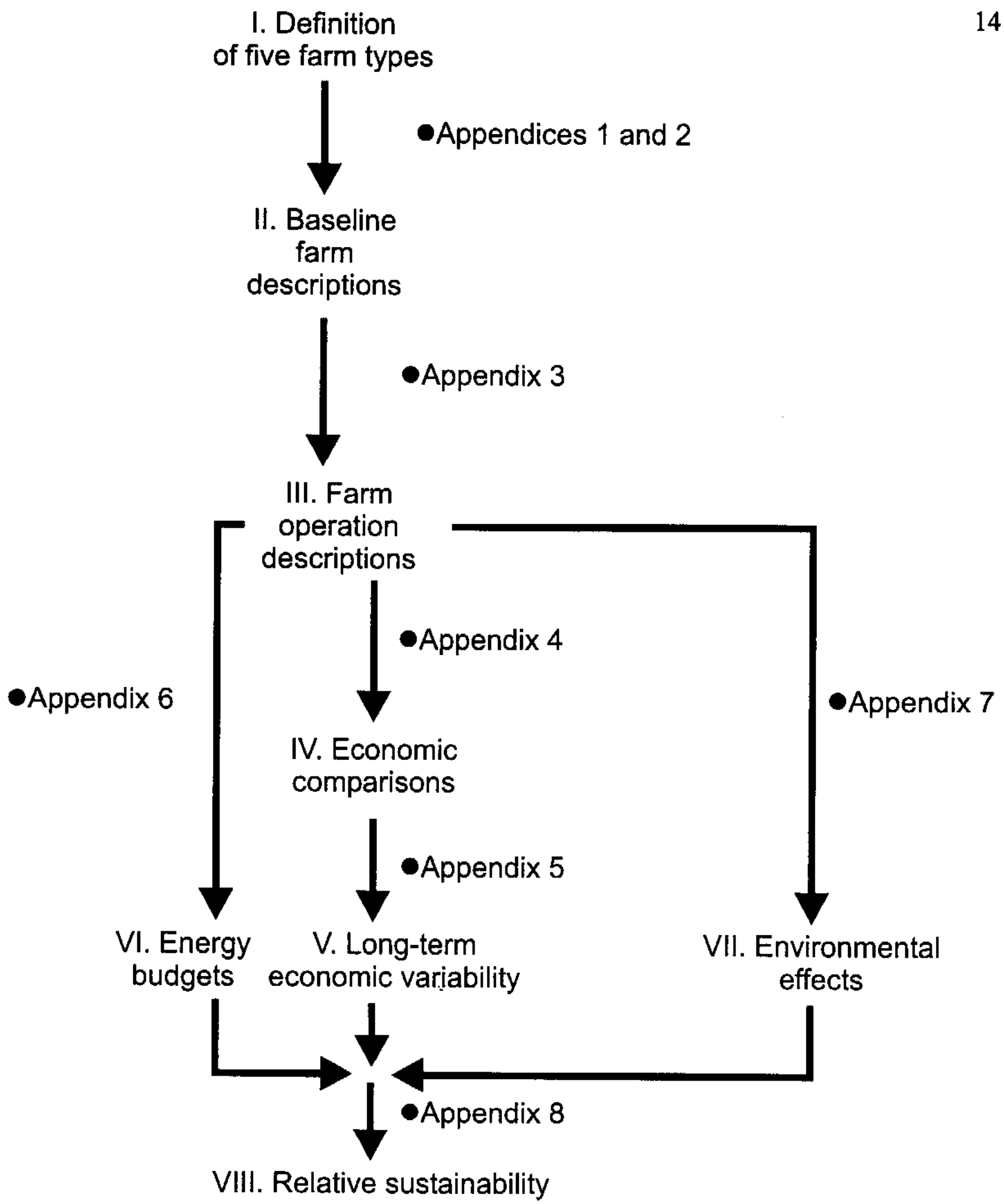


Figure I-1. The sequential steps in the analysis and evaluation of five alternative farming systems. The flow chart also illustrates the structure of this report. Roman numerals correspond to the sections in Part I that summarize results. The appendices contain the detailed calculations and supporting data.

II. Baseline Descriptions and Assumptions for the Five Farm Types

One way to compare farming systems is to select a particular size farm (e.g., 600 acres) with a standard complement of machinery, and then superimpose each of the five alternative systems and compare performance. In other words, hold as many factors as possible constant while changing the parameters of interest. This provides comparability of many of the results, but at a cost of realism and applicability. There is a wide range of sizes and types of farms in eastern Nebraska. To move towards greater sustainability, these existing farms, not some "average" farm, represent the starting point. Some types of farms will be more likely than others to adopt particular alternative systems, and will be more successful in the transition. Also, a key question is whether there are alternatives to getting bigger or getting out. Assuming that all five farms were the same size would make it more difficult to address this question.

Instead, a survey by Bernhardt et al. (1994) was used to describe farms currently existing in Nebraska. The survey characterized 381 Nebraska farms statewide in terms of 360 production and nonproduction variables, and grouped farms by common characteristics (see Appendix 1). Of the four main groups (Table II-1), the conventional farms (Clusters 1 and 2) are larger and more likely to use chemical fertilizers and pesticides. The "sustainable" farms (Clusters 3 and 4) tend to grow more crops, rely more on rotations, and generate a greater percentage of income from livestock. The more innovative nature of the farms in Cluster 1 is reflected in characteristics including manure use, crop rotations, and number of crops grown. Overall, there are clear differences in rotations, and number of crops grown. Overall, there are clear differences in structure and operation among the conventional, innovative conventional, and sustainable farms.

Table II-1. Selected characteristics of farms in Clusters 1-4 of the Nebraska farm survey (Bernhardt et al. 1994). The clusters were defined on a "conventional - sustainable" scale as Cluster 2 - conventional, Cluster 1 - innovative conventional, Cluster 3 - sustainable, and Cluster 4 - sustainable. See Appendix 1 for details.

Characteristic	Cluster 2	Cluster 1	Cluster 4	Cluster 3
farm size (median acres)	573	800	260	288
% of farms that:				
use anhydrous	87	78	13	41
use manure	24	64	80	82
broadcast or band herbicides	73	95	52	55
use cover crops for weed control	21	38	48	84
use crop rotation	40	83	82	81
avg. # crops grown	1.96	2.86	3.14	3.18
% income from livestock (1992)	17	29	50	46

After reducing the data set to include only dryland farms located in eastern Nebraska, the four clusters were sorted into five groups corresponding to the five case study farming systems (see Appendix 1, Table A1-2). Sorting was based on characteristics thought to increase the probability of adopting a particular system. For example, farms generating a large portion of their income from livestock (excluding hogs) were considered more likely to adopt a pasture-based beef strategy than farms whose income was derived mostly from crops.

The resulting five groups — conventional, modified conventional, agroforestry, organic, and pasture-based beef — show clear differences (Table A1-2) that correspond to the basic definitions of the different systems. The conventional farms grow an average of only 2.2 crops, and 73% grow continuous corn or a corn/soybean rotation. Chemical use in this group is high. By comparison, the modified conventional farms grow more crops and practice more strip cropping and other innovative practices. The beef production farms are clearly differentiated by the high percent of income derived from livestock (73%) and the lowest percent cropland. The organic farm group has the greatest crop diversity and highest use of reduced chemical pest control methods. The agroforestry group is somewhat intermediate between the conventional and organic groups.

Overall, the five farm groups seem to define reasonable starting points for developing models of the five farm types. Of course, these are not exact matches, but representations of the types of commercial farms in eastern Nebraska that would be most likely to adopt each of the farming systems.

Table II-2. Size and land tenure characteristics of five groups of Nebraska farms selected to correspond to the five case study farms.

Characteristic	conventional	modified conventional	agroforestry	organic	pastured beef
farm size (acres)	559	711	428	417	459
% owned	44	46	62	57	58

Table II-2 shows differences in size and land ownership among the five groups of farms with the farms labeled as conventional and modified conventional being larger and including more rented land than owned land. These real world differences were retained in the baseline descriptions assigned to the five model farms of the case study (Table II-3). The accompanying survey data on equipment ownership by each group was used to define different baseline equipment inventories for each model farm (see Appendix 1, Tables A1-3-5, and Appendix 2). The conventional and modified conventional farms use 8-row equipment and slightly larger tractors, while the other farms use 6-row equipment. The baseline equipment inventories described in Appendix 1 are a starting point — they are eventually modified as needed to match the detailed farm operations described in Section III.

Table II-3. Baseline descriptions of the five model farms.

Characteristic	conventional	modified conventional	agroforestry	organic	pastured beef
farm size (acres)	650	650	425	425	460
% owned	45	45	60	60	60
% cropland	100	100	100	100	0
equipment	Append. 1	Append. 1	Append. 1	Append. 1	Append.1

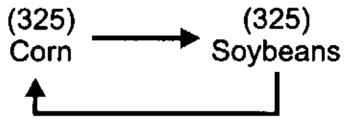
III. Operational Descriptions of the Five Farm Types

Referring to Figure I-1, the next step in evaluating the five farming systems is to develop a detailed description of each farm's operations that can support an economic, energy, and environmental analysis. Reference materials to support this step include agricultural statistics for the region of interest, and general information on topics such as crop rotations and windbreaks (Appendix 3). Farmers, extension personnel, and researchers who are experts on the local agriculture are essential sources of unpublished details, and are critical reality checks for the assumptions needed to establish each model.

A brief overview of the structure and operations of the case study farms is presented in this section. Each farm's description begins with a diagram showing the acres devoted to each crop each year, and the crop rotation that is followed. A narrative description of the farm and its workings follows. A table at the end of this section summarizes and compares the main characteristics of the farms.

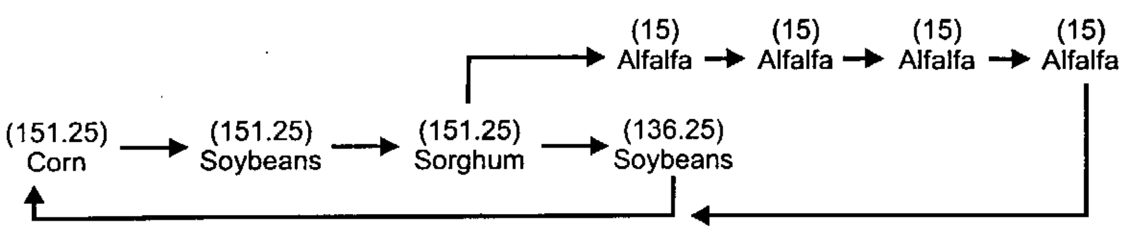
The complete and detailed descriptions of the five farms are presented in Appendix 4. Weekly schedules of operations and inputs for each crop are included in Appendix 4 as part of the economic analysis of each farm. Appendix 4 also includes a final equipment list for each farm, modified from the baseline list to match the exact operations of the farm. For example, the pasture-based beef farm has divested itself of all rowcrop production equipment.

Conventional Farm



The 650-acre conventional farm includes 375.5 acres of rented land (cash rent). A dryland corn-soybean rotation (the dominant crops in eastern Nebraska; see Appendix 3, Table A3-1) has each crop grown on half the acres each year. Most equipment is owned, although an anhydrous applicator and broadcast spreader are rented as needed. Chemical fertilizers and herbicides are applied based on standard recommendations for crop and yield goal; the crop rotation eliminates the need for insecticides. Labor is hired for roguing, and crops are sold for the going price at time of harvest. See Appendix 4A for a detailed description of the structure and operation of this farm.

Modified Conventional Farm

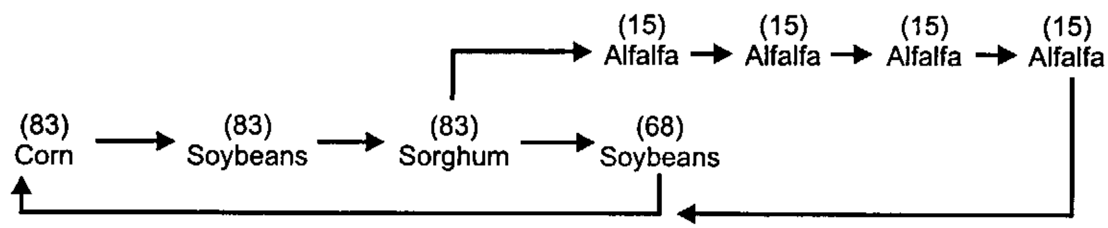


The 650-acre modified conventional farm includes 375.5 acres of rented land (cash rent). The farmer's objective is increased diversification without major changes in equipment or management skills. Grain sorghum and alfalfa are added to the corn-soybean rotation — these are the third and fourth most commonly grown crops in eastern

Nebraska (Table A3-1). Markets exist for these crops as does a knowledge base of how to grow them. Their inclusion in the rotation increases the functional diversification of the farm. Sorghum is more drought resistant than corn. Alfalfa is a nitrogen-fixing perennial, and its multiple harvests throughout the year help to distribute labor needs.

No additional equipment has to be purchased to add the new crops. An anhydrous applicator, broadcast spreader and seeder-packer are rented as needed. Swathing and baling of alfalfa is done custom because the small acreage in alfalfa doesn't justify owning the necessary equipment. Chemical fertilizers and herbicides are applied based on standard recommendations for crop and yield goal. The rotation eliminates the need for insecticides. Crops are sold at harvest. See Appendix 4B for a full system description.

<u>Agroforestry</u>



Scotch pine (9); American hazel (16); Shelterbelt (23)

The 425 acres of the agroforestry farm include 170 acres of rented land (cash rent). Crops are grown with chemical inputs. The challenge is to successfully counter the trend toward bigger farms by producing a reasonable income from a relatively small acreage. The strategy includes a further diversification of the modified conventional rotation through addition of woody perennials as crops and as windbreaks. Lack of long-term control by the farmer of rented land poses some difficulties for this strategy.

Agroforestry is a logical approach to further diversification. Shrubs and trees add structural diversity and increased perennialism to the farming system. Advantages include reductions in wind- and water erosion, improved wildlife habitat, and habitat for beneficial insects. Placement of 5.4% of the farm (23 acres) in shelterbelts provides full wind protection for all acres (Brandle et al. 1992), and a 5% to 15% increase in crop yields even after the land occupied by the windbreaks is considered (Kort 1988).

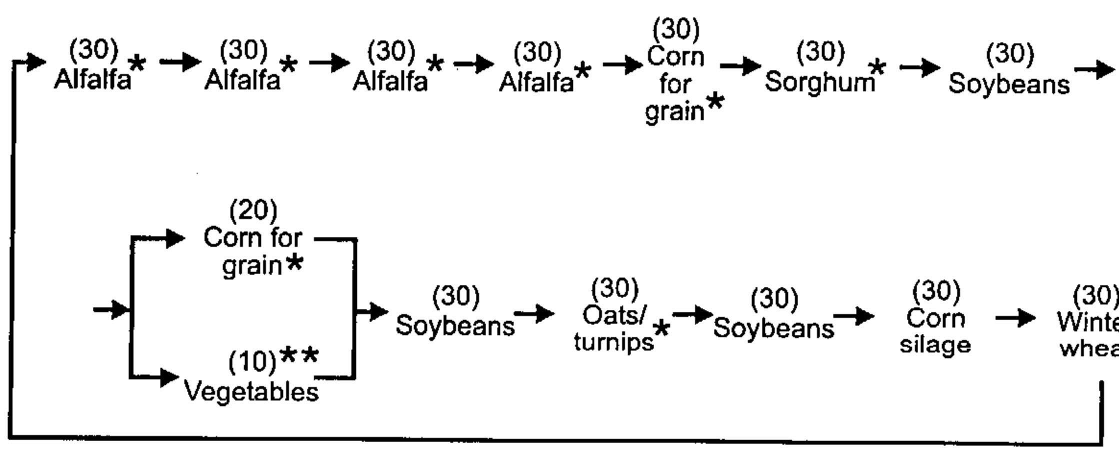
U-cut Christmas trees are a common tree crop in eastern Nebraska with Scotch pine (*Pinus sylvestris*) the preferred species (Laine et al. 1992a,b). American hazel (*Corylus americana*) is a native North American species that grows as a large shrub in Nebraska and is widely used in conservation/wildlife plantings and in landscaping. The nuts are too small for human consumption, but are harvested for seed. The University of Nebraska maintains a small hazel orchard near Ithaca, Nebraska to supply seed to the state nursery. Clearing of hazel from hedgerows and pastures has reduced the supply of wild seed, and demand currently exceeds supply (Judy Lovelace, Lovelace Seeds, Elsberry, MO).

From a system perspective, the addition of these tree crops distributes labor requirements more evenly. For example, the high labor demands associated with the harvest of hazel nuts (mid-summer) and Christmas trees (late November - early December) occur during low labor periods for traditional row crops. The many non-harvest operations associated with hazel nut and Christmas tree production also dovetail reasonably well with the activities required for the other crops (see Appendix 4C.).

The smaller size of the agroforestry farm means that the fixed costs of equipment ownership are spread across fewer acres. To alleviate this, the combine, corn head, grain head, swather/conditioner, and baler are co-owned with the organic farm. Given the total number of acres of alfalfa on the two farms, it is more economical to own the swather/conditioner and baler than to have the alfalfa custom harvested.

The management skills required on the agroforestry farm are higher than on the modified conventional farm. Christmas trees and hazel nuts are clearly niche enterprises that require different skills and equipment than row crop production. See Appendix 4C for full details on this system.

Organic Farm



Brome (12); Shelterbelts (23); * = residue grazed in fall; **Sweet corn (3); Pumpkins (2) Acorn squash (2); Bell peppers (2); Spinach (1)

The 425 acres of the organic farm include 170 rented acres (cash rent). To generate sufficient income from a smaller land base, the organic farm follows two of the agroforestry approaches:

1. Enhance yields through protection of crops with windbreaks.
2. Reduce fixed costs per acre by sharing major equipment with another farm.

However, the strategy goes considerably beyond that of the agroforestry farm, representing the high end of intensive management. Additional components include:

3. Further diversification of crops including irrigated high-value vegetable crops on a small portion of the farm.
4. Adding value to crop residues by fall grazing by backgrounding steers.
5. Organic production of all crops (although premium prices are likely for some organically grown crops, no price premiums are assumed in the economic analysis, a conservative assumption for this economic comparison).

Wheat, hay, corn silage and oat are the fifth through eighth most common crops (by acreage) in eastern Nebraska (Table A3-1), so they are logical additions to the rotation. They also provide the diversity necessary for a successful organic rotation (Table A3-2). Ten acres are irrigated and devoted to sweet corn, pumpkins, acorn squash, bell peppers, and spinach. All five vegetables are commercially grown in eastern Nebraska.

The primary source of nutrients is feedlot manure supplemented with a small amount of rock phosphate. Seven of the 13 stages in the rotation are legumes, greatly reducing external nitrogen requirements. Shelterbelts occupy 23 acres of the farm. Corn stalks and other suitable residues are rented for fall backgrounding of cattle. A 12-acre brome pasture provides a spring hay crop, some fall grazing, and a secure place to move cattle if wet conditions would result in unacceptable compaction in the crop fields.

Vegetable production areas are irrigated with a moveable pipe sprinkler system. Cooling of vegetables is accomplished with purchased crushed ice and a cooling room.

Organic pest control measures for the vegetables include Pyrellin E.C. (pyrethrum and rotenone), Bt-Dipel, insecticidal soap, and Trichogramma wasps. Rodents are trapped, and bee hives are rented for pollination of cucurbits. Weed control is achieved through crop rotation, increased seeding rates, increased cultivation, roguing, and heavy hoeing in vegetables.

Pasture-Based Beef Farm

Brome pasture (242)
Big bluestem pasture (212)
Handling facilities and lanes (6)

Of the 460 acres, 184 acres are rented (Table II-3). Grass is the only crop, harvested either by grazing or as hay during periods of excess production. Separate cool-season (brome) and warm-season (big bluestem) pastures are maintained in order to reduce the midsummer depression in forage availability. An intensive grazing system based on an 8-paddock rotation maximizes forage production.

Cattle spend a significant amount of time off-farm. Weaned steer calves are purchased in late October and backgrounded during the winter on rented cornstalks and alfalfa. Steers are moved to the farm's brome pastures May 1, shift to the warm-season pastures around July 1, and return to brome for October. After 84 days in the feedlot, they are slaughtered at about 1250 lbs in late January.

The equipment inventory is the minimum needed to make hay. Custom haying would be less expensive, but owning the equipment allows timely hay production as needed by the intensive grazing system. Fencing is high-tensile electric with 4-strand perimeter fences and 2-strand interior fences. Water is provided to each paddock with low-cost aboveground PVC pipe.

All pastures are fertilized annually. Cool-season grasses are controlled in the warm-season pastures by burning in late April and by spraying with Roundup in late October after the warm-season grasses have gone dormant. Seasonal and annual variability in grass production is addressed by making hay when production exceeds grazing demand, and by feeding hay (including purchased hay if necessary) when demand exceeds supply.

Table III-1. Summary of model farm characteristics.

Farm	# crops	livestock	shelterbelts	tree crops	irrigation	fertilizers	herbicides
Conventional	2	no	no	no	no	chemical	yes
Modified conventional	4	no	no	no	no	chemical	yes
Agroforestry	6	no	yes	yes	no	chemical	yes
Organic	14	graze residue	yes	no	vegetables	manure, rock phosphate	no
Pastured beef	1	yes	no	no	no	chemical	yes

Farm	insecticides	custom work	hired labor	equipment sharing
Conventional	no	none	no	no
Modified conventional	no	alfalfa harvest	no	no
Agroforestry	no	none	yes	yes
Organic	organic	silage harvest	yes	yes
Pastured beef	no	none	no	no

IV. Single-Year Economic Comparisons

The detailed descriptions of farm operations provide the foundation for an economic analysis and comparison of the five case study farming systems. The economic model used to generate these results is described in Appendix 4, Table A4-1. Prices used in developing the farm budgets are presented in Tables A4-2-4. Appendices 4A-E contain the detailed economic analysis of each farm with all assumptions and calculations shown. Some of the key assumptions include:

Crop yields	Set as 10-year average (1985-1994) for Saunders County, NE (Table A4-3). Yields of crops protected by windbreaks are increased by 5% to 15% (Table A3-3). Average organic yields are equal to conventional yields (Bender 1994).
Crop prices	Set as average market year prices (in constant 1996 dollars) for the Nebraska East Agricultural Statistics District, 1985-1994 (Tables A4-3 and A5-2). Vegetable prices based on average weekly Chicago wholesale market prices (Tables A4-4 and A5-3).
Input prices	All prices standardized to 1996 dollars

Outputs include a whole-farm budget as well as a detailed budget showing cost of production and returns ($/A) for each crop (Appendices 4A-E). The main results of these analyses are presented in this section.

Net income for all farms (Table IV-1) is fairly similar with an $8000 difference between the lowest (modified conventional) and highest (agroforestry). However, the agroforestry, organic, and beef farms achieve this parity with only 2/3s as much land as the more conventional farms. Agroforestry and organic have the lowest gross incomes, achieving higher net incomes through lower total expenses.

The pasture-based beef farm budget is quite distinct from the others. Gross income is three times that of the other farms, but so are expenses. One input — the annual purchase of calves — exceeds the total expenses of each of the other farms. Annual interest payments on borrowed operating capital are larger than the beef farm's net income. Without a willing banker, this system would not be viable, and in any case, it is very susceptible to increases in interest rates, and to fluctuations in cattle prices.

The organic farm budget assumes that no organic premiums are received for any of the crops, and so underestimates the potential farm income. In early 1998, MYCAL Corporation in Jefferson, Iowa was paying $22 to $25 per bushel for organic soybeans, approximately three times the price for conventional soybeans (AP 1998). MYCAL also reported that its suppliers achieved yields similar to those of conventional growers. If the organic farm received $20 per bushel for its beans, it would more than double the farm's net income. Organic vegetables, wheat and oats might also bring premium prices.

Table IV-1. Summary budgets for the five case study farming systems. All values in 1996 dollars.

	Conventional	Modified	Agroforestry	Organic	Beef
Land costs					
Owned	10,498	10,498	9,152	9,152	5,429
Rented	28,243	28,243	13,430	13,430	6,624
Equipment					
Ownership	34,906	34,906	30,501	31,591	15,748
Operation (excl. labor)	9,235	7,816	7,256	9,304	5,976
Equipment rental	1,789	1,493	683	529	681
Seed, chemicals, misc.	33,599	26,543	15,624	19,962	7,581
Cattle					
Purchase calves	—	—	—	—	261,477
Backgrounding, health	—	—	—	—	53,202
Feedlot finishing	—	—	—	—	69,584
Custom operations	10,498	11,879	8,391	8,092	1,115
Hired labor	0	0	3,915	751	0
Overhead and Interest					
Interest on operating capital	3,693	3,198	2,403	2,589	42,994
Overhead	2,941	2,546	1,914	2,061	22,131
Gross income	167,668	154,585	128,746	130,886	522,136
Total expenses	135,402	127,122	93,269	97,461	492,542
Net income	**32,266**	**27,463**	**35,477**	**33,425**	**29,594**

Agriculture consists of three sectors — inputs, farming, and marketing. Smith (1992) showed that the farming portion of the combined economic activity of the U.S. farming and input sectors was 14% in 1990. Estimated as net income/gross income, the farming share of inputs + farming for the five model farms is 19% for the conventional farm, 18% for modified conventional, 28% for agroforestry, 26% for organic, and 6% for beef. The conventional and modified conventional systems are close to the national average, while the organic and agroforestry farms capture a larger portion of this economic activity. Most of the economic activity of the beef system is off-farm.

Removing Differences in Land Costs

Because the cost of renting cropland ($79.00/A) exceeds the estimated ownership costs of $36.00 per acre (see Appendices 4A,B), total costs of land for the conventional and modified conventional are greater ($59.60/A) than for the agroforestry and organic farms ($53.13 /A). Beef farm land costs are only $26.20/A. Calculating net income exclusive of land costs removes this difference in comparing the five farms (Table IV-2).

Table IV-2. Annual net income, excluding land costs, for the five model farms.

	Conventional	Modified	Agroforestry	Organic	Beef
$/acre	109	102	137	132	91
$/farm	71,007	66,204	58,059	56,007	41,647

The per acre returns to land show the same relative pattern as farm net income except that the beef farm now has the lowest return. This is somewhat misleading — pasture land is generally less expensive than good crop land, so it is reasonable to include a land cost differential when comparing grazing and row crop systems. Even for the rowcrop farms, a land cost differential might not be unreasonable. If the agroforestry or organic farms wanted to expand, it would likely require rental or the purchase of land with lower equity and higher costs than on prior-owned land. Either way, expansion would bring an increase in per acre land costs.

Differences in expenses among farms

Table IV-3 illustrates the higher cost of land as a percentage of total expenses for the conventional and modified conventional farms. Otherwise, the four crop-farms are quite similar in their distribution of expenses. For the beef farm, on-farm expenses are a very small portion of the total. Most of the economic activity associated with producing beef by this approach occurs off-farm.

Costs and returns per acre

The cost of growing a particular crop varies from farm to farm. Major differences in production techniques such as organic versus conventional may contribute to differences in production costs. But, even if the same agronomic practices are followed, differences in the supporting systems can influence costs. For example, if fewer acres of a crop are grown, fixed costs such as machinery ownership will be spread across fewer acres, and per acre costs will rise.

Table IV-3. Comparison of farming system expenses — percent of total farm expenses by category.

	Conventional	Modified	Agroforestry	Organic	Beef
Land	29	30	24	23	2
Equipment					
Ownership and rental	27	29	33	33	3
Operation (excl. labor)	7	6	8	10	1
Seed, chemicals, misc.	25	21	17	20	2
Cattle: purchase and off-farm costs*	0	0	0	0	78
Custom operations	8	9	9	8	0
Hired labor	0	0	4	1	0
Overhead and Interest	5	5	5	5	13

*Includes purchase of calves, winter backgrounding, health costs, and feedlot finishing costs.

Table IV-4 presents a summary of per acre production costs and returns by crop for each farm. A detailed budget of per acre costs and returns can be found in Appendices 4A-E as part of the economic analysis of each farm. Production costs include costs of land as well as chemicals, machinery, other inputs, interest and overhead (see Table IV-1).

Corn for grain is the most expensive of the major field crops to produce. The conventional farm can produce corn for $234 per acre ($2.23/bu), while it costs the modified conventional farm $252 per acre ($2.40/bu). The difference is due to the smaller number of acres of corn and other row crops grown by the modified conventional farm. The costs of owning the machinery to produce these crops are spread across fewer acres, raising this component of crop production costs to $81.93 per acre of corn on the modified conventional farm (versus $62.87 per acre of corn on the conventional farm). See Appendix 4 for a detailed breakdown.

Specialty crops — Christmas trees, hazel nuts, vegetables — have the highest per acre production costs; more than $1000 per acre is spent for vegetables, with green peppers the highest at $5256 per acre. Their production requires intensive use of equipment, irrigation, labor, and organic pest control. Harvest costs include packing containers, ice and cooling, and marketing fees — large expenses not incurred in bulk grain production. However, these crops also have high gross sales per acre, and therefore net returns from $500 per acre for sweet corn to more than $3000 per acre for peppers.

Windbreaks on the agroforestry and organic farms take 23 acres out of production, but still create a net increase in farm income by increasing the yields of protected crops. Three organic crops — oats/turnips, wheat, and pasture (hay and grazing fees) — were money losers. However, in the context of the organic system, oats and wheat play important roles in weed control and other aspects of the crop rotation, and the pasture is essential for holding backgrounding cattle during periods when wet soils would be compacted in the rowcrop fields. These are intangible benefits that are difficult to quantify monetarily.

On a whole farm basis, the modified conventional farm has the lowest per acre production costs, but the agroforestry and organic farms have the highest per acre net income. The extremely high per acre expenses and gross income of the beef farm are somewhat misleading. They reflect the very high cash flow associated with the entire production system, calf purchase to feedlot, rather than the agricultural activity of the pastureland itself, which is a relatively small.

Table IV-4a. Conventional farm: Production costs and income ($/A) by crop.

	corn	soybeans	farm
Production costs	234	182	208
Gross income	278	238	258
Net income	44	56	50

Table IV-4b. Modified conventional farm: Production costs and income ($/A) by crop.

	corn	soybeans	sorghum	alfalfa	farm
Costs	252	186	171	159	196
Gross income	278	238	212	203	238
Net income	26	52	41	44	42

Table IV-4c. Agroforestry farm: Production costs and income ($/A) by crop.

	corn	soybeans	sorghum	alfalfa	Xmas trees	hazel	farm **
Costs*	263	212	197	171	484	522	219
Gross	299	258	219	228	1224	1380	303
Net	36	46	22	57	740	858	84

*Cost of 23 acres of windbreaks distributed proportionally among other crops.
**Includes windbreak acres.

Table IV-4d. Organic farm: Production costs and income ($/A) by crop.

	alfalfa	corn grain	milo	soybeans	oats/ turnip	corn silage	wheat	pasture
Costs	172	267	227	195	191	182	169	160
Gross	255	326	245	258	143	243	151	123
Net	83	59	18	63	-48	61	-18	-37

	sweet corn	pumpkins	acorn squash	peppers	spinach	whole farm*
Costs	1228	1240	1179	5256	2144	229
Gross	1732	2518	2306	8640	3717	308
Net	504	1278	1127	3384	1573	79

Windbreak costs prorated among crops; grazing fees prorated to gross income for crops with residues that were grazed.
*Includes windbreak acres.

Table IV-4e. Beef system:
Production costs and income ($/A).

	Whole system*
Costs	1071
Gross	1135
Net	64

*total system costs divided by 460 acres.

As a check on the reasonableness of the models, I compared the conventional farm results with the outcome of an analysis of an Iowa corn-soybean system (Craig and Duffy 1991). For the Iowa system, production costs excluding land were $190/A for corn, $127/A for soybeans, and $159/A for the whole system. Production costs excluding land for the model conventional farm are $174/A for corn, $122/A for soybeans, and $148/A for the farm.

Returns to land, labor, and management for the Iowa system were $125/A for corn, $95/A for soybeans, and $110/A for the whole system. For the conventional farm model the corresponding estimates are $104/A for corn, $116/A for beans, and $110/A for the farm. The good agreement between these two studies provides increased confidence in the assumptions underlying the models.

Labor requirements and seasonal distribution

Conventional cash grain farmers are often very busy for short periods in the spring and fall, and underemployed for the remainder of the year (Jamtgaard 1995). Alternative systems that require more total labor and distribute the labor needs more evenly through the year may be advantageous, if the extra labor inputs translate into greater net income per acre.

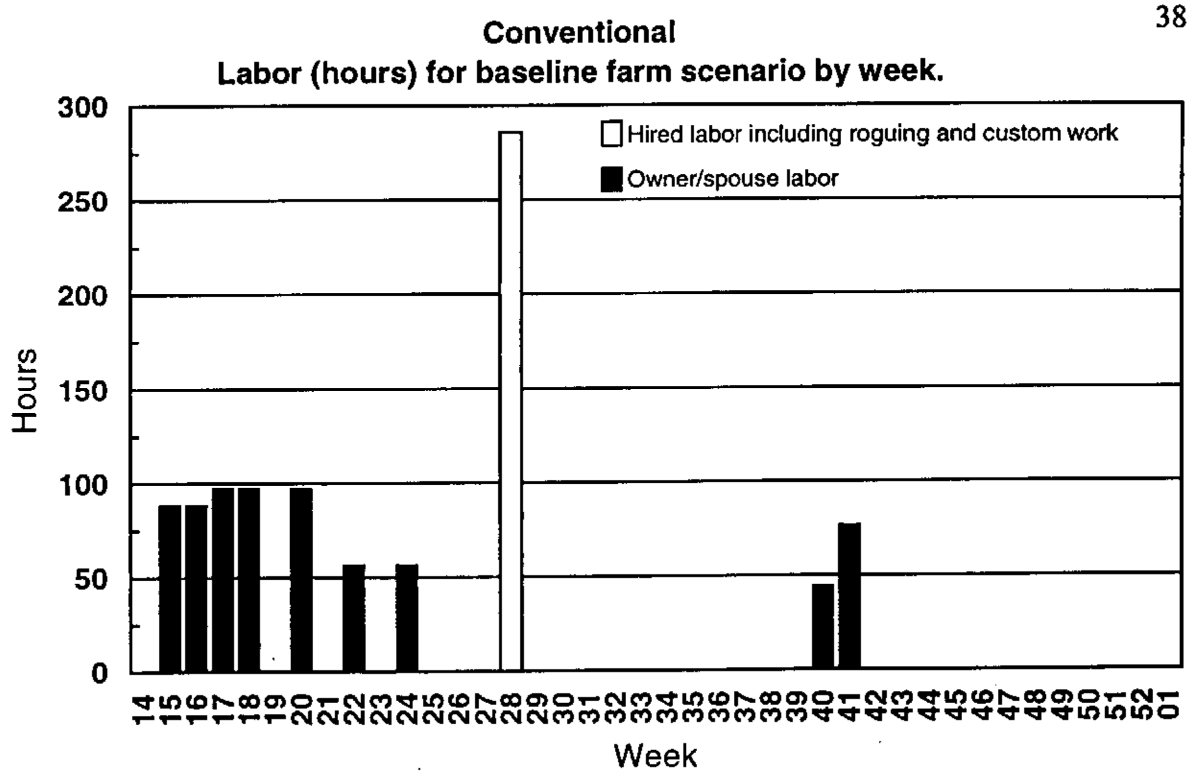
The agroforestry and organic systems require more than twice as much labor, both total and farmer/spouse, than the conventional systems (Table IV-5). Hired labor for the conventional and modified conventional farms is mostly for hand-weeding beans and sorghum, plus for custom harvest of alfalfa on the modified farm. In addition to weeding crops, the agroforestry farm uses a lot of labor for harvesting hazel nuts, and the organic farm requires considerable labor for weeding and harvesting vegetables.

Table IV-5. Labor requirements of five farming systems.

Farm	Owner/spouse	Hired and Custom	Total
Conventional	708	286	994
Modified	642	451	1093
Agroforestry	1621	864	2485
Organic	1606	719	2325
Beef	890	3	893

Figure IV-1 shows the weekly distribution of labor needs for each farm. The conventional and modified conventional farms have the expected spring and fall peaks for owner labor, and the mid-summer spike for hired labor for weeding. The greater crop diversity of the modified farm spreads out the farm's labor demands somewhat.

Labor needs are greater and more evenly distributed for the agroforestry and organic farms. Christmas tree sales extend the agroforestry work year into December, while backgrounding of cattle on stalks provides fall work on the organic farm. The pasture-based beef farm has a very even labor distribution.



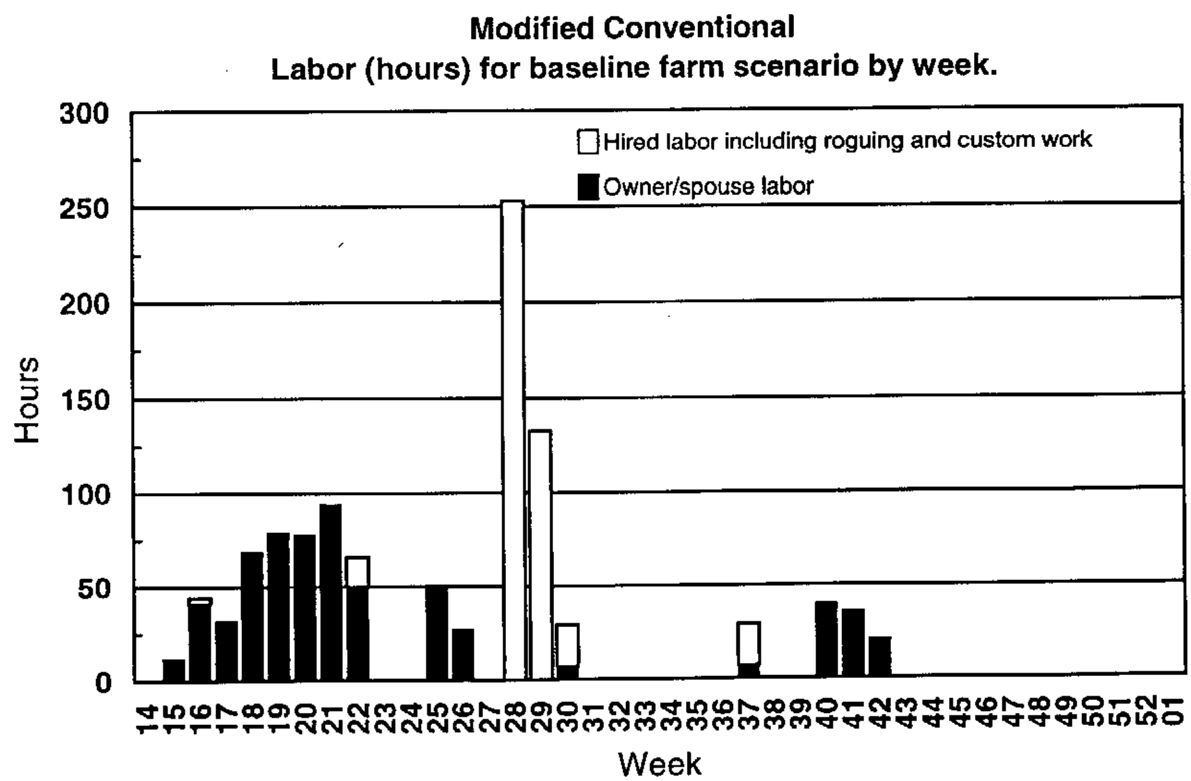
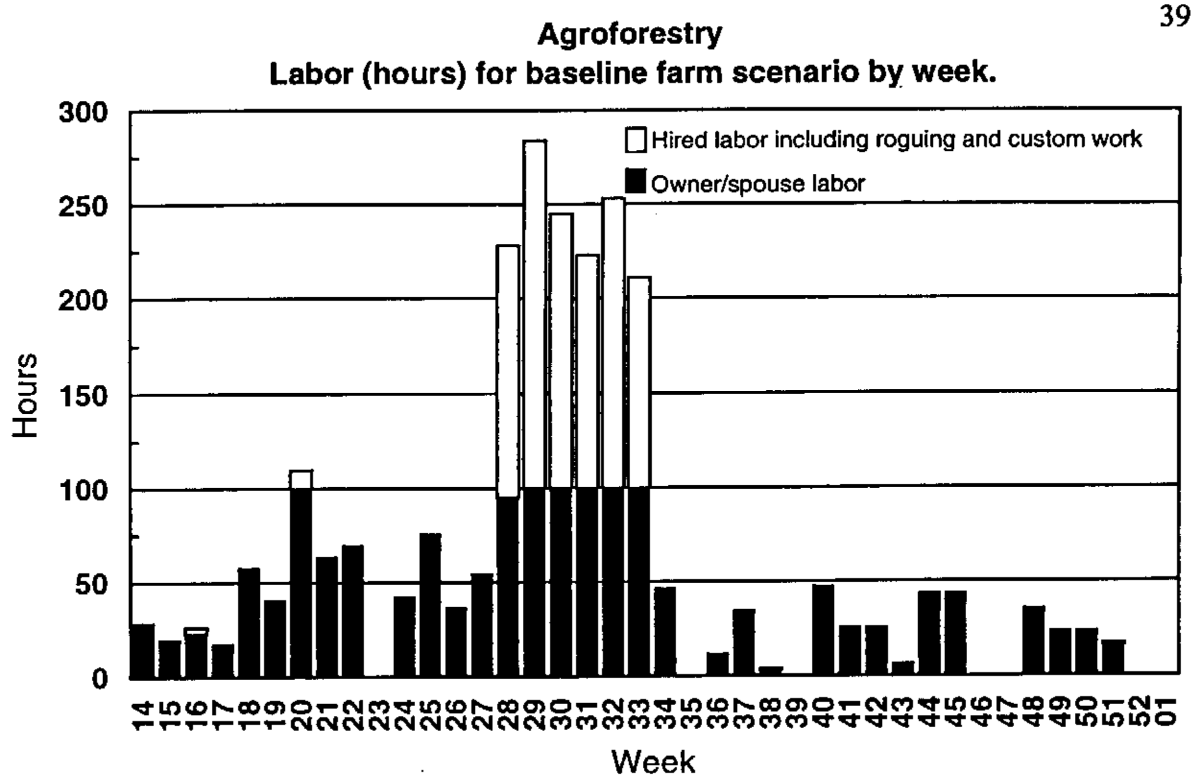


Figure IV-1a,b. Labor hours by week for conventional (top) and modified conventional (bottom) farms. Week 14 is 2-8 April.



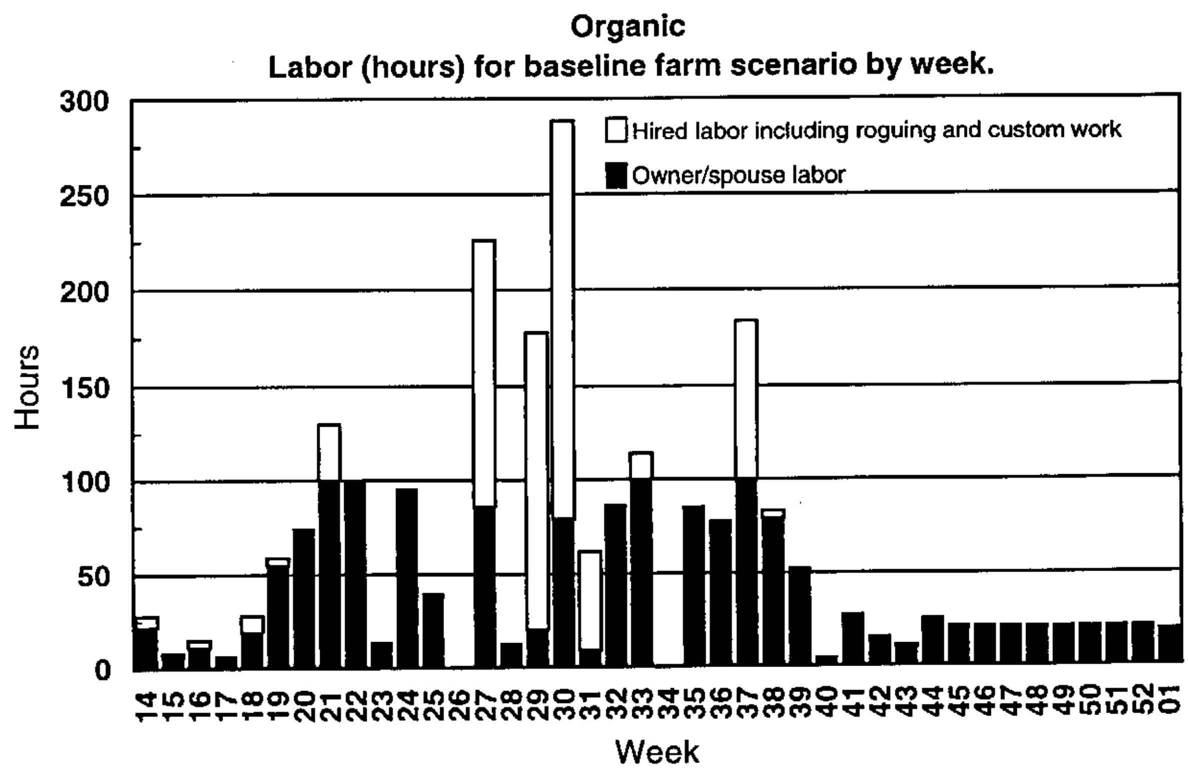


Figure IV-1c,d. Labor hours by week for agroforestry (top) and organic (bottom) farms. Week 14 is 2-8 April.

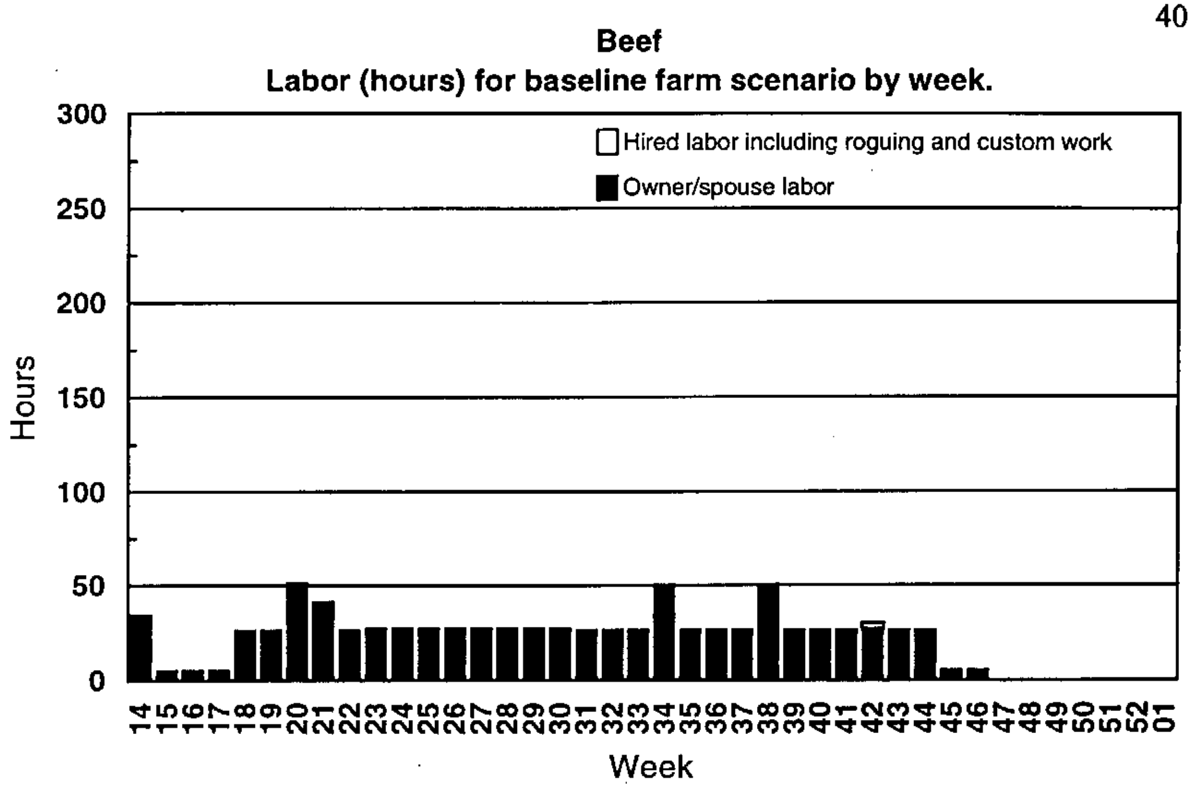


Figure IV-1e. Labor hours by week for pasture-based beef farm. Week 14 is 2-8 April.

These graphs show only field labor requirements plus preparation time. They underestimate total farmer labor, which would also include time spent ordering inputs, marketing crops, and other miscellaneous tasks associated with any major business enterprise. Marketing of vegetables occurs throughout the summer in the face of a volatile market. Purchase of calves involves considerable time at livestock sales. The total labor differential between the conventional systems and the three smaller farms is probably greater than Figure IV-1 indicates.

A breakdown of labor needs by crop (Table IV-6) helps to explain the differences in total labor needs among farms. Conventional corn requires the least labor — 1.2 hours per acre per year. Labor needs for rowcrops are slightly higher on the agroforestry farm because of the use of 6-row rather than 8-row equipment. Organic rowcrops require even more labor because of additional hand weeding.

Table IV-6. Labor hours per acre by crop and farming system. Labor includes owner/spouse, hired, and custom.

Crop	Conventional	Modified	Agroforestry	Organic	Beef
corn (grain)	1.2	1.2	1.5	3.2	
soybean	1.9	1.9	2.3	4.8	
sorghum		1.9	2.2	4.9	
alfalfa		1.5	1.9	1.9	
oat/turnip				1.2	
wheat				0.9	
corn (silage)				2.9	
pasture				1.1	1.9
windbreaks			1.4	0.8	
sweet corn				78.4	
pumpkin				65.1	
acorn squash				66.4	
bell pepper				145.4	
spinach				163.3	
Christmas tree			47.9		
hazel			78.7		
Whole farm	1.5	1.7	5.9	5.5	1.9

The specialty crops have much higher per acre labor needs, and these contribute to a per acre labor requirement for the agroforestry and organic farms that is more than three times that of the conventional and modified conventional farms. In effect, the smaller farms are substituting labor and intensive management for land.

V. Long-Term Economic Variability

Income Variability

In their excellent book "Sacred Cows and Hot Potatoes," Browne et al. (1992) write "The most important aspect of today's farm problem may well be the variability of farm income relative to that of the average citizen's. Farmers inescapably face highs and lows, often intense ones. As a consequence, those concerned about farmers should not focus on the level of farm income. Rather, they should look at the variance in farm income and the associated problem of variance in asset values." Although a farm's average annual income may be good, one or two bad years could create an insurmountable cash flow problem.

To compare the income variability of the five farming systems, I calculated whole farm expenses, gross income, and net income for each year from 1985-1994 (Appendix 5). Prices were standardized to 1996 dollars using the price index for gross domestic purchases (Table A5-1). Yields were based on annual averages for Saunders County, and prices for major crops on crop market year averages for eastern Nebraska (Table A5-2). Vegetable prices were based on Chicago wholesale market prices (Table A5-3).

Expenses that varied annually with changes in yield included costs for drying corn, trucking grains, custom harvest of alfalfa, packing and cooling vegetables, and vegetable marketing fees. The beef farm had to purchase hay in years when forage production fell below the amount needed by the cattle.

Annual variability in net income was calculated as the coefficient of variation for each farm's annual income during the ten-year period (Table V-1). The agroforestry and organic farms had the lowest variability and highest average incomes. Variability was extremely high for the beef farm with losses in three of the ten years, and net income exceeding $60,000 in two of the years.

Table V-1. Estimated annual net income for five model farms, 1985-1994. Values in constant 1996 dollars.

Year	Conventional	Modified	Agroforestry	Organic	Beef
1985	56,261	36,528	40,336	36,650	66,903
1986	25,395	16,438	27,921	27,363	43,339
1987	22,532	17,160	29,482	33,009	84,908
1988	35,176	43,210	46,746	57,831	23,716
1989	19,615	20,941	34,153	44,387	27,714
1990	7,066	13,003	27,237	20,885	48,734
1991	17,616	21,591	30,814	24,661	-22,950
1992	40,362	27,351	31,215	23,124	44,628
1993	19,629	10,604	25,160	21,144	-22,070
1994	45,400	38,183	41,464	27,778	-20,556
mean (C.V.)	28,905 (52%)	24,501 (46%)	33,453 (21%)	31,683 (37%)	27,437 (140%)

Variability by Crop

It is often suggested that a greater diversity of crops and enterprises decreases the income variability of a farm. One way this could happen is if crops with lower annual variability in gross returns were added to the existing crop mix of a farm. Christmas trees and hazel nuts have contributed in this way to the lower variability of the agroforestry farm. Although published price and yield records don't exist for these tree crops, conversations with long time growers and wholesale seed buyers indicate that demand and price for both of these crops were quite stable during the ten year period of the analysis.

The primary field crops tell a different story. Table V-2 presents gross income (county average yield x price) for the main crops grown by the five farms. Corn and soybean have the lowest variability of gross returns per acre. The alternative crops have higher variability as well as lower average gross returns, a double reason why corn and soybean are so popular. However, if a farm grew equal acres of the seven crops, the variability in gross income for the whole farm would be lower than that of any individual crop except soybean because the gross returns of crops are not synchronized. Although in 1993 all seven crops in Table V-2 had below average gross returns, and in 1988 six crops had above average returns, in most years some crops are up and some are down, reducing the whole-farm variability.

Vegetables have very high gross and net returns per acre (Appendix 4D). Although the coefficient of variation in annual gross income for the ten year period ranges from 12% for acorn squash to 35% for pumpkins, the coefficient of variation for the combined gross income from the five vegetables grown on the organic farm is only 14%.

Table V-2. Annual gross income by crop, constant (1996) dollars per acre (yield x price). Yield is average for Saunders County.

Year	corn	soybean	sorghum	alfalfa*	wheat	tame hay	oat	equal acres of all 7 crops
1985	356	236	206	183	175	110	147	202
1986	258	241	174	162	109	95	126	166
1987	251	233	181	195	127	111	122	174
1988	268	251	266	270	203	111	171	220
1989	253	220	189	279	168	159	89	194
1990	246	189	237	205	154	101	89	174
1991	271	199	269	165	119	103	82	173
1992	305	244	196	165	106	99	104	174
1993	247	227	154	179	81	102	49	148
1994	300	262	227	194	131	109	68	184
mean	275	230	210	200	137	110	105	181
C.V.	13%	10%	18%	21%	27%	16%	35%	11%

*Spring-seeded alfalfa average yield in east-central Nebraska is 2.25 tons/acre in the establishment year (Selley 1996) which is 64% of county average for all alfalfa. Because 1/4 of the alfalfa acres in the model farms that grow alfalfa are first year stands, average yield is estimated as 91% of county average for that year.

VI. Energy Analysis and Comparison of Five Farming Systems

Agricultural production accounts for about 17% of the energy used in the U.S. food system, and 3% of total U.S. energy use (Hendrickson 1997). On-farm energy use includes two types of energy (Fluck and Baird 1980):

Direct energy: The energy content of fuels (e.g., gasoline or diesel) and electricity.

Embodied energy: The sum of all the direct and indirect energy required to produce a good or provide a service.

The energy embodied in a tractor includes the energy required to mine and smelt the iron ore, fabricate the tractor, and ship the tractor to the farm. Fertilizer and pesticides embody the energy required for their production and transportation to the farm. Even diesel fuel requires energy to extract and refine the oil and then ship the fuel to the farm. A complete and valid energy accounting for a farm must include embodied as well as direct energy inputs. For example, fertilizers and pesticides can account for as much as one-third of total on-farm energy consumption (Stout 1984).

Appendix 6 includes information on the energy content of all inputs used in the models of the five farming systems, and the energy content of all crops grown on the farms. These data tables are followed by detailed energy budgets for each farm. The main results of the energy analyses are presented in this section. Energy contents are expressed as mega-calories (Mcal) with 1 Mcal equal to 1 million calories. One calorie equals 4.187 joules. An important distinction exists between calories and Calories. The capitalized version is the unit commonly used in nutrition, and is equal to 1000 calories or 1 kcal. A dieter counts Calories, not calories.

Summary energy budgets

Table VI-1 compares the basic energy budgets of the five farms. The four crop systems all show net gains in energy — the energy content of the harvested crops exceeds the amount of cultural energy required to grow and harvest them. The beef farm shows a net loss of energy with roughly five times as much cultural energy invested in the system as is produced as beef and hay. The output/input ratio for energy is highest for the modified conventional system and lowest for the beef system.

The organic and beef systems stand apart from the others. The high total energy input for the organic farm is due to its use of feedlot manure as its primary fertilizer. Per pound of nitrogen, the energy content of feedlot manure is more than 12 times greater than anhydrous ammonia. The calculation of the embodied energy of feedlot manure is shown in Appendix 6, Table A6-11. Basically, feeding grain to a steer is a very energy-expensive way to produce fertilizer. Some would argue that the organic farm is providing a service in removing a waste product, and that perhaps only the energy cost of

Table VI-1. Summary energy budgets for five farming systems. Units are Mcal.

	Conventional	Modified	Agroforestry	Organic	Beef
Energy input	1,085,252	773,142	573,757	1,785,870	5,200,239
Energy output	4,211,025	4,049,719	2,590,642	2,823,541	1,016,593
Gross output/A	6,479	6,230	6,096	6,611	2,210
Net output	3,125,773	3,276,577	2,016,885	1,037,670	-4,183,646
Net output/A	4,809	5,041	4,746	2,442	-9,095
Output/input	3.9	5.2	4.5	1.6	0.2

transporting and spreading the manure should accrue to the farm. My assumption is that if the successful operation of an organic farm is tied to the continued operation of an energy-intensive feedlot, then the organic farm incurs the full energy cost of the manure that it uses.

As a check on the models, I compared the energetics of corn production by the model conventional farm with an analysis by Pimentel (1980) of dryland corn production in Iowa. The Iowa system had inputs of 2339 Mcal/A, outputs of 8688 Mcal/A (for 98 bu/A), and an output/input ratio of 3.72. The model conventional farm had inputs of 2549 Mcal/A, outputs of 9128 Mcal/A (for 105 bu/A), and an output/input ratio of 3.58 (see Appendix 6, Table A6-6).

Table VI-2 describes the partitioning of energy use among the different input categories for each farm, and illustrates some important differences among the systems. For example, very little of the energy used in the beef production system is used on the 460 acres of pasture. The cattle spend their last 84 days in the feedlot, during which more than half of the system's total energy use occurs. Another forty percent of the energy use occurs before the steers arrive on pasture. Just as most of the economic activity associated with this system occurs off the core farm, most of the energy use occurs off-farm.

Table VI-2 also illustrates the effect of fertilizing with manure — more than 70% of the organic farm's energy use is attributed to fertilizer. The other three crop-farms have energy use patterns in which direct energy use on-farm, primarily to run equipment, represents 21% to 35% of total energy use. Crop drying represents a similar fraction of total energy use, and seed, fertilizer, and pesticides combined are the third main category.

With the exception of the agroforestry farm, labor is a very small part of the energy budgets.

Table VI-2. Relative energy use (%) by category for the five farms.

Energy input category	Conventional	Modified	Agroforestry	Organic	Beef
diesel/gas/electricity	21.2	27.3	35.4	13.7	1.5
equipment[1]	4.7	6.5	8.3	2.8	0.3
custom fieldwork		3.7	0.4	0.3	
seed	9.8	11.0	9.1	3.8	
fertilizer	11.6	10.6	8.7	71.5	4.0
pesticide	12.5	12.0	9.0	0.1	
labor[2]	1.8	2.6	8.2	2.2	0.3
packing containers, ice				1.5	
crop drying	36.3	23.7	18.9	3.6	
trucking crops or cattle	2.2	2.7	2.1	0.5	0.5
Cattle					
calves at purchase					16.8
receiving and backgrounding					23.0
finishing					53.3
Total system energy use (Mcal)	1,085,000	773,000	574,000	1,786,000	5,200,000

[1]Equipment energy represents depreciation of embodied energy of equipment, and includes energy associated with rental equipment. [2]Labor includes owner/spouse labor and hired labor.

Assuming average yields, corn silage and corn for grain provide the greatest gross energy output per acre of the food crops grown by the five farms (see Appendix 6, Table A6-5). Alfalfa provides the third highest energy output, and grain sorghum is fourth. All other crops lag considerably behind these four. Thus, crop mix strongly influences a farm's gross energy output. The lower gross outputs of the modified conventional and agroforestry farms (Table VI-1) relative to the conventional farm result from the reduction in the proportion of land in corn. The organic farm achieves the highest gross output by putting nearly one-third of the land in alfalfa, and by adding corn silage, a higher energy crop than corn for grain.

When crops are compared on the basis of energy output to input ratios (Table VI-3), alfalfa and sorghum show the largest net output of energy, while field corn and soybeans are considerably lower. With establishment required only once every four years, and no nitrogen fertilizer, the energy inputs for alfalfa are low. Sorghum has lower energy inputs in seed, fertilizer, and herbicides than does corn, and most importantly has no energy inputs for drying (see Appendix 6 for detailed farm and crop energy budgets). Also, gross energy output per acre for sorghum is almost twice that of soybeans (Table A6-5).

Organically grown alfalfa and soybeans have a somewhat higher output/input ratio than the same crops grown conventionally (Table VI-3). Organic corn and sorghum, because they require nitrogen fertilization with manure, have very low energy ratios as do the rest of the organic crops.

Table VI-3. Energy output to input ratios, by crop, for five farming systems.

crop	conventional	modified	agroforestry	organic	beef
alfalfa		9.0	9.8	11.1	
field corn	3.6	3.6	3.4	1.4	
sorghum		10.3	8.2	1.1	
soybean	4.9	4.8	4.1	5.0	
Xmas trees			0.6		
hazel nuts			0.1		
oat/turnip				1.2	
corn silage				1.0	
winter wheat				0.4	
brome pasture/hay				0.4	
vegetables				0.1	
steers*					0.2
Total farm	3.9	5.2	4.5	1.6	0.2

*Includes excess hay sold off-farm.

Energy intensity is a measure of the amount of energy required to produce $1.00 of economic output. Farms with lower energy intensity will have lower energy costs and possibly higher net returns. Systems with lower energy intensity would be particularly advantageous if energy prices increased significantly above their current low levels. From an environmental standpoint, lower energy intensity systems could reduce CO_2 outputs and decrease the rate of depletion of fossil fuels. The agroforestry and modified conventional systems have the lowest energy intensity (Table VI-4) due to their smaller proportion of land in corn, a very high energy intensity crop (Table VI-5).

Table VI-4. Energy intensity of farming systems measured as amount of energy required to produce $1.00 of output.

	Conventional	Modified	Agroforestry	Organic	Beef
energy input (Mcal)	1,085,252	773,142	573,757	1,785,870	5,200,239
gross income ($)	167,668	154,585	128,746	130,886	522,136
Mcal/$	6.5	5.0	4.5	13.6	10.0

Table VI-5. Energy intensity (Mcal input/$1.00 gross output) by crop and farming system. Income for organic crops includes grazing fees.

crop	conventional	modified	agroforestry	organic	beef
alfalfa		4.0	3.6	3.2	
field corn	9.2	9.2	9.5	22.3	
sorghum		3.4	4.3	28.5	
soybean	3.3	3.4	3.9	3.2	
Christmas trees			1.8		
hazel nut			1.6		
oat/turnip				19.9	
corn silage				49.7	
winter wheat				57.1	
brome pasture/hay				79.9	
vegetables				6.1	
steers*					10.0
Total farm	6.5	5.0	4.5	13.6	10.0

*Includes excess hay sold off-farm.

The energy intensity of the entire U.S. economy in 1994 was 3.1 Mcal/$1.00 (Bureau of the Census 1996). This indicates that the five farming systems are more energy intensive than many other sectors of the economy, and perhaps less competitive than other sectors should energy prices rise.

VII. Nutrient budgets and soil erosion of five farms

The input budgets developed for the five model farms follow standard recommendations for fertilizer applications based on yield goals and basic soil type. If the amounts of nitrogen and phosphorus applied do not balance with losses of these nutrients from the farms, the systems as operated are not sustainable. Shortfalls may be compensated for in the short term, but not forever, by drawdown of soil pools. Excess applications will eventually lead to environmental problems such as water pollution.

Rates of soil erosion are key factors in nutrient budgets. Soil erosion also removes soil organic matter and degrades soil properties such as water holding capacity and bulk density.

Rates of water erosion were estimated for each farm using PLANETOR, a farm planning software program that evaluates the environmental impacts of different farming systems (Center for Financial Farm Management 1995). Wind erosion, estimated separately with standard formulas (Smith and English 1983), was negligible for these systems in eastern Nebraska. Nutrient budgets (nitrogen and phosphorus) including inputs from fertilizers, atmospheric deposition, and nitrogen fixation, and outputs from erosion, denitrification and volatilization, and crop removal were summarized for each farm. The detailed budgets and methods are presented in Appendix 7.

Summary nutrient budgets are presented below on both a whole farm (Table VII-1) and per acre (Table VII-2) basis. All farms show a net loss of phosphorus, and all but the beef farm have a net loss of nitrogen. The crop farms need approximately a 50% increase in nitrogen and phosphorus application rates to balance the budgets. The main uncertainties associated with these budgets are discussed in Appendix 7.

Soil replacement value (T) is 5.0 tons per acre for all five farms, so all the systems are at or below T (Table VII-3). The whole-farm rate of soil erosion decreases from conventional (highest rate) to beef (lowest rate), corresponding to the increase in the proportion of each farm planted to perennials: conventional (0%), modified conventional (9%), agroforestry (25%), organic (36%), and beef (100%).

Table VII-1. Summary nitrogen and phosphorus budgets (lb N and lb P per year per farm).

	Conventional	Modified	Agroforestry	Organic	Beef
N inputs	47,775	47,400	30,970	47,491	43,024
N outputs	79,300	80,221	50,224	71,290	25,911
Balance	-31,525	-32,821	-19,254	-23,799	17,113
P inputs	7,150	5,222	2,970	4,077	846
P outputs	11,050	11,090	6,580	6,269	1,757
Balance	-3,900	-5,868	-3,610	-2,192	-911

Table VII-2. Summary nitrogen and phosphorus budgets (lb N/A and lb P/A).

	Conventional	Modified	Agroforestry	Organic	Beef
N inputs	74	73	73	112	95
N outputs	122	123	118	168	57
Balance	-48	-50	-45	-56	38
P inputs	11	8	7	10	2
P outputs	17	17	15	15	4
Balance	-6	-9	-8	-5	-2

Table VII-3. Weighted average erosion (tons/A) for five farms.

Conventional	Modified	Agroforestry	Organic	Beef
5.0	4.6	3.5	1.1	0

VIII. Relative sustainability of five farming systems

Sustainability is the ability of a farming system to maintain production through time, in the face of long-term ecological constraints and socioeconomic pressures (Altieri 1987). Our current farming systems face declining domestic energy reserves, soil loss in excess of regeneration, and a rapidly increasing human population with a concomitant increase in demand for agricultural products. A sustainable system has an adequate economic, ecological, and social performance.

Debate arises when we try to quantify the sustainability of a particular system. What characteristics of a system should be measured to determine sustainability? And how should these measurements be interpreted?

One thing is clear — no one measurement can indicate sustainability. What is needed is a suite of indicators representing the ecological and socioeconomic aspects of farming systems. Many such lists have been prepared (e.g., Smit et al. 1998), and the list presented in Table VIII-1 contains a small subset of all the proposed indicators. It is based on the assumptions that:

- Systems that can produce high yields with reduced inputs, while maintaining soil quality, will be more sustainable.
- Higher net income and a low debt service increase sustainability.
- The primary function of farming systems is to convert solar energy into useful commodities, and the more efficiently a farm uses cultural energy and water to achieve this goal, the greater is its sustainability.

Readers are encouraged to develop their own list of indicators to fit the systems of interest to them and their own philosophies of sustainability. Building such a list is an excellent teaching and learning exercise.

In deciding how to interpret the estimated value of an indicator for a farming system, I did not attempt to identify a specific point that demarcated "sustainable" from "unsustainable." Systems can function quite well within a wide range of values for a particular indicator, especially when deficiencies in one factor can be compensated for by other factors. Instead, I simply identified a range of values for each indicator from low to high sustainability (Table VIII-1). The rationale for each choice is given in Appendix 8.

Table VIII-1. Selected indicators of sustainability for farming systems.

INDICATOR	DEFINITION	VALUE INDICATING HIGH SUSTAINABILITY	VALUE INDICATING LOW SUSTAINABILITY
harvest [1]	weight of harvested crops and livestock (lb/A, dry weight)	7100	0
cultural energy input [2]	total non-solar energy inputs (MJ/A)*	0	24000
energy output/input [3]	ratio of energy in harvested crops to cultural energy inputs	5	< 1
energy capture efficiency [4]	energy in harvested crops as % of growing season PAR**	1.0	0
water use efficiency [5]	harvested biomass (g m^{-2}) divided by AET (mm)***	1.15	0
imported fertilizer [6]	N + P (lbs/A)	0	135
nitrogen losses [7]	N losses (lb/A) (erosion and leaching)	0	40
soil erosion [8]	wind+water (tons/A)	0	5
N balance [9]	N inputs/ N outputs (harvest + losses) (lbs/A)	1	< .8 > 1.2
P balance [10]	P inputs/ P outputs (harvest + losses) (lbs/A)	1	< .8 > 1.2
crop diversity [11]	# per farm	12	1
hired labor [12]	hrs per acre	0	2
net income [13]	$ per acre	95	36
capital borrowing [14]	debt/variable income	0	1
farmer knowledge [15]	total skills and knowledge held by farm family	high	low

[1 - 15] The footnotes explaining the rationale for the choice of high and low values for each indicator are found in Appendix 8.

* J = joule. 1 MJ = 239 kcal.

**PAR = photosynthetically active radiation; the portion of the solar spectrum that can be used by plants for photosynthesis (0.4 to 0.7 um).

***AET = Actual evapotranspiration

One end of each range is often anchored at the lowest possible value; for example, the smallest number of crops that a farm could grow is 1.

The estimated values of each indicator for each of the five farms are given in Table VIII-2. Calculations are based on the outputs of the economic, energy, and environmental analyses described in preceding sections. To make it easier to compare the five systems, we standardized each value along a scale of 0 to 1 (Table VIII-3) with 0 representing low sustainability and 1 representing high sustainability.

Table VIII-2. Raw values for sustainability indicators.

INDICATOR	CONVEN-TIONAL	MODIFIED CONVEN-TIONAL	AGRO-FORESTRY	ORGANIC	BEEF
harvest (lb/A)	3397	3473	3503	4277	566
cultural energy input (MJ/A)	6992	4980	5707	17593	47331
energy output/input	3.9	5.3	4.5	1.6	0.2
energy capture efficiency (%)	.38	.37	.35	.39	.05
water use efficiency	.59	.61	.61	.74	.03
imported fertilizer (lbs/A)	39	25	23	45	65
nitrogen losses (lb/A)	25	23	18	52	23
soil erosion (tons/A)	5.0	4.6	3.5	1.1	0
N balance	.60	.59	.62	.67	1.66
P balance	.65	.47	.45	.65	.48
crop diversity (# crops)	2	4	7	15	2
hired labor (hrs/A)	.44	.59	2.0	1.7	.01
net income ($/A)	50	42	84	79	64
capital borrowing ratio	.63	.64	.46	.51	.90
farmer knowledge	medium	medium	high	high	medium

Table VIII-3. Standardized (0 to 1) values for sustainability indicators. A standardized value of 0 indicates low sustainability; 1 indicates high sustainability.

INDICATOR	CONVENTIONAL	MODIFIED CONVENTIONAL	AGRO-FORESTRY	ORGANIC	BEEF
harvest (lb/A)	.48	.49	.49	.60	.08
cultural energy input (MJ/A)	.71	.79	.76	.27	0
energy output/input	.73	1.0	.88	.15	0
energy capture efficiency (%)	.38	.37	.35	.39	.05
water use efficiency	.51	.53	.53	.64	.03
imported fertilizer (lbs/A)	.71	.81	.83	.67	.52
nitrogen losses (lb/A)	.38	.43	.55	0	.43
soil erosion (tons/A)	0	.08	.30	.78	1.0
N balance	0	0	0	0	0
P balance	0	0	0	0	0
crop diversity (# crops)	.09	.27	.55	1.0	.09
hired labor (hrs/A)	.78	.70	0	.15	.99
net income ($/A)	.24	.10	.81	.73	.48
capital borrowing ratio	.37	.36	.54	.49	.10
farmer knowledge	.50	.50	1.0	1.0	.50

There is no quantitative way to synthesize the 15 indicator values into a single index that can be used to compare the sustainability of the different farms, unless one is willing to assume that these are the only indicators of importance and that the proper relative weightings are known. Instead, I chose a visual representation as a qualitative comparison of whole-farm sustainability. Figure VIII-1 presents the sustainability indicators for each farm in the form of a pie-slice polygon (derived from Gomez et al. 1996). The standardized indicator values are plotted along 15 axes with the 0 values at the center, and the quadrant corresponding to each indicator is shaded proportional to the indicator's value, forming a polygon of different-sized slices. The relative sizes and shapes of the polygons provide a quick visual assessment of the relative sustainability of the five systems.

Figure VIII-1 suggests that the grazing operation is the least sustainable system. The agroforestry system presents a robust polygon that suggests the highest relative sustainability. Low scores on energy indicators shrink the organic farm polygon relative to that of the agroforestry farm.

Pie-slice polygons serve as an excellent teaching tool and basis for discussion. They do not answer the question of whether a particular system is sustainable. The results presented in Sections IV-VII and their synthesis in Figure VIII-1 do suggest that viable alternatives exist to conventional corn-soybean farms in eastern Nebraska. It appears that alternative farming systems can be developed that allow smaller farms to be economically and environmentally competitive with larger conventional farms. Comparative analyses using the methods presented in this report are an excellent tool for evaluating different farming systems.

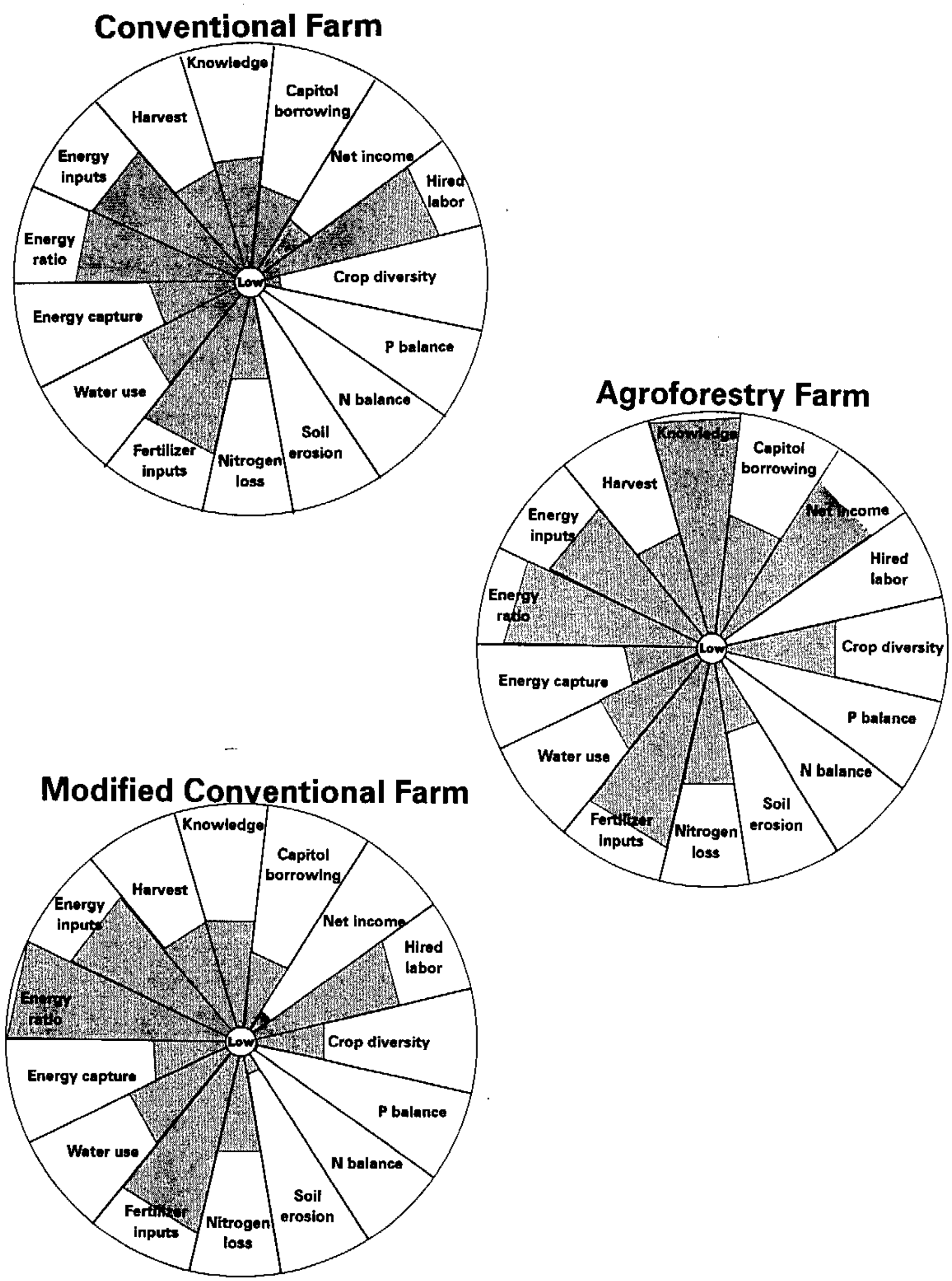
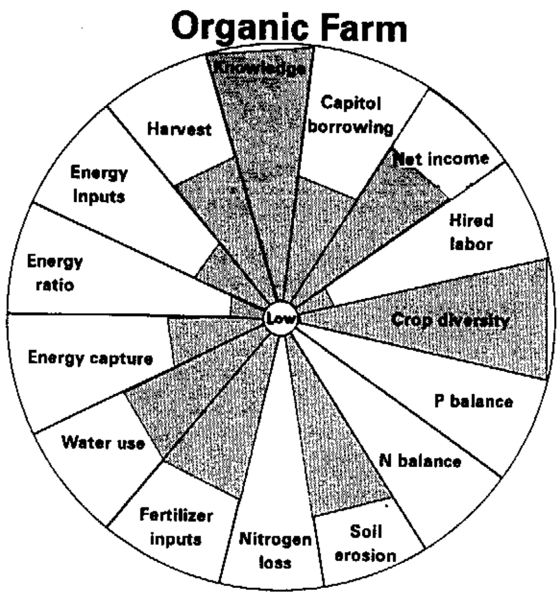


Figure VIII-1a. Pie-slice polygons for the conventional, modified conventional, and agroforestry farming systems. See text for explanation.



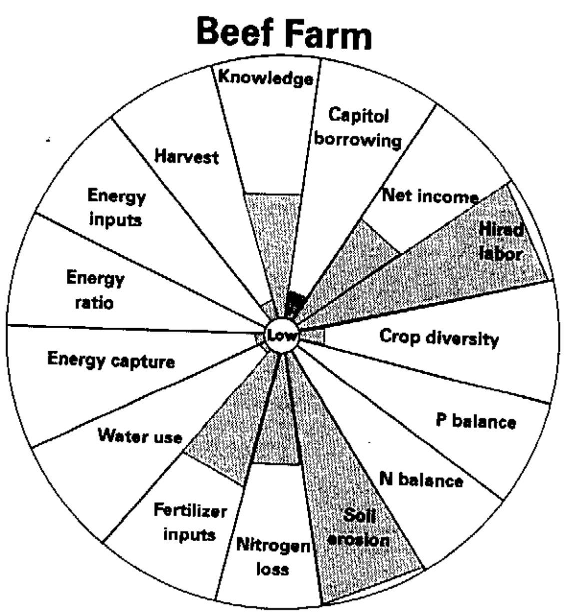


Figure VIII-1b. Pie-slice polygons for the organic and pasture-based beef farming systems. See text for explanation.

IX. Conclusions

Comparing alternative farming systems

Simple models, basically accounting procedures used to quantify inputs and outputs, and a few basic rules governing the interactions among system components, are sufficient to conduct a preliminary analysis and comparison of alternative farming systems. Estimates of production, economic performance, energy use, and environmental impacts can be derived for a wide range of different types of farming systems using readily available data, both current and historical.

This approach was demonstrated by an analysis and comparison of five farming systems for eastern Nebraska. The performances of two large conventional farms were evaluated relative to the performances of three smaller alternative systems. The results suggest that by increasing crop diversity and adding higher-value crops to the rotation, or by replacing rowcrops with pasture and cattle, farmers with smaller farms can increase net income per acre and remain competitive with larger conventional farms. Other key results include:

- Higher total labor requirements for the agroforestry and organic farms, and a more even temporal distribution of labor needs for all three alternative farms relative to the conventional farms.
- Lower energy efficiency of the organic and pasture-based beef systems as measured by energy output/input ratios and energy intensity.

- Reduced erosion rates for the alternative farms, correlated with increasing percentages of land in perennial crops.

The results also make clear the importance of a systems approach to farm evaluations by illustrating many non-additive system properties of these eastern Nebraska farms including:

- During a 10-year period, systems with higher crop diversity have reduced income variability because gross returns for different crops are not synchronized; that is, bad years for some crops are often off-set by good years for others.
- The profitability of a crop depends in part on whether other crops require the same machinery, thus allowing the fixed costs of machinery ownership to be spread over more acres.
- The organic system is linked through its importation of manure to an energy-intensive feedlot system, greatly reducing its energy efficiency.
- The pasture-based beef system has low on-farm energy use, but is tied to calf production and feedlot finishing systems that have high energy use.
- Although three crops grown on the organic farm — wheat, oat, and pasture — are money-losers when evaluated individually, they are essential parts of the overall rotation with regard to weed control, fertility, water use efficiency, and the fall backgrounding of cattle.

The case studies addressed "synthetic farms," not real farms but models designed to be representative of the types of farms that could occur in a particular region. The same approaches can be used in evaluating specific individual farms. The results should be more accurate, but will have less generality. This trade-off of generality for accuracy is the classic problem in modeling — a model cannot perform equally well both everywhere and somewhere.

Whether synthetic or real farms are being modeled, the modeler will have to make assumptions when data is lacking. The assumptions that are made can have major effects on the results; they need to be appropriate to the questions asked, and the reader needs to be aware of the assumptions in interpreting the results. For example, the economic model for the case studies assumes that the farmers have 80% equity in the land they own, and their mortgage payments are set accordingly. The 80% figure represents the average situation in eastern Nebraska. Because the question being asked concerns the type of systems that existing farmers could transition to, the assumption of 80% equity is proper.

If the case studies had focused on systems for beginning farmers starting with no land, then an assumption of perhaps 20% equity would be more appropriate, and land costs would have been much higher. The results of the case studies would have been quite different — none of the systems would be economically viable under the higher land costs.

Evaluating sustainability

When the relative sustainabilities of the farming systems are evaluated using a mix of indicators including both economic and non-economic measures, the relationships among the five farms are complex. For example, the organic farm compares poorly with the conventional farm in terms of energy efficiency, but favorably when water use efficiency and erosion are considered. Clearly, the choice of indicators can influence the outcome of an evaluation of the relative sustainability of different farming systems. This underlines the importance of exploring a complete suite of indicators when choosing sustainability criteria and procedures for analysis.

This study's definition of the farming systems did not include the homestead or the farm family, except in terms of labor. In some cases, this definition would be too narrow. For example, in a comparison of Amish and non-Amish farms, Johnson et al. (1977) found that many of the differences in economics and energy efficiency stemmed from the relatively low consumption of the Amish households. Money that the non-Amish spent on appliances and other consumer goods went toward land and a financial cushion for the Amish farms. If the boundaries of the study had stopped at the field's edge, this important aspect of system operation would have been missed.

Farming systems are nested within a spatial hierarchy (Olson and Francis 1995), and the appropriate positioning of the boundary of a system depends on the question being asked. The approaches described in this report are flexible and can be adapted to a wide range of questions. From the examples presented, it is apparent that the indicators and tools described provide a useful methodology for the agronomic, economic, and environmental evaluation of whole farm systems. Such evaluations are essential to any effort to reverse the ongoing trend toward the industrialization of agriculture.

A major transition

U.S. agriculture is rapidly changing. Within 20 years, the structure that we have traditionally associated with farming in the United States — many moderate-size family farms acting as independent producers of food and fiber — will be gone. Indeed, the statistics presented in the Introduction show that this vision is already largely a myth (Browne et al. 1992, Hanson 1996).

These structural changes are important. To quote Hamilton (1994), "Another way of looking at the structure of agriculture is to consider who will control agriculture — who will own the land, perform the labor, market the food, and profit from agriculture?" Most of the profits in agriculture now accrue to participants other than farmers, and the farmers' share continues to shrink. The power of the marketing and inputs oligopolies to control prices, and the increasing role of contracts and identity-preserved crops in production mean that even those farmers who still own their land are losing control of some of their operational decisions.

The globalization and industrialization of much of the agricultural sector seems inevitable (Urban 1991, Lehman and Krebs 1996). As advances in biotechnology and food technology lead to the industrial production of ersatz meat, milk, and even fruits and vegetables, the role of farms shifts to supplier of carbohydrate and vegetable protein feedstocks, and large volume, standardization, and low cost become the required characteristics of a farm's output.

An alternative paradigm

However, there is the potential for a bimodal agriculture that also supports many smaller producers that are integrated within a local agriculture and food system. Supplementing traditional crops with specialty crops, developing niche markets and marketing directly to consumers, these smaller farms could offer an alternative to industrialization, and a strengthening of local economies and food security (McFadden and Groh 1998).

Whether this alternative agriculture can develop and prosper depends in part on whether agricultural researchers, extension personnel, and policy makers are willing to accept small farms as part of a future agriculture, and to support the development of farming systems that are economically viable and environmentally sound on a reduced land base. Through its National Commission on Small Farms (USDA 1998), the U.S. Department of Agriculture has described the policy changes needed to preserve and strengthen the role of small farms in U.S. agriculture.

The changes recommended by the Commission would reduce the historical biases against small farms and in favor of large farms embodied in federal research priorities, tax and labor laws, farm programs, and trade policies. These changes would also increase federal support for the development of high-value crops and production systems, and the infrastructure that small farms need to survive including local processing and marketing systems that allow the farmer to capture a larger portion of the overall economic activity in agriculture. It remains to be seen whether these changes will be made.

Appendix 1. Deriving baseline descriptions of the five farm types

In developing models of each of the five alternative farming systems (conventional, modified conventional, agroforestry, organic, and pasture-based beef, we asked what would an analogous commercial farm in eastern Nebraska look like? How big would it be, what portion of the land would be rented, and what equipment would be owned? To complicate the question, only the conventional farming system is common in eastern Nebraska. The agroforestry, organic rowcrop, modified conventional, and pasture-based beef systems are rare, so the question becomes what type of eastern Nebraska farm would be most likely to adopt each system?

The Nebraska farm survey

The starting point for answering these questions is a detailed survey (Bernhardt et al. 1994) that characterized 381 Nebraska farms statewide in terms of 360 production and nonproduction variables. Farms were classified using a cluster analysis with 20 crop production variables in 9 categories:

1. nitrogen fertility sources
2. criteria used to determine nitrogen application rates
3. criteria to determine timing of nitrogen applications
4. weed control practices
5. insect control practices
6. crop diversification/rotation practices
7. cropping patterns/characteristics
8. tillage practices
9. miscellaneous, e.g., soil testing and crop scouting

The resulting five clusters were given a relative ranking from "conventional" to "sustainable" using a "sustainability index" based on (1) a subjective definition of which practices are most representative of conventional or sustainable farming (Bernhardt et al. 1994), and (2) the average score of each cluster on the Alternative/Conventional Agricultural Paradigm scale based on farmer attitudes and perceptions (Beus and Dunlap 1991). The final cluster designations were:

Cluster 2: conventional
Cluster 1: conventional but more flexible and innovative
Cluster 5: transitional, intermediate
Clusters 4 and 3: sustainable

Omitting the transitional Cluster 5, Table A1-1 presents some of the characteristics of the four groups of farms. The conventional farms are larger and more likely to use chemical fertilizers

Table A1-1. Selected characteristics of farms in Clusters 1-4 of the Nebraska farm survey (Bernhardt et al. 1994). The clusters were defined on a "conventional - sustainable" scale as Cluster 2 - conventional, Cluster 1 - innovative conventional, Cluster 3 - sustainable, and Cluster 4 - sustainable. See text for details.

Characteristic	Cluster 2	Cluster 1	Cluster 4	Cluster 3
farm size (median acres)	573	800	260	288
% of farms that:				
use anhydrous	87	78	13	41
use manure	24	64	80	82
broadcast or band herbicides	73	95	52	55
use cover crops for weed control	21	38	48	84
broadcast or band insecticides	60	52	11	31
use crop rotation	40	83	82	81
field windbreaks	5	10	11	33
rotational grazing	9	20	29	38
avg. # crops grown	1.96	2.86	3.14	3.18
% income from livestock (1992)	17	29	50	46

and pesticides. The "sustainable" farms tend to grow more crops, rely more on rotations, and generate a greater percentage of income from livestock. The more innovative nature of the farms in Cluster 1 is reflected in characteristics including manure use, crop rotations, and number of crops grown. Overall, there are clear differences in structure and operation among the conventional, innovative conventional, and sustainable farms.

Refining the survey results

As the next step in developing baseline descriptions of the five alternative farming systems, Clusters 1-4 were reduced to those farms (1) located in eastern Nebraska (defined as the Northeast, East, and Southeast Crop Reporting Districts (Massey 1994)), and (2) irrigating less than 20% of their total cropland. The clusters now contained only dryland farms in eastern Nebraska.

Cluster 2 (conventional) farms in this subset were designated as analogs of the conventional farm, while Cluster 1 (innovative conventional) was defined as analogous to the modified conventional farm. Analogous groups for the other model farms were derived from the combined Clusters 3 and 4 by the following rules:

Organic rowcrop:

- >50% of farm income from crops, and
- farmer uses or would consider using reduced chemical pest control

Agroforestry:

- >50% of farm income from crops
- farmer does not use or consider using reduced chemical pest control

Forage-based beef:

- >25% of farm income from livestock, and
- farm owns more than 25 head of cattle, and
- farm owns fewer than 500 hogs

As noted earlier, the farms in Clusters 3 and 4 are more likely than farms in other clusters to adopt alternative farming strategies. Within Cluster 3/4, farmers already using or considering using reduced chemical pest control are the most likely to try organic farming, and farms currently oriented toward cattle (as opposed to hog) production are the most likely to adopt forage-based beef production.

The characteristics of the five alternative groups resulting from this second sorting of the database are compared in Table A1-2. Key differences seen at the statewide level (Table A1-1) between conventional and alternative systems are retained in the eastern subset — the two conventional systems are larger, grow fewer crops, and are more likely to use chemical fertilizers or pesticides. Farms in the conventional group grow an average of only 2.2 crops, and 73% grow continuous corn or a corn/soybean rotation. By comparison, the modified conventional farms grow more crops and practice more strip cropping and other alternative practices.

The beef production group is clearly differentiated by the high percentage of income derived from livestock (73%) and the lowest percent cropland (59%) (this is likely due to greater amounts of pasture, although the survey did not include this information). Farms in the organic group have the greatest crop diversity and highest use of reduced chemical pest control methods. The agroforestry group is the least well defined, not surprising given that true examples of this system don't exist in eastern Nebraska. Farms in this group are similar to the organic farms, but tend to be somewhat more "conventional." In the use of field windbreaks, the only survey characteristic directly related to agroforestry practices, the agroforestry group was intermediate between the conventional and alternative systems.

Overall, the five farm groups seem to provide reasonable starting points for developing models of the five farm types. Not of course as exact matches, but as the types of commercial farms in eastern Nebraska that would be most likely to adopt each of the farming systems.

The types and ages of machinery owned by a farm are important economic variables that affect fixed and operational costs. The farm survey of Bernhardt et al. (1994) included questions on equipment, so the equipment complements of an average farm in each group in Table A1-2 can be described.

Table A1-2. Characteristics of the farm groups defined as most similar to the five alternative farming systems.

Characteristic	conventional	modified conventional	agroforestry	organic	pasture beef
farm size (A)	559	711	428	417	459
% owned	44	46	62	57	58
% cropland	85	80	77	78	59
avg. # crops	2.2	2.8	3.3	3.7	3.5
% farm income from crops	68	58	81	82	23
% farm income from livestock	15	26	16	14	73
% of farms that use:					
anhydrous	78	67	50	33	17
green manure	0	0	70	63	85
manure	17	67	55	56	100
broadcast insecticide	60	16	20	25	7
monocorn or corn/soybean rotation	73	35	25	10	7
use or consider reduced chemical pest control	22	47	82	100	85
field windbreaks	0	21	38	45	79
strip cropping	0	21	55	56	54

Tables A1-3-5 present the baseline characterizations of the five farm types for eastern Nebraska. Because of the similarity of the conventional and modified conventional groups in size and percent ownership (Table A1-2) and machinery (data not shown), a single baseline description was developed for these two farm types (Table A1-3). The agroforestry and organic farming systems are also represented by a single baseline characterization (Table A1-4), while a third baseline was developed for the pasture-based beef farm (Table A1-5). Within these baselines:

(1) Farm size is based on the average sizes for the groups as shown in Table A1-2.

(2) Percent ownership is based on Table A1-2.

(3) The beef farm model deviates from Table A1-2 by assuming that pasture is 100% of total land; the other systems begin with 100% cropland.

The baseline equipment list for each model farm is based on the actual equipment owned by the farms in each group in Table A1-2, but modified to correspond to the machinery expense tables in Powell et al. (1992) (Appendix 2). In these tables, the cost of owning and operating a piece of equipment depends on the type of equipment (e.g., 8 row x 30" row cultivator), age at trade (years), and annual use (acres or hours). By requiring that the equipment used in the models corresponds to choices in the tables, only one book of tables is needed to do the machinery part of the economic model, and consistent answers should be achieved by different users. The compromises in equipment designation required to do this are small relative to the actual variability in equipment owned by different farms in each group.

If 30% or more of the farms in a group reported owning a piece of machinery, the piece was included in the baseline machinery list for the farm type. The characteristics of each piece were determined for each of the baseline farms as follows:

(1) For each item, the most common type owned by the farms in a group was identified. For characteristics such as horsepower, averages were used, but in many cases averages have no meaning (e.g., a 6-row planter and an 8-row planter don't average to a 7-row planter).

(2) If the equipment type identified as most representative of the farm group is not listed in Powell et al. (1992), the nearest equivalent for which a table is included was selected. If the choice wasn't obvious, the standard machinery lists in Selley (1996) for eastern Nebraska were used as a guide.

(3) "Age at trade" was estimated as the average age of an item of equipment for the farms within the group. When average age exceeded the highest "age at trade" listed in the tables, the highest table value was used.

The resulting equipment lists show that the conventional farms use somewhat larger equipment than the alternative farms, and that all the farms keep their equipment for as long as possible.

Table A1-3. Baseline characteristics of the conventional and modified conventional farms.

farm size (acres)	650
% land owned	45
% cropland	100

Equipment:

Item	Age at trade (years)	Description
tractor #1	15	120 hp diesel cab
tractor #2	20	100 hp diesel cab
disc	15	tandem disc harrow 20'
row cultivator	15	8 row x 30"
rotary hoe	20	20'
moldboard plow	20	5 x 16"
field cultivator	10	24'
sprayer	15	300 gallon, 20', 3-point mount
combine	15	185 hp
corn head	15	8 row
grain head	15	20'
planter	10	8 row x 30"

Table A1-4. Baseline characteristics of the agroforestry and organic farms.

farm size (acres)	425
% land owned	60
% cropland	100

Equipment:

Item	Age at trade (years)	Description
tractor #1	15	120 hp diesel cab
tractor #2	20	75 hp diesel cab
disc	20	tandem disc harrow 20'
row cultivator	20	6 row x 30"
rotary hoe	15	15'
moldboard plow	20	5 x 16"
field cultivator	10	18'
sprayer	10	300 gallon, 15', pull-type
combine	15	185 hp
corn head	15	6 row
grain head	15	15'
planter	10	6 row x 30"

Table A1-5. Baseline characteristics of the pasture-based beef farm.

farm size (acres)	460
% land owned	60
% pasture	100

Equipment*:

Item	Age at trade (years)	Description
tractor #1	15	100 hp diesel cab
tractor #2	20	75 hp diesel cab
disc	20	tandem disc harrow 20'
row cultivator	20	6 row x 30"
rotary hoe	20	15'
moldboard plow	20	5 x 16"
field cultivator	15	18'
sprayer	15	300 gallon, 15', pull-type
combine	15	185 hp
corn head	15	6 row
grain head	15	15'
planter	15	6 row x 30"

*Obviously, most of the equipment in this baseline list will be removed from the final operational list of a farm with 100% pasture (see Appendix 4E).

Appendix 2. Machinery tables.

Selected tables from Powell et al. (1992) — Cost of Owning and Operating Farm Machinery.

DETERMINING MACHINERY COSTS FOR AN OPERATION

When only one machine is used for an operation, the costs can be taken directly from the table for the type of machine used. When two or more machines are used in an operation, the costs for each machine must be added together to obtain a total operation cost.

The procedure for determining total operation cost per acre for multiple machines is as follows:

Step 1 Find the cost per hour for the tractor (pages 15-23).
Step 2 Find the acres per hour and cost per acre for the implement (pages 24-50, 60-73).
Step 3 Divide the cost per hour for the power unit by acres per hour of the implement.
Step 4 Add this to the implement cost to obtain a total cost per acre.

Example 1: Assume a 100 hp tractor and a 6 row by 30" planter is used. The tractor logs 500 hours per year of use and is traded every 20 years. The planter is used on 200 acres per year, is traded every 15 years, and can plant 4.9 acres per hour. Estimate the total machine cost per acre for planting corn.

Example 1. Total Costs per Acre for a Field Operation

		$/Hour		Implement Acres/Hour		$/Acre
Step 1	Power Unit Cost (a)	(a) *24.82* (pg. 17)	÷	(b) *4.9* (pg. 45)	=	(c) *5.07*
Step 2	Implement Capacity and Cost (b) and (d)					(d) *9.79* (pg. 45)
Step 3	(divide a by b = c)					
Step 4	(add c + d = e)			Total Cost		(e) *14.86*

Example 2: Estimate the operating costs (repairs & maintenance, fuel and lube, and labor) for the same field operation.

Example 2. Operating Costs per Acre for a Field Operation

		$/Hour		Implement Acres/Hour		$/Acre
Step 1	Power Unit Cost (a)	(a) *16.07* (pg. 17)	÷	(b) *4.9* (pg. 45)	=	(c) *3.28*
Step 2	Implement Capacity and Cost (b) and (d)					(d) *1.02* (pg. 45)
Step 3	(divide a by b = c)					
Step 4	(add c + d = e)			Total Cost		(e) *4.30*

Tractor 100 hp diesel cab
Projected Cost Per Hour of Use

Annual Hours of Use	Age at Trade (Yrs.)	Salvage Value at Trade	Total Hours at Trade	Dep.	Int.	Taxes & Ins.	Total Ownership Cost	Repairs & Maint.	Fuel & Lube	Labor	Total Operating Cost	Total Cost per Hour
100	20	$5,954	2,000	$20.22	$20.94	$2.62	$43.78	$0.93	$4.23	$7.20	$12.36	$56.14
200	20	5,954	4,000	10.11	10.47	1.31	21.89	1.86	4.23	7.20	13.28	35.18
300	20	5,954	6,000	6.74	6.98	0.87	14.59	2.78	4.23	7.20	14.21	28.81
400	20	5,954	8,000	5.06	5.24	0.65	10.95	3.71	4.23	7.20	15.14	26.09
500	20	5,954	10,000	4.04	4.19	0.52	8.76	4.64	4.23	7.20	16.07	24.82
200	15	9,033	3,000	12.46	11.09	1.39	24.93	1.39	4.23	7.20	12.82	37.75
300	15	9,033	4,500	8.30	7.39	0.92	16.62	2.09	4.23	7.20	13.52	30.13
400	15	9,033	6,000	6.23	5.54	0.69	12.46	2.78	4.23	7.20	14.21	26.68
500	15	9,033	7,500	4.98	4.43	0.55	9.97	3.48	4.23	7.20	14.91	24.88
600	15	9,033	9,000	4.15	3.70	0.46	8.31	4.18	4.23	7.20	15.60	23.91
300	10	13,706	3,000	10.90	8.01	1.00	19.91	1.39	4.23	7.20	12.82	32.73
400	10	13,706	4,000	8.17	6.01	0.75	14.94	1.86	4.23	7.20	13.28	28.22
500	10	13,706	5,000	6.54	4.81	0.60	11.95	2.32	4.23	7.20	13.75	25.70
600	10	13,706	6,000	5.45	4.01	0.50	9.96	2.78	4.23	7.20	14.21	24.17
700	10	13,706	7,000	4.67	3.43	0.43	8.53	3.25	4.23	7.20	14.68	23.21
800	10	13,706	8,000	4.09	3.01	0.38	7.47	3.71	4.23	7.20	15.14	22.61
900	10	13,706	9,000	3.63	2.67	0.33	6.64	4.18	4.23	7.20	15.60	22.24
1,000	10	13,706	10,000	3.27	2.40	0.30	5.97	4.64	4.23	7.20	16.07	22.04
400	5	20,795	2,000	12.80	6.72	0.84	20.36	0.93	4.23	7.20	12.36	32.72
500	5	20,795	2,500	10.24	5.38	0.67	16.29	1.16	4.23	7.20	12.59	28.88
600	5	20,795	3,000	8.53	4.48	0.56	13.57	1.39	4.23	7.20	12.82	26.39
700	5	20,795	3,500	7.32	3.84	0.48	11.64	1.62	4.23	7.20	13.05	24.69
800	5	20,795	4,000	6.40	3.36	0.42	10.18	1.86	4.23	7.20	13.28	23.46
900	5	20,795	4,500	5.69	2.99	0.37	9.05	2.09	4.23	7.20	13.52	22.57
1,000	5	20,795	5,000	5.12	2.69	0.34	8.14	2.32	4.23	7.20	13.75	21.89
1,100	5	20,795	5,500	4.66	2.44	0.31	7.40	2.55	4.23	7.20	13.98	21.38
1,200	5	20,795	6,000	4.27	2.24	0.28	6.79	2.78	4.23	7.20	14.21	21.00
1,300	5	20,795	6,500	3.94	2.07	0.26	6.27	3.02	4.23	7.20	14.44	20.71
1,400	5	20,795	7,000	3.66	1.92	0.24	5.82	3.25	4.23	7.20	14.68	20.49
1,500	5	20,795	7,500	3.41	1.79	0.22	5.43	3.48	4.23	7.20	14.91	20.34
1,600	5	20,795	8,000	3.20	1.68	0.21	5.09	3.71	4.23	7.20	15.14	20.23
1,700	5	20,795	8,500	3.01	1.58	0.20	4.79	3.94	4.23	7.20	15.37	20.16
1,800	5	20,795	9,000	2.84	1.49	0.19	4.52	4.18	4.23	7.20	15.60	20.13
1,900	5	20,795	9,500	2.70	1.41	0.18	4.29	4.41	4.23	7.20	15.84	20.12
2,000	5	20,795	10,000	2.56	1.34	0.17	4.07	4.64	4.23	7.20	16.07	20.14

List Price:	$46,400	Hours to Wearout:	10,000
Fuel Price for Diesel:	$0.75	Maximum Years to Trade:	20
Labor Cost per Hour:	$6.00	PTO Horsepower:	100
Interest Rate (real):	8.00%	Engine Loading:	67%
Insurance Rate:	1.00%	Fuel per Hour: (gallons)	5.1

Tractor 120 hp diesel cab
Projected Cost Per Hour of Use

Annual Hours of Use	Age at Trade (Yrs.)	Salvage Value at Trade	Total Hours at Trade	Dep.	Int.	Taxes & Ins.	Total Ownership Cost	Repairs & Maint.	Fuel & Lube	Labor	Total Operating Cost	Total Cost per Hour
100	20	$6,775	2,000	$23.01	$23.83	$2.98	$49.82	$1.06	$5.07	$7.20	$13.33	$63.15
200	20	6,775	4,000	11.51	11.91	1.49	24.91	2.11	5.07	7.20	14.39	39.30
300	20	6,775	6,000	7.67	7.94	0.99	16.61	3.17	5.07	7.20	15.44	32.05
400	20	6,775	8,000	5.75	5.96	0.74	12.46	4.22	5.07	7.20	16.50	28.95
500	20	6,775	10,000	4.60	4.77	0.60	9.96	5.28	5.07	7.20	17.55	27.52
200	15	10,279	3,000	14.17	12.62	1.58	28.37	1.58	5.07	7.20	13.86	42.22
300	15	10,279	4,500	9.45	8.41	1.05	18.91	2.38	5.07	7.20	14.65	33.56
400	15	10,279	6,000	7.09	6.31	0.79	14.18	3.17	5.07	7.20	15.44	29.62
500	15	10,279	7,500	5.67	5.05	0.63	11.35	3.96	5.07	7.20	16.23	27.58
600	15	10,279	9,000	4.72	4.21	0.53	9.46	4.75	5.07	7.20	17.03	26.48
300	10	15,596	3,000	12.40	9.12	1.14	22.66	1.58	5.07	7.20	13.86	36.52
400	10	15,596	4,000	9.30	6.84	0.85	17.00	2.11	5.07	7.20	14.39	31.38
500	10	15,596	5,000	7.44	5.47	0.68	13.60	2.64	5.07	7.20	14.91	28.51
600	10	15,596	6,000	6.20	4.56	0.57	11.33	3.17	5.07	7.20	15.44	26.77
700	10	15,596	7,000	5.31	3.91	0.49	9.71	3.70	5.07	7.20	15.97	25.68
800	10	15,596	8,000	4.65	3.42	0.43	8.50	4.22	5.07	7.20	16.50	25.00
900	10	15,596	9,000	4.13	3.04	0.38	7.55	4.75	5.07	7.20	17.03	24.58
1,000	10	15,596	10,000	3.72	2.74	0.34	6.80	5.28	5.07	7.20	17.55	24.35
400	5	23,664	2,000	14.57	7.65	0.96	23.17	1.06	5.07	7.20	13.33	36.50
500	5	23,664	2,500	11.65	6.12	0.76	18.54	1.32	5.07	7.20	13.59	32.13
600	5	23,664	3,000	9.71	5.10	0.64	15.45	1.58	5.07	7.20	13.86	29.30
700	5	23,664	3,500	8.32	4.37	0.55	13.24	1.85	5.07	7.20	14.12	27.36
800	5	23,664	4,000	7.28	3.82	0.48	11.59	2.11	5.07	7.20	14.39	25.97
900	5	23,664	4,500	6.47	3.40	0.42	10.30	2.38	5.07	7.20	14.65	24.95
1,000	5	23,664	5,000	5.83	3.06	0.38	9.27	2.64	5.07	7.20	14.91	24.18
1,100	5	23,664	5,500	5.30	2.78	0.35	8.43	2.90	5.07	7.20	15.18	23.60
1,200	5	23,664	6,000	4.86	2.55	0.32	7.72	3.17	5.07	7.20	15.44	23.17
1,300	5	23,664	6,500	4.48	2.35	0.29	7.13	3.43	5.07	7.20	15.71	22.83
1,400	5	23,664	7,000	4.16	2.18	0.27	6.62	3.70	5.07	7.20	15.97	22.59
1,500	5	23,664	7,500	3.88	2.04	0.25	6.18	3.96	5.07	7.20	16.23	22.41
1,600	5	23,664	8,000	3.64	1.91	0.24	5.79	4.22	5.07	7.20	16.50	22.29
1,700	5	23,664	8,500	3.43	1.80	0.22	5.45	4.49	5.07	7.20	16.76	22.21
1,800	5	23,664	9,000	3.24	1.70	0.21	5.15	4.75	5.07	7.20	17.03	22.17
1,900	5	23,664	9,500	3.07	1.61	0.20	4.88	5.02	5.07	7.20	17.29	22.17
2,000	5	23,664	10,000	2.91	1.53	0.19	4.63	5.28	5.07	7.20	17.55	22.19

List Price:	$52,800	Hours to Wearout:	10,000
Fuel Price for Diesel:	$0.75	Maximum Years to Trade:	20
Labor Cost per Hour:	$6.00	PTO Horsepower:	120
Interest Rate (real):	8.00%	Engine Loading:	67%
Insurance Rate:	1.00%	Fuel per Hour: (gallons)	6.1

Blade Plow 35'(5x7)
Projected Cost Per Acre of Use

Annual Acres of Use	Age at Trade (Yrs.)	Salvage Value at Trade	Total Acres at Trade	Dep.	Int.	Taxes & Ins.	Total Ownership Cost	Repairs & Maint.	Total Operating Cost	Total Cost per Acre
400	20	$1,110	8,000	$2.52	$2.24	$0.28	$5.04	$0.14	$0.14	$5.19
800	20	1,110	16,000	1.26	1.12	0.14	2.52	0.23	0.23	2.76
400	15	2,045	6,000	3.21	2.33	0.29	5.84	0.12	0.12	5.95
800	15	2,045	12,000	1.60	1.17	0.15	2.92	0.19	0.19	3.11
1,200	15	2,045	18,000	1.07	0.78	0.10	1.95	0.25	0.25	2.20
800	10	3,767	8,000	2.19	1.25	0.16	3.60	0.14	0.14	3.75
1,200	10	3,767	12,000	1.46	0.84	0.10	2.40	0.19	0.19	2.59
1,600	10	3,767	16,000	1.10	0.63	0.08	1.80	0.23	0.23	2.03
2,000	10	3,767	20,000	0.88	0.50	0.06	1.44	0.27	0.27	1.71
1,200	5	6,938	6,000	2.39	0.94	0.12	3.45	0.12	0.12	3.57
1,600	5	6,938	8,000	1.80	0.71	0.09	2.59	0.14	0.14	2.73
2,000	5	6,938	10,000	1.44	0.56	0.07	2.07	0.17	0.17	2.24
2,400	5	6,938	12,000	1.20	0.47	0.06	1.73	0.19	0.19	1.92
2,800	5	6,938	14,000	1.03	0.40	0.05	1.48	0.21	0.21	1.69

List Price:	$21,300	Acres to Wearout:	32,455
Interest Rate (real):	8.00%	Maximum Years to Trade:	20
Insurance Rate:	1.00%	Acres per Hour:	16.2

Tandem Disc Harrow 14'
Projected Cost Per Acre of Use

Annual Acres of Use	Age at Trade (Yrs.)	Salvage Value at Trade	Total Acres at Trade	Dep.	Int.	Taxes & Ins.	Total Ownership Cost	Repairs & Maint.	Total Operating Cost	Total Cost per Acre
100	20	$360	2,000	$3.27	$2.90	$0.36	$6.54	$0.11	$0.11	$6.65
200	20	360	4,000	1.64	1.45	0.18	3.27	0.18	0.18	3.45
100	15	662	1,500	4.16	3.02	0.38	7.56	0.09	0.09	7.65
200	15	662	3,000	2.08	1.51	0.19	3.78	0.15	0.15	3.93
300	15	662	4,500	1.39	1.01	0.13	2.52	0.20	0.20	2.72
200	10	1,220	2,000	2.84	1.62	0.20	4.67	0.11	0.11	4.78
300	10	1,220	3,000	1.89	1.08	0.14	3.11	0.15	0.15	3.26
400	10	1,220	4,000	1.42	0.81	0.10	2.33	0.18	0.18	2.52
500	10	1,220	5,000	1.14	0.65	0.08	1.87	0.22	0.22	2.08
300	5	2,248	1,500	3.10	1.22	0.15	4.47	0.09	0.09	4.57
400	5	2,248	2,000	2.33	0.91	0.11	3.36	0.11	0.11	3.47
500	5	2,248	2,500	1.86	0.73	0.09	2.68	0.13	0.13	2.82
600	5	2,248	3,000	1.55	0.61	0.08	2.24	0.15	0.15	2.39
700	5	2,248	3,500	1.33	0.52	0.07	1.92	0.17	0.17	2.09

List Price:	$6,900	Acres to Wearout:	10,861
Interest Rate (real):	8.00%	Maximum Years to Trade:	20
Insurance Rate:	1.00%	Acres per Hour:	5.4

Tandem Disc Harrow 20'
Projected Cost Per Acre of Use

Annual Acres of Use	Age at Trade (Yrs.)	Salvage Value at Trade	Total Acres at Trade	Dep.	Int.	Taxes & Ins.	Total Ownership Cost	Repairs & Maint.	Total Operating Cost	Total Cost per Acre
200	20	$777	4,000	$3.53	$3.14	$0.39	$7.06	$0.22	$0.22	$7.28
400	20	777	8,000	1.77	1.57	0.20	3.53	0.35	0.35	3.88
200	15	1,430	3,000	4.49	3.27	0.41	8.16	0.18	0.18	8.34
400	15	1,430	6,000	2.24	1.63	0.20	4.08	0.29	0.29	4.37
600	15	1,430	9,000	1.50	1.09	0.14	2.72	0.38	0.38	3.11
400	10	2,635	4,000	3.07	1.75	0.22	5.04	0.22	0.22	5.26
600	10	2,635	6,000	2.04	1.17	0.15	3.36	0.29	0.29	3.65
800	10	2,635	8,000	1.53	0.88	0.11	2.52	0.35	0.35	2.87
1,000	10	2,635	10,000	1.23	0.70	0.09	2.02	0.41	0.41	2.43
600	5	4,853	3,000	3.35	1.32	0.16	4.83	0.18	0.18	5.01
800	5	4,853	4,000	2.51	0.99	0.12	3.62	0.22	0.22	3.84
1,000	5	4,853	5,000	2.01	0.79	0.10	2.90	0.25	0.25	3.15
1,200	5	4,853	6,000	1.67	0.66	0.08	2.42	0.29	0.29	2.70
1,400	5	4,853	7,000	1.44	0.56	0.07	2.07	0.32	0.32	2.39

List Price:	$14,900	Acres to Wearout:	15,515
Interest Rate (real):	8.00%	Maximum Years to Trade:	20
Insurance Rate:	1.00%	Acres per Hour:	7.8

Tandem Disc Harrow 28'
Projected Cost Per Acre of Use

Annual Acres of Use	Age at Trade (Yrs.)	Salvage Value at Trade	Total Acres at Trade	Dep.	Int.	Taxes & Ins.	Total Ownership Cost	Repairs & Maint.	Total Operating Cost	Total Cost per Acre
300	20	$1,115	6,000	$3.38	$3.00	$0.38	$6.76	$0.23	$0.23	$6.99
600	20	1,115	12,000	1.69	1.50	0.19	3.38	0.38	0.38	3.76
300	15	2,055	4,500	4.30	3.13	0.39	7.82	0.19	0.19	8.01
600	15	2,055	9,000	2.15	1.56	0.20	3.91	0.31	0.31	4.22
900	15	2,055	13,500	1.43	1.04	0.13	2.61	0.41	0.41	3.02
600	10	3,784	6,000	2.94	1.68	0.21	4.82	0.23	0.23	5.06
900	10	3,784	9,000	1.96	1.12	0.14	3.22	0.31	0.31	3.53
1,200	10	3,784	12,000	1.47	0.84	0.10	2.41	0.38	0.38	2.79
1,500	10	3,784	15,000	1.17	0.67	0.08	1.93	0.44	0.44	2.37
900	5	6,971	4,500	3.21	1.26	0.16	4.63	0.19	0.19	4.82
1,200	5	6,971	6,000	2.40	0.95	0.12	3.47	0.23	0.23	3.70
1,500	5	6,971	7,500	1.92	0.76	0.09	2.78	0.27	0.27	3.05
1,800	5	6,971	9,000	1.60	0.63	0.08	2.31	0.31	0.31	2.62
2,100	5	6,971	10,500	1.37	0.54	0.07	1.98	0.35	0.35	2.33

List Price:	$21,400	Acres to Wearout:	21,721
Interest Rate (real):	8.00%	Maximum Years to Trade:	20
Insurance Rate:	1.00%	Acres per Hour:	10.9

Subsoiler 13.5'
Projected Cost Per Acre of Use

Annual Acres of Use	Age at Trade (Yrs.)	Salvage Value at Trade	Total Acres at Trade	Dep.	Int.	Taxes & Ins.	Total Ownership Cost	Repairs & Maint.	Total Operating Cost	Total Cost per Acre
200	20	$214	4,000	$0.97	$0.86	$0.11	$1.94	$0.16	$0.16	$2.11
400	20	214	8,000	0.49	0.43	0.05	0.97	0.22	0.22	1.19
200	15	394	3,000	1.24	0.90	0.11	2.25	0.15	0.15	2.39
400	15	394	6,000	0.62	0.45	0.06	1.12	0.19	0.19	1.32
600	15	394	9,000	0.41	0.30	0.04	0.75	0.23	0.23	0.98
400	10	725	4,000	0.84	0.48	0.06	1.39	0.16	0.16	1.55
600	10	725	6,000	0.56	0.32	0.04	0.92	0.19	0.19	1.12
800	10	725	8,000	0.42	0.24	0.03	0.69	0.22	0.22	0.91
1,000	10	725	10,000	0.34	0.19	0.02	0.55	0.24	0.24	0.79
600	5	1,336	3,000	0.92	0.36	0.05	1.33	0.15	0.15	1.48
800	5	1,336	4,000	0.69	0.27	0.03	1.00	0.16	0.16	1.16
1,000	5	1,336	5,000	0.55	0.22	0.03	0.80	0.18	0.18	0.98
1,200	5	1,336	6,000	0.46	0.18	0.02	0.66	0.19	0.19	0.86
1,400	5	1,336	7,000	0.39	0.16	0.02	0.57	0.21	0.21	0.78

List Price:	$4,100	Acres to Wearout:	12,518
Interest Rate (real):	8.00%	Maximum Years to Trade:	20
Insurance Rate:	1.00%	Acres per Hour:	6.3

Field Cultivator 18'
Projected Cost Per Acre of Use

Annual Acres of Use	Age at Trade (Yrs.)	Salvage Value at Trade	Total Acres at Trade	Dep.	Int.	Taxes & Ins.	Total Ownership Cost	Repairs & Maint.	Total Operating Cost	Total Cost per Acre
200	20	$302	4,000	$1.37	$1.22	$0.15	$2.75	$0.12	$0.12	$2.86
400	20	302	8,000	0.69	0.61	0.08	1.37	0.15	0.15	1.53
200	15	557	3,000	1.75	1.27	0.16	3.18	0.10	0.10	3.28
400	15	557	6,000	0.87	0.64	0.08	1.59	0.14	0.14	1.73
600	15	557	9,000	0.58	0.42	0.05	1.06	0.16	0.16	1.22
400	10	1,026	4,000	1.19	0.68	0.09	1.96	0.12	0.12	2.08
600	10	1,026	6,000	0.80	0.46	0.06	1.31	0.14	0.14	1.45
800	10	1,026	8,000	0.60	0.34	0.04	0.98	0.15	0.15	1.14
1,000	10	1,026	10,000	0.48	0.27	0.03	0.78	0.17	0.17	0.95
600	5	1,889	3,000	1.30	0.51	0.06	1.88	0.10	0.10	1.98
800	5	1,889	4,000	0.98	0.38	0.05	1.41	0.12	0.12	1.53
1,000	5	1,889	5,000	0.78	0.31	0.04	1.13	0.13	0.13	1.26
1,200	5	1,889	6,000	0.65	0.26	0.03	0.94	0.14	0.14	1.08
1,400	5	1,889	7,000	0.56	0.22	0.03	0.81	0.15	0.15	0.95

List Price:	$5,800	Acres to Wearout:	20,400
Interest Rate (real):	8.00%	Maximum Years to Trade:	20
Insurance Rate:	1.00%	Acres per Hour:	10.2

Field Cultivator 24'
Projected Cost Per Acre of Use

Annual Acres of Use	Age at Trade (Yrs.)	Salvage Value at Trade	Total Acres at Trade	Dep.	Int.	Taxes & Ins.	Total Ownership Cost	Repairs & Maint.	Total Operating Cost	Total Cost per Acre
300	20	$500	6,000	$1.52	$1.35	$0.17	$3.03	$0.15	$0.15	$3.18
600	20	500	12,000	0.76	0.67	0.08	1.52	0.20	0.20	1.72
300	15	922	4,500	1.93	1.40	0.18	3.51	0.14	0.14	3.64
600	15	922	9,000	0.96	0.70	0.09	1.75	0.18	0.18	1.93
900	15	922	13,500	0.64	0.47	0.06	1.17	0.21	0.21	1.38
600	10	1,698	6,000	1.32	0.75	0.09	2.16	0.15	0.15	2.32
900	10	1,698	9,000	0.88	0.50	0.06	1.44	0.18	0.18	1.62
1,200	10	1,698	12,000	0.66	0.38	0.05	1.08	0.20	0.20	1.28
1,500	10	1,698	15,000	0.53	0.30	0.04	0.87	0.22	0.22	1.09
900	5	3,127	4,500	1.44	0.57	0.07	2.07	0.14	0.14	2.21
1,200	5	3,127	6,000	1.08	0.42	0.05	1.56	0.15	0.15	1.71
1,500	5	3,127	7,500	0.86	0.34	0.04	1.24	0.17	0.17	1.41
1,800	5	3,127	9,000	0.72	0.28	0.04	1.04	0.18	0.18	1.22
2,100	5	3,127	10,500	0.62	0.24	0.03	0.89	0.19	0.19	1.08

List Price:	$9,600	Acres to Wearout:	27,200
Interest Rate (real):	8.00%	Maximum Years to Trade:	20
Insurance Rate:	1.00%	Acres per Hour:	13.6

Field Cultivator 30'
Projected Cost Per Acre of Use

Annual Acres of Use	Age at Trade (Yrs.)	Salvage Value at Trade	Total Acres at Trade	Dep.	Int.	Taxes & Ins.	Total Ownership Cost	Repairs & Maint.	Total Operating Cost	Total Cost per Acre
300	20	$688	6,000	$2.09	$1.85	$0.23	$4.17	$0.15	$0.15	$4.32
600	20	688	12,000	1.04	0.93	0.12	2.08	0.20	0.20	2.29
300	15	1,267	4,500	2.65	1.93	0.24	4.82	0.14	0.14	4.96
600	15	1,267	9,000	1.33	0.96	0.12	2.41	0.18	0.18	2.59
900	15	1,267	13,500	0.88	0.64	0.08	1.61	0.21	0.21	1.82
600	10	2,334	6,000	1.81	1.04	0.13	2.98	0.15	0.15	3.13
900	10	2,334	9,000	1.21	0.69	0.09	1.98	0.18	0.18	2.16
1,200	10	2,334	12,000	0.91	0.52	0.06	1.49	0.20	0.20	1.69
1,500	10	2,334	15,000	0.72	0.41	0.05	1.19	0.22	0.22	1.41
900	5	4,300	4,500	1.98	0.78	0.10	2.85	0.14	0.14	2.99
1,200	5	4,300	6,000	1.48	0.58	0.07	2.14	0.15	0.15	2.29
1,500	5	4,300	7,500	1.19	0.47	0.06	1.71	0.17	0.17	1.88
1,800	5	4,300	9,000	0.99	0.39	0.05	1.43	0.18	0.18	1.61
2,100	5	4,300	10,500	0.85	0.33	0.04	1.22	0.19	0.19	1.41

List Price:	$13,200	Acres to Wearout:	34,000
Interest Rate (real):	8.00%	Maximum Years to Trade:	20
Insurance Rate:	1.00%	Acres per Hour:	17.0

Row crop Cultivator 6 row x 30"
Projected Cost Per Acre of Use

Annual Acres of Use	Age at Trade (Yrs.)	Salvage Value at Trade	Total Acres at Trade	Dep.	Int.	Taxes & Ins.	Total Ownership Cost	Repairs & Maint.	Total Operating Cost	Total Cost per Acre
100	20	$245	2,000	$2.23	$1.98	$0.25	$4.45	$0.07	$0.07	$4.52
200	20	245	4,000	1.11	0.99	0.12	2.23	0.15	0.15	2.38
100	15	451	1,500	2.83	2.06	0.26	5.15	0.05	0.05	5.20
200	15	451	3,000	1.42	1.03	0.13	2.58	0.11	0.11	2.68
300	15	451	4,500	0.94	0.69	0.09	1.72	0.18	0.18	1.89
200	10	831	2,000	1.93	1.11	0.14	3.18	0.07	0.07	3.25
300	10	831	3,000	1.29	0.74	0.09	2.12	0.11	0.11	2.23
400	10	831	4,000	0.97	0.55	0.07	1.59	0.15	0.15	1.74
500	10	831	5,000	0.77	0.44	0.06	1.27	0.20	0.20	1.47
300	5	1,531	1,500	2.11	0.83	0.10	3.05	0.05	0.05	3.09
400	5	1,531	2,000	1.58	0.62	0.08	2.29	0.07	0.07	2.35
500	5	1,531	2,500	1.27	0.50	0.06	1.83	0.09	0.09	1.91
600	5	1,531	3,000	1.06	0.42	0.05	1.52	0.11	0.11	1.63
700	5	1,531	3,500	0.91	0.36	0.04	1.31	0.13	0.13	1.44

List Price:	$4,700	Acres to Wearout:	10,182
Interest Rate (real):	8.00%	Maximum Years to Trade:	20
Insurance Rate:	1.00%	Acres per Hour:	5.1

Row crop Cultivator 6 row x 36"
Projected Cost Per Acre of Use

Annual Acres of Use	Age at Trade (Yrs.)	Salvage Value at Trade	Total Acres at Trade	Dep.	Int.	Taxes & Ins.	Total Ownership Cost	Repairs & Maint.	Total Operating Cost	Total Cost per Acre
200	20	$281	4,000	$1.28	$1.14	$0.14	$2.56	$0.12	$0.12	$2.67
400	20	281	8,000	0.64	0.57	0.07	1.28	0.27	0.27	1.55
200	15	518	3,000	1.63	1.18	0.15	2.96	0.08	0.08	3.04
400	15	518	6,000	0.81	0.59	0.07	1.48	0.19	0.19	1.67
600	15	518	9,000	0.54	0.39	0.05	0.99	0.31	0.31	1.30
400	10	955	4,000	1.11	0.64	0.08	1.83	0.12	0.12	1.94
600	10	955	6,000	0.74	0.42	0.05	1.22	0.19	0.19	1.41
800	10	955	8,000	0.56	0.32	0.04	0.91	0.27	0.27	1.18
1,000	10	955	10,000	0.44	0.25	0.03	0.73	0.35	0.35	1.08
600	5	1,759	3,000	1.21	0.48	0.06	1.75	0.08	0.08	1.83
800	5	1,759	4,000	0.91	0.36	0.04	1.31	0.12	0.12	1.43
1,000	5	1,759	5,000	0.73	0.29	0.04	1.05	0.15	0.15	1.20
1,200	5	1,759	6,000	0.61	0.24	0.03	0.88	0.19	0.19	1.07
1,400	5	1,759	7,000	0.52	0.20	0.03	0.75	0.23	0.23	0.98

List Price:	$5,400	Acres to Wearout:	12,218
Interest Rate (real):	8.00%	Maximum Years to Trade:	20
Insurance Rate:	1.00%	Acres per Hour:	6.1

Ridge-till Cultivator 6 row x 30"
Projected Cost Per Acre of Use

Annual Acres of Use	Age at Trade (Yrs.)	Salvage Value at Trade	Total Acres at Trade	Dep.	Int.	Taxes & Ins.	Total Ownership Cost	Repairs & Maint.	Total Operating Cost	Total Cost per Acre
100	20	$365	2,000	$3.32	$2.95	$0.37	$6.63	$0.10	$0.10	$6.73
200	20	365	4,000	1.66	1.47	0.18	3.32	0.23	0.23	3.54
100	15	672	1,500	4.22	3.07	0.38	7.67	0.07	0.07	7.74
200	15	672	3,000	2.11	1.53	0.19	3.84	0.16	0.16	4.00
300	15	672	4,500	1.41	1.02	0.13	2.56	0.26	0.26	2.82
200	10	1,238	2,000	2.88	1.65	0.21	4.73	0.10	0.10	4.83
300	10	1,238	3,000	1.92	1.10	0.14	3.16	0.16	0.16	3.32
400	10	1,238	4,000	1.44	0.82	0.10	2.37	0.23	0.23	2.59
500	10	1,238	5,000	1.15	0.66	0.08	1.89	0.30	0.30	2.19
300	5	2,280	1,500	3.15	1.24	0.15	4.54	0.07	0.07	4.61
400	5	2,280	2,000	2.36	0.93	0.12	3.40	0.10	0.10	3.50
500	5	2,280	2,500	1.89	0.74	0.09	2.72	0.13	0.13	2.85
600	5	2,280	3,000	1.57	0.62	0.08	2.27	0.16	0.16	2.43
700	5	2,280	3,500	1.35	0.53	0.07	1.95	0.19	0.19	2.14

List Price:	$7,000	Acres to Wearout:	10,182
Interest Rate (real):	8.00%	Maximum Years to Trade:	20
Insurance Rate:	1.00%	Acres per Hour:	5.1

Row crop Cultivator 8 row x 30"
Projected Cost Per Acre of Use

Annual Acres of Use	Age at Trade (Yrs.)	Salvage Value at Trade	Total Acres at Trade	Dep.	Int.	Taxes & Ins.	Total Ownership Cost	Repairs & Maint.	Total Operating Cost	Total Cost per Acre
200	20	$323	4,000	$1.47	$1.30	$0.16	$2.94	$0.11	$0.11	$3.04
400	20	323	8,000	0.73	0.65	0.08	1.47	0.24	0.24	1.71
200	15	595	3,000	1.87	1.36	0.17	3.40	0.08	0.08	3.47
400	15	595	6,000	0.93	0.68	0.08	1.70	0.17	0.17	1.87
600	15	595	9,000	0.62	0.45	0.06	1.13	0.28	0.28	1.41
400	10	1,096	4,000	1.28	0.73	0.09	2.10	0.11	0.11	2.20
600	10	1,096	6,000	0.85	0.49	0.06	1.40	0.17	0.17	1.57
800	10	1,096	8,000	0.64	0.36	0.05	1.05	0.24	0.24	1.29
1,000	10	1,096	10,000	0.51	0.29	0.04	0.84	0.32	0.32	1.16
600	5	2,020	3,000	1.39	0.55	0.07	2.01	0.08	0.08	2.09
800	5	2,020	4,000	1.05	0.41	0.05	1.51	0.11	0.11	1.61
1,000	5	2,020	5,000	0.84	0.33	0.04	1.21	0.14	0.14	1.35
1,200	5	2,020	6,000	0.70	0.27	0.03	1.00	0.17	0.17	1.18
1,400	5	2,020	7,000	0.60	0.23	0.03	0.86	0.21	0.21	1.07

List Price:	$6,200	Acres to Wearout:	13,576
Interest Rate (real):	8.00%	Maximum Years to Trade:	20
Insurance Rate:	1.00%	Acres per Hour:	6.8

Ridge-Till Planter 6 row x 30"
Projected Cost Per Acre of Use

Annual Acres of Use	Age at Trade (Yrs.)	Salvage Value at Trade	Total Acres at Trade	Dep.	Int.	Taxes & Ins.	Total Ownership Cost	Repairs & Maint.	Total Operating Cost	Total Cost per Acre
100	15	$1,603	1,500	$10.06	$7.32	$0.92	$18.30	$0.71	$0.71	$19.02
200	15	1,603	3,000	5.03	3.66	0.46	9.15	1.53	1.53	10.68
300	15	1,603	4,500	3.35	2.44	0.31	6.10	2.39	2.39	8.49
100	10	2,953	1,000	13.75	7.86	0.98	22.59	0.46	0.46	23.05
200	10	2,953	2,000	6.87	3.93	0.49	11.30	0.98	0.98	12.28
300	10	2,953	3,000	4.58	2.62	0.33	7.53	1.53	1.53	9.06
400	10	2,953	4,000	3.44	1.97	0.25	5.65	2.10	2.10	7.75
200	5	5,440	1,000	11.26	4.43	0.55	16.24	0.46	0.46	16.70
300	5	5,440	1,500	7.51	2.95	0.37	10.83	0.71	0.71	11.54
400	5	5,440	2,000	5.63	2.21	0.28	8.12	0.98	0.98	9.10
500	5	5,440	2,500	4.50	1.77	0.22	6.50	1.25	1.25	7.75
600	5	5,440	3,000	3.75	1.48	0.18	5.41	1.53	1.53	6.95
700	5	5,440	3,500	3.22	1.27	0.16	4.64	1.81	1.81	6.45
800	5	5,440	4,000	2.82	1.11	0.14	4.06	2.10	2.10	6.16

List Price:	$16,700	Acres to Wearout:	4,964
Interest Rate (real):	8.00%	Maximum Years to Trade:	15
Insurance Rate:	1.00%	Acres per Hour:	4.1

Row Crop Planter 8 row x 30"
Projected Cost Per Acre of Use

Annual Acres of Use	Age at Trade (Yrs.)	Salvage Value at Trade	Total Acres at Trade	Dep.	Int.	Taxes & Ins.	Total Ownership Cost	Repairs & Maint.	Total Operating Cost	Total Cost per Acre
100	15	$1,815	1,500	$11.39	$8.29	$1.04	$20.71	$0.31	$0.31	$21.02
300	15	1,815	4,500	3.80	2.76	0.35	6.90	1.03	1.03	7.94
500	15	1,815	7,500	2.28	1.66	0.21	4.14	1.81	1.81	5.95
200	10	3,342	2,000	7.78	4.45	0.56	12.78	0.42	0.42	13.21
400	10	3,342	4,000	3.89	2.22	0.28	6.39	0.91	0.91	7.30
600	10	3,342	6,000	2.59	1.48	0.19	4.26	1.42	1.42	5.68
100	5	6,156	500	25.49	10.02	1.25	36.76	0.09	0.09	36.85
300	5	6,156	1,500	8.50	3.34	0.42	12.25	0.31	0.31	12.56
500	5	6,156	2,500	5,10	2.00	0.25	7.35	0.54	0.54	7.89
700	5	6,156	3,500	3.64	1.43	0.18	5.25	0.78	0.78	6.03
900	5	6,156	4,500	2.83	1.11	0.14	4.08	1.03	1.03	5.12
1,100	5	6,156	5,500	2.32	0.91	0.11	3.34	1.29	1.29	4.63
1,300	5	6,156	6,500	1.96	0.77	0.10	2.83	1.55	1.55	4.38
1,500	5	6,156	7,500	1.70	0.67	0.08	2.45	1.81	1.81	4.26

List Price:	$18,900	Acres to Wearout:	7,855
Interest Rate (real):	8.00%	Maximum Years to Trade:	15
Insurance Rate:	1.00%	Acres per Hour:	6.5

Combine 185 Horsepower
Projected Cost Per Hour of Use

Annual Hours of Use	Age at Trade (Yrs.)	Salvage Value at Trade	Total Hours at Trade	Dep.	Int.	Ins.	Total Ownership Cost	Repair & Maint.	Fuel & Lube	Labor	Total Operating Cost	Total Cost per Hour
50	15	$9,964	750	$116.45	$85.81	$10.73	$212.99	$5.67	$7.82	$7.20	$20.69	$233.68
60	15	9,964	900	97.04	71.51	8.94	177.49	6.93	7.82	7.20	21.95	199.44
70	15	9,964	1,050	83.18	61.29	7.66	152.13	8.21	7.82	7.20	23.24	175.37
80	15	9,964	1,200	72.78	53.63	6.70	133.12	9.51	7.82	7.20	24.53	157.65
90	15	9,964	1,350	64.69	47.67	5.96	118.33	10.83	7.82	7.20	25.85	144.18
100	15	9,964	1,500	58.22	42.91	5.36	106.49	12.16	7.82	7.20	27.18	133.67
110	15	9,964	1,650	52.93	39.01	4.88	96.81	13.50	7.82	7.20	28.53	125.34
120	15	9,964	1,800	48.52	35.75	4.47	88.74	14.86	7.82	7.20	29.88	118.63
130	15	9,964	1,950	44.79	33.00	4.13	81.92	16.23	7.82	7.20	31.25	113.17
60	10	18,354	600	131.58	77.10	9.64	218.32	4.44	7.82	7.20	19.46	237.78
70	10	18,354	700	112.78	66.09	8.26	187.13	5.26	7.82	7.20	20.28	207.41
80	10	18,354	800	98.68	57.83	7.23	163.74	6.09	7.82	7.20	21.11	184.85
90	10	18,354	900	87.72	51.40	6.43	145.54	6.93	7.82	7.20	21.95	167.50
100	10	18,354	1,000	78.95	46.26	5.78	130.99	7.78	7.82	7.20	22.81	153.80
110	10	18,354	1,100	71.77	42.06	5.26	119.08	8.64	7.82	7.20	23.67	142.75
120	10	18,354	1,200	65.79	38.55	4.82	109.16	9.51	7.82	7.20	24.53	133.69
130	10	18,354	1,300	60.73	35.59	4.45	100.76	10.39	7.82	7.20	25.41	126.17
140	10	18,354	1,400	56.39	33.04	4.13	93.56	11.27	7.82	7.20	26.29	119.86
150	10	18,354	1,500	52.63	30.84	3.86	87.33	12.16	7.82	7.20	27.18	114.51
160	10	18,354	1,600	49.34	28.91	3.61	81.87	13.05	7.82	7.20	28.08	109.94
170	10	18,354	1,700	46.44	27.21	3.40	77.05	13.95	7.82	7.20	28.98	106.03
180	10	18,354	1,800	43.86	25.70	3.21	72.77	14.86	7.82	7.20	29.88	102.65
190	10	18,354	1,900	41.55	24.35	3.04	68.94	15.77	7.82	7.20	30.79	99.73
200	10	18,354	2,000	39.47	23.13	2.89	65.50	16.69	7.82	7.20	31.71	97.20
70	5	33,807	350	181.41	74.92	9.36	265.69	2.45	7.82	7.20	17.47	283.17
80	5	33,807	400	158.73	65.55	8.19	232.48	2.84	7.82	7.20	17.86	250.34
90	5	33,807	450	141.10	58.27	7.28	206.65	3.23	7.82	7.20	18.26	224.90
100	5	33,807	500	126.99	52.44	6.56	185.98	3.63	7.82	7.20	18.65	204.64
110	5	33,807	550	115.44	47.68	5.96	169.08	4.03	7.82	7.20	19.05	188.13
120	5	33,807	600	105.82	43.70	5.46	154.99	4.44	7.82	7.20	19.46	174.45
130	5	33,807	650	97.68	40.34	5.04	143.06	4.85	7.82	7.20	19.87	162.93
140	5	33,807	700	90.70	37.46	4.68	132.85	5.26	7.82	7.20	20.28	153.13
150	5	33,807	750	84.66	34.96	4.37	123.99	5.67	7.82	7.20	20.69	144.68
160	5	33,807	800	79.37	32.78	4.10	116.24	6.09	7.82	7.20	21.11	137.35
170	5	33,807	850	74.70	30.85	3.86	109.40	6.51	7.82	7.20	21.53	130.93
180	5	33,807	900	70.55	29.13	3.64	103.32	6.93	7.82	7.20	21.95	125.28
190	5	33,807	950	66.83	27.60	3.45	97.89	7.36	7.82	7.20	22.38	120.27
200	5	33,807	1,000	63.49	26.22	3.28	92.99	7.78	7.82	7.20	22.81	115.80

List Price:	$97,300	Hours to Wearout:	2,000
Fuel Price for Diesel:	$0.75	Maximum Years to Trade:	15
Labor Cost per Hour:	$6.00	PTO Horsepower:	185
Interest Rate (real):	8.00%	Engine Loading:	67%
Insurance Rate:	1.00%	Fuel per Hour: (gallons)	9.5

Six Row Corn Head
Projected Cost Per Acre of Use

Annual Acres of Use	Age at Trade (Yrs.)	Salvage Value at Trade	Total Acres at Trade	Dep.	Int.	Taxes & Ins.	Total Ownership Cost	Repairs & Maint.	Total Operating Cost	Total Cost per Acre
100	15	$1,946	1,500	$11.37	$8.38	$1.05	$20.80	$0.14	$0.14	$20.94
200	15	1,946	3,000	5.68	4.19	0.52	10.40	0.31	0.31	10.70
300	15	1,946	4,500	3.79	2.79	0.35	6.93	0.48	0.48	7.41
100	10	3,584	1,000	15.42	9.03	1.13	25.58	0.09	0.09	25.67
200	10	3,584	2,000	7.71	4.52	0.56	12.79	0.20	0.20	12.98
300	10	3,584	3,000	5.14	3.01	0.38	8.53	0.31	0.31	8.83
400	10	3,584	4,000	3.85	2.26	0.28	6.39	0.42	0.42	6.81
200	5	6,602	1,000	12.40	5.12	0.64	18.16	0.09	0.09	18.25
300	5	6,602	1,500	8.27	3.41	0.43	12.11	0.14	0.14	12.25
400	5	6,602	2,000	6.20	2.56	0.32	9.08	0.20	0.20	9.27
500	5	6,602	2,500	4.96	2.05	0.26	7.26	0.25	0.25	7.51
600	5	6,602	3,000	4.13	1.71	0.21	6.05	0.31	0.31	6.36
700	5	6,602	3,500	3.54	1.46	0.18	5.19	0.36	0.36	5.55
800	5	6,602	4,000	3.10	1.28	0.16	4.54	0.42	0.42	4.96

List Price:	$19,000	Acres to Wearout:	7,636
Interest Rate (real):	8.00%	Maximum Years to Trade:	15
Insurance Rate:	1.00%	Acres per Hour:	3.8

Eight Row Corn Head
Projected Cost Per Acre of Use

Annual Acres of Use	Age at Trade (Yrs.)	Salvage Value at Trade	Total Acres at Trade	Dep.	Int.	Taxes & Ins.	Total Ownership Cost	Repairs & Maint.	Total Operating Cost	Total Cost per Acre
200	15	$2,632	3,000	$7.69	$5.67	$0.71	$14.06	$0.23	$0.23	$14.29
400	15	2,632	6,000	3.84	2.83	0.35	7.03	0.48	0.48	7.52
600	15	2,632	9,000	2.56	1.89	0.24	4.69	0.76	0.76	5.44
200	10	4,848	2,000	10.43	6.11	0.76	17.30	0.14	0.14	17.44
400	10	4,848	4,000	5.21	3.05	0.38	8.65	0.31	0.31	8.96
600	10	4,848	6,000	3.48	2.04	0.25	5.77	0.48	0.48	6.25
800	10	4,848	8,000	2.61	1.53	0.19	4.32	0.66	0.66	4.99
400	5	8,930	2,000	8.39	3.46	0.43	12.28	0.14	0.14	12.43
600	5	8,930	3,000	5.59	2.31	0.29	8.19	0.23	0.23	8.41
800	5	8,930	4,000	4.19	1.73	0.22	6.14	0.31	0.31	6.45
1,000	5	8,930	5,000	3.35	1.39	0.17	4.91	0.40	0.40	5.31
1,200	5	8,930	6,000	2.80	1.15	0.14	4.09	0.48	0.48	4.58
1,400	5	8,930	7,000	2.40	0.99	0.12	3.51	0.57	0.57	4.08
1,600	5	8,930	8,000	2.10	0.87	0.11	3.07	0.66	0.66	3.73

List Price:	$25,700	Acres to Wearout:	10,182
Interest Rate (real):	8.00%	Maximum Years to Trade:	15
Insurance Rate:	1.00%	Acres per Hour:	5.1

Grain Head 15'

Projected Cost Per Acre of Use

Annual Acres of Use	Age at Trade (Yrs.)	Salvage Value at Trade	Total Acres at Trade	Dep.	Int.	Taxes & Ins.	Total Ownership Cost	Repairs & Maint.	Total Operating Cost	Total Cost per Acre
100	15	$768	1,500	$4.49	$3.31	$0.41	$8.21	$0.06	$0.06	$8.26
200	15	768	3,000	2.24	1.65	0.21	4.10	0.12	0.12	4.22
200	10	1,415	2,000	3.04	1.78	0.22	5.05	0.08	0.08	5.13
300	10	1,415	3,000	2.03	1.19	0.15	3.37	0.12	0.12	3.49
400	10	1,415	4,000	1.52	0.89	0.11	2.52	0.17	0.17	2.69
300	5	2,606	1,500	3.26	1.35	0.17	4.78	0.06	0.06	4.83
400	5	2,606	2,000	2.45	1.01	0.13	3.58	0.08	0.08	3.66
500	5	2,606	2,500	1.96	0.81	0.10	2.87	0.10	0.10	2.97
600	5	2,606	3,000	1.63	0.67	0.08	2.39	0.12	0.12	2.51
700	5	2,606	3,500	1.40	0.58	0.07	2.05	0.14	0.14	2.19

List Price:	$7,500	Acres to Wearout:	7,636
Interest Rate (real):	8.00%	Maximum Years to Trade:	15
Insurance Rate:	1.00%	Acres per Hour:	3.8

Grain Head 20'

Projected Cost Per Acre of Use

200	15	$881	3,000	$2.57	$1.90	$0.24	$4.71	$0.02	$0.02	$4.73
400	15	881	6,000	1.29	0.95	0.12	2.35	0.05	0.05	2.41
400	10	1,622	4,000	1.74	1.02	0.13	2.89	0.03	0.03	2.93
600	10	1,622	6,000	1.16	0.68	0.09	1.93	0.05	0.05	1.98
800	10	1,622	8,000	0.87	0.51	0.06	1.45	0.07	0.07	1.52
600	5	2,988	3,000	1.87	0.77	0.10	2.74	0.02	0.02	2.76
800	5	2,988	4,000	1.40	0.58	0.07	2.05	0.03	0.03	2.09
1,000	5	2,988	5,000	1.12	0.46	0.06	1.64	0.04	0.04	1.69
1,200	5	2,988	6,000	0.94	0.39	0.05	1.37	0.05	0.05	1.42
1,400	5	2,988	7,000	0.80	0.33	0.04	1.17	0.06	0.06	1.24

List Price:	$8,600	Acres to Wearout:	17,309
Interest Rate (real):	8.00%	Maximum Years to Trade:	15
Insurance Rate:	1.00%	Acres per Hour:	8.7

Grain Head 24'

Projected Cost Per Acre of Use

300	15	$983	4,500	$1.91	$1.41	$0.18	$3.50	$0.02	$0.02	$3.52
600	15	983	9,000	0.96	0.71	0.09	1.75	0.04	0.04	1.79
600	10	1,811	6,000	1.30	0.76	0.10	2.15	0.03	0.03	2.18
900	10	1,811	9,000	0.87	0.51	0.06	1.44	0.04	0.04	1.48
1,200	10	1,811	12,000	0.65	0.38	0.05	1.08	0.06	0.06	1.14
900	5	3,336	4,500	1.39	0.57	0.07	2.04	0.02	0.02	2.06
1,200	5	3,336	6,000	1.04	0.43	0.05	1.53	0.03	0.03	1.56
1,500	5	3,336	7,500	0.84	0.34	0.04	1.22	0.04	0.04	1.26
1,800	5	3,336	9,000	0.70	0.29	0.04	1.02	0.04	0.04	1.06
2,100	5	3,336	10,500	0.60	0.25	0.03	0.87	0.05	0.05	0.93

List Price:	$9,600	Acres to Wearout:	24,844
Interest Rate (real):	8.00%	Maximum Years to Trade:	15
Insurance Rate:	1.00%	Acres per Hour:	12.4

Pickup Head 15'
Projected Cost Per Acre of Use

Annual Acres of Use	Age at Trade (Yrs.)	Salvage Value at Trade	Total Acres at Trade	Dep.	Int.	Taxes & Ins.	Total Ownership Cost	Repairs & Maint.	Total Operating Cost	Total Cost per Acre
100	15	$1,632	1,500	$10.25	$7.45	$0.93	$18.63	$0.13	$0.13	$18.76
200	15	1,632	3,000	5.12	3.73	0.47	9.31	0.27	0.27	9.59
300	15	1,632	4,500	3.42	2.48	0.31	6.21	0.43	0.43	6.64
100	10	3,006	1,000	13.99	8.00	1.00	23.00	0.08	0.08	23.08
200	10	3,006	2,000	7.00	4.00	0.50	11.50	0.17	0.17	11.67
300	10	3,006	3,000	4.66	2.67	0.33	7.67	0.27	0.27	7.94
400	10	3,006	4,000	3.50	2.00	0.25	5.75	0.37	0.37	6.12
200	5	5,538	1,000	11.46	4.51	0.56	16.53	0.08	0.08	16.62
300	5	5,538	1,500	7.64	3.01	0.38	11.02	0.13	0.13	11.15
400	5	5,538	2,000	5.73	2.25	0.28	8.27	0.17	0.17	8.44
500	5	5,538	2,500	4.58	1.80	0.23	6.61	0.22	0.22	6.84
600	5	5,538	3,000	3.82	1.50	0.19	5.51	0.27	0.27	5.78
700	5	5,538	3,500	3.27	1.29	0.16	4.72	0.32	0.32	5.05
800	5	5,538	4,000	2.87	1.13	0.14	4.13	0.37	0.37	4.51

List Price:	$17,000	Acres to Wearout:	7,636
Interest Rate (real):	8.00%	Maximum Years to Trade:	15
Insurance Rate:	1.00%	Acres per Hour:	3.8

Swather/Conditioner 14' pull-type
Projected Cost Per Acre of Use

Annual Acres of Use	Age at Trade (Yrs.)	Salvage Value at Trade	Total Acres at Trade	Dep.	Int.	Taxes & Ins.	Total Ownership Cost	Repairs & Maint.	Total Operating Cost	Total Cost per Acre
200	20	$1,067	4,000	$4.53	$4.05	$0.51	$9.09	$0.70	$0.70	$9.80
400	20	1,067	8,000	2.27	2.03	0.25	4.55	1.07	1.07	5.61
200	15	1,966	3,000	5.74	4.23	0.53	10.51	0.59	0.59	11.10
400	15	1,966	6,000	2.87	2.12	0.26	5.25	0.90	0.90	6.15
600	15	1,966	9,000	1.91	1.41	0.18	3.50	1.14	1.14	4.65
400	10	3,622	4,000	3.89	2.28	0.29	6.46	0.70	0.70	7.16
600	10	3,622	6,000	2.60	1.52	0.19	4.31	0.90	0.90	5.20
800	10	3,622	8,000	1.95	1.14	0.14	3.23	1.07	1.07	4.30
1,000	10	3,622	10,000	1.56	0.91	0.11	2.58	1.22	1.22	3.80
600	5	6,671	3,000	4.18	1.72	0.22	6.12	0.59	0.59	6.71
800	5	6,671	4,000	3.13	1.29	0.16	4.59	0.70	0.70	5.29
1,000	5	6,671	5,000	2.51	1.03	0.13	3.67	0.80	0.80	4.47
1,200	5	6,671	6,000	2.09	0.86	0.11	3.06	0.90	0.90	3.95
1,400	5	6,671	7,000	1.79	0.74	0.09	2.62	0.98	0.98	3.60

List Price:	$19,200	Acres to Wearout:	11,455
Interest Rate (real):	8.00%	Maximum Years to Trade:	20
Insurance Rate:	1.00%	Acres per Hour:	5.7

Appendix 3.

Examples of reference materials used to derive descriptions of the operations of the farming systems.

Table A3-1. From NASS (1995), acres planted 1994 (preliminary), Nebraska East Agricultural Statistics District, irrigated and dryland.

Crop	Acres planted
corn for grain	2157000
soybeans	1052000
sorghum for grain	268000
all alfalfa hay	156000
all wheat	74000
wild hay	42000
corn for silage	32700
oats	27000
other tame hay	22000
sorghum for silage	4700
rye	1700
sunflowers	100

Table A3-2. Characteristics of a successful crop rotation (based on Kirschenmann 1988).

1. For weed control:

   Alternate between hot weather and cold weather plants in order to concentrate on a diversity of weed populations, one year eradicating early germinating weeds, another year late germinating weeds.

   Include plants that have natural weed germination inhibiters (like rye and sorghum) in the rotation.

   Include legumes in the rotation. Legumes may help balance the soil's base saturation ratio and serve as good weed competitors to choke weeds out.

   Include crops that lend themselves to mechanical weed control like row crops and late seeded crops.

   Adjust the rotation to attack target perennial weeds.

2. Include crops with different nutrient requirements, and a variety of root structures that extract nutrients and water from different depths.

3. Alternate high water users with plants requiring lesser amounts of water.

4. Include both high production and soil conserving crops.

5. Include a sufficient diversity of crops to increase economic stability and minimize risks.

6. Alternate crops with different insect and disease pests.

Table A3-3. Shelterbelt effects on crop yields. Data is for dryland farming (except vegetables). Field averages rather than maximums are reported where possible. For additional data, see Stoeckeler (1962). The yield increases used in the farm models are also shown.

Crop	Reported yield increases in shelter	Reference	Value selected for use in the models of the five farms
corn (grain)	46%	Zohar and Brandle (1978)	10%
	12%	Kort (1988)	
corn (silage)			10%
soybean	12%	Baldwin (1988) citing Baldwin and Johnston (1984)	12%
	8.5%	Frank et al. (1974)	
	20-26%	Ogbuehi and Brandle (1981)	
sorghum	no data		5%
alfalfa	99%	Kort (1988)	15%
winter wheat	+50% to -44% (mean= 15%)	Brandle et al. (1984)	15%
	23%	Kort (1988)	
hay	20%	Kort (1988)	15%
oat	6%	Kort (1988)	5%
turnip	no data		0%
vegetables	5% to 50%	Baldwin (1988)	0%*

*The benefits to vegetables of shelter assumed in the model are increased quality (e.g., Hodges 1997) and greater stability of yield.

Table A3-4. Week numbers.

Week no.	Calendar date	Week no.	Calendar date	Week no.	Calendar date	Week no.	Calendar date
1	Jan 1-7	14	Apr 2-8	27	Jul 2-8	40	Oct 1-7
2	Jan 8-14	15	Apr 9-15	28	Jul 9-15	41	Oct 8-14
3	Jan 15-21	16	Apr 16-22	29	Jul 16-22	42	Oct 15-21
4	Jan 22-28	17	Apr 23-29	30	Jul 23-29	43	Oct 22-28
5	Jan 29-Feb 4	18	Apr 30-May 6	31	Jul 30-Aug 5	44	Oct 29-Nov 4
6	Feb 5-11	19	May 7-13	32	Aug 6-12	45	Nov 5-11
7	Feb 12-18	20	May 14-20	33	Aug 13-19	46	Nov 12-18
8	Feb 19-25	21	May 21-27	34	Aug 20-26	47	Nov 19-25
9	Feb 26-Mar 4	22	May 28-Jun 3	35	Aug 27-Sep 2	48	Nov 26-Dec 2
10	Mar 5-11	23	Jun 4-10	36	Sep 3-9	49	Dec 3-9
11	Mar 12-18	24	Jun 11-17	37	Sep 10-16	50	Dec 10-16
12	Mar 19-25	25	Jun 18-24	38	Sep 17-23	51	Dec 17-23
13	Mar 26-Apr 1	26	Jun 25-Jul 1	39	Sep 24-30	52	Dec 24-30

Appendix 4: Economic Analysis

Budgets for the five farms were generated with a simple economic model — basically a spreadsheet and a small set of rules (Table A4-1). Standard lists of prices for inputs (Table A4-2), and prices and yields for crops (Tables A4-3, 4) were compiled. Appendices 4A-E show the calculations for the alternative farm budgets.

The foundation for the economic analysis of each farm is a detailed operations schedule describing the tasks required to produce each crop. Associated with the operations schedule is a list of the inputs (e.g., fertilizers, packing crates) required to perform the operations. Footnotes to the inputs lists identify the sources of information from which the types and amounts of inputs were derived.

Initial budget calculations are performed on a weekly basis, matching the schedule of operations. Two different formats are shown in this Appendix — users can choose the one they prefer. For the conventional, modified conventional, and beef farms, the weekly calculations include both the amounts and dollar costs of all operations and inputs. This allows expenditures to be tracked weekly, and the weekly dollar values are summed to produce the whole-farm annual budget.

For the agroforestry and organic farms, the weekly calculations determine only the amounts of inputs (e.g., hours of tractor use, pounds of seed). The amounts of each input are then summed and multiplied by price to give dollar values for the whole-farm budget.

The two methods give the same results. The second method — summing the input amounts before calculating costs — seems to provide better organization when the systems and budgets are complex.

As another way of summarizing the economics of each farm, a second budget is presented that breaks down costs and returns by crop. The weekly calculations of input amounts are easily compiled by crop to form the basis for this budget.

An economic model

Farm budgets are organized by the standard format shown in Table A4-1. The footnotes to the table explain how each value is obtained.

Table A4-1. A farm economic model.

Land costs		
Owned	1	
Rented	2	
Equipment		
	Ownership	Operation (excl. labor)
Power units	3	4
Implements	5	6
Equipment rental	7	
Seed and chemicals	8	
Custom operations	9	
Hired labor	10	
Overhead and Interest		
Interest on operating capital	11	
Overhead	12	
Total expenses		
Gross income	13	
Net income	14	

1. From Johnson (pers comm); average debt on owned farmland is 20% of value. To calculate interest and principle payments per acre, get average price of high grade dryland cropland (or pasture) from Johnson (1995; Table 3) and multiply by .2 (e.g., \$1345/A x .2 = \$269/A). Assume amortization for 30 years at 8%: (e.g., \$269/A x .088827 (from amortization table) = \$23.89/A interest and principle per year). Plus real estate taxes of \$12.00/A (Selley et al. 1994).

2. Cash rent from Johnson (1995); average 1995 values for dryland cropland or pasture, East Agricultural Statistics District.

3. From the farm's equipment list, get age at trade and annual hours of use. Use these with the table from Powell et al. (1992) (Appendix 2) that describes the power unit to determine cost of ownership per hour of use. Increase cost per hour by 10% to account for inflation (to mid-1996). Multiply inflation adjusted cost per hour of use by annual hours of use to get annual ownership cost. See Appendix 5, Table A5-1 for inflation factors.

4. From the farm's equipment list, get age at trade and annual hours of use. Use these with the table from Powell et al. (1992) (Appendix 2) that describes the power unit to determine total non-labor operation cost per hour of use (repair and maintenance + fuel and lube). Increase by 10% to adjust for inflation (to mid-1996). Multiply inflation adjusted non-labor operating cost per hour of use by total hours of use to get the operating cost for the year. The tables assume diesel fuel at $0.75 per gallon, the same price used by Selley (1996) for budgets. If in the future there were a major increase in fuel prices, an adjustment would be required.

5. Same as (3), but use "acres of use" instead of "hours of use."

6. Same as (4), but use "acres of use" instead of "hours of use."

7. Equipment rental from Selley (1996); other sources (see Table A4-2)

Rule 1. Activities requiring implements not owned by the farm can be custom hired or the implement rented.

Rule 2. A tractor or other power unit can be used for a maximum of 112 hours per week (7-16 hour days). If power requirements in any given week exceed the cumulative capacity of the units owned by the farm, the excess work must be custom hired.

Rule 3. When the farm owns two tractors, total weekly tractor use is evenly divided between the two tractors.

8. Seed, fertilizer, and pesticide costs from Selley (1996), and other sources (Table A4-2).

9. Costs of custom operations from Massey (1993, 1994) and other sources (Table A4-2).

10. Cost of hired labor is set at $6.00 per hour (Selley 1996). Machinery field hours increased by 20% to account for maintenance and preparation.

Rule 4. The farmer and spouse can provide up to 100 hours per week of labor for field operations and related prep time (e.g., machinery maintenance). Labor needs in excess of 100 hours in any week must be met by hiring help.

While the specific thresholds incorporated in the equipment and labor rules can be debated, the rules do force a recognition of the limits to the resources of an average-size farm, and the economic consequences of exceeding those limits.

11. Interest on operating capital is 10% (Selley 1996), assessed for 8 months for crop production. Operating capital includes the cost of seed and chemicals, equipment operation, custom work and hired labor.

12. Overhead is 5% of the total of operating capital and interest (Selley 1996).

13. Gross income (see Tables A4-3, 4 for average crop yields and prices; Table A5-5 for cattle prices)

Table A4-2. Input costs for analog farm budget exercises

Parameter	Value	Source
LAND		
Rent, pasture	$36/A	Johnson (1995); average high rent for pasture in eastern Nebraska
Rent, non-irrigated cropland	$79/A	Johnson (1995); average rent for dryland cropland in eastern Nebraska
Purchase price, pasture	$705/A	Johnson (1995); average value for high grade tillable grazing land, eastern Nebraska, Table 3
Purchase price, cropland	$1345/A	Johnson (1995); average value for high grade dryland cropland, eastern Nebraska, Table 3
Taxes, pasture	$7.15/A	Based on relative value of grazing land (with fencing) compared to crop land at $12/A tax rate
Taxes, non-irrigated cropland	$12.00/A	Selley (1996), p. 111
SEED		
Field corn	$87.70 per 50 lb	Selley (1996), p. x
Soybean	$15.47 per 50 lb	Selley (1996), p. x
Sorghum	$47.10 per 50 lb	Selley (1996), p. x
Alfalfa w/ inoculant	$159.08 per 50 lb	Selley (1996), p. x
Oat	$6.00/bu (32 lbs)	Selley (1996, p. x
Turnip	$1.25/lb	Bender (1994)
Winter wheat	$10.00 per 50 lb	Selley (1996), p. x
Sweet corn	$7.80/lb	Anfinson et al. (1996)
Pumpkin	$34.20/lb	Anfinson et al. (1996)
Acorn squash	$26.81/lb	Klonsky et al. (1994)
Spinach	$4.22/lb*	DeCourley and Moore (1987)
Annual rye	$4.05/bu*	Spence (1987)

Parameter	Value	Source
SEEDLINGS		
Bell pepper	$150/1000 transplants	Anfinson et al. (1996)
Eastern redcedar	$0.20 each	Adams (pers. comm.)
Scotch pine	$0.20 each	Adams (pers. comm.)
Hazel	$0.45 each	Bolander (pers. comm.)
FERTILIZER		
Anhydrous ammonia	$0.15/lb. N	Selley (1996), p. viii
Ammonium nitrate	$0.25/lb N	NASS (1994)
Triple super phosphate	$0.26/lb. P_2O_5	Selley (1996), p. viii
Manure, custom spread, no incorporation	$2.08/ton including 10 miles shipping	Mead Cattle Co., 1997
Rock phosphate (0-23-0)	$300/ton including shipping	Lane Inc., Charles City, IA
HERBICIDE		
Corn herbicides	$20.38/ac	See note 1
Soybean herbicides	$24.35/ac	See note 2
Sorghum herbicides	$16.41/ac	See note 3
Alfalfa herbicide	$10.26/ac	Selley (1996)
Roundup	$46.19/gal	Selley (1996), p. ix
PESTICIDE		
Cygon 2-E (Dimethoate)	$38.25/gallon	Hummert International, 1997
ORGANIC PEST CONTROL		
Pyrellin E.C.	$20.10/qt	Klonsky et al. (1994)
Bt-Dipel	$12.87/lb	Klonsky et al. (1994)
Trichogramma wasps	$16.09/card	Klonsky et al. (1994)
Insecticidal soap	$12.87/qt	Klonsky et al. (1994)

Parameter	Value	Source
Rodent trapping	2 hrs/A	Klonsky et al. (1994)
CUSTOM		
Hired labor	$6.00/hr	Selley (1996), p. x
Rogue beans	$5.00/A	Selley (1996), p. x
Rogue organic rowcrops	$10.00/A	Double rate of Selley (1996) to reflect higher weed pressure
Trucking grain	$.12/bu	Selley (1996), p. viii
Trucking, general	$.20/cwt	Selley (1996), p. viii
Drying corn	$.10/bu	Selley (1996), p. 109
Moldboard plowing	$8.88/A	Massey (1994)
Swathing	$7.76/ac*	Massey (1994)
Baling (large round)	$6.57/bale*	Massey (1994)
Spraying	$3.83/ac	Massey (1994)
Chop silage	$2.00/ton	Selley (1996), p. viii
Lay fabric mulch	$0.50/ft (materials + labor)	Rich Straight, pers. comm.
RENTAL		
Anhydrous applicator	$2.50/ac	Selley (1996), p. x
Broadcast spreader	$1.50/ac	Selley (1996), p. x
Seeder-packer	$3.75/ac	Selley (1996), p. x
Grain drill (16' disk)	$5.00/ac	Selley (1996), p. x
Bee hive	$45/hive	Marion Ellis (pers. comm.)
CHRISTMAS TREE PRODUCTION		
Hand planting	400 seedlings/day	Laine et al. (1992a)

Parameter	Value	Source
Shearing and staking, year 3	$0.10/tree or 60 trees/hr	Adams (pers. comm.)
Shearing and basal pruning, year 4	$0.05/tree or 120 trees/hr	Laine et al. (1992b)
Shearing, year 5	$0.15/tree or 40 trees/hr	Laine et al. (1992b)
Shearing, years 6-8 (per year)	$0.20/tree or 30 trees/hr	Laine et al. (1992b)
Removing unsold trees	100 trees/8 hrs	Adams (pers. comm.)
Custom ripping to remove stumps	$9.77/A	Massey (1994)
Moving ripped stumps	200 stumps/8 hrs	Adams (pers. comm.)
Backpack spraying	1000 trees/8 hrs	Adams (pers. comm.)
Marketing	$4.00/tree	Adams (pers. comm.)
Liability insurance (U-cut)	$300/year	Klonsky et al. (1994)
HAZEL NUT PRODUCTION		
Hand plant hazel seedlings	400 seedlings/day	Laine et al. (1992a)
Pruning	40 shrubs/hr	estimated
Harvest/clean/dry seed	84 hrs/A at 350 lb/A	Bolander
VEGETABLE PRODUCTION		
Sweet corn boxes (5 dozen ears)	$1.00 each*	DeCourley and Moore (1987)
Acorn squash box (20 lbs)	$0.64 each	Klonsky et al. (1994)
Pepper cartons (1 1/9 bu)	$1.10 each	Klonsky et al. (1994)
Spinach cartons (20 lbs)	$1.35 each*	DeCourley and Moore (1987)
Pumpkin crates/pallets (500 lb)	$12.50 each	Anfinson et al. (1996)

Parameter	Value	Source
Ice	$12/300 lbs	Valley Ice, Lincoln, NE
Marketing fees	see vegetable inputs table	
CATTLE PRODUCTION		
Trucking cattle	$2.00 per loaded mile	Massey (1993)
Receiving (acclimation)	$.74/hd/day	Shain et al. (1997)
Corn stalks	$.12/hd/day	Shain et al. (1997)
Winter alfalfa feeding	$.30/hd/day	Shain et al. (1997)
Winter mineral supplement, 1.5 lb/day	$.12/hd/day	Shain et al. (1997)
Winter yardage	$.10/hd/day	Shain et al. (1997)
Summer mineral supplement	$0.12/lb	Selley (1995)
Finishing yardage	$.30/hd/day	Shain et al. (1997)
Finishing feed	$.0467/lb DM	Shain et al. (1997)
MISCELLANEOUS		
Baling twine	$0.44 per large round bale	Selley (1996), p. x.
Electricity	$0.06/kWh	Selley (1996)
Interest on operating capital for crop production	10% for 8 months	Selley (1996)
Move bales	with tractor, 10 A/hr	Selley (1996), p. 117

*Price increased 4% to correct for inflation 1994-1996.

Note 1. For corn herbicides, the average cost of 40 pre-plant incorporated and pre-emergent herbicide mixtures given in the 1996 Guide to Herbicide Use in Nebraska (Nebraska Cooperative Extension 1996) for silty clay loam soils with >2% organic matter was $20.38 per acre.

Note 2. For soybean herbicides, the average cost of 40 different pre-emergent and pre-plant herbicide mixtures for silty clay loam soils with >2% organic matter as listed in the 1996 Guide to Herbicide Use in Nebraska was $24.35 per acre.

Note 3. For sorghum herbicides, the average cost of 10 different pre-emergent herbicide treatments for silty clay loam soils with >2% organic matter as listed in the 1996 Guide to Herbicide Use in Nebraska was $16.41 per acre.

At high end of pasture rents, landlord will provide materials (not labor) for exterior fencing, and will provide a water source (pond or well). Prices from Selley (1995) based on scenario of selling calves off grass from the ranch area.

Selley (pers. comm.): roguing at $5/A done under contract, takes about .75-1 hr labor/A.

Table A4-3. Average yield and market year prices (in 1996 dollars) for the Nebraska East Agricultural Statistics District, 1985-1994. See Table A5-2 for data sources and full data set by year.

Crop	yield per acre	price ($)/unit
corn	105 bu	2.65
soybeans	35 bu	6.79
sorghum	90 bu	2.35
alfalfa	3.5 tons	63.68
winter wheat	37 bu	3.68
tame hay	2 tons	56.64
oats	60 bu	1.78
corn silage	13.6 tons	16.67

Table A4-4. Average weekly Chicago wholesale market prices, 1985-1994, in 1996 dollars, for harvest dates used in organic farm model. From USDA, Chicago Wholesale Fruit and Vegetable Report, assorted issues and years. See Table A5-3 for price breakdown by year.

Crop	Unit	Date	Price ($)/unit
Spinach	20 lbs	3rd week May	12.29
		4th week May	12.49
Sweet corn	5 dozen ears	2nd week August	8.37
		3rd week August	8.97
		4th week August	8.46
		1st week September	8.42
		2nd week September	8.23
		3rd week September	8.74
Pumpkins	1000 lbs	2nd week September	140.00
		4th week September	140.00
Acorn squash	50 lbs	2nd week August	11.90
		3rd week August	10.87
		4th week August	10.22
Bell peppers	bushel	3rd week August	9.54
		4th week August	8.51
		1st week September	8.28
		2nd week September	8.42
		3rd week September	8.43

Appendix 4A.

Conventional Farm

Baseline economic analysis

I. Characteristics of the conventional farm

A. Size

farm size (acres)	650
% land owned	45
% cropland	100

B. Standardized equipment list:

Item	Age at trade	Annual use	Description
Tractor #1	15	245 hrs	120 hp diesel cab
Tractor #2	20	245 hrs	100 hp diesel cab
disk	15	650 A	tandem disk harrow 20'
row cultivator	15	650 A	8 row x 30"
field cultivator	10	650 A	24'
sprayer	15	650 A	300 gal 20' 3 point mount
combine	15	101 hrs	185 hp
corn head	15	325 A	8 row
grain head	15	325 A	20'
planter	10	650 A	8 row x 30"
pickup truck	15	280 hrs	½ ton

* rotary hoe and moldboard plow removed from baseline list; pickup truck added.

C. Operations summary

Operations for the baseline economic analysis are based on standard field operations for a farm of this type (Selley 1996). Planting and harvest dates based on average dates for the East Crop Reporting District of 50% acreage planted and harvested, 1989-1993 (NASS 1994).

Week no.*	corn for grain (325 acres)	soybeans (325 acres)
15 (April 9-15)	apply P_2O_5 disk	
16		apply P_2O_5 disk
17	apply anhydrous field cultivate	field cultivate
18	plant apply herbicide	
20		plant apply herbicide
22	cultivate	
24		cultivate
28		rogue
40		harvest truck
41 (Oct 8-14)	harvest truck dry	

* See Table A3-4 for listing of week numbers and calendar dates.

D. Summary of inputs (per acre)

Input	corn	soybeans
N fertilizer recommendation	100 lbs	0
N credit from previous crop	45 lbs	0
N applied	55 lbs	0
P_2O_5	25 lbs	25 lbs
seed	.25 bag	1 bag
herbicide	$20.38	$24.35

Fertilizer rates from Helmers et al. (1986). Soybean nitrogen credit from Ferguson et al. (1994) and Hergert et al. (1995). Planting rates from Selley (1996). Herbicide costs are average for all preemergence options given in Nebraska Cooperative Extension (1996).

E. Equipment ownership and use.

Costs interpolated from tables in Powell et al. (1992) with values increased 10% to account for inflation from 1992 to mid-1996. Pickup truck costs from Klonsky et al. (1994). Annual use derived from baseline operations scenario for the conventional farm.

Power unit	Annual cost of owning	Annual use (hrs)	Ownership cost per hour use	Operation cost per hour use
120 hp tractor	6241	245	25.47	7.71
100 hp tractor	4815	245	19.65	7.15
combine	11714	101	115.98	22.12
pickup	983	280	3.51	5.11

Implement	Annual cost of owning	Annual use (acres)	Ownership cost per acre use	Operation cost per acre use
disk	1794	650	2.76	.44
row cultivator	744	650	1.14	.34
field cultivator	1428	650	2.20	.17
sprayer	252	650	.39	.09

Implement	Annual cost of owning	Annual use (acres)	Ownership cost per acre use	Operation cost per acre use
corn head	3093	325	9.52	.42
grain head	1034	325	3.18	.04
planter	2808	650	4.32	1.70

Note: Combine annual use is about 100 hours. If combine were shared with another farmer, 200 hours annual use would require trade every ten years which increases annual cost of ownership so total savings is only $1400. So, sharing not included in budget.

II. Budget calculations for conventional farm (costs rounded to nearest dollar)

Land

Owned: 292.5 A x $35.89/A = $10,498

From Johnson (1994); average debt on owned farmland is 20% of value. For eastern Nebraska, $1345/A x .2 = $269/A. Amortized over 30 years at 8%: $269/A x .088827 (from amortization table) = $23.89/A interest and principle payments per year. Plus real estate taxes of $12.00/A = $35.89/A.

Rented: 357.5 A x $79.00/A = $28,243

A. Weekly calculations

Note: Labor hours associated with machinery use in the field are increased by 20% (x 1.2) to account for maintenance and preparation.

Week 15 (April 9-15):

Disking: 325 A ÷ 7.8 A/hr = 41.7 hrs (x 1.2 = 50 hrs)
Spread P_2O_5: 325 A ÷ 10 A/hr = 32.5 hrs (x 1.2 = 39 hrs)

Total labor = 89 hrs

120 hp tractor: 37.1 hrs x $7.71/hr = $286
100 hp tractor: 37.1 hrs x $7.15/hr = $265
disk: 325 A x $.44/A = $143

spreader rental: 325 A x \$1.50/A = \$488
P_2O_5: 325 A x 25 lbs/A x \$.26/lb = \$2,113

Week 16:

Disking: 325 A ÷ 7.8 A/hr = 41.7 hrs (x 1.2 = 50 hrs)
Spread P_2O_5: 325 A ÷ 10 A/hr = 32.5 hrs (x 1.2 = 39 hrs)

Total labor = 89 hrs

120 hp tractor: 37.1 hrs x \$7.71/hr = \$286
100 hp tractor: 37.1 hrs x \$7.15/hr = \$265
disk: 325 A x \$.44/A = \$143
spreader rental: 325 A x \$1.50/A = \$488
P_2O_5: 325 A x 25 lbs/A x \$.26/lb = \$2,113

Week 17:

Apply anhydrous: 325 A ÷ 9.7 A/hr = 33.5 hrs (x 1.2 = 40.2 hrs)
Field cultivation: 650 A ÷ 13.6 A/hr = 47.8 hrs (x 1.2 = 57.4 hrs)

Total labor = 97.6 hrs

120 hp tractor: 40.7 hrs x \$7.71/hr = \$314
100 hp tractor: 40.7 hrs x \$7.15/hr = \$291
Field cultivator: 650 A x \$.17/A = \$111
Anhydrous applicator rental: 325 A x \$2.50/A = \$813
Anhydrous: 325 A x 55 lbs N/A x \$.15/lb N = \$2681

Week 18:

Plant corn: 325 A ÷ 6.5 A/hr = 50.0 hrs (x 1.2 = 60.0 hrs)
Spray corn: 325 A ÷ 10.2 A/hr = 31.9 hrs (x 1.2 = 38.2 hrs)

Total labor = 98.2 hrs

120 hp tractor: 41.0 hrs x \$7.71/hr = \$316
100 hp tractor: 41.0 hrs x \$7.15/hr = \$293
Planter: 325 A x \$1.70/A = \$553
Sprayer: 325 A x \$.09/A = \$29
Herbicide: 325 A x \$20.38/A = \$6624
Corn seed: 325 A x 20,000 seeds/A x 1 bag/80,000 seeds x \$87.70/bag = \$7,126

Week 20:

Plant soybeans: 325 A ÷ 6.5A/hr = 50.0 hrs (x 1.2 = 60.0 hrs)
Spray beans: 325 A ÷ 10.2 A/hr = 31.9 hrs (x 1.2 = 38.2 hrs)

Total labor = 98.2 hrs

120 hp tractor: 41.0 hrs x $7.71/hr = $316
100 hp tractor: 41.0 hrs x $7.15/hr = $293
Planter: 325 A x $1.70/A = $553
Sprayer: 325 A x $.09/A = $29
Herbicide: 325 A x $24.35/A = $7,914
Bean seed: 325acres x 1 bag seed/A x $15.47/bag = $5,028

Week 22:

Cultivate corn: 325 A ÷ 6.8 A/hr = 47.8 hrs (x 1.2 = 57.4 hrs)

120 hp tractor: 23.9 hrs x $7.71/hr = $184
100 hp tractor: 23.9 hrs x $7.15/hr = $171
rowcrop cultivator: 325 A x $.34/A = $111

Week 24:

Cultivate beans: 325 A ÷ 6.8 A/hr = 47.8 hrs (x 1.2 = 57.4 hrs)

120 hp tractor: 23.9 hrs x $7.71/hr = $184
100 hp tractor: 23.9 hrs x $7.15/hr = $171
rowcrop cultivator: 325A x $.34/A = $111

Week 28:

Rogue beans: 325 A x $5.00/A = $1,625

Week 40:

Combine beans: 325 A ÷ 8.7 A/hr = 37.4 hrs (x 1.2 = 44.8 hrs)

Combine: 37.4 hrs x $22.12/hr = $827
Grain head: 325 A x $.04/A = $13
Yield: 325 A x 35 bu/A = 11,375 bu

Truck beans: \$.12/bu x 11,375 bu = \$1,365
Income: 11,375 bu x \$6.79/bu = \$77,237

Week 41 (Oct 8-14):

Combine corn: 325 A ÷ 5.1 A/hr = 63.7 hrs (x 1.2 = 76.5 hrs)

Combine: 63.7 hrs x \$22.12/hr = \$1,409
Corn head: 325 A x \$.42/A = \$137
Yield: 325 A x 105 bu/A = 34,125 bu
Truck corn to elevator: \$.12/bu x 34,125 bu = \$4,095
Dry grain: \$.10/bu x 34,125 bu = \$3,413
Income: 34,125 bu x \$2.65/bu = \$90,431

B. Summary budget

LAND

	Acres	Cost/A	Total
Owned	292.5	35.89/A	10,498
Rented	357.5	79.00/A	28,243

EQUIPMENT

Item	Annual ownership cost	Annual cost of operation (excl. labor)
Power units		
120 hp tractor	6,241	1,886
100 hp tractor	4,815	1,749
185 hp combine	11,714	2,236
½ ton pickup	983	1,431
Implements		
disk	1,794	286
rowcrop cultivator	744	222
field cultivator	1,428	111
sprayer	252	58
8 row corn head	3,093	137
20' grain head	1,034	13
8 row planter	2,808	1106
Total	34,906	9,235

EQUIPMENT RENTAL

anhydrous applicator	813
broadcast spreader	976
Total rental	1789

SEED AND CHEMICALS

Item	
seed	12,154
fertilizer	6,907
pesticides	14,538
Total seed/chemicals	33,599

CUSTOM OPERATIONS

operation	
rogue beans	1,625
haul grain	5,460
dry corn	3,413
Total custom	10,498
Hired labor	0
Total operations	55,121

OVERHEAD AND INTEREST

Interest on operating capital	3,693
Overhead	2,941
Total	6,634
TOTAL EXPENSES	135,402
TOTAL INCOME	167,668
NET INCOME	32,266

C. Equipment use per crop.

Conventional farm: Summary of equipment use for each crop

Equipment	corn	soybeans	total
120 hp tractor (hrs)	131	114	245
100 hp tractor (hrs)	131	114	245
combine (hrs)	64	37	101
pickup (hrs)	140	140	280
disk (A)	325	325	650
rowcrop cultivator (A)	325	325	650
field cultivator (A)	325	325	650
sprayer (A)	325	325	650
corn head (A)	325	0	325
grain head (A)	0	325	325
planter (A)	325	325	650

D. Per acre costs and returns, by crop.

Conventional farm: Cost of production and returns ($/acre) for each crop.

Input	corn	soybeans
Ownership costs		
120 hp tractor	10.27	8.93
100 hp tractor	7.92	6.89
combine	22.84	13.20
pickup	1.51	1.51
disk	2.76	2.76
rowcrop cultivator	1.14	1.14
field cultivator	2.20	2.20

Input	corn	soybeans
sprayer	.39	.39
corn head	9.52	0
grain head	0	3.18
planter	4.32	4.32
Total equip. ownership	62.87	44.52
Land ownership	16.15	16.15
Land rental	43.45	43.45
Total land cost	59.60	59.60
Equipment operation		
120 hp tractor	3.11	2.70
100 hp tractor	2.88	2.51
combine	4.36	2.52
pickup	2.20	2.20
disk	.44	.44
rowcrop cultivator	.34	.34
field cultivator	.17	.17
sprayer	.09	.09
corn head	.42	0
grain head	0	.04
planter	1.70	1.70
Total equipment operation	15.71	12.71
Equipment rental		
spreader	1.50	1.50

Input	corn	soybeans
anhydrous applicator	2.50	0
Total rental	4.00	1.50
Seed and chemicals		
seed	21.93	15.47
anhydrous	8.25	0
P_2O_5	6.50	6.50
herbicide	20.38	24.35
Total seed/chemicals	57.06	46.32
Custom and labor		
roguing	0	5.00
trucking	12.60	4.20
drying	10.50	0
hired labor	0	0
Total custom and labor	23.10	9.20
Total operations	99.87	69.73
Interest	6.69	4.67
Overhead	5.33	3.72
Total expenses	234.36	182.24
Crop value	278.25	237.66
Net income	43.89	55.42

Appendix 4B.

Modified Conventional Farm

Baseline economic analysis

I. Characteristics of the modified conventional farm

A. Size

farm size (acres)	650
% land owned	45
% cropland	100

B. Standardized equipment list:

Item	Age at trade	Annual use	Description
Tractor #1	15	228 hrs	120 hp diesel cab
Tractor #2	20	228 hrs	100 hp diesel cab
disk	15	605 A	tandem disk harrow 20'
row cultivator	15	590 A	8 row x 30"
field cultivator	10	605 A	24'
sprayer	15	605 A	300 gal 20' 3 point mount
combine	15	80 hrs	185 hp
corn head	15	151 A	8 row
grain head	15	439 A	20'
planter	10	590 A	8 row x 30"
pickup truck	15	280 hrs	½ ton

Rotary hoe removed from baseline list; pickup added.

C. Operations summary

Operations are based on standard field operations for a farm of this type. Planting and harvest dates based on average dates for the East Crop Reporting District of 50% acreage planted and harvested, 1989-1993 (NASS 1994). Alfalfa planting date from Anderson and Nichols (1983); alfalfa harvest dates personal communication from Bruce Anderson.

Week no.	corn (151.25 acres)	soybeans (287.5)	sorghum (151.25)	alfalfa (60)
15 (April 9-15)				(15 A only) apply P_2O_5 disk field cultivate seeder/packer spray herbicide
16	plow 4 yr alfalfa (15 acres) Apply P_2O_5 Disk			
17	apply anhydrous field cultivate			
18	plant apply herbicide		disk	
19		apply P_2O_5 disk		
20		field cultivate plant		
21		apply herbicide	apply anhydrous field cultivate plant	
22	cultivate		apply herbicide	(45 acres only) windrow bale move bales
25		cultivate		
26			cultivate	
27				
28		rogue		
29			rogue	
30				(60 A) windrow, bale, move bales

Week no.	corn (151.25 acres)	soybeans (287.5)	sorghum (151.25)	alfalfa (60)
37				(60 A) windrow, bale, move bales
40		combine truck		
41	combine truck, dry			
42			combine truck	

D. Summary of inputs (per acre) by crop for modified conventional farm

Input	Corn (105 bu) following soybeans	Corn (105 bu) following alfalfa	Soybeans (35 bu)	Sorghum (90 bu)	Alfalfa (establishment) **
N fertilizer recommendation	100 lb	100 lb	0	70 lb*	0
N credit from previous crop	45 lb	150 lb	0	45 lb	0
N applied	55 lb	0	0	25 lb	0
P_2O_5	25 lb	25 lb	25 lb	0	60 lb
seed	.25 bag	.25 bag	1 bag	5 lb	12 lb
herbicide	$20.38	$20.38	$24.35	$16.41	$10.26

*Increased from 60 lbs for higher yield goal of 90 bu.
**Average yield for the 60 acres of alfalfa is 3.19 tons/A due to the reduced yield of the spring planted 15A.

Fertilizer rates for corn and soybeans from Helmers et al. (1986); for sorghum and alfalfa from Selley (1996). Legume nitrogen credits from Ferguson et al. (1994) and Hergert et al. (1995). Planting rates from Selley (1996). Herbicide costs are average for all preemergent options given in Nebraska Cooperative Extension (1996) except alfalfa from Selley (1996).

E. Equipment ownership and use.

Costs interpolated from tables in Powell et al. (1992) with values increased 10% to account for inflation from 1992 to mid-1996. Pickup truck costs from Klonsky et al. (1994). Annual use derived from baseline operations scenario for the modified conventional farm.

Equipment	Annual use (hrs)	Annual cost of ownership	Ownership cost per hour use	Operating cost per hour use
120 hp tractor	228	$6241	$27.37	$7.56
100 hp tractor	228	$4815	$21.12	$6.98
combine	80	$11714	$146.06	$19.06
pickup truck	280	$983	$3.51	$5.11

Implement	Annual use (acres)	Annual cost of owning	Ownership cost per acre use	Operation cost per acre use
disk	605	$1794	$2.97	$0.42
field cultivator	605	$1428	$2.36	$0.17
planter	590	$2808	$4.76	$1.53
sprayer	605	$252	$0.42	$0.09
row crop cultivator	590	$744	$1.26	$0.30
corn head	151.25	$3093	$20.45	$0.19
grain head	439	$1034	$2.36	$0.06

II. Budget calculations (costs rounded to nearest dollar).

Land

Owned: 292.5 A x \$35.89/A = \$10,498

From Johnson (1994); average debt on owned farmland is 20% of value. For eastern Nebraska, \$1345/A x .2 = \$269/A. Amortized over 30 years at 8%: \$269/A x .088827 (from amortization table) = \$23.89/A interest and principle payments per year. Plus real estate taxes of \$12.00/A = \$35.89/A.

Rented: 357.5 x \$79.00/A = \$28,243

A. Weekly calculations

Note: Labor hours associated with machinery use in the field are increased by 20% (x 1.2) to account for maintenance and preparation.

Week 15 (April 9-15):

Disk: 15 A ÷ 7.8 A/hr = 1.9 hrs (x 1.2 = 2.3 hrs)
Spread fertilizer: 15 A ÷ 10 A/hr = 1.5 hrs (x 1.2 = 1.8 hrs)
Field cultivation: 15 A ÷ 13.6 A/hr = 1.1 hrs (x 1.2 = 1.3 hrs)
Plant alfalfa: 15 A ÷ 3.9 A/hr = 3.9 hrs (x 1.2 = 4.7 hrs)
Apply herbicide: 15 A ÷ 10.2 A/hr = 1.5 hrs (x 1.2 = 1.8 hrs)

Total labor = 11.9 hrs

120 hp tractor: 5 hrs x \$7.56/hr = \$38
100 hp tractor: 5 hrs x \$6.98/hr = \$35
disk: 15 A x \$.42/A = \$6
field cultivator: 15 A x \$.17/A = \$3
spreader rental: 15 A x \$1.50/A = \$23
P_2O_5: 15 A x 60 lb P_2O_5/A x \$.26/lb = \$234
sprayer: 15 A x \$.09/A = \$1
seeder/packer rental: 15 A x \$3.75/A = \$56
alfalfa seed: 15 A x 12 lbs/A x \$3.18/lb = \$572
herbicide: 15 A x \$10.26/A = \$154

Week 16:

Spread fertilizer: 151.25 A ÷ 10 A/hr = 15.1 hrs (x 1.2 = 18.1 hrs)
Disk: 151.25 A ÷ 7.8 A/hr = 19.4 hrs (x 1.2 = 23.3 hrs)

Total labor = 41.4 hrs

120 hp tractor: 17.3 hrs x $7.56/hr = $131
100 hp tractor: 17.3 hrs x $6.98/hr = $121
disk: 151.25 A x $.42/A = $64
spreader rental: 151.25 A x $1.50/A = $227
P_2O_5: 151.25 A x 25 lb P_2O_5/A x $.26/lb = $983
custom plowing: 15 A x $8.88/A = $133

Week 17:

Apply anhydrous: 136.25 A ÷ 9.7 A/hr = 14.1 hrs (x 1.2 = 16.9 hrs)
Field cultivate: 151.25 A ÷ 13.6 A/hr = 11.1 hrs (x 1.2 = 13.3 hrs)

Total labor = 30.2 hrs

120 hp tractor: 13.4 hrs x $7.56/hr = $101
100 hp tractor: 13.4 hrs x $6.98/hr = $94
anhydrous applicator rental: 151.25 A x $2.50/A = $378
anhydrous: [(136.25 A x 55 lbs N/A) + (15 A x 0 lbs N/A)] x $.15/lb N = $1124
field cultivator: 151.25 A x $.17/A = $26

Week 18:

Plant corn: 151.25 A ÷ 6.5 A/hr = 23.3 hrs (x 1.2 = 28 hrs)
Apply herbicide: 151.25 A ÷ 10.2 A/hr = 14.8 hrs (x 1.2 = 17.8 hrs)
Disk: 151.25 A ÷ 7.8 A/hr = 19.4 hrs (x 1.2 = 23.3 hrs)

Total labor = 69.1 hrs

120 hp tractor: 28.8 hrs x $7.56/hr = $218
100 hp tractor: 28.8 hrs x $6.98/hr = $201
planter: 151.25 A x $1.53/A = $231
sprayer: 151.25 A x $.09/A = $14
disk: 151.25 A x $.42/A = $64
corn herbicide: 151.25 A x $20.38/A = $3082
corn seed: 151.25 A x .25 bag/A x $87.70/bag = $3316

Week 19:

Spread fertilizer: 287.5 A ÷ 10 A/hr = 28.8 hrs (x 1.2 = 34.6 hrs)
Disk: 287.5 A ÷ 7.8 A/hr = 36.9 hrs (x 1.2 = 44.3 hrs)

Total labor = 78.9 hrs

120 hp tractor: 32.9 hrs x $7.56/hr = $249
100 hp tractor: 32.9 hrs x $6.98/hr = $230
disk: 287.5 A x $.42/A = $121
spreader rental: 287.5 A x $1.50/A = $431
P_2O_5: 287.5 A x 25 lb P_2O_5/A x $.26/lb = $1869

Week 20:

Field cultivate: 287.5 A ÷ 13.6 A/hr = 21.1 hrs (x 1.2 = 25.3 hrs)
Plant soybeans: 287.5 A ÷ 6.5 A/hr = 44.2 hrs (x 1.2 = 53 hrs)

Total labor = 78.3 hrs

120 hp tractor: 32.7 hrs x $7.56/hr = $247
100 hp tractor: 32.7 hrs x $6.98/hr = $228
planter: 287.5 A x $1.53/A = $440
field cultivator: 287.5 A x $.17/A = $49
bean seed: 287.5 A x 1 bag seed/A x $15.47/bag = $4448

Week 21:

Spray herbicide: 287.5 A ÷ 10.2 A/hr = 28.2 hrs (x 1.2 = 33.8 hrs)
Apply anhydrous: 151.25 A ÷ 9.7 A/hr = 15.6 hrs (x 1.2 = 18.7 hrs)
Field cultivate: 151.25 A ÷ 13.6 A/hr = 11.1 hrs (x 1.2 = 13.3 hrs)
Plant sorghum: 151.25 A ÷ 6.5A/hr = 23.3 hrs (x 1.2 = 28 hrs)

Total labor = 93.8 hrs

120 hp tractor: 39.1 hrs x $7.56/hr = $296
100 hp tractor: 39.1 hrs x $6.98/hr = $273
planter: 151.25 A x $1.53/A = $231
sprayer: 287.5 A x $.09/A = $26
field cultivator: 151.25 A x $.17/A = $26
anhydrous applicator rental: 151.25 A x $2.50/A = $378
anhydrous: 151.25 A x 25 lbs N/A x $.15/lb N = $567
sorghum seed: 151.25 A x 5 lbs seed/A x $.94/lb = $711
soybean herbicide: 287.5 A x $24.35/A = $7001

Week 22:

Apply sorghum herbicide: 151.25 A ÷ 10.2 A/hr = 14.8 hrs (x 1.2 = 17.8 hrs)
Cultivate corn: 151.25 A ÷ 6.8 A/hr = 22.2 hrs (x 1.2 = 26.6 hrs)
Move bales: 45 A ÷ 10 A/hr = 4.5 hrs (x 1.2 = 5.4 hrs)

Total labor = 49.8 hrs

120 hp tractor: 20.8 hrs x $7.56/hr = $157
100 hp tractor: 20.8 hrs x $6.98/hr = $145
rowcrop cultivator: 151.25 A x $.30/A = $45
sprayer: 151.25 A x $.09/A = $14
sorghum herbicide: 151.25 A x $16.41/A = $2482
custom swathing: 45 A x $7.76/A = $349
custom baling: 80.8 bales x $6.57/bale = $531
income: 52.5 tons x $63.68/ton = $3343

Week 25:

Cultivate beans: 287.5 A ÷ 6.8 A/hr = 42.3 hrs (x 1.2 = 50.8 hrs)

120 hp tractor: 21.2 hrs x $7.56/hr = $160
100 hp tractor: 21.2 hrs x $6.98/hr = $148
rowcrop cultivator: 287.5 A x $.30/A = $86

Week 26:

Cultivate sorghum: 151.25 A ÷ 6.8 A/hr = 22.2 hrs (x 1.2 = 26.6 hrs)

Total labor = 26.6 hrs

120 hp tractor: 11.1 hrs x $7.56/hr = $84
100 hp tractor: 11.1 hrs x $6.98/hr = $77
rowcrop cultivator: 151.25 A x $.30/A = $45

Week 28:

Rogue beans: 287.5 A x $5.00/A = $1438

Week 29:

Rogue sorghum: 151.25 A x \$5.00/A = \$756

Week 30:

Move bales: 60 A ÷ 10 A/hr = 6 hrs (x 1.2 = 7.2 hrs)

Total labor = 7.2 hrs

120 hp tractor: 3 hrs x \$7.56/hr = \$23
100 hp tractor: 3 hrs x \$6.98/hr = \$21
custom swathing: 60 A x \$7.76/A = \$466
custom baling: 106.8 bales x \$6.57/bale = \$702
income: 69.4 tons x \$63.68/ton = \$4419

yield: (2.25 tons/A/2 x 15 A) + (3.5 tons/A/3 x 45 A) = 69.4 tons

Week 37:

Move bales: 60 A ÷ 10 A/hr = 6 hrs (x 1.2 = 7.2 hrs)

Total labor = 7.2 hrs

120 hp tractor: 3 hrs x \$7.56/hr = \$23
100 hp tractor: 3 hrs x \$6.98/hr = \$21
custom swathing: 60 A x \$7.76/A = \$466
custom baling: 106.8 bales x \$6.57/bale = \$702
income: 69.4 tons x \$63.68/ton = \$4419

yield: (2.25 tons/A/2 x 15 A) + (3.5 tons/A/3 x 45 A) = 69.4 tons

Week 40:

Combine beans: 287.5 A ÷ 8.7 A/hr = 33.1 hrs (x 1.2 = 39.7 hrs)

combine: 33.1 hrs x \$19.06/hr = \$631
grain head: 287.5 A x \$.06/A = \$17
yield: 287.5 A x 35 bu/A = 10,063 bu
truck beans to elevator: \$.12/bu x 10,063 bu = \$1208
income: 10,063 bu x \$6.79/bu = \$68,328

Week 41:

Combine corn: 151.25 A ÷ 5.1 A/hr = 29.7 hrs (x 1.2 = 35.6 hrs)

combine: 29.7 hrs x $19.06/hr = $566
corn head: 151.25 A x $.19/A = $29
yield: 151.25 A x 105 bu/A = 15,881 bu
truck corn to elevator: $.12/bu x 15,881 bu = $1906
dry corn: 15,881 bu x $.10/bu = $1588
income: 15,881 bu x $2.65/bu = $42,085

Week 42 (Oct 15-21):

Combine sorghum: 151.25 A ÷ 8.7 A/hr = 17.4 hrs (x 1.2 = 20.9 hrs)

combine: 17.4 hrs x $19.06/hr = $332
grain head: 151.25 A x $.06/A = $9
yield: 151.25 A x 90 bu/A = 13,613 bu
truck sorghum to elevator: $.12/bu x 13,613 bu = $1634
income: 13,613 bu x $2.35/bu = $31,991

B. Modified conventional summary budget table

LAND

	Acres	Cost/A	Total
Owned	292.5	35.89/A	10,498
Rented	357.5	79.00/A	28,243

EQUIPMENT

Item	Annual ownership cost	Annual cost of operation (excl. labor)
Power units		
120 hp tractor	6,241	1,724
100 hp tractor	4,815	1,591
185 hp combine	11,714	1,524
½ ton pickup	983	1,431
Implements		
disk	1,794	254
rowcrop cultivator	744	177
field cultivator	1,428	103
sprayer	252	54
8 row corn head	3,093	29
20' grain head	1,034	26
8 row planter	2,808	903
Total	34,906	7,816

EQUIPMENT RENTAL

spreader	681
anhydrous applicator	756
seeder-packer	56
Total	1,493

SEED AND CHEMICALS

seed	9,047
fertilizer	4,777
pesticides	12,719
Total seed/chemicals	26,543

CUSTOM OPERATIONS

rogue beans/milo	2,194
haul grain	4,748
dry corn	1,588
plowing	133
swathing	1,281
baling	1,935
Total custom	11,879
Hired labor	0
Total operations costs	47,731

OVERHEAD AND INTEREST

Interest on operating capital	3,198
Overhead	2,546
Total overhead and interest	5,744
TOTAL EXPENSES	127,122
TOTAL SALES	154,585
NET INCOME	27,463

C. Equipment use per crop.

Modified conventional farm: Summary of equipment use for each crop.

Equipment	corn	soybeans	sorghum	alfalfa	total
120 hp tractor (hrs)	60.9	100.8	53.1	13.2	228
100 hp tractor (hrs)	60.9	100.8	53.1	13.2	228
combine (hrs)	29.7	33.1	17.4	0	80.2
pickup (hrs)	65	124	65	26	280
disk (A)	151.25	287.5	151.25	15	605
rowcrop cultivator (A)	151.25	287.5	151.25	0	590
field cultivator (A)	151.25	287.5	151.25	15	605
sprayer (A)	151.25	287.5	151.25	15	605
corn head (A)	151.25	0	0	0	151.25
grain head (A)	0	287.5	151.25	0	438.75
planter (A)	151.25	287.5	151.25	0	590

D. Per acre costs and returns, by crop.

Modified conventional farm: Cost of production and returns ($/A) for each crop.

Input	corn	soybeans	sorghum	alfalfa
Ownership costs				
120 hp tractor	11.02	9.60	9.61	6.02
100 hp tractor	8.50	7.40	7.41	4.65
combine	28.68	16.82	16.80	0
pickup	1.51	1.51	1.51	1.51
disk	2.97	2.97	2.97	.74
rowcrop cultivator	1.26	1.26	1.26	0

Input	corn	soybeans	sorghum	alfalfa
field cultivator	2.36	2.36	2.36	.59
sprayer	.42	.42	.42	.11
corn head	20.45	0	0	0
grain head	0	2.36	2.36	0
planter	4.76	4.76	4.76	0
Total equip. ownership	81.93	49.46	49.46	13.62
Land ownership	16.15	16.15	16.15	16.15
Land rental	43.45	43.45	43.45	43.45
Total land costs	59.60	59.60	59.60	59.60
Equipment operation				
120 hp tractor	3.04	2.65	2.65	1.66
100 hp tractor	2.81	2.45	2.45	1.54
combine	3.74	2.19	2.19	0
pickup	2.20	2.20	2.20	2.20
disk	.42	.42	.42	.11
rowcrop cultivator	.30	.30	.30	0
field cultivator	.17	.17	.17	.04
sprayer	.09	.09	.09	.02
corn head	.19	0	0	0
grain head	0	.06	.06	0
planter	1.53	1.53	1.53	0
Total equipment operation	14.49	12.06	12.06	5.57

Input	corn	soybeans	sorghum	alfalfa
Equipment rental				
spreader	1.50	1.50	0	.38
anhydrous applicator	2.50	0	2.50	0
seeder-packer	0	0	0	.94
Total rental	4.00	1.50	2.50	1.32
Seed and chemicals				
seed	21.93	15.47	4.70	9.53
anhydrous	7.43	0	3.75	0
P_2O_5	6.50	6.50	0	3.90
herbicide	20.38	24.35	16.41	2.57
Total seed/chemicals	56.24	46.32	24.86	16
Custom and labor				
roguing	0	5.00	5.00	0
trucking	12.60	4.20	10.80	0
drying	10.50	0	0	0
plowing	.88	0	0	0
hired labor	0	0	0	0
swathing	0	0	0	21.35
baling	0	0	0	32.25
Total custom and labor	23.98	9.20	15.80	53.60
Total operations	98.71	69.08	55.22	76.49
Interest	6.61	4.63	3.70	5.13

Input	corn	soybeans	sorghum	alfalfa
Overhead	5.27	3.69	2.95	4.08
Total expenses	252.12	186.49	170.93	158.92
Crop value	278.25	237.66	211.51	203.02
Net income	26.13	51.18	40.58	44.10

Appendix 4C.

Agroforestry Farm

Baseline economic analysis

I. Characteristics of the agroforestry farm

A. Size

farm size (acres)	425
% land owned	60 (255 acres)
% cropland	89
% tree crops	6
% shelterbelts	5

B. Standardized equipment list:

Item	Age at trade	Annual use	Description
Tractor #1	15	211 hrs	120 hp diesel cab
Tractor #2	20	211 hrs	100 hp diesel cab
combine*	10	144 hrs	185 hp
pickup truck	7	280 hrs	½ ton
disk	20	334 A	tandem disc harrow 20'
row cultivator	15	317 A	6 row x 30"
field cultivator	10	332 A	18'
sprayer	10	333 A	300 gal 15' pull-type
corn head*	15	133 A	6 row
grain head*	10	414 A	15'
planter	10	317 A	6 row x 30"
swather/conditioner*	15	549 A	14' pull-type
baler*	10	705 tons	large round
mower	10	144 A	flail 8'
seed cleaner	20	4416 lbs	100 lb capacity

*Ownership shared with organic farm; annual use is total for both farms.

Swather/conditioner, baler, pickup, and mower added to baseline equipment list: moldboard plow and rotary hoe removed.

C. Operations summary

Acres devoted to each crop: corn - 83A; soybeans - 151A; sorghum - 83A; alfalfa - 60A; Christmas trees - 9A; American hazel - 16A; windbreaks - 23A; Total - 425A.

week no.	corn	soybeans	sorghum	alfalfa	Xmas trees	hazel	windbreak
14 (Apr 2-8)					disk strips 2x plant spray	fertilize (1.6 A)	disk (.14 A) plant (.46A) spray
15				(For 15 acres) spread $P_2 0_5$ spray herbicide disk field cultivate seeder/packer		disk (.32A) plant spray	
16	plow 4 yr alfalfa (15 acres) apply P_2O_5 disk						
17	apply anhydrous field cultivate						
18	plant apply herbicide		disk		mow	mow	mow
19		apply P_2O_5 disk					
20		field cultivate plant			spray for pine tip moths		

week no.	corn	soybeans	sorghum	alfalfa	Xmas trees	hazel	windbreak
21		apply herbicide	apply anhydrous field cultivate plant				
22	cultivate		apply herbicide	(45 acres) windrow bale move bales	mow	mow	mow
24					shear yrs 7-8		
25		cultivate			shear yrs 5-6		
26			cultivate		shear yrs 3-4		
27					spray for pine tip moth		
28		rogue			mow spot spray	mow spot spray	mow spot spray
29			rogue			harvest nuts clean/dry	
30				(60 acres) windrow bale move bales		harvest nuts clean/dry	
31					mow	harvest nuts clean/dry mow	mow

week no.	corn	soybeans	sorghum	alfalfa	Xmas trees	hazel	windbreak
32					spray roundup	harvest nuts clean/dry	
33						harvest nuts clean/dry	
34						spot spray clear yr 50	spot spray
36					mow	mow	mow
37				(60 acres) windrow bale move bales			
38						rip stumps	
40		combine truck					
41	combine truck, dry						
42			combine truck				
43							clear year 50
44						prune	
45						prune	
48					U-cut sales		
49					U-cut sales		
50					U-cut sales		

week no.	corn	soybeans	sorghum	alfalfa	Xmas trees	hazel	windbreak
51					clear unsold year 9 trees		

D. Summary of inputs (per acre) by crop for agroforestry farm

Input	corn after soybeans	corn after alfalfa	soybeans	sorghum	alfalfa (establis hment)	Scotch pine Xmas trees	hazelnut	windbreak
Yield goal	113 bu	113 bu	38 bu	93 bu	2.54 ton year 1 3.9 ton years 2+	551 trees each year from 9 acres	276 lb clean and dry seed; avg 16 A	
P_2O_5	25 lb	25 lb	25 lb	0	60 lb	0	0	0
N fertilizer recommen dation	115 lb	115 lb	0	70 lb	0	0	2.5 lb*	0
N credit from previous crop	45 lb	150 lb	0	45	0	0	0	0
N applied	70lb	0	0	25 lb	0	0	2.5 lb	0
seed	.25 bag		1 bag	5 lb	12 lb	689 seedlings	230 seedlings	183 seedlings
preemerge herbicide	$20.38	$20.38	$24.35	$16.41	$10.26	$48.79	$46.95	$48.79
post-emerge herbicide						$26.50	$19.47	$26.50

Input	corn after soybeans	corn after alfalfa	soybeans	sorghum	alfalfa (establis hment)	Scotch pine Xmas trees	hazelnut	windbreak
insecticide						Cygon 2-E (Dimethoate);1 pint/100 gal. water		

*10% of shrubs (1.6 A) fertilized each year at 25 lb N/A.

Fertilizer rates from Selley (1996) except P_2O_5 rates for corn and soybeans from Helmers et al. (1986), and nitrogen fertilizer rate for hazel from Gustafson (pers. comm.). Legume nitrogen credits from Ferguson et al. (1994) and Hergert et al. (1995). Planting rates from Selley (1996). Christmas tree insecticide formula from Janssen and Jennings (1976). For derivation of rowcrop herbicide costs, see Table A4-2. Herbicide costs for tree crops are the average of all appropriate treatments in Nebraska Cooperative Extension (1996). Alfalfa herbicide cost from Selley (1996).

Average agroforestry yields increased for shelterbelt effects: corn (7.6%), soybeans (9.1%), sorghum (3.8%), and alfalfa (11.4%). These increases are 76% of expected increase in shelter (Table A3-3) because only 76% of farm is protected at any time (see Table A4-3 for explanation of windbreak establishment and growth).

E. Equipment ownership and use.

Costs interpolated from tables in Powell et al. (1992) with values increased 10% to account for inflation from 1992 to mid-1996. Pickup truck and mower costs from Klonsky et al. (1994). Annual use derived from baseline operations scenario for the analog farm.

Equipment	Annual use (hrs)	Annual cost of ownership	Ownership cost per hour use	Operating cost per hour use
120 hp tractor	211	$6241	$29.55	$7.41
100 hp tractor	211	$4815	$22.80	$6.81
combine*	83	$8357	$100.32	$21.39
pickup truck	280	$983	$3.51	$5.11

Implement	Annual use (acres)	Annual cost of owning	Ownership cost per acre use	Operation cost per acre use
disk	334	$1553	$4.65	$0.34
field cultivator	332	$862	$2.60	$0.13
planter	317	$2380	$7.51	$0.80
sprayer	333	$462	$1.39	$0.13
row crop cultivator	317	$515	$1.62	$0.21
corn head*	83	$1428	$17.20	$0.22
grain head*	234	$628	$2.68	$0.20
swather/conditioner*	165	$695	$4.21	$1.19
baler*	215 tons	$803	$3.73/ton	$0.78/ton
mower	144	$677	$4.70	$0.21
seed cleaner	4416 lbs	$102	$2.31/cwt	$1.36/cwt

*Ownership costs shared with organic farm; operations costs based on total use by both farms.

II. Budget calculations

Land

Owned: 255 A x $35.89/A = $9,152

From Johnson (pers. comm.); average debt on owned farmland is 20% of value. For eastern Nebraska, $1345/A x .2 = $269/A. Amortized over 30 years at 8%: $269/A x .088827 (from amortization table) = $23.89/A interest and principle payments per year. Plus real estate taxes of $12.00/A = $35.89/A.

Rented: 170 A x $79.00/A = $13,430

A. Weekly calculations of inputs

( ) = labor hours (field hours x 1.2)

Week 14 (April 2-8):

Disk: 2.14 A ÷ 7.8 A/hr = .3 hrs (.4 hrs)
Hand plant: 993 seedlings ÷ 400 seedlings/10 hrs = 24.8 hrs
Spray: .78 A ÷ 2.6 A/hr = .3 hrs (.4 hrs)
Fertilize shrubs: 1.6 A x 230 shrubs/A ÷ 1000 shrubs/8 hrs = 2.9 hrs (3.5 hrs)

Total labor = 29.1 hrs

tractors: .6 hrs
seedlings: 993 seedlings
preemergent herbicide for conifers: .78 A
ammonium nitrate: 1.6 A x 25 lbs N/A x 3 lbs ammon. nitrate/ 1 lb N = 120 lbs

Seedlings include 97 eastern redcedars for shelterbelt. Spray rate (A/hr) is 1/3 of normal because only a 5' strip is being covered; area sprayed includes shelterbelt and Christmas trees years 1 and 2. Approximately 1200' of shelterbelt planted each year; 1200' x 2 years x 5' strip sprayed = .28 A.

Week 15:

Disk: 15.32 A ÷ 7.8 A/hr = 2 hrs (2.4 hrs)
Spread fertilizer: 15 A ÷ 10 A/hr = 1.5 hrs (1.8 hrs)
Field cultivation: 15 A ÷ 10.2 A/hr = 5 hrs (6 hrs)

Plant alfalfa: 15 A ÷ 3.9 A/hr = 3.9 hrs (4.7 hrs)
Apply alfalfa herbicide: 15 A ÷ 7.7 A/hr = 2 hrs (2.4 hrs)
Hand plant hazel seedlings: 85 seedlings ÷ 50 seedlings/hr = 1.7 hrs
Apply hazel preemergent herbicide: .1 A ÷ 2.6 A/hr = .04 hr (1 hr)

Total labor = 20 hrs

tractors: 14.4 hrs
spreader rental: 15 A
P_2O_5: 15 A x 60 lb P_2O_5/A = 900 lb
seeder/packer rental: 15 A
alfalfa seed: 15 A x 12 lbs/A = 180 lbs
alfalfa preemergent herbicide: 15 A
hazel preemergent herbicide: .1 A

Week 16:

Spread fertilizer: 83 A ÷ 10 A/hr = 8.3 hrs (10 hrs)
Disk: 83 A ÷ 7.8 A/hr = 10.6 hrs (12.8 hrs)

Total labor = 22.8 hrs

tractors: 18.9 hrs
spreader rental: 83 A
P_2O_5: 83 A x 25 lb P_2O_5/A = 2075 lb
custom plowing: 15 A

Week 17:

Apply anhydrous: 68 A ÷ 9.7 A/hr = 7.0 hrs (8.4 hrs)
Field cultivate: 83 A ÷ 10.2 A/hr = 8.1 hrs (9.8 hrs)

Total labor = 18.2 hrs

tractors: 15.1 hrs
anhydrous applicator rental: 68 A
anhydrous: 68 A x 70 lbs N/A = 4760 lbs

Week 18:

Plant corn: 83 A ÷ 4.9 A/hr = 16.9 hrs (20.3 hrs)
Apply herbicide: 83 A ÷ 7.7 A/hr = 10.8 hrs (12.9 hrs)
Disk: 83 A ÷ 7.8 A/hr = 10.6 hrs (12.8 hrs)
Mow: 28.7 A ÷ 3 A/hr = 9.6 hrs (11.5 hrs)

Total labor = 57.5 hrs

tractors: 47.9 hrs
corn herbicide: 83 A
corn seed: 83 A x .25 bag/A = 20.75 bags

*Shelterbelt is mowed during years 1-8; 8 x .46 A = 3.7 A

Week 19:

Spread fertilizer: 151 A ÷ 10 A/hr = 15.1 hrs (18.1 hrs)
Disk: 151 A ÷ 7.8 A/hr = 19.4 hrs (23.2 hrs)

Total labor = 41.3 hrs

tractors: 34.5 hrs
spreader rental: 151 A
P_2O_5: 151 A x 25 lb P_2O_5/A = 3775 lbs

Week 20:

Field cultivate: 151 A ÷ 10.2 A/hr = 14.8 hrs (17.8 hrs)
Plant soybeans: 151 A ÷ 4.9 A/hr = 30.8 hrs (37 hrs)
Hand spray for pine tip moths: 5746 trees ÷ 1000 trees/8 hrs = 46 hrs (55.2 hrs)

Total labor = 110 hrs

tractors: 45.6 hrs
bean seed: 151 A x 1 bag seed/A = 151 bags
Cygon 2-E: 1 pt Cygon/100 gallons water x 1.5 pt water/tree x 5746 trees = 10.77 pts
hired labor: 10 hrs

Week 21:

Spray herbicide: 151 A ÷ 7.7 A/hr = 19.6 hrs (23.5 hrs)
Apply anhydrous: 83 A ÷ 9.7 A/hr = 8.6 hrs (10.3 hrs)
Field cultivate: 83 A ÷ 10.2 A/hr = 8.1 hrs (9.8 hrs)
Plant sorghum: 83 A ÷ 4.9 A/hr = 16.9 hrs (20.3 hrs)

Total labor = 63.9 hrs

tractors: 53.2 hrs

anhydrous applicator rental: 83 A
anhydrous: 83 A x 25 lbs N/A = 2075 lbs
sorghum seed: 83 A x 5 lbs seed/A = 415 lbs
soybean herbicide: 151 A

Week 22:

Apply sorghum herbicide: 83 A ÷ 7.7 A/hr = 10.8 hrs (12.9 hrs)
Cultivate corn: 83 A ÷ 5.1 A/hr = 16.3 hrs (19.5 hrs)
Swather: 45 A ÷ 5.7 A/hr = 7.9 hrs (9.5 hrs)
Bale: 59 tons ÷ 6.3 tons/hr = 9.4 hrs (11.2 hrs)
Move bales: 45 A ÷ 10 A/hr = 4.5 hrs (5.4 hrs)
Mow: 28.7 A ÷ 3 A/hr = 9.6 hrs (11.5 hrs)

Total labor = 70 hrs

tractors: 58.5 hrs
sorghum herbicide: 83 A
baling twine: 91 bales

Week 24:

Shear pines: 1282 trees ÷ 30 trees/hr = 42.7 hrs

Week 25:

Cultivate beans: 151 A ÷ 5.1 A/hr = 29.6 hrs (35.5 hrs)
Shear pines: (689 trees ÷ 30 trees/hr) + (689 trees ÷ 40 trees/hr) = 40.2 hrs

Total labor = 75.7 hrs

tractors: 29.6 hrs

Week 26:

Cultivate sorghum: 83 A ÷ 5.1 A/hr = 16.3 hrs (19.5 hrs)
Shear pines: (689 trees ÷ 120 trees/hr) + (689 trees ÷ 60 trees/hr) = 17.2 hrs

Total labor = 36.7 hrs

tractors: 16.3 hrs

Week 27:

Hand spray for pine tip moths: 5746 trees ÷ 1000 trees/8 hrs = 46 hrs (55.2 hrs)

Cygon 2-E: 1 pt Cygon/100 gallons water x 1.5 pt water/tree x 5746 trees = 10.77 pts

Week 28:

Mow: 28.7 A ÷ 3 A/hr = 9.6 hrs (11.5 hrs)
Directed postemergent spray around seedlings:

776 e. redcedar ÷ 1000 trees/8 hrs = 6.2 hrs (7.4 hrs)
4368 pines ÷ 1000 trees/8 hrs = 34.9 hrs (41.9 hrs)
3532 hazel ÷ 1000 trees/8 hrs = 28.3 hrs (33.9 hrs)

*Year 1 and 2 pines and hazel not included because receiving Princep. Spot spraying in shelterbelts stops after year 8.

Total labor = 95 hrs

tractors: 9.6 hrs
conifer postemergent herbicide: 3.54 A
hazel postemergent herbicide: 2.43 A
rogue beans: 151 A

Hazels: assume 30 ft^2 area sprayed for each shrub
Conifers: assume 30 ft^2 area sprayed for each tree

redcedar: 776 trees x 30 ft^2/tree = .53 A
pines: 4368 trees x 30 ft^2/tree = 3.01 A
hazel: 3532 shrubs x 30 ft^2/shrub = 2.43 A

Week 29:

Harvest, clean, and dry nuts (20%): .2 x 16 A x 66 hr/A = 211 hrs*

rogue sorghum: 83 A
hired labor: 111 hrs
seed cleaner: 883 lbs

*See description of hazel system (Table A4-6) for derivation of labor requirements.

Week 30:

Swather: 60 A ÷ 5.7 A/hr = 10.5 hrs (12.6 hrs)
Bale: 78 tons ÷ 6.3 tons/hr = 12.4 hrs (14.9 hrs)
Move bales: 60 A ÷ 10 A/hr = 6 hrs (7.2 hrs)
Harvest, clean, and dry nuts (20%): .2 x 16 A x 66 hrs/A = 211 hrs

Total labor = 245 hrs

tractors: 28.9 hrs
hired labor: 145 hrs
baling twine: 120 bales
seed cleaner: 883 lbs

Week 31:

Harvest, clean, and dry nuts (20%): .2 x 16 A x 66 hrs/A = 211 hrs
Mow: 28.7 A ÷ 3 A/hr = 9.6 hrs (11.5 hrs)

Total labor = 222.5 hrs

tractors: 9.6 hrs
hired labor: 122.5 hrs
seed cleaner: 883 lbs

Week 32:

Harvest, clean, and dry nuts (20%): .2 x 16 A x 66 hrs/A = 211 hrs

Directed spray around seedlings:
4368 pines ÷ 1000 trees/8 hrs = 34.9 hrs (41.9 hrs)

Total labor = 252.9 hrs

conifer postemergent herbicide: 3.01 A
hired labor: 152.9 hrs
seed cleaner: 883 lbs

Week 33:

Harvest, clean, and dry nuts (20%): .2 x 16 A x 66 hrs/A = 211 hrs

Total labor = 211 hrs

hired labor: 111 hrs
seed cleaner: 883 lbs

Week 34:

Cut and burn year 50 shrubs: 74 shrubs ÷ 100 shrubs/8 hrs = 5.9 hrs
Directed spray around seedlings:
776 e. redcedar ÷ 1000 trees/8 hrs = 6.2 hrs (7.4 hrs)
3532 hazel ÷ 1000 trees/8 hrs = 28.3 hrs (33.9 hrs)

Total labor = 47.2 hrs

conifer postemergent herbicide: .53 A
hazel postemergent herbicide: 2.43 A

Week 36:

Mow: 28.7 A ÷ 3 A/hr = 9.6 hrs (11.5 hrs)

Total labor = 11.5 hrs

tractors: 9.6 hrs

Week 37:

Swather: 60 A ÷ 5.7 A/hr = 10.5 hrs (x 1.2 = 12.6 hrs)
Bale: 78 tons ÷ 6.3 tons/hr =12.4 hrs (14.9 hrs)
Move bales: 60 A ÷ 10 A/hr = 6 hrs (x 1.2 = 7.2 hrs)

Total labor = 34.7 hrs

tractors: 28.9 hrs
baling twine: 120 bales

Week 38:

move and burn hazel stumps: 74 stumps ÷ 100 stumps/4 hrs = 3 hrs

custom ripping: .32 A x $9.77/A = $3
ship hazelnuts: 4416 lbs

Week 40:

Combine beans: 151 A ÷ 3.8 A/hr = 39.7 hrs (47.7 hrs)

grain head: 151 A
yield: 151 A x 38 bu/A = 5738 bu
truck beans: 5738 bu

Week 41:

Combine corn: 83 A ÷ 3.8 A/hr = 21.8 hrs (26.2 hrs)

corn head: 83 A
yield: 83 A x 113 bu/A = 9379 bu
truck corn: 9379 bu
dry corn: 9379 bu

Week 42:

Combine sorghum: 83 A ÷ 3.8 A/hr = 21.8 hrs (26.2 hrs)

grain head: 83 A
yield: 83 A x 93 bu/A = 7719 bu
truck sorghum: 7719 bu

Week 43:

Clear year 50 cedars: 84 trees ÷ 100 trees/8 hrs = 6.7 hrs

Week 44:

Prune hazel shrubs: 1766 shrubs ÷ 40 shrubs/hr = 44.2 hrs

Week 51 (Dec 17-23):

Cut and burn unsold year 9 Christmas trees: 150 trees ÷ 100 trees/8 hrs = 12 hrs
Move and burn stumps: 1 A ÷ 4 hrs/A = 4 hrs

Custom rip stumps: 1 A x $9.77/A = $10

B. Summary of inputs (total for crop; not per acre).

Input	corn	soybeans	sorghum	alfalfa	Christmas trees	hazel	wind-breaks
Land (A)	83	151	83	60	9	16	23
Power units (hrs)							
tractors	78.5	129.3	71.3	93.9	15.0	27.0	6.2
combine	21.8	39.7	21.8				
pickup	55	99	55	40	6	11	14
Implement (A)							
disk	83	151	83	15	2	.3	.14
field cultivator	83	151	83	15			
planter	83	151	83				
sprayer	83	151	83	15	.5	.32	.28
row crop cultivator	83	151	83				
corn head	83						
grain head		151	83				
swather				165			
baler (tons)				215			
mower					45	80	19
seed cleaner (lbs)						4416	
Equipment rental (A)							
spreader	83	151		15			
seeder/ packer				15			
anhydrous applicator	68		83				
Inputs							
seed (lb)	20.75 bags	151 bags	415	180			

Input	corn	soybeans	sorghum	alfalfa	Christmas trees	hazel	wind-breaks
seedlings					896	85	97
anhydrous (lbs N)	4760		2075				
ammon. nitrate (lbs)						120	
P2O5 (lbs)	2075	3775		900			
preemerge herbicide (A)	83	151	83	15	.5	.1	.28
post-emerge herbicide (A)					6.02	4.86	1.06
insecticide					21.5 pts		
baling twine (bales)				331			
Custom work							
plowing (A)	15						
roguing (hrs)		133	73				
hired labor (hrs)		5			5	642.4	
owner labor (hrs)	120	203	112	113	425	527	25
ripping (A)					1	.32	
shipping nuts (lbs)						4416	
truck grain (bu)	9379	5738	7719				
dry corn (bu)	9379						

*labor associated with custom work is not shown

C. Costs and returns on production ($/A).

Input	corn	soybeans	sorghum	alfalfa	Christmas trees	hazel	wind-breaks
Land	53.13	53.13	53.13	53.13	53.13	53.13	53.13
Equipment ownership							
tractors	24.76	22.42	22.49	40.97	43.63	44.18	7.06
combine	26.35	26.38	26.35				
pickup	2.33	2.30	2.33	2.34	2.34	2.41	2.14
disk	4.65	4.65	4.65	1.16	1.03	.09	.03
field cultivator	2.60	2.60	2.60	.65			
planter	7.51	7.51	7.51				
sprayer	1.39	1.39	1.39	.35	.08	.03	.02
row crop cultivator	1.62	1.62	1.62				
corn head	17.20						
grain head		2.68	2.68				
swather				11.58			
baler				13.37			
mower					23.50	23.50	3.88
nut cleaner						6.38	
shelterbelt fixed costs	3.79	3.79	3.79	3.79	3.79	3.79	-------*
Total fixed costs	145.33	128.47	128.54	127.34	127.50	133.51	-------*
Equipment operation							
tractors	6.72	6.09	6.11	11.13	11.85	12.00	1.92
combine	5.62	5.62	5.62				
pickup	3.39	3.35	3.39	3.41	3.41	3.51	3.11
disk	.34	.34	.34	.09	.08	.01	.01

Input	corn	soybeans	sorghum	alfalfa	Christmas trees	hazel	wind-breaks
field cultivator	.13	.13	.13	.03			
planter	.80	.80	.80				
sprayer	.13	.13	.13	.03	.01	.01	.01
row crop cultivator	.21	.21	.21				
corn head	.22						
grain head		.20	.20				
swather				1.19			
baler (tons)				2.80			
mower					1.05	1.05	.17
nut cleaner						3.75	
Equipment rental							
spreader	1.50	1.50		.38			
seeder/ packer				.94			
anhydrous applicator	2.05		2.50				
Inputs							
seed	21.93	15.47	4.71	9.54			
seedlings					19.91	2.39	.84
anhydrous	8.60		3.75				
ammonium nitrate						1.88	
P_2O_5	6.50	6.50		3.90			
preemerge herbicide	20.38	24.35	16.41	2.57	2.71	.29	.59
post-emerge herbicide					17.73	5.91	1.22
insecticide					11.42		

Input	corn	soybeans	sorghum	alfalfa	Christmas trees	hazel	wind-breaks
baling twine				2.43			
Custom work							
plowing	1.60						
roguing		5.00	5.00				
hired labor		.20			3.33	240.90	
ripping					1.09	.20	
shipping nuts (1)						5.52	
marketing (2)					244.89	69.00	
truck grain	13.56	4.56	11.16				
dry corn	11.30						
shelterbelt variable costs	.45	.45	.45	.45	.45	.45	-----*
Total variable costs	105.43	74.90	60.91	38.89	317.93	346.87	-----*
interest on operating capital	7.06	5.02	4.08	2.61	21.30	23.24	
overhead	5.62	4.00	3.25	2.07	16.96	18.51	
Total expenses	263.44	212.39	196.78	170.91	483.69	522.13	
Crop sales	299.45	258.02	218.55	228.19	1224.44	1380.00	
Net income	36.01	45.63	21.77	57.28	740.75	857.87	

*Fixed and variable costs for windbreaks are distributed proportionately among other crops.

(1) Shipping charge for nuts is 10x regular rate of $.20/cwt because of longer distance.
(2) Marketing fee for nuts is 5% of wholesale price.

Calculation of gross income per acre:

Corn: 113 bu/A x $2.65/bu = $299.45/A
Sorghum: 93 bu/A x $2.35/bu = $218.55/A
Soybeans: 38 bu/A x $6.79/bu = $258.02/A
Alfalfa: 3.58 tons/A x $63.68/ton = $228.19/A
Christmas trees: 551 trees/9 A x $20.00*/tree = $1224.44/A
Hazelnuts: 4416 lbs/16 A x $5.00/lb = $1380/A

*Dennis Adams, a Christmas tree grower near Lincoln, NE charges $25 per 6' tree; Iowa extension puts price of a 6' tree at $15 (Laine et al. 1992a).

D. Agroforestry summary budget table

LAND

	Acres	Cost/A	Total
Owned	255	35.89/A	9,152
Rented	170	79.00/A	13,430

EQUIPMENT

Item	Annual ownership cost	Annual cost of operation (excl. labor)
Power units		
120 hp tractor	6241	1565
100 hp tractor	4815	1438
185 hp combine	8357	1782
½ ton pickup	983	1431

Implements		
disk	1553	114
rowcrop cultivator	515	67
field cultivator	862	43
sprayer	462	43
6 row corn head	1428	18
15' grain head	628	47
6 row planter	2380	254
swather	695	196
baler	803	168
mower	677	30
seed cleaner	102	60
Total	30501	7256

EQUIPMENT RENTAL

spreader	374
anhydrous applicator	253
seeder-packer	56
Total	683

INPUTS

seedlings	237
seed	5119
fertilizer	2810
pesticides	7312
baling twine	146
Total inputs	15624

CUSTOM OPERATIONS

marketing	3308
rogue beans/sorghum	1170
trucking/shipping	2829
dry corn	938
plowing	133
ripping	13
Total custom	8391

hired labor	3915
Total operations costs	35869
OVERHEAD AND INTEREST	
Interest on operating capital	2403
Overhead	1914
Total overhead and interest	4317
TOTAL EXPENSES	93,269
TOTAL SALES	128746
NET INCOME	35,477

Table A4-5. Assumptions for modeling windbreak economics for the agroforestry and organic farms.

For a single row windbreak constructed of a tree species with a moderate rate of growth (25 ft in 20 years) such as red cedar, and providing a moderate zone of protection (16.8H), protection of adjacent cropland begins in the sixth year after establishment (Brandle et al. 1992). The windbreak provides full protection at age 20, and remains effective through age 50 after which it is replanted.

Assuming that a windbreak system is at a steady state, 1/50 of the windbreak area is removed and replanted each year. The crop area actually protected in any year = (30/50) + ((5/50) x 0) + ((1/50) x (1/15)) + ((1/50) x (2/15)) + ... = .76. In the models of the agroforestry and organic farms, yield increases due to windbreak effects are assumed to be 76% of the expected increase (Table A3-3) because only 76% of the crop acres are protected at any time. For example, if a crop might be expected to show a 5% yield increase in shelter, on the agroforestry farm it will be given a .76 x 5 = 3.8% yield increase.

The row width for the single row shelterbelt is 20 ft (Brandle et al. 1992); trees are planted at 12' spacings (Brandle et al. 1984) so there are 100 trees per 1200 ft of windbreak; 1 acre = 43560 sq. ft.; windbreaks have 100 seedlings per 24000 ft2 or 182 seedlings per acre.

The agroforestry farm has 23 acres in windbreaks; 23/50 = .46 acres replanted each year and requiring 84 seedlings plus 13 seedlings for year 2 and 3 replacements (10% year 2, 5% year 3) for a total of 97 seedlings to plant each year.

Table A4-6. Assumptions for modelling hazel nut (*Corylus americana*) production.

Information from harvest data of UNL hazel nut orchard near Ithaca, NE; personal communication from Bruce Bolander, UNL Department of Forestry, Fisheries and Wildlife; and other sources:

Shrubs are grown on 12' (within row) x 15' spacing. Five percent of the area is devoted to lanes for a shrub density of 230/A.

The agroforestry farm model assumes a 50-year steady-state orchard with 1/50 of the orchard replanted each year — for the agroforestry farm this is .32 acres or 74 shrubs. Assume 10% replacement due to mortality for year 2 and 5% for year three giving a total of 85 seedlings to plant each year.

Plant mid-April, 12' within rows and 15' between rows. Hand planting takes 4-5 hrs per acre. Seedlings cost $.45 each delivered. Seedling strips are sprayed years 1-3 with an herbicide to control weeds; assume sprayed strips are 7.5' wide so ½ of area (.16 acres) is sprayed for year 1-3 plantings or a total of .48 acres each year. After year 3, mow for weed control.

Estimated hazelnut production for agroforestry system:

Assume maximum yield of 350 lbs clean, dry nuts per acre with this maximum being maintained for years 10-45. Assume production years 46-50 averages one-half of maximum or 175 lbs/A. No production years 1 and 2. Production begins year 3 and doubles each year until maximum at year 10, giving the series year 3 - 2.5 lbs/A, year 4 - 5 lbs/A, year 5 - 10 lbs/A, year 6 - 20 lbs/A, year 7 - 40 lbs/A, year 8 - 80 lbs/A, year 9 - 175 lbs/A. The average yield for years 3-9 is 47 lbs/A.

The weighted average yield for the 16 acres is 276 lbs/A or a total yield of 4416 lbs per year.

Time required for harvesting and processing the nuts is proportional to yield. 70 hours required to harvest one acre at maximum production; assume 20% additional labor required for cleaning and drying, for a total of 84 hours labor per acre at maximum production. (276 lbs/350 lbs) x 84 hrs = 66 hrs/A at an average production of 276 lbs/A. 66 hrs/A x 16 A = 1056 hrs; divided equally among five weeks = 211 hours/week.

No problems with insects or diseases. Squirrels and mice may be a problem and will likely require trapping for control.

Table A4-7. Description of Christmas tree system

Details of Christmas tree farm operations available in Laine et al. (1992a,b).

For the model of the agroforestry farm, Scotch pine is planted on 6' x 10' spacing; with 5% of land devoted to roads, this results in a planting of 689 trees per acre. Twenty-five percent of the seedlings need to be replanted in year 2; 5% in year 3.

The agroforestry farm has nine acres of Christmas trees on a nine-year rotation. Including replacement seedlings, 896 Scotch pine are planted each spring. After year 3, of the 689 trees on an acre, 10% don't reach maturity, and 10% aren't saleable, leaving 551 saleable trees per acre for sale during years 7-9. In year 7, 96 are sold; 359 in year 8, and 96 in year 9.

Appendix 4D.

Organic Farm

Baseline economic analysis

I. Characteristics of the organic analog farm

A. Size

farm size (acres)	425
% land owned	60 (255 A)
% cropland	92
% pasture	3
% shelterbelts	5

B. Customized equipment list:

Item	Age at trade	Annual use	Description
Tractor #1	15	286 hrs	120 hp diesel cab
Tractor #2	20	286 hrs	100 hp diesel cab
disk	20	354 A	tandem disk harrow 20'
rowcrop cultivator	20	222 A	6 row x 30"
rotary hoe	15	437 A	15'
field cultivator	10	311 A	18'
sprayer	15	14 A	300 gal 15' pull-type
combine*	10	144 hrs	185 hp
corn head*	15	133 A	6 row
grain head*	10	414 A	15'
planter	10	207 A	6 row x 30"
swather/conditioner*	15	549 A	14' pull-type
baler*	10	705 tons	large round
trailer	10	115 A	flat bed
trailer	20	20 A	pipe
planter	10	1 A	1-row
pickup truck	7	280 hrs	½ ton
mower	10	18.5 A	8' flail
bed shaper	10	3 A	40"
transplanter	10	2 A	2-row
cooling room	20	360 hrs	280 ft^3
ice crusher	15	12 hrs	300 lb capacity

Moldboard plow removed from baseline list; swather/conditioner, baler, trailer, pipe trailer, 1-row planter, pickup truck, mower, bed shaper, and transplanter added.

*Ownership shared with agroforestry analog farm; annual use is total use by both farms.

C. Operations summary

i. Non-vegetable crops

Operations and schedule based largely on Bender (1994). Later planting has major advantages in relation to mechanical weed control. Planting dates for corn, sorghum, and soybeans for the organic farm are one week later than average dates for East Crop Reporting District. Alfalfa cutting dates from Bruce Anderson, UNL Agronomy. Alfalfa is at 15% moisture when baled; dries in bale to 12%.

Acres devoted to each crop: alfalfa - 120A; corn for grain - 50A; sorghum - 30A; soybeans - 90A; vegetables - 10A; oats/turnips - 30A; corn for silage - 30A; winter wheat - 30A; pasture - 12A; windbreak - 23A; total - 425A.

week	alfalfa	corn for grain	sorghum	soybeans	vegetables see Cii.	oats/ turnip	corn for silage	winter wheat	pasture	windbreak
14 (Apr 2-8)						manure disk field cult. plant			manure	
15										disk (.14 A) plant (.46 A)
16							manure disk			
18		manure (20A) plow disk								mow
19		field cult. plant	manure disk				field cult. plant			
21		rotary hoe		disk field cult. plant			rotary hoe		swath bale move bale	

week	alfalfa	corn for grain	sorghum	soybeans	vegetables see Cii.	oats/ turnip	corn for silage	winter wheat	pasture	windbreak
22	windrow bale move bales	rotary hoe	field cult. plant rotary hoe				rotary hoe			mow
24				rotary hoe						
25		cultivate	rotary hoe	rotary hoe			cultivate			
26			rotary hoe			combine truck			swath bale move bale	
27		hand weed		cultivate			hand weed			mow
28			cultivate							
29				hand weed				combine truck		
30	windrow bale move bales		hand weed	hand weed		disk broadcast turnip seed				
31			hand weed							mow
33	(30 acres) apply P disk field cult. plant alfalfa									
35										mow

week	alfalfa	corn for grain	sorghum	soybeans	vegetables see Cii.	oats/ turnip	corn for silage	winter wheat	pasture	windbreak
37	windrow bale move bales									
38							harvest truck	manure disk		
39								field cult. drill		
41				combine truck						
42		combine truck dry								
43	erect cattle fence		combine truck							
44	begin grazing									remove .46 acres of old windbreak
04	end grazing	remove fence								

Seed, pesticide, and irrigation inputs (per acre) by crop for organic farm non-vegetable crops.

Input	alfalfa	corn for grain after alfalfa	grain sorghum	soybean	corn for grain after soybeans	vegetables	oats followed by turnips	corn for silage	winter wheat	pasture	windbreak
yield goal	3.9 tons	113 bu	93 bu	38 bu	113 bu	See veg. table	62 bu	14.6 tons	41 bu	4 AUM	-------
seed	12 #	.275 bag	5.5 #	1.1 bag	.275 bag	See veg. table	70 # (oats) 1 # (turnip)	.275 bag	75 #	0	
organic pesticide						See veg. table					
irrigation	0	0	0	0	0	1.4"/week	0	0	0	0	0

Planting rates for corn, corn silage, sorghum, and soybeans increased by 10% to compensate for losses in rotary hoeing (Bender 1994).

Due to shelterbelt effects, yields represent the following increases from county averages: corn for grain (7.6%), soybeans (9.1%), grain sorghum (3.8%), alfalfa (11.4%), oats (3.8%), winter wheat (11.4%), corn silage (7.6%). For rationale, see Table A4-3.

ii. Vegetable crops

Operations schedule for organic vegetables. Based on DeCourley and Moore (1987), Lorenz and Maynard (1988), Anfinson et al. (1996), Hodges personal communication. For sweet corn, the numbers 1,2, and 3 following an operation refer to three successive plantings. For spinach, there are two successive plantings, 1 and 2. *No irrigation in average precipitation year.

Week no.	sweet corn (3 A)	pumpkins (2 A)	acorn squash (2 A)	bell peppers (2 A)	spinach (1 A)
previous fall					spread manure disk/harrow
14 (Apr 2-8)	spread manure disk/harrow 2x	spread manure disk/harrow 2x	spread manure disk/harrow 2x	spread manure disk/harrow 2x	disk 2x 12 field cult. 12 shape beds 1 install irrig 1 plant 1
15					disk 2 field cult. 2 shape beds 2 install irrig 2 plant 2
16	disk	disk	disk	disk	irrigate 12 hand hoe 1
17					irrigate 12 cultivate 1 insecticide 1 hand hoe 2
18	field cultivate	field cultivate	field cultivate		irrigate 12 cultivate 2 hand hoe 1 insectic. 1,2
19	install irrig. pipe	install irr. pipe	install irr. pipe	disk field cultivate	irrigate 12* cultivate 1 hand hoe 2 insectic. 12
20	field cultivate plant 1	field cultivate plant	field cultivate plant	shape beds install irrig. pipe	harvest 1 pack/grade 1 irrigate 2 cultivate 2 insectic. 2
21	irrigate 1	pre-emerge rotary hoe irrigate	pre-emerge rotary hoe irrigate	transplant irrigate	harvest 2 pack/grade 2

Week no.	sweet corn (3 A)	pumpkins (2 A)	acorn squash (2 A)	bell peppers (2 A)	spinach (1 A)
22	irrigate 1 rotary hoe 1 field cultivate 23 plant 2	irrigate	irrigate	irrigate	disk 2x 12 plant cover crop 12
24	cultivate 1 irrigate 12*	cultivate irrigate*	cultivate irrigate*	cultivate irrigate*	irrigate*
25	irrigate 12 hoe 1 rotary hoe 2 field cultivate 3 plant 3	hand hoe irrigate apply insecticide	irrigate apply insecticide hand hoe	hand hoe irrigate	irrigate remove pipe
26	cultivate 12 irrigate 123*	irrigate* cultivate	cultivate irrigate*	cultivate irrigate*	
27	hoe 12 irrigate 123* rotary hoe 3	hand hoe irrigate*	hand hoe irrigate*	hand hoe irrigate*	
28	irrigate 123 cultivate 23	irrigate apply insecticide	irrigate apply insecticide	cultivate irrigate	
29	irrigate 123* hoe23	irrigate*	irrigate*	irrigate*	
30	irrigate 123* cultivate 3	irrigate*	irrigate*	irrigate*	
31	irrigate 123 hoe 3	irrigate	irrigate	irrigate	
32	harvest, grade, pack, truck 1 irrigate 23	irrigate	main harvest (70%), grade/pack, truck	irrigate	
33	harvest, grade, pack, truck 1 irrigate 23*		2nd harvest (20%), grade/pack, truck	harvest, grade/pack, truck	
35	harvest, grade, pack, truck 2 irrigate 3		final harvest (10%), grade/pack, truck	harvest, grade/pack, truck	
36	harvest, grade, pack, truck 2 irrigate 3		remove pipe disk 2x	harvest, grade/pack, truck	
37	harvest, grade, pack, truck 3	harvest 100 day grade, pack, truck	plant wheat	harvest, grade/pack, truck	

Week no.	sweet corn (3 A)	pumpkins (2 A)	acorn squash (2 A)	bell peppers (2 A)	spinach (1 A)
38	harvest, grade, pack, truck 3			harvest, grade/pack, truck	
39		harvest 110 day grade, pack, truck		remove pipe disk 2x plant wheat	
40	remove pipe	remove pipe disk			
43					manure disk

Summary of inputs (per acre)

input	sweet corn	pumpkin	acorn squash	bell peppers	spinach
nitrogen (lbs)	110 (7)	75 (2)	75 (2)	125 (6, 7)	120 (1)
P_2O_5 (lbs)	50 (7)	120 (3)	120 (3)	100 (7)	60 (1)
K_2O (lbs)	150 (7)	200 (7)	200 (7)	200 (7)	60 (1)
seed	12 lbs (7)	medium: 1 lb large: .87 lb (2)	1 lb (2)	14000 plants (7)	10 lbs (1) *rye cover crop - 1.5 bu (11)
pest control	Trichogramma wasps - 2 cards, rodent trapping - 2 hrs/A (4)	Pyrellin E.C. - 3 qt/A, rodent trapping - 2 hrs/A (4)	Pyrellin E.C. - 3 qts/A, rodent trapping - 2 hrs/A (4)	rodent trapping - 2 hrs/A (4)	rodent trapping - 2 hrs/A (4) Bt - .75 lb/A/date (4) Insecticidal soap - 3 qt/A/date (4)
irrigation (in)	1.4"/week if no rain (6)	1.4"/week if no rain (6)	1.4"/week if no rain (6)	1.4"/week if no rain (6)	1.4"/week if no rain (6)
other		1 bee hive/acre (6)	1 bee hive/acre (6)		
yield goal	1000 dozen (8)	medium: 16,000 lb large: 20,000 lb (5)	10,000 lbs (5)	1000 bu (7)	6000 lbs (1)
transplant labor (hrs)	---	---	---	.68 (7)	---
hand hoeing labor (hrs)	5 hrs/A/date	9 hrs/A/date (4)	9 hrs/A/date (4)	8.5 hrs/A/date (7)	10 hrs/A/date

input	sweet corn	pumpkin	acorn squash	bell peppers	spinach
irrigation labor (hrs)	.3 hrs/irrigation (1)	.3 hrs/irrigation (1)	.3 hrs/irrigation (1)	.3 hrs/ irrigation (1)	.3 hrs/irrigation (1)
harvest labor (hrs)	48 (7)	34 (7)	34 (9)	85 (7)	60 (1)
grade/pack labor (hrs)	4.8 (7) plus 5.2 for icing	3.5 (7)	3.5 (9)	16 (7) plus 4 for cooling	30 (1) plus 30 for bunching and icing
ice (cwt)	48 (12)	0	0	0 (10)	48 (12)
marketing fee	$.15/crate (10)	$1.40/ pallet (13)	$.10/ ctn (13)	$.50/bu (10)	$.70/ctn (13)

(1) DeCourley and Moore 1987
(2) Marr et al. 1995
(3) Hodges et al. 1992
(4) Klonsky et al. 1994
(5) Marr et al. 1995; Pumpkin and squash yields reduced approximately 20% for loss to powdery mildew.
(6) Hodges and Baxendale 1991
(7) Anfinson et al. 1996
(8) Anfinson et al. (1996) give 1200 dozen as expected yield; this reduced to 1000 dozen to reflect possible losses (unmarketable ears) from corn ear worm.
(9) Values for pumpkins used.
(10) Taylor and Smith 1989
(11) Spence 1987
(12) Boyette and Estes 1992
(13) Marketing fees are 2% for corn, pumpkins, acorn squash; 6% for peppers and spinach.

Crate of sweet corn = 5 doz.; pallet of pumpkins = 500 lbs; carton of acorn squash = 20 lbs; 1 1/9 bu acorn squash = 50 lbs; bushel of bell peppers = 25 lbs (1 1/9 bu = 28 lbs) ; carton of spinach (24 bnch) = 20 lbs; bin of pumpkins, jack-o-lantern type = 1000 lbs

D. Equipment ownership and use.

Costs interpolated from tables in Powell et al. (1992) with values increased 10% to account for inflation from 1992 to mid-1996. Pickup truck, mower, and pipe trailer costs from Klonsky et al. (1994). Costs for bed shaper, transplanter, trailer, fabric layer, and 1-row planter from DeCourley and Moore (1987) and increased 32% for inflation. Annual use derived from baseline operations scenario for the analog farm. *Ownership shared with agroforestry farm; operating costs based on combined use; ownership cost based on proportional use.

Equipment	Annual use (hrs)	Annual cost of ownership	Ownership cost per hour use	Operating cost per hour use
120 hp tractor	286	$6241	$22.45	$8.07
100 hp tractor	286	$4815	$16.84	$7.57
combine*	61	$6052	$99.87	$21.39
pickup truck	280	$983	$3.51	$5.11

Implement	Annual use (acres)	Annual cost of owning	Ownership cost per acre use	Operation cost per acre use
disk	354	$1553	$4.39	$0.35
field cultivator	311	$862	$2.77	$0.13
6-row planter	207	$2380	$11.50	$0.76
sprayer	14	$373	$26.64	$0.15
row crop cultivator	222	$490	$2.21	$0.19
corn head*	50	$860	$17.20	$0.22
grain head*	180	$483	$2.68	$0.20
rotary hoe	437	$398	$0.91	$0.07
swather*	384	$1617	$4.21	$1.19
baler* (tons)	490	$1841	$3.76	$0.78
bed shaper	3	$148	$49.33	$0.78
pipe trailer	20	$75	$3.75	$1.25
transplanter	2	$231	$115.50	$1.60
trailer	115	$258	$2.24	$0.39
1-row planter	1	$92	$92.00	$0.33
mower	18.5	$677	$36.59	$0.21

Implement	Annual use (acres)	Annual cost of owning	Ownership cost per acre use	Operation cost per acre use
irrigation system (A, A-in)	10 A, 73.5 A-in	$541	$54.11/A	$5.66*/A-in
cooling room (hrs)	360	$204	$0.57	$0.47 (incl. elec)/hr
ice crusher (cwt ice)	192	$117	$0.61	$0.39 (incl elec)/cwt

*Includes electricity cost of $2.05/A-in (at $0.06 per kWh).

II. Budget calculations

A. Land

Owned: 255 A x $35.89/A = $9,152

From Johnson (pers. comm.); average debt on owned farmland is 20% of value. For eastern Nebraska (Johnson 1995), $1345/A x .2 = $269/A. Amortized over 30 years at 8%: $269/A x .088827 (from amortization table) = $23.89/A interest and principle payments per year. Plus real estate taxes of $12.00/A = $35.89/A.

Rented: 170 A x $79.00/A = $13,430

B. Operations and labor by week for rowcrops and alfalfa

( ) = labor hours as 1.2 x equipment operation hours

Week 14 (2-8 April):

Disk: 30 A ÷ 7.8 A/hr = 3.9 hrs (4.6 hrs)
Field cultivation: 30 A ÷ 10.2 A/hr = 2.9 hrs (3.5 hrs)
Drill: 30 A ÷ 5.4 A/hr = 5.6 hrs (6.7 hrs)

Total labor = 14.8 hrs

tractors: 12.4 hrs
rent drill: 30 A
oat seed: 30 A x 70 lbs seed/A = 2100 lbs seed
custom spread manure: 12 A x 10.6 tons/A = 127.2 tons; 30 A x 2.2 tons/A = 66 tons

Week 15:

Disk: .14 A ÷ 2.34 A/hr = .1 hr (.2 hr)
Hand plant: 97 seedlings ÷ 400 seedlings/10 hrs = 2.4 hrs

Total labor = 2.6 hrs

tractors: .1 hr
seedlings: 97 seedlings x $0.20/seedling = $19
custom lay weed barrier fabric: 1008'

Week 16:

Disk: 30 A ÷ 7.8 A/hr = 3.9 hrs (4.6 hrs)

Total labor = 4.6 hrs

tractors: 3.9 hrs
custom spread manure: 30 A x 13.26 tons/A = 397.8 tons

Week 18:

Disk: 50 A ÷ 7.8 A/hr = 6.4 hrs (7.7 hrs)
Mow: 3.7 A ÷ 3 A/hr = 1.2 hrs (1.5 hrs)

Total labor = 9.2 hrs

tractors: 7.6 hrs
custom plowing: 30 A
custom apply manure: 20 A x 14 tons/A = 280 tons

Week 19:

Disk: 30 A ÷ 7.8 A/hr = 3.9 hrs (4.6 hrs)
Field cultivation: 80 A ÷ 10.2 A/hr = 7.8 hrs (9.4 hrs)
Plant corn: 80 A ÷ 4.9 A/hr = 16.3 hrs (19.6 hrs)

Total labor = 33.6 hrs

tractors: 28 hrs
custom apply manure: 30 A x 7 tons/A = 210 tons

Week 21:

Disk: 90 A ÷ 7.8 A/hr = 11.5 hrs (13.9 hrs)
Field cultivation: 90 A ÷ 10.2 A/hr = 8.8 hrs (10.6 hrs)
Plant beans: 90 A ÷ 4.9 A/hr = 18.4 hrs (22 hrs)
Rotary hoe: 80 A ÷ 10.2 A/hr = 7.8 hrs (9.4 hrs)
Swather: 12 A ÷ 5.7 A/hr = 2.1 hrs (2.5 hrs)
Bale: 14.4 tons ÷ 6.3 tons/hr = 2.3 hrs (2.8 hrs)
Move bales: 12 A ÷ 10 A/hr = 1.2 hrs (1.4 hrs)

Total labor = 62.6 hrs

tractors: 52.1 hrs
baling twine: 22 bales

Week 22:

Field cultivation: 30 A ÷ 10.2 A/hr = 2.9 hrs (3.5 hrs)
Plant sorghum: 30 A ÷ 4.9 A/hr = 6.1 hrs (7.4 hrs)
Rotary hoe: 110 A ÷ 10.2 A/hr = 10.8 hrs (12.9 hrs)
Swather: 120 A ÷ 5.7 A/hr = 21.1 hrs (25.3 hrs)
Bale: 156 tons ÷ 6.3 tons/hr = 24.8 hrs (29.7 hrs)
Move bales: 120 A ÷ 10 A/hr = 12 hrs (14.4 hrs)
Mow: 3.7 A ÷ 3 A/hr = 1.2 hrs (1.5 hrs)

Total labor = 94.7 hrs

tractors: 78.9 hrs
baling twine: 240 bales

Week 24:

Rotary hoe: 90 A ÷ 10.2 A/hr = 8.8 hrs (10.6 hrs)

Total labor = 10.6 hrs

tractors: 8.8 hrs

Week 25:

Rotary hoe: 120 A ÷ 10.2 A/hr = 11.8 hrs (14.1 hrs)
Cultivate: 80 A ÷ 5.1 A/hr = 15.7 hrs (18.8 hrs)

Total labor = 32.9 hrs

tractors: 27.5 hrs

Week 26:

Rotary hoe: 30 A ÷ 10.2 A/hr = 2.9 hrs (3.5 hrs)
Combine: 30 A ÷ 3.8 A/hr = 7.9 hrs (9.5 hrs)
Swather: 12 A ÷ 5.7 A/hr = 2.1 hrs (2.5 hrs)
Bale: 7.2 tons ÷ 6.3 tons/hr = 1.1 hrs (1.3 hrs)
Move bales: 12 A ÷ 10 A/hr = 1.2 hrs (1.4 hrs)

Total labor = 18.2 hrs

tractors: 7.3 hrs
grain head: 30 A
yield: 30 A x 62 bu/A = 1860 bu oats
truck oats: 1890 bu
baling twine: 11 bales

Week 27:

Cultivate: 90 A ÷ 5.1 A/hr = 17.7 hrs (21.2 hrs)
Mow: 3.7 A ÷ 3 A/hr = 1.2 hrs (1.5 hrs)

Total labor = 22.7 hrs

tractors: 18.9 hrs
rogue: 80 A

Week 28:

Cultivate: 30 A ÷ 5.1 A/hr = 5.9 hrs (7.1 hrs)

Total labor = 7.1 hrs

tractors: 5.9 hrs

Week 29:

Combine: 30 A ÷ 3.8 A/hr = 7.9 hrs (9.5 hrs)

Total labor = 9.5 hrs

grain head: 30 A

yield: 30 A x 41 bu/A = 1230 bu wheat
truck wheat: 1230 bu
rogue soybeans: 90 A

Week 30:

Disk: 30 A ÷ 7.8 A/hr = 3.9 hrs (4.6 hrs)
Broadcast turnip seed: 30 A ÷ 10 A/hr = 3 hrs (3.6 hrs)
Swather: 120 A ÷ 5.7 A/hr = 21.1 hrs (25.3 hrs)
Bale: 156 tons ÷ 6.3 tons/hr = 24.8 hrs (29.7 hrs)
Move bales: 120 A ÷ 10 A/hr = 12 hrs (14.4 hrs)

Total labor = 77.6

tractors: 64.8 hrs
spreader rental: 30 A
roguing: 120 A
baling twine: 240 bales

Week 31:

Mow: 3.7 A ÷ 3 A/hr = 1.2 hrs (1.5 hrs)

Total labor = 1.5 hrs

tractors: 1.2 hrs
roguing: 30 A

Week 33:

Spread fertilizer: 30 A ÷ 10 A/hr = 3 hrs (3.6 hrs)
Disk: 30 A ÷ 7.8 A/hr = 3.9 hrs (4.6 hrs)
Field cultivate: 30 A ÷ 10.2 A/hr = 2.9 hrs (3.5 hrs)
Plant alfalfa: 30 A ÷ 3.9 A/hr = 7.7 hrs (9.2 hrs)

Total labor = 20.9 hrs

tractors: 17.5 hrs
rent spreader: 30 A
rent seeder/packer: 30 A
alfalfa seed: 30 A x 12 lb/A = 360 lbs

Week 35:

Mow: 3.7 A ÷ 3 A/hr = 1.2 hrs (x 1.2 = 1.5 hrs)

Total labor = 1.5 hrs

tractors: 1.2 hrs

Week 37:

Swather: 120 A ÷ 5.7 A/hr = 21.1 hrs (25.3 hrs)
Bale: 156 tons ÷ 6.3 tons/hr = 24.8 hrs (29.7 hrs)
Move bales: 120 A ÷ 10 A/hr = 12 hrs (14.4 hrs)

Total labor = 69.4 hrs

tractor: 57.9 hrs
baling twine: 240 bales

Week 38:

Disk: 30 A ÷ 7.8 A/hr = 3.9 hrs (4.6 hrs)

Total labor = 4.6 hrs

tractors: 3.9 hrs
custom apply manure: 30 A x 9.28 tons/A = 278.4 tons

Week 39:

Field cultivation: 30 A ÷ 10.2 A/hr = 2.9 hrs (3.5 hrs)
Drill: 30 A ÷ 5.4 A/hr = 5.6 hrs (6.7 hrs)

Total labor = 10.2 hrs

tractors: 8.5 hrs
rent drill: 30 A
wheat seed: 30 A x 75 lbs seed/A = 2250 lbs

Week 41:

Combine beans: 90 A ÷ 3.8 A/hr = 23.7 hrs (28.4 hrs)

Total labor = 28.4 hrs

grain head: 90 A
yield: 90 A x 38 bu/A = 3420 bu beans
truck beans: 3420 bu

Week 42:

Combine corn: 50 A ÷ 3.8 A/hr = 13.2 hrs (15.8 hrs)

Total labor = 15.8 hrs

corn head: 50 A x $/A = $
yield: 50 A x 113 bu/A = 5650 bu
truck corn: 5650 bu
dry corn: 5650 bu

Week 43:

Combine sorghum: 30 A ÷ 3.8 A/hr = 7.9 hrs (9.5 hrs)

grain head: 30 A
yield: 30 A x 93 bu/A = 2790 bu
truck sorghum: 2790 bu

Week 44:

Clear year 50 cedars: 84 trees ÷ 100 trees/8 hrs = 6.7 hrs

tractors: 4 hrs

C. Operations and labor for vegetables

( ) = total labor hours for the operation (equipment operation hours x 1.2)

Week 14 (2-8 April):

Disk: 20 A ÷ 7.8 A/hr = 2.6 hrs (3.1 hrs)
Field cultivate: 1 A ÷ 10.2 A/hr = .1 hr (.2 hr)
Shape beds: .5 A x 2 hrs/A = 1.0 hrs (1.2 hrs)
Install irrigation pipe: .5 A x 2 hrs/A = 1.0 hr* (1.2 hrs)
Plant spinach: .5 A x 1.79 hrs/A = .9 hr (1.1 hrs)

Total labor = 6.8 hrs

*Tractor operation hours assumed to be 1/4 of in-field installation hours; in this example, tractor operation time = .25 hours

tractors: 4.9 hrs
spinach seed: .5 A x 10 lbs/A = 5 lbs
custom spread manure: (3 A x 13 tons/A) + (4 A x 6 tons/A) + (2 A x 16 tons/A) = 95 tons

Week 15:

Disk: .5 A ÷ 7.8 A/hr = .1 hr (.2 hr)
Field cultivate: .5 A ÷ 10.2 A/hr = .1 hr (.2 hr)
Shape beds: .5 A x 2 hrs/A = 1.0 hr (1.2 hrs)
Install irrigation pipe: .5 A x 2 hrs/A = 1.0 hr (1.2 hrs)
Plant spinach: .5 A x 1.79 hrs/A = .9 hr (1.1 hrs)

Total labor = 3.9 hrs

tractors: 2.4 hrs
spinach seed: .5 A x 10 lbs/A = 5 lbs

Week 16:

Disk: 9 A ÷ 7.8 A/hr = 1.2 hrs (1.4 hrs)
Irrigate: .5A x .3 hrs/A = .15 hrs
Hand hoe: .5 A x 10 hrs/A = 5 hrs

Total labor = 6.6 hrs

tractors: 1.2 hrs
irrigation water: 0.7 ac-in

Week 17:

Irrigate: 1 A x .3 hrs/A = .3 hrs
Cultivate: .5 A ÷ 1.1 A/hr* = .5 hr (.6 hr)
Apply Bt: .5 A ÷ 1.7 A/hr* = .3 hr (.4 hr)
Apply insecticidal soap: .5 A ÷ 1.7 A/hr* = .3 hr (.4 hr)
Hand hoe .5 A x 10 hrs/A = 5 hrs

Total labor = 6.7 hrs

*40" beds are being treated instead of 15' swaths, so the normal cultivation and spraying rates are decreased proportionally.

tractors: 1.1 hrs
irrigation water: 1.4 ac-in
Bt: .5 A x .75 lb/A = .38 lb
insecticidal soap: .5 A x 3 qt/A = 1.5 qt

Week 18:

Field cultivation: 7 A ÷ 10.2 A/hr = .7 hrs (.8 hrs)
Irrigate: 1 A x .3 hrs/A = .3 hrs
Cultivate: .5 A ÷ 1.1 A/hr* = .5 hr (.6 hr)
Apply Bt: 1 A ÷ 1.7 A/hr* = .6 hr (.7 hr)
Apply insecticidal soap: 1 A ÷ 1.7 A/hr* = .6 hr (.7 hr)
Hand hoe .5 A x 10 hrs/A = 5 hrs
Rodent trapping (spinach): 1 A x 2 hrs/A = 2 hrs

Total labor = 10.1 hrs

tractors: 2.4 hrs
Bt: 1 A x .75 lb/A = .75 lb
insecticidal soap: 1 A x 3 qt/A = 3 qt
irrigation water: 1.4 ac-in

Week 19:

Install irrigation pipe: 7A x 2 hrs/A = 14 hrs
Disk: 2 A ÷ 7.8 A/hr = .3 hr (.4 hr)
Field cultivate: 2 A ÷ 10.2 A/hr = .2 hr (.3 hr)

Cultivate: .5 A ÷ 1.1 A/hr = .5 hr (.6 hr)
Hand hoe: .5 A x 10 hr/A = 5 hrs

Apply Bt: 1 A ÷ 1.7 A/hr = .6 hr (.7 hr)
Apply insecticidal soap: 1A ÷ 1.7 A/hr = .6 hr (.7 hr)

Total labor = 21.7 hrs

tractors: 5.7 hrs
Bt: 1 A x .75 lb/A = .75 lb
insecticidal soap: 1 A x 3 qt/A = 3 qt

Week 20:

Field cultivate: 7A ÷ 10.2 A/hr = .7 hr (.8 hr)
Plant sweet corn: 1A ÷ 4.9 A/hr = .2 hr (.3 hr)
Plant pumpkins: 2A ÷ 4.9 A/hr = .4 hr (.5 hr)
Plant acorn squash: 2A ÷ 4.9 A/hr = .4 hr (.5 hr)
Shape beds: 2A x 2 hrs/A = 4.0 hrs (4.8 hrs)
Install irrigation pipe: 2 A x 2 hrs/A = 4.0 hrs (4.8 hrs)
Harvest spinach: .5 A x 60 hrs/A = 30 hrs
Pack/grade spinach: .5 A x 60 hrs/A = 30 hrs**
Irrigate: .5 A x .3 hr/A = .15 hr
Cultivate: .5 A ÷ 1.1 A/hr = .5 hr (.6 hr)
Apply Bt: .5 A ÷ 1.7 A/hr = .6 hr (.7 hr)
Apply insecticidal soap: .5 A ÷ 1.7 A/hr = .6 hr (.7 hr)
Trailer: .5 A x 1 hr/A = .5 hr (.6 hr)

Total labor = 74.5 hrs

**Pack/grade labor doubled from DeCourley and Moore (1987) to include labor for bunching and icing.

tractors: 8.9 hrs
irrigation water: 0.7 ac-in
Bt: .5 A x .75 lb/A = .38 lb
insecticidal soap: .5 A x 3 qt/A = 1.5 qt
sweet corn seed: 1 A x 12 lbs/A = 12 lbs
pumpkin seed: (1 A x 1 lb/A) + (1 A x .87 lb/A) = 1.87 lbs
squash seed: 2 A x 1 lb/A = 2 lbs
spinach cartons: 3000 lbs spinach x 1 carton/20 lbs = 150 cartons
truck spinach: 30 cwt
ice: 150 cartons x 16 lbs ice/carton = 2400 lbs ice
ice crusher: 1.5 hrs
marketing fee: $0.70/carton spinach

Week 21:

Irrigate: 7 A x .3 hr/A = 2.1 hrs
Rotary hoe: 4 A ÷ 10.2 A/hr = .4 hr (.5 hr)
Transplant peppers: 2 A x 1.67 hrs/A = 3.3 hrs (4.0 hrs)
Harvest spinach: .5 A x 60 hrs/A = 30 hrs
Pack/grade spinach: .5 A x 60 hrs/A = 30 hrs**
Trailer: .5 A x 1 hr/A = .5 hr (.6 hr)

Total labor = 67.2 hrs

**Pack/grade labor doubled from DeCourley and Moore (1987) to include labor for bunching and icing.

tractors: 4.2 hrs
irrigation water: 12.6 ac-in
spinach cartons: 3000 lbs spinach x 1 carton/20 lbs = 150 cartons
truck spinach: 30 cwt
ice: 150 cartons x 16 lbs ice/carton = 2400 lbs ice
ice crusher: 1.5 hrs
marketing fee: $0.70/carton spinach
pepper transplants: 2 A x 14000 plants/A = 28000 transplants

Week 22:

Disk: 2 A ÷ 7.8 A/hr = .3 hr (.4 hr)
Irrigate: 9 A x .3 hr/A = 2.7 hrs
rotary hoe: 1A ÷ 10.2 A/hr = .1 hr (.2 hr)
Field cultivate: 3 A ÷ 10.2 A/hr = .3 hr (.4 hr)
Plant sweet corn: 1 A ÷ 4.9 A/hr = .2 hr (.3 hr)
Drill: 1 A ÷ 5.4 A/hr = .2 hr (.3 hr)

Total labor = 4.1 hrs

tractors: 1.1 hrs
irrigation water: 12.6 ac-in
sweet corn seed: 1 A x 12 lbs/A = 12 lbs
annual rye seed: 1 A x 1.5 bu/A = 1.5 bu
drill rental: 1 A

Week 24:

Cultivate: 5 A ÷ 5.1 A/hr = 1.0 hr (1.2 hrs)
Cultivate peppers: 2 A ÷1.1 A/hr = 1.8 hrs (2.2 hrs)

Total labor = 3.4 hrs

tractors: 2.8 hrs

Week 25:

Irrigate: 9 A x .3 hr/A = 2.7 hrs
Hand hoe: (1 A x 5 hrs/A) + (4 A x 9 hrs/A) + (2 A x 8.5 hrs/A) = 58 hrs
Rotary hoe: 1 A ÷ 10.2 A/hr = .1 hr (.2 hr)
Field cultivate: 1 A ÷ 10.2 A/hr = .1 hr (.2 hr)
Plant sweet corn: 1 A ÷ 4.9 A/hr = .2 hr (.3 hr)
Spray: 4 A ÷ 7.7 A/hr = .5 hr (.6 hr)
Remove irrigation pipe: 1 A x 1 hr/A = 1.0 hr (1.2 hrs)

Total labor = 63.2 hrs

tractors: 0.9 hr
irrigation water: 12.6 ac-in
sweet corn seed: 1 A x 12 lbs/A = 12 lbs
Pyrellin E.C.: 4 A x 3 qts/A = 12 qts

Week 26:

Cultivate: 6 A ÷ 5.1 A/hr = 1.2 hrs (1.4 hrs)
Cultivate peppers: 2 A ÷ 1.1 A/hr = 1.8 hrs (2.2 hrs)
Rodent trapping: 9 A x 2 hrs/A = 18 hrs

Total labor = 21.6 hrs

tractors: 3.0 hrs

Week 27:

Hand hoe: (2 A x 5 hrs/A) + (4 A x 9 hrs/A) + (2 A x 8.5 hrs/A) = 63 hrs
Rotary hoe: 1 A ÷ 10.2 A/hr = .1 hr (.2 hr)

Total labor = 63.2 hrs

tractors: 0.1 hr

Week 28:

Irrigate: 9 A x .3 hr/A = 2.7 hrs
Cultivate: 2 A ÷ 5.1 A/hr = .4 hr (.5 hr)
Cultivate peppers: 2 A ÷ 1.1 A/hr = 1.8 hrs (2.2 hrs)
Spray: 4 A ÷ 7.7 A/hr = .5 hr (.6 hr)

Total labor = 6.0 hrs

tractors: 2.7 hrs
irrigation water: 12.6 ac-in
Pyrellin E.C.: 4 A x 3 qts/A = 12 qts

Week 29:

Hand hoe: 2 A x 5 hrs/A = 10 hrs

Total labor = 10 hrs

Week 30:

Cultivate: 1 A ÷ 5.1 A/hr = .2 hr (.3 hr)

Total labor = 0.3 hr

tractors: 0.2 hr

Week 31:

Irrigate: 9 A x .3 hr/A = 2.7 hrs
hand hoe: 1 A x 5 hrs/A = 5 hrs

Total labor = 7.7 hrs

irrigation water: 12.6 ac-in

Week 32:

Irrigate: 6 A x .3 hr/A = 1.8 hrs
Harvest sweet corn (50%): 1 A x .5 x 48 hrs/A = 24 hrs
Grade/pack corn: 1 A x .5 x 10 hrs/A = 5.0 hrs

Harvest squash (70%): 2 A x .7 x 34 hrs/A = 47.6 hrs
Trailer: 3 A x 1 hr/A = 3.0 hrs (3.6 hrs)
Grade/pack squash: 2 A x .7 x 3.5 hrs/A = 4.9 hrs

Total labor = 86.9 hrs

tractors: 3.0 hrs
irrigation water: 8.4 ac-in
sweet corn boxes: .5 A x 1000 dozen/A x 1 box/5 dozen = 100 boxes
ice (corn): 100 boxes x 24 lbs ice/box = 2400 lbs ice
ice crusher: 1.5 hrs
marketing fee (corn): $0.15/box
squash boxes: 2 A x 10000 lb/A x .7 x 1 box/20 lb = 700 boxes
marketing fee (squash): $0.10/carton
trucking corn: 30 cwt
trucking squash: 140 cwt

Week 33:

Irrigate: 2 A x .3 hr/A = .6 hr
Harvest sweet corn (50%): 1 A x .5 x 48 hrs/A = 24 hrs
Grade/pack sweet corn: 1 A x .5 x 10 hrs/A = 5.0 hrs
Harvest squash (20%): 2A x .2 x 34 hrs/A = 13.6 hrs
Grade/pack squash: 2 A x .2 x 3.5 hrs/A = 1.4 hrs
Harvest peppers (20%): 2 A x .2 x 85 hrs/A = 34 hrs
Grade/pack peppers: 2 A x .2 x 20 hrs/A = 8 hrs
Trailer: 5 A x 1 hr/A = 5 hrs (6.0 hrs)

Total labor = 92.6 hrs

tractors: 5.0 hrs
irrigation water: 2.8 ac-in
corn boxes: .5 A x 1000 dozen/A x 1 box/5 dozen = 100 boxes
ice (corn): 100 boxes x 24 lbs ice/box = 2400 lbs ice
ice crusher: 1.5 hrs
marketing fee (corn): $0.15/box
trucking corn: 30 cwt
squash boxes: 2 A x 10000 lb/A x .2 x 1 box/20 lb = 200 boxes
marketing fee (squash): $0.10/box
trucking squash: 40 cwt
pepper cartons: 2 A x 1000 bu/A x .2 x 1 carton/ 1 1/9 bu = 360 cartons
cooling (peppers): 72 hrs
marketing fee (peppers): $0.50/bu
trucking peppers: 10.08 cwt

Week 35:

Irrigate: 1 A x .3 hr/A = .3 hr
Harvest sweet corn: 1 A x .5 x 48 hrs/A = 24 hrs
Grade/pack sweet corn: 1 A x .5 x 10 hrs/A = 5.0 hrs
Harvest squash (10%): 2A x .1 x 34 hrs/A = 6.8 hrs
Grade/pack squash: 2 A x .1 x 3.5 hrs/A = .7 hr
Harvest peppers (20%): 2 A x .2 x 85 hrs/A = 34 hrs
Grade/pack peppers: 2 A x .2 x 20 hrs/A = 8 hrs
Trailer: 5 A x 1 hr/A = 5 hrs (6 hrs)

Total labor = 84.8 hrs

tractors: 5 hrs
irrigation water: 1.4 ac-in
corn boxes: .5 A x 1000 dozen/A x 1 box/5 dozen = 100 boxes
ice (corn): 100 boxes x 24 lbs ice/box = 2400 lbs
ice crusher: 1.5 hrs
marketing fee (corn): $0.15/box
trucking corn: 30 cwt
squash boxes: 2 A x 10000 lb/A x .1 x 1 box/20 lb = 100 boxes
marketing fee (squash): $0.10/box
trucking squash: 20 cwt
pepper cartons: 2 A x 1000 bu/A x .2 x 1 carton/ 1 1/9 bu = 360 cartons
cooling (peppers): 72 hrs
marketing fee (peppers): $0.50/bu
trucking peppers: 10.08 cwt

Week 36:

Irrigate: 1 A x .3 hr/A = .3 hr
Harvest sweet corn (50%): 1 A x .5 x 48 hrs/A = 24 hrs
Grade/pack sweet corn: 1 A x .5 x 10 hrs/A = 5 hrs
Harvest peppers (20%): 2 A x .2 x 85 hrs/A = 34 hrs
Grade/pack peppers: 2 A x .2 x 20 hrs/A = 8 hrs
Trailer: 3 A x 1 hr/A = 3 hrs (3.6 hrs)
Remove irrigation pipe: 2 A x 1 hr/A = 2 hrs (2.4 hrs)
Disk: 4 A ÷ 7.8 A/hr = .5 hr (.6 hr)

Total labor = 77.9 hrs

tractors: 4 hrs
irrigation water: 1.4 ac-in
corn boxes: .5 A x 1000 dozen/A x 1 box/5 dozen = 100 boxes

ice (corn): 100 boxes x 24 lbs ice/box = 2400 lbs ice
ice crusher: 1.5 hrs
marketing fee (corn): $0.15/box
trucking corn: 30 cwt
pepper cartons: 2 A x 1000 bu/A x .2 x 1 carton/ 1 1/9 bu = 360 cartons
cooling (peppers): 72 hrs
marketing fee (peppers): $0.50/bu
trucking peppers: 10.08 cwt

Week 37:

Harvest sweet corn (50%): 1 A x .5 x 48 hrs/A = 24 hrs
Grade/pack sweet corn: 1 A x .5 x 10 hrs/A = 5 hrs
Harvest peppers (20%): 2 A x .2 x 85 hrs/A = 34 hrs
Grade/pack peppers: 2 A x .2 x 20 hrs/A = 8 hrs
Harvest pumpkins: 1 A x 34 hrs/A = 34 hrs
Grade/pack pumpkins: 1 A x 3.5 hrs/A = 3.5 hrs
Drill: 2 A ÷ 5.4 A/hr = .4 hr (.5 hr)
Trailer: 4 A x 1 hr/A = 4 hrs (4.8 hrs)

Total labor = 113.8 hrs

tractors: 4.4 hrs
corn boxes: .5 A x 1000 dozen/A x 1 box/5 dozen = 100 boxes
ice (corn): 100 boxes x 24 lbs ice/box = 2400 lbs ice
ice crusher: 1.5 hrs
marketing fee (corn): $0.15/box
trucking corn: 30 cwt
pepper cartons: 2 A x 1000 bu/A x .2 x 1 carton/ 1 1/9 bu = 360 cartons
cooling (peppers): 72 hrs
marketing fee (peppers): $0.50/bu
trucking peppers: 10.08 cwt
pumpkin crates/pallets: 1 A x 16000 lbs/A x 1 pallet/500 lbs = 32 pallets
marketing fee (pumpkins): $1.40/pallet
trucking (pumpkins): 160 cwt
wheat seed: 2 A x 75 lbs/A = 150 lbs

Week 38:

Harvest sweet corn: 1 A x .5 x 48 hrs/A = 24 hrs
Grade/pack sweet corn: 1 A x .5 x 10 hrs/A = 5 hrs
Harvest peppers (20%): 2 A x .2 x 85 hrs/A = 34 hrs

Grade/pack peppers: 2 A x .2 x 20 hrs/A = 8 hrs
Trailer: 3 A x 1 hr/A = 3 hrs (3.6 hrs)

Total labor = 74.6 hrs

tractors: 3 hrs
corn boxes: .5 A x 1000 dozen/A x 1 box/5 dozen = 100 boxes
ice (corn): 100 boxes x 24 lbs ice/box = 2400 lbs ice
ice crusher: 1.5 hrs
marketing fee (corn): $0.15/box
trucking corn: 30 cwt
pepper cartons: 2 A x 1000 bu/A x .2 x 1 carton/ 1 1/9 bu = 360 cartons
cooling (peppers): 72 hrs
marketing fee (peppers): $0.50/bu
trucking peppers: 10.08 cwt

Week 39:

Harvest pumpkins: 1 A x 34 hrs/A = 34 hrs
Grade/pack pumpkins: 1 A x 3.5 hrs/A = 3.5 hrs
Remove irrigation pipe: 2 A x 1 hr/A = 2 hrs (2.4 hrs)
Disk: 4 A ÷ 7.8 A/hr = .5 hr (.6 hr)
Drill: 2 A ÷ 5.4 A/hr = .4 hr (.5 hr)
Trailer: 1 A x 1 hr/A = 1.0 hr (1.2 hrs)

Total labor = 42.4 hrs

tractors: 2.4 hrs
drill rental: 2 A
wheat seed: 2 A x 75 lbs/A = 150 lbs
pumpkin crates/pallets: 1 A x 20,000 lbs/A x 1 pallet/500 lbs = 40 pallets
marketing fee (pumpkins): $1.40/pallet
trucking (pumpkins): 200 cwt

Week 40:

Remove irrigation pipe: 5 A x 1 hr/A = 5 hrs
Disk: 2 A ÷ 5.4 A/hr = .4 hr (.5 hr)

Total labor = 5.4 hrs

tractors: 1.7 hrs

Week 43:

Disk land for next year's spinach: 1 A ÷ 7.8 A/hr = .1 hr (.2 hr)

Total labor = .2 hrs

tractors: 0.1 hr
custom spread manure: 1 A x 15 tons/A = 15 tons

D. Organic farm residue grazing economics

Summary of residues available for fall grazing on organic farm:

Crop	acres	AUM/acre	total AUMs	days grazing for weaned calves (.5 AU)
alfalfa aftermath	120	.5 (1)	60	17
corn stalks (2)	53	2 (3)	106	30
grain sorghum stalks	30	2 (4)	60	17
turnips	30	2.5 (5)	75	21
brome pasture	12	1.6 (6)	19	5
Total AUMs			320	90

320 AUMs of residue will provide grazing for (320/.5 = 640) weaned calves for one month or 213 weaned calves for approximately 90 days. Shain et al. (1996) set fees for stalk grazing of weaned calves at $.12/day/head and grazing yardage at $.10/day/head. Gross income to organic farm for backgrounding 213 yearling cattle for 90 days would be $4,217.

(1) Bruce Anderson, pers. comm.; (2) Includes sweet corn stalks; (3) Waller et al. 1986; (4) Selley 1996; (5) Vieselmeyer et al. 1994; (6) Waller et al. 1986

Fencing for organic residue grazing

Field	Acres	Perimeter (feet)	Fence type
Brome pasture	12	2892	HTE, 2-strand
Field corn	50	5903	single wire electric
Sweet corn	3	1446	single wire electric
Alfalfa	60 + 60	12933	single wire electric
Sorghum	30	4573	single wire electric
Turnips	30	4573	single wire electric

Costs for 2-strand HTE (from beef farm economic analysis): Materials cost per 1/4 mile = $281; labor hours for initial construction = 30 hrs; two gates = $20; energizer system including ½ mile lead-out fence = $560; labor hours for energizer system plus ½ mile lead-out fence = 23 hrs.

Total initial cost of brome pasture fence including energizer system = $1196 plus 53 hrs labor. At 8% interest and amortized for 25 year lifespan, annual payments = $112.04. Annual maintenance costs for materials are $60 (5% of initial cost); maintenance labor = 2.7 hours per year.

Cost for 1-strand electric: From Norton et al. (1996), materials for 1/4 mile of single wire electric fence = $76.00 (assumes 30 foot post spacing). Labor at 50% of materials costs and $12/hr = 3.2 hrs. Two gates = $20. Energizer system including ½ mile lead-out fence = $560; labor hours for energizer system plus ½ mile lead-out fence = 23 hrs.

Initial cost for stalk fencing including perimeter fence plus gates plus lead-out fence = $522 materials; 30.7 hours labor. Assuming a 10-year lifespan for materials at 8% interest, annual payments = $77.79; annual maintenance costs (5% of initial materials cost) = $26. Assume 30.7 hours to set-up; 15 hours to dismantle.

Initial cost of energizer system including lead-out fence for perimeter stalk fencing is $410; 25-year lifespan at 8% interest gives annual payments of $38.41; annual maintenance costs = $20.50 (.05 x $410); annual maintenance labor = 1 hour.

Electricity costs for energizers: 90 days x 24 hrs/day x 2.9 watts = 6.26 kwh ($0.62).

Cattle water

213 calves x 5 gal/day (NRC 1996) = 1060 gallons per day = 4 trips with 300 gal tank at 15 minutes per trip.

Initial cost of 300 gallon water transport tank = $1000; two 300-gallon galvanized stock tanks cost $238 (Wheelers, Lincoln). Total initial cost of $1238 amortized for 15 years at 8% gives annual payments of $144.64.

Transporting water requires 90 hours of tractor use ($2471.40 ownership and operation) and 90 hrs of trailer use ($236.70 ownership and operation).

Electricity for pumping water: Assuming a 125' (38 m) head, pumping 1 ha-cm of water takes 17.7 kwh (Batty and Keller 1980). 1 ha-cm = 26417 gallons; at 5 gal/day/hd x 213 hd x 90 days = 95850 gallons. Therefore a total of 64.2 kwh ($6.42) needed to pump cattle water.

Labor requirements

Selley (1996) gives two winter backgrounding budgets for calves that include estimates of labor. Wintering calves for 180 days in the ranch area on stalk pasture and silage requires 2.6 hours labor per head. Wintering calves for 200 days in the crop area of Nebraska on stalk pasture and alfalfa hay requires 2.65 hours labor per head. These labor estimates do not include labor associated with upkeep of fences and water.

The backgrounding period on the organic farm is 90 days or ½ that of Selley's budgets. Also, no moving and feeding of hay or silage occurs on the organic farm. If feeding hay is assumed to account for ½ of the time spent per head in Selley's budgets, then labor per head in the organic farm is .65 hours or 1/4 that of Selley's scenarios. Calculated as labor per day, .65 hrs/hd/90 days x 212 hd = 137.8 hrs/90 days or 1.53 hrs/day. Bringing water to the cattle takes 1 hour per day for the organic farm, and fencing requires .56 hours/day. Total labor associated with backgrounding cattle on the organic farm = 3.09 hrs/day for the 90 day grazing period. An additional 4 hours is assumed for receiving the cattle, and 4 hours for loading the cattle at the end of the 90 days.

Cost summary for backgrounding cattle

Annual costs of owning and operating for components of organic cattle system:

Trailer:	$ 236.70
Water tanks:	$ 144.64
Tractors:	$2471.40
Brome pasture fencing:	$ 112.04
Stalk pasture fencing:	$ 116.20
Electricity:	$ 6.42
Total:	$3087.40

Proportioning of fixed- and variable costs associated with fencing and water systems, and income from grazing fees, based on relative AUMs/A for the different forage types.

Field	Fixed-costs of grazing ($/A)	Variable costs of grazing ($/A)	Total cost of grazing ($/A)	Income from grazing ($/A)
Brome pasture	17.36	6.10	23.48	20.87
Field corn	13.56	4.77	18.33	26.36
Sweet corn	14.65	5.15	19.80	26.36
Alfalfa	3.63	1.28	4.91	6.59
Sorghum	13.68	4.81	18.49	26.36
Turnips	16.98	5.97	22.95	32.95

III. Cost of production

A. Summary of inputs for rowcrops and forages (total for crop; not per acre)

Input	alfalfa	corn grain	milo	soybean	oats/ turnip	corn silage	winter wheat	pasture	wind-break
Land (A)	120	50	30	90	30	30	30	12	23
Power units (hrs)									
tractors	193.0	41.1	27.5	74.1	19.3	24.7	12.4	10.0	6.3
combine		13.2	7.9	23.7	7.9		7.9		
pickup truck	52.1	21.7	13.0	39.0	13.0	13.0	13.0	5.2	10.0
Implements (A)									
disk	30	50	30	90	60	30	30	0	0
field cultivator	30	50	30	90	30	30	30	0	0
6-row planter	0	50	30	90	0	30	0	0	0
row crop cultivator	0	50	30	90	0	30	0	0	0
rotary hoe	0	100	90	180	0	60	0	0	0
mower									18.5
swather	360							24	
baler (tons)	480							21.6	
corn head		50							
grain head			30	90	30		30		
Equipment rental (A)									
seeder/packer	30								
drill					30		30		
spreader	30				30				
Seed, fertilizer, pesticides									

Input	alfalfa	corn grain	milo	soybean	oats/ turnip	corn silage	winter wheat	pasture	wind-break
corn head		.22							
grain head			.20	.20	.20		.20		
Total equip. operation	21.65	16.08	16.85	16.06	13.91	10.23	11.76	12.54	5.94
Equipment rental									
seeder/packer	.94								
drill					5.00		5.00		
spreader	.38				1.50				
Inputs									
baling twine	2.64							1.21	
crop seed	9.54	24.12	5.18	17.02	14.38	24.12	15.00	0	0
seedlings									.84
manure	0	11.65	14.56	0	4.58	27.58	19.30	22.05	0
rock phosphate	3.26								
Custom work									
plowing		5.33							
lay fabric mulch									21.91
trucking	0	13.56	11.16	4.56	7.44	0	4.92	0	0
drying		11.30							
roguing		10.00	20.00	20.00		10.00			
hired labor	1.75	0.47	0	0.26	0	0.78	0	1.95	0
residue grazing variable costs	1.28	4.77	4.81	0	5.97	0	0	6.10	0
shelterbelt variable costs	1.64	1.64	1.64	1.64	1.64	1.64	1.64	1.64	----*
Total variable costs	42.96	98.92	74.20	59.54	54.42	74.35	57.62	45.50	-----*

Input	alfalfa	corn grain	milo	soybean	oats/ turnip	corn silage	winter wheat	pasture	wind-break
field cultivator	.69	2.77	2.77	2.77	2.77	2.77	2.77	0	0
6-row planter	0	11.50	11.50	11.50	0	11.50	0	0	0
row crop cultivator	0	2.21	2.21	2.21	0	2.21	0	0	0
rotary hoe	0	1.82	2.73	1.82	0	1.82	0	0	0
mower	0	0	0	0	0	0	0	0	29.43
swather	12.63							8.42	
baler	14.66							6.89	
corn head		17.20							
grain head			2.68	2.68	2.68		2.68		
residue grazing fixed costs	3.63	13.56	13.68	0	16.98	0	0	17.36	0
shelterbelt fixed costs	5.32	5.32	5.32	5.32	5.32	5.32	5.32	5.32	----*
Total fixed costs	124.26	155.93	144.23	127.81	130.11	98.83	104.22	109.01	-----*
Operating costs									
tractors	12.58	6.42	7.16	6.44	5.03	6.44	3.23	6.52	3.54
combine	0	5.65	5.63	5.63	5.63	0	5.63	0	0
pickup truck	2.22	2.22	2.22	2.22	2.22	2.22	2.22	2.22	2.22
disk	.09	.35	.35	.35	.70	.35	.35	0	.01
field cultivator	.03	.13	.13	.13	.13	.13	.13	0	0
6-row planter	0	.76	.76	.76	0	.76	0	0	0
row crop cultivator	0	.19	.19	.19	0	.19	0	0	0
rotary hoe	0	.14	.21	.14	0	.14	0	0	0
mower									.17
swather	3.57							2.38	
baler	3.04							1.43	

Input	alfalfa	corn grain	milo	soybean	oats/ turnip	corn silage	winter wheat	pasture	wind-break
crop seed	360 lb	13.75 bag	165 lb	99 bag	2100 lb (oats) 30 lb turnip	8.25 bag	2250 lb	0	
seedlings									97
manure (tons)		280	210		66	398	278	128	
rock phosphate (lbs)	2610								
Custom work									
plowing (A)		30							
lay fabric mulch (feet)									1008
trucking (bu)		5650	2790	3420	1860		1230		
drying (bu)		5650							
roguing (A)		50	60	180		30			
hired labor (hrs)	35	3.9		3.9		3.9		3.9	

Laying fabric mulch; 84 seedlings on 12' spacings = 1008' of fabric

B. Costs and returns ($/A), organic row and forage crops.

Input	alfalfa	corn grain	milo	soybean	oats/ turnip	corn silage	winter wheat	pasture	wind-break
Land	53.13	53.13	53.13	53.13	53.13	53.13	53.13	53.13	53.13
Ownership costs									
tractors	31.58	16.14	18.00	16.17	12.63	16.17	8.11	16.37	8.89
combine	0	26.37	26.30	26.30	26.30	0	26.30	0	0
pickup truck	1.52	1.52	1.52	1.52	1.52	1.52	1.52	1.52	1.52
disk	1.10	4.39	4.39	4.39	8.78	4.39	4.39	0	.03

Input	alfalfa	corn grain	milo	soybean	oats/ turnip	corn silage	winter wheat	pasture	wind-break
interest on operating capital	2.88	6.63	4.97	3.99	3.65	4.98	3.86	3.05	
overhead	2.29	5.28	3.96	3.18	2.90	3.97	3.07	2.43	
Total expenses	172.39	266.76	227.36	194.52	191.08	182.13	168.77	159.99	
Crop sales	248.35	299.45	218.55	258.02	110.36	243.38	150.88	101.95	
Grazing fees	6.59	26.36	26.36	0	32.95	0	0	20.87	
Net income	82.55	59.05	17.55	63.50	-47.77	61.25	-17.89	-37.17	

*Shelterbelt fixed and variable costs distributed proportionally among other crops based on acreage.

Calculating gross income:

Alfalfa hay: 3.9 tons/A x $63.68/ton = $248.35/A
Corn: 113 bu/A x $2.65/bu = $299.45/A
Sorghum: 93 bu/A x $2.35/bu = $218.55/A
Soybeans: 38 bu/A x $6.79/bu = $258.02/A
Oats: 62 bu x $1.78/bu = $110.36/A
Corn for silage: 14.6 tons/A x $16.67/ton = $243.38/A
Wheat: 41 bu/A x $3.68/bu = $150.88/A
Grass hay: 1.8 tons/A x $56.64/ton = $101.95/A

C. Summary of inputs for vegetable crops (total for crop; not per acre)

Input	Sweet corn	Pumpkins	Acorn squash	Peppers	Spinach
Land (A)	3	2	2	2	1
Power units (hrs)					
tractors	12	7	11.2	26.1	12.9
pickup truck	30	20	20	20	10
cooling room				360	

Input	Sweet corn	Pumpkins	Acorn squash	Peppers	Spinach
ice crusher (cwt ice)	144				48
Implements (A)					
disk	6	6	8	10	6.5
field cultivator	9	4	4	2	1.5
6-row planter	3	2	2		
1-row planter					1
sprayer		4	4		4
row crop cultivator	6	4	4	6	2
rotary hoe	3	2	2		
bed shaper				2	1
pipe trailer	6	4	4	4	2
transplanter				2	
trailer	6	2	6	10	1
irrigation system	3	2	2	2	1
Equipment rental (A)					
drill			2	2	1
Seed, fertilizer, pesticides					
crop seed (lb)	36	1.87	2.0		10
transplants				28000	
annual rye (lb)					*

Input	Sweet corn	Pumpkins	Acorn squash	Peppers	Spinach
wheat (lb)			150	150	
manure (tons)	39	12	12	32	15
Trichogramma (card)	6				
Pyrellin E.C. (qt)		6	6		
Bt-Dipel (lb)					2.25
insecticidal soap (qt)					9.0
Irrigation water (ac-in)	19.6	16.8	14	16.8	6.3
Hired labor (hr)	19	16	19.5	19.5	0
Custom operations					
spread manure (A)	3	2	2	2	1
truck produce (cwt)	180	360	200	504	60
Harvest costs					
packing containers	600	72	1000	2000	300
cooling (hrs)				360	
ice (lb)	14,400				4800
marketing fee					

D. Vegetable costs of production and net returns ($/A)

Input	Sweet corn	Pumpkins	Acorn squash	Peppers	Spinach
Land	53.13	53.13	53.13	53.13	53.13
Equipment ownership					
tractors	78.56	68.75	109.99	256.30	253.36
pickup truck	35.10	35.10	35.10	35.10	35.10
disk	8.78	13.17	17.56	21.95	28.54
field cultivator	8.31	5.54	5.54	2.77	4.16
6-row planter	11.50	11.50	11.50		
1-row planter					92.00
sprayer		53.28	53.28		106.56
row crop cultivator	4.42	4.42	4.42	6.63	4.42
rotary hoe	0.91	0.91	0.91		
bed shaper				49.33	49.33
pipe trailer	7.50	7.50	7.50	7.50	7.50
transplanter				115.50	
trailer	4.48	2.24	6.72	11.20	2.24
irrigation system	54.11	54.11	54.11	54.11	54.11
cooling room	0	0	0	101.85	0
ice crusher	29.21	0	0	0	29.21
Total equip-ment owning	270.37	261.69	326.22	662.24	663.90
residue grazing fixed costs	14.65				
shelterbelt fixed costs	5.32	5.32	5.32	5.32	5.32

Input	Sweet corn	Pumpkins	Acorn squash	Peppers	Spinach
Total fixed costs	343.47	320.14	384.67	720.69	722.35
Equipment operation					
tractors	31.28	27.38	43.80	102.06	100.88
pickup truck	51.10	51.10	51.10	51.10	51.10
disk	0.70	1.05	1.40	1.75	2.28
field cultivator	0.39	0.26	0.26	0.13	0.20
6-row planter	0.76	0.76	0.76		
1-row planter					0.33
sprayer		0.30	0.30		0.60
row crop cultivator	0.38	0.38	0.38	0.57	0.38
rotary hoe	0.07	0.07	0.07		
bed shaper				0.78	0.78
pipe trailer	2.50	2.50	2.50	2.50	2.50
transplanter				1.60	
trailer	0.78	0.39	1.17	1.95	0.39
irrigation system	36.98	47.54	39.62	47.54	35.66
cooling room	0	0	0	84.60	0
ice crusher	18.75	0	0	0	18.75
Total equipment operation	147.60	130.64	139.62	294.58	209.85
Equipment rental (A)					
drill			5.00	5.00	5.00
Seed, fertilizer, pesticides					

Input	Sweet corn	Pumpkins	Acorn squash	Peppers	Spinach
crop seed	93.60	31.98	26.81		42.20
transplants				2100.00	
annual rye					6.08
wheat			15.00	15.00	
manure	27.04	12.48	12.48	33.28	31.20
Trichogramma	32.18				
Pyrellin E.C.		60.30	60.30		
Bt					28.96
insecticidal soap					115.83
Hired labor	39.00	48.00	58.50	58.50	0
Custom operations					
truck produce	12.00	36.00	20.00	50.40	12.00
Harvest costs					
packing containers	200.00	450.00	320.00	990.00	405.00
ice (incl. shipping)	201.60				201.60
marketing fee	30.00	50.40	50.00	500.00	210.00
residue grazing variable costs	5.15				
shelterbelt variable costs	1.64	1.64	1.64	1.64	1.64
Total variable costs	789.81	821.44	709.35	4048.40	1269.36
interest on operating capital	52.92	55.04	47.53	271.24	85.05

Input	Sweet corn	Pumpkins	Acorn squash	Peppers	Spinach
overhead	42.14	43.82	37.84	215.98	67.72
Total expenses	1228.34	1240.44	1179.39	5256.31	2144.48
Crop sales	1706	2518	2306	8640	3717
Grazing fees	26.36	0	0	0	0
Net income	504	1278	1127	3384	1573

Calculation of gross income:

Sweet corn: 1000 doz/A x $8.53/5 doz = $1706/A
Pumpkins: 18000 lbs/A x $139.89/1000 lbs = $2518/A
Acorn squash: 10000 lbs/A x $11.53/50 lbs = $2306/A
Peppers: 1000 bu/A x $8.64/bu = $8640/A
Spinach: 6000 lbs/A x $12.39/20 lbs = $3717

Organic farm summary budget table

LAND

	Acres	Cost/A	Total
Owned	255	35.89/A	9,152
Rented	170	79.00/A	13,430

EQUIPMENT

Item	Annual ownership cost	Annual cost of operation (excl. labor)
Power units		
120 hp tractor	6241	2308
100 hp tractor	4815	2165
185 hp combine*	6052	1305
½ ton pickup	983	1431
Implements		
disk	1553	124
rowcrop cultivator	490	42
field cultivator	862	40
rotary hoe	398	31
sprayer	373	2
6 row corn head*	860	11
15' grain head*	483	36
6 row planter	2380	157
swather*	1617	457
baler*	1841	382
flatbed trailer	258	45
pipe trailer	75	25
1-row planter	92	1
mower	677	4
bed shaper	148	2
transplanter	231	3
irrigation system	541	416
cooling room	204	169

ice crusher	117	75
fencing	155	73
water tanks	145	0
Total equipment costs	31591	9304

*Ownership costs shared with agroforestry farm.

EQUIPMENT RENTAL

spreader	91
drill	325
seeder-packer	113
Total	529

INPUTS

baling twine	331
seedlings	4219
seed	6150
fertilizer	3448
pesticides	483
ice	806
packing containers	4525
Total inputs	19962

CUSTOM OPERATIONS

lay fabric weed barrier	504
roguing	3200
trucking	2055
dry corn	565
plowing	267
marketing fees	1501
Total custom	8092
Hired labor	751
Total operations costs	38,638

OVERHEAD AND INTEREST

Interest on operating capital	2589
Overhead	2061
Total overhead and interest	4650

GROSS INCOME

alfalfa hay	29802
brome hay	1223
corn grain	14973
corn silage	7301
sorghum	6557
oats	3311
wheat	4526
soybeans	23222
sweet corn	5118
pumpkins	5036
acorn squash	4610
bell peppers	17272
spinach	3717
grazing rent	4218
Total	130886

TOTAL EXPENSES	97461
SALES	130886
NET INCOME	33425

Table A4-8. Fertilizer recommendations and contributions from manure in the organic rotation. Crops are listed in their order in the rotation. Nitrogen availability from manure follows decay series of Gilbertson et al. (1979). See text for details.

N fertilizer	Alfalfa year 1	Alfalfa year 2	Alfalfa year 3	Alfalfa year 4	corn for grain	grain sorghum	soybeans	vegetables/corn *	soybeans	oats/-turnips	soybeans	corn silage	winter wheat
recommended N	0	0	0	0	115	70	0	110	0	60	0	112	60
legume credit N					150	35	0	45	0	45	0	45	0
N needed	0	0	0	0	0	35	0	65	0	15	0	67	60
manure applied (tons/A)	0	0	0	0	0	7.00	0	12.56	0	2.20	0	13.26	9.28
available N from manure **						35	7	2.2 62.8	1.0 12.6	4.0 11.0	1.9 2.2	.7 66.3	.3 13.3 46.4
P2O5 recom.	60	0	0	0	25	0	25	46	25	30	25	25	25
P2O5 in manure	***					42		75.4		13.2		79.6	55.7
K2O recom.								57					
K2O in manure						70		126		22		133	93

(Table footnotes on next page)

* Weighted mean for 30 acres consisting of 20 acres field corn (14 tons manure/A), 3 acres sweet corn (13 tons/A), 2 acres pumpkins (6 tons/A), 2 acres acorn squash (6 tons/A), 2 acres peppers (16 tons/A), and 1 acre spinach (15 tons/A). Pasture receives 10.6 tons/A.

** Multiple values for one crop show the nitrogen available from different applications of manure. The sum of values in a cell is the total N available to the crop.

From Gilbertson et al. (1979), Table 13, manure at 3% N (dry weight basis; = 12 lb N/ton at 80% moisture) has decay constants of .50 for year 1, .20 for year 2, .08 for year 3, and .04 for years 4 and beyond. This means that 50% of the N in the original manure (6 lbs/ton) is available the first year; 20% of the residual nitrogen is available the second year, etc. Page 31, Table 12, the amount of manure needed to provide a certain level of N is increased by a factor of 1.2 to account for volatilization and denitrification in a Sharpsburg silty clay loam soil with immediate incorporation of the manure. A factor of 1.33 is used for surface application with no incorporation on the pasture.

*** 87 lbs rock phosphate applied per acre (= 20 lbs P2O5, 1-3% of which is available).

Legume nitrogen credits from Ferguson et al. (1994) and Hergert et al. (1995).

Beef cattle manure assumed to have 80% moisture, 12 lbs N/ton, 6 lbs P2O5/ton, and 10 lbs K_2O/ton. Composition is based on the mean of values for beef cattle manure given by Ensminger (1983), Brady (1974), and Souchelli (1965). UNL feedlot manure averages 12 lbs N/ton (Lesoing, pers. comm.).

Corn silage N fertilizer rate based on 14 ton yield goal and prorated from Selley (1996) recommendations for 20 ton (irrigated) yield goal.

Brome pasture gets 80 lbs N/yr; Manure is 3% N on dry wt basis; from table 14 in Gilbertson et al. (1979), after 20 years of yearly applications, 1.6 tons dry manure needed annually to ensure supply of 80 lbs N if no volatilization or denitrification; multiply by 1.33 (table 12) to account for losses in surface applied manure = 2.13 dry tons = 10.6 tons/A at 80% moisture.

Table A4-9. Estimating the cost of the organic farm irrigation system.

Irrigation pump: Cost in 1988 of a pump for a 5 acre vegetation irrigation system was $2100 (Dan Rogers, KSU). Adjusted for inflation, the 1996 price is $2730. From Klonsky et al. (1994), 10 acre irrigation system (above-ground) costs $2583. Cost of well not included.

Total irrigation system cost = $5313. At 8% for 20 years, annual payments are $541. Annual maintenance costs (5% of initial materials cost) = $266.

Energy costs: From Batty and Keller (1980), energy required to pump 1 ha-cm of water with an electric pump and a total head of 75 m = 33.2 kwh. 1 ac-in = 1.03 ha-cm, so pumping 1 ac-in requires 34.1 kwh of electricity which costs $2.05 at $0.06/kwh.

Appendix 4E.

Forage-based Beef Farm

Baseline economic analysis

I. Characteristics of the beef farm

A. Size

farm size (acres)	460	
% land owned	60	(276 acres)
% pasture	100	

B. Customized equipment list:

Item	Age at trade (yrs)	Annual use	Description
Tractor #1	20	107 hrs	100 hp diesel cab
swather/conditioner	20	107 A	14' pull-type
baler	20	153 tons	large round
pickup	15	280 hrs	½ ton

*Swather/conditioner, baler, and pickup added to baseline list; second tractor, disc, row cultivator, rotary hoe, moldboard plow, field cultivator, sprayer, combine, corn head, grain head, and planter removed from list. Age at trade of tractor increased to 20 years because of low annual use.

C. Operations summary

All land is in pasture with 242 acres of smooth brome (cool season) and 212 acres of big bluestem (warm season). Six acres are devoted to lanes and handling facilities. Weaned calves are purchased in late October, acclimated at an off-farm lot for 28 days, then wintered on rented stalks and alfalfa hay until May when rotational grazing of brome begins. Rotational grazing of big bluestem begins in July, and cattle move back to brome in October until being sent to the feedlot 1 November for finishing.

Yearling cattle from 12-17 months of age are classified as 0.7 Animal Units (AU), and yearlings 18-24 months are 0.8 AU (Waller et al. 1986). In the beef farm model, steers are considered 0.7 AU during May through September, and 0.8 AU in October. Monthly forage demand for May through September is 491 steers (average number after accounting for deaths) x 0.7 = 344 AUM (Animal Unit Month; the forage required to support one AU for one month). Forage demand for October is 487 steers x 0.8 = 390 AUM.

For a pasture in eastern Nebraska on silty soils, intensively managed with rotational grazing and some fertilization, smooth brome can be reasonably expected to produce 4.0 AUM/acre, and big bluestem 5.0 AUM/acre (Waller et al. 1986). The brome AUMs are distributed 40% in May, 20% in June, and 40% in October. The big bluestem AUMs are distributed 20% in July, 40% August, and 40% September. Given 242 acres of brome pasture and 212 A of big bluestem pasture, forage availability on the beef farm in an average year will be May (387 AUM), June (194 AUM), July (212 AUM), August (424 AUM), September (424 AUM), and October (387 AUM).

When forage availability and forage demand are considered in an average year, there is a surplus of forage in May, August, and September; a deficit in June and July; and an approximate balance in October (see Table A5-7; 1993 is an average year for forage production). Surplus grass is converted into hay (1.33 AUM grass makes 1 ton hay; Anderson pers. comm.), which is fed to cattle during deficit months (1 ton hay equals 2.5 AUM; Waller et al. (1986)). Any hay not fed during the summer is used to replenish the farm's carry-over supply of hay, and any remaining after replenishment is sold.

If enough hay is available, the farm carries 119 tons of hay to the following year. This allows the farm to make it through a year in which grass production is 10% below average without having to purchase hay.

Date	brome pasture (242 acres)	big bluestem pasture (212 acres)	British-breed steers
24 Oct			purchase 497 steers*; begin acclimation
22 Nov			begin stalk grazing
17 Feb			begin feeding alfalfa hay
5 April	apply nitrogen fertilizer		
25 April		burn 25% of total area each year	
1 May			move steers to brome pasture; begin rotational grazing

Date	brome pasture (242 acres)	big bluestem pasture (212 acres)	British-breed steers
18 May		apply nitrogen fertilizer	
28 May	cut and bale excess grass		
1 July			move steers to bluestem pasture; begin rotational grazing
18 August		cut and bale excess grass	
18 September		cut and bale excess grass	
1 October			return to brome pasture; begin final rotation
18 October		spray 10% of total area each year	
1 November			move to feedlot for finishing; sell after 84 days (23 January)

*Death loss of 2% assumed; results in 487 steers sold for slaughter following January.

Synthetic beef gain schedule derived from Shain et al. (1995, 1996, 1997).

Date	Activity	# days	gain (lb)/day	final weight (lbs)
24 Oct	Purchase			475
24 Oct-21 Nov	Receiving	28	1.1	505
22 Nov-30 Apr	Backgrounding*	160	0.6	601
1 May-31 Oct	Grazing	184	1.8	932
1 Nov-23 Jan	Finishing	84	3.8	1251

*90 days on corn stalks; 70 days fed alfalfa hay

D. Summary of inputs (per acre) by crop for the pasture-based beef farm.

Input	brome pasture	bluestem pasture	cattle (per head)
N (as ammonium nitrate)	80 lbs N (240 lbs ammonium nitrate)	50 lbs N (150 lbs ammonium nitrate)	
Roundup		12 oz/A	
health costs (vet, implants, fly tags, etc)			$15.00
Winter mineral supplement			1.5 lb/day
Summer mineral supplement			40 lbs total
Water			10 gal/hd/day

Health costs from Shain et al. (1997). Roundup rate from Nebraska Herbicide Guide.

At high end of pasture rents, landlord will provide materials (not labor) for exterior fencing, and will provide a water source (pond or well).

E. Equipment ownership and use.

Costs interpolated from tables in Powell et al. (1992) with values increased 10% to account for inflation from 1992 to mid-1996. Pickup truck costs from Klonsky et al. (1994). Annual use derived from baseline operations scenario for the beef farm.

Power unit	Annual cost of owning	Annual use (hrs)	Ownership cost per hour use	Operation cost per hour use
100 hp tractor	4986	107 hrs	46.60	5.75
pickup	983	600	3.51	5.11

Implement	Annual cost of owning	Annual use (acres)	Ownership cost per acre use	Operation cost per acre use
swather	1818	107.2	$16.96	$.77
baler	1678	153 tons	$10.97/ton	$.50/ton
fence system	4247	460	$9.23	$3.44*
water system	1136	460	$2.47	$1.19*
handling facilities**	900	460	$1.96	$0.98

*Includes electricity

** Based on total annual cost for buildings and equipment of $2.75/head (Selley 1995) apportioned 67% to cost of ownership and 33% to maintenance. For 21 acres annual use, cost per acre to own a 300 gallon 15' pull-type sprayer = $16.14. Average cost per acre for custom spraying in eastern Nebraska = $3.83. Therefore, custom spraying is used.

II. Calculations (costs rounded to nearest dollar)

Land

Owned: 276 A x $19.67/A = $5429

From Johnson (pers. comm.); average debt on owned farmland is 20% of value. For eastern Nebraska, $705/A (average value for high grade tillable grazing land, eastern Nebraska, Johnson (1995)) x .2 = $141/A. Amortized for 30 years at 8%: $141/A x .088827 (from amortization table) = $12.52/A interest and principle payments per year. Plus real estate taxes of $7.15/A = $19.67/A.

Rented: 184 A x $36/A = $6624

A. Weekly calculations

Note: Routine cattle care (e.g., moving between paddocks) for the 184 days on pasture is estimated as 1.1 hrs/hd (540 hours total for all steers for the summer). Estimate based on $0.25/A labor costs (Selley 1995) and $6.00 per hour for labor. Fence maintenance requires 160 hours/year, and water system maintenance requires 40 hours/year (see Section III, Appendix 4E). Including 22 hours for other miscellaneous tasks, total annual labor for routine care and maintenance equals 762 hours; approximately 6 hours/week during 1-30 April and 1-15 November, and 27 hours/week when cattle are in residence 1 May - 31 October. These routine hours are not shown in the following weekly calculations.

1st week April:

Spread ammonium nitrate: 242 A ÷ 10 A/hr = 24.2 hrs (x 1.2 = 29.0 hrs)

100 hp tractor: 24.2 hrs x $5.75 /hr = $139
spreader rental: 242 A x $1.50/A = $363
ammonium nitrate: 242 A x 80 lbs N/A x $.25 /lb N = $4840

3rd week May:

Spread ammonium nitrate: 212 A ÷ 10 A/hr = 21.2 hrs (x 1.2 = 25.4 hrs)

100 hp tractor: 21.2 hrs x $5.75 /hr = $122
spreader rental: 212 A x $1.50/A = $318
ammonium nitrate: 212 A x 50 lbs N/A x $.25/lb N = $2650

4th week May:

Cut and swath hay: 27.4 A ÷ 5.7 A/hr = 4.8 hrs (x 1.2 = 5.8 hrs)
Bale hay: 33 tons ÷ 6.3 tons/hr = 5.2 hrs (x 1.2 = 6.2 hrs)
Move bales: 27.4 A ÷ 10 A/hr = 2.7 hrs (x 1.2 = 3.2 hrs)

Total labor = 15.2 hrs

100 hp tractor: 12.7 hrs x $5.75/hr = $73
swather/conditioner: 27.4 A x $.77/A = $21
baler: 33 tons x $.50/ton = $17

1st week June through 4th week June:

Move bales to feed cattle: 15.05 tons/week x 4.2 minutes per ton = 1.05 hrs (x 1.2 = 1.3 hrs) per week

100 hp tractor: 1.05 hrs x $5.75/hr = $6

1st week July through 4th week July:

Move bales to feed cattle: 13.2 tons/week x 4.2 minutes per ton = .92 hrs (x 1.2 = 1.1 hrs)

100 hp tractor: 1.05 hrs x $5.75/hr = $6

3rd week August:

Cut and swath hay: 39.9 A ÷ 5.7 A/hr = 7.0 hrs (x 1.2 = 8.4 hrs)
Bale hay: 60 tons ÷ 6.3 tons/hr = 9.5 hrs (x 1.2 = 11.4 hrs)
Move bales: 39.9 A ÷ 10 A/hr = 4.0 hrs (x 1.2 = 4.8 hrs)

100 hp tractor: 20.5 hrs x $5.75/hr = $118
swather/conditioner: 39.9 A x $.77/A = $31
baler: 60 tons x $.50/ton = $30

3rd week September:

Cut and swath hay: 39.9 A ÷ 5.7 A/hr = 7.0 hrs (x 1.2 = 8.4 hrs)
Bale hay: 60 tons ÷ 6.3 tons/hr = 9.5 hrs (x 1.2 = 11.4 hrs)
Move bales: 39.9 A ÷ 10 A/hr = 4.0 hrs (x 1.2 = 4.8 hrs)

100 hp tractor: 20.5 hrs x $5.75/hr = $118
swather/conditioner: 39.9 A x $.77 = $31
baler: 60 tons x $.50/ton = $30

3rd week October:

Custom spray: 21 A x $3.83/A = $80
Roundup: 12 oz/A x 21 A x $46.19/gal = $91

B. Calculation of other expenses

Trucking cattle:

24 October: $2/mile/50,000 lbs x 50 miles x 497 steers x 475 lbs/hd = $472

22 November: 495 steers x 505 lbs/hd x $2/mile/50,000 lbs x 20 miles = $200

1 November: 487 steers x 932 lbs/hd x $2/mile/50,000 lbs x 20 miles = $363

Total trucking: $1,035

24 October: Purchase -- 497 steers x 475 lbs/hd x $110.76/cwt = $261,477

Health expenses: 497 steers x $15/hd = $7,455

receiving: $0.74/hd/day x 497 hd x 28 days = $10,298
corn stalks: $0.12/hd/day x 495 hd x 90 days = $5,346
winter alfalfa: $0.30/hd/day x 493 hd x 70 days = $10,353
winter mineral supplement: ($0.12/hd/day x 495 hd x 90 days) + ($0.12/hd/day x 493 hd x 70 days) = $9,487
winter yardage: ($0.10/hd/day x 495 hd x 90 days) + ($0.10/hd/day x 493 hd x 70 days) = $7,906
summer mineral supplement: $0.12/lb x 40 lbs/hd x 491 hd = $2,357
finishing yardage: $.30/hd/day x 487 hd x 84 days = $12,272
finishing feed: $.0467/lb DM x 30 lb DM/hd/day x 487 hd x 84 days = $57,312

C. Beef farm summary budget table

LAND

	Acres	Cost/A	Total
Owned	276	19.67/A	5429
Rented	184	36.00/A	6624

EQUIPMENT

Item	Annual ownership cost	Annual cost of operation (excl. labor)
Power units		
100 hp tractor	4,986	618
½ ton pickup	983	3,066

Implements

swather	1,818	83
baler	1,678	77
fence system	4,247	1,307
water system	1,136	374
handling facilities	900	451
Total	15,748	5,976

EQUIPMENT RENTAL

spreader	681
Total	681

CHEMICALS

fertilizer	7,490
herbicide	91
Total chemicals	7,581

LIVESTOCK

purchase calves	261,477
health costs	7,455
receiving	10,298
corn stalks	5,346
winter alfalfa	10,353
winter mineral supplement	9,487
winter yardage	7,906
summer mineral supplement	2,357
finishing yardage	12,272
finishing feed	57,312
Total livestock	384,263

CUSTOM OPERATIONS

trucking cattle	1,035
spraying	80
Total custom	1,115

Hired labor	0
Total operations costs	399,616
Total ownership and ops costs	427,417

OVERHEAD AND INTEREST

Interest on operations excluding finishing: 330,032 x .10 x 15/12 = 41,254
Interest on finishing costs: 69,584 x .10 x .25 = 1,740
Overhead: 442,610 x .05 = 22,131

Total overhead and interest: 65,125

TOTAL EXPENSES	492,542
TOTAL SALES	
cattle*	519,984
hay**	2,152
NET INCOME	29,594

*23 January: Sell 487 steers x 1251 lbs/hd x $85.35/cwt = $519,984
**38 tons excess hay sold at $56.64/ton; 38 tons is the excess in 1993, the benchmark (average) year for hay yield

III. Beef farm fencing and water system

Fence design and costs for analog beef farm

Assumptions:

The 245 acres of smooth brome pasture are equally divided among four 61.25 acre permanent pastures. The 215 acres of big bluestem pasture are equally divided among four 53.75 acre permanent pastures. The eight pastures are square, and share no common exterior fence. Each pasture is divided with interior fencing into eight equal paddocks. An 18' wide alley runs down the middle of each pasture 3/4 of its length.

This design gives each 61.25 acre pasture 6534' of perimeter fence and 7757' of interior fence. The 53.75 acre pastures have 6120' of perimeter fence and 7268' of interior fence. Totals for the eight pastures are 50,616' (9.59 miles) of perimeter fence and 60,100' (11.38 miles) of interior fence.

Exterior fencing is 4-strand high-tensile electric. Interior fences are 2-strand high-tensile electric.

Costs of fencing materials from Norton et al. (1996):

Cost of materials for perimeter 4-strand high-tensile electric (HTE) fencing.

Component	total amount	cost ($) per unit	total cost per 1/4 mile
wire, 12.5 gauge (4 strands)	5280 feet	.021/ft	$111.00
Line posts, 45' spacing	29	$4.40/post	$128.00
Other fencing materials			$50.00
H-braces	2	$30.00/brace	$60.00
Total			$349.00

Contractor labor for 1/4 mile costs $454. At $12/hr, assume 38 hours labor.

Cost of materials for permanent interior 2-strand high-tensile electric (HTE) fencing.

Component	total amount	cost ($) per unit	total cost per 1/4 mile
wire, 12.5 gauge (2 strands)	2640 feet	.021/ft	$55.00
Line posts, 45' spacing	29	$4.00/post	$116.00
Other fencing materials			$50.00
H-braces	2	$30.00/brace	$60.00
Total			$281.00

Contractor labor for 1/4 mile is $363. At $12/hr, this is 30 hours labor.

Gates: Assume total of 16 perimeter gates and 64 interior gates at $15 per exterior gate and $10 per interior gate = $880.

Power source: Only 2 of the 4 perimeter wires are hot, and both interior wires are hot. Total electrified wire for a cool-season pasture is approximately 5.5 miles. A medium-strength, 110V, 2.1-3.7 joules AC energizer can easily handle this: cost = $180. Assume a half-mile HTE lead-out fence to connect energizer to the fence: cost = $150.

Total materials costs ($) for the eight beef farm pastures.

Components	Total amount	Cost per unit	Total cost
Perimeter fence	9.59 miles	$349 per 1/4 mile	$13388
Interior fence	11.38 miles	$281 per 1/4 mile	$12791
Energizers	8	$180 each	$1440
Grounding rod	40	$8 each	$320
Lightning arrestor	8	$8 each	$64
Cut-out switch	32	$8 each	$256
Lead-out fence	4 miles	$150 per 1/4 mile	$2400
Perimeter gate	16	$15 each	$240
Interior gate	64	$10 each	$640
Total			$31539

Labor costs: 3207 hours of labor are needed to build the entire fencing system. At $6/hr, this costs $19242.

Annual fencing costs

The lifespan of HTE fence is 25 years. Average annual maintenance costs are 5% of initial materials cost.

For rented land, the landowner pays cost of materials for perimeter fencing. Forty percent of land is rented, so landlord pays 40% of materials cost for perimeter fencing = $5451.

Initial cost to the beef farm of building the fence system is $31539 - $5451 + $19242 = $45,330. At 8% interest for 25 years, annual payments = $4247. Average annual maintenance costs for materials are $31539 x .05 = $1577 of which the landlord pays $273 for materials associated with the perimeter fence.

Labor hours for fence construction and maintenance:

Labor hours for building components are 1/4 mile interior fence = 30 hours; 1/4 mile perimeter fence = 38 hours; 1 gate = 1 hour; 1 energizer system = 8 hours; 1/4 mile lead-out fence = 15 hours. Total hours to build the entire 8-pasture system = 3207. To do annual maintenance on all fencing takes 3207 x .05 = 160 hours.

Cost of electricity:

Energizers are 2.1 to 3.7 joules or an average of 2.9 joules. One hour of operation requires 2.9 watt-hours of electricity. Only four energizers operate at one time, and the total grazing period is 184 days. So, a total of 51.2 kwh electricity are used to energize the fences each year at a cost of $0.06/kwh or $3.07 total.

Water system design and costs for analog beef farm

Materials and costs for water system for one pasture. Water source and transfer to edge of pasture not included. Design and costs from Cramer (1992).

Component	cost per unit	amount	total cost
2" PVC pipe, buried	$.30 per foot	1400'	$420
3/4" GEM 409 pipe, aboveground	$.16 per foot	400'	$64
water tank - 25 gal. UV stabilized polyethylene	$35 each	4	$140
full-flow tank valves	$24 each	4	$96
coupler	$17 each	4	$68
other hardware for tank hook-up	$10 per tank	4	$40
Total			$828

Annual water system costs

Total within-pasture water system costs for beef farm = (4 x $828) + (4 x $524) = $5408; the water tanks, flow valves and couplers are moved from the cool- to the warm-season pastures, so only one set purchased per pair of pastures. Cost of pump = $2730 (see organic farm irrigation notes). Assume 5280' of aboveground 2" PVC pipe to connect well to edge of pasture systems at a cost of $1584. Well is a very long term purchase and is not included in the annual cost of the water system.

Total initial cost for water system = $9722. At 8% for 15 years, annual payments are $1136. Annual maintenance materials cost for entire system is 3% of original materials cost or $292. Annual maintenance labor estimated at 25% of that for fencing system or 40 hours.

Energy costs: From Batty and Keller (1980), energy required to pump 1 ha-cm of water with an electric pump and a total head of 75 m = 33.2 kwh. 1 ac-in = 1.03 ha-cm, so pumping 1 ac-in requires 34.1 kwh of electricity which costs $2.05 at $0.06/kWh. 1 ac-in = 27,154 gallons. At 12 gallons/head/day (NRC 1996), 491 head will drink 1084128 gallons of water during the 184 day grazing period. Pumping this much water will use 1361 kWh of electricity costing $82.

Appendix 5.

Estimating annual variability in net income for five farming systems.

Annual expenses, gross income and net income were calculated for each farming system for each year from 1985 through 1994, the last year for which complete data was available at the time these analyses were performed. All prices were deflated to constant (1996) dollars using quarterly inflation data (Table A5-1). This removes the effect of inflation and makes the calculated incomes for different years directly comparable.

Gross income from the major field crops was determined using average annual yields for Saunders County and average market year prices for eastern Nebraska (Table A5-2). Based on discussions with local growers and personnel at Lovelace Seed Company, constant prices were used for Christmas trees and hazel nuts for the ten-year period. Vegetable prices follow weekly Chicago Wholesale Market prices (Table A5-3), and vegetable yields are adjusted for spring and fall frosts (Table A5-4). Cattle prices are based on monthly sale prices at Omaha, Nebraska (Table A5-5).

No attempt was made to track yearly variations in prices of individual inputs or interest rates. Instead, annual variations in expenses for each farm were calculated based on yield-sensitive expenses such as drying corn. An increase or decrease in corn yield results in an increase or decrease in farm expenditures for drying. Other yield sensitive expenses include trucking, baling, packing and cooling vegetables, and marketing fees for vegetables.

Irrigation requirements and related expenses for the organic farm vegetables fluctuate depending on precipitation amounts and patterns (Table A5-6).

The beef farm makes hay when the grass supply exceeds the needs of the cattle, and hay is purchased if demand exceeds production and stored hay. A 10-year grass and hay budget for the beef farm is shown in Table A5-7, and used to calculate annual changes in expenses for this farm.

The 10-year series of estimated expenses, gross income and net income for each farm are presented in Table A5-8.

Ancillary data

Table A5-1. Price index for gross domestic purchases; % change by quarter expressed as annual rate of change (Larkin et al. 1996). This index is a measure of the prices paid for goods and services purchased by U.S. residents.

Year/quarter	Index	Year/quarter	Index	Year/quarter	Index
1996-II	2.5	1992-II	3.2	1988-II	5.0
I	2.5	I	2.7	I	3.3
1995 - IV	2.1	1991-IV	2.2	1987-IV	3.7
III	1.7	III	2.5	III	3.8
II	2.9	II	2.4	II	4.7
I	2.8	I	3.6	I	4.4
1994-IV	2.6	1990-IV	6.3	1986-IV	3.5
III	3.5	III	5.1	III	2.8
II	3.2	II	2.9	II	.4
I	2.5	I	7.1	I	1.7
1993-IV	2.3	1989-IV	4.0	1985-IV	4.5
III	1.8	III	2.5	III	2.7
II	2.9	II	5.4	II	3.6
I	3.4	I	5.0	I	4.0
1992-IV	2.9	1988-IV	4.2		
III	2.5	III	5.3		

Table A5-2. Crop yields[1] and prices[2], 1985-1994. Prices deflated to constant dollar basis (mid-1996).

	Field corn		Soybean		Sorghum		Alfalfa		Wheat		Other tame hay	
Year	Yield	Price	Yield	Price	Yield	Price	Yield	Price	Yield	Price	Yield	Price
1985	113	3.15	34	6.93	75	2.74	3.6	55.95	43	4.08	2.2	49.84
1986	123	2.10	38	6.35	92	1.89	3.6	49.35	34	3.22	2.1	45.04
1987	96	2.61	30	7.75	84	2.15	3.7	57.86	38	3.35	2.1	52.67
1988	85	3.15	27	9.30	96	2.77	3.1	95.89	43	4.72	1.4	79.50
1989	90	2.81	33	6.67	76	2.49	3.1	98.82	36	4.66	1.9	83.45
1990	93	2.64	29	6.52	99	2.39	3.4	66.12	51	3.02	1.7	59.28
1991	103	2.63	32	6.22	106	2.54	3.4	53.11	34	3.50	2.1	48.82
1992	133	2.29	41	5.95	99	1.98	3.7	48.95	30	3.54	2.2	44.99
1993	92	2.68	34	6.68	63	2.45	3.6	54.57	26	3.11	2.0	50.83
1994	121	2.48	47	5.57	110	2.06	3.8	56.16	36	3.64	2.1	52.00
mean	105	2.65	35	6.79	90	2.35	3.5	63.68	37	3.68	2.0	56.64

	Oat		Corn silage (tons/A)	
Year	Yield	Price	Yield	Price
1985	84	1.75	16	20.34
1986	78	1.61	15	12.58
1987	55	2.22	16	16.35
1988	55	3.11	12	20.34
1989	46	1.94	11	17.83
1990	64	1.39	11	16.57
1991	62	1.33	10	16.49
1992	73	1.43	17	13.98
1993	32	1.52	12	16.86
1994	47	1.45	16	15.39
mean	60	1.78	13.6	16.67

[1]Yields in bu/ac except alfalfa hay and other tame hay which are tons/ac. Yields are averages for dryland farming in Saunders County. Data from Nebraska Agricultural Statistics, Nebraska

Agricultural Statistics Service, Nebraska Department of Agriculture, Lincoln, 1993/94, 1991/92, 1990/91, 1989, 1988, 1986, 1994-95.

[2] Crop prices are crop market year averages for the East Agricultural Statistics District. Crop market years are 1 Sept - 31 August for corn, sorghum, soybean; 1 June - 31 May for wheat, oat, and hay. Silage price is price for corn standing in field (field value) based on price of corn grain by formula of Guyer and Duey (1986).

Crop prices are deflated to a constant dollar basis (mid-1996) using the price index for gross domestic purchases (U.S. Department of Commerce, Survey of Current Business). This index measures the prices paid by U.S. residents for goods and services. Increases in the index are reported by quarter as the percent increase at an annual rate from the previous quarter. To develop a price trend from 1 January 1986, the quarterly figures were each divided by 4, then multiplied to capture compound rather than additive growth.

The January 1 index falling within the crop market year is used to deflate each price; for example, the average price for the 1985 crop market year is deflated using the 1 January 1986 index. For cattle, the November prices are deflated using the index for the following January. April prices are deflated using the average of the index for the prior and following Januaries.

Table A5-3. Chicago Wholesale Market Prices (USDA 1994 and other years) adjusted for inflation to constant 1996 dollars. Prices are for Illinois produce with prices for California produce occasionally substituted for spinach. Records no longer available from USDA for 1986, so average of the other nine years used as a surrogate (except spinach; actual price available for 1986). Pumpkin prices are earliest reported each year, generally first week of October. Pumpkin price series 1990-1994 used in place of unavailable data for 1985-1989.

week/month	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
Spinach, cartons, bunched, 24s										
3rd week May	13.65	14.75	13.18	11.70	14.24	11.89	11.11	11.64	10.78	9.99
4th week May	13.65	14.75	13.18	11.70	14.24	11.89	13.10	11.64	10.78	9.99
Sweet corn, crates and cartons, 4-5 dozen, yellow, pre-cooled										
2nd week August	9.34	8.37	6.08	9.10	5.57	8.32	13.10	8.04	9.70	6.05
3rd week August	8.62	8.97	6.08	11.38	11.76	7.73	12.53	6.65	9.70	6.31
4th week August	8.26	8.46	8.45	11.70	12.69	4.16	11.96	6.10	7.55	5.26
1st week September	7.19	8.42	10.82	9.75	11.76	6.54	10.82	5.55	7.01	6.31
2nd week September	6.47	8.23	10.82	9.10	11.76	6.84	9.11	5.55	7.82	6.58
3rd week September	7.90	8.74	10.82	9.10	12.38	8.32	9.11	5.82	8.62	6.58
Pumpkins, bins, Jack-o'-lantern type										
2nd week September	136.	227.	105.	140.	89.42	136.	227.	105.	140.	89.42
4th week September	136.	227.	105.	140.	89.42	136.	227.	105.	140.	89.42

week/month	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
Acorn squash, 1 1/9 bu crates, medium										
2nd week August	10.06	11.90	9.46	13.00	12.38	10.70	14.24	13.31	12.40	11.57
3rd week August	9.34	10.87	9.46	12.35	12.38	9.51	10.25	12.20	11.86	10.52
4th week August	8.62	10.22	8.79	13.65	11.76	8.32	6.26	12.20	11.86	10.52
Bell pepper (green), large, 1 1/9 bu cartons										
3rd week August	10.06	10.60	12.84	14.95	11.76	8.92	9.68	7.76	10.24	9.21
4th week August	7.90	9.45	10.48	13.33	11.14	7.73	8.54	8.32	9.70	7.89
1st week September	7.19	9.20	10.82	11.70	10.83	7.73	8.54	9.43	9.16	7.36
2nd week September	7.90	9.35	12.17	13.00	11.76	5.65	8.54	8.59	9.16	7.36
3rd week September	7.90	9.37	12.17	9.75	11.14	7.73	11.11	7.21	9.70	7.63

Table A5-4. Estimated vegetable yields based on frost dates in Table A5-6.

Year	Spinach (lbs)	Pumpkins (110 days) (lbs)	Peppers (bu)
1985	6000	20000	1000
1986	6000	20000	1000
1987	6000	20000	1000
1988	6000	20000	1000
1989	4800	16000	1000
1990	4800	20000	1000
1991	6000	16000	900
1992	4800	20000	1000
1993	6000	20000	1000
1994	4800	20000	1000

Table A5-5. Omaha, Nebraska sale prices ($/cwt) for steers (Wellman 1995) in constant 1996 dollars.

Year	October price, choice feeder steers, 400-500 lbs	January price, choice slaughter steers, 1100-1300 lbs
1984	100.16	-------------
1985	99.57	-------------
1986	96.98	85.82
1987	123.97	82.17
1988	128.31	87.69
1989	115.82	93.02
1990	117.53	94.99
1991	110.60	91.79
1992	108.89	80.47
1993	105.72	87.06
1994	---------	76.05
1995	----------	74.39*
Mean	110.76	85.35

*From USDA (1995) for week ending 1/28/95.

Table A5-6. Calculation of estimated annual irrigation requirements for organic farm vegetables.

Vegetables need 1" of water per week, and peppers may require 2" if it is very hot at the time of flowering and fruiting (Laurie Hodges, UNL Horticulture). Assuming a 70% irrigation efficiency (Kittiampon and Favis 1989), 1.4" of water should be applied if 1" of available water is needed.

Monthly precipitation data from the Mead, NE weather station (NOAA 1985-1994; data not shown) were used to determine monthly irrigation requirements for organic vegetables:

Month's ppt	# of 1.4" irrigations
0-2"	4
2-4"	2
4-6"	1
>6"	0

The number of 1.4" irrigations needed each month for organic vegetable production. Frost dates are used in estimating vegetable yields in Table A5-4.

Year	April	May	June	July	August	Sept	last spring frost	first fall frost
1985	2	2	2	2	2	2	4-9	9-26
1986	1	2	2	1	1	0	4-22	10-13
1987	4	0	4	2	0	4	4-13	10-3
1988	4	2	4	2	4	1	4-28	10-7
1989	4	4	1	1	4	1	5-7	9-23
1990	4	1	1	0	4	4	5-1	10-10
1991	2	2	0	2	4	2	4-11	9-19
1992	4	4	4	0	4	2	5-6	10-11
1993	2	1	0	0	0	1	4-20	10-9
1994	4	4	0	1	4	2	5-2	10-25
Mean	3.1	2.2	1.8	1.1	2.7	1.9	4-24	10-6

Based on last frost date, reduce spinach yields 20% in 1989, 1990, 1992 and 1994. Based on first frost date, reduce pepper yield 10% in 1991; 110 day pumpkin yield 20% in 1989 and 1991.

Table A5-7. Grass production (AUMs) by month for the beef analog farm, 1985-1994. Annual differences in production are proportional to annual deviations from the mean of tame hay yields for Saunders County (see Table A5-2) — 1993 is an average year for grass production.

Yearling cattle from 12-17 months of age are classified as 0.7 Animal Units (AU), and yearlings 18-24 months are 0.8 AU (Waller et al. 1986). In the beef farm model, steers are considered 0.7 AU during May through September, and 0.8 AU in October. Monthly forage demand for May through September is 491 steers (average number after accounting for deaths) x 0.7 = 344 AUM (Animal Unit Month; the forage required to support one AU for one month). Forage demand for October is 487 steers x 0.8 = 390 AUM.

For a pasture in eastern Nebraska on silty soils, intensively managed with rotational grazing and some fertilization, smooth brome can be reasonably expected to produce 4.0 AUM/acre, and big bluestem 5.0 AUM/acre (Waller et al. 1986). The brome AUMs are distributed 40% in May, 20% in June, and 40% in October. The big bluestem AUMs are distributed 20% in July, 40% August, and 40% September. Given 242 acres of brome pasture and 212 A of big bluestem pasture, forage availability on the beef farm in an average year will be May (387 AUM), June (194 AUM), July (212 AUM), August (424 AUM), September (424 AUM), and October (387 AUM).

When forage availability and forage demand are considered in an average year, there is a surplus of forage in May, August, and September; a deficit in June and July; and an approximate balance in October (see Table A5-7; 1993 is an average year for forage production). Surplus grass is converted into hay (1.33 AUM grass makes 1 ton hay; Anderson pers. comm.), which is fed to cattle during deficit months (1 ton hay equals 2.5 AUM; Waller et al. (1986)). Any hay not fed during the summer is used to replenish the farm's carry-over supply of hay, and any remaining after replenishment is sold. If enough hay is available, the farm carries 119 tons of hay to the following year. This allows the farm to make it through a year in which grass production is 10% below average without having to purchase hay.

Year		May	June	July	Aug	Sept	Oct	total hay sold (tons)	hay carryover (tons)
1985	grass AUMs	426	213	233	466	466	426		
	hay made* (tons)	61	-52	-44	92	92	27	148	119
	hay bought (tons)	0	0	0	0	0	0		

Year		May	June	July	Aug	Sept	Oct	total hay sold (tons)	hay carryover (tons)
1986	grass AUMs	407	203	223	445	445	407		
	hay made	47	-56	-49	76	76	12	94	119
	hay bought	0	0	0	0	0	0		
1987	grass AUMs	407	203	223	445	445	407		
	hay made	47	-56	-49	76	76	12	94	119
	hay bought	0	0	0	0	0	0		
1988	grass AUMs	271	136	148	297	297	271		
	hay made	-29	-83	-78	-19	-19	-48	0	0
	hay bought	0	0	72	19	19	48		
1989	grass AUMs	368	184	201	403	403	368		
	hay made	18	-64	-57	44	44	-9	0	79
	hay bought	0	46	57	0	0	0		
1990	grass AUMs	329	165	180	360	360	329		
	hay made	-6	-72	-66	12	12	-24	0	0
	hay bought	0	0	64	0	0	0		
1991	grass AUMs	407	203	223	445	445	407		
	hay made	47	-56	-49	76	76	12	33	119

Year		May	June	July	Aug	Sept	Oct	total hay sold (tons)	hay carryover (tons)
	hay bought	0	9	49	0	0	0	(58)	
1992	grass AUMs	426	213	233	466	466	426		
	hay made	61	-52	-44	92	92	27	148	119
	hay bought	0	0	0	0	0	0		
1993	grass AUMs	387	194	212	424	424	387		
	hay made	32	-60	-53	60	60	-1	38	119
	hay bought	0	0	0	0	0	0		
1994	grass AUMs	407	203	223	445	445	407		
	hay made	47	-56	-49	76	76	12	94	119
	hay bought	0	0	0	0	0	0	0	

* A negative number means tons of hay fed to cover forage deficit.

For the 10-year period, total hay bought = 382 tons; total hay sold = 313 tons.

Calculation of 10-year variability in annual net income

For each farm, a formula is used to calculate annual expenses based on changes in yield and related expenses. The conventional farm serves as an example:

Total farm expenses if yields of corn and beans both equaled the Saunders County 10-year average (105 bu corn, 35 bu beans) = $135,402 (see Appendix 4 for baseline conventional budget).

Yield sensitive expenses for corn are trucking ($0.12/bu) and drying ($0.10/bu). The conventional farm grows 325 acres of corn, so a 1 bushel change in yield results in a change in whole farm expenses of 325A x 1 bu/A x ($0.12/bu + $0.10/bu) = $71.50; plus interest and overhead (see Appendix 4 for rates) = $80.11.

The only yield-sensitive expense for soybean is trucking, so by the same reasoning used for corn, a 1 bu change in yield with 325 acres changes whole farm expenses by $43.68.

For corn or beans, an increase in yield increases expenses, and a decrease in yield decreases expenses. The resulting formula for the conventional farm is shown below.

1. Conventional farm

Yield-sensitive expenses: corn, drying and trucking; beans, trucking.

Formula for calculating annual expenses based on deviation from average yields:

$135,402 + ((corn (bu) - 105) x $80.11) + ((bean (bu) - 35) x $43.68)

Table A5-8a. Conventional farm annual budgets in constant (1996) dollars.

Year	expenses	crop sales	net income
1985	135999	192260	56261
1986	136975	162370	25395
1987	134463	156995	22532
1988	133450	168626	35176
1989	134113	153728	19615
1990	134179	141245	7066
1991	135111	152727	17616
1992	137907	178269	40362
1993	134317	153946	19629
1994	137208	182608	45400
mean (C.V.)			28905 (52%)

2. Modified conventional farm

Yield-sensitive expenses are: corn, trucking and drying; beans, trucking; sorghum, trucking; alfalfa, custom baling.

Formula for calculating annual expenses based on deviation from average yields:

$127,122 + ((corn (bu) - 105) x $37.28) + ((bean (bu) - 35) x $38.65) + ((sorghum (bu) - 90) x $20.33) + ((alfalfa (tons) - 3.5) x $618.40)

Table A5-8b. Modified conventional farm annual budgets in constant (1996) dollars.

Year	expenses	crop sales	net income
1985	127138	163666	36528
1986	128011	144449	16438
1987	126595	143755	17160
1988	125942	169152	43210
1989	125954	146895	20941
1990	126564	139567	13003
1991	127195	148786	21591
1992	128396	155747	27351
1993	126065	136669	10604
1994	128403	166586	38183
mean (C.V.)			24501 (46%)

3. Agroforestry farm

Yield-sensitive expenses are: corn, trucking and drying; beans, trucking; sorghum, trucking; alfalfa, baling and twine.

Formula for yield correction of agroforestry expenses = $93,269 + [(bu corn - 113) * $20.46] + [(bu beans - 38) * $20.30] + [(bu sorghum - 93) * $11.16] + [(tons alfalfa - 3.9) * $135.69]

Table A5-8c. Annual variations in expenses and income (constant 1996 dollars): agroforestry.

year	total expenses	crops income	Christmas tree income	hazel nut income	net farm income
1985	93,279	100,515	11,020	22,080	40,336
1986	93,766	88,587	11,020	22,080	27,921
1987	92,923	89,305	11,020	22,080	29,482
1988	92,660	106,306	11,020	22,080	46,746
1989	92,691	93,744	11,020	22,080	34,153
1990	92,979	87,116	11,020	22,080	27,237
1991	93,343	91,057	11,020	22,080	30,814
1992	94,164	95,279	11,020	22,080	31,215
1993	92,663	84,723	11,020	22,080	25,160
1994	94,156	102,520	11,020	22,080	41,464
Mean (C.V.)					33,453 (21%)

4. Organic farm

Yield-sensitive expenses are: field corn, trucking and drying; sorghum, trucking; soybean, trucking; alfalfa, baling and twine; oat, trucking; wheat, trucking; brome hay, baling and twine; spinach, cartons, ice, harvest labor, shipping, marketing fees; pumpkins, pallets, harvest labor, shipping, marketing fees; peppers, cartons, harvest labor, shipping, marketing fees. (sweet corn and acorn squash yields don't vary from year to year)

Formula for yield correction of organic farm expenses = $97,461 + [(bu corn - 113) * $12.32] + [(bu beans - 38) * $12.10] + [(bu sorghum - 93) * $4.03] + [(tons alfalfa - 3.9) * $297.12] + [(bu oat - 62) * $4.03] + [(bu wheat - 41) * $4.03] + [(tons brome hay - 1.8) * $26.52] + [(cwt spinach - 60) * $28.74] + [(1000 lbs 110 day pumpkins - 20) * $45.99] + [(100 bu peppers - 10) * $486.00]

Table A5-8d. Annual variations in expenses and income (constant 1996 dollars): organic farm.

year	total farm expenses	field crop income	vegetable income	grazing fee income	net farm income
1985	97663	97678	32417	4218	36650
1986	97840	81,400	39585	4218	27363
1987	97299	88230	37860	4218	33009
1988	96985	108270	42328	4218	57831
1989	96472	98446	38195	4218	44387
1990	96967	84012	29622	4218	20885
1991	96768	79554	37657	4218	24661
1992	97700	86198	30408	4218	23124
1993	97028	78482	35472	4218	21144
1994	97603	93136	28027	4218	27778
Mean (C.V.)					31683 (37%)

5. Beef

Table A5-8e. Annual variations in costs and income for beef farm (constant 1996 dollars). Year refers to the year for which calves are purchased the previous October and steers are sold the following January. Not shown in this table are expenses totaling $183,119 that are constant from year to year.

Year	cost of calves	hay purchase	cost of hay production	interest	overhead	hay sold	steers sold	net farm income
1985	236453	0	754	29651	13343	7376	522847	66903
1986	235060	0	611	29459	13256	4234	500610	43339
1987	228946	0	611	28695	12913	4951	534240	84908
1988	292662	12751	0	37327	17137	0	566712	23716
1989	302908	8719	323	38412	17518	0	578714	27714
1990	273422	3871	72	34413	15589	0	559219	48734
1991	277459	2902	611	34928	15795	1611	490253	-22950
1992	261099	0	754	32732	14729	6659	530402	44628
1993	257062	0	469	32191	14486	1932	463325	-22070
1994	249578	0	611	31274	14073	4888	453211	-20556

Cost of hay production includes only cost of operating machinery. Hay purchases include cost of hay plus trucking 15 miles at $2.00 per loaded (50,000 lbs) mile (Massey 1993). Six months interest charged on hay purchases. Average net income for the 10 years is $27,437; C.V. = 140%.

Appendix 6. Calculation of farm energy budgets.

The lists of inputs and the calculated yields (outputs) that serve as the foundation of the economic analyses of the five farms in Appendix 4 also serve as the starting point for developing energy budgets. Instead of assigning dollar values to each input and output, an energy analysis assigns energy values. The energy inputs and outputs for each farm are then compiled as an energy budget in the same manner that monetary expenses and income are compiled into an economic budget.

On-farm energy use includes two types of energy (Fluck and Baird 1980):

Direct energy: The energy content of fuels (e.g., gasoline or diesel) and electricity.

Embodied energy: The sum of all the direct and indirect energy required to produce a good or provide a service.

The energy embodied in a tractor includes the energy required to mine and smelt the iron ore, fabricate the tractor, and ship the tractor to the farm. Fertilizer and pesticides embody the energy required for their production and transportation to the farm. Even diesel fuel requires energy to extract and refine the oil and then ship the fuel to the farm.

Tables A6-1-4 present the energy values assigned to each input. As the footnotes illustrate, the information comes from a wide variety of sources. Table A6-5 gives crop energy values. Tables A6-6 through 10 present detailed energy budgets for each farm. Tables A6-11 and 12 present ancillary information in support of some of the energy assumptions.

Table A6-1. Embodied energy of machinery

Item	Weight (kg)	Embodied and repair energy (kcal) [1]	Shipping energy (kcal) [2]	Total energy (kcal)
120 hp diesel tractor [3]	6202	111636000	6251616	117887616
100 hp diesel tractor [3]	5087	91566000	5127696	96693696
185 hp combine [4]	9542	171756000	9618336	181374336
pickup truck ½ ton [5]	1900	34200000	1915200	36115200
sprayer, 300 gal, 15' pull-type [5]	200	3600000	201600	3801600

Item	Weight (kg)	Embodied and repair energy (kcal) [1]	Shipping energy (kcal) [2]	Total energy (kcal)
sprayer, 300 gal, 20', 3-point mount [5]	200	3600000	201600	3801600
swather, 14', pull-type[6]	1808	32544000	1822464	34366464
baler, large round[6]	1798	32364000	1812384	34176384
tandem disk harrow 20' [5]	2100	37800000	2116800	39916800
rowcrop cultivator, 6 row x 30" [6]	831	14958000	837648	15795648
rowcrop cultivator, 8 row x 30" [6]	1186	21348000	1195488	22543488
field cultivator 18' [6]	1337	24066000	1347696	25413696
field cultivator 24' [6]	1479	26622000	1490832	28112832
corn head 6 row [4]	1782	32076000	1796256	33872256
corn head 8 row [4]	2402	43236000	2421216	45657216
grain head 15' [7]	1485	26730000	1496880	28226880
grain head 20' [7]	1975	35550000	1990800	37540800
planter 6 row x 30" [4]	1397	25146000	1408176	26554176
planter 8 row x 30" [4]	1630	29340000	1643040	30983040
planter, 1-row [6]	225	4050000	226800	4276800
mower, flail 8' [5]	400	7200000	403200	7603200
seed cleaner, 100 lb capacity [8]	--	6242000	---	6242000
rotary hoe, 15' [5]	400	7200000	403200	7603200
trailer, flat bed [9]	227	4086000	228816	4314816
trailer, pipe [9]	227	4086000	228816	4314816
bed shaper, 40" [8]	--	3816350	---	3816350
transplanter, 2-row [8]	--	6242000	---	6242000

Item	Weight (kg)	Embodied and repair energy (kcal) [1]	Shipping energy (kcal) [2]	Total energy (kcal)
cooling room (280 ft^3) [10]	--	1520000	---	1520000
ice crusher, 300 lb capacity [8]	--	6242000	---	6242000

Table A6-2. Energy use associated with operating machinery.

Power unit	unit	energy use (kcal) [11]
120 hp tractor [12]	hr	285150
100 hp tractor [12]	hr	238404
100/120 hp tractor average	hr	261777
185 hp combine [12]	hr	444086
½ ton pickup [13]	hr	163637
seed cleaner [14]	cwt seed	6843
cooling room [15]	72 hrs operation	645893
ice crusher [16]	300 lbs ice	11184

Table A6-3. Energy values associated with machinery rentals (depreciation only) and custom work

Activity	Unit	Energy value (kcal)
Rented machinery		
seeder-packer [8]	acre	11704
grain drill (16' disk) [8]	acre	15605
broadcast spreader [8]	acre	4682
anhydrous applicator [8]	acre	7803
Custom operations		
trucking (produce or small grain) [17]	100 lbs/10 miles	871
dry corn [18]	bu	10987
moldboard plowing [19]	acre	119327
ripping [19]	acre	146877
chop silage [19]	ton	99110
lay fabric mulch (materials and labor) [8]	foot	1561
swathing and baling (lg rnd bales) [19]	ton	134929
spraying [19]	acre	46521

Table A6-4. Energy values of inputs.

Input	Unit	Embodied energy (kcal)	Shipping energy (kcal)	Total energy value (kcal)
Energy sources				
gasoline [20]	gal	38292	2596	40909
diesel fuel [20]	gal	43259	3487	46746
electricity [21]	kWh	2863	--	2863
Fertilizers				
anhydrous ammonia [22]	lb N	5455		5455
triple super phosphate [22]	lb $P_2 0_5$	1364		1364
ammonium nitrate [22]	lb N	6682		6682
manure (80% moisture) [23]	ton	807106	20369 (incl.spreading)	827475
rock phosphate [22]	lb $P_2 0_5$	591		591
Pesticides				
Cygon 2-E (dimethoate) [8]	gallon	119378		119378
pre-emerge herbicides:				
corn [24]	ac	271820		271820
beans [25]	ac	124588		124588
sorghum [26]	ac	69636		69636
alfalfa [27]	ac	55870		55870
conifer seedlings [8]	acre	152274		152274
hardwood seedlings [8]	acre	146531		146531
post-emerge herbicides:				
conifer seedlings [8]	acre	82707		82707
hardwood seedlings [8]	acre	60766		60766

Input	Unit	Embodied energy (kcal)	Shipping energy (kcal)	Total energy value (kcal)
Roundup (12 oz/A) ??	ac	32240		32240
trichogramma wasps [8]	card	50217		50217
Pyrellin E.C. [8]	qt	62732		62732
Bt [8]	lb	40167		40167
insecticidal soap [8]	qt	40167		40167
Seed and seedlings				
field corn seed [28]	lb	11275		11275
soybean seed [28]	lb	3447		3447
sorghum seed [28]	lb	6464		6464
alfalfa seed w/ inoculant [28]	lb	28009		28009
pumpkin seed [29]	lb	220355		220355
acorn squash seed [29]	lb	172740		172740
sweet corn seed [29]	lb	50140		50140
spinach seed [30]	lb	1636		1636
oat seed [28]	lb	1867		1867
turnip seed [29]	lb	8054		8054
wheat seed [28]	lb	1365		1365
rye seed [28]	lb	5530		5530
bell pepper transplants [8]	seedling	468		468
scotch pine seedlings [31]	seedling	4000	6	4006
hazel seedlings [31]	seedling	4000	6	4006
e. red cedar seedlings [31]	seedling	4000	6	4006
Miscellaneous				
labor [32]	hr	18726		18726

Input	Unit	Embodied energy (kcal)	Shipping energy (kcal)	Total energy value (kcal)
baling twine [8]	per bale	1373		1373
operate seed cleaner [33]	cwt	4245		4245
irrigation system - materials and installation (10 acres) [34]	year	781530		781530
rented bee hive [35]	ac	30824	6720	37544
pumping water (75m head) [36]	ac-in			97699
ice [37]	lb	69	6	75
sweet corn box (5 doz. ears) [38]	box	4096	920	5016
acorn squash box (20 lbs) [38]	box	4096	920	5016
pepper carton (1 1/9 bu) [38]	box	4096	920	5016
pumpkin pallet (500 lbs) [39]	pallet	51200	11500	62700
spinach carton (20 lbs) [38]	box	4096	920	5016
beef farm fence system (materials, installation, repair) [8]	year	6656475		6656475
organic farm fence system (materials, installation) [8]	year	737055		737055
300 gallon water transport tank [8]	tank	3121000		3121000
300 gallon galvanized stock tank [8]	tank	371399		371399
cattle mineral supplement (summer) [8]	lb	375		375
cattle vet inputs [8]	hd	46815		46815
trucking cattle [17]	ton/mile		1756	
winter backgrounding (188 days) [40]	hd	2289412		2289412

Input	Unit	Embodied energy (kcal)	Shipping energy (kcal)	Total energy value (kcal)
finishing (84 days) [41]	hd	5423660		5423660
calves (475 lbs) [42]	1 calf	1670906		
beef water system (materials, installation, repair) [8]	year	2934156		2934156

Notes for Tables A6-1-4

[1] Embodied energy and the energy required for repairs during the lifespan of a piece of machinery is estimated as 18000 kcal kg-1 by Pimentel and Burgess (1980) based on Doering (1980).

[2] From Pimentel and Pimentel (1996): Each kg of farm supplies (e.g., fertilizers, pesticides, machinery, fuel) is transported an average of 1500 km to the farm, 60% by rail and 40% by truck, at a weighted average of .67 kcal/kg/km or 1008 kcal kg^{-1} total energy cost for shipping.

[3] Chancellor et al. (1980)

[4] Weight an average of appropriate John Deere models as listed in Hot Line Farm Equipment Guides Quick Reference Guide for Farm Tractors and Combines, 14th edition, 1995. Heartland Ag-Business Group, 1003 Central Avenue, P.O. Box 1115, Fort Dodge, IA 50501.

[5] Weight from Scott and Krummel (1980).

[6] Weight the average of appropriate models from J. Hudson (1993), Implement & Tractor Red Book, Farm Press Publications, Clarksdale, MS.

[7] Weight from Wahoo Implement Co.

[8] Energy content estimated from retail price based on conversion factor of 3121 kcal per dollar. Conversion based on U.S. energy consumption per dollar gross domestic product (1994) from Statistical Abstract of the United States 1996, 116th edition. Bureau of the Census, U.S. Department of Commerce.

[9] Proebsting (1980)

[10] Embodied energy of farm service buildings from Doering (1980)

[11] The energy value of diesel fuel and gasoline includes energy used in production and shipping as well as the combustion energy.

[12] Hourly fuel consumption from Powell et al. (1992).

[13] Gasoline consumption is 4 gallons per hour (Johnson and Chancellor 1980)

[14] Energy use estimated as 2.26 kWh per cwt seed

[15] 3.1 kW per hour of operation. See cooling room description in organic farm economics section for details.

[16] Based on estimated annual electricity cost of $25.

[17] Pimentel and Pimentel (1996)

[18] Peart et al. (1980)

[19] Diesel fuel use for the operation taken from Powell et al. (1992). Cost of the fuel @ $1/gallon subtracted from the custom rate in Massey (1992, 1994). Total energy use calculated as the energy value of the diesel fuel consumed plus the energy represented by the non-fuel portion of the custom rate as calculated in note (8).

[20] Cervinka (1980) — includes energy used to produce the fuel as well as the energy content of the fuel. Shipping energy based on 680 g/l for gasoline and 920 g/l for diesel.

[21] Cervinka (1980)

[22] Lockeretz (1980)

[23] See Table A6-11

[24] Pimentel and Burgess (1980)

[25] Scott and Krummel (1980)

[26] Bukantis (1980)

[27] Heichel and Martin (1980); establishment year only

[28] Heichel (1980)

[29] Based on price relative to field corn

[30] Bradley (1980)

[31] Ramming (1980)

[32] Using the net energy analysis of Fluck and Baird (1980): $6/hr x 3121 kcal/$ = 18726 kcal/hr

[33] Based on operating costs of $1.36/cwt

[34] Batty and Keller (1980)

[35] Johnson and Chancellor (1980); assume transport of 80 km round trip with 1 hive weighing 70 kg (Baker 1980)

[36] Batty and Keller (1980)

[37] Pimentel (1996; p. 188)

[38] Johnson and Chancellor (1980); for transport, a carton for 20 lbs cantaloupe weighs 0.907 kg, x 1008 kcal/kg = 920 kcal

[39] Based on relative price of pallets and cartons (12.5x)

[40] See Table A6-12

[41] See Table A6-13

[42] Cultural energy inputs required to support a cow for one year and her spring calf through weaning in October (Heitschmidt et al. 1996) = 1,237,000 kcal. Tissue energy in a 475 lb steer = 433,906 kcal (Agricultural Research Council 1980, NRC 1996).

Table A6-5. Energy content of crops

crop	crop yield per acre	% moisture	yield in lbs dry weight	energy content (kcals/100 g dry wt)	energy yield per acre (Mcal)
corn (grain)	105 bu (56 lbs/bu)	15.5%	4969	405	9128
corn silage	13.6 ton	70%	8160	309	11437
soybean	35 bu (60 lb/bu)	13%	1827	462	3829
sorghum	90 bu (56 lb/bu)	14%	4334	381	7490
alfalfa	3.5 ton	15%	5950	295	7962
w. wheat-grain	37 bu (60 lb/bu)	12.5%	1943	377	3323
w. wheat - straw	3330 lbs	11%	2964	172	2312
oat (grain)	59.6 bu (32 lb/bu)	12.5%	1669	433	3278
oat straw	2556 lbs	10%	2300	198	2066
brome hay	2 ton	12%	3520	273	4359
bluestem hay	2 ton	8%	3680	220	3672
sweet corn - whole ear	1000 doz (6 lb/doz)	41%	3540	112	1798
bell pepper	1000 bu (25 lbs/bu)	93%	1764	357	2857
pumpkin	18000 lbs	92%	1440	325	2123
acorn squash	10000 lbs	89%	1100	336	1676
spinach	6000 lbs	91%	540	289	708
hazelnut	350 lbs	1.7%	344	252	393
Christmas tree	18,180 lbs (551 trees)	67%	6000	425	11567

Sweet corn energy values, Holland et al. (1991); pumpkin, pepper, acorn squash, Lorenz and Maynard (1988); winter wheat (hard red), Watt and Merrill (1963); wheat straw, oat straw, brome hay, bluestem (prairie) hay, Church (1984); hazelnut, Holland et al. (1992); others from

Pimentel (1980). Energy content of Christmas tree is weighted average of foliage (20%; 17 MJ/kg) and wood (80%; 18 MJ/kg) (Loomis and Connor 1992).

Table A6-6. Conventional farm energy budget.

Summary of inputs (total for crop; not per acre).

Input	corn	soybeans
Land (A)	325	325
Power units (hrs)		
120 hp tractor	131	114
100 hp tractor	131	114
combine	64	37
pickup	140	140
Implements (A)		
disk	325	325
rowcrop cultivator	325	325
field cultivator	325	325
sprayer	325	325
corn head	325	0
grain head	0	325
planter	325	325
Equipment rental (A)		
spreader	325	325
anhydrous applicator	325	0

Input	corn	soybeans
Seed and chemicals		
seed (lbs)	4063	16250
anhydrous (lb N)	17875	0
P_2O_5 (lbs)	8125	8125
herbicide (A)	325	325
Custom and labor		
trucking (bu)	34125	11375
drying (bu)	34125	
owner labor	390	318
hired labor	0	286

Conventional farm: Energy budget (Mcal) for each crop.

	corn	soybeans	total
Equipment depreciation			
120 hp tractor	4202	3657	7859
100 hp tractor	2585	2250	4835
combine	7662	4430	12092
pickup	1204	1204	2408
disk	1331	1331	2662
rowcrop cultivator	751	751	1502
field cultivator	1406	1406	2812
sprayer	127	127	254
corn head	3044	0	3044
grain head	0	2503	2503
planter	1549	1549	3098

	corn	soybeans	total
Total equip. depreciation	23861	19208	43069
Fuel			
diesel	97007	76116	173123
gasoline	22909	22909	45818
Equipment rental			
spreader	1522	1522	3044
anhydrous applicator	2536	0	2536
Total rental	4058	1522	5580
Seed and chemicals			
seed	45710	55901	101611
anhydrous	97296	0	97296
P_2O_5	11056	11056	22112
herbicide	88341	40491	128832
Total seed/chemicals	242403	107448	349851
Custom and labor			
trucking	16643	5944	22587
drying	374931	0	374931
owner labor	7303	5955	13258
hired labor	0	5356	5356
Total custom and labor	398877	17255	416132

	corn	soybeans	total
Total operations	789115	244458	1033573
Overhead (5% of ops)	39456	12223	51679
Total energy use	828571	256681	1085252
Crop value	2966600	1244425	4211025
Net gain	2138029	987744	3125773
Output/input	3.58	4.85	3.88

Table A6-7. Modified conventional farm energy budget.

Summary of inputs (total for crop; not per acre).

Input	corn	soybeans	sorghum	alfalfa
Land (A)	151.25	287.5	151.25	60
Power units (hrs)				
120 hp tractor	60.9	100.8	53.1	13.2
100 hp tractor	60.9	100.8	53.1	13.2
combine	29.7	33.1	17.4	0
pickup	65	124	65	26
Implements (A)				
disk	151.25	287.5	151.25	15
rowcrop cultivator	151.25	287.5	151.25	0
field cultivator	151.25	287.5	151.25	15
sprayer	151.25	287.5	151.25	15
corn head	151.25	0	0	0
grain head	0	287.5	151.25	0
planter	151.25	287.5	151.25	0

Input	corn	soybeans	sorghum	alfalfa
Equipment rental (A)				
spreader	151.25	287.5		15
anhydrous applicator	151.25		151.25	
seeder-packer				15
Seed and chemicals				
seed (lbs)	1891	14375	756	180
anhydrous (lb N)	7494		3781	
P_2O_5 (lbs)	3781	7188		900
herbicide (A)	151.25	287.5	151.25	15
Custom and labor				
plowing (A)	15			
swathing (A)				165
baling (tons)				191
trucking (bu)	15881	10063	13613	
drying (bu)	15881			
owner labor (hrs)	181	282	149	31
hired labor		253	133	

Modified conventional farm: Energy budget (Mcal) for each crop.

	corn	soybeans	sorghum	alfalfa	total
Equipment depreciation					
120 hp tractor	2099	3475	1830	455	7859
100 hp tractor	1291	2138	1126	280	4835
combine	4489	5003	2630	0	12122
pickup	559	1066	559	224	2408
disk	666	1265	666	66	2663
rowcrop cultivator	385	732	385	0	1502
field cultivator	701	1336	701	70	2808
sprayer	64	121	64	6	255
corn head	3044				3044
grain head		1639	864		2503
planter	794	1510	794		3098
Total equip. depreciation	14092	18285	9629	1101	43107
Fuel					
diesel	45074	67473	35528	6911	154986
gasoline	10636	20291	10636	4255	45818
Equipment rental					
spreader	708	1346		70	2124
anhydrous applicator	1180		1180		2360
seeder-packer				176	176
Total rental	1888	1346	1180	246	4660

	corn	soybeans	sorghum	alfalfa	total
Seed and chemicals					
seed	21321	49551	4887	5042	80801
anhydrous	40880		20625		61505
P_2O_5	5157	9804		1228	16189
herbicide	41113	35819	10532	838	88302
Total seed/chemicals	108471	95174	36044	7108	246797
Custom and labor					
plowing	1790				1790
swathing and baling				25771	25771
trucking	7745	5258	6639		19642
drying	174485				174485
labor	3389	10018	5281	581	19269
Total custom and labor	187409	15276	11920	26352	240957
Total operations	367570	217845	104937	45973	736325
Overhead (5% of ops)	18379	10892	5247	2299	36817
Total energy use	385949	228737	110184	48272	773142
Crop value	1380610	1100838	1132863	435408	4049719
Net gain	994661	872101	1022679	387136	3276577
Output/input	3.58	4.81	10.28	9.02	5.24

Table A6-8. Agroforestry farm energy budget.

Summary of inputs (total for crop; not per acre).

Input	corn	soybeans	sorghum	alfalfa	Christmas trees	hazel	wind-breaks
Land (A)	83	151	83	60	9	16	23
Power units (hrs)							
tractors	78.5	129.3	71.3	93.9	15.0	27.0	6.2
combine	21.8	39.7	21.8				
pickup	55	99	55	40	6	11	14
Implements (A)							
disk	83	151	83	15	2	.3	.14
field cultivator	83	151	83	15			
planter	83	151	83				
sprayer	83	151	83	15	.5	.32	.28
row crop cultivator	83	151	83				
corn head	83						
grain head		151	83				
swather				165			
baler (tons)				215			
mower					45	80	19
seed cleaner (lbs)						4416	
Equipment rental (A)							
spreader	83	151		15			
seeder/ packer				15			

Input	corn	soybeans	sorghum	alfalfa	Christmas trees	hazel	wind-breaks
anhydrous applicator	68		83				
Inputs							
seed (lb)	20.75 bags	151 bags	415	180			
seedlings					896	85	97
anhydrous (lbs N)	4760		2075				
ammon. nitrate (lbs N)						120	
P2O5 (lbs)	2075	3775		900			
preemerge herbicide (A)	83	151	83	15	.5	.1	.28
post-emerge herbicide (A)					6.02	4.86	1.06
insecticide					21.5 pts		
baling twine (bales)				331			
Custom work							
plowing (A)	15						
hired labor (hrs)		138	73		5	642.4	
owner labor (hrs)	120	203	112	113	425	527	25
ripping (A)					1	.32	
shipping nuts (lbs)						4416	

Input	corn	soybeans	sorghum	alfalfa	Christmas trees	hazel	wind-breaks
truck grain (bu)	9379	5738	7719				
dry corn (bu)	9379						

Agroforestry farm: Energy budget (Mcal) for each crop. *Equipment co-owned with organic farm; annual energy depreciation proportional to agroforestry share of total annual use.

	corn	soybean	sorghum	alfalfa	Xmas trees	hazel nut	wind-breaks	total
Equipment depreciation								
tractors	2361	3889	2145	2825	451	812	187	12670
combine*	2736	4982	2736					10454
pickup	1013	1824	1013	737	111	203	258	5159
disk	496	902	496	90	12	2	1	1999
rowcrop cultivator	276	502	276					1054
field cultivator	635	1156	635	115				2541
sprayer	95	172	95	17	1			380
corn head*	1409							1409
grain head*		1031	565					1596
planter	695	1265	695					2655
swather*				689				689
baler*				1043				1043
mower					238	422	100	760
seed cleaner						312		312
Total equip. depreciation	9716	15723	8656	5516	813	1751	546	42721

	corn	soybean	sorghum	alfalfa	Xmas trees	hazel nut	wind-breaks	total
Fuel								
diesel	30231	51478	28346	24581	3927	7068	1623	147254
gasoline	9000	16200	9000	6546	982	1800	2291	45819
electricity						286		
Equipment rental								
spreader	389	707		70				1166
seeder/packer				176				176
anhydrous applicator	531		648					1179
Total rental	920	707	648	246				2521
Seed, chemicals, other inputs								
seed	11698	26025	2683	5042				45448
seedlings					3589	341	389	4319
anhydrous	25966		11319					37285
ammonium nitrate						802		802
P_2O_5	2830	5149		1228				9207
preemerge herbicide	22561	18813	5780	838	76	15	43	48126
postemerge herbicide					498	295	88	881
insecticide					321			321

	corn	soybean	sorghum	alfalfa	Xmas trees	hazel nut	wind-breaks	total
baling twine				454				454
Total seed, chemicals, etc.	63055	49987	19782	7562	4484	1453	520	146843
Custom and labor								
plowing	1790							1790
ripping					147	47		194
trucking	4574	2998	3765					11337
drying	103047							103047
labor	2247	6386	3464	2116	8052	21891	468	44624
Total custom and labor	111658	9384	7229	2116	8199	21938	468	160992
Prorated windbreak energy	1125	2046	1125	813	122	217	---	----
Total operations	225705	145525	74786	47380	18527	34513	---	546436
Overhead (5% of ops)	11285	7276	3739	2369	926	1726	---	27321
Total energy use	236990	152801	78525	49749	19453	36239	---	573757
Crop value	815348	627737	642392	488639	11567	4959	---	2590642
Net gain	578358	474936	563867	438890	-7886	-31280	---	2016885
Output/input	3.44	4.10	8.18	9.82	0.59	0.14	---	4.52

Table A6-9. Organic farm energy budget

A. Summary of inputs for rowcrops and forages (total for crop; not per acre)

Input	alfalfa	corn grain	sor-ghum	soybean	oat/ turnip	corn silage	winter wheat	pasture	wind-break
Land (A)	120	50	30	90	30	30	30	12	23
Power units (hrs)									
tractors (crops)	193.0	41.1	27.5	74.1	19.3	24.7	12.4	10.0	6.3
tractors (cattle water)	16.9	28.1	16.9		21.1			5.3	
combine		13.2	7.9	23.7	7.9		7.9		
pickup truck	52.1	21.7	13.0	39.0	13.0	13.0	13.0	5.2	10.0
Implements (A)									
disk	30	50	30	90	60	30	30	0	0
field cultivator	30	50	30	90	30	30	30	0	0
6-row planter	0	50	30	90	0	30	0	0	0
row crop cultivator	0	50	30	90	0	30	0	0	0
rotary hoe	0	100	90	180	0	60	0	0	0
mower									18.5
swather	360							24	
baler (tons)	480							21.6	
corn head		50							
grain head			30	90	30		30		
trailer (cattle water)	16.9	28.1	16.9		21.1			5.3	
Equipment rental (A)									
seeder/packer	30								
drill					30		30		

Input	alfalfa	corn grain	sor-ghum	soybean	oat/ turnip	corn silage	winter wheat	pasture	wind-break
spreader	30				30				
Seed, fertilizer, pesticides									
crop seed	360 lb	13.75 bag	165 lb	99 bag	2100 lb (oat) 30 lb turnip	8.25 bag	2250 lb	0	
seedlings									97
manure (tons)		280	210		66	398	278	128	
rock phosphate (lbs P_2O_5)	600								
Custom work									
plowing (A)		30							
lay fabric mulch (feet)									1008
trucking (bu)		5650	2790	3420	1860		1230		
drying (bu)		5650							
roguing (A)		50	60	180		30			
hired labor (hrs)	35	3.9		3.9		3.9		3.9	
total owner + hired labor * (hrs)	229.1	109.1	95.4	275.7	32.5	56.0	24.3	11.9	16.5
cattle labor (hrs) **	41.6	69.4	41.6		52.0			13.3	

*Owner + hired labor includes labor associated with roguing, but not with custom work or cattle care (cattle labor shown separately)

** Cattle labor distributed among crops proportionally to crop AUMs.

B. Summary of inputs for vegetable crops (total for crop; not per acre)

Input	Sweet corn	Pumpkins	Acorn squash	Peppers	Spinach
Land (A)	3	2	2	2	1
Power units (hrs)					
tractors (crops)	12	7	11.2	26.1	12.9
tractors (cattle)	1.7				
pickup truck	30	20	20	20	10
cooling room				360	
ice crusher	9				3
Implements (A)					
disk	6	6	8	10	6.5
field cultivator	9	4	4	2	1.5
6-row planter	3	2	2		
1-row planter					1
sprayer		4	4		4
row crop cultivator	6	4	4	6	2
rotary hoe	3	2	2		
bed shaper				2	1
pipe trailer	6	4	4	4	2
transplanter				2	
trailer (crop)	6	2	6	10	1
trailer (cattle water)	1.7				

Input	Sweet corn	Pumpkins	Acorn squash	Peppers	Spinach
irrigation system	3	2	2	2	1
Equipment rental (A)					
drill			2	2	1
Seed, fertilizer, pesticides					
crop seed (lb)	36	1.87	2.0		10
transplants				28000	
annual rye (lb)					70
wheat (lb)			150	150	
manure (tons)	39	12	12	32	15
Trichogramma (card)	6				
Pyrellin E.C. (qt)		6	6		
Bt-Dipel (lb)					2.25
insecticidal soap (qt)					9.0
Irrigation water (ac-in)	19.6	16.8	14	16.8	6.3
Hired labor (hr)	19	16	19.5	19.5	0
Custom operations					
spread manure (A)	3	2	2	2	1

Input	Sweet corn	Pumpkins	Acorn squash	Peppers	Spinach
truck produce (cwt)	180	360	200	504	60
Harvest costs					
packing containers	600	72	1000	2000	300
cooling (hrs)				360	
ice (lb)	14,400				4800
marketing fee					
total labor (owner + hired)*	235.1	130.2	132.7	290.7	163.3
cattle labor	4.2				

*Owner + hired labor includes roguing labor, but not labor associated with custom work or with cattle care (cattle associated labor shown separately).

Organic analog farm: Energy budget (Mcal) for each crop. *Equipment co-owned with agroforestry farm; annual energy depreciation proportional to organic farm share of total annual use. Energy and equipment use associated with backgrounding of cattle are included with energy costs for crop production.

Input	alfalfa	corn grain	milo	soybean	oats/ turnip	corn silage	winter wheat	pasture	wind brk
Equipment depreciation									
tractors	4658	1536	985	1644	896	548	275	340	140
combine*		1674	1002	3005	1002		1002		
pickup truck	960	400	240	719	240	240	240	96	184
cooling room									
ice crusher									
disk	168	280	168	504	336	168	168		
field cultivator	246	409	246	737	246	246	246		
6-row planter		641	384	1154		384			
1-row planter									
sprayer									
row crop cultivator		178	107	320		107			
rotary hoe		116	104	209		70			
mower									760
swather*	1503							100	
baler*	2273							102	
corn head*		849							
grain head*			205	614	205		205		
bed shaper									
pipe trailer									
transplanter									
flat trailer	63	105	63		79			20	

Input	alfalfa	corn grain	milo	soybean	oats/ turnip	corn silage	winter wheat	pasture	wind brk
cattle water tanks	126	53	31		31			13	
Total equipment depreciation	9997	6241	3535	8906	3035	1763	2136	671	1084
Fuel									
diesel	54947	23977	15131	29923	14083	6466	6754	4005	1649
gasoline	8525	3551	2127	6382	2127	2127	2127	851	1636
electricity	38	64	38		47			12	
Total fuel	63510	27592	17296	36305	16257	8593	8881	4868	3285
Infrastructure									
fence system	361	150	90		90			36	
irrigation system									
Total infrastructure	361	150	90		90			36	
Equipment rental									
seeder/packer	351								
drill					468		468		
spreader	140				140				
Total rental	491				608		468		
Seed, fertilizer, other inputs									
crop seed	10083	7752	1067	17063	4162	4651	3071	0	0
cover crop seed									
seedlings									389
manure	0	231693	173770	0	54613	329335	230038	105917	0

Input	alfalfa	corn grain	milo	soybean	oats/ turnip	corn silage	winter wheat	pasture	wind brk
rock phosphate	355								
Tricho- gramma									
Pyrellin E.C.									
Dipel									
insecticidal soap									
packing containers									
ice									
Total inputs	10438	239445	174837	17063	58775	333986	233109	105917	389
Custom work									
plowing		3580							
lay fabric mulch									1573
trucking	0	2756	1361	1787	518	0	643	0	0
drying		62077							
labor	5069	3343	2565	5163	1582	1049	455	470	309
Total custom and labor	5069	71756	3296	6950	2100	1049	1098	470	1882
Prorated windbreak energy	1982	826	496	1487	496	496	496	198	---
Total operations	91848	346010	199550	70711	81361	345887	246188	112160	
Overhead	4592	17301	9978	3536	4068	17294	12309	5608	
Total energy use	96440	363311	209528	74247	85429	363181	258497	117768	
Crop value	1064633	491173	232190	374148	102300	368339	110467	47077	
Beef gain	2596	4327	2596		3245			822	

Input	alfalfa	corn grain	milo	soybean	oats/ turnip	corn silage	winter wheat	pasture	wind brk
Gross energy	1067229	495500	234786	374148	105545	368339	110467	47899	
Net gain	970789	132189	25258	299901	20116	5158	-148030	-69869	
Output/input	11.1	1.4	1.1	5.0	1.2	1.0	0.4	0.4	

Input	sweet corn	pump-kin	acorn sqsh	bell pepper	spinach	Farm Total
Equipment depreciation						
tractors	304	155	249	579	286	12595
combine*						7685
pickup truck	553	369	369	369	184	5163
cooling room				76		76
ice crusher	312				104	416
disk	34	34	45	56	36	1997
field cultivator	74	33	33	16	12	2544
6-row planter	38	26	26			2653
1-row planter					428	428
sprayer		85	84		84	253
row crop cultivator	21	14	14	21	7	789
rotary hoe		3	2	2		506
mower						760
swather*						1603
baler*						2375
corn head*						849
grain head*						1229
bed shaper				255	127	382
pipe trailer	65	43	43	43	22	216
transplanter				624		624
flat trailer	28	8	22	37	4	429

Input	sweet corn	pump-kin	acorn sqsh	bell pepper	spinach	Farm Total
cattle water tanks	3					257
Total equipment depreciation	1432	770	887	2078	1294	43829
Fuel						
diesel	3586	1832	2932	6832	3377	175494
gasoline	4909	3273	3273	3273	1636	45817
electricity	2455	1641	1368	4871	795	11329
Total fuel	10950	6746	7573	14976	5808	232640
Infrastructure						
fence system	9					736
irrigation system	235	156	156	156	78	781
Total infrastructure	244	156	156	156	78	1517
Equipment rental						
seeder/packer						351
drill			31	31	16	1014
spreader						280
Total rental			31	31	16	1645
Seed, fertilizer, other inputs						
crop seed	1805	412	345	0	16	50427
cover crop seed			205	205	387	797
seedlings				13104		13493
manure	32272	9930	9930	26479	12412	1216389

Input	sweet corn	pump-kin	acorn sqsh	bell pepper	spinach	Farm Total
rock phosphate						355
Tricho-gramma	301					301
Pyrellin E.C.		376	376			752
Dipel					90	90
insecticidal soap					362	362
packing containers	3010	4514	5016	10032	1505	24077
ice	1080				360	1440
Total inputs	38468	15232	15872	49820	15132	1308483
Custom work						
plowing						3580
lay fabric mulch						1573
trucking	157	314	174	439	52	8201
drying						62077
labor	4481	2438	2485	5444	3058	37911
Total custom and labor	4638	2752	2659	5883	3110	112712
Prorated windbreak energy	50	33	33	33	17	----
Total operations	55782	25689	27211	72977	25455	1700829
Overhead	2789	1284	1361	3649	1273	85041
Total energy use	58571	26973	28572	76626	26728	1785870
Crop value	5394	4246	3352	5668	708	2809695
Beef gain	260					13846

Input	sweet corn	pump-kin	acorn sqsh	bell pepper	spinach	Farm Total
Gross energy	5654	4246	3352	5668	708	2823541
Net gain	-52917	-22727	-25220	-70958	-26020	1037670
Output/input	0.1	0.2	0.1	0.1	0.0	1.6

Table A6-10. Pasture-based beef farm energy budget.

Summary of inputs (total; not per acre)

Input	Pastures
Land (A)	460
Power unit (hrs)	
100 hp tractor	107
pickup truck	280
Implements	
swather (A)	107
baler (tons)	153
Infrastructure (A)	
fencing system	460
water system	460
handling facilities	---
Equipment rental (A)	
broadcast spreader	454
Inputs	
ammonium nitrate (lbs N)	29960
Roundup (A)	21
calf, 475 lbs (#)	497
electricity (fence; kWh)	51
electricity (water; kWh)	1361

Custom and labor	
spraying (A)	21
receiving and backgrounding (hd, days)	497 hd, 188 days
finishing (hd, days)	487 hd, 84 days
labor (hrs)	890
trucking (tons x miles)	12941

Beef farm: Energy budget (Mcal).

Equipment depreciation	
100 hp tractor	4835
pickup truck	2408
swather	1718
baler	1709
Total equipment depreciation	10670
Fuel	
diesel	25509
gasoline	45818
electricity	4043
Total fuel	75370

Infrastructure	
fencing system	6656
water system	2934
handling facilities	4221
Total infrastructure	13811
Equipment rental	
broadcast spreader	2126
Inputs	
ammonium nitrate	200193
Roundup	677
calves	830440
Total inputs	1031310
Custom and labor	
spraying	977
receiving and backgrounding	1137633
finishing	2641322
labor	16666
trucking	22724
Total custom and labor	3819322
Total operations	4952609
Overhead (5% ops)	247630
Total energy use	5200239

Cattle output	946825
Hay output	69768
Total output	1016593
Net gain	-4183646
Output/input	.20

Table A6-11. Calculation of energy value of manure used as fertilizer on organic farm.

The gross energy content of feedlot beef cattle manure is 4347 kcal/kg (dry weight basis; Gilbertson et al. 1974). Assuming manure is 80% water, 1 ton (2000 lb) will have a gross energy of 788,706 kcal.

From Brown (1988): A feeder steer (>700 lbs) will produce raw waste each day containing 6.9 lbs total solids. Assuming 400 lbs total solids per ton of manure, it will take 58 days for one steer to produce 1 ton of manure at 80% moisture.

From Cook et al. (1980), the energy cost (machinery depreciation plus fuel) for waste handling in a 1000 head feedlot = 60.2 Mcal/hd/190 days = 18.4 Mcal/hd/58 days.

From Pimentel (1980), energy for trucking = 1.2 kcal/kg/km. Assuming the manure is trucked 16 km (10 miles) to the organic farm, trucking 1 ton (907 kg) requires 17414 kcal.

Spreading manure: Average application rate is 8.86 tons/A on organic farm. Spreading occurs at 9.7A/hr (Powell et al. 1992) or .1 hrs/A, and requires 261777 kcal/hr (Table A6-2) or 26178 kcal/A. At 8.86 tons/A, energy costs of spreading manure are 2955 kcal/ton.

Total energy value of 1 ton of manure used as fertilizer on organic farm is 788706 kcal (gross energy) + 18400 kcal (on-lot waste handling) + 17414 kcal (trucking) + 2955 kcal (spreading) = 827475 kcal.

Table A6-12. Energy costs of winter backgrounding of steers.

Input	days	cost/day/hd	total kcal/hd
receiving*	28	$0.74	64,667
stalk grazing**	90	-----	1,170,180
alfalfa***	70	-----	944,706
yardage*	160	$0.10	49,936
supplement*	160	$0.12	59,923
Total			2,289,412

* Energy values estimated as 3121 kcal/$; see footnote 8, page 248. ** Energy content of corn stover assumed to be 1182 kcal/lb (Church 1984), and steers eat 11 lbs stover per day for 90 days. *** Each steer eats .33 ton alfalfa (Shain et al. 1997 and alfalfa at $64.00/ton); total solar and embodied (production) energy of .33 ton alfalfa = 944706 kcal (Church 1984, Cook et al. 1980).

Table A6-13. Energy costs of feedlot finishing of steers.

Input	kcal/hd/84 days	Reference
Feedlot operations: labor, fuel, equipment depreciation	158,860	Cook et al. 1980
Cultural energy embodied in feed: production, harvest, transport, grinding	1,300,000	Cook et al. 1980
Feed energy in 23.6 lbs TDN/day x 84 days	3,964,800	Ensminger 1983
Total	5,423,660	

Table A6-14. Energy content (Mcal) of crops and livestock exported from five farms.

Crop	Conventional	Modified conventional	Agroforestry	Organic	Beef
corn (grain)	2,966,600	1,380,610	815,348	491,173	
corn silage	0	0	0	368,339	
soybeans	1,244,425	1,100,838	627,737	374,148	
sorghum	0	1,132,863	642,392	232,190	
alfalfa hay	0	435,408	488,639	1,064,633	
wheat (grain)	0	0	0	110,467	
oat (grain)	0	0	0	102,300	
hay	0	0	0	47,077	69,768
sweet corn	0	0	0	5,394	
bell pepper	0	0	0	5,668	
pumpkin	0	0	0	4,246	
acorn squash	0	0	0	3,352	
spinach	0	0	0	708	
hazel nuts	0	0	4,959	0	
Scotch pine	0	0	11,567	0	
steers	0	0	0		946,825
Total	4,211,025	4,049,719	2,590,642	2,809,695	1,016,593
Mcal/A	6,479	6,230	6,096	6,611	2,210

Appendix 7.

Estimation of soil erosion, and nitrogen and phosphorus budgets.

SOIL EROSION AND NITROGEN LEACHING

Rates of soil erosion (water) and nitrate leaching were calculated for the five farms using PLANETOR, a commercial software package for whole-farm environmental and economic planning (Center for Farm Financial Management 1995). PLANETOR uses the methodology of the Revised Universal Soil Loss Equation (RUSLE) to estimate soil erosion by water. Leaching losses of nitrogen are estimated using the Nitrate Leaching and Economic Analysis Package (NLEAP).

Erosion is calculated for each crop in a rotation sequence, and the average soil loss of the different stages is the whole-farm average. For the modified conventional and agroforestry systems, following sorghum in the rotation with both alfalfa (15 acres) and soybeans creates two rotations within the farm, and the acre-weighted average of the different stages of the two rotations is the whole-farm average soil loss rate.

For the PLANETOR runs, each farm was assumed to consist entirely of Sharpsburg silty clay loam, 4% to 6% slope. This is the most common soil type in Saunders County, Nebraska. Climate data for running the RUSLE subprogram was from Des Moines, IA (the closest of the data sets available in the program). For the NLEAP program, climate data from Saunders County were selected.

For all farms, T (soil loss tolerance) = 5.0 tons/A.

Conventional farm

Rotation stage	Erosion (tons/A)	NO_3-N leached (lbs/A)
corn	6.1	9.0
soybeans	4.0	1.0
rotation average	5.0	5.0

Modified conventional farm

Rotation #1

Rotation stage	Erosion (tons/A)	NO_3-N leached (lbs/A)
corn	6.0	9
soybeans	4.1	1
sorghum	6.1	5
soybeans	3.7	1
rotation average	5.0	4

Rotation #2

Rotation stage	Erosion (tons/A)	NO_3-N leached (lbs/A)
corn	2.7	1
soybeans	3.8	2
sorghum	6.1	5
soybeans	3.7	1
alfalfa	3.4	1
alfalfa	0.2	1
alfalfa	0.1	1
alfalfa	0.1	1
rotation average	2.5	1

Area weighted average soil loss for farm = 4.6 tons/A. Leaching loss of nitrogen = 4 lbs N/A.

Agroforestry farm

Rotation #1

Rotation phase	Erosion (tons/A)	NO_3-N leached (lbs/A)
corn	4.0	1
soybeans	3.3	2
sorghum	5.8	6
alfalfa	1.8	1
alfalfa	0.2	1
alfalfa	0.1	1
alfalfa	0.1	1
rotation average	2.2	2

Rotation #2

Rotation phase	Erosion (tons/A)	NO_3-N leached (lbs/A)
corn	5.8	9
soybeans	3.5	1
sorghum	5.9	5
soybeans	3.2	1
rotation average	4.6	4

Acres in windbreaks, Christmas trees, and American hazel shrubs have no erosion and no leaching losses of nitrogen.

Area weighted average soil loss for farm = 3.5 tons/A. Leaching loss of nitrogen = 3.1 lbs N/A.

<u>Organic farm</u>

PLANETOR cannot run a 13-year rotation, so organic farm rotation evaluated in two parts:

Years 1-7 of rotation

Rotation phase	Erosion (tons/A)	NO_3-N leached (lbs/A)
alfalfa	0.1	1
alfalfa	0.1	1
alfalfa	0.1	1
alfalfa	0.1	1
corn	3.8	1
sorghum	0.8	41
soybeans	2.4	21

Years 7-13 of rotation

Rotation phase	Erosion (tons/A)	NO_3-N leached (lbs/A)
soybeans	2.0	42
corn/vegetables	0.7	150
beans	3.3	37
oats	0.1	86
soybeans	2.7	28
corn silage	0.3	18
winter wheat	0.2	175

Weighted average leaching for 13 years = 43 lbs N/A/yr for crop acres; x 390 = 16770 lbs.
Brome pasture erosion = 0; N leaching can't be calculated for pasture by PLANETOR.
Shelterbelts = 0 erosion and N leaching.

Weighted average erosion = ((390 A crops x 1.2 tons/A) + (35 A x 0 tons/A))/425 A = 1.1 tons/A

<u>N leaching</u>

(390 A crops x 43 lbs N/A) + (23 A windbreaks x 0) + (12 A pasture x 1 lb N/A) = 16,782 lbs N leached from the farm, or 39 lbs N/A.

Beef farm

For well-managed permanent pasture, soil erosion = 0. PLANETOR does not calculate nitrate leaching for pasture.

NUTRIENT BUDGETS

Outputs consist of:

crops removed at harvest (Table A7-1)
associated with soil erosion [1]
denitrification and volatilization (nitrogen only) [2]
leaching (nitrate) (see PLANETOR results)

Nitrogen and phosphorus inputs to the farms consist of:

fertilizers [3]
atmospheric deposition [4]
nitrogen fixation (see Table A7-7)

[1] Calculating N and P loss accompanying soil erosion: SOM in top 12" = 3% = 300 lbs in 5 tons of soil. SOM:N ratio = 20:1, so 300 lbs SOM contains 15 lbs N, and every 667 pounds of soil eroded carries with it 1 pound of nitrogen. From Brady (1974), surface soils in humid temperate regions have N:P ratio = 3.75:1, so divide N loss in erosion by 3.75 to get P loss in erosion.

[2] Estimates based on model results of Loomis and Connor (1992, p. 468)

[3] Fertilizer rates as shown in inputs tables for each farm in Appendix 4.

[4] Personal communication, Mark Mesarch, Dept. of Agricultural Meteorology, University of Nebraska-Lincoln, 1997; Annual average atmospheric deposition of nitrogen at Mead, NE during last 18 years is 11.2 lbs N/A; Atmospheric deposition of phosphorus is negligible.

Table A7-1. Calculation of average annual nitrogen and phosphorus removal by crop based on ten-year (1985-1994) average yields for Saunders County, NE (row and grain crops) or expected yields (other crops). N and P contents are % dry matter.

Crop	yield	% moisture	yield in lbs dry weight	N content (%)	P content (%)	N export (lbs N)	P export (lbs P)
corn (grain)	105 bu (56 lbs/bu)	15.5%	4969	1.6	.275	80	14
corn silage	13.6 ton	70%	8160	1.34	.24	109	20
soybean	35 bu (60 lb/bu)	13%	1827	6.25	.636	114	12
sorghum	90 bu (56 lb/bu)	14%	4334	1.73	.363	75	16
alfalfa	3.5 ton	15%	5950	2.83	.218	168	13
w. wheat-grain	37 bu (60 lb/bu)	12.5%	1943	2.18	.615	42	12
w. wheat - straw	3330 lbs	11%	2964	.667	.073	20	2
oat (grain)	59.6 bu (32 lb/bu)	12%	1678	2.24	.341	38	6
oat straw	2556 lbs	10%	2300	.625	.164	14	4
brome hay	2 ton	12%	3520	2.29	.218	81	8
big bluestem hay	2 ton	8%	3680	1.12	.13	41	5
sweet corn - whole ear	1000 doz (6 lb/doz)	41%	3540	2.13	.37	75	13
bell pepper	1000 bu (25.2 lb/bu)	93%	1764	2.06	.31	36	5
pumpkin	18,000 lbs	92%	1440	2.00	.55	29	8
acorn squash	10,000 lbs	89%	1100	2.18	.29	24	3
spinach	6000 lbs	91%	540	5.7	.57	31	3
hazelnut w/ shells	400 lbs	1.7%	393	1.03	.11	4	0
Scotch pine	18180	67%	6000	0.4	0.04	24	2

(Data sources listed on next page)

For Table A7-1: N and P content data for sweet corn, Holland et al. (1991); peppers, pumpkin and acorn squash, (Lorenz and Maynard 1988); hazelnuts, Holland et al. (1992); big bluestem hay, Church (1984); oat straw, Weaver (1980); spinach, Watt and Merrill (1963); all others, Hanson (1990). Yield of wheat straw based on 1.5 lbs field residue per pound of grain (Hanson 1990) and 67% of residue baled. Yield of oat straw based on 2 lb field residue per pound grain (Hanson 1990) and 67% of residue baled. Silage moisture from Heichel (1980).

Table A7-2. Conventional farm nutrient budget. Each value in the nutrients per acre columns is based on 650 acres (i.e., N exported in corn divided by 650 acres (whole farm) rather than 325 acres).

Flux	Nitrogen (lb/farm/yr)	Nitrogen (lb/A/yr)	Phosphorus (lb P/farm/yr)	Phosphorus (lb P/A/yr)
Inputs				
atmospheric deposition	7150	11.0	0	0
chemical fertilizer	17875	27.5	7150	11
symbiotic N-fixation	22750 (16250 to 29250)	35 (25 to 45)	—	—
Total inputs	47775	73.5	7150	11
Outputs				
volatilization + denitrification	3250	5.0	—	—
leaching	3250	5.0	0	0
erosion/runoff	9750	15	2600	4.0
corn grain	26000	40	4550	7
soybeans	37050	57	3900	6
Total outputs	79300	121	11050	17
Net flux	-31525	-48.5	-3900	-6

Table A7-3. Modified conventional farm nutrient budget. Each value in the nutrients per acre columns is based on 650 acres (i.e., N exported in corn divided by 650 acres (whole farm) rather than 151.25 acres).

Flux	Nitrogen (lb/farm/yr)	Nitrogen (lb/A/yr)	Phosphorus (lb P/farm/yr)	Phosphorus (lb P/A/yr)
Inputs				
atmospheric deposition	7150	11	0	0
chemical fertilizer	11275	17.4	5222	8.0
symbiotic N-fixation	28975 (21575 to 36375)	44.6 (33.2 to 56.0)	—	—
Total inputs	47400	73.0	5222	8.0
Outputs				
volatilization + denitrification	3250	5	0	0
leaching	2600	4	0	0
erosion/runoff	8970	13.8	2392	3.7
corn	12100	18.6	2118	3.3
soybean	32775	50.4	3450	5.3
sorghum	11344	17.5	2420	3.7
alfalfa hay	9182	14.1	710	1.1
Total outputs	80221	123.4	11090	17.1
Net flux	-32821	-50.4	-5868	-9.1

Fixation estimates: soybean, 14375 to 25875 lbs N/farm/yr; alfalfa, 7200 to 10500 lbs N/farm/yr.

Table A7-4. Agroforestry farm nutrient budget. Each value in the nutrients per acre columns is based on 425 acres (i.e., N exported in wheat divided by 425 acres (whole farm) rather than 30 acres).

Flux	Nitrogen (lb/farm/yr)	Nitrogen (lb/A/yr)	Phosphorus (lb P/farm/yr)	Phosphorus (lb P/A/yr)
Inputs				
atmospheric deposition	4675	11.0	0	0
chemical fertilizer	6875	16.2	2970	7.0
symbiotic N-fixation	19420 (14750 to 24090)	46.0 (34.7 to 56.7)	—	—
Total inputs	30970	73.2	2970	7.0
Outputs				
volatilization + denitrification	1870	4.4	0	0
leaching	1296	3.1	0	0
erosion/runoff	4463	10.5	1190	2.8
corn	7146	16.8	1251	2.9
soybean	18689	44.0	1967	4.6
sorghum	6433	15.1	1372	3.2
alfalfa hay	10253	24.1	793	1.9
scotch pine	24	0.1	2	0
hazel nuts	50	0.1	5	0
Total outputs	50224	118.2	6580	15.4
Net flux	-19254	-45.0	-3610	-8.4

N-fixation: beans, 7550 to 13590 lbs N/farm/yr; alfalfa, 7200 to 10500 lbs N/farm/yr.

Table A7-5. Organic farm nutrient budget. Each value in the nutrients per acre columns is based on 425 acres (i.e., N exported in wheat divided by 425 acres (whole farm) rather than 30 acres).

Flux	Nitrogen (lb/farm/yr)	Nitrogen (lb/A/yr)	Phosphorus (lb P/farm/yr)	Phosphorus (lb P/A/yr)
Inputs				
atmospheric deposition	4675	11.0	0	0
manure	17474	37.5	3508	8.3
rock phosphate	—	—	264	0.6
symbiotic N-fixation	24000 (18900 to 29100)	56.5 (44.5 to 68.5)	—	—
cattle biomass	1342	3.2	305	0.7
Total inputs	47491	108.2	4077	9.6
Outputs				
volatilization + denitrification	3998	9.4	0	0
leaching	16782	39.5	0	0
erosion/runoff	1428	3.4	385	0.9
corn	4305	10.1	753	1.8
soybean	11139	26.2	1173	2.8
sorghum	2325	5.5	496	1.2
alfalfa hay	22464	52.9	1738	4.1
sweet corn	225	0.5	39	0.1
pumpkin	58	0.1	16	0
acorn squash	48	0.1	6	0
bell pepper	72	0.2	10	0
spinach	31	0.1	3	0

Flux	Nitrogen (lb/farm/yr)	Nitrogen (lb/A/yr)	Phosphorus (lb P/farm/yr)	Phosphorus (lb P/A/yr)
oat	1186	2.8	187	0.4
corn silage	3510	8.3	644	1.5
winter wheat	1396	3.3	399	0.9
brome hay	875	2.1	86	0.2
cattle biomass	1448	3.4	334	0.8
Total outputs	71290	167.9	6269	14.7
Net flux	-23799	-59.7	-2192	-5.1

N-fixation: beans, 4500 to 8100 lbs N/farm/yr; alfalfa, 14400 to 21000 lbs N/farm/yr.

<u>N loss by erosion and runoff</u>

390 A crops x 1.2 tons soil eroded/A x 3 lbs N/ton soil = 1404 lbs N
23 A windbreaks x 0 = 0 lbs N
12 A pasture x 2 lbs N/A lost from surface runoff after manure applied = 24 lbs N

Total N lost through erosion and runoff = 1428 lbs

<u>Volatilization of N from cattle manure and urine</u>

213 calves x 525 lbs live wt/calf x 0.4 lbs N excreted/day/1000 lbs live weight x 90 days backgrounding = 4,026 lbs N excreted. Assuming 30% of N volatilized (Loomis and Connor 1992), 1208 lbs N volatilized.

Manure, standard composition per ton	12 lbs N, 6 lbs P_2O_5, 10 lbs K_2O, 80% water	Sauchelli (1965), Ensminger (1983), Brady (1974)

Table A7-6. Beef farm nutrient budget. Each value in the nutrients per acre columns is based on 454 acres (handling facilities excluded).

Flux	Nitrogen (lb/farm/yr)	Nitrogen (lb/A/yr)	Phosphorus (lb/farm/yr)	Phosphorus (lb/A/yr)
Inputs				
atmospheric deposition	4994	11.0	0	0
chemical fertilizer	29960	66.0	0	0
cattle biomass	8070	17.8	846	1.9
Total inputs	43024	94.8	846	1.9
Outputs				
volatilization + denitrification*	8870	19.5	0	0
leaching**	454	1	0	0
runoff**	908	2	242	0.5
cattle biomass	11876	26.2	1343	3.0
brome hay	1330	2.9	127	0.3
big bluestem hay	2473	5.4	287	0.6
Total outputs	25911	57.0	1757	3.9
Net flux	17113	37.8	-911	-2.0

*Volatilization and denitrification from manure = 7054 lbs N; from chemical fertilizers = 1816 lbs N (Loomis and Connor (1992), p.468)
**Loomis and Connor (1992)

Nitrogen inputs in cattle biomass: 492 steers x 7.44 kg N per steer = 3660.5 kg N; ÷ 454 acres = 8.06 kg N per acre = 17.8 lbs N per acre.

Nitrogen outputs in cattle biomass: 492 steers x 10.95 kg N per steer = 5387 kg N; ÷ 454 acres = 11.9 kg N per acre = 26.2 lbs N per acre

Brome hay N: 33 tons x .88 (dry wt) x .0229 = 1330 lbs N; ÷ 454 acres = 2.93 lbs N per acre
Brome hay P: 33 tons x .88 x .00218 = 127 lbs P; ÷ 454 acres = .28 lbs P per acre
Bluestem hay N: 120 tons x .92 x .0112 = 2473 lbs N; ÷ 454 acres = 5.4 lbs N per acre
Bluestem hay P: 120 tons x .92 x .0013 = 287 lbs P; ÷ 454 acres = .63 lbs P per acre

Brown (1988):

Manure production and characteristics <u>per 1000 lb live weight</u>:

Beef, yearling (400-700 lbs): 90 lbs raw waste (feces + urine)/day; 11.5 lbs total solids; 0.4 lbs N

Beef (> 700 lbs): 60 lbs raw waste/day; 6.9 lbs total solids; 0.34 lbs N

490 steers x 767 lbs/steer x .34 lbs N excreted/1000 lbs live weight/day x 184 days on pasture = 23,512 lbs N in feces and urine; x .3 = 7054 lbs N volatilized.

From Loomis and Connor (1992):

* 30% of N deposited during grazing is lost through volatilization

* N lost in runoff from pasture is 2 lbs N/A/year

* Denitrification losses estimated as 4 lb N/A for cropland, 3 lb N/A for pasture.

* Leaching losses of N from pasture estimated as 1 lb N/A/year.

* Loss of P by leaching and runoff after spreading manure is less than losses of N.

Table A7-7. Estimating nitrogen fixation rates for legumes in crop rotations.

One of the largest uncertainties in a nitrogen budget of a farming system is the rate of nitrogen fixation by legumes. N-fixation is difficult to quantify and highly variable. Factors influencing the amount of N fixed by legumes include soil pH (optimum just below neutral), length of growing season, concentration of plant available soil N, water availability, insect and pathogen damage, species of legume, and growth stage of legume. Legumes obtain nitrogen from fertilizers, mineralization of soil organic matter, and nitrogen fixation, and it is difficult to apportion total uptake among the sources.

A literature review by Heichel (1987) showed a wide range of estimated N-fixation values (lbs N/A/growing season) including (1) alfalfa - 189 lbs in Kentucky, (2) alfalfa - 102-199 lbs in MN, (3) red clover - 61-101 lbs in MN, (4) soybean values including 76, 52, 13-75, 68-135, and 12-67 lbs (Iowa), 20-71 lbs (MN), 49-115 lbs (MN), and 93 lbs (NE). In one study, N-fixation by alfalfa was shown to vary considerably with age of stand: year 1=142 lbs N/A, year 2=102, year 3=143, year 4=199 (Heichel et al. 1981, 1984). N-fixation by the alfalfa ranged from 33% to 78% of total N uptake by the plants each year.

Loomis and Connor (1992) estimated soybean N-fixation as 58% of total plant uptake in their model of an Iowa corn-soybean farm. Heichel (1987) suggests that in the Midwestern U.S., soybeans may fix 40% of their N and obtain 60% from the soil.

For the model farms, soybeans yielding 35 bu/A had 114 lbs N in the grain (Table A7-1) and 40 lbs N in the residue (Heichel 1987) for a total of 154 lbs N uptake by the plants. Forty percent fixation equals 62 lbs of fixed N per acre. The budgets in Tables A7-2-6:

- Assume a range of N-fixation for soybeans from 50 lbs/A to 90 lbs/A, average of 70 lbs/A when yield is 35 bu/A.
- Assume a range of N-fixation for alfalfa from 120 lbs/A to 175 lbs/A, average 147.5 lbs/A when yield is 3.5 tons/A.

Appendix 8. Indicators of sustainability for farming systems.

Table A8-1. Selected indicators of sustainability for agroecosystems.

INDICATOR	DEFINITION	VALUE INDICATING HIGH SUSTAINABILITY	VALUE INDICATING LOW SUSTAINABILITY
harvest [1]	weight of harvested crops and livestock (lb/A, dry weight)	7100	0
cultural energy input [2]	total non-solar energy inputs (MJ/A)	0	24000
energy output/input [3]	ratio of energy in harvested crops to cultural energy inputs	5	< 1
energy capture efficiency [4]	energy in harvested crops as % of growing season PAR	1.0	0
water use efficiency [5]	harvested biomass (g m^{-2}) divided by AET (mm)	1.15	0
imported fertilizer [6]	N + P (lbs/A)	0	135
nitrogen losses [7]	N losses (lb/A) (erosion and leaching)	0	40
soil erosion [8]	wind+water (tons/A)	0	5
N balance [9]	N inputs/ N outputs (harvest + losses) (lbs/A)	1	< .8 > 1.2
P balance [10]	P inputs/ P outputs (harvest + losses) (lbs/A)	1	< .8 > 1.2
crop diversity [11]	# per farm	12	1
hired labor [12]	hrs per acre	0	2
net income [13]	$ per acre	95	36
capital borrowing [14]	debt/variable income	0	1
farmer knowledge [15]	total skills and knowledge held by farm family	high	low

[1] High value is dry weight of grain from Nebraska irrigated corn (150 bu/A).

[2] The value indicating low sustainability is the energy input per acre to produce irrigated corn in Nebraska (Pimentel 1980).

[3] From Pimentel and Pimentel (1996), energy output/input ratio for U.S. soybean production is 4.15:1; Ohio alfalfa is 6.17:1; corn and wheat are around 2.5:1. So, 5:1 is a reasonable upper end to scale.

[4] Loomis and Connor (1992) show that the theoretical maximum daily energy capture efficiency of a crop is 12% PAR (photosynthetically active radiation). However, Tivy (1990, p. 109) writes that only in exceptional cases do crop efficiencies exceed 2% PAR for an entire growing season, and efficiency in terms of economic yields is only 0.3 to 0.4%. If 2% capture of PAR is a high efficiency, then 1% PAR in harvest (50% of total NPP harvested) is a high upper bound for energy capture efficiency.

[5] 1.15 is the water use efficiency for corn (grain only) on a central Iowa farm (Loomis and Connor 1992).

[6] Irrigated corn yielding 150 bu/A would export 114 lbs N and 20 lbs P per acre harvested.

[7] High value (40 lbs/A) is 2x the estimated nitrogen losses for corn on a central Iowa farm (Loomis and Connor 1992).

[8] 5 tons/A is T-value for Sharpsburg silty clay loam, 4-6% slope.

[9] System outputs (harvest and losses) within + or - 20% of inputs (imported and N-fixation) is considered close to balance.

[10] System outputs (harvest and losses) within + or - 20% of inputs (imported P) is considered close to balance.

[11] Bender (1994) grows 12 crops on his eastern Nebraska organic farm. Diversity of this magnitude is required to implement flexible rotations for weed control and fertility, and provide sod and pasture crops for grazing and erosion control.

[12] Irrigated corn in Nebraska requires 2 hours labor per acre (Selley 1996).

[13] A 425-acre farm would have to generate $36/acre in net income to keep a four-person family above the official poverty line ($15141; Statistical Abstract of the United States 1996, Table 732). An average size Nebraska cash grain farm (630 acres) generating $95/acre would be in the 90th percentile of net farm income for that type of farm. (Johnson, B. 1995. A Financial Profile of Nebraska Farm Businesses, unpub. ms.)

[14] A value of 1 indicates that the income remaining after fixed costs are covered is just sufficient to repay operating loans plus interest.

[15] This is very difficult to quantify, but it is assumed to be positively correlated with the number of crops and enterprises on the farm.

Table A8-2. Raw and standardized (0 to 1) values for sustainability indicators. A standardized value of 0 indicates low sustainability; 1 indicates high sustainability.

INDICATOR	CONVEN-TIONAL	MODIFIED CONVEN-TIONAL	AGRO-FORESTRY	ORGANIC	GRAZING
harvest (lb/A)	3397 (.48)	3473 (.49)	3503 (.49)	4277 (.60)	566 (.08)
cultural energy input (MJ/A)	6992 (.71)	4980 (.79)	5707 (.76)	17593 (.27)	47331 (0)
energy output/input	3.9 (.73)	5.3 (1.0)	4.5 (.88)	1.6 (.15)	0.2 (0)
energy capture efficiency (%)	.38 (.38)	.37 (.37)	.35 (.35)	.39 (.39)	.05 (.05)
water use efficiency	.59 (.51)	.61 (.53)	.61 (.53)	.74 (.64)	.03 (.03)
imported fertilizer (lbs/A)	39 (.71)	25 (.81)	23 (.83)	45 (.67)	65 (.52)
nitrogen losses (lb/A)	25 (.38)	23 (.43)	18 (.55)	52 (0)	23 (.43)
soil erosion (tons/A)	5.0 (0)	4.6 (.08)	3.5 (.30)	1.1 (.78)	0 (1.0)
N balance	.60 (0)	.59 (0)	.62 (0)	.67 (0)	1.66 (0)
P balance	.65 (0)	.47 (0)	.45 (0)	.65 (0)	.48 (0)
crop diversity (# crops)	2 (.09)	4 (.27)	7 (.55)	15 (1.0)	2 (.09)
hired labor (hrs/A)	.44 (.78)	.59 (.70)	2.0 (0)	1.7 (.15)	.01 (.99)
net income ($/A)	50 (.24)	42 (.10)	84 (.81)	79 (.73)	64 (.48)
capital borrowing ratio	.63 (.37)	.64 (.36)	.46 (.54)	.51 (.49)	.90 (.10)
farmer knowledge	medium (.50)	medium (.50)	high (1.0)	high (1.0)	medium (.50)

References

Agricultural Research Council Working Party. 1980. The Nutrient Requirements of Ruminant Livestock. Commonwealth Agricultural Bureaux, Slough, England.

Albrecht, D.E., and S.H. Murdock. 1990. The Sociology of U.S. Agriculture. Iowa State University Press, Ames.

Altieri, M.A. 1987. Agroecology: The Scientific Basis of Alternative Agriculture. Westview Press, Boulder, CO.

Anderson, B., and J.T. Nichols. 1983. Seeding and renovating alfalfa. NebGuide G83-652, Institute of Agriculture and Natural Resources, University of Nebraska, Lincoln.

Anderson, J. 1998. Report: Small hog farms aid economy. Omaha World-Herald, 17 January, pp. 23, 30.

Anfinson, S., H. Taber, and W. Edwards. 1996. Vegetable Crop Budgets. Pm-1185d. University Extension, Iowa State University, Ames, IA.

AP. 1998. Iowa looking to add value to ag products. Omaha World Herald, 15 Mar, 9B.

Baldwin, C.S. 1988. The influence of field windbreaks on vegetable and specialty crops. Agricultural Ecosystems and Environment 22/23:191-204.

Baldwin, C.S., and E.F. Johnston. 1984. Windbreaks on the farm. Publication of the Ontario Ministry of Agriculture and Food No. 527, Ontario, Canada, 20 pp.

Ball, R.M., J.R. Brooker, and R.P. Jenkins. 1991. Packing Fresh Vegetables in Tennessee: A Break-even Analysis. Bulletin 664, University of Tennessee Agricultural Experiment Station, Knoxville, TN.

Batty, J.C., and J. Keller. 1980. Energy requirements for irrigation. pp. 35-44. In: D. Pimentel (ed.) Handbook of Energy Utilization in Agriculture. CRC Press, Boca Raton, FL.

Bender, J. (1994) Future Harvest. University of Nebraska Press, Lincoln, NE.

Beus, C.E. and R.E. Dunlap (1991) Measuring adherence to alternative vs. conventional agricultural paradigms: A proposed scale. Rural Sociology 56:432-460

Bernhardt, K.J., G.A. Helmers and J.C. Allen (1994) Economic, environmental and sociological characteristics of alternative agricultural production systems in Nebraska -- A cluster analysis approach. Draft manuscript, Department of Agricultural Economics, University of Nebraska, Lincoln, NE.

Boyette, M.D., and E.A. Estes. 1992. Crushed and liquid ice cooling. AG-414-5. North Carolina Cooperative Extension Service, N.C. State University, Raleigh, N.C.

Bradley, G.A. 1980. Energy use in spinach (*Spinacia oleracea*) production. pp. 227-231. In: D. Pimentel (ed.) Handbook of Energy Utilization in Agriculture. CRC Press, Boca Raton, FL.

Brady, N.C. 1974. The Nature and Properties of Soils. Macmillan Publishing, New York.

Brandle, J.R., B.B. Johnson, and D.D. Dearmont. 1984. Windbreak economics: The case of winter wheat production in eastern Nebraska. Journal of Soil and Water Conservation 39:339-343.

Brandle, J.R., B.B. Johnson, and T. Akeson. 1992. Field windbreaks: Are they economical? Journal of Production Agriculture 5:393-398.

Brown, R.H. (ed.) 1988. CRC Handbook of Engineering in Agriculture. CRC Press, Boca Raton, FL.

Browne, W.P., J.R. Skees, L.E. Swanson, P.B. Thompson, and L.J. Unnevehr. 1992. Sacred Cows and Hot Potatoes: Agrarian Myths in Agricultural Policy. Westview Press, Boulder.

Bukantis, R. 1980. Energy inputs in sorghum production. pp. 103-108. In: D. Pimentel (ed.) Handbook of Energy Utilization in Agriculture. CRC Press, Boca Raton, FL.

Bureau of the Census. 1983. Farm Population of the United States: 1982. Current Population Reports, Series P-27, No. 56. U.S. Department of Commerce, Washington, D.C.

Bureau of the Census. 1984. Census of Agriculture, 1982. Vol. 1, Geographic Area Series: Pt. 51, U.S. Summary, Final Report. Government Printing Office, Washington, D.C. Available: http://govinfo.kerr.orst.edu/cgi-bin/ag-list?01-state.usa [30 January 1998]

Bureau of the Census. 1992. Residents of farms and rural areas, 1991. Current Population Reports, Population Characteristics, P20-472, U.S. Department of Commerce, Washington, D.C.

Bureau of the Census. 1994. Census of Agriculture, 1992. Vol. 1, Geographic Area Series: Pt. 51, U.S. Summary, Final Report. Government Printing Office, Washington, D.C. Available: http://govinfo.kerr.orst.edu/cgi-bin/ag-list?01-state.usa [30 January 1998]

Bureau of the Census. 1996. Statistical Abstract of the United States 1996, 116th edition. U.S. Department of Commerce, Washington, D.C.

Center for Farm Financial Management. 1995. Planetor User's Manual. University of Minnesota, St. Paul, MN.

Cervinka, V. 1980. Fuel and energy efficiency. pp. 15-21. In: D. Pimentel (ed.) Handbook of Energy Utilization in Agriculture. CRC Press, Boca Raton, FL.

Chancellor, W.J., P.K. Avlani, V. Cervinka, and J.T. Alexander. 1980. Energy requirements for sugar beet production and processing. pp. 137-153. In: D. Pimentel (ed.) Handbook of Energy Utilization in Agriculture. CRC Press, Boca Raton, FL.

Church, D.C. 1984. Livestock Feeds and Feeding. O&B Books, Corvallis, OR.

Cook, C.W., J.J. Combs, and G.M. Ward. 1980. Cultural energy in U.S. beef production. pp. 405-418. In: D. Pimentel (ed.) Handbook of Energy Utilization in Agriculture. CRC Press, Boca Raton, FL.

Craig, C., and M. Duffy. 1991. An economic comparison of conventional and reduced-chemical farming systems in Iowa. American Journal of Alternative Agriculture 6:168-173.

Cramer, C. 1992. Put water in every paddock. The New Farm 14(2):18-23.

Dansingburg, J., C. Chan-Muehlbauer, and D. Gunnink. 1995. What makes sustainable farms successful? Case studies of three Minnesota farms. pp. 123-128. In: E.A.R. Bird, G.L. Bultena, and J.C. Gardner (eds.) Planting the Future. Iowa State University Press, Ames.

DeCourley, C.D., and K.C. Moore. 1987. Selected Fruit and Vegetable Planning Budgets, EC 959. Department of Agricultural Economics, University of Missouri-Columbia.

Doering, O.C., III. 1980. Accounting for energy in farm machinery and buildings. pp. 9-14. In: D. Pimentel (ed.) Handbook of Energy Utilization in Agriculture. CRC Press, Boca Raton, FL.

Doering, O. 1992. Federal policies as incentives or disincentives to ecologically sustainable agricultural systems. pp. 21-36. In: R.K. Olson (ed.) Integrating Sustainable Agriculture, Ecology, and Environmental Policy. The Haworth Press, Binghamton, NY.

Ensminger, M.E. 1983. Animal Science. The Interstate Printers & Publishers, Danville, IL.

Ferguson, R.B., E.J. Penas, C.A. Shapiro, and G.W. Hergert. 1994. Fertilizer Nitrogen Best Management Practices. NebGuide G94-1178-A, IANR, University of Nebraska, Lincoln.

Fluck, R.C., and C.D. Baird. 1980. Agricultural Energetics. AVI Publishing, Westport, CT.

Frank, A.B., D.G. Harris, and W.O. Willis. 1974. Windbreak influence on water relations, growth, and yield of soybeans. Crop Science 14:761-765.

Friedland, W.H. 1994. The global fresh fruit and vegetable system: An industrial organization analysis. pp. 173-189. In: P. McMichael (ed.) The Global Restructuring of Agro-Food Systems. Cornell University Press, Ithaca, NY.

Gilbertson, C.B., J.A. Nienaber, J.R. Ellis, T.M. McCalla, T.J. Klopfenstein, and S.D. Farlin. 1974. Nutrient and energy composition of beef cattle feedlot waste fractions. Research Bulletin 262, Agricultural Experiment Station, University of Nebraska-Lincoln.

Gilbertson, C.B., F.A. Norstadt, A.C. Mathers, R.F. Holt, A.P. Barnett, T.M. McCalla, C.A. Onstad, and R.A. Young. 1979. Animal Waste Utilization on Cropland and Pastureland: A Manual for Evaluating Agronomic and Environmental Effects. U.S.D.A Utilization Research Report No. 6, U.S. Department of Agriculture, Science and Education Administration, Washington, D.C.

Goldschmidt, W. 1946. Small Business and the Community: A Study in the Central Valley of California on the Effects of Scale of Farm Operation. Report of the Special Committee to Study Problems of American Small Business. U.S. Senate, 79th Congress, 2nd session, Committee Print 13. U.S. Government Printing Office, Washington, D.C.

Gomez, A.A., D.E.S. Kelly, J.K. Syers, and K.J. Coughlan. 1996. Measuring sustainability of agricultural systems at the farm level. pp. 401-410. In: J.W. Doran and A.J. Jones (eds.) Methods for Assessing Soil Quality. Soil Science Society of America, Madison, WI.

Guyer, P.Q., and D.D. Duey. 1986. Estimating corn and sorghum silage value. NebGuide G74-99, Institute of Agriculture and Natural Resources, University of Nebraska-Lincoln.

Hamilton, N.D. 1993. Who owns dinner: Evolving legal mechanisms for ownership of plant genetic resources. Tulsa Law Journal 28:587-643.

Hamilton, N.D. 1994. Agriculture without farmers? Is industrialization restructuring American food production and threatening the future of sustainable agriculture? Northern Illinois University Law Review 14:613-657.

Hanson, A.A. (ed) 1990. Practical Handbook of Agricultural Science. CRC Press, Boca Raton, FL.

Hassebrook, C. 1998. Time to act for family-sized farms. Farm Journal (March), p. 36.

Heffernan, W., D. Constance, R. Gronski, and M. Hendrickson. 1996. Concentration of agricultural markets. pp. 61-64. In: H. Carter and C. Francis (eds.) Proceedings of Planning and Review Meeting, North Central Sustainable Agriculture Training Program, Kansas City, MO, 17-18 November 1996. Center for Sustainable Agricultural Systems, University of Nebraska, Lincoln.

Heichel, G.H. 1980. Assessing the fossil energy costs of propagating agricultural crops. pp. 27-33. In: D. Pimentel (ed.) Handbook of Energy Utilization in Agriculture. CRC Press, Boca Raton, FL.

Heichel, G.H. 1987. Legumes as a source of nitrogen in conservation tillage systems. pp. 29-35. *In*: J.F. Power (ed.) The Role of Legumes in Conservation Tillage Systems. Soil Conservation Society of America

Heichel, G.H., and N.P. Martin. 1980. Alfalfa. pp. 155-161. In: D. Pimentel (ed.) Handbook of Energy Utilization in Agriculture. CRC Press, Boca Raton, FL.

Heichel, G.H., D.K. Barnes, and C.P. Vance. 1981. Nitrogen fixation of alfalfa in the seeding year. Crop Science 21:330-335.

Heichel, G.H., D.K. Barnes, C.P. Vance, and K.I. Henjum. 1984. Dinitrogen fixation, and N and dry matter partitioning during a 4-year alfalfa stand. Crop Science 24:811-815.

Heitschmidt, R.K., R.E. Short, and E.E. Grings. 1996. Ecosystems, sustainability, and animal agriculture. Journal of Animal Science 74:1395-1405.

Helmers, G.A., M.R. Langemeier, and J. Atwood. 1986. An economic analysis of alternative cropping systems for east-central Nebraska. American Journal of Alternative Agriculture 1(4):153-158

Hendrickson, J. 1997. Energy use in the U.S. food system: A summary of existing research and analysis. Sustainable Farming 7(4):15-18.

Hergert, G.W., R.B. Ferguson, and C.A. Shapiro. 1995. Fertilizer Suggestions for Corn. NebGuide G74-174-A (Revised July 1995), IANR, University of Nebraska, Lincoln.

Hodges, L. 1997. Windbreaks increase pepper yields. CSAS Newsletter (Jan/Feb):4.

Hodges, L., and F. Baxendale. 1991. Bee Pollination of Cucurbit Crops. NebFacts NF 91-50. Cooperative Extension, Institute of Agriculture and Natural Resources, University of Nebraska, Lincoln.

Hodges, L., F.P. Baxendale, and D.S. Wysong. 1992. Growing Squash and Pumpkin for Food and Ornamentation. Nebraska Cooperative Extension EC92-1248-C, University of Nebraska-Lincoln.

Holland, B., A.A. Welch, I.D. Unwin, D.H. Buss, A.A. Paul, and D.A.T. Southgate. 1991. McCance and Widdowson's The Composition of Foods, Fifth Revised and Extended Edition. Royal Society of Chemistry, Cambridge.

Holland, B., I.D. Unwin, and D.H. Buss. 1992. Fruits and Nuts. First Supplement to the Fifth Edition of McCance and Widdowson's The Composition of Foods. Royal Society of Chemistry, Cambridge.

Jackson, W. 1987. Alters of Unhewn Stone. North Point Press, San Francisco.

Jackson, W. 1994. Becoming Native to this Place. University Press of Kentucky, Lexington, KY.

Jamtgaard, K. 1995. Farm labor and management. pp. 83-92. In: E.A.R. Bird, G.L. Bultena, and J.C. Gardner (eds.) Planting the Future. Iowa State University Press, Ames.

Janssen, D.E., and N.E. Jennings. 1976. Christmas Trees: A Management Guide. EC 76-1741. Institute of Agriculture and Natural Resources, University of Nebraska, Lincoln, NE.

Johnson, B. (1995) Nebraska farm real estate market developments 1994-95. Nebraska Cooperative Extension EC 94-809, Institute of Agriculture and Natural Resources, University of Nebraska, Lincoln, 37p

Johnson, H., Jr., and W.J. Chancellor. 1980. Cantaloupes. pp. 209-217. In: D. Pimentel (ed.) Handbook of Energy Utilization in Agriculture. CRC Press, Boca Raton, FL.

Kirschenmann, F. 1988. Switching to a Sustainable System. Northern Plains Sustainable Agriculture Society, Windsor, ND.

Kittiampon, A., and J.E. Favis. 1989. Economies of size in South Carolina vegetable production and packing. Bulletin 667. South Carolina Agricultural Experiment Station, Clemson University, Clemson, S.C.

Klonsky, K., L. Tourte, D. Chaney, P. Livingston, and R. Smith. 1994. Cultural Practices and Sample Costs for Organic Vegetable Production on the Central Coast of California. Giannini Foundation Information Series No. 94-2, Division of Agriculture and Natural Resources, University of California, Davis.

Kort, J. 1988. Benefits of windbreaks to field and forage crops. Agricultural Ecosystems and Environment 22/23:165-190.

Laine, P., D.W. Countryman, and P.H. Wray. 1992a. Christmas Tree Production in Iowa: Economics and Marketing, PM-1500. University Extension, Iowa State University, Ames, Iowa.

Laine, P., D.W. Countryman, and P.H. Wray. 1992b. Christmas Tree Production in Iowa: Economics and Marketing, PM-1499. University Extension, Iowa State University, Ames, Iowa.

Larkin, D., L.R. Moran, R.W. Morris, and D.Y. Sieff. 1996. Business situation. Survey of Current Business, Volume 76(5), May 1996. U.S. Department of Commerce, Washington, D.C.

Lehman, K., and A. Krebs. 1996. Control of the World's food supply. pp. 122-130. In: J. Mander and E. Goldsmith (eds.) The Case Against the Global Economy: And For a Turn Toward the Local. Sierra Club Books, San Francisco.

Liebhardt, W.C. 1993. The Dairy Debate: Consequences of Bovine Growth Hormone and Rotational Grazing Technologies. Sustainable Agriculture Research and Education Program, University of California - Davis.

Lobao, L.M. 1990. Locality and Inequality. SUNY Press, Albany, NY.

Lockeretz, W. 1980. Energy inputs for nitrogen, phosphorus, and potash fertilizers. pp. 23-24. In: D. Pimentel (ed.) Handbook of Energy Utilization in Agriculture. CRC Press, Boca Raton, FL.

Loomis, R.S., and D.J. Connor. 1992. Crop Ecology. Cambridge University Press, Cambridge.

Lorenz, O.A., and D.N. Maynard. 1988. Knott's Handbook for Vegetable Growers. John Wiley and Sons, New York.

Lyson, T.A., C.C. Geisler, and C. Schlough. 1998. Preserving community agriculture in a global economy. Chapter 5. In: R.K. Olson and T.A. Lyson (eds.) Under the Blade: The Conversion of Agricultural Landscapes. Westview Press, Boulder, CO, in press.

Marr, C., T. Schaplowsky, N. Tisserat, and B. Bauernfeind. 1995. Pumpkins. Cooperative Extension Service, Kansas State University, Manhattan, KS

Massey, R.E. 1993. 1992 Nebraska farm custom rates - Part II (revised 1993). NebGuide G75-249.

Massey, R.E. 1994. 1994 Nebraska farm custom rates - Part I. NebGuide G75-249.

McFadden, S., and T. Groh. 1998. Farms of Tomorrow Revisited. Biodynamic Farming & Gardening Association, Kimberton, PA.

NASS. 1994 and 1995. Nebraska crops and weather. Nebraska Agricultural Statistics Service, Lincoln.

Nebraska Cooperative Extension. 1996. A 1996 Guide for Herbicide Use in Nebraska, EC 96-130-D. IANR, University of Nebraska-Lincoln.

NOAA. 1985-1994. Climatological Data Annual Summaries for Nebraska. National Climatic Data Center, Asheville, NC.

Norton, N.A., R.T. Clark, M.E. Baker, and L.A. Malm. 1996. Livestock Fencing Costs and Information. Cooperative Extension EC96-820-B.

NRC. 1996. Nutrient Requirements of Beef Cattle, Seventh Revised Edition. National Academy Press, Washington, D.C.

Ogbuehi, S.N., and J.R. Brandle. 1981. Influence of windbreak-shelter on soybean production under rain-fed conditions. Agronomy Journal 73:625-628.

Olson, R.K., and C.A. Francis. 1995. A hierarchical framework for evaluating diversity in agroecosystems. pp. 5-34. In: R.K. Olson, C.A. Francis, and S. Kaffka (eds.) Exploring the Role of Diversity in Sustainable Agriculture. American Society of Agronomy, Madison, WI.

Olson, R.K., M.M. Schoeneberger, and S.G. Aschmann. 1998. Ecological foundations for temperate agroforestry. Chapter 2. In: W. Rietveld (ed.) North American Temperate Agroforestry. American Society of Agronomy, Madison, WI.

Omernik, J.M. 1987. Ecoregions of the conterminous United States. Supplement to the Annals of the Association of American Geographers, Vol. 77, No. 1.

O'Neill, R.V., D.L. DeAngelis, J.B. Waide, and T.F.H. Allen. 1986. A Hierarchical Concept of Ecosystems. Princeton University Press, Princeton, NJ.

Orr, D. 1992. Ecological Literacy: Education and the Transition to a Post-modern World. State University of New York Press, Albany.

Peart, R.M., R. Brook, and M.R. Okos. 1980. Energy requirements for various methods of crop drying. pp. 49-54. In: D. Pimentel (ed.) Handbook of Energy Utilization in Agriculture. CRC Press, Boca Raton, FL.

Peterson, W.L. 1997. Are Large Farms More Efficient? Staff Paper P97-2. University of Minnesota, Department of Applied Economics.

Pimentel, D. 1980. Energy inputs for the production, formulation, packaging, and transport of various pesticides. pp. 45-48. In: D. Pimentel (ed.) Handbook of Energy Utilization in Agriculture. CRC Press, Boca Raton, FL.

Pimentel, D., and M. Burgess. 1980. Energy inputs in corn production. pp. 67-84. In: D. Pimentel (ed.) Handbook of Energy Utilization in Agriculture. CRC Press, Boca Raton, FL.

Pimentel, D., and M. Giampietro. 1994. Food, Land, Population, and the U.S. Economy. Carrying Capacity Network, Washington, D.C.

Pimentel, D., and M. Pimentel. 1996. Transport of agricultural supplies and foods. pp. 199-201. In: D. Pimentel and M. Pimentel (eds.) Food, Energy, and Society. University Press of Colorado, Niwot.

Powell, T.A., D.E. Ellis and D.L. Hansen (1992) Cost of owning & operating farm machinery, Nebraska Cooperative Extension EC92-892-G, Institute of Agriculture and Natural Resources, University of Nebraska, Lincoln, 73 pp.

Proebsting, E.L. 1980. Energy inputs in cherry production. pp. 251-254. In: D. Pimentel (ed.) Handbook of Energy Utilization in Agriculture. CRC Press, Boca Raton, FL.

Ramming, D.W. 1980. Energy use for the production of plums and prunes. pp. 261-267. In: D. Pimentel (ed.) Handbook of Energy Utilization in Agriculture. CRC Press, Boca Raton, FL.

Rogers, D. 1993. Leasing farmland. pp. 17-25. In: G. Wunderlich (ed.) Land Ownership & Taxation in American Agriculture. Westview Press, Boulder, CO.

SARE. 1998. 1998 Project Highlights. Sustainable Agriculture Research and Education Program, U.S. Department of Agriculture, Washington, D.C.

Sauchelli, V. 1965. Phosphates in Agriculture. Reinhold, New York.

Scott, W.O., and J. Krummel. 1980. Energy used in producing soybeans. pp. 117-121. In: D. Pimentel (ed.) Handbook of Energy Utilization in Agriculture. CRC Press, Boca Raton, FL.

Selley, R.A. (ed) 1995. Nebraska Livestock Budgets. Nebraska Cooperative Extension EC95-818-S, Institute of Agriculture and Natural Resources, University of Nebraska, Lincoln.

Selley, R.A. (ed.) 1996. Nebraska Crop Budgets. Nebraska Cooperative Extension EC96-872-S. Institute of Agriculture and Natural Resources, University of Nebraska, Lincoln, NE.

Shain, D., T. Klopfenstein, R. Stock, and B. Vieselmeyer. 1995. Grazing systems utilizing forage combinations. pp. 18-20. 1995 Nebraska Beef Cattle Report MP 62-A, Institute of Agriculture and Natural Resources, University of Nebraska, Lincoln.

Shain, D., T. Klopfenstein, R. Stock, and M. Klemesrud. 1996. Grazing systems utilizing forage combinations. pp. 48-51. 1996 Nebraska Beef Cattle Report MP 63-A, Institute of Agriculture and Natural Resources, University of Nebraska, Lincoln.

Shain, D., T. Klopfenstein, R. Stock, and M. Klemesrud. 1997. Forage combinations for summer and fall grazing. pp. 56-59. 1997 Nebraska Beef Cattle Report MP 67-A, Institute of Agriculture and Natural Resources, University of Nebraska, Lincoln.

Smit, B., D. Waltner-Toews, D. Rapport, E. Wall, G. Wichert, E. Gwyn, and J. Wandel. 1998. Agroecosystem Health: Analysis and Assessment. The Agroecosystem Health Project, University of Guelph, Guelph, Ontario, Canada.

Smith, E.G., and B.C. English. 1983. Determining Wind Erosion on the Great Plains. Misc. Report 1983-1, Center for Agricultural and Rural Development, Iowa State University, Ames, IA.

Smith, S. 1992. "Farming" — It's declining in the U.S. Choices (First quarter):8-10.

Sorensen, A.A., R.P. Greene, and K. Russ. 1997. Farming on the Edge. American Farmland Trust, Center for Agriculture in the Environment, Northern Illinois University, DeKalb, IL.

Souchelli, V. 1965. Phosphates in Agriculture. Reinhold Publishing, New York.

Spence, G.B. 1987. Growing Mustard Greens. Fact Sheet 462, Enterprise Guide for Southern Maryland. Cooperative Extension Service, The University of Maryland, College Park, MD.

Standard and Poors. 1994. Standard and Poors Industry Surveys. Standard and Poors Corporation, New York.

Stoeckeler, J.H. 1962. Shelterbelt Influence on Great Plains Field Environment and Crops: A Guide for Determining Design and Orientation. Production Research Report No. 62. U.S. Department of Agriculture, Forest Service, Washington, D.C.

Stout, B.A. 1984. Energy Use and Management in Agriculture. Breton Publishers, North Scituate, MA.

Taylor, T.G., and S.A. Smith. 1989. Production Costs for Selected Florida Vegetables, 1988-89. Economics Information Report 257. Institute of Food and Agricultural Sciences, University of Florida, Gainesville.

Tivy, J. 1990. Agricultural Ecology. Longman Scientific & Technical, Harlow, Essex, England.

Urban, T.N. 1991. "Agricultural industrialization: It's inevitable." Choices 6(4):4-6.

USDA. 1994 and other years. Chicago Wholesale Market Prices, Fresh Fruits and Vegetables. Agricultural Marketing Service, Market News Branch, Chicago, IL.

USDA. 1995a. Summary Report: 1992 Natural Resources Inventory. U.S. Department of Agriculture Natural Resources Conservation Service, Washington, D.C.

USDA. 1995b. Market News. Livestock, Meat, Wool -- Weekly Summary and Statistics, Vol. 63, No. 04. Agricultural Marketing Service, U.S. Department of Agriculture, Washington, D.C.

USDA. 1998. A Time to Act: A Report of the USDA National Commission on Small Farms. MP-1545. U.S. Department of Agriculture, Washington, D.C.

Vieselmeyer, B., T. Klopfenstein, R. Stock, and R. Huffman. 1994. Extensive beef production systems: Forage combinations managed as one unit. pp. 20-23. 1994 Nebraska Beef Cattle Report MP 61-A, Institute of Agriculture and Natural Resources, University of Nebraska, Lincoln.

Waller, S.S., L.E. Moser, and B. Anderson. 1986. A Guide for Planning and Analyzing a Year-Round Forage Program, EC 86-113-C. Nebraska Cooperative Extension, IANR, University of Nebraska-Lincoln.

Watt, B.K., and A.L. Merrill. 1963. Composition of Foods. Agriculture Handbook No. 8, U.S. Department of Agriculture, Washington, D.C.

Weaver, S.H. 1980. Energy use in the production of oats. pp. 85-92. In: D. Pimentel (ed.) Handbook of Energy Utilization in Agriculture. CRC Press, Boca Raton, FL.

Wellman, A.C. 1995. Crop and Livestock Prices for Nebraska Producers. Nebraska Cooperative Extension EC95-883-C, Institute of Agriculture and Natural Resources, University of Nebraska, Lincoln.

Zohar, Y., and J.R. Brandle. 1978. Shelter effects on growth and yield of corn in Nebraska. Layaaran 28:11-20 (in Hebrew).