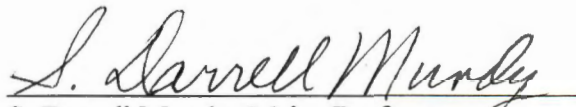
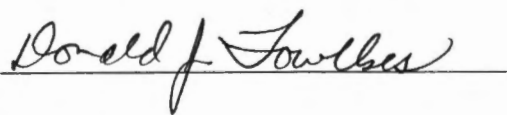


To the Graduate Council:

I am submitting herewith a thesis written by Tara Elizabeth Hobbs entitled "A Preliminary Case Study of a Leased Research-Demonstration Farm Using Linear Programming." I have examined the final copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Agricultural Economics.


S. Darrell Mundy, Major Professor

We have read this thesis
and recommend its acceptance:





Accepted for the Council:


Associate Vice Chancellor
and Dean of The Graduate School

**A Preliminary Case Study of a Leased Research-Demonstration
Farm Using Linear Programming**

A Thesis

Presented for the

Master of Science

Degree

The University of Tennessee, Knoxville

Tara Elizabeth Hobbs

May 1997

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DEDICATION

This thesis is dedicated to the author's parents

Mr. and Mrs. Jimmy and Jane Murray

and

Mr. G. Ralph Hobbs

whose understanding and support made this possible.

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Many people contributed to the development and completion of this thesis. The work completed for this study would not have been possible without the assistance, encouragement, and support of a number of professors, family and friends. Any omission of names does not indicate a lack of gratitude.

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ABSTRACT

This research study focused on using linear programming to do a baseline income optimization study of a diversified operating farm leased by The University of Tennessee Tobacco Experiment Station in Greeneville, Tennessee. The more precise management of land resources over and above what is typical of most farm operations in East Tennessee was the primary objective. A more specific division of the original crop fields and pastures was deemed necessary to improve upon management precision of land resources. Therefore, the original crop fields and pastures were further divided into smaller management blocks and referred to as “farming units.”

The farm’s 109.10 cropable acreage was divided into 31 farming units for this study based on variabilities in soil types and slopes. The actual acreage in each farming unit was then measured using topographic maps of the farm. The soil types predominately covering each farming unit were determined through soil sampling and the use of soil maps. The production capacities of each soil type were used to calculate the yields of each crop option for all 31 farming units. Once the yields were established, they were used in the linear programming model to assist in the determination of the optimal enterprise mixes that would maximize gross margins. The analysis focused on the use of the farm’s land resources under both full- and part-time labor situations.

The model was used to determine optimal alternative crop and/or livestock enterprise systems that returned the highest gross margins for differing scenarios on both a full- and part-time basis. This was completed to establish a baseline scenario of enterprise

systems that best suited the given land as well as generated the greatest net returns as measured by gross margins for the research farm. Of the 14 scenarios, the full-time free model scenario generated the greatest returns with an objective value of \$227,570.76, and included okra, PYO strawberries, no-till corn, and broiler production. All 109.10 acres of available cropland were utilized. The free model of the part-time scenarios also employed all available cropland, but selected conventional-till corn, okra, PYO strawberries, no-till corn, and broiler production in the solution. This model had an objective value of \$109,702.69 and yielded the highest net returns of the part-time scenarios. The results of each scenario considered by the model served as guides in determining the optimal mix of enterprises that not only best suited the limited land resources but also returned the highest gross margins for the research farm.

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Chapter 1

Introduction

Economic Setting/Problem

Changes in the economic setting of farming have motivated many producers to employ more of their management skills in stressing the broader perspective of the “business” of farming rather than focusing primarily on production in their operations. As shown by census data, between 1982 and 1992, the number of farms in Tennessee has declined from 90,565 to 75,076. Acreage of land in farms has also decreased from 12.4 million to 11.1 million acres. However, the average size of farms in Tennessee has increased from 138 to 149 acres over the same period. The same trend is seen nationally. The number of farms in the United States decreased from 2.2 million to 1.9 million from 1982 to 1992 while the acres of land in production fell from 986.7 million acres to 945.4 million acres (1992 Agriculture Census for United States). The average size of farms has increased nationally from 440 acres to 491 acres. Hence, the current trend is one of fewer but larger farms.

These trends can be attributed to numerous factors. Farmers are lured by the benefits, fixed and usually fewer work hours, and more stable and generally higher incomes that off-farm jobs offer. Many younger, potential farmers are moving away from farming as a professional choice, particularly as full-time operators, due to the lower and fluctuating incomes they foresee in agriculture. Farmers, whether full- or part-time, who do stay in business must adjust to new technologies to stay competitive in today's market.

Adopting these new technologies generally requires new capital as well as enhanced management skills.

Stressing better management of resources and the optimal allocation of these resources is one of the cornerstones of farm management. In doing so, farmers can possibly increase their incomes. If farm income can be raised, more people might be enticed to stay in farming or enter the profession.

The continuing search for new enterprises and methods of production is also a result of the current economic setting of agriculture. Under the alleged “cost-price squeeze”, as farmers face higher input costs as compared to product prices, they tend to look for more cost effective means of production and marketing as well as the expansion of production volume; another response of agricultural producers is the search for newer, allegedly more profitable enterprises. With many conventional enterprises such as dairy, beef, corn, tobacco, soybeans, and wheat, either experiencing low profits or the perception of low profits, farmers are considering alternative enterprises such as ginseng, fruits and vegetables, ornamentals, and nontraditional livestock such as ostriches and emus.

Diversification is another option many agricultural producers are contemplating as a solution to low profits in agriculture. Multiple enterprises, crop rotations, sequential cropping systems, and use of family labor and capital in off-farm activities related to the farm business, or to business and employment activities not related to the farm are various forms of diversification that producers are considering. Diversification has been promoted as one strategy to reduce the risk involved in agricultural production for many years. For

example, a 1918 farm management text stated, “No system of agriculture can succeed on one crop” (Babb and Long, 1987).

A diversified operating farm is currently being leased by The University of Tennessee Tobacco Experiment Station in Greeneville, Tennessee. By combining the details listed above, a case-study problem has been developed to identify better ways of managing the farm’s limited resources while still adhering to conservation regulations. Determining the best enterprise combinations for the farm based on researched methods of allocating the farm’s limited resources are problems to be solved. This preliminary study will give direction to future research on the farm.

Justification of Research

In Tennessee, many "typical" full-time farming operations are either going completely or partially out of business or expanding production volume and/or looking for complementary or supplementary farm and nonfarm enterprises. Land ownership patterns, housing characteristics, topography, soils, off-farm employment and investment alternatives, and cultural traditions, found in the state result in types of farming characteristics that include several important enterprises that generally are not as land extensive as traditional row crops. In East and Middle Tennessee, typical examples of such enterprises are dairy and tobacco. In addition, beef cattle production, although a land-extensive enterprise, is also a popular enterprise even among small landholders throughout the state. Many of these beef producers work full-time off the farm (Mundy and Gray, 1986).

The number of dairy operations in Tennessee has decreased substantially over the last ten years. As more of these operations close, many dairy producers either retire from farming altogether or switch to a different enterprise such as beef production and/or crops such as tobacco and speciality crops. Tobacco farmers in the area are faced with problems of a diminishing domestic labor pool, uncertainty regarding migrant worker status and regulations, and an uncertain future for their crop due to intense international competition and the anti-tobacco movement.

Many farmers face uncertain futures unless other enterprises can be found to help increase their cash flow and raise farm income; therefore, farmers are looking beyond traditional enterprises for alternatives to help meet these goals. Many producers are looking at diversification as a method of reducing risks and maximizing profit by gaining from complementary and supplementary relationships of various enterprises. Farmers are looking for enterprises in which they can use the labor and other resources that they already have available to them, and/or to which they can gain access, to combine with their present crop and/or livestock production.

Land is generally perceived by many producers to be a relatively fixed resource. Finding ways to better utilize the soils and other characteristics of this somewhat fixed and limited resource will assist producers in maximizing their use of the land. In turn, the foundation to raise farm income is laid. A current trend in improving agricultural land utilization is precision farming. Paul Hollis (1996), states, "The goal of every farm is to maximize profits from every farming unit of production. Prior to now, maximizing profit

on every unit of production meant every field. This is no longer true. This system [precision farming] allows us to work with parts of fields.”

According to Mundy (1996), there are several fundamental economic questions posed by farmers. “Some examples include the following:

- 1.) Should I farm at all?
- 2.) What crop and/or livestock enterprises should I produce?
- 3.) When, and how much should I produce?
- 4.) How do the enterprises I produce or contemplate producing complement, supplement, and/or compete with each other economically and environmentally?
- 5.) Can I farm profitably while meeting environmental, safety, labor, health, and other regulations?”

Each producer must answer these questions for himself as each operation has its own set of advantages and disadvantages, benefits and problems, and each producer's objectives differ. These questions can be addressed by economic research. Mundy continues to say that an "integrated, holistic farm-size approach to answering [these] questions regarding individual or multiple-enterprise (whole-farm) systems can be effective."

According to Gebrehedhin and Tweeten (1991), “Research is essential to address complex problems demanding objective analysis.” These authors find that by using research, “we attempt to answer questions for which no answers exist, to solve problems that have not as yet been solved, or to reaffirm those answers and solutions which we assume to be valid but need confirmation,” (Gebremedhin and Tweeten, 1991). There are two types of research: basic and applied. Basic research may have no immediate

application, and often this type of research modifies existing theories. Applied research, the second type of research, is done to solve problems. Results from basic research are employed and used in applied research. In doing any type of research, the scientific method approach is followed; the process is termed a systems analysis approach. This analysis “emphasizes that each component or subsystem of the phenomenon or problem being analyzed must be identified and understood in its relationship to other subsystems and to the total system,” (Gebremedhin and Tweeten, 1991).

“Integrated, holistic research problems are complex and often require substantial data. Data sources usually include actual operating farms, synthetic data from economic engineering analyses and other synthetic modeling approaches, and large farm-size replicated experiments, and/or case studies conducted on a research station. The farm source could also be an operating farm leased or owned by the research entity for conducting farm-size systems management research. Whatever the level of analysis (i.e., sub-enterprise, single enterprise, or multiple enterprise), proper attention to the holistic aspects of the physical, biological, economic, and institutional interrelationships will be required. Appropriate care and attention to details in the setting(s) of a “typical” or “representative” farm situation can provide much needed, readily usable, practical economic information. This information may be used to satisfy a variety of needs” (Mundy, 1996).

Research Objectives

This research focused on using linear programming to do a preliminary income optimization study of a diversified operating farm leased by the Tennessee Agricultural

Experiment Station. The farm, located in Greene County, was leased for a minimum of ten years for the purpose of serving as a research-demonstration “laboratory” to stimulate as closely as possible a typical “working” or operating farm in East Tennessee. The study had the following objectives:

- 1.) To create more precise land management units for the research demonstration farm;
- 2.) To develop a preliminary case study of the farm determining optimal alternative crop and/or livestock enterprise systems which show the greatest gross margins and to evaluate optimal solutions (gross margins) given the enterprise systems and resource constraints.

Chapter 2

Review of Literature

Numerous studies and research projects have been conducted in the areas of farm management and optimal farm resource allocation. Many articles and books on these subjects have been reviewed for this study, and most of the information can be broken down into two major categories. These two categories include 1) production economics, specifically dealing with resource allocation and farm management, and 2) the use of linear programming (LP) in agriculture.

Production Economics and Farm Management

A basic understanding of production economics is essential to this study. Work done by Heady (1952) provides a review of the fundamentals of production economics with a specific emphasis on resource allocation. The major issues of production economics, as described by Heady, are the determination of the optimal allocation of resources and of farm income.

Heady (1952) lists two major goals of production economics: "(1) to provide guidance to individual farmers in using their resources most efficiently, and (2) to facilitate the most efficient use of resources from the standpoint of the consuming economy." He repeatedly emphasizes the point that production economics draws heavily from the physical sciences as well as from other social sciences. One example of this is the concept of the production function, which examines the input-output relationship.

A production function (Beattie and Taylor, 1985) graphically depicts the physical

relationship between inputs and outputs, among inputs (interaction), and if among outputs multiple products (multiple product-multiple function systems) . By varying one input amount while holding all other input amounts constant, the resulting expression is the relationship between the input required for and the output from production. Because farming involves physical, biological, and chemical processes, the production function is an indispensable tool in making sound economic decisions regarding agricultural production (Farm and Ranch Management Manual, 1987). The production function is a fundamental tool in decision making because it assists in determining the most profitable level of input usage.

According to the Farm and Ranch Management Manual (1987), the law of diminishing returns is another principle used in decision making. This law is derived from the production function and is another physical relationship to which economic rationale can be applied. The law demonstrates the economic principle that inputs are used to the point where marginal input cost equals marginal value product ($MIC=MVP$). Producers will not apply costly inputs above the rate where marginal returns are less than their marginal input costs.

Producers must make decisions within the context of two time frames: the short-run and the long-run. They look to increase profit (income) and decrease the variability of income during the short-run period. When used appropriately as a risk-reduction strategy, diversification is a production strategy that involves the scientific selection and combination of enterprises that will decrease the variability of farm income (Barry, 1977). Furthermore, in a static, riskless context, it is a method of maximizing profits by gaining

from complementary and supplementary relationships and equating substitution and price ratios for competitive products (Heady, 1952). Diversification involves the adoption of several production activities instead of a single activity to manage effectively both production and marketing risks. For example, to minimize production risks, enterprise mixes are selected to not be similarly affected by factors such as temperature and rainfall; therefore, when the yield of one enterprise is low, other enterprise yields will not be similarly lowered and may even have an increased yield. Similarly, diversification for the purpose of reducing price risks requires a combination of enterprises whose prices have opposite or somewhat differing price cycles or at least unrelated price cycles (Castle, et al., 1987).

Heady concludes that there are two different approaches of diversification to reduce risk. The first approach involves increasing total resources to produce additional enterprises (e.g. add more capital). The second approach holds the amount of total resources constant and reallocates some resources to the added enterprises (same amount of resources but a partial shift to different enterprises). Heady explains that bankers encourage the use of more capital while “spreading their risks”, but the second approach is a more realistic choice because most farmers operate on limited amounts of capital. Castle, et al. (1987) explains that diversification actually has a horizontal aspect and a vertical aspect. Horizontal diversification is the production of several commodities while the production, distribution, and/or processing of one commodity involving stages beyond production is vertical diversification.

Linear Programming and Its Uses in Agriculture

Linear programming (LP), a mathematical problem solving tool, was first developed during World War II for the purposes of determining supply and shipping routes to the allied troops and allocating scarce labor and capital supplies for war materials (North Dakota State University, 1992). During the 1960's and 1970's, LP shifted from an exclusively military tool to one available to the general public. Agricultural researchers found it to be effective in farm modeling (Isaacs, 1992). Until the advent of the computer, LP was only used for smaller models as the calculations were done by hand. However, with the aid of computers, LP models are now larger and more complex and used by researchers, farm managers, and agricultural students to solve a variety of farm management problems (North Dakota State University, 1992 and Isaacs, 1992). Examples of micro-level applications of LP include the identification of optimal livestock rations and optimal crop rotations while examples of macro-level uses involve studies determining optimal facility locations and policy impact analyses (Jeffrey, Gibson, and Faminow, 1992). The major objective of LP is the calculation of the combination of enterprises that yield the best use of limited resources to achieve a specified goal (North Dakota State University, 1992 and Aakre, Olson, Egeberg, Swenson, and Hughes, 1992).

Jeffrey, et al. (1992) lists three major benefits of using LP as an analytical tool. These benefits are: (1) no need for extended time series data, (2) specific guidelines are provided for achieving an optimal solution, and (3) the opportunity costs for alternative uses of resources can be deduced through analysis of the dual solution. Another advantage of using LP is its ability to consider various enterprises and production

alternatives while accounting for the production relationships and interactions in the farm model (North Dakota State University, 1992 and Aakre, et al., 1992).

The work done by Jeffrey, et al. (1992) also describes the limitations that LP presents. The three main limitations cited include: (1) a very structured model requiring restrictive assumptions, (2) the assumption of complete knowledge of all parameters, and (3) the tendency to focus on a single optimal solution. Furthermore, as noted in North Dakota State University (1992), LP requires extremely accurate and detailed information for a complete, precise analysis.

Studies Using Linear Programming

Heady was a front-runner in solving agricultural problems using LP. He described LP as a procedure that allowed farmers to consider many different enterprise combinations and then select a plan to maximize profits. Heady recognized the greatest advantage of LP to be the opportunity for farmers to include personal preferences in the planning process by allowing the exclusion of activities not meeting their particular needs and circumstances.

In the research bulletin, "Farm Planning for Maximum Profits on The Cresco-Clyde Soils in Northeast Iowa, and Comparison of Farm and Nonfarm Incomes for Beginning Farmers," by Heady and Loftgard (1957), farm capital was reallocated in various ways while land and labor were held constant to determine the optimal farm plan using LP. The objectives of the study were: (1) to find profit maximizing farm plans, (2) to demonstrate how optimum plans vary with differing levels of managerial skills and

resource quantities, (3) to estimate the income of optimal farm plans, and (4) to compare optimal farm incomes with potential off-farm incomes.

Linear programming was used to develop a simulation model of commercial sugar cane farms in Shuker, Heagler, and Chapman's study (1986). That LP model recognized the production costs and yield differences between two different soil types. They noted that the LP model acted as a "resource allocation simulator" that gave them data for economic analysis but did not, in itself, provide any type of economic analysis. Shuker, et al. (1986) chose LP because of its capacity and ability to analyze large numbers of alternative production activities within the various constraints found in sugar cane production. Another advantage was the flexibility LP provided in changing exogenous and endogenous factors in the model by altering the values in the LP matrix.

The Rapid Adjustment Program (RAP), developed in cooperation with the Tennessee Valley Authority (TVA) and local land-grant institutions (including the University of Tennessee) in the seven-state TVA regions, used LP to optimally allocate resources for selected farms in the TVA region. The RAP was in place from 1962 to 1987. During this time span, the developers of the program selected farms that were thought to have the potential to increase their income. The RAP worked in cooperation with the farm manager of each representative farm. Farm management specialists from the Agricultural Extension Service informed each farm manager about the efficient allocation of resources and the resultant variations on income (Gray, 1989 and Owusu, 1985). Gray (1989) listed the two primary objectives of the RAP as: "(1) to determine the types and

rates of farm adjustment possibilities, given the diverse sets of available resources on each farm; and (2) to implement these adjustments on the farm."

Economics is not the only field in which linear programming is applied for research purposes; other fields of study also use LP. Animal science is an example of one such field. Brennan and Hoffman (1989) used LP to show how ration type, feeding management, and marketing alternatives affected the profitability of feedlot cattle production in the Midwest. A LP model was developed to simulate a Midwestern farm feedlot production system. The model was then used to analyze research data generated from cattle feeding trials to identify optimal feeding systems and other management strategies that contributed to efficient feedlot cattle production.

In a study done by Trede, Boehlje, and Geasler (1977), LP was used to determine what most affected cattle profits. They considered various differing housing systems and diets. An analysis was done to identify the impact of changes in feed efficiency on average daily gain. They found that the differences in profits were mainly due to the differences in the fixed costs of the systems. In their study, Trede, et al. (1977), designed the LP model to maximize gross income minus variable costs, or gross margins.

A linear programming model was used in a study done by Bowling (1994) to evaluate the impact that Conservation Compliance has on farm-level net returns in the short run as erosion is also reduced. The model incorporated the Erosion-Productivity Impact Calculator (EPIC) to determine erosion rates and determined the relationship between erosion and productivity. According to Bowling (1994), the model was composed of "physically based components for simulating erosion, plant growth, and

related processes. It also contained economic components for assessing the cost of erosion, determining optimal management strategies, etc.”

Chapter 3

Procedure

Linear programming was used to determine the most beneficial combinations of enterprises (as measured by the optimal use of resources) and the gross margins of the demonstration farm in this study. The linear programming results were generated by the General Algebraic Modelling System (GAMS). Various assumptions regarding land, labor, and capital will be indicated.

Overview of the On-Going Multi-Year Project

Economic research, based on a farm representative of the East Tennessee region, is necessary to assist local farmers in answering many questions related to optimizing production and maximizing profits. The farm used for this research is being managed in a manner that utilizes: (1) managerial applications of typical farming technologies, practices, and systems; (2) recommended technologies, practices, and systems, many of which are not currently well integrated into most farm situations; and (3) newer, nonconventional technologies, practices, and systems. Research and Extension scientists composed of agricultural economists, agricultural engineers, animal scientists, and plant and soil scientists are studying the farm and helping determine the enterprises, practices, and techniques used. This combination of disciplines helps ensure that multiple aspects of the business and production processes are considered (Mundy, Hatch Proposal, 1996).

Several factors must be examined when selecting crop enterprises and determining the cropping methods and inputs for production. Bender, Kahan, and Mylander (1992)

believe that the decision maker should focus first on the activities that can be undertaken. One reason for this is that most decision makers think in terms of activities and enterprises, and once these activities have been identified, considering the limiting constraints and factors of these activities is easier. For example, physical factors to consider include soil types, topography, climate, machinery, and buildings. Economic factors to evaluate include crop prices, input costs, risk, and uncertainty. Careful consideration of labor requirements, the need for irrigation, and other miscellaneous resources is also imperative. The most limiting factor in the crop selection process, however, could be the manager's ability to strategize and direct resources (Farm and Ranch Management Manual, 1987). Consideration must be given to all these factors in order to determine the best mix of enterprises.

While the procedure for selecting enterprises varies according to the conditions of each situation, the Farm and Ranch Management Manual (1987) suggests following six basic steps. The six steps are as follows: (1) develop a list of physical factors such as capital, soil types, climate, topography, irrigation water, buildings, machinery, and available labor; (2) develop a list of current or potential biological factors such as insects, diseases, weeds, and predators; (3) develop a list of economic factors including prices, costs, investment, and risk; (4) define the availability of markets for each potential commodity; (5) develop a list of institutional factors such as government, leasing, and industry activities; and (6) access personal resources of capital, training, and managerial ability. Upon completion of these tasks, various farm enterprises can be evaluated and compared to other operations having similar enterprise mixes.

The selection of livestock enterprises should be approached in a manner similar to that used in crop selection; however, the criteria exercised will be somewhat different. The differing criteria include questions regarding feed crops (feed to livestock and/or to sell at market); which livestock are best suited to the available feed supply, which livestock have the best available market, and what is the managerial capacity of the operator to manage the livestock. The producer must recognize that under certain conditions buying feed is more economical than using limited land resources to produce feed; it is sometimes more profitable for the producer to use the limited land resources to produce feed and in some situations a higher profit can be made using limited land resources to raise crops with a higher rate of return than feed crops.

One of the most important decisions made by agricultural producers is what combination of crops and livestock to grow on their limited land area given restricted quantities of labor, capital, and management. Most farmers strive for an economic balance between livestock and crop production (Heady, 1952). The analysis for this report addresses a small- to medium-size farm and determines the optimal allocation of resources and enterprise mixes that would most likely maximize the gross margins (the return over variable costs) of the farm. The extent to which a farm of this size can handle diversification is another concern of this study. The farm under consideration is typical of many East and Middle Tennessee farms regarding land availability, soil types, and available resources (1992 Agriculture Census for Tennessee). Tobacco, hay crops, and a 30-head cow/calf operation are currently supported by the farm. Various alternative

enterprises are considered in this study as well as the traditional enterprises already in place.

Linear Programming

LP analyzes alternative enterprises and selects those that are the most efficient in achieving the desired objective. That is, linear programming determines the best solution to a problem, based upon the stated objective, the given restrictions, and the various alternative activities available (Pennsylvania State University Cooperative Extension Service, Special Circular 309).

The objective, alternative activities, and resource constraints are the three components of an LP problem and each is expressed numerically in the analyses (Boehjle and Pennsylvania State University, Special Circular 309). Each activity in a linear program has four characteristics to be specified. These include: (1) the type of activity to be considered and its economic content (2) a consistent unit of measurement for each activity (3) the contribution of each activity to the objective function value (4) the input-output coefficients for each resource or constraint used by each activity.

The activities in linear programming models can be divided into four types. The first type of activity is the different production processes used. These are processes that use resources to produce outputs. Resource supply processes are the second type of activity specification. These are the processes used to acquire additional inputs and make them available for use in production processes (i.e., hiring of labor, borrowing of capital, renting of land). The third type of activity is the marketing process and is included in the

model to sell the products or commodities produced. The last activity is the transfer process used to move resources or commodities from one constraint to another.

Constraints, another element of LP problems, can be broken down into two types: mathematical constraints and economic constraints. There are four types of mathematical constraints:

- 1.) Maximizing constraints where the amount of the resource used must be less than or equal to the amount of the resource available;
- 2.) Minimizing constraints wherein the amount of the resource used must exceed the minimum amount available;
- 3.) Equality constraints where the amount of the resource used must equal the amount of resource available;
- 4.) Nonconstraining constraints which are used in the objective function.

The economic limitations are categorized according to three types of economic constraints and are as follows:

- 1.) Real constraints - these are restrictions regarding the use of physical resources such as land, pasture, labor, capital, and water.
- 2.) Institutional constraints - these restrictions are imposed on the farm by two differing sources. Outside institutions are those that limit the activities that can be performed on the farm (i.e., government regulations such as allotments and Environmental Protection Agency regulations). The second source of institutional constraints are the personal preferences of the farmer.
- 3.) Accounting constraints - they are used to keep track of resources transferred between processes, to collect information on resources or processes, and to provide structure for the model. Accounting constraints are used most frequently in the case of intermediate products. For example, an accounting constraint can be used in transferring hay from the hay production process to the cattle feeding process when an enterprise mix includes both hay production and cattle feeding.

Bowling (1994), states that LP is a choice analytical tool for many reasons. The first reason is that LP can be applied to most any resource allocation problem. Secondly, LP is more accurate and efficient than either budgeting and marginal analysis techniques when evaluating complex situations. Furthermore, LP provides information on the values of differing resources and the “sensitivity” of farm plans. Another advantage of LP is the ease in which it accounts for opportunity cost within the model. The opportunity cost is the income foregone in using a given resource in an alternative enterprise. In Bowling’s study, LP was determined to be “one of the few techniques available that can solve a realistically defined farm management problem using mathematical procedures consistent with economic concepts of marginal analysis.”

Hazell and Norton (1986) and Bowling (1994) state that every LP model requires specification of the following:

- 1.) The alternative farm activities, their unit of measurement, their resource requirements, and any specific constraints on their production.
- 2.) The fixed resource constraints of the farm.
- 3.) The objective of the model, which may be expressed in various terms, depending upon the problem being analyzed.

To depict the LP problem mathematically, the following notation will be used (Hazell and Norton 1986):

X_j = The level of the j th farm activity, such as the number of acres of corn grown. Let n denote the number of possible activities; then $j = 1$ to n .

c_j = The forecasted gross margin of a unit of the j th activity (e.g., dollars per acre).

a_{ij} = The quantity of the i th resource (e.g., acres of land or days of labor) required to produce one unit of the j th activity. Let m denote the number of resources; then $i = 1$ to m .

b_i = The amount of the i th resource available (e.g., acres of land or days of labor).

Using the notations above, the LP model can be written as follows:

$$\text{Maximize } Z = \sum_{j=1}^n c_j X_j \quad (1)$$

subject to:

$$\sum_{j=1}^n a_{ij} X_j \leq b_i \quad (2)$$

$$X_j \geq 0 \quad (3)$$

These equations represent the objective of finding the farm plan that maximizes gross margins (Z) (defined by a set of activity levels X_j , where $j = 1$ to n) that has the largest total gross margin (Z) possible, but does not breach any of the fixed resource constraints or allow any negative activity levels.

Linear programming operates under a number of assumptions that are based on the production process, the available resources, and activities. Hazell and Norton (1986) emphasize eight assumptions:

- 1.) The objective function is assumed to be maximized or minimized. This presumption is referred to as optimization.
- 2.) Fixedness is the assumption that at least one constraint has a non-zero right-hand side coefficient.
- 3.) A finite number of constraints and activities are assumed to be considered so that a solution may be found. This assumption is referred to as finiteness.
- 4.) Determinism assumes the c_j , a_{ij} , and b_i coefficients are known constants.
- 5.) Continuity assumes that resources can be used and output produced in fractional units.
- 6.) The assumption that all units of the same resource or activity are identical is the concept of homogeneity.
- 7.) Additivity is the assumption that when two activities are used, the sum of their total product is the sum of their individual products. This assumption ensures that no interaction between activities is permitted.
- 8.) The gross margins and resource requirements per unit of activity are assumed to be constant no matter what level of activity is used. This is the concept of proportionality.

The last two assumptions, additivity and proportionality, explain linearity in the activities and give rise to the name linear programming.

The LP assumptions stated above are rigid in their application and meaning.

Hazell and Norton (1986) note that while the assumptions must “hold for all the rows and columns of a model, they do not have to hold for the farm production processes themselves.” Various adjustments can be made, however, to create a more applicable and simplistic model without violating any of the underlying assumptions. By relaxing the additivity assumption, activities can be defined to represent mixed enterprises and allow joint production and complementary and supplementary relationships. No matter what

flexibility is given in relaxing the assumptions, however, the whole farm production function always displays constant returns to scale (Hazell and Norton, 1986).

General Algebraic Modelling System

The General Algebraic Modelling System (GAMS) was developed by the World Bank as a mathematical modelling language. Models for GAMS are written in a computer code that scarcely differs from standard mathematical notation and are used to identify optimal solutions to given situations. Once an optimal solution has been determined, GAMS can also perform further calculations to aid in decision making and report writing (Jefferson and Boisvert, 1989).

Once the mathematical problem is established, it is written in a code readable by GAMS to go through the iterations required for the model optimization. GAMS works by converting the linear inequality constraints to equalities through introduction of slack variables into the problem using a technique referred to as the Simplex Method. Solutions to the problem are obtained through the adjustment of variables in the basis, and through the exchange of basic and non-basic variables. The process continues until the optimum feasible value of the objective function has been found (Jefferson and Boisvert, 1989 and Bender, Kahan, and Mylander, 1992).

The GAMS software not only finds the optimal mix of enterprises, but also offers several other valuable pieces of information. The solution output report of each scenario of the model contains not only the maximized gross margin objective value but also includes data on resource constraints and enterprise activities.

Each upper and lower bound of the resource constraints is shown along with the level of use in the model. Another source of information regarding each resource constraint is called the “marginal number” or shadow price in LP literature. This number shows the amounts by which the objective value would increase if the amount of a particular resource were increased by one unit, holding the amounts of other resources constant. The shadow price pinpoints the amount of money that a producer would be willing to pay for each additional unit of a resource. When the marginal value of a resource is zero, the amount of the resource available is not completely used; this fact confirms the complementary slackness theorems of LP, and the slack variable is included in the final basis (Jefferson and Boisvert, 1989).

The enterprise activities have a lower bound of zero, but they have an upper limit bounded by the amounts of the resources available. The “marginal” column for the enterprise activities shows the penalty costs of bringing the activity into the solution. These reduced cost values indicate the “cost” of deviating from the optimal solution. It is the amount by which the objective function would decrease if a unit of the corresponding activity were forced into the solution. Furthermore, the negative of the reduced cost value is the amount by which the activity per unit gross margin would have to increase before the activity would become profitable enough to be included in the farm plan (Hazell and Norton, 1986). If an activity (X_j) is included in the basis, then a one unit increase in its gross margin (Z_j) is exactly offset by a one unit increase in the opportunity cost of producing X_j , thus having a marginal value equal to zero (Jefferson and Boisvert, 1989).

The Model

Models are “abstractions from reality designed to provide explanation and prediction,” (Gebremedhin and Tweeten, 1991). For this study, a linear programming model was designed to do a baseline study of a research-demonstration farm with all its limitations and constraints to more accurately optimize the gross margins of the farm and to analyze the effects of varying enterprises on the farm. When alternative enterprises have similar requirements for fixed resources, a partial budgeting model makes the comparisons between the alternative enterprises much simpler than complete budgeting, and a gross margins approach is considered a method of partial budgeting analysis. Furthermore, when there are various alternative plans which have some aspects in common, partial budgeting can be used (Dent, Harrison, and Woodford, 1986).

Gebremedhin and Tweeten (1991) define a model as a “set of interrelated constructs, a systematic view of phenomena specifying relations among variables useful to explain or predict phenomenon.” In building a model for research, the researcher finds that keeping only the relationships necessary to make the model feasible is important. (Gebremedhin and Tweeten, 1991).

The mathematical model built for this study involved numerous rows and columns. The rows were indicative of the constraints while the columns represented each enterprise and other activities considered in the model. Various combinations of enterprises were placed into the model to determine which ones would result in the optimal allocation of resources as well as show the greatest total gross margin. Using the LP model built for the GAMS software, the model was altered by allowing different choices of enterprise and

activity mixes. Each of these adjustments to the “general” model is referred to as a scenario; in a sense, each scenario was another model because it was a unique specification of a farm plan. By combining different sets of enterprises and other activities with each set being a unique scenario, the model determined which enterprises competed with one another and how each enterprise reacted to the unique aspects in each scenario. Fourteen different scenarios were established--seven full-time scenarios and seven part-time scenarios. The scenarios (enterprise and activity mixes) examined in the model were selected by the project leader, Dr. Darrell Mundy, Dr. Denton, and the researcher as representing typical farming operations in East Tennessee.

Several equations were included in each model. The equation which solved the objective value found the total net returns minus the variable costs for the selected enterprises. Another equation accounted for the land and resource constraints in the model and ensured that these constraints were not violated during the selection of enterprises. A separate equation dealt with labor allocation in the model. These equations were included in each scenario evaluated.

A beef cow/calf enterprise was included in three of the four scenarios specified in this study. Because the gross margins were so low for this enterprise, a separate equation was required to ensure that this enterprise entered into the solution. The equation written for the activity of beef cow/calf production forced a 30-cow herd into the selected models. Various other assumptions regarding land, labor, and capital were also made to obtain the differing scenarios and are stated as necessary.

Conservation Compliance and Current Farm Practices

The farm used in this study contains 183 surveyed acres and is composed of cleared land, ponds, and wooded areas. Currently, the farm is divided into 13 fields for planning and production purposes. Crops are rotated as appropriate based on a conservation plan. All land that is suitable and not presently used for growing crops or pasture for the cattle is mowed for hay. The hay is used for feed in the beef enterprise and the remainder is sold.

Using the Revised Universal Soil Loss Equation (RUSLE) which includes the Erodibility Index (EI) and the soil loss tolerance (T) of the area, the researcher, under the leadership and guidance of Dr. Paul Denton, Professor of Soil Management and Water Quality at The University of Tennessee, determined that all of the farm is cropable using no-till technology and contour farming methods. Certain areas of the farm could also withstand conventional tillage of row crops usually in rotation with sod crops.

Estimated erosion is determined by evaluating the cropping practices used and the soil's potential to erode. The Erodibility Index (EI) measures the soil's potential to erode if left completely exposed to the elements. The greater the EI, the more potential there is for soil erosion. Soil with an EI greater than or equal to eight is considered to be highly erodible. The T is the erosion level thought to maintain cropland productivity. In Greene County, where the research-demonstration farm is situated, the T is set at 5 tons per acre per year.

The RUSLE equation measures the vulnerability of soil to erosion. In addition to the T and EI factors mentioned above, the RUSLE considers several other major factors

known to contribute to rainfall erosion (Bowling 1994).

The RUSLE is shown below:

$$A = Rk(LS)CP \quad (4)$$

where:

A	=	annual soil loss in tons per acre per year,
R	=	climate factor,
k	=	soil erodibility factor,
L	=	slope length factor,
S	=	slope steepness factor,
C	=	cropping system factor, this represents the reduction in soil erosion when a specific cropping system or rotation is compared with continuous fallow land, and
P	=	mechanical conservation factor, this represents the reduction in soil erosion when certain conservation practices, such as contour farming are used.

Determination of Farming Units and Enterprises Based on Soil Type Characteristics

Of the farm's 183.0 total surveyed acres, the actual croplable acreage was determined to be 109.1. This value was calculated in consultation with Dr. Paul Denton. During on-site visits, the soil types, slopes, and current cropping practices and methods were surveyed and recorded. The croplable acreage was then divided into smaller farming units based on the variability of these factors; the farm was divided into 31 farming units for this study. The actual acreage in each farming unit was then measured using

topographic maps of the farm, generated by Joe Sarten, Engineer, at The University of Tennessee Agricultural Experiment Station in Knoxville, Tennessee, and a grid provided by Denton for the measurement of the farming units.

The soil types predominately covering each farming unit were determined through soil sampling and the use of soil maps (Figure 3.1). Using the percentage of each soil type in a farming unit, the yields for each farming unit were determined by weighting the production capabilities of specific soil types by the percentage of that soil in the farming unit. Therefore, a “weighted” method was used to calculate appropriate yields for each crop for each of the 31 farming units included in the analysis. These steps allowed for increased accuracy in the determination of the farm’s potential productivity levels. Once the yields were established, they were used in the LP model to assist in the determination of the optimal enterprise mixes that would maximize gross margins.

Only conservationally sound crops and cropping systems as determined by the RUSLE were included as crop enterprise options in the model. Therefore, all the alternative enterprise systems considered in this model can be produced without violating any conservation practices. The results generated by the employment of the RUSLE showed that about 60 percent of the farm could be cropped using either traditional, no-till, and/or contour farming practices.

Labor Assumptions

Many of the labor assumptions for the model were based upon a 1988 study entitled “The Incorporation of Risk into the Farm Income and Alternative Enterprise Problem for Burley Tobacco Producers” by S. Darrell Mundy, W. Robert Goodman, and

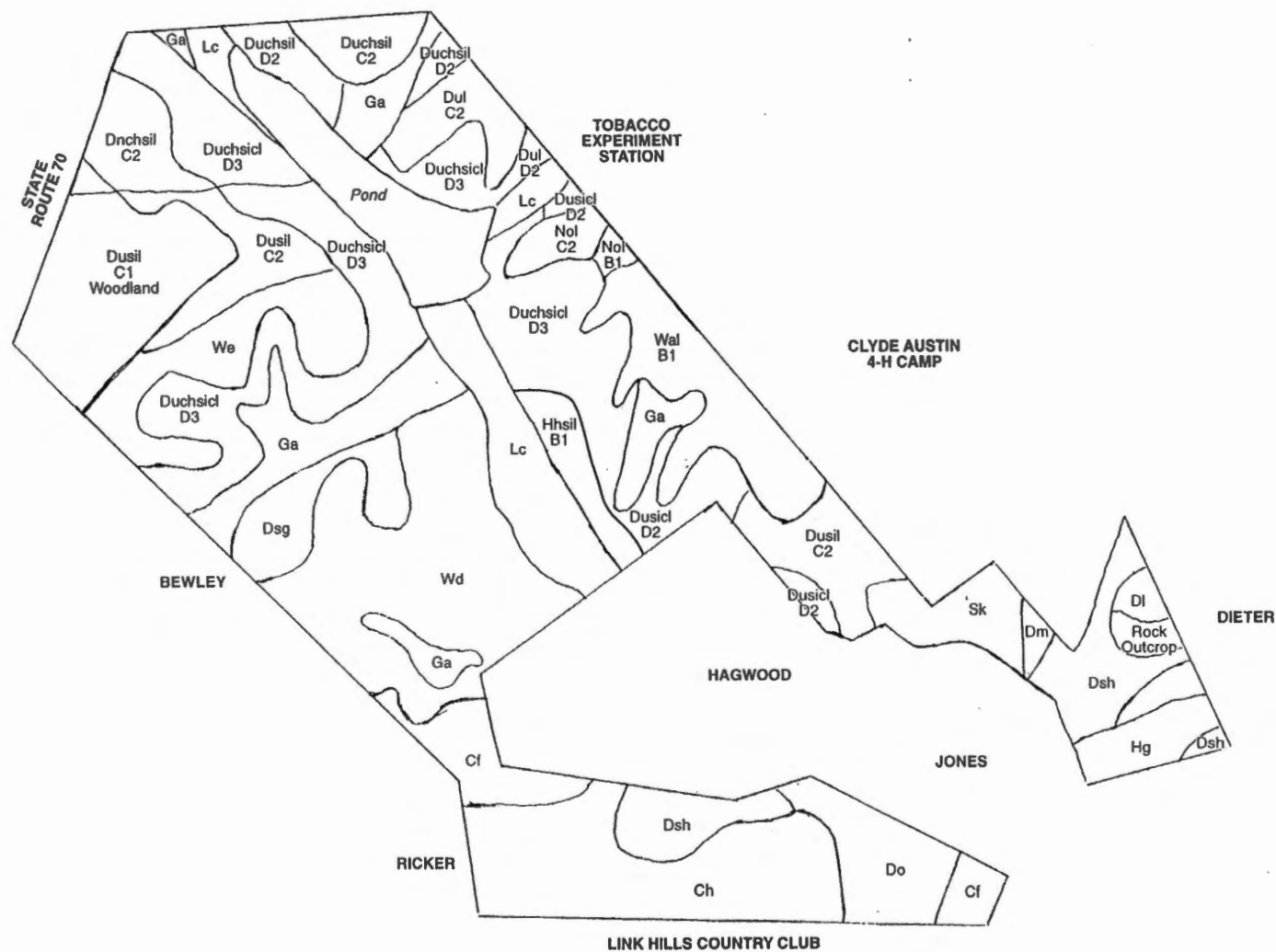


Figure 3.1. Soils Map of Leased Research-Demonstration Farm, Greeneville, Tennessee.

Steven G. Isaacs. In this particular study, labor was subdivided into operator labor, hired labor, family labor, and seasonal labor. Hours available per week for each division of labor were then calculated and assessed in full-time and part-time scenarios.

According to a survey conducted by the Tennessee Agricultural Statistics Service, 65 percent of all agricultural workers are part-time or migrant workers who are employed approximately two months out of the year ("Farm Facts", USDA, 1996). Therefore, for the LP model used in this study, labor was subdivided into two categories: domestic labor and migrant labor. Domestic labor was used first; migrant labor was used only when domestic labor was fully utilized. Labor was further evaluated under part-time versus full-time farming conditions. Using the assumptions of Mundy, Goodman, and Isaacs (1988) for determining labor availability for a medium-size Middle and East Tennessee farm, a total of 1560 hours of domestic labor and 2079 hours of migrant labor were available per year in the part-time situations. In the full-time scenario, 3640 hours of domestic and 5200 hours of migrant labor were available per year. Domestic labor included operator and family labor.

Domestic and migrant labor also varied in cost per hour as well as in availability. Domestic labor was priced at \$6.00 per hour whereas migrant labor was available at a cost of \$7.00 per hour. Both labor prices included a cash wage for hired labor plus social security taxes as well as an amount to cover payroll administration costs. The extra costs for migrant labor were due to governmental fees and other overhead costs. All labor periods were based upon hours available every two months. A breakdown of labor availability is shown in Table 3.1.

Table 3.1. Domestic and migrant labor availability for part-time and full-time scenarios.

Time Period	Part-Time Domestic Labor Hours	Part-Time Migrant Labor Hours	Full-Time Domestic Labor Hours	Full-Time Migrant Labor Hours
January-February	223	104	520	260
March-April	223	395	520	988
May-June	334	395	780	988
July-August	334	395	780	988
September-October	223	395	520	988
November-December	223	395	520	988
Total	1560	2079	3640	5200

Capital Assumptions

Capital includes land, buildings, machinery, livestock, and money as cash and available credit. Except for the physical limits set on the land, for any single scenario in this study, the farm operator was assumed to have access to all capital in an unconstrained fashion. The various enterprises considered in the model often require the same equipment; however, speciality crops such as plasticulture strawberries and cantaloupes that are produced on black plastic require implements that vary greatly from traditional farming equipment. This study further assumed the machinery required in the production of all enterprises was either owned by the farm or available through custom hire. All costs for custom work are accounted for in the budgets used to generate the various farming scenarios.

Enterprise Budgets

Each enterprise utilized a budget that examined its expected revenues and projected costs. These budgets were obtained from the Tennessee Agricultural Extension Service and the Virginia Cooperative Extension. The budgets were adjusted to reflect 1996 costs and revenues and to allow for differing yields based on soil types. Costs in the budgets were broken down into fixed and variable costs. A list of the adjusted budgets is found in Appendix A.

Variable costs are defined as costs that increase when the firm increases its output (McConnell, 1987). These costs are for production items that are used within a given production period such as seed, plants, fertilizer, chemicals, and some machinery costs such as fuel, lubrication, and repair costs (Johnson, 1992). McConnell (1987) defines fixed costs as those costs that do not change when the firm varies or alters its output. Once established, these are the costs incurred by the firm no matter what level of output is produced. Machinery depreciation, insurance, and housing costs are considered fixed as well as building and equipment costs (Johnson, 1992). In the model, interest expense is also considered a fixed cost. The interest expense on fixed capital is viewed as a payment which has to be made regardless of whether anything is produced. The budgets used in this study do not account for the fixed costs of the enterprises because the gross margins approach, which is revenue minus the variable costs of production, is used. The net returns include a return to all “unpaid” factors including the fixed costs components.

Several terms and assumptions have been made to ease the modeling process and are highlighted in the following paragraphs. Unless otherwise noted, the numbers used

were taken directly from the enterprise budgets. Enterprises referred to as “traditional” or “conventional” are those assumed to be those that require plowing, disking, and/or cultimulching before planting. Eliminating all tillage operations and planting seed using a sod planter or a no-till drill indicates an enterprise which is referred to as “no-till”.

In the forage budgets, the costs to establish the perennial crops are spread over the productive life of the crop so that each year of production “repays” a portion of the cost to establish them. The grass hay is baled in 1,000-pound round bales and the alfalfa hay is baled in 60- to 80-pound square bales in the budgets. These budgets, however, do not take into account the cost of storing or feeding the hay (Cross and Bowling, 1995).

All information regarding plasticulture strawberry production is from the Virginia Cooperative Extension where research on plasticulture production has been going on for several years. Plasticulture strawberry production was chosen over traditional, matted-row strawberry production for several reasons. Plasticulture generally produces bigger berries as well as more berries per acre than does matted-row. Also, when using plasticulture the harvest season is earlier and longer, as well as easier. Finally, fewer fungicides are needed, and weed control is better when using plasticulture.

Plasticulture, however, costs more per acre to produce and requires more management than does matted row. The budgets from Virginia Cooperative Extension do not contain the costs of a sprinkler irrigation system for frost protection; however, they stress that this is one of the most important components required in the production of plasticulture strawberries. Because this type of production is relatively new in the Southeast, many farms will not have the machinery complements necessary to produce

plasticulture strawberries. Therefore, the Virginia budget in this study incorporates the cost of the specialized equipment necessary for plasticulture strawberry production as a custom hire charge (O'Dell and Williams, 1995).

One of the two livestock enterprises considered in the model is beef cow/calf production. In the budgets, a 90-percent calf crop and a 16.66-percent replacement rate is assumed. Thirteen crossbred steers weighing 550 pounds and nine crossbred heifers weighing 500 pounds are sold in the budget. The cows can calve in either January, February, or March. The \$13.10 per head veterinary and medicine costs include several vaccinations, fly and internal parasite control, pregnancy checking, and implants for the calves. The market prices for steers, heifers, and cull cows are based on a personal consultation with Dr. Emmit Rawls, Professor of Agricultural Economics at The University of Tennessee.

The other livestock enterprise considered by the model is contract broiler production. The budget from The University of Tennessee Agricultural Extension Service assumes that each broiler house will raise 5.5 broods of 23,000 birds per year. In the model, one house requires one acre of land. Denton determined 37.3 acres suitable for the construction of houses. Of these 37.3 acres, 11.1 acres directly compete for the land with the high value crops.

The houses in the budget are assumed to be 40' x 400', with an estimated new cost of \$75,000 with a building life expectancy of twenty years. The \$75,000 cost takes into account the new house (\$32,000), site preparation (\$3,000), and equipment such as feeders and waterers (\$40,000). Since broiler production is handled on a contract basis,

the responsibilities of the grower and the contractor vary from one situation to another. However, most contractors furnish feed, chicks, medication, and a customer service representative while the grower is responsible for supplying fuel, electricity, water, repairs, litter removal, insurance, taxes, labor, and other miscellaneous expenses. Tennessee growers usually average between \$0.17 and \$0.21 per bird from the contractor. Therefore, for this study, the average of \$0.19 per bird was used. In the model, an assumption was that the producer had established a contract with a poultry company for production of broilers.

Various other assumptions were made regarding the model. Included in these assumptions were current farm ownership of an 8000-pound tobacco quota. The model was also given the option of leasing an additional 50,000-pound quota. Leasing of the tobacco quota was treated as a separate activity within the model and reflected the \$0.20 per pound cost of renting the quota. Therefore, there are two separate activities of tobacco production in the model; tobacco production using own quota and the production of tobacco using leased quota, with the only difference being the cost of leasing quota.

Another assumption in the model involves hay for the beef cow/calf enterprise. If the 30-head enterprise is optimal, 40.9 tons of hay are necessary. Should the hay not be produced on the farm, it must be purchased. Many beef producers find it to be more economical and less time consuming to purchase hay rather than raise and harvest themselves. Hay production often interferes with the production of higher valued crops and diminishes already scarce labor; therefore, the decision to raise hay or purchase it often depends upon the available labor pool in the model. For this reason, the option to

purchase hay was included as an activity within the model and could either be grown or purchased at a cost of \$32.00 a ton.

Chapter 4

Results and Discussion

This study focused on using linear programming to perform a preliminary income optimization study for a diversified operating farm leased by The University of Tennessee Tobacco Experiment Station located in Greeneville, Tennessee. The objectives of the study were to create more precise land management units for the research demonstration farm and to establish a preliminary case-study of the farm determining optimal alternative crop and/or livestock enterprise systems which show the greatest gross margins and to evaluate optimal solutions (gross margins) given the enterprise systems and resource constraints.

Determination of Farming Units and Yields

Conservation Compliance and the effects of erosion force the actual acreage that can be used for crops on the farm to 109.1 acres. This value was calculated with the help of Denton. Soil types, slopes, topographic maps, and current cropping practices were examined. The farmable acreage was divided into smaller management blocks (farming units) based on the variability of these factors. For economic reasons, a management block had to be at least an acre in size to be considered as a single farming unit. This criterion was used to ensure the units were of a reasonable size to be farmed. Based on this information, the farm was divided into 31 farming units for the model. Once the farming units were determined, the farming units were measured using available farm maps to determine the actual acreage of each management block. Figure 4.1 is a visual

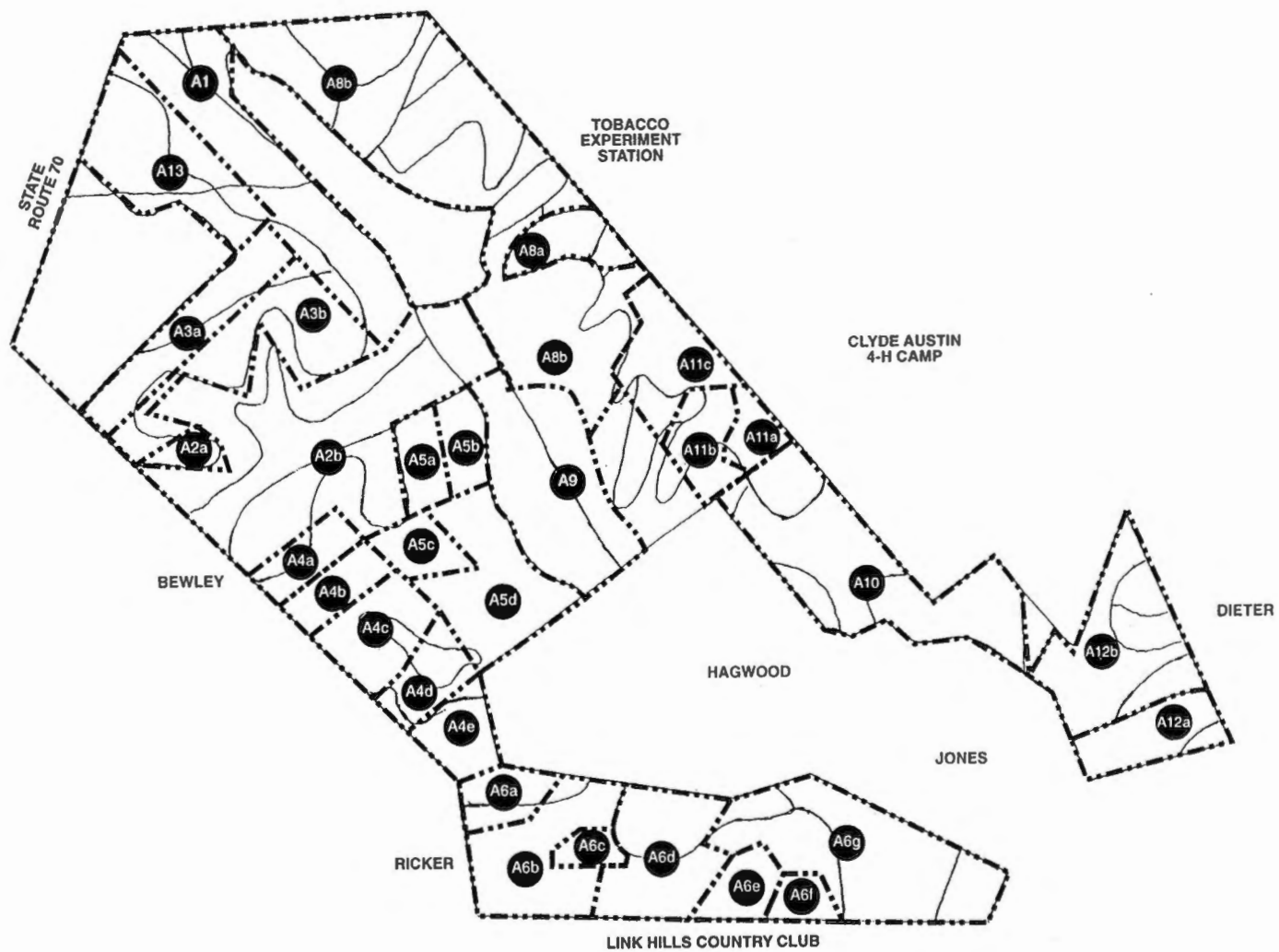


Figure 4.1 Farming Units for Leased Research-Demonstration Farm, Greeneville, Tennessee.

presentation of the farm with these farming units. Measurement of the size of the farming units was performed using the survey maps prepared by Sarten and a grid measuring device provided by Denton. Table 4.1 lists the farming units and acreage calculated.

Conservationally sound crops and cropping systems used in this model were determined by using the RUSLE, as described in Chapter 3 of this study. By using the results generated by RUSLE, 11.1 acres were found to be capable of supporting the production of high intensity crops such as vegetables, fruits, and tobacco, thus leaving 98 acres of land suitable for other uses such as hay, no-till corn, and pasture. The 11.1 acres suited for the production of high intensity crops could also be used in the production of lower intensity enterprises; therefore, all enterprises competed for the use of the 11.1 acres. A listing of the selected enterprises and farming units is found in Table 4.2.

Once the feasible crops were determined, the yields for each were adjusted based on the soil type of each farming unit. The predominant soil types in each unit were determined through soil sampling. The soil type information was used to calculate appropriate yields for each crop included in the model. These steps allowed for more accurate determination of the productivity of the model farm. A catalog of soil types and yield information is found in Table 4.3. Once the crops yields were established, they were used in the model for determining the optimal enterprise mix that maximized gross margins.

Different scenarios, developed by varying enterprise combinations and alternating labor constraints between full- and part-time farming situations, were evaluated using the

Table 4.1. Farming Units with Soils and Acreages, Leased Research-Demonstration Farm, Greene County, Tennessee, 1996.

Farming Unit	Soil Type(s)¹	Acreage(s)
Y1	Ga, Lc, We, Average Dunmore	13.0
Y2	We	3.0
Y3	Dsg, Dsd, Ga, Lc	10.8
Y4	Dsd, We	4.3
Y5	We, Dsh, Dsd	3.3
Y6	Wd	1.6
Y7	Wd	1.3
Y8	Ga, Wd, Cf	4.0
Y9	Wd, Ga	1.3
Y10	Cf	2.0
Y11	Wd	1.0
Y12	Wd	1.0
Y13	Wd	1.3
Y14	Wd	5.0
Y15	Cf	1.1
Y16	Ch	4.5
Y17	Ch	1.0
Y18	Ch, Dsh	3.5
Y19	Ch	2.0
Y20	Ch	1.0
Y21	Ch, Dg	3.8
Y22	Ng, Nk	2.1
Y23	We	4.0
Y24	Lc, Hh	4.5
Y25	Dsh, Dsg, We	6.5
Y26	We	1.6
Y27	We, Ga	1.3
Y28	We, Ga	3.2
Y30	Hg, Dsh	3.4
Y31	Dsh, Hg, Dnl	5.7
Y32	Dnh, Average Dunmore	7.0

¹See Appendix B for soil names.

Table 4.2. Farming units and the Enterprises They Can Support, Leased Research-Demonstration Farm, Greene County, Tennessee, 1996.

Enterprise	Farming Units
Traditional Corn	Y2, Y6, Y10, Y24
Wheat	Y2, Y6, Y10, Y24
Grass Hay	Y1, Y2, Y3, Y4, Y5, Y6, Y7, Y8, Y9, Y10, Y11, Y12, Y13, Y14, Y15, Y16, Y17, Y18, Y19, Y20, Y21, Y22, Y23, Y24, Y25, Y26, Y27, Y28, Y30, Y31, Y32
Tobacco	Y2, Y6, Y10, Y24
Cabbage	Y2, Y6, Y10, Y24
Tomato	Y2, Y6, Y10, Y24
Okra	Y2, Y6, Y10, Y24
Sweet Corn	Y2, Y6, Y10, Y24
Pumpkin	Y2, Y6, Y10, Y24
Sweet Potato	Y2, Y6, Y10, Y24
Pepper	Y2, Y6, Y10, Y24
Yellow Squash	Y2, Y6, Y10, Y24
PYO Strawberries	Y2, Y6, Y10, Y24
Cantelope	Y2, Y6, Y10, Y24
Alfalfa Hay	Y2, Y6, Y10, Y24
No-Till Corn	Y1, Y2, Y3, Y4, Y5, Y6, Y7, Y8, Y9, Y10, Y11, Y12, Y13, Y14, Y15, Y16, Y17, Y18, Y19, Y20, Y21, Y22, Y23, Y24, Y25, Y26, Y27, Y28, Y30, Y31, Y32
Broiler	Y2, Y4, Y6, Y10, Y13, Y14, Y22, Y24, Y25, Y32
Pasture	Y1, Y2, Y3, Y4, Y5, Y6, Y7, Y8, Y9, Y10, Y11, Y12, Y13, Y14, Y15, Y16, Y17, Y18, Y19, Y20, Y21, Y22, Y23, Y24, Y25, Y26, Y27, Y28, Y30, Y31, Y32
Tobacco-Leased Poundage	Y2, Y6, Y10, Y24

Table 4.3. Soil Types and Yields, Leased Research-Demonstration Farm, Greene County, Tennessee, 1996.

Soil Type		Corn	Wheat	Grass Hay	Tobacco	Cabbage	Tomatoes	Okra	Sweet Corn
		bushels	bushels	tons	pounds	bags	lugs	baskets	dozen ears
Waynesboro									
	We loam	125	60	3.2	2700	552	1344	1152	960
	Wd loam	105	50	2.7	2300	472	1148	984	820
Cumberland									
	Cf sil	130	65	3.2	2800	575	1400	1200	1000
	Ch sicl	110	55	2.7	2400	495	1204	1032	860
Dewey									
	Do sicl	80	45	2.4	2000	408	994	852	710
Hermitage									
	Hh sil	140	65	3.4	2900	598	1456	1248	1040
	Hg sil	120	55	3.1	2500	512	1246	1068	890
Nolichucky									
	Nk loam	130	60	3.4	2800	575	1400	1200	1000
	Ng loam	110	50	3.1	2400	495	1204	1032	860
Greendale									
	Ga sil	140	65	3.5	2900	598	1456	1248	1040

Table 4.3. (Continued).

		Corn	Wheat	Grass Hay	Tobacco	Cabbage	Tomatoes	Okra	Sweet Corn
		bushels	bushels	tons	pounds	bags	lugs	baskets	dozen ears
Lindside									
	Lc sil	140	55	3.5	2600	535	1302	1116	930
Dunmore									
	Dsb sil	95	50	2.8	2200	454	1106	948	790
	Dsh sil	90	48	2.5	2100	431	1050	900	750
	Dnm l	90	48	2.4	2100	431	1050	900	750
	Dnh chsil	85	45	2.2	2000	408	994	852	710
	Dnl l	80	45	2.3	1800	368	896	768	640
	Dsg sicil	75	40	2.2	1800	368	896	768	640
	Dng chsicl	75	40	2.2	1700	351	854	732	610
	Dsd sicil	70	38	2.0	1600	328	798	684	570
	Dnd chsicl	70	35	1.8	1500	311	756	648	540
	Average Dunmore	81	43	2	1867	383	933	800	667

Table 4.3. (Continued).

Soil Type		Pumpkins	Sweet Potatoes	Peppers	Squash	Strawberries	Cantaloupes	Alfalfa Hay	No-Till Corn
		pounds	bushels	tons	cartons	quarts	each	tons	bushels
Waynesboro									
	We loam	26880	384	7.2	576	16727	7680	4	115
	Wd loam	22960	328	6.15	492	14288	6560	3.7	98
Cumberland									
	Cf sil	28000	400	7.5	600	17424	8000	4.4	120
	Ch sicl	24080	344	6.45	516	14985	6880	4	103
Dewey									
	Do sicl	19880	284	5.33	426	12371	5680	3	85
Hermitage									
	Hh sil	29120	416	7.8	624	18121	8320	4.5	125
	Hg sil	24920	356	6.68	534	15507	7120	4.2	107
Nolichucky									
	Nk loam	28000	400	7.5	600	17424	8000	4	120
	Ng loam	24080	344	6.45	516	14985	6880	3.7	103
Greendale									
	Ga sil	29120	416	7.8	624	18121	8320	4	125

Table 4.3. (Continued).

Soil Type		Pumpkins	Sweet Potatoes	Peppers	Squash	Straw-berries	Canta-loupes	Alfalfa Hay	No-Till Corn
		pounds	bushels	tons	cartons	quarts	each	tons	bushels
Lindside									
	Lc sil	26040	372	6.98	558	16204	7440	3	112
Dunmore									
	Dsb sil	22120	316	5.93	474	13765	6320	3.5	95
	Dsh sil	21000	300	5.63	450	13068	6000	3.3	90
	Dnm l	21000	300	5.63	450	13068	6000	3.3	90
	Dnh chsil	19880	284	5.33	426	12371	5680	3.1	85
	Dnl l	17920	256	4.8	384	11151	5120	3	77
	Dsg sicil	17920	256	4.8	384	11151	5120	3	77
	Dng chsicl	17080	244	4.58	366	10629	4880	2.7	73
	Dsd sicil	15960	228	4.28	342	9932	4560	2.7	68
	Dnd chsicl	15120	216	4.05	324	9409	4320	2.4	65
	Average Dunmore	18667	267	5	400	11616	5333	3	80

linear programming model. The results of the differing scenarios for full-time and part-time farming situations, respectively, are listed below.

Free Model, Full-Time Scenario

In this scenario, the model was written such that all enterprise options were chosen with limits set only on available labor hours and field capabilities. The model inputs for this scenario are in Appendix C, which includes a map outlining the farming units and enterprises produced on them. The enterprises under consideration were conventionally tilled corn, wheat, grass hay, tobacco, cabbage, tomato, okra, sweet corn, pumpkin, sweet potato, pepper, yellow squash, PYO strawberries, cantaloupe, alfalfa hay, no-till corn, pasture, beef cow/calf, and broiler production. The model determined the optimal enterprise mix which included okra, PYO strawberries, broiler production, and no-till corn which, combined, resulted in an objective value of \$227,570.76 (Table 4.4). The inclusion of the no-till corn production option resulted in all land not utilized in the production of higher value crops be put into no-till corn production. All domestic labor in each time period was used by the model; however, the January-February and May-June time periods were the only situations in which migrant labor was fully used. In the remaining months, migrant labor was employed but not to the extent available.

Farming unit Y10 had a shadow price of \$4839.66, which was the highest of all the farming units. The next highest shadow price was \$4424.76 from farming unit Y24. Both of these values were much higher than the other shadow prices in this scenario. This implies that \$4839.66 is the maximum amount a producer would be willing to pay for an extra acre of Y10 land and \$4424.76 for an additional acre of Y24 land. The

Table 4.4. Full-time Scenario (free model) Results for Leased Research-Demonstration Farm, Greene County, Tennessee, 1996.

Enterprise(s)	Units	Farming Units
Okra	0.42 ac	Y6
PYO Strawberries	10.68 ac	Y2, 6, 10, 24
No-till Corn	91.27 ac	Y1, 3, 4, 5, 7, 8, 9, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 25, 26, 27, 28, 30, 31, 32
Chicken Production-Broilers	6.70 houses	Y32
Total Acres	109.10	
Domestic Labor Hours	3640.00	
Migrant Labor Hours	2824.07	
Objective Value (\$)	227,570.76	

January-February labor period for both domestic and migrant labor held the highest labor shadow prices. There was only a one-dollar difference between the domestic and the migrant shadow prices; they were \$74.10 for domestic labor and \$73.10 for migrant labor. Each measure represents the maximum amount that a producer would be willing to pay for an additional hour of the respective labor types in this particular time period.

The activity of tobacco production using leased poundage had the highest reduced cost values of all the enterprise activities. The values ranged from \$9629.25 on Y10 land to \$6493.25 on Y6 land. Grass hay production on Y10 land resulted in the next highest reduced cost value of \$5073.59. The pasture growing activity on Y10 land with a marginal value of \$4911.54 was the next highest reduced cost value followed by broiler production on Y10 land with a reduced cost value of \$4777.27. These numbers indicate

the amount by which the objective function value would decrease if an additional acre of tobacco production was forced into the solution. The lowest reduced cost values were found to be broiler production enterprises. Broiler production on Y25 had a value of \$23.00 while broiler production on Y4 land had a value of \$27.25. With the exception of alfalfa hay production, the shadow prices of each activity considered were higher on the Y10 land than any other farming unit.

Full-Time, Scenario 1

Tobacco was the only enterprise selected by the model in this scenario (Table 4.5). Other activities allowed but not included grass hay, alfalfa hay, pasture, and beef cow/calf production. Use of domestic labor was maximized during the November-December time period, which is when labor requirements are greatest in tobacco production.

Farming units Y10 and Y24 had the highest shadow prices at \$2393.23 and \$2260.10 respectively. Labor shadow prices were not notable for any particular time period, domestic nor migrant. Furthermore, leased poundage tobacco production resulted in the highest reduced cost values of the enterprises in the model. These values ranged from \$5040.00 on Y10 land to \$4140.00 on Y6 land. The next highest reduced cost values were \$2444.72 on grass hay production and pasture production, both on Y10 land. The lowest reduced cost value was found to be grass hay production on Y27 land at \$48.29. The next lowest reduced cost value was \$50.94 and was found in pasture production on Y1, Y3, Y4, Y5, Y7, Y8, Y9, Y11, Y12, Y13, Y14, Y15, Y16, Y17, Y18, Y19, Y20, Y21, Y23, Y25, Y26, Y27, Y28, Y30, Y31, and Y32 farming units.

Table 4.5. Full-time Scenario 1 Results for Leased Research-Demonstration Farm, Greene County, Tennessee, 1996.

Enterprise(s)	Units	Farming Units
Burley Tobacco	11.10 ac	Y2, 6, 10, 24
Total Acres	11.10 ac	
Domestic Labor Hours	1854.33	
Migrant Labor Hours	678.80	
Objective Value (\$)	24,505.45	

Full-Time, Scenario 2

The model examined tobacco, cabbage, tomato, okra, sweet corn, pumpkin, sweet potato, pepper, yellow squash, PYO strawberries, cantaloupe, and broiler production as potential enterprises in this scenario. Okra, PYO strawberries, and broiler production were included in the final results as the enterprises that maximized net returns as measured by gross margins (Table 4.6). The July-August time period was the only one where domestic labor was not fully utilized, and consequently, was the only time period where migrant labor was not employed.

Farming units Y10 and Y24 once again had the highest shadow prices at \$4985.22 and \$4570.32, respectively. The shadow prices for labor ranged from \$77.47 for domestic January-February labor and migrant labor during the same time period was \$76.47. These were the highest labor shadow prices. The March-April labor period, however, demonstrated important shadow prices of \$62.88 for domestic labor and \$61.88 for migrant labor.

The trend continued in this scenario with leased poundage tobacco production

Table 4.6. Full-time Scenario 2 Results for Leased Research-Demonstration Farm, Greene County, Tennessee, 1996.

Enterprise(s)	Units	Farming Units
Okra	0.13 ac	Y6
PYO Strawberries	10.97 ac	Y2, 6, 10, 24
Chicken Production - Broilers	6.70 houses	Y4, 13, 14
Total Acres	17.80	
Domestic Labor Hours	3602.87	
Migrant Labor Hours	2695.77	
Objective Value (\$)	218,272.38	

being the enterprise with the highest reduced cost values ranging from \$9672.96 on Y10 land to \$6536.96 on Y6 land. Yellow squash production exhibited the next highest reduced cost value of \$6795.19 on Y10 land followed by sweet potato production on Y10 having a value of \$6554.70. Tomato production resulted in the lowest reduced cost values at \$492.13 on Y2, \$548.75 on Y24, and \$632.88 on Y10.

Full-Time, Scenario 3

The enterprise options allowed in this scenario were tobacco and no-till corn. The model chose to raise tobacco on all land which was capable of producing it and no-till corn was placed on the remaining land (Table 4.7). No domestic labor was used during the January-February period, however, the maximum available domestic labor was employed during the September-October and November-December time periods. Migrant labor was required only in the September-October and November-December time periods.

Table 4.7. Full-time Scenario 3 Results for Leased Research-Demonstration Farm, Greene County, Tennessee, 1996.

Enterprise(s)	Units	Farming Units
Burley Tobacco	11.10 ac	Y2, 6, 10, 24
No-till Corn	98.00 ac	Y1, 3, 4, 5, 7, 8, 9, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 25, 26, 27, 28, 30, 31, 32
Total Acres	109.10	
Domestic Labor Hours	1978.22	
Migrant Labor Hours	709.75	
Objective Value (\$)	36,054.65	

As in the previous scenarios, the Y10 and Y24 farming units had the highest shadow prices of \$2352.60 for Y10 and \$2219.40 for Y24. The Y2 farming unit had the next highest shadow price of \$2172.60. Labor shadow prices were not notable. Once again, tobacco production using leased poundage had the highest reduced cost values ranging from \$5040.00 to \$4140.00. No-till corn production held the next highest reduced cost value of \$2181.58 on Y10 followed by farming unit Y24 with a reduced cost value of \$2054.63. No-till corn also had the lowest reduced cost values at \$1336.58 for the Y6 farming unit and \$2014.08 for the Y2 farming unit.

Full-Time, Scenario 4

In the model for Scenario 4, grass hay, alfalfa hay, and no-till corn were the enterprise options. No-till corn was the sole enterprise chosen so all land that was utilized was put into no-till corn production (Table 4.8). No-till corn is less labor intensive than other enterprises and, as a result, no migrant labor was used and very little domestic labor

Table 4.8. Full-time Scenario 4 Results for Leased Research-Demonstration Farm, Greene County, Tennessee, 1996.

Enterprise(s)	Units	Farming Units
No-till Corn	109.10 ac	Y1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 30, 31, 32
Total Acres	109.10	
Domestic Labor Hours	172.38	
Migrant Labor Hours		
Objective Value (\$)	13,336.16	

was required to produce the no-till corn.

The highest shadow prices in this scenario were found on the Y10 and Y15 farming units; both farming units had the same shadow price of \$172.04. The farming unit with the next highest shadow price was Y24 with a price of \$165.79. The shadow prices for both domestic and migrant labor showed no differences among time periods. In fact, all labor shadow prices were found to be either zero or very close to zero. The highest reduced cost value for any of the enterprises was \$74.08 for alfalfa hay production on Y24 land followed by \$42.47 for grass hay production on Y21 land. The lowest reduced cost value was found to be \$0.40 for grass hay production on the Y22 farming unit with \$7.42 being the next lowest reduced cost value on Y3 land.

Full-Time, Scenario 5

The model for Scenario 5 chose PYO strawberries and no-till corn from a list of enterprises that included conventionally tilled corn, cabbage, tomato, okra, sweet corn,

pumpkin, sweet potato, pepper, yellow squash, and cantaloupe production. All land that was capable of producing highly intensive enterprises was put into strawberry production while the rest of the land was used for no-till corn (Table 4.9). Domestic labor was used exclusively with the exception of the time periods of May-June and September-October when migrant labor was also needed.

Farming units Y10 and Y24 obtained the highest shadow prices in this scenario. The shadow prices were \$11980.57 for Y10 and \$11565.67 for Y24. Labor shadow prices were only \$1.00 for domestic labor during time periods May-June and September-October. No-till corn had the highest reduced cost value of all the enterprises at \$11810.00 for production on Y10 land. Traditional corn production had the next highest reduced cost value of \$11780.00 on Y10 land. The lowest reduced cost value was found in tomato production on the Y24 farming unit at \$24.51 with the Y2 farming unit having the next lowest at \$41.95 for the tomato production enterprise.

Table 4.9. Full-time Scenario 5 Results for Leased Research-Demonstration Farm, Greene County, Tennessee, 1996.

Enterprise(s)	Units	Farming Units
PYO Strawberries	11.10 ac	Y2, 6, 10, 24
No-till Corn	98.00 ac	Y1, 3, 4, 5, 6, 7, 8, 9, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 25, 26, 27, 28, 30, 31, 32
Total Acres	109.10	
Domestic Labor Hours	1854.69	
Migrant Labor Hours	575.65	
Objective Value (\$)	136,761.42	

Full-Time, Scenario 6

This scenario is similar to the free model situation where all enterprise activities were allowed to compete for inclusion within the model; however, the scenario differs from the other full-time scenarios in that the beef cow/calf activity was forced into the solution as it was in several of the part-time scenarios. Traditional corn, wheat, grass hay, tobacco, tomato, okra, sweet corn, pumpkin, sweet potato, pepper, yellow squash, PYO strawberries, cantaloupe, no-till corn, alfalfa hay, pasture, and broiler production were the activities considered by the model. Okra, PYO strawberries, no-till corn, and broiler production were the activities brought into the solution (Table 4.10). Because the beef cow/calf enterprise was forced into the solution, pasture was included in the solution for the cattle. The model also chose to raise grass hay for the cattle activity rather than purchase it. All 109.10 possible acres were used by the model.

The farming units of Y10 and Y24 again had the highest shadow prices with Y10 being \$4984.79 and Y24 being \$4569.89. The January-February time period for domestic labor had the highest shadow price of \$76.37 with the migrant labor shadow price for the same time period being \$75.37. The May-June time period for domestic and migrant labor had the next highest shadow prices of \$62.99 for domestic labor and \$61.99 for migrant labor. Once again, tobacco production with leased poundage had the largest reduced cost values ranging from a high of \$9676.14 on Y10 land to a low of \$6540.14 on Y6. The next highest reduced cost value was \$4886.69 per acre for pasture production on Y10 land and broiler production on Y10 land. No-till corn production had the lowest reduced cost values in the model. These values were \$0.50 for the Y5 farming unit and \$1.50 for

Table 4.10. Full-time Scenario 6 Results for Leased Research-Demonstration Farm, Greene County, Tennessee, 1996.

Enterprise(s)	Units	Farming Units
Okra	0.10 ac	Y6
PYO Strawberries	11.00 ac	Y2, 6, 10, 24
Chicken Production - Broilers	5.86 houses	Y4, 13, 14
Grass Hay	13.03 ac	Y3, 22, 27
Pasture	47.40 ac	Y1, 5, 14, 18, 21, 25, 31, 32
Beef cow/calf	30 head	
No-Till Corn	31.71 ac	Y3, 7, 8, 9, 11, 12, 13, 15, 16, 17, 19, 20, 23, 26, 28, 30
Total Acres	109.10	
Domestic Labor Hours	3562.63	
Migrant Labor Hours	2718.97	
Objective Value (\$)	181,636.64	

the Y18 farming unit.

Free Model, Part-Time Scenario

As in the full-time free model, all the enterprise options were included in the model for the selection of the optimal enterprise mix with the only limitations being labor hours and field capabilities. Conventional-till corn, wheat, grass hay, tobacco, tomato, okra, sweet corn, pumpkin, sweet potato, pepper, yellow squash, plasticulture strawberries, cantaloupe, no-till corn, alfalfa hay, pasture, beef cow-calf, and broiler production were the enterprises considered. From these options, the model chose conventional-till corn, okra, plasticulture strawberries, no-till corn, and broilers. After producing enterprises

such as conventional-till corn, okra, strawberries, and broilers, the rest of the acreage was put into no-till corn production, which is less labor intensive than the other enterprises.

Table 4.11 details the acreage breakdown of the enterprises as well as the gross margins of the scenario. All available domestic labor was used in this scenario, but only a portion of the available migrant labor was expended. Migrant labor, however, was utilized in each time period.

Land in two farming units, Y10 and Y24, each had shadow prices that were substantially higher than the others. The shadow prices were \$875.06 and \$460.16 respectively for the two farming units. This implies that \$875.06 is the maximum amount a producer would be willing to pay for an extra acre of Y10 land and \$460.16 for an additional acre of Y24 land. Farming unit Y2 had the next highest shadow price at \$178.06. The May-June time period displayed the highest shadow prices for both domestic and migrant labor at \$109.59 per hour for domestic labor and \$108.59 per hour for migrant labor. Each measure represents the maximum amount that a producer would be willing to pay for an additional hour of the respective labor types in this particular time period.

Tobacco production based on leased poundage had the largest reduced cost value of all enterprises included in the model. The values of the four activities of land classes on which this tobacco could be grown ranged from \$7872.29 to \$7175.29. These numbers indicate the amount by which the objective function value would decrease if an additional acre of tobacco production was forced into the solution. Other enterprises which had high reduced cost values include PYO strawberry production at \$2389.00 on Y6, tomato

Table 4.11. Part-time Scenario (free model) Results for Leased Research-Demonstration Farm, Greene County, Tennessee, 1996.

Enterprise(s)	Units	Farming Units
Conventional-till corn	4.02 ac	Y2, 6
Okra	3.04 ac	Y24
PYO Strawberries	4.04 ac	Y2, 10, 24
No-till corn	95.13 ac	Y1, 3, 4, 5, 7, 8, 9, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 25, 26, 27, 28, 30, 31, 32
Chicken Production-Broilers	2.87 houses	Y32
Total Acres	109.10	
Domestic Labor Hours	1560.00	
Migrant Labor Hours	1586.00	
Objective Value (\$)	\$109,702.69	

production at \$1772.68 on Y6, and cabbage production at \$1533.70 on Y6. The wheat production enterprise had the lowest reduced cost value at \$10.11 for the Y6 farming unit followed by the alfalfa hay production enterprise on farming unit Y6 at \$18.10.

Part-Time, Scenario 1

In Scenario 1, no fruit or vegetable enterprise options were allowed in the model. The enterprise options available in the model were grass hay, tobacco, beef cow/calf, broiler, and pasture production. In this situation, the beef cow/calf enterprise was forced into the model. This model was set up to represent a “typical” East Tennessee farm situation. All of the enterprise options mentioned above were included in the optimal

solution of the model. All domestic labor was expended while migrant labor was only partially utilized in every time period. In Table 4.12 the acreages of the enterprises are listed.

The Y10 farming unit sustained the highest shadow price at \$148.85 per acre as did the January-February labor period for both domestic and migrant labor with shadow prices of \$118.68 and \$117.68 respectively. Tobacco production using leased poundage on Y6 land resulted in the largest reduced cost value of all the activities with an income of \$751.15 per acre. Pasture production on Y27 land had the lowest reduced cost value at \$5.22. The next lowest reduced cost value was \$10.44 for the grass hay production enterprises on Y3, Y9, and Y30 farming units.

Table 4.12. Part-time Scenario 1 Results for Leased Research-Demonstration Farm, Greene County, Tennessee, 1996.

Enterprise(s)	Units	Farming Units
Grass hay	12.09 ac	Y2, 15, 22, 23, 24, 27
Tobacco	2.94 ac	Y10, 24
Beef cow/calf	30 head	
Pasture	47.40 ac	Y14, 16, 17, 18, 19, 20, 21, 23, 25, 26, 28, 30, 31, 32
Chicken Production-Broilers	2.43 houses	Y14
Total Acres	64.86	
Domestic Labor Hours	1560.00	
Migrant Labor Hours	999.80	
Objective Value (\$)	12,085.93	

Part-Time, Scenario 2

Scenario 2 enterprise options included grass hay, pasture, and beef cow/calf production. This scenario generated the lowest gross margin return of -\$28,914.16, shown in Table 4.13. A 30-head beef cow/calf operation was forced into the solution and required 12.01 acres of grass hay and 47.40 acres of pasture. Although given the options of producing or purchasing the hay necessary for the cattle operation, the model opted to raise the hay rather than buy it. No migrant labor was employed and few domestic labor hours were required by the enterprises in the model. The Y24 farming unit possessed the highest shadow price at \$14.43 while grass hay production on the Y32 farming unit had the largest reduced cost value at \$48.09 per acre. Pasture production on Y27 land had the lowest reduced cost value of \$4.81 followed by a reduced cost value of \$9.62 for grass hay production on farming units Y3, Y9, and Y30.

Table 4.13. Part-time Scenario 2 Results for Leased Research-Demonstration Farm, Greene County, Tennessee, 1996.

Enterprise(s)	Units	Farming Units
Grass hay	12.01 ac	Y10, 15, 24, 27, 28
Pasture	47.40 ac	Y3, 11, 12, 13, 14, 16, 17, 18, 19, 20, 21, 25, 30, 31, 32
Beef cow/calf	30 head	
Total Acre	59.41	
Domestic Labor Hours	432.29	
Migrant Labor Hours		
Objective Value (\$)	-28,914.16	

Part-Time, Scenario 3

Grass hay, cabbage, tomato, okra, sweet corn, pumpkin, sweet potato, pepper, yellow squash, PYO strawberries, cantaloupe, pasture, and beef cow/calf production were the enterprises under consideration in Scenario 3. Of these, okra and PYO strawberries were chosen by the model. Beef cow/calf production, which required pasture, was forced into the results. The solution elected to buy the grass hay necessary for the cattle rather than produce it. Both domestic and migrant labor were utilized, however, the migrant labor was only necessary from March through October. Table 4.14 presents the results from this scenario.

The farming units which have the capability of growing high intensity crops such as vegetables were found to have high shadow price values in this scenario. The shadow values for these farming units are as follows: Y2, \$2588.59; Y6, \$1617.09; Y10, \$3285.59; and Y24, \$2870.69. The May-June labor time period resulted in the highest marginal values at \$87.65 for domestic labor and \$86.65 for migrant labor. Cabbage production held the highest reduced cost value on the four farming units capable of producing it. These values ranged from a high of \$11980.00 to a low of \$8479.00. The next highest marginal value was \$6549.90 from yellow squash production on Y10. The grass hay enterprise resulted in the lowest reduced cost value of \$289.70 for production on Y27 land. The next lowest reduced cost value was \$292.90 for grass hay production on Y15, Y26, and Y28 farming units.

Table 4.14. Part-time Scenario 3 Results for Leased Research-Demonstration Farm, Greene County, Tennessee, 1996.

Enterprise(s)	Units	Farming Units
Okra	4.36 ac	Y6, 24
PYO Strawberries	6.74 ac	Y2, 10, 24
Pasture	47.40 ac	Y9, 11, 12, 13, 14, 16, 17, 18, 19, 20, 21, 25, 30, 31, 32
Beef cow/calf	30 head	
Total Acres	58.50	
Domestic Labor Hours	1373.76	
Migrant Labor Hours	1085.95	
Objective Value (\$)	62,274.68	

Part-Time, Scenario 4

For Scenario 4, the model chose to produce only no-till corn on all available land as Table 4.15 shows. Along with no-till corn, other enterprise options permitted in the model were alfalfa hay and grass hay. No-till corn is not a labor intensive crop, and therefore only 172.38 hours of domestic labor were used. No migrant labor was employed. All shadow prices for farming units in this particular scenario were relatively close and ranged from \$172.04 for Y10 and Y15 to \$81.79 for Y32. The lowest reduced cost value was \$0.40 for grass hay production on Y22 land followed by a value of \$7.42 for grass hay produced on Y3 land.

Table 4.15. Part-time Scenario 4 Results for Leased Research-Demonstration Farm, Greene County, Tennessee, 1996.

Enterprise(s)		Units	Farming Units
	No-till Corn	109.10 ac	Y1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 30, 31, 32
Total Acres		109.10	
Domestic Labor Hours		172.38	
Migrant Labor Hours			
Objective Value (\$)		13,336.16	

Part-Time, Scenario 5

The model for this scenario only included the no-till corn option. As seen in Table 4.16, the objective value, acreage, and labor hours in this scenario were the same as those in part-time Scenario 4. Furthermore, the shadow prices were also the same, ranging from \$172.04 for Y10 and Y15 to \$81.79 for Y32.

Table 4.16. Part-time Scenario 5 Results for Leased Research-Demonstration Farm, Greene County, Tennessee, 1996.

Enterprise(s)		Units	Farming Units
	No-till corn	109.10 ac	Y1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 30, 31, 32
Total Acres		109.10	
Domestic Labor Hours		172.38	
Migrant Labor Hours			
Objective Value (\$)		13,336.16	

Part-Time, Scenario 6

Using only 3.27 acres of land, this scenario generated a return of \$46,459.45. In this scenario the permitted enterprise options were grass hay, alfalfa hay, and broiler production. The model selected 3.27 houses for broiler production and used both domestic and migrant labor. The migrant labor was needed during the January through April and September through December time periods. These results are shown in Table 4.17.

The January-February domestic and migrant labor shadow prices were \$140.35 and \$139.35 respectively. Shadow prices for farming units were negligible. The highest reduced cost value in this scenario was on farming unit Y32 at \$61.34 for grass hay production. The lowest reduced cost value was \$9.44 for grass hay production on the Y27 farming unit.

Table 4.17. Part-time Scenario 6 Results for Leased Research-Demonstration Farm, Greene County, Tennessee, 1996.

Enterprise(s)	Units	Farming Units
Chicken Production - Broilers	3.27 houses	Y2, 6
Total Acres	3.27	
Domestic Labor Hours	1546.00	
Migrant Labor Hours	416.00	
Objective Value (\$)	46,459.45	

Discussion

The division of the farm's 13 original fields into 31 smaller farming units enhanced the model's ability to select the enterprise(s) that would best utilize each farming unit under the various scenarios. Of the 109.10 total cropable acres on the research farm, it was determined that only 11.10 acres were suitable for production of the high intensity crops which included vegetables, tobacco, and berries based on soil capabilities and productivity. Although this small amount of acreage severely limited the production of these high value speciality crops, the scenarios that included vegetable and berry enterprises tended to have higher objective values than the other situations. These particular crops have a higher per acre return than do more traditional enterprises such as hay and beef cow/calf. When given the option of speciality enterprises such as vegetables and berries, all land available for production of these enterprises was used. Pasture and grass hay were only produced when the solution included the beef cow/calf enterprise.

All 31 farming units are capable of producing no-till corn, grass hay, and pasture. Once the 11.10 acres were delegated to the higher value enterprises, and the remaining land to broiler production, pasture, and grass hay, any excess land was placed in no-till corn production. The pasture and grass hay enterprises differed from no-till corn because the two were included in the model's solution only if the beef cow/calf enterprise was also in the solution. No-till corn is not a labor intensive crop; therefore, no-till corn production was more profitable than leaving the land idle. Furthermore, no-till corn does not interfere with labor necessary to the production of the other enterprises.

Burley tobacco, one of East Tennessee's most widely produced crops, did not enter into the solution of any scenario unless no other high intensity crop options were available. The large amount of labor necessary to produce tobacco (228.21 hours/acre as compared to the next highest labor requirement of 216.96 hours/acre for okra production and a low of 38.69 hours/acre for sweet corn production) decreases tobacco's ability to compete with other high intensity enterprises. Tobacco does not always provide the highest returns per acre when compared with other enterprises, but tobacco does have the most secure market and is less risky to produce than other crops. Risk is not accounted for in this model, and therefore, accounts for one reason why tobacco unexpectedly does not enter into each scenario's solution.

Beef cow/calf production and broiler production were the only two livestock enterprise options included in the model. Whenever given the option, broiler production was included in the solution of each scenario. Broiler production, however, operates on a contractual basis with poultry companies, and therefore, depends upon the producer's ability to obtain and maintain a contract with a poultry company. The beef cow/calf enterprise was included as an activity in the solution only when the model was forced to do so. Revenues generated by this enterprise were not enough to warrant the inclusion of beef cow/calf production in any scenario. However, beef cow/calf production is predominant in East Tennessee where the research farm is located and reasons other than monetary ones account for this occurrence. These reasons include the ability of beef cattle to utilize land that would otherwise be idle as well as their ability to aid in maintaining the aesthetic value of the land.

Chapter 5

Summary, Conclusions, Limitations, and Implications for Further Research

Summary

This research study focused on using linear programming to do a baseline income optimization study of a diversified operating farm leased by The University of Tennessee Tobacco Experiment Station in Greeneville, Tennessee. The more precise management of land resources over and above what is typical of most farm operations in East Tennessee was the primary objective. The study had the following objectives:

- 1.) To create more precise land management units for the research demonstration farm;
- 2.) To develop a preliminary case study of the farm determining optimal alternative crop and/or livestock enterprise systems which show the greatest gross margins and to evaluate optimal solutions (gross margins) given the enterprise systems and resource constraints.

A more precise division of the original crop fields and pastures was deemed necessary to improve upon management precision of land resources. Therefore, the original crop fields and pastures were further divided into smaller management blocks and are referred to as “farming units.”

Of the farm’s 183.0 total surveyed acres, the actual cropable acreage was determined to be 109.10. This value was calculated in consultation with Dr. Paul Denton, Professor of Soil Management and Water Quality at The University of Tennessee. During on-site visits, the soil types, slopes, and current cropping practices and methods were

surveyed and recorded. The cropable acreage was then divided into smaller farming units based on the variability of these factors; the farm was divided into 31 farming units for this study. The actual acreage in each farming unit was then measured using topographic maps of the farm, generated by Joe Sarten, Engineer, at The University of Tennessee Agricultural Experiment Station in Knoxville, Tennessee.

The soil types predominately covering each farming unit were determined through soil sampling and the use of soil maps. Production capabilities of each soil type were used to calculate appropriate yields for each crop for each of the 31 farming units included in the analysis. These steps allowed for increased accuracy in the determination of the farm's potential productivity levels. Once the yields were established, they were used in the LP model to assist in the determination of the optimal enterprise mixes that would maximize gross margins. Various combinations of enterprises were put into the model to see which ones resulted in the optimal allocation of resources giving the largest total gross margin. Using the LP model built for the GAMS software, the model was altered by mixing the various enterprises from which the model could select. Each of these adjustments to the model is referred to as a scenario. By mixing the enterprise options for the model and making them separate scenarios enabled the study to look at which enterprises would compete with one another and how each enterprise would react to the different situations posed in the scenarios. The model was also adjusted to reflect either part- or full-time farming situations; therefore, scenarios reflecting part- and full-time situations were established. There was a total of 14 different scenarios, seven part-time scenarios and seven full-time scenarios. The scenarios examined in the model were selected by the

project leader, Dr. Darrell Mundy, Dr. Denton, and the researcher as representing typical farming operations in East Tennessee. The analysis focused on the use of the land resources on the farm under both full- and part-time situations. The results include the optimal enterprise mix and gross margin value for each scenario.

Only conservationally sound crops and cropping systems as determined by the Revised Universal Soil Loss Equation (RUSLE) were included as crop enterprise options in the model. Soil loss tolerance (T), which is a variable of the RUSLE, represents the maximum erosion level thought to maintain cropland productivity. In Greene County, where the research-demonstration farm is situated, the T is set at five tons per acre per year. Therefore, all the alternative enterprise systems considered in this model can be produced without violating any conservation practices. The results generated by the employment of the RUSLE showed that about 60 percent of the farm could be cropped using either traditional, no-till, and/or contour farming practices.

A linear programming (LP) model was chosen as the tool for this study because LP analyzes alternative enterprises and selects those that are the most efficient in achieving the desired objective. Linear programming determines the best solution to a problem, based upon the stated objective, the given restrictions, and the various alternative activities available (Pennsylvania State University Cooperative Extension Service, Special Circular 309).

The objective, alternative activities, and resource constraints are the three components of an LP problem and each is expressed numerically in the analyses (Boehjile and Eidman, 1984). Once the mathematical problem was established, it was written in a

code readable by GAMS to go through the iterations required for the model optimization. The iterations continue until the optimum feasible value of the objective function has been found (Jefferson and Boisvert, 1989 and Bender, Kahan, and Mylander, 1992).

Different full- and part-time scenarios, developed by varying enterprise combinations and alternating labor constraints between full- and part-time farming situations, were evaluated using the LP model. Labor was subdivided into two categories: domestic labor and migrant labor. Domestic labor was used first; migrant labor was used only when domestic labor was fully utilized. A total of 1560 hours of domestic labor and 2079 hours of migrant labor were available per year in the part-time situations. In the full-time scenarios, 3640 hours of domestic and 5200 hours of migrant labor were available per year. Examples of GAMS models for free model scenarios including both full- and part-time situations are found in Appendix C.

Results for the different scenarios, both part- and full-time, are summarized in Tables 5.1 and 5.2. The enterprises, total acres, domestic labor hours, migrant labor hours, and objective values are listed.

In the full-time scenarios, the free model was given the option of all enterprises and yielded the highest objective value of \$227,570.76 and included okra, PYO strawberries, no-till corn, and broiler production. The lowest objective value of the full-time situations was Scenario 4, which had an objective value of \$13,336.16. This scenario selected only no-till corn production from the options of grass hay, alfalfa hay, and no-till corn. The free model of the part-time scenarios had the highest objective value at \$109,702.69. This particular scenario included all of the alternative enterprise options as

Table 5.1. Part-Time Summary Results.

Scenario	Enterprise(s)	Total Units	Domestic Labor Hours	Migrant Labor Hours	Objective Value (\$)
Free Model	Conventional-till corn, Okra, PYO strawberries, No-till corn, Broiler Production	109.10 ac	1560.00	1586.00	109,702.69
1	Grass hay, Tobacco, Beef cow/calf, Pasture, Broiler Production	64.86 ac	1560.00	999.80	12,085.93
2	Grass hay, Pasture, Beef cow/calf	59.41 ac	432.29		-28,914.16
3	Okra, PYO strawberries, Pasture, Beef cow/calf	58.50 ac	1373.76	1085.95	62,274.68
4	No-till corn	109.10 ac	172.38		13,336.16
5	No-till corn	109.10 ac	172.38		13,336.16
6	Broiler Production	3.27 houses	1546.00	416.00	46,459.45

Table 5.2. Full-Time Summary Results.

Scenario	Enterprise(s)	Total Units	Domestic Labor Hours	Migrant Labor Hours	Objective Value (\$)
Free Model	Okra, PYO strawberries, No-till corn, Broiler Production	109.10 ac	3640.00	2824.07	227,570.76
1	Tobacco	11.10 ac	1854.33	678.80	24,505.45
2	Okra, PYO strawberries, Broiler Production	17.80 ac	3602.87	2695.77	218,272.38
3	Tobacco, No-till corn	109.10 ac	1978.22	709.75	36,054.65
4	No-till corn	109.10 ac	172.38		13,336.16
5	PYO strawberries, No-till corn	109.10 ac	1854.69	575.65	136,761.42
6	Okra, PYO strawberries, Broiler Production, Grass Hay, Pasture, Beef cow/calf, No-till corn	109.10 ac	3562.63	2718.97	181,636.64

in the free model of the full-time scenarios. From the alternatives, conventional corn, okra, PYO strawberries, no-till corn, and broiler production were chosen. The lowest objective value was -\$28,914.16 and held by part-time Scenario 2. In this situation, the model was given the options of grass hay and pasture production with beef cow/calf production forced into the solution. This solution raised enough grass hay and pasture to support the beef cow/calf enterprise.

Conclusions

In many farming operations, the land is viewed as a fixed resource by producers. Producers strive to utilize the land to its fullest potential to increase their income while still complying with conservation compliance regulations. Most producers currently consider each field as a single unit and generally do not attempt to manage the potential variations found in most fields. Management strategies based on an “average” of field conditions likely limits the producer’s full utilization of the land. To ensure compliance with conservation regulations, many producers under-utilize their land with low intensity enterprise activities such as grass hay, pasture, and cattle. By doing so, they knowingly or unknowingly set an upper boundary on the potential production of high intensity enterprises. Based on the results, this limitation further limits their income potential. However, by dividing a field into smaller farming units using the criteria previously mentioned, a producer can perhaps better utilize the land’s biological and physical resources. With this knowledge, a more accurate determination of the land’s potential productivity level can be found. Furthermore, producers would have the information to

more accurately determine which farming enterprises would show the best returns on each farming unit.

For this study, land was the only fixed resource considered. No management or capital constraints were considered by the model and the only labor constraints considered being the full-time versus part-time labor scenarios. The research farm was further divided into 31 smaller, more precise farming units from the original 13 fields. The fields were divided into smaller units based upon the soil types, slopes, and current cropping practices of each field. These new farming units were then included in the LP model built for the research farm. Net returns (gross margins) based on using the more precise, smaller land areal units was the focus of the study.

The model was used to determine optimal alternative crop and/or livestock enterprise systems that returned the highest gross margins for differing scenarios on both a full- and part-time basis. This was completed to establish a preliminary study of enterprise systems that best suited the given land as well as generated the greatest net returns as measured by gross margins for the research farm. Of the 14 scenarios, the full-time free model scenario generated the greatest returns with an objective value of \$227,570.76, and included okra, PYO strawberries, no-till corn, and broiler production. All 109.10 acres of available cropland were utilized. The free model of the part-time scenarios also employed all available cropland, but selected conventional-till corn, okra, PYO strawberries, no-till corn, and broiler production in the solution. This model had an objective value of \$109,702.69 and yielded the highest net returns of the part-time scenarios. The results of each scenario considered by the model served as guides in determining the optimal mix of

enterprises that not only best suited the limited land resources but also returned the highest gross margins for the research farm.

Limitations

The model is a single period preliminary income optimization model of a research demonstration farm leased by The University of Tennessee Tobacco Experiment Station in Greeneville, Tennessee. An LP model was used for the study. This type of model was chosen because linear programming determines the best solution to a problem, based upon the stated objective, the given restrictions, and the various alternative activities available (Pennsylvania State University Cooperative Extension Service, Special Circular 309). However, there are drawbacks to this type of model.

In this study, the LP model was static; therefore, the results were applicable for only a single moment in time. This limitation implies that the optimal enterprises and gross margins generated by the model for each scenario are for one single year or “snapshot” in time. Unexpectedly, two of the most common enterprises currently produced on the leased research farm and on many farms in the area did not enter into each scenario’s optimal solution. The only time that tobacco was produced was when there was no other highly intensive enterprise option permitted in the scenario such as vegetables. The only time that the beef cow/calf enterprise entered into the optimal solution was when it was forced into the optimal solution. Therefore, other reasons in addition to strictly monetary ones account for the production of tobacco and cattle in the region. Some of these reasons include the culture and traditions in the area, as well as the ability of beef cattle to utilize land that would otherwise be idle. Although the results of

the study indicate that these enterprises do not generate the highest gross margins when compared to other enterprises under the resource limitations of this farm, the study does not suggest that producers should stop producing tobacco and cattle. The model is static and somewhat naive being based on a single-valued objective, the maximization of gross margins. Therefore, the naivete of the model excludes other motivating factors which influence producers. Two important factors which are excluded are the risks involved in producing and marketing and the exclusion of preferences of the producers other than simply maximizing gross margins.

For this first preliminary study, the decision was made to set the parameters for a strict view of the land by the project leader, Dr. S. Darrell Mundy, Dr. Paul Denton, and the researcher. A strict view of land usage meant that there were no crop rotations considered within the framework of this model. However, in the future, a possible second phase of this research is the inclusion of rotations, the inclusion of more no-till options of high intensity crops such as sweet corn, tobacco, tomatoes, and cabbage, and the study of the interactions between no-till practices and conventional tillage practices. Dent, Harrison, and Woodford (1986) regard multi-period programming as a method for addressing this problem. In a multi-period programming model, the resource constraints are “progressively modified over time so that production opportunities and the optimal enterprise mix within years vary over time” (Dent, Harrison, and Woodford, 1986). The multi-period programming model is comprised of tableaus for each period which are a “complete static planning model” (Dent, Harrison, and Woodford, 1986). These tableaus

are then linked together by transfer activities that can carry forward inventories from the previous period.

In addition to Conservation Compliance rules there are other reasons to include rotations within the framework of the model. One of the reasons concerns disease and pest control. Furthermore, the production of a single crop on the same acreage for consecutive years can exhaust the soil's nutrient base and lead to increased problems with diseases, weeds, and insects. Rotations to counteract this problem are essential to the longevity of the soil's productivity.

The LP model used in this study utilizes assumptions that do not appear to represent reality. Dent, Harrison, and Woodford (1986) list the following problem areas:

- 1.) Divisibility - the linearity assumption of linear programming implies that each enterprise activity can be conducted and resources used in fractional units;
- 2.) Additivity - the resource demand of activities and the gross margin per unit activity are independent of the level of that activity and of any other activity;
- 3.) Profit maximization - the objective is to either maximize or minimize the objective function, which is comprised of single-value estimates of activity costs and return. Other goals such as risk minimization are excluded.

These assumptions are usually not a problem when the model is being used to support decision making activities. However, in some cases these assumptions do cause difficulties.

To make the model more realistic, activity levels can be limited to integer (whole-number) values. For example, when the solution for the model includes 2.86 chicken houses and raises 93.1 acres of no-till corn, the unlikelihood of having 2.86 chicken

houses is apparent; however, the production of 93.1 acres of no-till corn is feasible. In many cases, rounding figures from the model's solution to whole numbers is sufficient for decision making purposes. This problem can also be resolved by using an algorithm that allows the optimal solution to be modified so that certain activities are allowed to take on only integer values (Dent, Harrison, and Woodford, 1986 and Bender, Kahan, and Mylander, 1991). This method is referred to as mixed integer programming. Dent, Harrison, and Woodford (1986) find that mixed integer programming provides "tremendous scope for extending the efficacy of the short-run planning model of a farm." However, they warn that integer variables should be chosen with care because of the increased computer time necessary to solve problems with integer variables; therefore, "only critical variables should be flagged in this way" (Dent, Harrison, and Woodford, 1986). Bender, Kahan, and Mylander (1991) also warn that algorithms for integer problems are new and inefficient and that this limits the uses of mixed integer programming.

A major assumption of LP is that the producer wants to maximize or minimize linear functions such as expected total farm gross margins, or costs, respectively. Therefore, the objective function of an LP model is of a singular dimension and indifferent to risk. The model used in this study is no exception. However, most farmers are somewhat risk averse because predictable returns are of more value to them than higher, inconsistent returns possible by taking risks (Dent, Harrison, and Woodford, 1986).

Additional constraints can be incorporated into models to account for risk. Risk can also be assessed from outside the model framework and then the optimal farm plan

adjusted in a subjective manner. However, Dent, Harrison, and Woodford (1986), find that it is possible to “incorporate risk formally into the planning framework using linear risk programming or quadratic risk programming.” In linear risk programming, multiple observations of gross margins are put into the Simplex tableau. Using the minimum of total absolute deviations (MOTAD) method is one way of doing this. The expected gross margin for any activity is the mean across all individual years, and the sum of all individual means will equal the sum of all individual means below the mean. Therefore, by minimizing the sum of the shortfalls minimizes the sum of deviations both above and below the expected gross margin. This is the method employed by MOTAD. Quadratic risk programming uses the variance of the net returns for each activity and the covariances between all activity returns. In both linear risk programming and quadratic risk programming, a set of plans which are “risk efficient” is generated as opposed to a single optimal solution as in LP models. For each of these “risk efficient” plans, there is no other plan that has both a higher expected total gross margin and a lower variance of profit. Linear risk programming and quadratic risk programming greatly enhance the accuracy of LP modelling, but have not been widely used due to a lack of computer software and sufficient data (Dent, Harrison, and Woodford, 1986).

Implications for Further Research

The goal of this study was to establish a preliminary assessment of the farm leased by the Tennessee Agricultural Experiment Station to determine optimal alternative crop and/or livestock enterprise systems that would return the highest gross margins based on 1996 prices and information. A linear programming model was developed to accomplish

this task. Although this type of research is not uncommon, some of the methods employed in this study differ from other models of this type and clear the path for continued research on this farm in areas such as precision farming.

Precision farming is defined as “the ability to precisely target and meter agricultural inputs for optimized production efficiencies and economic returns,” (Pryor, 1996). The need to enhance producer profits by decreasing unnecessary applications of fertilizer and pesticides, and the environmental impact of farm chemicals have caused a surge of interest in precision agriculture technology (Pryor, 1996).

The research farm was divided into 31 farming units from 13 fields according to soil productivity. This type of breakdown is similar to what would be implemented if the technology of precision farming was utilized on this farm. In an article titled “Growers See Pluses of Precision Farming” written by Paul Hollis for the *Farm Press* (September 1996), the benefits of breaking down traditional farm fields into smaller management units are discussed. One farmer, Mike Newberry, states, “The goal of every farm is to maximize profits from every unit of production. Prior to now, maximizing profit on every unit of production meant every field. This is no longer true. This system allows us to work with parts of fields.” This article further states that farmers currently can and/or do divide their fields into smaller work management blocks if they feel there is enough variability to warrant the division.

The method in which yields were calculated for enterprise activities in this model was also unique in that it calculates an average of the yields of the various soil types found in each farming unit. This is another step necessary to implementing precision farming

technology on this farm, except however, with the new technology available, the yields of the farming units can be broken down even into smaller increments. Hollis (1996) states that “farming by the foot” will find its place in production economics because it is “economical and environmentally friendly.”

Further viable initiatives include the possibility of changing the model from an LP to a mixed integer programming model and then comparing the results of the different model solutions. The concept of risk could also be incorporated into the model framework by using linear risk programming or quadratic risk programming as previously described. To further improve the model used in this study, the incorporation of risk factors and mixed integer programming are implicated.

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APPENDICES

APPENDIX A

Prices, Variable Expenses, and Labor Hours for Enterprise Options

BURLEY TOBACCO:

Labor per acre in hours.

Jan./Feb.	March/April	May/June	July/Aug.	Sept./Oct.	Nov./Dec.	Total
	1.33	31.79	46.46	40.63	108.0	228.21

Price per pound = \$ 1.80

Variable Expenses per acre = \$1169.51

FRESH MARKET CABBAGE:

Labor per acre in hours.

Jan./Feb.	March/April	May/June	July/Aug.	Sept./Oct.	Nov./Dec.	Total
2.34	18.67	84.42				105.43

Price per 50-pound bag = \$4.25 (price is average of prices ranging from \$5.00 to \$3.50)

Variable Expenses per acre = \$817.26

FRESH MARKET TOMATOES:

Labor per acre in hours.

Jan./Feb.	March/April	May/June	July/Aug.	Sept./Oct.	Nov./Dec.	Total
	82.39	48.13	29.20			159.72

Price per 20-pound lug = \$5.88 (price is average of prices ranging from \$7.75 to \$3.75)

Variable Expenses per acre = \$5486.68 (includes both greenhouse and field variable expenses)

OKRA, FRESH MARKET, SPRING CROP:

Labor per acre in hours.

Jan./Feb.	March/April	May/June	July/Aug.	Sept./Oct.	Nov./Dec.	Total
	1.89	3.76	139.0	72.0		216.96

Price per 5-pound basket = \$4.00 (price is average of prices ranging from \$5.00 to \$3.00)

Variable Expenses per acre = \$476.56

SWEET CORN, FRESH MARKET, SPRING CROP:

Labor per acre in hours.

Jan./Feb.	March/April	May/June	July/Aug.	Sept./Oct.	Nov./Dec.	Total
	1.89	3.60	33.20			38.69

Price per dozen roasting ears = \$1.25 (price is average of prices ranging from \$1.50 to \$1.00)

Variable Expenses per acre = \$685.89

PUMPKINS, HALLOWEEN:

Labor per acre in hours.

Jan./Feb.	March/April	May/June	July/Aug.	Sept./Oct.	Nov./Dec.	Total
	1.89	14.31	10.36	43.93		70.49

Price per pound = \$0.09

Variable Expenses per acre = \$303.82

SWEET POTATOES, FRESH MARKET:

Labor per acre in hours.

Jan./Feb.	March/April	May/June	July/Aug.	Sept./Oct.	Nov./Dec.	Total
20.0	1.89	25.98	.65	26.50	24.5	99.52

Price per bushel = \$7.33 (price is average of prices ranging from \$10.00 to \$4.00)

Variable Expenses per acre = \$668.44 (includes both seedbed & other expenses)

BELL PEPPERS, PROCESSING:

Labor per acre in hours.

Jan./Feb.	March/April	May/June	July/Aug.	Sept./Oct.	Nov./Dec.	Total
	1.77	15.69	19.93	27.85		65.24

Price per ton = \$240.00

Variable Expenses per acre = \$511.47

YELLOW SQUASH, FRESH MARKET:

Labor per acre in hours.

Jan./Feb.	March/April	May/June	July/Aug.	Sept./Oct.	Nov./Dec.	Total
	1.89	55.67	75.50			133.06

Price per 1/2 bushel carton = \$5.63 (price is average of prices ranging from \$8.00 to \$3.00)

Variable Expenses per acre = \$887.10

STRAWBERRIES, PLASTICULTURE, PICK YOUR OWN (PYO):

Labor per acre in hours.

Jan./Feb.	March/April	May/June	July/Aug.	Sept./Oct.	Nov./Dec.	Total
10.0	25.0	100.0	5.0	57.5	7.5	205.0

Price per quart = \$1.00

Variable Expenses per acre = \$4055.93

CANTALOUPE, RETAIL FRESH MARKET, BLACK PLASTIC:

Labor per acre in hours.

Jan./Feb.	March/April	May/June	July/Aug.	Sept./Oct.	Nov./Dec.	Total
	21.44	16.04	130.60			168.08

Price per melon = \$0.63 (price is average of prices ranging from \$0.75 to \$0.50)

Variable Expenses per acre = \$1111.55

CATTLE, WINTER CALVING, 30-COW HERD:

Labor per head in hours.

Jan./Feb.	March/April	May/June	July/Aug.	Sept./Oct.	Nov./Dec.	Total
2.7	1.37	.77	.77	1.47	1.93	9.01

Price per pound (heifers)	=	\$0.53 (medium grade 2 or up-selling one 500 pound heifer)
Price per pound (steers)	=	\$0.62 (medium grade 2 or up-selling one 550 steer)
Price per pound (cull cows)	=	\$0.40 (utility-selling one 1050 pound cow)
Beef Checkoff	=	(\$27.00) (\$1/hd with 27 head sold @ mkt)
Death Loss (2%)	=	(\$40.50)

Variable Expenses (herd)	=	\$1069.39 (less 40.90 tons hay worth \$2249.50, pasture worth \$1996.58, and marketing expenses of \$283.50)
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**Cattle prices Dr. Emmit Rawls, personal consultation.

*Assumes a 90% weaning rate.

*Crop sold is 41.85 cwt. heifers; 66.30 cwt. steers; 45.00 cwt. cull cows.

Replacement Heifer Costs:

Salt & minerals (\$11.00 per head)	=	\$11.00
Vet. and medicine (\$13.10 per head)	=	\$13.10

TOTAL COST (per head)	=	\$24.10
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*Assumes a 16.66% replacement rate.

COOL SEASON GRASS/CLOVER HAY, NO-TILL ESTABLISHMENT :

Labor per acre in hours.

Jan./Feb.	March/April	May/June	July/Aug.	Sept./Oct.	Nov./Dec.	Total
.04	2.69	2.69		2.94		8.36

Price per ton	=	\$32.00
Variable Expenses per acre	=	\$103.73 (includes prorated establishment costs)

PASTURE COOL SEASON GRASS/CLOVER, CONTINUOUS GRAZING:

Labor per acre in hours.

Jan./Feb.	March/April	May/June	July/Aug.	Sept./Oct.	Nov./Dec.	Total
.06	.17	.32	.52	.23		1.30

Variable Expenses per acre = \$38.03

ALFALFA HAY, NO-TILL ESTABLISHMENT:

Labor per acre in hours.

Jan./Feb.	March/April	May/June	July/Aug.	Sept./Oct.	Nov./Dec.	Total
		3.8	2.37	1.58		7.75

Price per ton = \$55.00

Variable Expenses per acre = \$223.29 (includes prorated establishment costs)

CONTRACT BROILER PRODUCTION - ONE HOUSE:

Labor per house in hours.

Jan./Feb.	March/April	May/June	July/Aug.	Sept./Oct.	Nov./Dec.	Total
100	100	100	100	100	100	600

Price per bird = \$0.19

Variable Expenses per house = \$6100.00

NO-TILL CORN, 4-ROW EQUIPMENT:

Labor per acre in hours.

Jan./Feb.	March/April	May/June	July/Aug.	Sept./Oct.	Nov./Dec.	Total
	.28	.28		1.02		1.58

Price per bushel = \$2.50

Variable Expenses per acre = \$118.48

CONVENTIONAL CORN, 4-ROW EQUIPMENT:

Labor per acre in hours.

Jan./Feb.	March/April	May/June	July/Aug.	Sept./Oct.	Nov./Dec.	Total
	1.02	.08		1.02		2.12

Price per bushel = \$2.50

Variable Expenses per acre = \$110.91

WHEAT, 4-ROW EQUIPMENT:

Labor per acre in hours.

Jan./Feb.	March/April	May/June	July/Aug.	Sept./Oct.	Nov./Dec.	Total
	.24	.78		.36	.36	1.74

Price per bushel = \$3.25

Variable Expenses per acre = \$85.70

HIRING DOMESTIC LABOR:

Wages per hour (\$/hour) = \$6.00 (\$5.50/hr, plus \$0.50/hr for taxes & payroll)

HIRING MIGRANT LABOR:

Wages per hour (\$/hour) = \$7.00 (includes all taxes for H2A labor regulations)

APPENDIX B

Legend of Soil Types on Research-Demonstration Farm, Greeneville, Tennessee

Soil Symbol	Soil Name
Cf	Cumberland silt loam, undulating phase
Ch	Cumberland silty clay loam, eroded rolling phase
Dg	Dandridge silt loam, very steep phase
Dnd	Dunmore cherty silty clay, severely eroded hilly phase
Dng	Dunmore cherty silty clay loam, eroded hilly phase
Dnh	Dunmore cherty silty clay loam, eroded rolling phase
Dnl	Dunmore loam, eroded hilly phase
Dnm	Dunmore loam, eroded rolling phase
Do	Dewey silty clay loam, eroded hilly phase
Dsb	Dunmore silt loam, rolling phase
Dsd	Dunmore silty clay, hilly phase
Dsh	Dunmore silty clay loam, rolling phase
Dsg	Dunmore silty clay loam, hilly phase
Ga	Greendale silt loam
Hg	Hermitage silt loam, eroded phase
Hh	Hermitage silt loam, undulating phase
Lc	Lindside silt loam
Ng	Nolichucky loam, eroded rolling phase
Nk	Nolichucky loam, undulating phase
We	Waynesboro loam, undulating phase
Wd	Waynesboro loam, eroded rolling phase

APPENDIX C

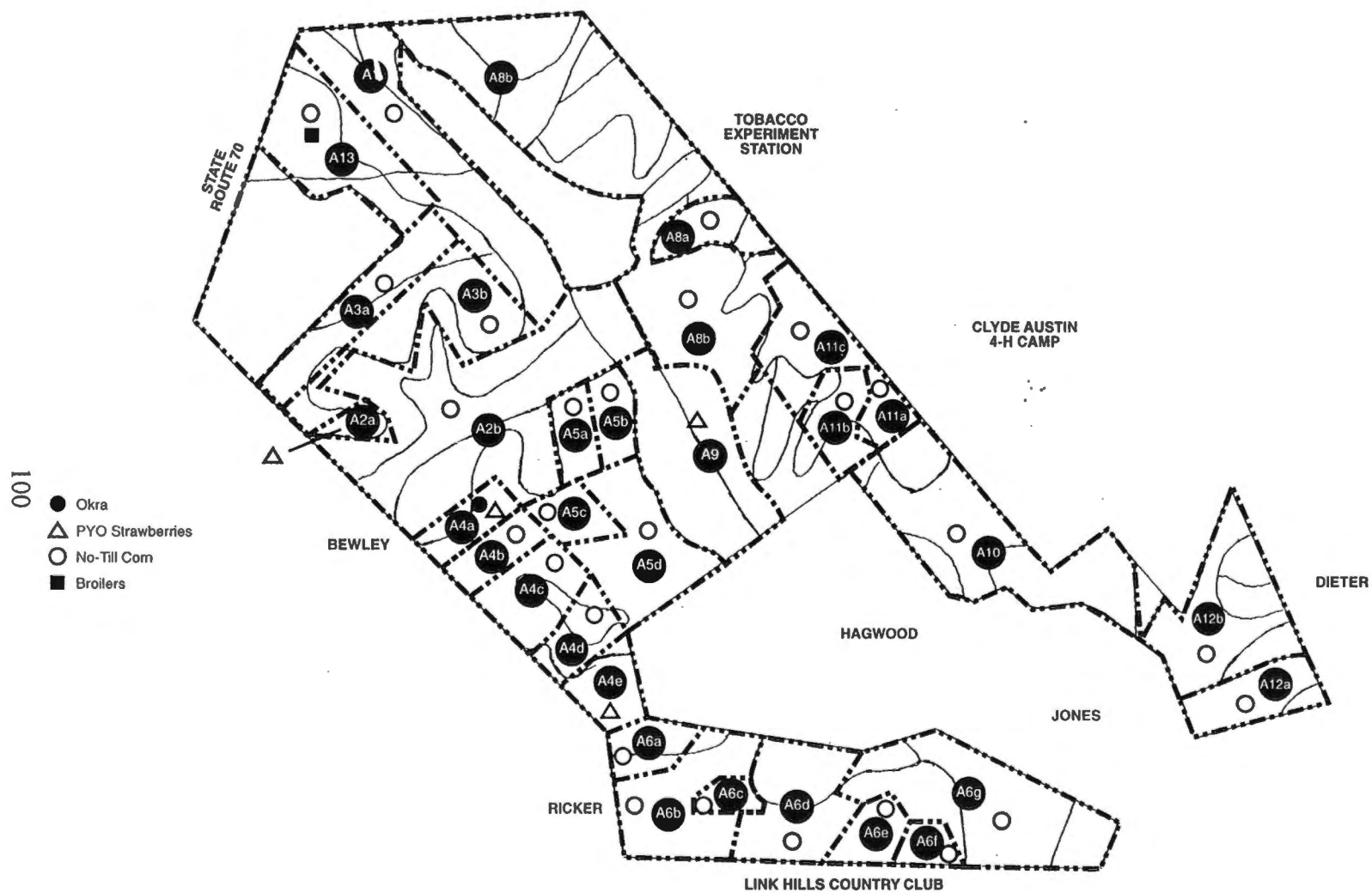


Figure C.1. Full-Time Scenario (Free Model) Map Showing Farming Units and Enterprises.

GAMS INPUT FOR FULL-TIME FREE MODEL

*LIST OF ACTIVITIES:

*X1Y2 = CORN PRODUCTION (ACRE). A2A
*X1Y6 = CORN PRODUCTION (ACRE). A4A
*X1Y10 = CORN PRODUCTION (ACRE). A4E
*X1Y24 = CORN PRODUCTION (ACRE). A9
*X2Y2 = WHEAT PRODUCTION (ACRE). A2A
*X2Y6 = WHEAT PRODUCTION (ACRE). A4A
*X2Y10 = WHEAT PRODUCTION (ACRE). A4E
*X2Y24 = WHEAT PRODUCTION (ACRE). A9
*X3Y1 = GRASS HAY PRODUCTION (ACRE). A1
*X3Y2 = GRASS HAY PRODUCTION (ACRE). A2A
*X3Y3 = GRASS HAY PRODUCTION (ACRE). A2B
*X3Y4 = GRASS HAY PRODUCTION (ACRE). A3A
*X3Y5 = GRASS HAY PRODUCTION (ACRE). A3B
*X3Y6 = GRASS HAY PRODUCTION (ACRE). A4A
*X3Y7 = GRASS HAY PRODUCTION (ACRE). A4B
*X3Y8 = GRASS HAY PRODUCTION (ACRE). A4C
*X3Y9 = GRASS HAY PRODUCTION (ACRE). A4D
*X3Y10 = GRASS HAY PRODUCTION (ACRE). A4E
*X3Y11 = GRASS HAY PRODUCTION (ACRE). A5A
*X3Y12 = GRASS HAY PRODUCTION (ACRE). A5B
*X3Y13 = GRASS HAY PRODUCTION (ACRE). A5C
*X3Y14 = GRASS HAY PRODUCTION (ACRE). A5D
*X3Y15 = GRASS HAY PRODUCTION (ACRE). A6A
*X3Y16 = GRASS HAY PRODUCTION (ACRE). A6B
*X3Y17 = GRASS HAY PRODUCTION (ACRE). A6C
*X3Y18 = GRASS HAY PRODUCTION (ACRE). A6D
*X3Y19 = GRASS HAY PRODUCTION (ACRE). A6E
*X3Y20 = GRASS HAY PRODUCTION (ACRE). A6F
*X3Y21 = GRASS HAY PRODUCTION (ACRE). A6G
*X3Y22 = GRASS HAY PRODUCTION (ACRE). A8A
*X3Y23 = GRASS HAY PRODUCTION (ACRE). A8B
*X3Y24 = GRASS HAY PRODUCTION (ACRE). A9
*X3Y25 = GRASS HAY PRODUCTION (ACRE). A10
*X3Y26 = GRASS HAY PRODUCTION (ACRE). A11A
*X3Y27 = GRASS HAY PRODUCTION (ACRE). A11B
*X3Y28 = GRASS HAY PRODUCTION (ACRE). A11C
*X3Y30 = GRASS HAY PRODUCTION (ACRE). A12A
*X3Y31 = GRASS HAY PRODUCTION (ACRE). A12B
*X3Y32 = GRASS HAY PRODUCTION (ACRE). A13
*X4Y2 = TOBACCO PRODUCTION (ACRE). A2A

*X41Y6 = TOBACCO PRODUCTION (ACRE). A4A
 *X4Y10 = TOBACCO PRODUCTION (ACRE). A4E
 *X4Y24 = TOBACCO PRODUCTION (ACRE). A9
 *X5Y2 = CABBAGE PRODUCTION (ACRE). A2A
 *X5Y6 = CABBAGE PRODUCTION (ACRE). A4A
 *X5Y10 = CABBAGE PRODUCTION (ACRE). A4E
 *X5Y24 = CABBAGE PRODUCTION (ACRE). A9
 *X6Y2 = TOMATO PRODUCTION (ACRE). A2A
 *X6Y10 = TOMATO PRODUCTION (ACRE). A4A
 *X6Y10 = TOMATO PRODUCTION (ACRE). A4E
 *X6Y24 = TOMATO PRODUCTION (ACRE). A9
 *X7Y2 = OKRA PRODUCTION (ACRE). A2A
 *X7Y6 = OKRA PRODUCTION (ACRE). A4A
 *X7Y10 = OKRA PRODUCTION (ACRE). A4E
 *X7Y24 = OKRA PRODUCTION (ACRE). A9
 *X8Y2 = SWEET CORN PRODUCTION (ACRE). A2A
 *X8Y6 = SWEET CORN PRODUCTION (ACRE). A4A
 *X8Y10 = SWEET CORN PRODUCTION (ACRE). A4E
 *X8Y24 = SWEET CORN PRODUCTION (ACRE). A9
 *X9Y2 = PUMPKIN PRODUCTION (ACRE). A2A
 *X9Y6 = PUMPKIN PRODUCTION (ACRE). A4A
 *X9Y10 = PUMPKIN PRODUCTION (ACRE). A4E
 *X9Y24 = PUMPKIN PRODUCTION (ACRE). A9
 *X10Y2 = SWEET POTATO PRODUCTION (ACRE). A2A
 *X10Y6 = SWEET POTATO PRODUCTION (ACRE). A4A
 *X10Y10 = SWEET POTATO PRODUCTION (ACRE). A4E
 *X10Y24 = SWEET POTATO PRODUCTION (ACRE). A9
 *X11Y2 = PEPPER PRODUCTION (ACRE). A2A
 *X11Y6 = PEPPER PRODUCTION (ACRE). A4A
 *X11Y10 = PEPPER PRODUCTION (ACRE). A4E
 *X11Y24 = PEPPER PRODUCTION (ACRE). A9
 *X12Y2 = YELLOW SQUASH PRODUCTION (ACRE). A2A
 *X12Y6 = YELLOW SQUASH PRODUCTION (ACRE). A4A
 *X12Y10 = YELLOW SQUASH PRODUCTION (ACRE). A4E
 *X12Y24 = YELLOW SQUASH PRODUCTION (ACRE). A9
 *X13Y2 = STRAWBERRY-PYO PRODUCTION (ACRE). A2A
 *X13Y6 = STRAWBERRY-PYO PRODUCTION (ACRE). A4A
 *X13Y10 = STRAWBERRY-PYO PRODUCTION (ACRE). A4E
 *X13Y24 = STRAWBERRY-PYO PRODUCTION (ACRE). A9
 *X14Y2 = CANTELOPE PRODUCTION (ACRE). A2A
 *X14Y6 = CANTELOPE PRODUCTION (ACRE). A4A
 *X14Y10 = CANTELOPE PRODUCTION (ACRE). A4E
 *X14Y24 = CANTELOPE PRODUCTION (ACRE). A9

*X15Y2 = ALFALFA HAY PRODUCTION (ACRE). A2A
 *X15Y6 = ALFALFA HAY PRODUCTION (ACRE). A4A
 *X15Y10 = ALFALFA HAY PRODUCTION (ACRE). A4E
 *X15Y24 = ALFALFA HAY PRODUCTION (ACRE). A9
 *X16Y1 = NO-TILL CORN PRODUCTION (ACRE). A1
 *X16Y2 = NO-TILL CORN PRODUCTION (ACRE). A2A
 *X16Y3 = NO-TILL CORN PRODUCTION (ACRE). A2B
 *X16Y4 = NO-TILL CORN PRODUCTION (ACRE). A3A
 *X16Y5 = NO-TILL CORN PRODUCTION (ACRE). A3B
 *X16Y6 = NO-TILL CORN PRODUCTION (ACRE). A4A
 *X16Y7 = NO-TILL CORN PRODUCTION (ACRE). A4B
 *X16Y8 = NO-TILL CORN PRODUCTION (ACRE). A4C
 *X16Y9 = NO-TILL CORN PRODUCTION (ACRE). A4D
 *X16Y10 = NO-TILL CORN PRODUCTION (ACRE). A4E
 *X16Y11 = NO-TILL CORN PRODUCTION (ACRE). A5A
 *X16Y12 = NO-TILL CORN PRODUCTION (ACRE). A5B
 *X16Y13 = NO-TILL CORN PRODUCTION (ACRE). A5C
 *X16Y14 = NO-TILL CORN PRODUCTION (ACRE). A5D
 *X16Y15 = NO-TILL CORN PRODUCTION (ACRE). A6A
 *X16Y16 = NO-TILL CORN PRODUCTION (ACRE). A6B
 *X16Y17 = NO-TILL CORN PRODUCTION (ACRE). A6C
 *X16Y18 = NO-TILL CORN PRODUCTION (ACRE). A6D
 *X16Y19 = NO-TILL CORN PRODUCTION (ACRE). A6E
 *X16Y20 = NO-TILL CORN PRODUCTION (ACRE). A6F
 *X16Y21 = NO-TILL CORN PRODUCTION (ACRE). A6G
 *X16Y22 = NO-TILL CORN PRODUCTION (ACRE). A8A
 *X16Y23 = NO-TILL CORN PRODUCTION (ACRE). A8B
 *X16Y24 = NO-TILL CORN PRODUCTION (ACRE). A9
 *X16Y25 = NO-TILL CORN PRODUCTION (ACRE). A10
 *X16Y26 = NO-TILL CORN PRODUCTION (ACRE). A11A
 *X16Y27 = NO-TILL CORN PRODUCTION (ACRE). A11B
 *X16Y28 = NO-TILL CORN PRODUCTION (ACRE). A11C
 *X16Y30 = NO-TILL CORN PRODUCTION (ACRE). A12A
 *X16Y31 = NO-TILL CORN PRODUCTION (ACRE). A12B
 *X16Y32 = NO-TILL CORN PRODUCTION (ACRE). A13
 *X17Y1 = BEEF COW/CALF PRODUCTION (ONE COW). A1
 *X18Y2 = CHICKEN PRODUCTION-BROILERS (ONE HOUSE). A2A
 *X18Y4 = CHICKEN PRODUCTION-BROILERS (ONE HOUSE). A3A
 *X18Y6 = CHICKEN PRODUCTION-BROILERS (ONE HOUSE). A4A
 *X18Y10 = CHICKEN PRODUCTION-BROILERS (ONE HOUSE). A4E
 *X18Y13 = CHICKEN PRODUCTION-BROILERS (ONE HOUSE). A5C
 *X18Y14 = CHICKEN PRODUCTION-BROILERS (ONE HOUSE). A5D
 *X18Y22 = CHICKEN PRODUCTION-BROILERS (ONE HOUSE). A8A

*X18Y24 = CHICKEN PRODUCTION-BROILERS (ONE HOUSE). A9
 *X18Y25 = CHICKEN PRODUCTION-BROILERS (ONE HOUSE). A10
 *X18Y32 = CHICKEN PRODUCTION-BROILERS (ONE HOUSE). A13
 *X52Y1 = PASTURE GROWING AND HARVESTING (ACRE). A1
 *X52Y2 = PASTURE GROWING AND HARVESTING (ACRE). A2A
 *X52Y3 = PASTURE GROWING AND HARVESTING (ACRE). A2B
 *X52Y4 = PASTURE GROWING AND HARVESTING (ACRE). A3A
 *X52Y5 = PASTURE GROWING AND HARVESTING (ACRE). A3B
 *X52Y6 = PASTURE GROWING AND HARVESTING (ACRE). A4A
 *X52Y7 = PASTURE GROWING AND HARVESTING (ACRE). A4B
 *X52Y8 = PASTURE GROWING AND HARVESTING (ACRE). A4C
 *X52Y9 = PASTURE GROWING AND HARVESTING (ACRE). A4D
 *X52Y10 = PASTURE GROWING AND HARVESTING (ACRE). A4E
 *X52Y11 = PASTURE GROWING AND HARVESTING (ACRE). A5A
 *X52Y12 = PASTURE GROWING AND HARVESTING (ACRE). A5B
 *X52Y13 = PASTURE GROWING AND HARVESTING (ACRE). A5C
 *X52Y14 = PASTURE GROWING AND HARVESTING (ACRE). A5D
 *X52Y15 = PASTURE GROWING AND HARVESTING (ACRE). A6A
 *X52Y16 = PASTURE GROWING AND HARVESTING (ACRE). A6B
 *X52Y17 = PASTURE GROWING AND HARVESTING (ACRE). A6C
 *X52Y18 = PASTURE GROWING AND HARVESTING (ACRE). A6D
 *X52Y19 = PASTURE GROWING AND HARVESTING (ACRE). A6E
 *X52Y20 = PASTURE GROWING AND HARVESTING (ACRE). A6F
 *X52Y21 = PASTURE GROWING AND HARVESTING (ACRE). A6G
 *X52Y22 = PASTURE GROWING AND HARVESTING (ACRE). A8A
 *X52Y23 = PASTURE GROWING AND HARVESTING (ACRE). A8B
 *X52Y24 = PASTURE GROWING AND HARVESTING (ACRE). A9
 *X52Y25 = PASTURE GROWING AND HARVESTING (ACRE). A10
 *X52Y26 = PASTURE GROWING AND HARVESTING (ACRE). A11A
 *X52Y27 = PASTURE GROWING AND HARVESTING (ACRE). A11B
 *X52Y28 = PASTURE GROWING AND HARVESTING (ACRE). A11C
 *X52Y30 = PASTURE GROWING AND HARVESTING (ACRE). A12A
 *X52Y31 = PASTURE GROWING AND HARVESTING (ACRE). A12B
 *X52Y32 = PASTURE GROWING AND HARVESTING (ACRE). A13
 *X54Y2 = TOBACCO PRODUCTION-LEASED POUNDAGE (ACRE). A2A
 *X54Y6 = TOBACCO PRODUCTION-LEASED POUNDAGE (ACRE). A4A
 *X54Y10 = TOBACCO PRODUCTION-LEASED POUNDAGE (ACRE). A4E
 *X54Y24 = TOBACCO PRODUCTION-LEASED POUNDAGE (ACRE). A9
 *X19 = SELL CORN (BUSHEL).
 *X20 = SELL WHEAT (BUSHEL).
 *X21 = SELL GRASS HAY (TON).
 *X22 = SELL BURLEY TOBACCO (POUND).
 *X23 = SELL CABBAGE (ONE BAG (50 LBS)).

*X24 = SELL TOMATOES (ONE LUG).
 *X25 = SELL OKRA (ONE BASKET).
 *X26 = SELL SWEET CORN (ONE DOZEN EARS).
 *X27 = SELL PUMPKINS (ONE POUND).
 *X28 = SELL SWEET POTATOES (ONE BUSHEL).
 *X29 = SELL PEPPERS (ONE TON).
 *X30 = SELL YELLOW SQUASH (1/2 BUSHEL CARTON).
 *X31 = SELL PYO STRAWBERRIES (ONE QUART).
 *X32 = SELL CANTELOPES (ONE MELON).
 *X33 = SELL ALFALFA HAY (TON).
 *X34 = SELL NO-TILL CORN (BUSHEL).
 *X35 = SELL STEERS (ONE STEER WEIGHING 550 LBS).
 *X36 = SELL HEIFERS (ONE HEIFER WEIGHING 500 LBS).
 *X37 = SELL CULL COWS (ONE COW WEIGHING 1050 LBS).
 *X38 = SELL CHICKENS (ONE BROILER).
 *X39 = REPLACEMENT HEIFER GROWING AND BREEDING (ONE HEIFER).
 *X40 = BUY DOMESTIC LABOR (JAN-FEB) (HOUR).
 *X41 = BUY DOMESTIC LABOR (MARCH-APRIL) (HOUR).
 *X42 = BUY DOMESTIC LABOR (MAY-JUNE) (HOUR).
 *X43 = BUY DOMESTIC LABOR (JULY-AUG) (HOUR).
 *X44 = BUY DOMESTIC LABOR (SEPT-OCT) (HOUR).
 *X45 = BUY DOMESTIC LABOR (NOV-DEC) (HOUR).
 *X46 = BUY MIGRANT LABOR (JAN-FEB) (HOUR).
 *X47 = BUY MIGRANT LABOR (MARCH-APRIL) (HOUR).
 *X48 = BUY MIGRANT LABOR (MAY-JUNE) (HOUR).
 *X49 = BUY MIGRANT LABOR (JULY-AUG) (HOUR).
 *X50 = BUY MIGRANT LABOR (SEPT-OCT) (HOUR).
 *X51 = BUY MIGRANT LABOR (NOV-DEC) (HOUR).
 *X53 = BUY COOL SEASON/GRASS HAY FOR CATTLE (TON).
 *X55 = LEASE TOBACCO QUOTA (POUND).
 *X56 = GRASS HAY FEEDING ACTIVITY (TON).

***LIST OF CONSTRAINTS:**

*Y1 = LAND CONSTRAINT FOR A1 FARMING UNIT (ACRE).
 *Y2 = LAND CONSTRAINT FOR A2A FARMING UNIT (ACRE).
 *Y3 = LAND CONSTRAINT FOR A2B FARMING UNIT (ACRE).
 *Y4 = LAND CONSTRAINT FOR A3A FARMING UNIT (ACRE).
 *Y5 = LAND CONSTRAINT FOR A3B FARMING UNIT (ACRE).
 *Y6 = LAND CONSTRAINT FOR A4A FARMING UNIT (ACRE).
 *Y7 = LAND CONSTRAINT FOR A4B FARMING UNIT (ACRE).
 *Y8 = LAND CONSTRAINT FOR A4C FARMING UNIT (ACRE).
 *Y9 = LAND CONSTRAINT FOR A4D FARMING UNIT (ACRE).

*Y10 = LAND CONSTRAINT FOR A4E FARMING UNIT (ACRE).
 *Y11 = LAND CONSTRAINT FOR A5A FARMING UNIT (ACRE).
 *Y12 = LAND CONSTRAINT FOR A5B FARMING UNIT (ACRE).
 *Y13 = LAND CONSTRAINT FOR A5C FARMING UNIT (ACRE).
 *Y14 = LAND CONSTRAINT FOR A5D FARMING UNIT (ACRE).
 *Y15 = LAND CONSTRAINT FOR A6A FARMING UNIT (ACRE).
 *Y16 = LAND CONSTRAINT FOR A6B FARMING UNIT (ACRE).
 *Y17 = LAND CONSTRAINT FOR A6C FARMING UNIT (ACRE).
 *Y18 = LAND CONSTRAINT FOR A6D FARMING UNIT (ACRE).
 *Y19 = LAND CONSTRAINT FOR A6E FARMING UNIT (ACRE).
 *Y20 = LAND CONSTRAINT FOR A6F FARMING UNIT (ACRE).
 *Y21 = LAND CONSTRAINT FOR A6G FARMING UNIT (ACRE).
 *Y22 = LAND CONSTRAINT FOR A8A FARMING UNIT (ACRE).
 *Y23 = LAND CONSTRAINT FOR A8B FARMING UNIT (ACRE).
 *Y24 = LAND CONSTRAINT FOR A9 FARMING UNIT (ACRE).
 *Y25 = LAND CONSTRAINT FOR A10 FARMING UNIT (ACRE).
 *Y26 = LAND CONSTRAINT FOR A11A FARMING UNIT (ACRE).
 *Y27 = LAND CONSTRAINT FOR A11B FARMING UNIT (ACRE).
 *Y28 = LAND CONSTRAINT FOR A11C FARMING UNIT (ACRE).
 *Y30 = LAND CONSTRAINT FOR A12A FARMING UNIT (ACRE).
 *Y31 = LAND CONSTRAINT FOR A12B FARMING UNIT (ACRE).
 *Y32 = LAND CONSTRAINT FOR A13 FARMING UNIT (ACRE).
 *Y64 = CORN TRANSFER (BUSHEL).
 *Y65 = WHEAT TRANSFER (BUSHEL).
 *Y66 = GRASS HAY TRANSFER (BUSHEL).
 *Y67 = TOBACCO TRANSFER (OWN, LB).
 *Y68 = CABBAGE TRANSFER (BAG).
 *Y69 = TOMATO TRANSFER (LUG).
 *Y70 = OKRA TRANSFER (BASKET).
 *Y71 = SWEET CORN TRANSFER (DOZEN EARS).
 *Y72 = PUMPKIN TRANSFER (POUND).
 *Y73 = SWEET POTATO TRANSFER (BUSHEL).
 *Y74 = PEPPER TRANSFER (TON).
 *Y75 = YELLOW SQUASH TRANSFER (1/2 BUSHEL CARTON).
 *Y76 = PYO STRAWBERRY TRANSFER (QUART).
 *Y77 = CANTELOPE TRANSFER (MELON).
 *Y78 = ALFALFA HAY TRANSFER (TON).
 *Y79 = NO-TILL CORN TRANSFER (BUSHEL).
 *Y80 = TOBACCO QUOTA AVAILABLE ON FARM (POUND).
 *Y81 = TOBACCO QUOTA MAX THAT FARM CAN LEASE FOR ONE
 YEAR (POUND).
 *Y82 = MAX DOMESTIC LABOR JAN-FEB TRANSFER ROW (HOUR).
 *Y83 = MAX DOMESTIC LABOR MARCH-APRIL TRANSFER ROW

(HOUR).

*Y84 = MAX DOMESTIC LABOR MAY-JUNE TRANSFER ROW (HOUR).
 *Y85 = MAX DOMESTIC LABOR JULY-AUG TRANSFER ROW (HOUR).
 *Y86 = MAX DOMESTIC LABOR SEPT-OCT TRANSFER ROW (HOUR).
 *Y87 = MAX DOMESTIC LABOR NOV-DEC TRANSFER ROW (HOUR).
 *Y88 = JAN-FEB MAX DOMESTIC LABOR CONSTRAINT (HOUR).
 *Y89 = MARCH-APRIL DOMESTIC LABOR CONSTRAINT (HOUR).
 *Y90 = MAY-JUNE DOMESTIC LABOR CONSTRAINT (HOUR).
 *Y91 = JULY-AUG DOMESTIC LABOR CONSTRAINT (HOUR).
 *Y92 = SEPT-OCT DOMESTIC LABOR CONSTRAINT (HOUR).
 *Y93 = NOV-DEC DOMESTIC LABOR CONSTRAINT (HOUR).
 *Y94 = CATTLE - 30 HEAD HERD.
 *Y97 = MAX MIGRANT JAN-FEB LABOR (HOUR).
 *Y98 = MAX MIGRANT MARCH-APRIL LABOR (HOUR).
 *Y99 = MAX MIGRANT MAY-JUNE LABOR (HOUR).
 *Y100 = MAX MIGRANT JULY-AUG LABOR (HOUR).
 *Y101 = MAX MIGRANT SEPT-OCT LABOR (HOUR).
 *Y102 = MAX MIGRANT NOV-DEC LABOR (HOUR).
 *Y103 = OWNED QUOTA TRANSFER ROW.
 *Y104 = LEASED QUOTA TRANSFER ROW.
 *Y106 = STEER TRANSFER ROW (550 LB STEER).
 *Y107 = HEIFER TRANSFER ROW (500 LB HEIFER).
 *Y108 = CULL COW TRANSFER ROW (1050 LB CULL COW).
 *Y109 = CHICKEN TRANSFER ROW (ONE CHICKEN).
 *Y110 = REPLACEMENT HEIFER ROW (ONE HEIFER).
 *Y111 = PASTURE GROWING ACTIVITY (ACRE).
 *Y112 = MINIMUM HAY REQUIREMENT (TON).

SETS

I CONSTRAINTS OF RESOURCES

/Y1, Y2, Y3, Y4, Y5, Y6, Y7, Y8, Y9, Y10, Y11, Y12, Y13, Y14, Y15, Y16, Y17,
 Y18, Y19, Y20, Y21, Y22, Y23, Y24, Y25, Y26, Y27, Y28, Y30, Y31, Y32, Y64,
 Y65, Y66, Y67, Y68, Y69, Y70, Y71, Y72, Y73, Y74, Y75, Y76, Y77, Y78, Y79,
 Y80, Y81, Y82, Y83, Y84, Y85, Y86, Y87, Y88, Y89, Y90, Y91, Y92, Y93,
 Y94,
 Y97, Y98, Y99, Y100, Y101, Y102, Y103, Y104, Y106, Y107, Y108, Y109,
 Y110, Y111, Y112/

J ACTIVITIES OF THE OBJECTIVE FUNCTION

/X1Y2, X1Y6, X1Y10, X1Y24, X2Y2, X2Y6, X2Y10, X2Y24, X3Y1, X3Y2,
 X3Y3, X3Y4, X3Y5, X3Y6, X3Y7, X3Y8, X3Y9, X3Y10, X3Y11, X3Y12,
 X3Y13, X3Y14, X3Y15, X3Y16, X3Y17, X3Y18, X3Y19, X3Y20, X3Y21,
 X3Y22, X3Y23, X3Y24, X3Y25, X3Y26, X3Y27, X3Y28, X3Y30, X3Y31,

X3Y32, X4Y2, X4Y6, X4Y10, X4Y24, X5Y2, X5Y6, X5Y10, X5Y24, X6Y2, X6Y6, X6Y10, X6Y24, X7Y2, X7Y6, X7Y10, X7Y24, X8Y2, X8Y6, X8Y10, X8Y24, X9Y2, X9Y6, X9Y10, X9Y24, X10Y2, X10Y6, X10Y10, X10Y24, X11Y2, X11Y6, X11Y10, X11Y24, X12Y2, X12Y6, X12Y10, X12Y24, X13Y2, X13Y6, X13Y10, X13Y24, X14Y2, X14Y6, X14Y10, X14Y24, X15Y2, X15Y6, X15Y10, X15Y24, X16Y1, X16Y2, X16Y3, X16Y4, X16Y5, X16Y6, X16Y7, X16Y8, X16Y9, X16Y10, X16Y11, X16Y12, X16Y13, X16Y14, X16Y15, X16Y16, X16Y17, X16Y18, X16Y19, X16Y20, X16Y21, X16Y22, X16Y23, X16Y24, X16Y25, X16Y26, X16Y27, X16Y28, X16Y30, X16Y31, X16Y32, X17Y1, X18Y2, X18Y4, X18Y6, X18Y10, X18Y13, X18Y14, X18Y22, X18Y24, X18Y25, X18Y32, X52Y1, X52Y2, X52Y3, X52Y4, X52Y5, X52Y6, X52Y7, X52Y8, X52Y9, X52Y10, X52Y11, X52Y12, X52Y13, X52Y14, X52Y15, X52Y16, X52Y17, X52Y18, X52Y19, X52Y20, X52Y21, X52Y22, X52Y23, X52Y24, X52Y25, X52Y26, X52Y27, X52Y28, X52Y30, X52Y31, X52Y32, X54Y2, X54Y6, X54Y10, X54Y24, X19, X20, X21, X22, X23, X24, X25, X26, X27, X28, X29, X30, X31, X32, X33, X34, X35, X36, X37, X38, X39, X40, X41, X42, X43, X44, X45, X46, X47, X48, X49, X50, X51, X53, X55, X56/;

TABLE A(I,J) LAND RESOURCES AND CROP YIELDS

	X1Y2	X1Y6	X1Y10	X1Y24	X2Y2	X2Y6
Y2	1				1	
Y6		1				1
Y10			1			
Y24				1		
Y64	-125	-105	-130	-140		
Y65					-60	-50
	+ X2Y10	X2Y24	X3Y1	X3Y2	X3Y3	X3Y4
Y1			1			
Y2				1		
Y3					1	
Y4						1
Y10	1					
Y24		1				
Y65	-65	-59.2				
Y66			-2.4	-3.2	-3.0	-2.7

	+ X3Y5	X3Y6	X3Y7	X3Y8	X3Y9	X3Y10
Y5	1					
Y6		1				
Y7			1			
Y8				1		
Y9					1	
Y10						1
Y66	-2.7	-2.7	-2.7	-2.9	-3.0	-3.2

	+ X3Y11	X3Y12	X3Y13	X3Y14	X3Y15	X3Y16
Y11	1					
Y12		1				
Y13			1			
Y14				1		
Y15					1	
Y16						1
Y66	-2.7	-2.7	-2.7	-2.7	-3.2	-2.7

	+ X3Y17	X3Y18	X3Y19	X3Y20	X3Y21	X3Y22
Y17	1					
Y18		1				
Y19			1			
Y20				1		
Y21					1	
Y22						1
Y66	-2.7	-2.6	-2.7	-2.7	-2.4	-3.2

	+ X3Y23	X3Y24	X3Y25	X3Y26	X3Y27	X3Y28
Y23	1					
Y24		1				
Y25			1			
Y26				1		
Y27					1	
Y28						1
Y66	-3.2	-3.5	-2.6	-3.2	-3.3	-3.2

	+ X3Y30	X3Y31	X3Y32	X4Y2	X4Y6	X4Y10
Y30	1					
Y31		1				
Y32			1			
Y2				1		
Y6					1	
Y10						1
Y66	-3.0	-2.6	-2.2			
Y67				-2700	-2300	-2800
Y80				1	1	1

	+ X4Y24	X5Y2	X5Y6	X5Y10	X5Y24	X6Y2
Y2		1				1
Y6			1			
Y10				1		
Y24	1				1	
Y67	-2726					
Y68		-552	-472	-575	-561.5	
Y69						-1344
Y80	1					

	+ X6Y6	X6Y10	X6Y24	X7Y2	X7Y6	X7Y10
Y2				1		
Y6	1				1	
Y10		1				1
Y24			1			
Y69	-1148	-1400	-1366.7			
Y70				-1152	-984	-1200

	+ X7Y24	X8Y2	X8Y6	X8Y10	X8Y24	X9Y2
Y2		1				1
Y6			1			
Y10				1		
Y24	1				1	
Y70	-1171.4					
Y71		-960	-820	-1000	-976.2	
Y72						-26880

	+ X9Y6	X9Y10	X9Y24	X10Y2	X10Y6	X10Y10
Y2				1		
Y6	1				1	
Y10		1				1
Y24			1			
Y72	-22960	-28000	-27333.6			
Y73				-384	-328	-400

	+ X10Y24	X11Y2	X11Y6	X11Y10	X11Y24
Y2		1			
Y6			1		
Y10				1	
Y24	1				1
Y73	-390.5				
Y74		-7.2	-6.2	-7.5	-7.3

	+ X12Y2	X12Y6	X12Y10	X12Y24	X13Y2	X13Y6
Y2	1				1	
Y6		1				1
Y10			1			
Y24				1		
Y75	-576	-492	-600	-585.7		
Y76					-16727	-14288

	+ X13Y10	X13Y24	X14Y2	X14Y6	X14Y10	X14Y24
Y2			1			
Y6				1		
Y10	1				1	
Y24		1				1
Y76	-17424	-17009.1				
Y77			-7680	-6560	-8000	-7809.6

	+ X15Y2	X15Y6	X15Y10	X15Y24	X16Y1	X16Y2
Y1					1	
Y2	1					1
Y6		1				
Y10			1			
Y24				1		
Y78	-4	-3.7	-4.4	-3.6		
Y79					-88.5	-115

	+ X16Y3	X16Y4	X16Y5	X16Y6	X16Y7	X16Y8
Y3	1					
Y4		1				
Y5			1			
Y6				1		
Y7					1	
Y8						1
Y79	-102.2	-94.8	-97.8	-98	-98	-103.6

	+ X16Y9	X16Y10	X16Y11	X16Y12	X16Y13
Y9	1				
Y10		1			
Y11			1		
Y12				1	
Y13					1
Y79	-106.6	-120	-98	-98	-98

	+ X16Y14	X16Y15	X16Y16	X16Y17	X16Y18
Y14	1				
Y15		1			
Y16			1		
Y17				1	
Y18					1
Y79	-98	-120	-103	-103	-97.4

	+ X16Y19	X16Y20	X16Y21	X16Y22	X16Y23
Y19	1				
Y20		1			
Y21			1		
Y22				1	
Y23					1
Y79	-103	-103	-94.3	-106.7	-115

	+ X16Y24	X16Y25	X16Y26	X16Y27	X16Y28
Y24	1				
Y25		1			
Y26			1		
Y27				1	
Y28					1
Y79	-117.5	-93.1	-115	-118.5	-116.1

	+ X16Y30	X16Y31	X16Y32	X17Y1	X56
Y1					
Y2					
Y30	1				
Y31		1			
Y32			1		
Y79	-105	-91.2	-83.9		
Y106				-.45	
Y107				-.45	
Y108				-.16	
Y110				.16	
Y111				1.5	
Y66					1
Y112				1.17	-1

	+ X18Y2
Y2	1
Y28	
Y30	
Y31	
Y32	
Y109	-126500

	+ X18Y4	X18Y6	X18Y10	X18Y13	X18Y14
Y4	1				
Y6		1			
Y10			1		
Y13				1	
Y14					1
Y109	-126500	-126500	-126500	-126500	-126500

	+ X18Y22	X18Y24	X18Y25	X18Y32	X52Y1
Y1					1
Y22	1				
Y24		1			
Y25			1		
Y32				1	
Y109	-126500	-126500	-126500	-126500	
Y111					-1

	+ X52Y2	X52Y3	X52Y4	X52Y5	X52Y6
Y2	1				
Y3		1			
Y4			1		
Y5				1	
Y6					1
Y111	-1	-1	-1	-1	-1

	+ X52Y7	X52Y8	X52Y9	X52Y10	X52Y11
Y7	1				
Y8		1			
Y9			1		
Y10				1	
Y11					1
Y111	-1	-1	-1	-1	-1

	+ X52Y12	X52Y13	X52Y14	X52Y15	X52Y16
Y12	1				
Y13		1			
Y14			1		
Y15				1	
Y16					1
Y111	-1	-1	-1	-1	-1

	+ X52Y17	X52Y18	X52Y19	X52Y20	X52Y21
Y17	1				
Y18		1			
Y19			1		
Y20				1	
Y21					1
Y111	-1	-1	-1	-1	-1

	+ X52Y22	X52Y23	X52Y24	X52Y25	X52Y26
Y22	1				
Y23		1			
Y24			1		
Y25				1	
Y26					1
Y111	-1	-1	-1	-1	-1

	+ X52Y27	X52Y28	X52Y30	X52Y31	X52Y32
Y27	1				
Y28		1			
Y30			1		
Y31				1	
Y32					1
Y111	-1	-1	-1	-1	-1

	+ X54Y2	X54Y6	X54Y10	X54Y24	X19	X53
Y2	1					
Y6		1				
Y10			1			
Y24				1		
Y104	-2700	-2300	-2800	-2726		
Y64					1	
Y81	1	1	1	1		
Y66						-1

	+ X20	X21	X22	X23	X24	X25	X26	X27	X28	X29
Y65	1									
Y66		1								
Y67			1							
Y68				1						
Y69					1					
Y70						1				
Y71							1			
Y72								1		
Y73									1	
Y74										1

	+ X30	X31	X32	X33	X34	X35	X36	X37	X38	X39
Y75	1									
Y76		1								
Y77			1							
Y78				1						
Y79					1					
Y106						1				
Y107							1			1
Y108								1		
Y109								1		
Y110										-1
Y111										.5
Y112										1;

TABLE C(I,J) CATTLE CONSTRAINT

X17Y1

Y94 1;

TABLE D(I,J) LABOR CONSTRAINTS & REQUIREMENTS

X1Y2 X1Y6 X1Y10 X1Y24 X2Y2 X2Y6

Y82

Y83 1.02 1.02 1.02 1.02 .24 .24

Y84 .08 .08 .08 .08 .78 .78

Y85

Y86 .36 .36

Y87 1.02 1.02 1.02 1.02 .36 .36

+ X2Y10 X2Y24 X3Y1 X3Y2 X3Y3 X3Y4

Y82 .04 .04 .04 .04

Y83 .24 .24 2.69 2.69 2.69 2.69

Y84 .78 .78 2.69 2.69 2.69 2.69

Y85

Y86 .36 .36 2.94 2.94 2.94 2.94

Y87 .36 .36

+ X3Y5 X3Y6 X3Y7 X3Y8 X3Y9 X3Y10

Y82 .04 .04 .04 .04 .04 .04

Y83 2.69 2.69 2.69 2.69 2.69 2.69

Y84 2.69 2.69 2.69 2.69 2.69 2.69

Y85

Y86 2.94 2.94 2.94 2.94 2.94 2.94

Y87

+ X3Y11 X3Y12 X3Y13 X3Y14 X3Y15 X3Y16

Y82 .04 .04 .04 .04 .04 .04

Y83 2.69 2.69 2.69 2.69 2.69 2.69

Y84 2.69 2.69 2.69 2.69 2.69 2.69

Y85

Y86 2.94 2.94 2.94 2.94 2.94 2.94

Y87

+ X3Y17 X3Y18 X3Y19 X3Y20 X3Y21 X3Y22

Y82 .04 .04 .04 .04 .04 .04

Y83 2.69 2.69 2.69 2.69 2.69 2.69

Y84 2.69 2.69 2.69 2.69 2.69 2.69

Y85

Y86 2.94 2.94 2.94 2.94 2.94 2.94

Y87

	+ X3Y23	X3Y24	X3Y25	X3Y26	X3Y27	X3Y28
Y82	.04	.04	.04	.04	.04	.04
Y83	2.69	2.69	2.69	2.69	2.69	2.69
Y84	2.69	2.69	2.69	2.69	2.69	2.69
Y85						
Y86	2.94	2.94	2.94	2.94	2.94	2.94
Y87						

	+ X3Y30	X3Y31	X3Y32	X4Y2	X4Y6	X4Y10
Y82	.04	.04	.04			
Y83	2.69	2.69	2.69	1.33	1.33	1.33
Y84	2.69	2.69	2.69	31.79	31.79	31.79
Y85				46.46	46.46	46.46
Y86	2.94	2.94	2.94	40.63	40.63	40.63
Y87				108.0	108.0	108.0

	+ X4Y24	X5Y2	X5Y6	X5Y10	X5Y24	X6Y2
Y82		2.34	2.34	2.34	2.34	
Y83	1.33	18.67	18.67	18.67	18.67	82.39
Y84	31.79	84.42	84.42	84.42	84.42	48.13
Y85	46.46					29.20
Y86	40.63					
Y87	108.0					

	+ X6Y6	X6Y10	X6Y24	X7Y2	X7Y6	X7Y10
Y82						
Y83	82.39	82.39	82.39	1.89	1.89	1.89
Y84	48.13	48.13	48.13	3.76	3.76	3.76
Y85	29.20	29.20	29.20	139.0	139.0	139.0
Y86				72.0	72.0	72.0
Y87						

	+ X7Y24	X8Y2	X8Y6	X8Y10	X8Y24	X9Y2
Y82						
Y83	1.89	1.89	1.89	1.89	1.89	1.89
Y84	3.76	3.6	3.6	3.6	3.6	14.31
Y85	139.0	33.2	33.2	33.2	33.2	10.36
Y86				43.93		
Y87						

	+ X9Y6	X9Y10	X9Y24	X10Y2	X10Y6	X10Y10
Y82				20.0	20.0	20.0
Y83	1.89	1.89	1.89	1.89	1.89	1.89
Y84	14.31	14.31	14.31	25.98	25.98	25.98
Y85	10.36	10.36	10.36	.65	.65	.65
Y86	43.93	43.93	43.93	26.5	26.5	26.5
Y87				24.5	24.5	24.5

	+ X10Y24	X11Y2	X11Y6	X11Y10	X11Y24
Y82	20.0				
Y83	1.89	1.77	1.77	1.77	1.77
Y84	25.98	15.69	15.69	15.69	15.69
Y85	.65	19.93	19.93	19.93	19.93
Y86	26.5	27.85	27.85	27.85	27.85
Y87	24.5				

	+ X12Y2	X12Y6	X12Y10	X12Y24	X13Y2	X13Y6
Y82					10.0	10.0
Y83	1.89	1.89	1.89	1.89	25.0	25.0
Y84	55.67	55.67	55.67	55.67	100.0	100.0
Y85	75.5	75.5	75.5	75.5	5.0	5.0
Y86					57.5	57.5
Y87			7.5	7.5		

	+ X13Y10	X13Y24	X14Y2	X14Y6	X14Y10	X14Y24
Y82	10.0	10.0				
Y83	25.0	25.0	21.44	21.44	21.44	21.44
Y84	100.0	100.0	16.04	16.04	16.04	16.04
Y85	5.0	5.0	130.6	130.6	130.6	130.6
Y86	57.5	57.5				
Y87	7.5	7.5				

	+ X15Y2	X15Y6	X15Y10	X15Y24	X16Y1	X16Y2
Y82						
Y83					.28	.28
Y84	3.8	3.8	3.8	3.8	.28	.28
Y85	2.37	2.37	2.37	2.37		
Y86	1.58	1.58	1.58	1.58	1.02	1.02
Y87						

	+ X16Y3	X16Y4	X16Y5	X16Y6	X16Y7	X16Y8
Y82						
Y83	.28	.28	.28	.28	.28	.28
Y84	.28	.28	.28	.28	.28	.28
Y85						
Y86	1.02	1.02	1.02	1.02	1.02	1.02
Y87						

	+ X16Y9	X16Y10	X16Y11	X16Y12	X16Y13
Y82					
Y83	.28	.28	.28	.28	.28
Y84	.28	.28	.28	.28	.28
Y85					
Y86	1.02	1.02	1.02	1.02	1.02
Y87					

	+ X16Y14	X16Y15	X16Y16	X16Y17	X16Y18
Y82					
Y83	.28	.28	.28	.28	.28
Y84	.28	.28	.28	.28	.28
Y85					
Y86	1.02	1.02	1.02	1.02	1.02
Y87					

	+ X16Y19	X16Y20	X16Y21	X16Y22	X16Y23
Y82					
Y83	.28	.28	.28	.28	.28
Y84	.28	.28	.28	.28	.28
Y85					
Y86	1.02	1.02	1.02	1.02	1.02
Y87					

	+ X16Y24	X16Y25	X16Y26	X16Y27	X16Y28
Y82					
Y83	.28	.28	.28	.28	.28
Y84	.28	.28	.28	.28	.28
Y85					
Y86	1.02	1.02	1.02	1.02	1.02
Y87					

Y87					
Y86	+	X52Y7	X52Y8	X52Y9	X52Y10
Y85		.23	.23	.23	.23
Y84		.52	.52	.52	.52
Y83		.32	.32	.32	.32
Y82		.17	.17	.17	.17
Y82		.06	.06	.06	.06
Y83		.17	.17	.17	.17
Y84		.32	.32	.32	.32
Y85		.52	.52	.52	.52
Y86		.23	.23	.23	.23
Y87					
Y82	+	X52Y12	X52Y13	X52Y14	X52Y15
Y82		.06	.06	.06	.06
Y83		.17	.17	.17	.17
Y84		.32	.32	.32	.32
Y85		.52	.52	.52	.52
Y86		.23	.23	.23	.23
Y87					
Y82	+	X52Y17	X52Y18	X52Y19	X52Y20
Y82		.06	.06	.06	.06
Y83		.17	.17	.17	.17
Y84		.32	.32	.32	.32
Y85		.52	.52	.52	.52
Y86		.23	.23	.23	.23
Y87					
Y82	+	X52Y22	X52Y23	X52Y24	X52Y25
Y82		.06	.06	.06	.06
Y83		.17	.17	.17	.17
Y84		.32	.32	.32	.32
Y85		.52	.52	.52	.52
Y86		.23	.23	.23	.23
Y87					
Y82	+	X52Y27	X52Y28	X52Y30	X52Y31
Y82		.06	.06	.06	.06
Y83		.17	.17	.17	.17
Y84		.32	.32	.32	.32
Y85		.52	.52	.52	.52
Y86		.23	.23	.23	.23
Y87					

	+ X54Y2	X54Y6	X54Y10	X54Y24
Y82				
Y83	1.33	1.33	1.33	1.33
Y84	31.79	31.79	31.79	31.79
Y85	46.46	46.46	46.46	46.46
Y86	40.63	40.63	40.63	40.63
Y87	108.0	108.0	108.0	108.0

	+ X40	X41	X42	X43	X44	X45
Y82	-1					
Y83		-1				
Y84			-1			
Y85				-1		
Y86					-1	
Y87						-1
Y88	1					
Y89		1				
Y90			1			
Y91				1		
Y92					1	
Y93						1

	+ X46	X47	X48	X49	X50	X51
Y82	-1					
Y83		-1				
Y84			-1			
Y85				-1		
Y86					-1	
Y87						-1
Y97	1					
Y98		1				
Y99			1			
Y100				1		
Y101					1	
Y102						1 ;

PARAMETER AA(I) LAND ACREAGES AVAILABLE PER FARMING UNIT

/Y1 13.0
Y2 3.0
Y3 10.8

Y4	4.3
Y5	3.3
Y6	1.6
Y7	1.3
Y8	4.0
Y9	1.3
Y10	2.0
Y11	1.0
Y12	1.0
Y13	1.3
Y14	5.0
Y15	1.1
Y16	4.5
Y17	1.0
Y18	3.5
Y19	2.0
Y20	1.0
Y21	3.8
Y22	2.1
Y23	4.0
Y24	4.5
Y25	6.5
Y26	1.6
Y27	1.3
Y28	3.2
Y30	3.4
Y31	5.7
Y32	7.0
Y64	0
Y65	0
Y66	0
Y67	0
Y68	0
Y69	0
Y70	0
Y71	0
Y72	0
Y73	0
Y74	0
Y75	0
Y76	0
Y77	0
Y78	0

Y79	0
Y80	8000
Y81	50000
Y103	0
Y104	0
Y106	0
Y107	0
Y108	0
Y109	0
Y110	0
Y111	0
Y112	0/;

PARAMETER CC(I) CATTLE CONSTRAINTS

/Y94	0/;
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PARAMETER DD(I) LABOR CONSTRAINTS AND REQUIREMENTS

/Y82	0
Y83	0
Y84	0
Y85	0
Y86	0
Y87	0
Y88	520
Y89	520
Y90	780
Y91	780
Y92	520
Y93	520
Y97	260
Y98	988
Y99	988
Y100	988
Y101	988
Y102	988/;

PARAMETER BB(J) COSTS OF PRODUCTION

/X1Y2	-110.91
X1Y6	-110.91
X1Y10	-110.91
X1Y24	-110.91
X2Y2	-85.70
X2Y6	-85.70

X2Y10	-85.70
X2Y24	-85.70
X3Y1	-103.73
X3Y2	-103.73
X3Y3	-103.73
X3Y4	-103.73
X3Y5	-103.73
X3Y6	-103.73
X3Y7	-103.73
X3Y8	-103.73
X3Y9	-103.73
X3Y10	-103.73
X3Y11	-103.73
X3Y12	-103.73
X3Y13	-103.73
X3Y14	-103.73
X3Y15	-103.73
X3Y16	-103.73
X3Y17	-103.73
X3Y18	-103.73
X3Y19	-103.73
X3Y20	-103.73
X3Y21	-103.73
X3Y22	-103.73
X3Y23	-103.73
X3Y24	-103.73
X3Y25	-103.73
X3Y26	-103.73
X3Y27	-103.73
X3Y28	-103.73
X3Y30	-103.73
X3Y31	-103.73
X3Y32	-103.73
X4Y2	-1169.51
X4Y6	-1169.51
X4Y10	-1169.51
X4Y24	-1169.51
X5Y2	-817.26
X5Y6	-817.26
X5Y10	-817.26
X5Y24	-817.26
X6Y2	-5486.68
X6Y6	-5486.68

X6Y10	-5486.68
X6Y2	-5486.68
X7Y2	-476.56
X7Y6	-476.56
X7Y10	-476.56
X7Y24	-476.56
X8Y2	-685.89
X8Y6	-685.89
X8Y10	-685.89
X8Y24	-685.89
X9Y2	-303.82
X9Y6	-303.82
X9Y10	-303.82
X9Y24	-303.82
X10Y2	-668.44
X10Y6	-668.44
X10Y10	-668.44
X10Y24	-668.44
X11Y2	-511.47
X11Y6	-511.47
X11Y10	-511.47
X11Y24	-511.47
X12Y2	-887.10
X12Y6	-887.10
X12Y10	-887.10
X12Y24	-887.10
X13Y2	-4055.93
X13Y6	-4055.93
X13Y10	-4055.93
X13Y24	-4055.93
X14Y2	-1111.55
X14Y6	-1111.55
X14Y10	-1111.55
X14Y24	-1111.55
X15Y2	-223.29
X15Y6	-223.29
X15Y10	-223.29
X15Y24	-223.29
X16Y1	-118.48
X16Y2	-118.48
X16Y3	-118.48
X16Y4	-118.48
X16Y5	-118.48

X16Y6	-118.48
X16Y7	-118.48
X16Y8	-118.48
X16Y9	-118.48
X16Y10	-118.48
X16Y11	-118.48
X16Y12	-118.48
X16Y13	-118.48
X16Y14	-118.48
X16Y15	-118.48
X16Y16	-118.48
X16Y17	-118.48
X16Y18	-118.48
X16Y19	-118.48
X16Y20	-118.48
X16Y21	-118.48
X16Y22	-118.48
X16Y23	-118.48
X16Y24	-118.48
X16Y25	-118.48
X16Y26	-118.48
X16Y27	-118.48
X16Y28	-118.48
X16Y30	-118.48
X16Y31	-118.48
X16Y32	-118.48
X17Y1	-1069.39
X18Y2	-6100.00
X18Y4	-6100.00
X18Y6	-6100.00
X18Y10	-6100.00
X18Y13	-6100.00
X18Y14	-6100.00
X18Y22	-6100.00
X18Y24	-6100.00
X18Y25	-6100.00
X18Y32	-6100.00
X19	2.50
X20	3.25
X21	32.00
X22	1.80
X23	4.25
X24	5.88

X25	4.00
X26	1.25
X27	.09
X28	7.33
X29	240.00
X30	5.63
X31	1.00
X32	.63
X33	55.00
X34	2.50
X35	341.00
X36	265.00
X37	420.00
X38	.19
X39	-24.10
X40	-6.00
X41	-6.00
X42	-6.00
X43	-6.00
X44	-6.00
X45	-6.00
X46	-7.00
X47	-7.00
X48	-7.00
X49	-7.00
X50	-7.00
X51	-7.00
X52Y1	-38.03
X52Y2	-38.03
X52Y3	-38.03
X52Y4	-38.03
X52Y5	-38.03
X52Y6	-38.03
X52Y7	-38.03
X52Y8	-38.03
X52Y9	-38.03
X52Y10	-38.03
X52Y11	-38.03
X52Y12	-38.03
X52Y13	-38.03
X52Y14	-38.03
X52Y15	-38.03
X52Y16	-38.03

X52Y17	-38.03
X52Y18	-38.03
X52Y19	-38.03
X52Y20	-38.03
X52Y21	-38.03
X52Y22	-38.03
X52Y23	-38.03
X52Y24	-38.03
X52Y25	-38.03
X52Y26	-38.03
X52Y27	-38.03
X52Y28	-38.03
X52Y30	-38.03
X52Y31	-38.03
X52Y32	-38.03
X53	-32.00
X54Y2	-1169.51
X54Y6	-1169.51
X54Y10	-1169.51
X54Y24	-1169.51
X55	-.20/;

VARIABLES

X(J) ACTIVITIES
Z NET REVENUE;

POSITIVE VARIABLE X;

EQUATIONS

PROFIT	TOTAL NET RETURNS MINUS VARIABLE COSTS
CATTLE (I)	FORCE CATTLE INTO PRODUCTION
RESOURCE (I)	LAND AND CROPS RESOURCE CONSTRAINTS
LABOR (I)	LABOR CONSTRAINTS AND REQUIREMENTS;

PROFIT.. $Z = E = \text{SUM}(J, BB(J) * X(J));$

CATTLE(I).. $\text{SUM}(J, C(I, J) * X(J)) = L = CC(I);$

RESOURCE(I).. $\text{SUM}(J, A(I, J) * X(J)) = L = AA(I);$

LABOR(I).. $\text{SUM}(J, D(I, J) * X(J)) = L = DD(I);$

MODEL PROJECT /ALL/;

OPTION LIMROW = 54;

OPTION LIMCOL = 57;

SOLVE PROJECT USING LP MAXIMIZING Z;

DISPLAY X.L, X.M;

GENERAL ALGEBRAIC MODELLING SYSTEM COMPILATION FOR FULL-TIME FREE MODEL

SYMBOL TYPE REFERENCES

A	PARAM	DECLARED	316	DEFINED	316	REF	1197
AA	PARAM	DECLARED	897	DEFINED	898	REF	1197
BB	PARAM	DECLARED	980	DEFINED	981	REF	1193
C	PARAM	DECLARED	615	DEFINED	615	REF	1195
CATTLE	EQU	DECLARED	1189	DEFINED	1195	IMPL-ASN	1207
		REF	1201				
CC	PARAM	DECLARED	957	DEFINED	958	REF	1195
D	PARAM	DECLARED	619	DEFINED	619	REF	1199
DD	PARAM	DECLARED	960	DEFINED	961	REF	1199
I	SET	DECLARED	283	DEFINED	284	REF	316
			615	619	897	957	960
			1189	1190	1191	2*1195	2*1197
			2*1199	CONTROL	1195	1197	1199
J	SET	DECLARED	292	DEFINED	293	REF	316
			615	619	980	1182	2*1193
			2*1195	2*1197	2*1199	CONTROL	1193
			1195	1197	1199		
LABOR	EQU	DECLARED	1191	DEFINED	1199	IMPL-ASN	1207
		REF	1201				
PROFIT	EQU	DECLARED	1188	DEFINED	1193	IMPL-ASN	1207
		REF	1201				
PROJECT	MODEL	DECLARED	1201	DEFINED	1201	IMPL-ASN	1207
		REF	1207				
RESOURCE	EQU	DECLARED	1190	DEFINED	1197	IMPL-ASN	1207
		REF	1201				
X	VAR	DECLARED	1182	IMPL-ASN	1207	REF	1185
			1193	1195	1197	1199	2*1209
Z	VAR	DECLARED	1183	IMPL-ASN	1207	REF	1193
			1207				

SETS

I	CONSTRAINTS OF RESOURCES
J	ACTIVITIES OF THE OBJECTIVE FUNCTION

PARAMETERS

A LAND RESOURCES AND CROP YIELDS
AA LAND ACREAGES AVAILABLE PER FARMING UNIT
BB COSTS OF PRODUCTION
C CATTLE CONSTRAINT
CC CATTLE CONSTRAINTS
D LABOR CONSTRAINTS & REQUIREMENTS
DD LABOR CONSTRAINTS AND REQUIREMENTS

VARIABLES

X ACTIVITIES
Z NET REVENUE

EQUATIONS

CATTLE FORCE CATTLE INTO PRODUCTION
LABOR LABOR CONSTRAINTS AND REQUIREMENTS
PROFIT TOTAL NET RETURNS MINUS VARIABLE COSTS
RESOURCE LAND AND CROPS RESOURCE CONSTRAINTS

MODELS

PROJECT

COMPILATION TIME = 2.140 SECONDS VERID MW2-25-069

---- PROFIT =E= TOTAL NET RETURNS MINUS VARIABLE COSTS

PROFIT.. $110.91 * X(X1Y2) + 110.91 * X(X1Y6) + 110.91 * X(X1Y10) +$
 $110.91 * X(X1Y24)$
 $+ 85.7 * X(X2Y2) + 85.7 * X(X2Y6) + 85.7 * X(X2Y10) + 85.7 * X(X2Y24)$
 $+ 103.73 * X(X3Y1) + 103.73 * X(X3Y2) + 103.73 * X(X3Y3) + 103.73 * X(X3Y4)$
 $+ 103.73 * X(X3Y5) + 103.73 * X(X3Y6) + 103.73 * X(X3Y7) + 103.73 * X(X3Y8)$
 $+ 103.73 * X(X3Y9) + 103.73 * X(X3Y10) + 103.73 * X(X3Y11) + 103.73 * X(X3Y12)$

$$\begin{aligned}
& + 103.73 * X(X3Y13) + 103.73 * X(X3Y14) + 103.73 * X(X3Y15) + \\
& 103.73 * X(X3Y16) \\
& + 103.73 * X(X3Y17) + 103.73 * X(X3Y18) + 103.73 * X(X3Y19) + \\
& 103.73 * X(X3Y20) \\
& + 103.73 * X(X3Y21) + 103.73 * X(X3Y22) + 103.73 * X(X3Y23) + \\
& 103.73 * X(X3Y24) \\
& + 103.73 * X(X3Y25) + 103.73 * X(X3Y26) + 103.73 * X(X3Y27) + \\
& 103.73 * X(X3Y28) \\
& + 103.73 * X(X3Y30) + 103.73 * X(X3Y31) + 103.73 * X(X3Y32) + \\
& 1169.51 * X(X4Y2) \\
& + 1169.51 * X(X4Y6) + 1169.51 * X(X4Y10) + 1169.51 * X(X4Y24) \\
& + 817.26 * X(X5Y2) + 817.26 * X(X5Y6) + 817.26 * X(X5Y10) + 817.26 * X(X5Y24) \\
& + 5486.68 * X(X6Y2) + 5486.68 * X(X6Y6) + 5486.68 * X(X6Y10) \\
& + 5486.68 * X(X6Y24) + 476.56 * X(X7Y2) + 476.56 * X(X7Y6) + 476.56 * X(X7Y10) \\
& + 476.56 * X(X7Y24) + 685.89 * X(X8Y2) + 685.89 * X(X8Y6) + 685.89 * X(X8Y10) \\
& + 685.89 * X(X8Y24) + 303.82 * X(X9Y2) + 303.82 * X(X9Y6) + 303.82 * X(X9Y10) \\
& + 303.82 * X(X9Y24) + 668.44 * X(X10Y2) + 668.44 * X(X10Y6) \\
& + 668.44 * X(X10Y10) + 668.44 * X(X10Y24) + 511.47 * X(X11Y2) \\
& + 511.47 * X(X11Y6) + 511.47 * X(X11Y10) + 511.47 * X(X11Y24) \\
& + 887.1 * X(X12Y2) + 887.1 * X(X12Y6) + 887.1 * X(X12Y10) + 887.1 * X(X12Y24) \\
& + 4055.93 * X(X13Y2) + 4055.93 * X(X13Y6) + 4055.93 * X(X13Y10) \\
& + 4055.93 * X(X13Y24) + 1111.55 * X(X14Y2) + 1111.55 * X(X14Y6) \\
& + 1111.55 * X(X14Y10) + 1111.55 * X(X14Y24) + 223.29 * X(X15Y2) \\
& + 223.29 * X(X15Y6) + 223.29 * X(X15Y10) + 223.29 * X(X15Y24)
\end{aligned}$$

$$\begin{aligned}
& + 118.48 * X(X16Y1) + 118.48 * X(X16Y2) + 118.48 * X(X16Y3) + \\
& 118.48 * X(X16Y4) \\
& + 118.48 * X(X16Y5) + 118.48 * X(X16Y6) + 118.48 * X(X16Y7) + \\
& 118.48 * X(X16Y8) \\
& + 118.48 * X(X16Y9) + 118.48 * X(X16Y10) + 118.48 * X(X16Y11) \\
& + 118.48 * X(X16Y12) + 118.48 * X(X16Y13) + 118.48 * X(X16Y14) \\
& + 118.48 * X(X16Y15) + 118.48 * X(X16Y16) + 118.48 * X(X16Y17) \\
& + 118.48 * X(X16Y18) + 118.48 * X(X16Y19) + 118.48 * X(X16Y20) \\
& + 118.48 * X(X16Y21) + 118.48 * X(X16Y22) + 118.48 * X(X16Y23) \\
& + 118.48 * X(X16Y24) + 118.48 * X(X16Y25) + 118.48 * X(X16Y26) \\
& + 118.48 * X(X16Y27) + 118.48 * X(X16Y28) + 118.48 * X(X16Y30) \\
& + 118.48 * X(X16Y31) + 118.48 * X(X16Y32) + 1069.39 * X(X17Y1) \\
& + 6100 * X(X18Y2) + 6100 * X(X18Y4) + 6100 * X(X18Y6) + 6100 * X(X18Y10) \\
& + 6100 * X(X18Y13) + 6100 * X(X18Y14) + 6100 * X(X18Y22) + 6100 * X(X18Y24) \\
& + 6100 * X(X18Y25) + 6100 * X(X18Y32) + 38.03 * X(X52Y1) + 38.03 * X(X52Y2) \\
& + 38.03 * X(X52Y3) + 38.03 * X(X52Y4) + 38.03 * X(X52Y5) + 38.03 * X(X52Y6) \\
& + 38.03 * X(X52Y7) + 38.03 * X(X52Y8) + 38.03 * X(X52Y9) + 38.03 * X(X52Y10) \\
& + 38.03 * X(X52Y11) + 38.03 * X(X52Y12) + 38.03 * X(X52Y13) + \\
& 38.03 * X(X52Y14) \\
& + 38.03 * X(X52Y15) + 38.03 * X(X52Y16) + 38.03 * X(X52Y17) + \\
& 38.03 * X(X52Y18) \\
& + 38.03 * X(X52Y19) + 38.03 * X(X52Y20) + 38.03 * X(X52Y21) + \\
& 38.03 * X(X52Y22) \\
& + 38.03 * X(X52Y23) + 38.03 * X(X52Y24) + 38.03 * X(X52Y25) + \\
& 38.03 * X(X52Y26)
\end{aligned}$$

$$\begin{aligned}
& + 38.03 * X(X52Y27) + 38.03 * X(X52Y28) + 38.03 * X(X52Y30) + \\
& 38.03 * X(X52Y31) \\
& + 38.03 * X(X52Y32) + 1169.51 * X(X54Y2) + 1169.51 * X(X54Y6) \\
& + 1169.51 * X(X54Y10) + 1169.51 * X(X54Y24) - 2.5 * X(X19) - 3.25 * X(X20) \\
& - 32 * X(X21) - 1.8 * X(X22) - 4.25 * X(X23) - 5.88 * X(X24) - 4 * X(X25) \\
& - 1.25 * X(X26) - 0.09 * X(X27) - 7.33 * X(X28) - 240 * X(X29) - 5.63 * X(X30) \\
& - X(X31) - 0.63 * X(X32) - 55 * X(X33) - 2.5 * X(X34) - 341 * X(X35) \\
& - 265 * X(X36) - 420 * X(X37) - 0.19 * X(X38) + 24.1 * X(X39) + 6 * X(X40) \\
& + 6 * X(X41) + 6 * X(X42) + 6 * X(X43) + 6 * X(X44) + 6 * X(X45) + 7 * X(X46) \\
& + 7 * X(X47) + 7 * X(X48) + 7 * X(X49) + 7 * X(X50) + 7 * X(X51) + 32 * X(X53) \\
& + 0.2 * X(X55) + Z = E = 0 ; (LHS = 0)
\end{aligned}$$

---- CATTLE =L= FORCE CATTLE INTO PRODUCTION

$$CATTLE(Y94).. X(X17Y1) = L = 0 ; (LHS = 0)$$

---- RESOURCE =L= LAND AND CROPS RESOURCE CONSTRAINTS

$$RESOURCE(Y1).. X(X3Y1) + X(X16Y1) + X(X52Y1) = L = 13 ; (LHS = 0)$$

$$RESOURCE(Y2).. X(X1Y2) + X(X2Y2) + X(X3Y2) + X(X4Y2) + X(X5Y2) + X(X6Y2)$$

$$\begin{aligned}
& + X(X7Y2) + X(X8Y2) + X(X9Y2) + X(X10Y2) + X(X11Y2) + X(X12Y2) \\
& + X(X13Y2) + X(X14Y2) + X(X15Y2) + X(X16Y2) + X(X18Y2) + X(X52Y2) \\
& + X(X54Y2) = L = 3 ; (LHS = 0)
\end{aligned}$$

$$\begin{aligned}
& \text{RESOURCE}(Y_3) \dots X(X_3Y_3) + X(X_{16}Y_3) + X(X_{52}Y_3) = L = 10.8; (\text{LHS} = 0) \\
& \text{RESOURCE}(Y_4) \dots X(X_3Y_4) + X(X_{16}Y_4) + X(X_{18}Y_4) + X(X_{52}Y_4) = L = 4.3; (\text{LHS} = 0) \\
& \text{RESOURCE}(Y_5) \dots X(X_3Y_5) + X(X_{16}Y_5) + X(X_{52}Y_5) = L = 3.3; (\text{LHS} = 0) \\
& \text{RESOURCE}(Y_6) \dots X(X_{16}Y_6) + X(X_{26}Y_6) + X(X_{36}Y_6) + X(X_{46}Y_6) + X(X_{56}Y_6) + \\
& \quad + X(X_{76}Y_6) + X(X_{86}Y_6) + X(X_{96}Y_6) + X(X_{106}Y_6) + X(X_{116}Y_6) + X(X_{126}Y_6) \\
& \quad + X(X_{136}Y_6) + X(X_{146}Y_6) + X(X_{156}Y_6) + X(X_{166}Y_6) + X(X_{186}Y_6) + X(X_{526}Y_6) \\
& \quad + X(X_{546}Y_6) = L = 1.6; (\text{LHS} = 0) \\
& \text{RESOURCE}(Y_7) \dots X(X_3Y_7) + X(X_{16}Y_7) + X(X_{52}Y_7) = L = 1.3; (\text{LHS} = 0) \\
& \text{RESOURCE}(Y_8) \dots X(X_3Y_8) + X(X_{16}Y_8) + X(X_{52}Y_8) = L = 4; (\text{LHS} = 0) \\
& \text{RESOURCE}(Y_9) \dots X(X_3Y_9) + X(X_{16}Y_9) + X(X_{52}Y_9) = L = 1.3; (\text{LHS} = 0) \\
& \text{RESOURCE}(Y_{10}) \dots X(X_{16}Y_{10}) + X(X_{26}Y_{10}) + X(X_{36}Y_{10}) + X(X_{46}Y_{10}) + X(X_{56}Y_{10}) \\
& \quad + X(X_{66}Y_{10}) + X(X_{76}Y_{10}) + X(X_{86}Y_{10}) + X(X_{96}Y_{10}) + X(X_{106}Y_{10}) + X(X_{116}Y_{10}) \\
& \quad + X(X_{126}Y_{10}) + X(X_{136}Y_{10}) + X(X_{146}Y_{10}) + X(X_{156}Y_{10}) + X(X_{166}Y_{10}) + \\
& \quad + X(X_{186}Y_{10}) \\
& \quad + X(X_{526}Y_{10}) + X(X_{546}Y_{10}) = L = 2; (\text{LHS} = 0) \\
& \text{RESOURCE}(Y_{11}) \dots X(X_3Y_{11}) + X(X_{16}Y_{11}) + X(X_{52}Y_{11}) = L = 1; (\text{LHS} = 0) \\
& \text{RESOURCE}(Y_{12}) \dots X(X_3Y_{12}) + X(X_{16}Y_{12}) + X(X_{52}Y_{12}) = L = 1; (\text{LHS} = 0)
\end{aligned}$$

$$\text{RESOURCE}(Y13).. X(X3Y13) + X(X16Y13) + X(X18Y13) + X(X52Y13) = L = 1.3 ;$$

$$(LHS = 0)$$

$$\text{RESOURCE}(Y14).. X(X3Y14) + X(X16Y14) + X(X18Y14) + X(X52Y14) = L = 5 ;$$

$$(LHS = 0)$$

$$\text{RESOURCE}(Y15).. X(X3Y15) + X(X16Y15) + X(X52Y15) = L = 1.1 ; (LHS = 0)$$

$$\text{RESOURCE}(Y16).. X(X3Y16) + X(X16Y16) + X(X52Y16) = L = 4.5 ; (LHS = 0)$$

$$\text{RESOURCE}(Y17).. X(X3Y17) + X(X16Y17) + X(X52Y17) = L = 1 ; (LHS = 0)$$

$$\text{RESOURCE}(Y18).. X(X3Y18) + X(X16Y18) + X(X52Y18) = L = 3.5 ; (LHS = 0)$$

$$\text{RESOURCE}(Y19).. X(X3Y19) + X(X16Y19) + X(X52Y19) = L = 2 ; (LHS = 0)$$

$$\text{RESOURCE}(Y20).. X(X3Y20) + X(X16Y20) + X(X52Y20) = L = 1 ; (LHS = 0)$$

$$\text{RESOURCE}(Y21).. X(X3Y21) + X(X16Y21) + X(X52Y21) = L = 3.8 ; (LHS = 0)$$

$$\text{RESOURCE}(Y22).. X(X3Y22) + X(X16Y22) + X(X18Y22) + X(X52Y22) = L = 2.1 ;$$

$$(LHS = 0)$$

$$\text{RESOURCE}(Y23).. X(X3Y23) + X(X16Y23) + X(X52Y23) = L = 4 ; (LHS = 0)$$

$$\begin{aligned} \text{RESOURCE}(Y24).. X(X1Y24) + X(X2Y24) + X(X3Y24) + X(X4Y24) + X(X5Y24) \\ + X(X6Y24) + X(X7Y24) + X(X8Y24) + X(X9Y24) + X(X10Y24) + X(X11Y24) \\ + X(X12Y24) + X(X13Y24) + X(X14Y24) + X(X15Y24) + X(X16Y24) + \end{aligned}$$

$$X(X18Y24)$$

$$+ X(X52Y24) + X(X54Y24) = L = 4.5 ; (LHS = 0)$$

$$RESOURCE(Y25).. X(X3Y25) + X(X16Y25) + X(X18Y25) + X(X52Y25) = L = 6.5 ;$$

$$(LHS = 0)$$

$$RESOURCE(Y26).. X(X3Y26) + X(X16Y26) + X(X52Y26) = L = 1.6 ; (LHS = 0)$$

$$RESOURCE(Y27).. X(X3Y27) + X(X16Y27) + X(X52Y27) = L = 1.3 ; (LHS = 0)$$

$$RESOURCE(Y28).. X(X3Y28) + X(X16Y28) + X(X52Y28) = L = 3.2 ; (LHS = 0)$$

$$RESOURCE(Y30).. X(X3Y30) + X(X16Y30) + X(X52Y30) = L = 3.4 ; (LHS = 0)$$

$$RESOURCE(Y31).. X(X3Y31) + X(X16Y31) + X(X52Y31) = L = 5.7 ; (LHS = 0)$$

$$RESOURCE(Y32).. X(X3Y32) + X(X16Y32) + X(X18Y32) + X(X52Y32) = L = 7 ;$$

$$(LHS = 0)$$

$$RESOURCE(Y64).. - 125 * X(X1Y2) - 105 * X(X1Y6) - 130 * X(X1Y10) - 140 * X(X1Y24)$$

$$+ X(X19) = L = 0 ; (LHS = 0)$$

$$RESOURCE(Y65).. - 60 * X(X2Y2) - 50 * X(X2Y6) - 65 * X(X2Y10) - 59.2 * X(X2Y24)$$

$$+ X(X20) = L = 0 ; (LHS = 0)$$

$$RESOURCE(Y66).. - 2.4 * X(X3Y1) - 3.2 * X(X3Y2) - 3 * X(X3Y3) - 2.7 * X(X3Y4)$$

$$\begin{aligned}
& - 2.7*X(X3Y5) - 2.7*X(X3Y6) - 2.7*X(X3Y7) - 2.9*X(X3Y8) - 3*X(X3Y9) \\
& - 3.2*X(X3Y10) - 2.7*X(X3Y11) - 2.7*X(X3Y12) - 2.7*X(X3Y13) \\
& - 2.7*X(X3Y14) - 3.2*X(X3Y15) - 2.7*X(X3Y16) - 2.7*X(X3Y17) \\
& - 2.6*X(X3Y18) - 2.7*X(X3Y19) - 2.7*X(X3Y20) - 2.4*X(X3Y21) \\
& - 3.2*X(X3Y22) - 3.2*X(X3Y23) - 3.5*X(X3Y24) - 2.6*X(X3Y25) \\
& - 3.2*X(X3Y26) - 3.3*X(X3Y27) - 3.2*X(X3Y28) - 3*X(X3Y30) \\
& - 2.6*X(X3Y31) - 2.2*X(X3Y32) + X(X21) - X(X53) + X(X56) = L = 0 ; \\
& (LHS = 0)
\end{aligned}$$

$$\begin{aligned}
& \text{RESOURCE}(Y67).. - 2700*X(X4Y2) - 2300*X(X4Y6) - 2800*X(X4Y10) \\
& - 2726*X(X4Y24) + X(X22) = L = 0 ; (LHS = 0)
\end{aligned}$$

$$\begin{aligned}
& \text{RESOURCE}(Y68).. - 552*X(X5Y2) - 472*X(X5Y6) - 575*X(X5Y10) - \\
& 561.5*X(X5Y24) \\
& + X(X23) = L = 0 ; (LHS = 0)
\end{aligned}$$

$$\begin{aligned}
& \text{RESOURCE}(Y69).. - 1344*X(X6Y2) - 1148*X(X6Y6) - 1400*X(X6Y10) \\
& - 1366.7*X(X6Y24) + X(X24) = L = 0 ; (LHS = 0)
\end{aligned}$$

$$\begin{aligned}
& \text{RESOURCE}(Y70).. - 1152*X(X7Y2) - 984*X(X7Y6) - 1200*X(X7Y10) \\
& - 1171.4*X(X7Y24) + X(X25) = L = 0 ; (LHS = 0)
\end{aligned}$$

$$\begin{aligned}
& \text{RESOURCE}(Y71).. - 960*X(X8Y2) - 820*X(X8Y6) - 1000*X(X8Y10) - \\
& 976.2*X(X8Y24) \\
& + X(X26) = L = 0 ; (LHS = 0)
\end{aligned}$$

$$\begin{aligned} \text{RESOURCE(Y72).. } & - 26880 * X(X9Y2) - 22960 * X(X9Y6) - 28000 * X(X9Y10) \\ & - 27333.6 * X(X9Y24) + X(X27) = L = 0 ; (\text{LHS} = 0) \end{aligned}$$

$$\begin{aligned} \text{RESOURCE(Y73).. } & - 384 * X(X10Y2) - 328 * X(X10Y6) - 400 * X(X10Y10) \\ & - 390.5 * X(X10Y24) + X(X28) = L = 0 ; (\text{LHS} = 0) \end{aligned}$$

$$\begin{aligned} \text{RESOURCE(Y74).. } & - 7.2 * X(X11Y2) - 6.2 * X(X11Y6) - 7.5 * X(X11Y10) \\ & - 7.3 * X(X11Y24) + X(X29) = L = 0 ; (\text{LHS} = 0) \end{aligned}$$

$$\begin{aligned} \text{RESOURCE(Y75).. } & - 576 * X(X12Y2) - 492 * X(X12Y6) - 600 * X(X12Y10) \\ & - 585.7 * X(X12Y24) + X(X30) = L = 0 ; (\text{LHS} = 0) \end{aligned}$$

$$\begin{aligned} \text{RESOURCE(Y76).. } & - 16727 * X(X13Y2) - 14288 * X(X13Y6) - 17424 * X(X13Y10) \\ & - 17009.1 * X(X13Y24) + X(X31) = L = 0 ; (\text{LHS} = 0) \end{aligned}$$

$$\begin{aligned} \text{RESOURCE(Y77).. } & - 7680 * X(X14Y2) - 6560 * X(X14Y6) - 8000 * X(X14Y10) \\ & - 7809.6 * X(X14Y24) + X(X32) = L = 0 ; (\text{LHS} = 0) \end{aligned}$$

$$\begin{aligned} \text{RESOURCE(Y78).. } & - 4 * X(X15Y2) - 3.7 * X(X15Y6) - 4.4 * X(X15Y10) - \\ & 3.6 * X(X15Y24) \end{aligned}$$

$$+ X(X33) = L = 0 ; (\text{LHS} = 0)$$

$$\begin{aligned} \text{RESOURCE(Y79).. } & - 88.5 * X(X16Y1) - 115 * X(X16Y2) - 102.2 * X(X16Y3) \\ & - 94.8 * X(X16Y4) - 97.8 * X(X16Y5) - 98 * X(X16Y6) - 98 * X(X16Y7) \\ & - 103.6 * X(X16Y8) - 106.6 * X(X16Y9) - 120 * X(X16Y10) - 98 * X(X16Y11) \\ & - 98 * X(X16Y12) - 98 * X(X16Y13) - 98 * X(X16Y14) - 120 * X(X16Y15) \end{aligned}$$

$$\begin{aligned}
& - 103 * X(X16Y16) - 103 * X(X16Y17) - 97.4 * X(X16Y18) - 103 * X(X16Y19) \\
& - 103 * X(X16Y20) - 94.3 * X(X16Y21) - 106.7 * X(X16Y22) - 115 * X(X16Y23) \\
& - 117.5 * X(X16Y24) - 93.1 * X(X16Y25) - 115 * X(X16Y26) - 118.5 * X(X16Y27) \\
& - 116.1 * X(X16Y28) - 105 * X(X16Y30) - 91.2 * X(X16Y31) - 83.9 * X(X16Y32) \\
& + X(X34) = L = 0 ; (LHS = 0)
\end{aligned}$$

$$\text{RESOURCE}(Y80).. X(X4Y2) + X(X4Y6) + X(X4Y10) + X(X4Y24) = L = 8000 ; (LHS = 0)$$

$$\begin{aligned}
& \text{RESOURCE}(Y81).. X(X54Y2) + X(X54Y6) + X(X54Y10) + X(X54Y24) = L = 50000 ; \\
& (LHS = 0)
\end{aligned}$$

$$\begin{aligned}
& \text{RESOURCE}(Y104).. - 2700 * X(X54Y2) - 2300 * X(X54Y6) - 2800 * X(X54Y10) \\
& - 2726 * X(X54Y24) = L = 0 ; (LHS = 0)
\end{aligned}$$

$$\text{RESOURCE}(Y106).. - 0.45 * X(X17Y1) + X(X35) = L = 0 ; (LHS = 0)$$

$$\text{RESOURCE}(Y107).. - 0.45 * X(X17Y1) + X(X36) + X(X39) = L = 0 ; (LHS = 0)$$

$$\text{RESOURCE}(Y108).. - 0.16 * X(X17Y1) + X(X37) = L = 0 ; (LHS = 0)$$

$$\begin{aligned}
& \text{RESOURCE}(Y109).. - 126500 * X(X18Y2) - 126500 * X(X18Y4) - 126500 * X(X18Y6) \\
& - 126500 * X(X18Y10) - 126500 * X(X18Y13) - 126500 * X(X18Y14) \\
& - 126500 * X(X18Y22) - 126500 * X(X18Y24) - 126500 * X(X18Y25) \\
& - 126500 * X(X18Y32) + X(X38) = L = 0 ; (LHS = 0)
\end{aligned}$$

REMAINING 3 ENTRIES SKIPPED

---- LABOR =L= LABOR CONSTRAINTS AND REQUIREMENTS

$$\begin{aligned} \text{LABOR}(Y82).. & 0.04*X(X3Y1) + 0.04*X(X3Y2) + 0.04*X(X3Y3) + 0.04*X(X3Y4) \\ & + 0.04*X(X3Y5) + 0.04*X(X3Y6) + 0.04*X(X3Y7) + 0.04*X(X3Y8) \\ & + 0.04*X(X3Y9) + 0.04*X(X3Y10) + 0.04*X(X3Y11) + 0.04*X(X3Y12) \\ & + 0.04*X(X3Y13) + 0.04*X(X3Y14) + 0.04*X(X3Y15) + 0.04*X(X3Y16) \\ & + 0.04*X(X3Y17) + 0.04*X(X3Y18) + 0.04*X(X3Y19) + 0.04*X(X3Y20) \\ & + 0.04*X(X3Y21) + 0.04*X(X3Y22) + 0.04*X(X3Y23) + 0.04*X(X3Y24) \\ & + 0.04*X(X3Y25) + 0.04*X(X3Y26) + 0.04*X(X3Y27) + 0.04*X(X3Y28) \\ & + 0.04*X(X3Y30) + 0.04*X(X3Y31) + 0.04*X(X3Y32) + 2.34*X(X5Y2) \\ & + 2.34*X(X5Y6) + 2.34*X(X5Y10) + 2.34*X(X5Y24) + 20*X(X10Y2) \\ & + 20*X(X10Y6) + 20*X(X10Y10) + 20*X(X10Y24) + 10*X(X13Y2) + \\ & 10*X(X13Y6) \\ & + 10*X(X13Y10) + 10*X(X13Y24) + 2.7*X(X17Y1) + 100*X(X18Y2) \\ & + 100*X(X18Y4) + 100*X(X18Y6) + 100*X(X18Y10) + 100*X(X18Y13) \\ & + 100*X(X18Y14) + 100*X(X18Y22) + 100*X(X18Y24) + 100*X(X18Y25) \\ & + 100*X(X18Y32) + 0.06*X(X52Y1) + 0.06*X(X52Y2) + 0.06*X(X52Y3) \\ & + 0.06*X(X52Y4) + 0.06*X(X52Y5) + 0.06*X(X52Y6) + 0.06*X(X52Y7) \\ & + 0.06*X(X52Y8) + 0.06*X(X52Y9) + 0.06*X(X52Y10) + 0.06*X(X52Y11) \\ & + 0.06*X(X52Y12) + 0.06*X(X52Y13) + 0.06*X(X52Y14) + 0.06*X(X52Y15) \\ & + 0.06*X(X52Y16) + 0.06*X(X52Y17) + 0.06*X(X52Y18) + 0.06*X(X52Y19) \\ & + 0.06*X(X52Y20) + 0.06*X(X52Y21) + 0.06*X(X52Y22) + 0.06*X(X52Y23) \end{aligned}$$

$$\begin{aligned}
& + 0.06 * X(X52Y24) + 0.06 * X(X52Y25) + 0.06 * X(X52Y26) + 0.06 * X(X52Y27) \\
& + 0.06 * X(X52Y28) + 0.06 * X(X52Y30) + 0.06 * X(X52Y31) + 0.06 * X(X52Y32) \\
& - X(X40) - X(X46) = L = 0 ; (LHS = 0)
\end{aligned}$$

$$\begin{aligned}
\text{LABOR}(Y83).. \quad & 1.02 * X(X1Y2) + 1.02 * X(X1Y6) + 1.02 * X(X1Y10) + 1.02 * X(X1Y24) \\
& + 0.24 * X(X2Y2) + 0.24 * X(X2Y6) + 0.24 * X(X2Y10) + 0.24 * X(X2Y24) \\
& + 2.69 * X(X3Y1) + 2.69 * X(X3Y2) + 2.69 * X(X3Y3) + 2.69 * X(X3Y4) \\
& + 2.69 * X(X3Y5) + 2.69 * X(X3Y6) + 2.69 * X(X3Y7) + 2.69 * X(X3Y8) \\
& + 2.69 * X(X3Y9) + 2.69 * X(X3Y10) + 2.69 * X(X3Y11) + 2.69 * X(X3Y12) \\
& + 2.69 * X(X3Y13) + 2.69 * X(X3Y14) + 2.69 * X(X3Y15) + 2.69 * X(X3Y16) \\
& + 2.69 * X(X3Y17) + 2.69 * X(X3Y18) + 2.69 * X(X3Y19) + 2.69 * X(X3Y20) \\
& + 2.69 * X(X3Y21) + 2.69 * X(X3Y22) + 2.69 * X(X3Y23) + 2.69 * X(X3Y24) \\
& + 2.69 * X(X3Y25) + 2.69 * X(X3Y26) + 2.69 * X(X3Y27) + 2.69 * X(X3Y28) \\
& + 2.69 * X(X3Y30) + 2.69 * X(X3Y31) + 2.69 * X(X3Y32) + 1.33 * X(X4Y2) \\
& + 1.33 * X(X4Y6) + 1.33 * X(X4Y10) + 1.33 * X(X4Y24) + 18.67 * X(X5Y2) \\
& + 18.67 * X(X5Y6) + 18.67 * X(X5Y10) + 18.67 * X(X5Y24) + 82.39 * X(X6Y2) \\
& + 82.39 * X(X6Y6) + 82.39 * X(X6Y10) + 82.39 * X(X6Y24) + 1.89 * X(X7Y2) \\
& + 1.89 * X(X7Y6) + 1.89 * X(X7Y10) + 1.89 * X(X7Y24) + 1.89 * X(X8Y2) \\
& + 1.89 * X(X8Y6) + 1.89 * X(X8Y10) + 1.89 * X(X8Y24) + 1.89 * X(X9Y2) \\
& + 1.89 * X(X9Y6) + 1.89 * X(X9Y10) + 1.89 * X(X9Y24) + 1.89 * X(X10Y2) \\
& + 1.89 * X(X10Y6) + 1.89 * X(X10Y10) + 1.89 * X(X10Y24) + 1.77 * X(X11Y2) \\
& + 1.77 * X(X11Y6) + 1.77 * X(X11Y10) + 1.77 * X(X11Y24) + 1.89 * X(X12Y2)
\end{aligned}$$

+ 1.89*X(X12Y6) + 1.89*X(X12Y10) + 1.89*X(X12Y24) + 25*X(X13Y2)
 + 25*X(X13Y6) + 25*X(X13Y10) + 25*X(X13Y24) + 21.44*X(X14Y2)
 + 21.44*X(X14Y6) + 21.44*X(X14Y10) + 21.44*X(X14Y24) + 0.28*X(X16Y1)
 + 0.28*X(X16Y2) + 0.28*X(X16Y3) + 0.28*X(X16Y4) + 0.28*X(X16Y5)
 + 0.28*X(X16Y6) + 0.28*X(X16Y7) + 0.28*X(X16Y8) + 0.28*X(X16Y9)
 + 0.28*X(X16Y10) + 0.28*X(X16Y11) + 0.28*X(X16Y12) + 0.28*X(X16Y13)
 + 0.28*X(X16Y14) + 0.28*X(X16Y15) + 0.28*X(X16Y16) + 0.28*X(X16Y17)
 + 0.28*X(X16Y18) + 0.28*X(X16Y19) + 0.28*X(X16Y20) + 0.28*X(X16Y21)
 + 0.28*X(X16Y22) + 0.28*X(X16Y23) + 0.28*X(X16Y24) + 0.28*X(X16Y25)
 + 0.28*X(X16Y26) + 0.28*X(X16Y27) + 0.28*X(X16Y28) + 0.28*X(X16Y30)
 + 0.28*X(X16Y31) + 0.28*X(X16Y32) + 1.37*X(X17Y1) + 100*X(X18Y2)
 + 100*X(X18Y4) + 100*X(X18Y6) + 100*X(X18Y10) + 100*X(X18Y13)
 + 100*X(X18Y14) + 100*X(X18Y22) + 100*X(X18Y24) + 100*X(X18Y25)
 + 100*X(X18Y32) + 0.17*X(X52Y1) + 0.17*X(X52Y2) + 0.17*X(X52Y3)
 + 0.17*X(X52Y4) + 0.17*X(X52Y5) + 0.17*X(X52Y6) + 0.17*X(X52Y7)
 + 0.17*X(X52Y8) + 0.17*X(X52Y9) + 0.17*X(X52Y10) + 0.17*X(X52Y11)
 + 0.17*X(X52Y12) + 0.17*X(X52Y13) + 0.17*X(X52Y14) + 0.17*X(X52Y15)
 + 0.17*X(X52Y16) + 0.17*X(X52Y17) + 0.17*X(X52Y18) + 0.17*X(X52Y19)
 + 0.17*X(X52Y20) + 0.17*X(X52Y21) + 0.17*X(X52Y22) + 0.17*X(X52Y23)
 + 0.17*X(X52Y24) + 0.17*X(X52Y25) + 0.17*X(X52Y26) + 0.17*X(X52Y27)
 + 0.17*X(X52Y28) + 0.17*X(X52Y30) + 0.17*X(X52Y31) + 0.17*X(X52Y32)
 + 1.33*X(X54Y2) + 1.33*X(X54Y6) + 1.33*X(X54Y10) + 1.33*X(X54Y24)

$$- X(X41) - X(X47) = L = 0 ; (LHS = 0)$$

$$\begin{aligned} \text{LABOR}(Y84).. & 0.08*X(X1Y2) + 0.08*X(X1Y6) + 0.08*X(X1Y10) + 0.08*X(X1Y24) \\ & + 0.78*X(X2Y2) + 0.78*X(X2Y6) + 0.78*X(X2Y10) + 0.78*X(X2Y24) \\ & + 2.69*X(X3Y1) + 2.69*X(X3Y2) + 2.69*X(X3Y3) + 2.69*X(X3Y4) \\ & + 2.69*X(X3Y5) + 2.69*X(X3Y6) + 2.69*X(X3Y7) + 2.69*X(X3Y8) \\ & + 2.69*X(X3Y9) + 2.69*X(X3Y10) + 2.69*X(X3Y11) + 2.69*X(X3Y12) \\ & + 2.69*X(X3Y13) + 2.69*X(X3Y14) + 2.69*X(X3Y15) + 2.69*X(X3Y16) \\ & + 2.69*X(X3Y17) + 2.69*X(X3Y18) + 2.69*X(X3Y19) + 2.69*X(X3Y20) \\ & + 2.69*X(X3Y21) + 2.69*X(X3Y22) + 2.69*X(X3Y23) + 2.69*X(X3Y24) \\ & + 2.69*X(X3Y25) + 2.69*X(X3Y26) + 2.69*X(X3Y27) + 2.69*X(X3Y28) \\ & + 2.69*X(X3Y30) + 2.69*X(X3Y31) + 2.69*X(X3Y32) + 31.79*X(X4Y2) \\ & + 31.79*X(X4Y6) + 31.79*X(X4Y10) + 31.79*X(X4Y24) + 84.42*X(X5Y2) \\ & + 84.42*X(X5Y6) + 84.42*X(X5Y10) + 84.42*X(X5Y24) + 48.13*X(X6Y2) \\ & + 48.13*X(X6Y6) + 48.13*X(X6Y10) + 48.13*X(X6Y24) + 3.76*X(X7Y2) \\ & + 3.76*X(X7Y6) + 3.76*X(X7Y10) + 3.76*X(X7Y24) + 3.6*X(X8Y2) \\ & + 3.6*X(X8Y6) + 3.6*X(X8Y10) + 3.6*X(X8Y24) + 14.31*X(X9Y2) \\ & + 14.31*X(X9Y6) + 14.31*X(X9Y10) + 14.31*X(X9Y24) + 25.98*X(X10Y2) \\ & + 25.98*X(X10Y6) + 25.98*X(X10Y10) + 25.98*X(X10Y24) + 15.69*X(X11Y2) \\ & + 15.69*X(X11Y6) + 15.69*X(X11Y10) + 15.69*X(X11Y24) + 55.67*X(X12Y2) \\ & + 55.67*X(X12Y6) + 55.67*X(X12Y10) + 55.67*X(X12Y24) + 100*X(X13Y2) \\ & + 100*X(X13Y6) + 100*X(X13Y10) + 100*X(X13Y24) + 16.04*X(X14Y2) \end{aligned}$$

$$\begin{aligned}
& + 16.04 * X(X14Y6) + 16.04 * X(X14Y10) + 16.04 * X(X14Y24) + 3.8 * X(X15Y2) \\
& + 3.8 * X(X15Y6) + 3.8 * X(X15Y10) + 3.8 * X(X15Y24) + 0.28 * X(X16Y1) \\
& + 0.28 * X(X16Y2) + 0.28 * X(X16Y3) + 0.28 * X(X16Y4) + 0.28 * X(X16Y5) \\
& + 0.28 * X(X16Y6) + 0.28 * X(X16Y7) + 0.28 * X(X16Y8) + 0.28 * X(X16Y9) \\
& + 0.28 * X(X16Y10) + 0.28 * X(X16Y11) + 0.28 * X(X16Y12) + 0.28 * X(X16Y13) \\
& + 0.28 * X(X16Y14) + 0.28 * X(X16Y15) + 0.28 * X(X16Y16) + 0.28 * X(X16Y17) \\
& + 0.28 * X(X16Y18) + 0.28 * X(X16Y19) + 0.28 * X(X16Y20) + 0.28 * X(X16Y21) \\
& + 0.28 * X(X16Y22) + 0.28 * X(X16Y23) + 0.28 * X(X16Y24) + 0.28 * X(X16Y25) \\
& + 0.28 * X(X16Y26) + 0.28 * X(X16Y27) + 0.28 * X(X16Y28) + 0.28 * X(X16Y30) \\
& + 0.28 * X(X16Y31) + 0.28 * X(X16Y32) + 0.77 * X(X17Y1) + 100 * X(X18Y2) \\
& + 100 * X(X18Y4) + 100 * X(X18Y6) + 100 * X(X18Y10) + 100 * X(X18Y13) \\
& + 100 * X(X18Y14) + 100 * X(X18Y22) + 100 * X(X18Y24) + 100 * X(X18Y25) \\
& + 100 * X(X18Y32) + 0.32 * X(X52Y1) + 0.32 * X(X52Y2) + 0.32 * X(X52Y3) \\
& + 0.32 * X(X52Y4) + 0.32 * X(X52Y5) + 0.32 * X(X52Y6) + 0.32 * X(X52Y7) \\
& + 0.32 * X(X52Y8) + 0.32 * X(X52Y9) + 0.32 * X(X52Y10) + 0.32 * X(X52Y11) \\
& + 0.32 * X(X52Y12) + 0.32 * X(X52Y13) + 0.32 * X(X52Y14) + 0.32 * X(X52Y15) \\
& + 0.32 * X(X52Y16) + 0.32 * X(X52Y17) + 0.32 * X(X52Y18) + 0.32 * X(X52Y19) \\
& + 0.32 * X(X52Y20) + 0.32 * X(X52Y21) + 0.32 * X(X52Y22) + 0.32 * X(X52Y23) \\
& + 0.32 * X(X52Y24) + 0.32 * X(X52Y25) + 0.32 * X(X52Y26) + 0.32 * X(X52Y27) \\
& + 0.32 * X(X52Y28) + 0.32 * X(X52Y30) + 0.32 * X(X52Y31) + 0.32 * X(X52Y32) \\
& + 31.79 * X(X54Y2) + 31.79 * X(X54Y6) + 31.79 * X(X54Y10) + 31.79 * X(X54Y24) \\
& - X(X42) - X(X48) = L = 0 ; (LHS = 0)
\end{aligned}$$

LABOR(Y85).. 46.46*X(X4Y2) + 46.46*X(X4Y6) + 46.46*X(X4Y10) +
 46.46*X(X4Y24)

 + 29.2*X(X6Y2) + 29.2*X(X6Y6) + 29.2*X(X6Y10) + 29.2*X(X6Y24)

 + 139*X(X7Y2) + 139*X(X7Y6) + 139*X(X7Y10) + 139*X(X7Y24)

 + 33.2*X(X8Y2) + 33.2*X(X8Y6) + 33.2*X(X8Y10) + 33.2*X(X8Y24)

 + 10.36*X(X9Y2) + 10.36*X(X9Y6) + 10.36*X(X9Y10) + 10.36*X(X9Y24)

 + 0.65*X(X10Y2) + 0.65*X(X10Y6) + 0.65*X(X10Y10) + 0.65*X(X10Y24)

 + 19.93*X(X11Y2) + 19.93*X(X11Y6) + 19.93*X(X11Y10) + 19.93*X(X11Y24)

 + 75.5*X(X12Y2) + 75.5*X(X12Y6) + 75.5*X(X12Y10) + 75.5*X(X12Y24)

 + 5*X(X13Y2) + 5*X(X13Y6) + 5*X(X13Y10) + 5*X(X13Y24) +
 130.6*X(X14Y2)

 + 130.6*X(X14Y6) + 130.6*X(X14Y10) + 130.6*X(X14Y24) + 2.37*X(X15Y2)

 + 2.37*X(X15Y6) + 2.37*X(X15Y10) + 2.37*X(X15Y24) + 0.77*X(X17Y1)

 + 100*X(X18Y2) + 100*X(X18Y4) + 100*X(X18Y6) + 100*X(X18Y10)

 + 100*X(X18Y13) + 100*X(X18Y14) + 100*X(X18Y22) + 100*X(X18Y24)

 + 100*X(X18Y25) + 100*X(X18Y32) + 0.52*X(X52Y1) + 0.52*X(X52Y2)

 + 0.52*X(X52Y3) + 0.52*X(X52Y4) + 0.52*X(X52Y5) + 0.52*X(X52Y6)

 + 0.52*X(X52Y7) + 0.52*X(X52Y8) + 0.52*X(X52Y9) + 0.52*X(X52Y10)

 + 0.52*X(X52Y11) + 0.52*X(X52Y12) + 0.52*X(X52Y13) + 0.52*X(X52Y14)

 + 0.52*X(X52Y15) + 0.52*X(X52Y16) + 0.52*X(X52Y17) + 0.52*X(X52Y18)

 + 0.52*X(X52Y19) + 0.52*X(X52Y20) + 0.52*X(X52Y21) + 0.52*X(X52Y22)

 + 0.52*X(X52Y23) + 0.52*X(X52Y24) + 0.52*X(X52Y25) + 0.52*X(X52Y26)

 + 0.52*X(X52Y27) + 0.52*X(X52Y28) + 0.52*X(X52Y30) + 0.52*X(X52Y31)

$$+ 0.52 * X(X52Y32) + 46.46 * X(X54Y2) + 46.46 * X(X54Y6) + 46.46 * X(X54Y10) \\ + 46.46 * X(X54Y24) - X(X43) - X(X49) = L = 0 ; (LHS = 0)$$

$$\begin{aligned} \text{LABOR}(Y86).. & 0.36 * X(X2Y2) + 0.36 * X(X2Y6) + 0.36 * X(X2Y10) + 0.36 * X(X2Y24) \\ & + 2.94 * X(X3Y1) + 2.94 * X(X3Y2) + 2.94 * X(X3Y3) + 2.94 * X(X3Y4) \\ & + 2.94 * X(X3Y5) + 2.94 * X(X3Y6) + 2.94 * X(X3Y7) + 2.94 * X(X3Y8) \\ & + 2.94 * X(X3Y9) + 2.94 * X(X3Y10) + 2.94 * X(X3Y11) + 2.94 * X(X3Y12) \\ & + 2.94 * X(X3Y13) + 2.94 * X(X3Y14) + 2.94 * X(X3Y15) + 2.94 * X(X3Y16) \\ & + 2.94 * X(X3Y17) + 2.94 * X(X3Y18) + 2.94 * X(X3Y19) + 2.94 * X(X3Y20) \\ & + 2.94 * X(X3Y21) + 2.94 * X(X3Y22) + 2.94 * X(X3Y23) + 2.94 * X(X3Y24) \\ & + 2.94 * X(X3Y25) + 2.94 * X(X3Y26) + 2.94 * X(X3Y27) + 2.94 * X(X3Y28) \\ & + 2.94 * X(X3Y30) + 2.94 * X(X3Y31) + 2.94 * X(X3Y32) + 40.63 * X(X4Y2) \\ & + 40.63 * X(X4Y6) + 40.63 * X(X4Y10) + 40.63 * X(X4Y24) + 72 * X(X7Y2) \\ & + 72 * X(X7Y6) + 72 * X(X7Y10) + 43.93 * X(X9Y2) + 43.93 * X(X9Y6) \\ & + 43.93 * X(X9Y10) + 43.93 * X(X9Y24) + 26.5 * X(X10Y2) + 26.5 * X(X10Y6) \\ & + 26.5 * X(X10Y10) + 26.5 * X(X10Y24) + 27.85 * X(X11Y2) + 27.85 * X(X11Y6) \\ & + 27.85 * X(X11Y10) + 27.85 * X(X11Y24) + 57.5 * X(X13Y2) + 57.5 * X(X13Y6) \\ & + 57.5 * X(X13Y10) + 57.5 * X(X13Y24) + 1.58 * X(X15Y2) + 1.58 * X(X15Y6) \\ & + 1.58 * X(X15Y10) + 1.58 * X(X15Y24) + 1.02 * X(X16Y1) + 1.02 * X(X16Y2) \\ & + 1.02 * X(X16Y3) + 1.02 * X(X16Y4) + 1.02 * X(X16Y5) + 1.02 * X(X16Y6) \\ & + 1.02 * X(X16Y7) + 1.02 * X(X16Y8) + 1.02 * X(X16Y9) + 1.02 * X(X16Y10) \\ & + 1.02 * X(X16Y11) + 1.02 * X(X16Y12) + 1.02 * X(X16Y13) + 1.02 * X(X16Y14) \\ & + 1.02 * X(X16Y15) + 1.02 * X(X16Y16) + 1.02 * X(X16Y17) + 1.02 * X(X16Y18) \end{aligned}$$

$$\begin{aligned}
& + 1.02 * X(X16Y19) + 1.02 * X(X16Y20) + 1.02 * X(X16Y21) + 1.02 * X(X16Y22) \\
& + 1.02 * X(X16Y23) + 1.02 * X(X16Y24) + 1.02 * X(X16Y25) + 1.02 * X(X16Y26) \\
& + 1.02 * X(X16Y27) + 1.02 * X(X16Y28) + 1.02 * X(X16Y30) + 1.02 * X(X16Y31) \\
& + 1.02 * X(X16Y32) + 1.47 * X(X17Y1) + 100 * X(X18Y2) + 100 * X(X18Y4) \\
& + 100 * X(X18Y6) + 100 * X(X18Y10) + 100 * X(X18Y13) + 100 * X(X18Y14) \\
& + 100 * X(X18Y22) + 100 * X(X18Y24) + 100 * X(X18Y25) + 100 * X(X18Y32) \\
& + 0.23 * X(X52Y1) + 0.23 * X(X52Y2) + 0.23 * X(X52Y3) + 0.23 * X(X52Y4) \\
& + 0.23 * X(X52Y5) + 0.23 * X(X52Y6) + 0.23 * X(X52Y7) + 0.23 * X(X52Y8) \\
& + 0.23 * X(X52Y9) + 0.23 * X(X52Y10) + 0.23 * X(X52Y11) + 0.23 * X(X52Y12) \\
& + 0.23 * X(X52Y13) + 0.23 * X(X52Y14) + 0.23 * X(X52Y15) + 0.23 * X(X52Y16) \\
& + 0.23 * X(X52Y17) + 0.23 * X(X52Y18) + 0.23 * X(X52Y19) + 0.23 * X(X52Y20) \\
& + 0.23 * X(X52Y21) + 0.23 * X(X52Y22) + 0.23 * X(X52Y23) + 0.23 * X(X52Y24) \\
& + 0.23 * X(X52Y25) + 0.23 * X(X52Y26) + 0.23 * X(X52Y27) + 0.23 * X(X52Y28) \\
& + 0.23 * X(X52Y30) + 0.23 * X(X52Y31) + 0.23 * X(X52Y32) + 40.63 * X(X54Y2) \\
& + 40.63 * X(X54Y6) + 40.63 * X(X54Y10) + 40.63 * X(X54Y24) - X(X44) - X(X50) \\
& = L = 0 ; (LHS = 0)
\end{aligned}$$

$$\begin{aligned}
\text{LABOR}(Y87).. & 1.02 * X(X1Y2) + 1.02 * X(X1Y6) + 1.02 * X(X1Y10) + 1.02 * X(X1Y24) \\
& + 0.36 * X(X2Y2) + 0.36 * X(X2Y6) + 0.36 * X(X2Y10) + 0.36 * X(X2Y24) \\
& + 108 * X(X4Y2) + 108 * X(X4Y6) + 108 * X(X4Y10) + 108 * X(X4Y24) \\
& + 24.5 * X(X10Y2) + 24.5 * X(X10Y6) + 24.5 * X(X10Y10) + 24.5 * X(X10Y24) \\
& + 7.5 * X(X13Y2) + 7.5 * X(X13Y6) + 7.5 * X(X13Y10) + 7.5 * X(X13Y24)
\end{aligned}$$

$$\begin{aligned}
& + 1.93 * X(X17Y1) + 100 * X(X18Y2) + 100 * X(X18Y4) + 100 * X(X18Y6) \\
& + 100 * X(X18Y10) + 100 * X(X18Y13) + 100 * X(X18Y14) + 100 * X(X18Y22) \\
& + 100 * X(X18Y24) + 100 * X(X18Y25) + 100 * X(X18Y32) + 108 * X(X54Y2) \\
& + 108 * X(X54Y6) + 108 * X(X54Y10) + 108 * X(X54Y24) - X(X45) - X(X51) = L = 0 \\
& ; (LHS = 0)
\end{aligned}$$

$$LABOR(Y88).. X(X40) = L = 520 ; (LHS = 0)$$

$$LABOR(Y89).. X(X41) = L = 520 ; (LHS = 0)$$

$$LABOR(Y90).. X(X42) = L = 780 ; (LHS = 0)$$

$$LABOR(Y91).. X(X43) = L = 780 ; (LHS = 0)$$

$$LABOR(Y92).. X(X44) = L = 520 ; (LHS = 0)$$

$$LABOR(Y93).. X(X45) = L = 520 ; (LHS = 0)$$

$$LABOR(Y97).. X(X46) = L = 260 ; (LHS = 0)$$

$$LABOR(Y98).. X(X47) = L = 988 ; (LHS = 0)$$

$$LABOR(Y99).. X(X48) = L = 988 ; (LHS = 0)$$

$$LABOR(Y100).. X(X49) = L = 988 ; (LHS = 0)$$

$$LABOR(Y101).. X(X50) = L = 988 ; (LHS = 0)$$

LABOR(Y102).. X(X51) =L= 988 ; (LHS = 0)

--- X ACTIVITIES

X(X1Y2)

(.LO, .L, .UP = 0, 0, +INF)

110.91 PROFIT

1 RESOURCE(Y2)

-125 RESOURCE(Y64)

1.02 LABOR(Y83)

0.08 LABOR(Y84)

1.02 LABOR(Y87)

X(X1Y6)

(.LO, .L, .UP = 0, 0, +INF)

110.91 PROFIT

1 RESOURCE(Y6)

-105 RESOURCE(Y64)

1.02 LABOR(Y83)

0.08 LABOR(Y84)

1.02 LABOR(Y87)

X(X1Y10)

(.LO, .L, .UP = 0, 0, +INF)

110.91 PROFIT

1 RESOURCE(Y10)

-130 RESOURCE(Y64)

1.02 LABOR(Y83)

0.08 LABOR(Y84)

1.02 LABOR(Y87)

X(X1Y24)

(.LO, .L, .UP = 0, 0, +INF)

110.91 PROFIT

1 RESOURCE(Y24)

-140 RESOURCE(Y64)

1.02 LABOR(Y83)

0.08 LABOR(Y84)

1.02 LABOR(Y87)

X(X2Y2)
 (.LO, .L, .UP = 0, 0, +INF)
 85.7 PROFIT
 1 RESOURCE(Y2)
 -60 RESOURCE(Y65)
 0.24 LABOR(Y83)
 0.78 LABOR(Y84)
 0.36 LABOR(Y86)
 0.36 LABOR(Y87)

X(X2Y6)
 (.LO, .L, .UP = 0, 0, +INF)
 85.7 PROFIT
 1 RESOURCE(Y6)
 -50 RESOURCE(Y65)
 0.24 LABOR(Y83)
 0.78 LABOR(Y84)
 0.36 LABOR(Y86)
 0.36 LABOR(Y87)

X(X2Y10)
 (.LO, .L, .UP = 0, 0, +INF)
 85.7 PROFIT
 1 RESOURCE(Y10)
 -65 RESOURCE(Y65)
 0.24 LABOR(Y83)
 0.78 LABOR(Y84)
 0.36 LABOR(Y86)
 0.36 LABOR(Y87)

X(X2Y24)
 (.LO, .L, .UP = 0, 0, +INF)
 85.7 PROFIT
 1 RESOURCE(Y24)
 -59.2 RESOURCE(Y65)
 0.24 LABOR(Y83)
 0.78 LABOR(Y84)
 0.36 LABOR(Y86)
 0.36 LABOR(Y87)

X(X3Y1)
 (.LO, .L, .UP = 0, 0, +INF)
 103.73 PROFIT
 1 RESOURCE(Y1)
 -2.4 RESOURCE(Y66)
 0.04 LABOR(Y82)
 2.69 LABOR(Y83)
 2.69 LABOR(Y84)
 2.94 LABOR(Y86)

X(X3Y2)
 (.LO, .L, .UP = 0, 0, +INF)
 103.73 PROFIT
 1 RESOURCE(Y2)
 -3.2 RESOURCE(Y66)
 0.04 LABOR(Y82)
 2.69 LABOR(Y83)
 2.69 LABOR(Y84)
 2.94 LABOR(Y86)

X(X3Y3)
 (.LO, .L, .UP = 0, 0, +INF)
 103.73 PROFIT
 1 RESOURCE(Y3)
 -3 RESOURCE(Y66)
 0.04 LABOR(Y82)
 2.69 LABOR(Y83)
 2.69 LABOR(Y84)
 2.94 LABOR(Y86)

X(X3Y4)
 (.LO, .L, .UP = 0, 0, +INF)
 103.73 PROFIT
 1 RESOURCE(Y4)
 -2.7 RESOURCE(Y66)
 0.04 LABOR(Y82)
 2.69 LABOR(Y83)
 2.69 LABOR(Y84)
 2.94 LABOR(Y86)

X(X3Y5)
 (.LO, .L, .UP = 0, 0, +INF)
 103.73 PROFIT
 1 RESOURCE(Y5)
 -2.7 RESOURCE(Y66)
 0.04 LABOR(Y82)
 2.69 LABOR(Y83)
 2.69 LABOR(Y84)
 2.94 LABOR(Y86)

X(X3Y6)
 (.LO, .L, .UP = 0, 0, +INF)
 103.73 PROFIT
 1 RESOURCE(Y6)
 -2.7 RESOURCE(Y66)
 0.04 LABOR(Y82)
 2.69 LABOR(Y83)
 2.69 LABOR(Y84)
 2.94 LABOR(Y86)

X(X3Y7)
 (.LO, .L, .UP = 0, 0, +INF)
 103.73 PROFIT
 1 RESOURCE(Y7)
 -2.7 RESOURCE(Y66)
 0.04 LABOR(Y82)
 2.69 LABOR(Y83)
 2.69 LABOR(Y84)
 2.94 LABOR(Y86)

X(X3Y8)
 (.LO, .L, .UP = 0, 0, +INF)
 103.73 PROFIT
 1 RESOURCE(Y8)
 -2.9 RESOURCE(Y66)
 0.04 LABOR(Y82)
 2.69 LABOR(Y83)
 2.69 LABOR(Y84)
 2.94 LABOR(Y86)

X(X3Y9)
 (.LO, .L, .UP = 0, 0, +INF)
 103.73 PROFIT
 1 RESOURCE(Y9)
 -3 RESOURCE(Y66)
 0.04 LABOR(Y82)
 2.69 LABOR(Y83)
 2.69 LABOR(Y84)
 2.94 LABOR(Y86)

X(X3Y10)
 (.LO, .L, .UP = 0, 0, +INF)
 103.73 PROFIT
 1 RESOURCE(Y10)
 -3.2 RESOURCE(Y66)
 0.04 LABOR(Y82)
 2.69 LABOR(Y83)
 2.69 LABOR(Y84)
 2.94 LABOR(Y86)

X(X3Y11)
 (.LO, .L, .UP = 0, 0, +INF)
 103.73 PROFIT
 1 RESOURCE(Y11)
 -2.7 RESOURCE(Y66)
 0.04 LABOR(Y82)
 2.69 LABOR(Y83)
 2.69 LABOR(Y84)
 2.94 LABOR(Y86)

X(X3Y12)
 (.LO, .L, .UP = 0, 0, +INF)
 103.73 PROFIT
 1 RESOURCE(Y12)
 -2.7 RESOURCE(Y66)
 0.04 LABOR(Y82)
 2.69 LABOR(Y83)
 2.69 LABOR(Y84)
 2.94 LABOR(Y86)

X(X3Y13)
 (.LO, .L, .UP = 0, 0, +INF)
 103.73 PROFIT
 1 RESOURCE(Y13)
 -2.7 RESOURCE(Y66)
 0.04 LABOR(Y82)
 2.69 LABOR(Y83)
 2.69 LABOR(Y84)
 2.94 LABOR(Y86)

X(X3Y14)
 (.LO, .L, .UP = 0, 0, +INF)
 103.73 PROFIT
 1 RESOURCE(Y14)
 -2.7 RESOURCE(Y66)
 0.04 LABOR(Y82)
 2.69 LABOR(Y83)
 2.69 LABOR(Y84)
 2.94 LABOR(Y86)

X(X3Y15)
 (.LO, .L, .UP = 0, 0, +INF)
 103.73 PROFIT
 1 RESOURCE(Y15)
 -3.2 RESOURCE(Y66)
 0.04 LABOR(Y82)
 2.69 LABOR(Y83)
 2.69 LABOR(Y84)
 2.94 LABOR(Y86)

X(X3Y16)
 (.LO, .L, .UP = 0, 0, +INF)
 103.73 PROFIT
 1 RESOURCE(Y16)
 -2.7 RESOURCE(Y66)
 0.04 LABOR(Y82)
 2.69 LABOR(Y83)
 2.69 LABOR(Y84)
 2.94 LABOR(Y86)

X(X3Y17)
 (.LO, .L, .UP = 0, 0, +INF)
 103.73 PROFIT
 1 RESOURCE(Y17)
 -2.7 RESOURCE(Y66)
 0.04 LABOR(Y82)
 2.69 LABOR(Y83)
 2.69 LABOR(Y84)
 2.94 LABOR(Y86)

X(X3Y18)
 (.LO, .L, .UP = 0, 0, +INF)
 103.73 PROFIT
 1 RESOURCE(Y18)
 -2.6 RESOURCE(Y66)
 0.04 LABOR(Y82)
 2.69 LABOR(Y83)
 2.69 LABOR(Y84)
 2.94 LABOR(Y86)

X(X3Y19)
 (.LO, .L, .UP = 0, 0, +INF)
 103.73 PROFIT
 1 RESOURCE(Y19)
 -2.7 RESOURCE(Y66)
 0.04 LABOR(Y82)
 2.69 LABOR(Y83)
 2.69 LABOR(Y84)
 2.94 LABOR(Y86)

X(X3Y20)
 (.LO, .L, .UP = 0, 0, +INF)
 103.73 PROFIT
 1 RESOURCE(Y20)
 -2.7 RESOURCE(Y66)
 0.04 LABOR(Y82)
 2.69 LABOR(Y83)
 2.69 LABOR(Y84)
 2.94 LABOR(Y86)

X(X3Y21)
 (.LO, .L, .UP = 0, 0, +INF)
 103.73 PROFIT
 1 RESOURCE(Y21)
 -2.4 RESOURCE(Y66)
 0.04 LABOR(Y82)
 2.69 LABOR(Y83)
 2.69 LABOR(Y84)
 2.94 LABOR(Y86)

X(X3Y22)
 (.LO, .L, .UP = 0, 0, +INF)
 103.73 PROFIT
 1 RESOURCE(Y22)
 -3.2 RESOURCE(Y66)
 0.04 LABOR(Y82)
 2.69 LABOR(Y83)
 2.69 LABOR(Y84)
 2.94 LABOR(Y86)

X(X3Y23)
 (.LO, .L, .UP = 0, 0, +INF)
 103.73 PROFIT
 1 RESOURCE(Y23)
 -3.2 RESOURCE(Y66)
 0.04 LABOR(Y82)
 2.69 LABOR(Y83)
 2.69 LABOR(Y84)
 2.94 LABOR(Y86)

X(X3Y24)
 (.LO, .L, .UP = 0, 0, +INF)
 103.73 PROFIT
 1 RESOURCE(Y24)
 -3.5 RESOURCE(Y66)
 0.04 LABOR(Y82)
 2.69 LABOR(Y83)
 2.69 LABOR(Y84)
 2.94 LABOR(Y86)

X(X3Y25)
 (.LO, .L, .UP = 0, 0, +INF)
 103.73 PROFIT
 1 RESOURCE(Y25)
 -2.6 RESOURCE(Y66)
 0.04 LABOR(Y82)
 2.69 LABOR(Y83)
 2.69 LABOR(Y84)
 2.94 LABOR(Y86)

X(X3Y26)
 (.LO, .L, .UP = 0, 0, +INF)
 103.73 PROFIT
 1 RESOURCE(Y26)
 -3.2 RESOURCE(Y66)
 0.04 LABOR(Y82)
 2.69 LABOR(Y83)
 2.69 LABOR(Y84)
 2.94 LABOR(Y86)

X(X3Y27)
 (.LO, .L, .UP = 0, 0, +INF)
 103.73 PROFIT
 1 RESOURCE(Y27)
 -3.3 RESOURCE(Y66)
 0.04 LABOR(Y82)
 2.69 LABOR(Y83)
 2.69 LABOR(Y84)
 2.94 LABOR(Y86)

X(X3Y28)
 (.LO, .L, .UP = 0, 0, +INF)
 103.73 PROFIT
 1 RESOURCE(Y28)
 -3.2 RESOURCE(Y66)
 0.04 LABOR(Y82)
 2.69 LABOR(Y83)
 2.69 LABOR(Y84)
 2.94 LABOR(Y86)

X(X3Y30)
 (.LO, .L, .UP = 0, 0, +INF)
 103.73 PROFIT
 1 RESOURCE(Y30)
 -3 RESOURCE(Y66)
 0.04 LABOR(Y82)
 2.69 LABOR(Y83)
 2.69 LABOR(Y84)
 2.94 LABOR(Y86)

X(X3Y31)
 (.LO, .L, .UP = 0, 0, +INF)
 103.73 PROFIT
 1 RESOURCE(Y31)
 -2.6 RESOURCE(Y66)
 0.04 LABOR(Y82)
 2.69 LABOR(Y83)
 2.69 LABOR(Y84)
 2.94 LABOR(Y86)

X(X3Y32)
 (.LO, .L, .UP = 0, 0, +INF)
 103.73 PROFIT
 1 RESOURCE(Y32)
 -2.2 RESOURCE(Y66)
 0.04 LABOR(Y82)
 2.69 LABOR(Y83)
 2.69 LABOR(Y84)
 2.94 LABOR(Y86)

X(X4Y2)
 (.LO, .L, .UP = 0, 0, +INF)
 1169.51 PROFIT
 1 RESOURCE(Y2)
 -2700 RESOURCE(Y67)
 1 RESOURCE(Y80)
 1.33 LABOR(Y83)
 31.79 LABOR(Y84)
 46.46 LABOR(Y85)
 40.63 LABOR(Y86)
 108 LABOR(Y87)

X(X4Y6)
 (.LO, .L, .UP = 0, 0, +INF)
 1169.51 PROFIT
 1 RESOURCE(Y6)
 -2300 RESOURCE(Y67)
 1 RESOURCE(Y80)
 1.33 LABOR(Y83)
 31.79 LABOR(Y84)
 46.46 LABOR(Y85)
 40.63 LABOR(Y86)
 108 LABOR(Y87)

X(X4Y10)
 (.LO, .L, .UP = 0, 0, +INF)
 1169.51 PROFIT
 1 RESOURCE(Y10)
 -2800 RESOURCE(Y67)
 1 RESOURCE(Y80)
 1.33 LABOR(Y83)
 31.79 LABOR(Y84)
 46.46 LABOR(Y85)
 40.63 LABOR(Y86)
 108 LABOR(Y87)

X(X4Y24)
 (.LO, .L, .UP = 0, 0, +INF)
 1169.51 PROFIT
 1 RESOURCE(Y24)
 -2726 RESOURCE(Y67)
 1 RESOURCE(Y80)
 1.33 LABOR(Y83)
 31.79 LABOR(Y84)
 46.46 LABOR(Y85)
 40.63 LABOR(Y86)
 108 LABOR(Y87)

X(X5Y2)

(.LO, .L, .UP = 0, 0, +INF)

817.26 PROFIT

1 RESOURCE(Y2)

-552 RESOURCE(Y68)

2.34 LABOR(Y82)

18.67 LABOR(Y83)

84.42 LABOR(Y84)

X(X5Y6)

(.LO, .L, .UP = 0, 0, +INF)

817.26 PROFIT

1 RESOURCE(Y6)

-472 RESOURCE(Y68)

2.34 LABOR(Y82)

18.67 LABOR(Y83)

84.42 LABOR(Y84)

X(X5Y10)

(.LO, .L, .UP = 0, 0, +INF)

817.26 PROFIT

1 RESOURCE(Y10)

-575 RESOURCE(Y68)

2.34 LABOR(Y82)

18.67 LABOR(Y83)

84.42 LABOR(Y84)

X(X5Y24)

(.LO, .L, .UP = 0, 0, +INF)

817.26 PROFIT

1 RESOURCE(Y24)

-561.5 RESOURCE(Y68)

2.34 LABOR(Y82)

18.67 LABOR(Y83)

84.42 LABOR(Y84)

X(X6Y2)
 (.LO, .L, .UP = 0, 0, +INF)
 5486.68 PROFIT
 1 RESOURCE(Y2)
 -1344 RESOURCE(Y69)
 82.39 LABOR(Y83)
 48.13 LABOR(Y84)
 29.2 LABOR(Y85)

X(X6Y6)
 (.LO, .L, .UP = 0, 0, +INF)
 5486.68 PROFIT
 1 RESOURCE(Y6)
 -1148 RESOURCE(Y69)
 82.39 LABOR(Y83)
 48.13 LABOR(Y84)
 29.2 LABOR(Y85)

X(X6Y10)
 (.LO, .L, .UP = 0, 0, +INF)
 5486.68 PROFIT
 1 RESOURCE(Y10)
 -1400 RESOURCE(Y69)
 82.39 LABOR(Y83)
 48.13 LABOR(Y84)
 29.2 LABOR(Y85)

X(X6Y24)
 (.LO, .L, .UP = 0, 0, +INF)
 5486.68 PROFIT
 1 RESOURCE(Y24)
 -1366.7 RESOURCE(Y69)
 82.39 LABOR(Y83)
 48.13 LABOR(Y84)
 29.2 LABOR(Y85)

X(X7Y2)
 (.LO, .L, .UP = 0, 0, +INF)
 476.56 PROFIT
 1 RESOURCE(Y2)
 -1152 RESOURCE(Y70)
 1.89 LABOR(Y83)
 3.76 LABOR(Y84)
 139 LABOR(Y85)
 72 LABOR(Y86)

X(X7Y6)
 (.LO, .L, .UP = 0, 0, +INF)
 476.56 PROFIT
 1 RESOURCE(Y6)
 -984 RESOURCE(Y70)
 1.89 LABOR(Y83)
 3.76 LABOR(Y84)
 139 LABOR(Y85)
 72 LABOR(Y86)

X(X7Y10)
 (.LO, .L, .UP = 0, 0, +INF)
 476.56 PROFIT
 1 RESOURCE(Y10)
 -1200 RESOURCE(Y70)
 1.89 LABOR(Y83)
 3.76 LABOR(Y84)
 139 LABOR(Y85)
 72 LABOR(Y86)

X(X7Y24)
 (.LO, .L, .UP = 0, 0, +INF)
 476.56 PROFIT
 1 RESOURCE(Y24)
 -1171.4 RESOURCE(Y70)
 1.89 LABOR(Y83)
 3.76 LABOR(Y84)
 139 LABOR(Y85)

X(X8Y2)
 (.LO, .L, .UP = 0, 0, +INF)
 685.89 PROFIT
 1 RESOURCE(Y2)
 -960 RESOURCE(Y71)
 1.89 LABOR(Y83)
 3.6 LABOR(Y84)
 33.2 LABOR(Y85)

X(X8Y6)
 (.LO, .L, .UP = 0, 0, +INF)
 685.89 PROFIT
 1 RESOURCE(Y6)
 -820 RESOURCE(Y71)
 1.89 LABOR(Y83)
 3.6 LABOR(Y84)
 33.2 LABOR(Y85)

REMAINING 143 ENTRIES SKIPPED

--- Z NET REVENUE

Z
 (.LO, .L, .UP = -INF, 0, +INF)
 1 PROFIT

MODEL STATISTICS

BLOCKS OF EQUATIONS	4	SINGLE EQUATIONS	77
BLOCKS OF VARIABLES	2	SINGLE VARIABLES	201
NON ZERO ELEMENTS	1265		

GENERATION TIME = 1.370 SECONDS

EXECUTION TIME = 1.430 SECONDS VERID MW2-25-069

SOLVE SUMMARY

MODEL PROJECT OBJECTIVE Z
TYPE LP DIRECTION MAXIMIZE
SOLVER BDMLP FROM LINE 1207

**** SOLVER STATUS 1 NORMAL COMPLETION
**** MODEL STATUS 1 OPTIMAL
**** OBJECTIVE VALUE 227570.7570

RESOURCE USAGE, LIMIT 1.210 1000.000
ITERATION COUNT, LIMIT 182 1000

BDM - LP VERSION 1.01

Work space allocated -- 0.09 Mb

EXIT -- OPTIMAL SOLUTION FOUND.

LOWER LEVEL UPPER MARGINAL

---- EQU PROFIT . . . 1.000

PROFIT TOTAL NET RETURNS MINUS VARIABLE COSTS

---- EQU CATTLE FORCE CATTLE INTO PRODUCTION

LOWER LEVEL UPPER MARGINAL

Y94 -INF . . .

--- EQU RESOURCE LAND AND CROPS RESOURCE CONSTRAINTS

LOWER LEVEL UPPER MARGINAL

Y1	-INF	13.000	13.000	73.895
Y2	-INF	3.000	3.000	4142.664
Y3	-INF	10.800	10.800	108.145
Y4	-INF	4.300	4.300	89.645
Y5	-INF	3.300	3.300	97.145
Y6	-INF	1.600	1.600	1703.664
Y7	-INF	1.300	1.300	97.645
Y8	-INF	4.000	4.000	111.645
Y9	-INF	1.300	1.300	119.145

LOWER LEVEL UPPER MARGINAL

Y10	-INF	2.000	2.000	4839.664
Y11	-INF	1.000	1.000	97.645
Y12	-INF	1.000	1.000	97.645
Y13	-INF	1.300	1.300	97.645
Y14	-INF	5.000	5.000	97.645
Y15	-INF	1.100	1.100	152.645
Y16	-INF	4.500	4.500	110.145
Y17	-INF	1.000	1.000	110.145
Y18	-INF	3.500	3.500	96.145
Y19	-INF	2.000	2.000	110.145
Y20	-INF	1.000	1.000	110.145
Y21	-INF	3.800	3.800	88.395
Y22	-INF	2.100	2.100	119.395
Y23	-INF	4.000	4.000	140.145
Y24	-INF	4.500	4.500	4424.764
Y25	-INF	6.500	6.500	85.395
Y26	-INF	1.600	1.600	140.145
Y27	-INF	1.300	1.300	148.895
Y28	-INF	3.200	3.200	142.895
Y30	-INF	3.400	3.400	115.145
Y31	-INF	5.700	5.700	80.645
Y32	-INF	7.000	7.000	62.395
Y64	-INF	.	.	17.471
Y65	-INF	.	.	37.023
Y66	-INF	.	.	32.000
Y67	-INF	.	.	2.823
Y68	-INF	.	.	18.646

Y69	-INF	.	.	9.905
Y70	-INF	.	.	4.000
Y71	-INF	.	.	3.524
Y72	-INF	.	.	0.149
Y73	-INF	.	.	18.853
Y74	-INF	.	.	591.947
Y75	-INF	.	.	14.358
Y76	-INF	.	.	1.000
Y77	-INF	.	.	0.764
Y78	-INF	.	.	600.804
Y79	-INF	.	.	2.500
Y80	-INF	.	8000.000	.
Y81	-INF	.	50000.000	.
Y104	-INF	.	.	.
Y106	-INF	.	.	341.000
Y107	-INF	.	.	265.000
Y108	-INF	.	.	420.000
Y109	-INF	.	.	0.190
Y110	-INF	.	.	.
Y111	-INF	.	.	.
Y112	-INF	.	.	.

--- EQU LABOR LABOR CONSTRAINTS AND REQUIREMENTS

		LOWER	LEVEL	UPPER	MARGINAL
Y82	-INF	.	.	80.102	
Y83	-INF	.	.	7.000	
Y84	-INF	.	.	70.624	
Y85	-INF	.	.	7.000	
Y86	-INF	.	.	7.000	
Y87	-INF	.	.	7.000	
Y88	-INF	520.000	520.000	74.102	
Y89	-INF	520.000	520.000	1.000	
Y90	-INF	780.000	780.000	64.624	
Y91	-INF	780.000	780.000	1.000	
Y92	-INF	520.000	520.000	1.000	
Y93	-INF	520.000	520.000	1.000	
Y97	-INF	260.000	260.000	73.102	
Y98	-INF	446.498	988.000	.	
Y99	-INF	988.000	988.000	63.624	
Y100	-INF	5.538	988.000	.	
Y101	-INF	890.728	988.000	.	

Y102 -INF 233.310 988.000 .

--- VAR X ACTIVITIES

	LOWER	LEVEL	UPPER	MARGINAL
X1Y2	.	+INF	-2089.571	
X1Y6	.	+INF	.	
X1Y10	.	+INF	-2699.213	
X1Y24	.	+INF	-2109.599	
X2Y2	.	+INF	-2068.766	
X2Y6	.	+INF	.	
X2Y10	.	+INF	-2580.649	
X2Y24	.	+INF	-2380.485	
X3Y1	.	+INF	-333.418	
X3Y2	.	+INF	-4376.587	
X3Y3	.	+INF	-348.468	
X3Y4	.	+INF	-339.568	
X3Y5	.	+INF	-347.068	
X3Y6	.	+INF	-1953.587	
X3Y7	.	+INF	-347.568	
X3Y8	.	+INF	-355.168	
X3Y9	.	+INF	-359.468	
X3Y10	.	+INF	-5073.587	
X3Y11	.	+INF	-347.568	
X3Y12	.	+INF	-347.568	
X3Y13	.	+INF	-347.568	
X3Y14	.	+INF	-347.568	
X3Y15	.	+INF	-386.568	
X3Y16	.	+INF	-360.068	
X3Y17	.	+INF	-360.068	
X3Y18	.	+INF	-349.268	
X3Y19	.	+INF	-360.068	
X3Y20	.	+INF	-360.068	
X3Y21	.	+INF	-347.918	
X3Y22	.	+INF	-353.318	
X3Y23	.	+INF	-374.068	
X3Y24	.	+INF	-4649.087	
X3Y25	.	+INF	-338.518	
X3Y26	.	+INF	-374.068	
X3Y27	.	+INF	-379.618	
X3Y28	.	+INF	-376.818	
X3Y30	.	+INF	-355.468	

X3Y31	.	.	+INF	-333.768
X3Y32	.	.	+INF	-328.318
X4Y2	.	.	+INF	-1309.740
X4Y6	.	.	+INF	.
X4Y10	.	.	+INF	-1724.425
X4Y24	.	.	+INF	-1518.438
X5Y2	.	.	+INF	-947.285
X5Y6	.	.	+INF	.
X5Y10	.	.	+INF	-1215.417
X5Y24	.	.	+INF	-1052.244
X6Y2	.	.	+INF	-497.678
X6Y6	.	.	+INF	.
X6Y10	.	.	+INF	-640.015
X6Y24	.	.	+INF	-554.941
X7Y2	.	.	+INF	-1767.000
X7Y6	.	0.424	+INF	.
X7Y10	.	.	+INF	-2272.000
X7Y24	.	.	+INF	-1467.500
X8Y2	.	.	+INF	-1945.683
X8Y6	.	.	+INF	.
X8Y10	.	.	+INF	-2501.735
X8Y24	.	.	+INF	-2170.699
X9Y2	.	.	+INF	-1856.571
X9Y6	.	.	+INF	.
X9Y10	.	.	+INF	-2387.162
X9Y24	.	.	+INF	-2071.275
X10Y2	.	.	+INF	-1383.240
X10Y6	.	.	+INF	.
X10Y10	.	.	+INF	-1778.595
X10Y24	.	.	+INF	-1542.797
X11Y2	.	.	+INF	-1847.053
X11Y6	.	.	+INF	.
X11Y10	.	.	+INF	-2366.469
X11Y24	.	.	+INF	-2069.958
X12Y2	.	.	+INF	-1232.930
X12Y6	.	.	+INF	.
X12Y10	.	.	+INF	-1585.339
X12Y24	.	.	+INF	-1375.758
X13Y2	.	3.000	+INF	.
X13Y6	.	1.176	+INF	.
X13Y10	.	2.000	+INF	.
X13Y24	.	4.500	+INF	.
X14Y2	.	.	+INF	-1583.241

X14Y6	.	.	+INF	.
X14Y10	.	.	+INF	-2035.739
X14Y24	.	.	+INF	-1766.318
X15Y2	.	.	+INF	-2258.759
X15Y6	.	.	+INF	.
X15Y10	.	.	+INF	-2715.437
X15Y24	.	.	+INF	-2781.180
X16Y1	.	13.000	+INF	.
X16Y2	.	.	+INF	-4002.519
X16Y3	.	10.800	+INF	.
X16Y4	.	4.300	+INF	.
X16Y5	.	3.300	+INF	.
X16Y6	.	.	+INF	-1606.019
X16Y7	.	1.300	+INF	.
X16Y8	.	4.000	+INF	.
X16Y9	.	1.300	+INF	.
X16Y10	.	.	+INF	-4687.019
X16Y11	.	1.000	+INF	.
X16Y12	.	1.000	+INF	.
X16Y13	.	1.300	+INF	.
X16Y14	.	5.000	+INF	.
X16Y15	.	1.100	+INF	.
X16Y16	.	4.500	+INF	.
X16Y17	.	1.000	+INF	.
X16Y18	.	3.500	+INF	.
X16Y19	.	2.000	+INF	.
X16Y20	.	1.000	+INF	.
X16Y21	.	3.800	+INF	.
X16Y22	.	2.100	+INF	.
X16Y23	.	4.000	+INF	.
X16Y24	.	.	+INF	-4278.369
X16Y25	.	6.500	+INF	.
X16Y26	.	1.600	+INF	.
X16Y27	.	1.300	+INF	.
X16Y28	.	3.200	+INF	.
X16Y30	.	3.400	+INF	.
X16Y31	.	5.700	+INF	.
X16Y32	.	0.268	+INF	.
X17Y1	.	.	+INF	-1038.926
X18Y2	.	.	+INF	-4080.269
X18Y4	.	.	+INF	-27.250
X18Y6	.	.	+INF	-1641.269
X18Y10	.	.	+INF	-4777.269

X18Y13	.	.	+INF	-35.250
X18Y14	.	.	+INF	-35.250
X18Y22	.	.	+INF	-57.000
X18Y24	.	.	+INF	-4362.369
X18Y25	.	.	+INF	-23.000
X18Y32	.	6.732	+INF	.
X52Y1	.	.	+INF	-145.771
X52Y2	.	.	+INF	-4214.540
X52Y3	.	.	+INF	-180.021
X52Y4	.	.	+INF	-161.521
X52Y5	.	.	+INF	-169.021
X52Y6	.	.	+INF	-1775.540
X52Y7	.	.	+INF	-169.521
X52Y8	.	.	+INF	-183.521
X52Y9	.	.	+INF	-191.021
X52Y10	.	.	+INF	-4911.540
X52Y11	.	.	+INF	-169.521
X52Y12	.	.	+INF	-169.521
X52Y13	.	.	+INF	-169.521
X52Y14	.	.	+INF	-169.521
X52Y15	.	.	+INF	-224.521
X52Y16	.	.	+INF	-182.021
X52Y17	.	.	+INF	-182.021
X52Y18	.	.	+INF	-168.021
X52Y19	.	.	+INF	-182.021
X52Y20	.	.	+INF	-182.021
X52Y21	.	.	+INF	-160.271
X52Y22	.	.	+INF	-191.271
X52Y23	.	.	+INF	-212.021
X52Y24	.	.	+INF	-4496.640
X52Y25	.	.	+INF	-157.271
X52Y26	.	.	+INF	-212.021
X52Y27	.	.	+INF	-220.771
X52Y28	.	.	+INF	-214.771
X52Y30	.	.	+INF	-187.021
X52Y31	.	.	+INF	-152.521
X52Y32	.	.	+INF	-134.271
X54Y2	.	.	+INF	-8932.246
X54Y6	.	.	+INF	-6493.246
X54Y10	.	.	+INF	-9629.246
X54Y24	.	.	+INF	-9214.346
X19	.	.	+INF	-14.971
X20	.	.	+INF	-33.773

X21	.	.	+INF	EPS
X22	.	.	+INF	-1.023
X23	.	.	+INF	-14.396
X24	.	.	+INF	-4.025
X25	.	417.092	+INF	.
X26	.	.	+INF	-2.274
X27	.	.	+INF	-0.059
X28	.	.	+INF	-11.523
X29	.	.	+INF	-351.947
X30	.	.	+INF	-8.728
X31	.	1.7837E+5	+INF	.
X32	.	.	+INF	-0.134
X33	.	.	+INF	-545.804
X34	.	9083.243	+INF	.
X35	.	.	+INF	.
X36	.	.	+INF	.
X37	.	.	+INF	.
X38	.	8.5165E+5	+INF	.
X39	.	.	+INF	-289.100
X40	.	520.000	+INF	.
X41	.	520.000	+INF	.
X42	.	780.000	+INF	.
X43	.	780.000	+INF	.
X44	.	520.000	+INF	.
X45	.	520.000	+INF	.
X46	.	260.000	+INF	.
X47	.	446.498	+INF	.
X48	.	988.000	+INF	.
X49	.	5.538	+INF	.
X50	.	890.728	+INF	.
X51	.	233.310	+INF	.
X53	.	.	+INF	.
X55	.	.	+INF	-0.200
X56	.	.	+INF	-32.000

LOWER LEVEL UPPER MARGINAL

---- VAR Z -INF 2.2757E+5 +INF .

Z NET REVENUE

**** REPORT SUMMARY : 0 NONOPT

0 INFEASIBLE
0 UNBOUNDED

---- 1209 VARIABLE X.L ACTIVITIES

X7Y6	0.424,	X13Y2	3.000,	X13Y6	1.176
X13Y10	2.000,	X13Y24	4.500,	X16Y1	13.000
X16Y3	10.800,	X16Y4	4.300,	X16Y5	3.300
X16Y7	1.300,	X16Y8	4.000,	X16Y9	1.300
X16Y11	1.000,	X16Y12	1.000,	X16Y13	1.300
X16Y14	5.000,	X16Y15	1.100,	X16Y16	4.500
X16Y17	1.000,	X16Y18	3.500,	X16Y19	2.000
X16Y20	1.000,	X16Y21	3.800,	X16Y22	2.100
X16Y23	4.000,	X16Y25	6.500,	X16Y26	1.600
X16Y27	1.300,	X16Y28	3.200,	X16Y30	3.400
X16Y31	5.700,	X16Y32	0.268,	X18Y32	6.732
X25	417.092,	X31	178374.432,	X34	9083.243
X38	851647.012,	X40	520.000,	X41	520.000
X42	780.000,	X43	780.000,	X44	520.000
X45	520.000,	X46	260.000,	X47	446.498
X48	988.000,	X49	5.538,	X50	890.728
X51	233.310				

---- 1209 VARIABLE X.M ACTIVITIES

X1Y2 -2089.571, X1Y10 -2699.213, X1Y24 -2109.599, X2Y2 -2068.766
 X2Y10 -2580.649, X2Y24 -2380.485, X3Y1 -333.418, X3Y2 -4376.587
 X3Y3 -348.468, X3Y4 -339.568, X3Y5 -347.068, X3Y6 -1953.587
 X3Y7 -347.568, X3Y8 -355.168, X3Y9 -359.468, X3Y10 -5073.587
 X3Y11 -347.568, X3Y12 -347.568, X3Y13 -347.568, X3Y14 -347.568
 X3Y15 -386.568, X3Y16 -360.068, X3Y17 -360.068, X3Y18 -349.268
 X3Y19 -360.068, X3Y20 -360.068, X3Y21 -347.918, X3Y22 -353.318
 X3Y23 -374.068, X3Y24 -4649.087, X3Y25 -338.518, X3Y26 -374.068
 X3Y27 -379.618, X3Y28 -376.818, X3Y30 -355.468, X3Y31 -333.768
 X3Y32 -328.318, X4Y2 -1309.740, X4Y10 -1724.425, X4Y24 -1518.438
 X5Y2 -947.285, X5Y10 -1215.417, X5Y24 -1052.244, X6Y2 -497.678
 X6Y10 -640.015, X6Y24 -554.941, X7Y2 -1767.000, X7Y10 -2272.000
 X7Y24 -1467.500, X8Y2 -1945.683, X8Y10 -2501.735, X8Y24 -2170.699
 X9Y2 -1856.571, X9Y10 -2387.162, X9Y24 -2071.275, X10Y2 -1383.240
 X10Y10 -1778.595, X10Y24 -1542.797, X11Y2 -1847.053, X11Y10 -2366.469
 X11Y24 -2069.958, X12Y2 -1232.930, X12Y10 -1585.339, X12Y24 -1375.758
 X14Y2 -1583.241, X14Y10 -2035.739, X14Y24 -1766.318, X15Y2 -2258.759
 X15Y10 -2715.437, X15Y24 -2781.180, X16Y2 -4002.519, X16Y6 -1606.019
 X16Y10 -4687.019, X16Y24 -4278.369, X17Y1 -1038.926, X18Y2 -4080.269
 X18Y4 -27.250, X18Y6 -1641.269, X18Y10 -4777.269, X18Y13 -35.250
 X18Y14 -35.250, X18Y22 -57.000, X18Y24 -4362.369, X18Y25 -23.000
 X52Y1 -145.771, X52Y2 -4214.540, X52Y3 -180.021, X52Y4 -161.521
 X52Y5 -169.021, X52Y6 -1775.540, X52Y7 -169.521, X52Y8 -183.521
 X52Y9 -191.021, X52Y10 -4911.540, X52Y11 -169.521, X52Y12 -169.521
 X52Y13 -169.521, X52Y14 -169.521, X52Y15 -224.521, X52Y16 -182.021
 X52Y17 -182.021, X52Y18 -168.021, X52Y19 -182.021, X52Y20 -182.021
 X52Y21 -160.271, X52Y22 -191.271, X52Y23 -212.021, X52Y24 -4496.640
 X52Y25 -157.271, X52Y26 -212.021, X52Y27 -220.771, X52Y28 -214.771
 X52Y30 -187.021, X52Y31 -152.521, X52Y32 -134.271, X54Y2 -8932.246
 X54Y6 -6493.246, X54Y10 -9629.246, X54Y24 -9214.346, X19 -14.971
 X20 -33.773, X21 EPS, X22 -1.023, X23 -14.396
 X24 -4.025, X26 -2.274, X27 -0.059, X28 -11.523
 X29 -351.947, X30 -8.728, X32 -0.134, X33 -545.804
 X39 -289.100, X55 -0.200, X56 -32.000

EXECUTION TIME = 0.390 SECONDS VERID MW2-25-069

**** FILE SUMMARY

INPUT C:\QE\BECKYF.GMS

OUTPUT C:\GAMS386\BECKYF.LST

VITA

Tara Elizabeth Hobbs was born in Washington County, Tennessee on November 9, 1971; she was reared in Greeneville, Tennessee, where she attended elementary school in the Greene County School System. In May, 1990 she graduated from Greeneville High School. She entered The University of Tennessee, Knoxville the following August and in May, 1994 received the degree of Bachelor of Science in Agriculture in Agricultural Economics and Rural Sociology. In August, 1994, she reentered The University of Tennessee, Knoxville, obtaining a Master of Science degree in Agricultural Economics in May 1997.

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