Methods for Evaluating Agricultural Enterprises in the Framework of Uncertainty Facing Tobacco Producing Regions of Virginia

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METHODS FOR EVALUATING AGRICULTURAL ENTERPRISES IN THE FRAMEWORK OF UNCERTAINTY FACING TOBACCO PRODUCING REGIONS OF VIRGINIA

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(ABSTRACT)

The purpose of this study was to develop and demonstrate an analytical framework to filter technical and economic information regarding alternative agricultural enterprises in order to enable farmers to make more informed diversification and adjustment decisions. This is particularly important for areas that need to adjust the structure of income sources as a result of dramatic changes in market demand and/or agricultural policy. Tobacco producing regions are currently facing such a problem in the United States. These regions need to consider a wide range of alternatives to maintain or enhance income and standards of living.

The problem involved both strategic economic decisions and operational economic decisions. The method used combined information in the ArcView Geographic Information Systems (GIS) with Linear Programming (LP).

Part of Pittsylvania County, Virginia, served as a case study example. A GIS database including soils and climatic conditions of the study area was created. Soils belonging to land capability classes 1 to 4 were considered for agricultural purposes. Agronomic requirements for specific yield levels of the enterprises considered were tabulated. An ArcView GIS analysis was conducted based on soil map unit symbols. Soil depth, soil series, soil texture, slope, flood potential and average summer temperature were factors associated with yield. Natural drainage, pH, natural fertility, content of organic matter and annual rainfall were factors that served for enterprise budget adjustments. The output of ArcView GIS analysis is maps of physically viable enterprise boundaries or enterprise reference units and tables of attributes for each field.

Marketing of agricultural products that have prices that fluctuate seasonally is feasible only within the period of time called the “market window”. When average historical prices were above total costs, a market window was identified.

The optimal enterprise mix was addressed by LP from a whole farm planning perspective based on the results of ArcView GIS analysis and other constraints, including crop rotations, and irrigation limits. Various levels of tobacco production, vegetable enterprise activity levels, and limits on irrigation were employed to generate, fourteen scenarios. Results include the optimal enterprise mix, net revenue (above variable costs), shadow prices and sensitivity analysis. It is shown that specialty crops are not likely to replace tobacco income, at least in the near term. Developing a diversified farm plan could help farmers to make a smooth transition to other alternatives.

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TABLE OF CONTENTS

Page

Chapter 1 **INTRODUCTION** 1

1.1 Introduction 1
1.2 Problem Delineation and the Justification of the Study 2
1.3 Objectives 7
1.4 A Brief Overview of Methods 8
1.5 Dissertation Outline 9

Chapter 2 **LITERATURE REVIEW** 11

2.1 Developing and Introducing New Crops to Virginia Farmers 11
2.2 Studies in Alternative Agricultural Enterprises Evaluation 14
2.3 Land Evaluation and Agricultural Enterprises Assessment 16
2.4 Spatial Dimension of Farm Management 18
2.5 Farm Level Diversification 21
2.6 Summary of Literature Review 25

Chapter 3 **CONCEPTUAL FRAMEWORK** 27

3.1 Introduction 27
3.2 Relationships Between Agricultural Enterprises 28
3.3 The Principle of Comparative Advantage in Agricultural Production 31
3.4 The Price Effect of a Supply Shock 35
3.5 The GIS Approach to Agricultural Enterprise Evaluation 37
3.6 The Nature of Decision Making and Whole Farm Planning 40
3.7 Summary of Conceptual Framework 45

Chapter 4 **PROCEDURES** 47

4.1 The Study Area 47
4.2 Data Description 51
4.3 GIS and LP Models Specification 52
    4.3.1 The ArcView GIS Model Specification 52
    4.3.2 Linear Programming Model Specification 59

Chapter 5 **RESULTS** 72

5.1 ArcView GIS Results 72
5.1.1 The Production Feasibility Approach 72
5.2 Market Window Analysis 87
5.3 Linear Programming Results 95
5.4 Price Flexibility Implications 114

Chapter 6 **SUMMARY AND CONCLUSIONS** 117

6.1 A Summary of the Study 117
6.2 Conclusions 120
6.3 Limitations of the Study and Suggestions for Further Research 121

LITERATURE CITED 124

APPENDIX A: GIS Database 131

APPENDIX B: Enterprise Budgets 139

APPENDIX C: Mathematically Stated LP Model 163

APPENDIX D: ArcView GIS Result Table 171

APPENDIX E: Terminal Market Prices 181

VITA 191

LIST OF TABLES

Page

Table 1.1 U.S. Farm Cash Receipts From Tobacco and From Total Crops, 1992-97 3

Table 1.2 Value of Main Virginia Crop Production in 1996 and 1997 and Their Estimated Variable Costs 4

Table 4.1 Estimated Acres and Production of Tobacco in Top Five Tobacco Counties of Virginia, 1997........ 48

Table 4.2 Acreage of Main Crops Harvested in Pittsylvania County, Virginia... 49

Table 4.3 Tic Locations Used for Digitizing All Themes........ 53

Table 4.4 Soil Type Layers of the Study Area........ 55

Table 4.5 Budget Example for Fall Broccoli with Sprinkler Irrigation 61

Table 4.6 LP Acreage Constraints for High-Yield Wheat and Corn, Average-Yield Wheat, and Low-Yield Wheat According to Rotation Possibilities........ 65

Table 4.7 The Matrix of Rotation Constraints Used in the LP Model........ 65

Table 4.8 The Description of Selling and Buying Corn Constraint........ 66

Table 4.9 The Description of Irrigation Constraint 67

Table 4.10 Prices, Variable Costs and Yields Used in LP Model 68

Table 4.11 Distinguishing Features and Intentions of LP Scenarios 70

Table 5.1 Factors Affecting Yields Used to Identify Enterprise Boundaries....... 73

Table 5.2 Factors Affecting the Budgets of the Identified Enterprises........ 86

Table 5.3 The Calculation of Transportation Costs per Carton for Tomatoes and Broccoli 88

Table 5.4 Optimal Farm Plans 97

Table 5.5 Total Area Utilized and Net Revenue per Acre for Each Scenario...... 98

Table 5.6 The Average Shadow Price of Land per Acre 100

Table 5.7 Shadow Prices Generated by Each Scenario 102

Table 5.8 Prices and Operational Costs Ranges (Scenarios I to V).................. 105

Table 5.9 Prices and Operational Costs Ranges (Scenarios VI to X)................ 107

Table 5.10 Boundries of Prices and Variable Costs (Excerpt from Tables 5.8 and 5.9).. 109

Table 5.11 Acreage, Livestock and Irrigation Water Ranges 111

Table 5.12 Illustration of the Price Effect of a Significant Increase in Tomato Supply.. 115

LIST OF FIGURES

Page

Figure 2.1 Relationship Between the Return from an Agricultural Enterprise and the Distance of the Farm to the Market Place.............................. 19

Figure 2.2 Distribution of Portfolio Returns for Various Correlation Coefficients... 24

Figure 3.1 Conceptual Model of Agricultural Enterprise Evaluation.................. 28

Figure 3.2 Production Possibility Frontier Describing Competitive Enterprises. 29

Figure 3.3 Production Possibility Frontier Describing Supplementary Enterprises 30

Figure 3.4 Production Possibility Frontier Describing Complementary Enterprises 31

Figure 3.5 Production Possibility Frontier Describing Comparative Advantage of Enterprises.. 34

Figure 3.6 A Simplified GIS Model for Corn Cultivating Site Selection 39

Figure 3.7 An Optimal Choice of Farm Plan Which Maximizes Farmer's Utility.. 42

Figure 4.1 Map of Virginia's Counties and Independent Cities.......................... 47

Figure 4.2 Location of Study Area.. 50

Figure 4.3 The Flowchart of GIS Model for One Enterprise 58

Figure 4.4 The Flowchart of LP Model 60

Figure 5.1 Map of Fields Having High-Tobacco Yield Potential........................ 76

Figure 5.2 Map of Fields Having Average-Tobacco Yield Potential.................. 77

Figure 5.3 Map of Fields Having Low-Tobacco Yield Potential......................... 78

Figure 5.4 Map of Fields Having High-Corn Yield Potential 79

Figure 5.5 Map of Fields Having Average-Corn, Barley, Soybeans, Cotton and Wheat Double Cropped with Soybeans Yield Potential 80

Figure 5.6 Map of Fields Having Low-Corn, Barley, Soybeans, Cotton and Wheat Double Cropped with Soybean Yield Potential................ 81

Figure 5.7 Map of Fields Having High-Soybeans and Wheat Double Cropped with Soybean Yield Potential 82

Figure 5.8 Map of Fields Having High-Wheat Yield Potential 83

Figure 5.9 Map of Fields Having Average-Wheat Yield Potential...................... 84

Figure 5.10 Map of Fields Having Average-Broccoli and Tomato Yield Potential 85

Figure 5.11 Market Window for Tomatoes, Atlanta Market............................... 89

Figure 5.12 Market Window for Tomatoes, Baltimore Market........................... 90

Figure 5.13 Market Window for Tomatoes, Boston Market 90

Figure 5.14 Market Window for Tomatoes, Columbia, SC Market 91

Figure 5.15 Market Window for Tomatoes, New York Market 92

Figure 5.16 Market Window for Broccoli, Atlanta Market................................. 93

Figure 5.17 Market Window for Broccoli, Baltimore Market............................. 93

Figure 5.18 Market Window for Broccoli, Boston Market 94

Figure 5.19 Market Window for Broccoli, New York Market 95

Chapter 1

INTRODUCTION

1.1 Introduction

Annually, farmers need to decide what to produce. They generally have several alternatives available to them based on land characteristics, climate, location of their farm, available technology, production costs, market availability, market price, access to capital and management skills. Agricultural decision making is a dynamic process. The need to reconsider an enterprises mix is dictated by a low level of profitability which either comes from low productivity, high costs, and/or from low prices. Also, farmers evaluate the relative profitability of enterprises because they are in a continuous search for the best economic opportunity for their farm. Enterprise combinations and their magnitude are corrected due to changes in market demand, government regulations, and market competition, among other factors.

Farmers respond in a rational way, which means that, for the most part, they adjust gradually according to their expectations, avoiding shocks when possible. From this perspective they expand an existing enterprise or add a new one, which they believe has good prospects and drop, or decrease, an existing enterprise which is not as profitable. Adding a new enterprise must be done in light of the farm's natural endowments, the requirements of alternatives, production costs, marketing channels, and/or market price for this new product and its interrelationships with other farm activities, making the innovation process one of whole farm planning. Making a right decision, which contributes to a smooth adjustment, requires a lot of information about the farm and enterprises.

Land has some unique features which should be taken into account in farm decision making. Two of them are interesting for this study. First, land cannot be transferred to another location. Other resources must be moved to where the land is located if something has to be produced from that land. Second, the soil type, organic content, acidity, slope and other characteristics differ greatly from parcel to parcel and even from one point to another within a parcel. These soil characteristics have a great influence on what can be produced on that land.

Agricultural production, except for greenhouses to some extent, is influenced by climatic factors such as sunlight, soil and air temperatures, precipitation, and natural hazards. All of these factors are different in different locations.

The question of interest is which crops or agricultural enterprises are the most suitable for a given location with respect to land characteristics, climatic conditions, market proximity and market prices. The quick answer is that they are selected according to the comparative advantage of different enterprises. A lot of research has been done in the field of international trade related to comparative advantage based on the assumption that not all factors of production are mobile (Houck, 1992). Immobility of land, climatic, and environmental conditions make comparative advantage a driving force in trading between regions and regional specialization in production. Comparative advantage changes over time because of investments in land, technology and human capital. Changes in market conditions and government intervention also affect comparative and competitive advantage.

In summary, many rural areas need to develop diversification of enterprises to maintain or enhance income and standards of living. The problem in practice is how to evaluate the alternatives and to determine whether they possess sustainable profitability. An analytical process is needed for this important evaluation. Such a refined procedure in the hands of decision makers will help them in making the right decisions.

1.2 Problem Delineation and Justification of the Study

Tobacco producing regions of the United States are facing a decrease in the domestic demand for tobacco because of changes in consumer preferences and government actions. American consumers are becoming more and more concerned about the effects of tobacco on their health. Virtually all legislatively-based “solutions” being considered involve raising federal taxes on tobacco and increasing prices to consumers. During the period 1992-1995 the U.S farm cash receipts from tobacco decreased. Since

1996, there has been a slight increase that never reached the level of 1992. The cash receipts for total crops constantly increased during the entire period 1992-1997 (Table 1.1).

Table 1.1 U.S Farm Cash Receipts From Tobacco and From Total Crops, 1992-97 (in million dollars)

Item	1992	1993	1994	1995	1996	1997
Tobacco cash receipts	2,958	2,948	2,656	2,548	2,796	2,886
Total crops cash receipts	85,722	87,582	93,072	101,090	106,575	112,097

Adopted from USDA, NASS, Statistical Highlights of U.S Agriculture 1996/97 and 1998/1999, p. 10-11.

Since tobacco is an important source of farm income in many areas of the country, a reduction in tobacco production will eventually worsen the rural income situation in those areas. Tobacco production adjustments will have a significant impact in Virginia. Tobacco is an important economic activity, which has direct and indirect effects on income and employment. Flue-cured tobacco production in Virginia is concentrated mostly in the Southeast (referred to as Southside). Burley production is concentrated in the Southwest. Virginia is the fifth largest domestic tobacco producing state, and it is also ranked fifth in cash receipts from tobacco following North Carolina, Kentucky, Tennessee and South Carolina (USDA, NASS 1998/99, p. 10 and 19). Tobacco for some rural areas of Virginia is not only a source of income but it is part of the family heritage and a lifestyle. Field crops were the second largest commodity group in Virginia, after poultry, in terms of cash receipts in 1997, earning 24.2 percent of cash receipts from all commodities. Tobacco was the biggest source of Virginia's cash receipts from field crops with 22.0 percent of all field crops cash receipts, followed by greenhouse and nursery at 18.9 percent, soybeans at 11.5 percent, vegetables at 9.0 percent, corn at 8.0 percent, wheat at 6.2 percent, peanuts at 5.6 percent, fruits at 5.0 percent, and other crops (includes hay, cotton, barley, etc.) at 13.8 percent (Virginia Agricultural Statistics Bulletin 1997, p.3.)

Tobacco is a labor intensive crop and the value of its production per acre can be compared to that of specialty crops. Table 1.2 gives a rough comparison of profitability between the main Virginia crops. The value of production per acre is a state average for one year and operating costs are typical estimated costs. The table data show that tobacco is a very profitable crop.

Table 1.2 Value of Main Virginia Crop Production in 1996 and 1997 and Their Estimated
Variable Costs (per acre)

Crops	*Value of production per acre 1996 (in dollars)* [1]	*Value of production per acre 1997 (in dollars)* [2]	*Variable costs per acre in 1997 (according to the typical Virginia crop budgets)* [3]
Tobacco	4,019.68	3,908.80	2,412.06
Corn for grain	409.5	251.10	185.65
Soybeans	232.9	143.75	124.48
Wheat, winter	219.95	207.40	148.22
Hay	195.56	151.28	161.62
Tomatoes, fresh market	6,916.11	13,356.06	7,266.32
Potatoes, summer	2,790.8	2,106.67	1,815.50
Barley	197.2	178.51	168.74
Cucumbers, fresh market	1,500	1,437.50	919.77
Bell peppers, fresh market	1,260	2,388.24	1,326.94
Corn, sweet	705.5	500.00	1,618.49
Potatoes, sweet	1,526	1,740.00	1,752.66

1) Virginia agricultural statistics bulletin 1996, Virginia agricultural statistics service 1997, p.2.
2) Virginia agricultural statistics bulletin 1997, Virginia agricultural statistics service, 1998, p.2.
3) Virginia Cooperative Extension, Crop and livestock enterprise budgets, 1997, Publication 446-047, 45 Selected Costs and Returns Budgets for Horticultural Food Crops Production/Marketing, Virginia Cooperative Extension, Publication 438-898, 1994.

Direct employment, including farm operators, full-time equivalent workers and full-time equivalent contract workers, growing Virginia's tobacco are estimated to be in the range of 9,336 to 11,215 (Knapp, 1995). Jobs related to tobacco production including auction warehouses, manufacturing, wholesale, retail input supply, and so forth increase the influence of tobacco on employment. The indirect effect on employment is estimated to be about four times higher than the direct effect, but it is difficult to calculate an accurate estimate and it is often overestimated (Knapp, 1995).

It is thus well established that, with today's conditions, tobacco is the best economic alternative in the areas like Southside, Virginia and, as such, farmers will not switch to other activities unless conditions change and tobacco becomes less profitable than other activities. In an unregulated tobacco market, the return per acre from tobacco will decline. Production would be expected to increase, pushing prices down at the farm level. This means that, to maintain farm income levels, tobacco producers must decrease their per unit costs, perhaps by increasing their tobacco acreage at a time when domestic demand is likely to be falling. Furthermore, the termination of the quota program could remove the barriers to reallocation of tobacco regionally (USDA, Economic Research Service, 1998). There are studies that suggest that flue-cured tobacco will contract or move out of Virginia and will expand in areas such as the coastal plains of Carolinas, south Georgia and north Florida, if the tobacco program is eliminated (Brown, 1998).

Developing alternative agricultural enterprises may not be a substitute for tobacco from the income generating perspective, but farmers that are prepared with alternatives will be likely to suffer less from the adjustment process. According to Gale (1998), 33 counties in the U.S. have a ratio of tobacco receipts to locally earned personal income higher than 10 percent, and 4 of them are in North Carolina and Virginia. This is an indicator of the tobacco dependency of these counties, which should try to develop a wide range of economic alternatives (USDA, Economic Research Service, 1998). A decline in tobacco income will find farmers of these counties unprepared and they will be more likely to encounter severe impacts than other counties that have already created a wider range of alternatives.

In a situation where income from tobacco most likely will decrease, the biggest challenge for farmers will be to find viable alternative uses of land, labor and capital that are now used in producing tobacco. Using the land left from reduced tobacco production for some non-farm activities such as housing or commercial development, may be more profitable, but we assume that not all farmers that need to adjust will have the opportunity to develop their land or have lucrative employment possibilities outside the agricultural sector. Given these two assumptions, this research may help farmers and extension agents to understand the process of assessing alternatives and to make more informed decisions about farm-level diversification and change.

So far, the adjustment of tobacco farms has not produced desirable results. Growth rates in real personal income, employment, earnings per job, and population are lower in the tobacco producing counties than the rate for the state of Virginia (Knapp, 1995). Gale (1997) uses the ratio of average growth in personal income, after adjusting for inflation, to tobacco gross receipts to examine how tobacco counties are adjusting to generate enough income to offset the decline in tobacco income. A ratio lower than one means that the particular county has an economic growth rate that does not cover losses from tobacco income. Results showed that only about half of U.S tobacco counties had a ratio higher than one. The other half, or about 170 counties, had a ratio less than one. Some of these problematic counties are located in Virginia.

Since domestic demand for tobacco is likely to further decrease in the future, despite the fact that Virginia's tobacco is well known in the world market, the foreign demand for tobacco and export competitiveness are going to have a greater impact on tobacco farmers of this region than they have to date (Purcell, 1996). As production increases in other countries, there is no evidence that export demand will grow sufficiently to offset the decline in domestic demand. U.S. cigarette consumption is estimated 2.08 percent less in 1998 compared to 1997, exports of flue-cured tobacco (3-year average) declined 4.49 percent in 1999 compared to 1998, and effective quota of flue-cured tobacco decreased by 17.4 percent in 1999 compared to 1998 (USDA, Economic Research Service, 1999).

In summary, there is a lack of information on the best alternative uses for land currently in tobacco production in Virginia. An analytically rigorous way to evaluate the competitiveness and profitability of alternative enterprises is needed to guide land-owners' adjustment decisions. Farmers are considered price takers. Market forces shape the pattern of resource allocation among competing alternatives within a farm. Information and analytical support is needed to make decisions that comply with these forces. Otherwise the adjustment process will have a higher cost than might be necessary. The support should be provided in the form of a logical decision process which takes into account as much information as it can. It is then the decision makers who should choose the path this process will follow and who will make the final decision according to their preferences, resources, and abilities.

1.3 Objectives

The main objective of this study is to develop an analytical framework for assessing the viability of alternative production activities. A subset of potential agricultural activities in Pittsylvania County, Virginia, will be used as an example to demonstrate the developed procedures. Specific objectives are:

1) To document the characteristics of natural resources that influence agricultural enterprise production such as soil and climatic characteristics for the study area in a Geographic Information Systems (GIS) environment.

2) To adopt or develop a set of crop and livestock enterprises that appear economically viable and profitable for the study area.

3) To examine how these profitable enterprises fit into a whole farm plan that involves varying levels of tobacco production.

4) To develop and analyze a series of scenarios to assess how sustainable the profitable combination of enterprises will be under varying production and marketing conditions.

1.4 A Brief Overview of Methods

An enormous amount of information must be processed to assess enterprises. Therefore, a systematic method is needed to include all that information in the decision making process. One of the advanced methods which can be used in defining the comparative advantage of agricultural enterprises based on physical features and location of natural resources is Geographic Information Systems (GIS).

GIS methods are similar to linear programming (LP) methods. Crema (1996) compared LP with a GIS approach in solving land allocation problems in the presence of multiobjective decision making. Results were similar for both methods in five case studies considering a limited number of alternatives. GIS and LP results became different as the number of alternatives was increased.

GIS models are not representative farm models. They are analytical models of a specific location which can manage a lot of information. The more relevant the information stored in the GIS, the less uncertain the decision based on it will be. Defining the feasibility of specific enterprises based on natural resources does not mean that broader technical progress is ignored. On the contrary, using high payoff inputs such as qualified labor, water, fertilizer, pesticides, and/or high technology machinery may increase yields and reduce production costs.

GIS methods are widely used in supporting decision making in the field of agriculture. Most applications are related to regional economics such as environmental issues associated with resource management, forest management, land management, or government regulations (GIS/LIS ’96 Annual Conference and Exposition Proceedings, 1996, The GIS Applications Book Examples in Natural Resources: a Compendium, 1994). Quite a few applications deal with farm management, and they often address decisions like pest management or farming technology, such as the fertilizer application rates (Weiss, 1996). Such methods are known as precision farming or site-specific technology approaches to farming. The idea is to map the variability of soil characteristics, pest infestations, the current state of vegetative cover, crop yield, and other factors of interest within a parcel and to apply inputs according to the needs of specific sites in the parcel. This is done using GIS and satellite images. Then, by using a global positioning system (GPS) device, the precise spot on the ground is found according to the coordinates of the image. Precision farming may allow for reducing production cost. However, the profitability of this method depends on the cost of information acquired and the degree of factor variability within the land parcel (Weiss, 1996).

The development of new software which is less costly and more effective makes it possible to undertake more GIS analysis. The agricultural economics profession is still taking its first steps in the field of GIS methods and will benefit from the use of GIS in the near future. This study is part of these steps and will serve as an example to make GIS tools more familiar to agricultural economics researchers.

Mathematical programming models can be used to find an integrated optimal farm plan when properly constructed. These models can help to assure that activities taken into consideration are feasible from both the production and market perspective. An optimal farm plan with the optimal size of each enterprise is calculated while enterprises compete for a given amount of limited resources. In order to have more reliable results the feasible region for the optimization problem must be defined in a rigorous way. This is especially important in the case of adding new enterprises to the farm plan. This process includes both agronomic and economic issues. A combination of GIS with LP is in harmony with the nature of the problem in this study.

1.5 Dissertation Outline

The reminder of the dissertation is organized in the following way:

Chapter two is a literature review. The focus is on how different authors have approached the issue of agriculture enterprise evaluation.

Chapter three presents the theory which underlines the problems faced in this study. This is the basis of the empirical model. It is a description of how theory approaches the nature of relationships between agricultural enterprises, comparative advantage evaluation, factors that affect farm income, and the decision making process.

Chapter four starts with a picture of current situation in Pittsylvania County, Virginia and a description of data used in this study. The reason for including this material is to provide a flavor of the potential role of agriculture enterprises in the county and to examine the potential constraints to expanding their presence in the farm plan. The question to be answered is that which are the most profitable among many crops that can be grown in the study area. To answer this question, it is necessary to go through a screening process based on natural endowments and market conditions. The procedures, developed in this chapter, describe this screening process.

Chapter five shows the results of combining GIS analysis, market window analysis and LP. First, the most efficient activities are identified from the production perspective. In order to do that a GIS data model is constructed to take into account all the information about soil (type, organic content, pH, moisture, slope), climate, location of parcels, and crop requirements. Then analysis of a specific query such as which crop requirements have a match with parcel(s) conditions is performed. Overlays of thematic maps are used extensively. Second, timing of the marketing is analyzed by identifying market windows for products that have seasonal prices. Third, based on market constraints, land constraints, and other constraints different scenarios are analyzed for maximizing net farm revenue. The range of parameters for which the optimal solution is not changed is then identified and interpreted in the context of the sensitivity of the results to changes in production and/or marketing parameters.

Chapter six contains a summary of the study, the conclusions, limitations and a general description of problems that need further research.

Chapter 2

LITERATURE REVIEW

This chapter contains a review of literature on introducing new crops and the evaluation of agricultural enterprises. Changes in tobacco production in Southside Virginia will have a significant impact not only in the agricultural sector but also in other industries which are related to it (Wise and Reaves, 1997). Tobacco producers may have different options, based on the characteristics of their farms. Reaves and Purcell (1996) identified four alternatives for tobacco farmers as adjustment actions; remaining in tobacco farming, diversifying, obtaining financing, and finding off-farm employment. Literature related to remaining in tobacco farming and diversifying is explored in subsequent sections of this chapter.

2.1 Developing and Introducing New Crops to Virginia Farmers

The effort to develop new crops in Virginia is being made to introduce more choices to farming communities and to help farmers to tailor their farm plans in such a way that resources can be used more effectively to increase the profitability of the farm.

Welbaum (1993) conducted a survey on projects concerned with the development of new crops in Virginia that were under way at that time. The term “new crop” does not necessarily mean that it is a new agronomic crop. In some cases it means that the crop is not cultivated in Virginia but is cultivated elsewhere in other parts of the U.S or the world. Actually, from 24 projects that were in progress, 15 of them were addressing the adaptation of crops from other regions of United States to Virginia and 9 projects were research on exotic plants. Among other crops, broccoli had been selected to be a potential cash crop alternative to tobacco. Conducted about 10 years from the beginning of the broccoli project, which also had an implementation component, the survey analyzed the impact of the project. Surprisingly, broccoli accounted for less than 100 acres in Southside Virginia. Instead, pickling cucumbers, cotton, and rapeseed were more successful. A comparison is made between broccoli and pickling cucumbers, cotton and rapeseed in order to reveal factors that affected the broccoli project failure. The main factors are discussed below.

First, the decrease in demand for tobacco in the early 1980's was temporary instead of a permanent shift as it was anticipated to be. Second, in the presence of tobacco production other production activities must be compatible with the tobacco schedule. This is the case for pickling cucumbers, cotton and rapeseed but not for broccoli. Third, broccoli needed management skills different and more complicated management than what farmers were used to.

Irvin, (1987), concludes that test plot data were insufficient to support large acres of broccoli production in Southside Virginia and some farmers were not convinced by the extension information and soon quit producing broccoli.

Bhardwaj et al., (1996) present another survey on alternative crop research in Virginia, which describes the projects undertaken since 1991 that are not discussed in the Welbaum survey. From 43 crops that were included in research projects, less than half of them were identified as profitable or high potential crops for different areas of Virginia. Basil, cilantro, cotton, dill, elephant garlic and grapes were classified as profitable crops. Adzuki bean, bitter melon, bottle gourd, canola, castor, chinese cabbage, fuzzy gourd, goldenseal, grain sorghum, kenaf, mungbean, matua, purslane and winter melon were distinguished as high potential crops.

There is discussion about using agricultural niche markets as an alternative for tobacco production (Debertin, 1996). A classic niche market, as the word niche implies, is a small, specific and thin market segment. It exists as an opportunity and it is discovered by firms or it is created by innovative action. A regional perspective for niche markets refers to developing niche markets as resource based niche markets, which leads to the creation of a niche zone, that offers some special products or services. Special natural resources, skills, community heritage, amenities or some other features that make the region unique are used. An individual firm perspective for a niche market refers to developing a new market, as a product based niche market from the existing market.

These firms exploit opportunities to differentiate their product or to supply a particular market segment. Examples can be growing specialty crops such as high quality fresh fruits, vegetables, and organic products.

Whether the niche markets are based on a niche region or on a niche good, there are some unique characteristics that distinguish them from the traditional markets. These characteristics are discussed in the OECD publication “Niche markets as Rural Development Strategy” (1995). Niche markets are characterized by product differentiation, market segmentation and advertising special features of the product. These markets may posses some degree of imperfectly competitive market features because firms in this case find a small specific market segment within which they are able to avoid the market wide competition and substitute products or new entrants. Because the product is so unique, the niche market may generate a higher price. Market demand for the products is heterogeneous and it can be interpreted as the aggregate demand of several demand segments. Preferences and willingness to pay differ across different consumers.

Niche markets are also often characterized by a small demand. One single firm may contribute a high percentage of the aggregate market demand. Demand is not only small in size but also tends to be highly inelastic. This means that for a small change in quantity supplied, there is a big change in the market price. If firms cannot restrict new entrants, the problem is that soon they may face a lower price as quantity supplied increases from new entrants. Since the demand is limited for niche products, a low price may be unable to induce an increase in consumption sufficient to fully compensate for the lower price.

Based on the definition and the characteristics of niche markets, their potential for economic development can be evaluated. Since demand is inelastic, niche markets can be useful if supply is kept limited within a reasonable range or if the firm has monopoly power to maintain the high price in the market. This means that niche markets can have good results for some farms. Debertin (1986), emphasizes that niche markets do not work for the whole agricultural sector. An individual farmer should be cautious about entering niche markets because other farmers may do the same thing. In such cases, farmers should estimate the potential effect of a higher supply on the market price to see whether profitability can be maintained.

Possibilities for niche markets can be found by studying consumers' willingness to pay for goods that are related to a high quality of life such as clean environment, healthy food or modern life style such as away from home food consumption, and so forth. Public institutions should provide information and encourage farmers to benefit from niche market possibilities but at the same time they should make them aware of potential risks involved with the niche markets (Debertin, 1986).

2.2 Studies in Alternative Agricultural Enterprise Evaluation

Identifying competitive crop enterprises in Virginia has been an important topic of past research and continues to engage many current studies. Besides research projects that are focused on introducing new crops in certain parts of the state, as summarized in the previous section, there is other research related directly to economics of enterprise mix and marketing strategies (Coale, et al., Jan. 1994, Sterrett, et al., 1996, Kalo, 1998).

An interesting methodological example on the process of evaluating agricultural alternative enterprises is given by Sterrett et al. (1996). They introduce five steps that should be followed in this process, which are the evaluation of production potential; cost; marketing feasibility; profitability; and risk. Each step is analyzed separately and in the context of the integrated process. The whole farm plan is a demand driven model. This example from the Eastern Shore of Virginia is a general procedure and gives insights on how to combine agronomic knowledge with economic and managerial expertise in order to be successful in adopting a new enterprise. A linear programming model under different scenarios is developed to evaluate farm profitability and farm income variability. Their conclusion, that a unique solution does not exist for all farms but rather for each and every farm, reminds us about the heterogeneity of farm conditions.

Marketing literature addresses the introduction of a new product with rating schemes or product profile analyses that evaluate the many facets of the new product. O'Meara (1973) uses index numbers in rating new products. He identified three factors that influence the overall index number for the product: 1) a group-factor that contains qualitative features of the product as sub-factors; 2) short-term profitability factor; and 3) a long-term profitability factor. The second factor index is calculated as a ratio of expected short-run profits to expected cost. The third factor index is simply the ratio of expected profit to sales. The first factor index, which includes four sub-factors - marketability, growth potential, productive ability and durability - is difficult to calculate directly. It is estimated in a probabilistic way. The expected value is calculated for each sub-factor based on subjective weights of sub-factors and subjective probabilities of success for each sub-factor. Then, the index number of factor one is calculated by applying weights for each sub-factor and multiplying them by the expected values of each sub-factor. The overall index for the new product is calculated by assigning weights for each of the three factors and multiplying them by their individual index. This evaluation is conducted by experts who put weights and probabilities on the sub-factors according to their experience. Alternative products are rated according to their index numbers.

Freimer and Simon (1973) pointed out that product profile analysis is simple to understand and integrates all features of the new product in one number, but it leaves out the interaction among factors. Trying to improve the analysis, they introduced a linear discriminant analysis to calculate the probability of success for a new product. Based on the scores calculated by O'Meara (1973), they calculated a linear function of observed scores, which is a product of the vector of observed scores with the variance-covariance matrix of probability distributions of successful products and failed products, and the difference between the two distributions' mean vectors. Two loss functions are calculated, one for marketing and one for not marketing the new product, which depend on the linear function of observed scores. The adoption decision is made by comparing the losses.

Gillespie, Schupp, and Taylor (1997) examine technical efficiency in a new alternative multiple output enterprise (ratite industry, emu and ostrich) and factors affecting it. Using a linear programming method, they find the optimal weights of each output in the total output and calculate technical efficiency as a ratio of total weighted output to the total weighted input. Then, by using their results and other data, they conduct regression analysis to estimate the factors that influence technical efficiency of this enterprise. Their conclusions show that information and management are the most important factors for the success of a new enterprise. Producers with past experience with a similar production process had a higher technical efficiency.

2.3 Land Evaluation and Agricultural Enterprise Assessment

Land evaluation literature gives interesting insights about agricultural enterprise assessment. Profitability of agricultural production affects the demand for land. Land supply is inelastic. Therefore, a small change in demand for land is reflected in a larger change in land prices. Land price and rent among other things contain the information about profitability of agricultural enterprises allocated to that particular piece of land. This is why studies in land evaluation and farm appraisal deal with the profitability of agricultural production.

In the early 1980's the Soil Conservation Service (SCS) of United States Department of Agriculture (USDA) developed a method for Land Evaluation and Site Assessment (LESA) (Wright, et al., 1983). The goal was to guide local planners in the conversion of land for non-agricultural uses. LESA has two components: land evaluation and site assessment. Land evaluation is an assessment of soil suitability for agricultural use. Factors taken into account are land capability, the importance of the specific area as farmland, and soil productivity. Site assessment considers other factors besides soil to show if the site should remain in agricultural use. Such factors are percentage of area in agricultural use bordering the site, distance to urban areas, the size of farm, land ownership, investments on the land, land use regulations and tax advantages, alternatives to proposed use and compatibility with comprehensive development plans. Points are assigned to each factor. The site with the minimum points may be converted to non-agricultural uses.

Dunford et al. (1983) analyzed the LESA system and pointed out its main advantages and disadvantages. As major advantages they list taking productivity and net returns into consideration in addition to the biophysical properties of soil, providing a wide range of soil classes and developing a method that is consistent and uniform for rating soils. The disadvantage consists of the huge amount of data it requires and in the way the soil potential index, as an indicator of soil productivity, is calculated, which is based only on one crop as a typical crop for the area.

LESA gained popularity among county planners in the mid 1980’s. Actual results of implementing LESA vary from county to county depending on the attitude of community and the ability of local planners (Markert, 1984).

Later studies on land evaluation emphasized the need to assess land suitability for different uses, not just for one crop as a general indicator of the agricultural potential (Warkentin, 1995).

LESA studies are useful for their methodology. Dudal (1986) explains a general procedure for land evaluation developed by FAO in 1976. Two major factors, soil and climate inventories, are compared with crop requirements for these two factors. Since the aim of these studies is to preserve agricultural land, the evaluation is global and takes into account only production potential. The studies are based on the assumption of assessing the long-run viability of the site and not the current viability based on current performance of farm and market. Their results show that the particular land is suitable for producing certain agricultural products, but economic evaluation is not an object of these studies. However, it is appealing to combine this methodology with economic analysis.

Rossiter (1994) discusses Automated Land Evaluation System (ALES) approach to economic land evaluation. ALES evaluates land according to land uses. This is done based on the level of restrictions that land characteristics may impose to yield or land management. GIS is used to evaluate location features of land, such as distance to a market and distance to an urban zone. LP addresses the issue of finding the maximum gross margin, which measures the expected economic value of land.

2.4 Spatial Dimensions of Farm Management

Researchers have wondered about the impact of farm location on the production plan. In some cases they hold all other factors constant, except for the distance to the market, in order to estimate the effect of market proximity. In other studies they are interested in the impact of natural endowments on the prosperity of the farm. Recent research is using GIS methods to tackle the spatial dimension of agriculture and the heterogeneity of characteristics of natural resources that are used in the farming system.

Studying the way agricultural production is located across regions of the United States, Heady and Jensen (1954) analyze factors affecting prices and costs that farmers of different regions face. The price received by local farmers is affected by transportation cost, which in turn is influenced by the bulkiness of the product, perishability and losses in weight during processing. The cost of production is affected by factors such as soil, topography, climate and biological forces. The bottom line is that production patterns follow comparative advantage.

Given the demand from urban areas, agricultural production is organized spatially. Unlike other industries, farming needs space and cannot be concentrated at the same distance to the market.

Lloyd and Dicken (1977) show how the distance to market influences the spatial allocation of agricultural enterprises. They define the expected market return per acre from a given parcel as economic rent of land. Assuming the cost of production to be equal in different locations, the variable to be considered is the distance to the market. Assuming also that there is only one market center, they construct distance-return lines to show the maximum profitable distance to the market for different enterprises (Figure 2.1).

Suppose that line BD is for corn for grain and line AC is for vegetables. The return is higher for vegetables in the distance range to the market OE. Beyond point E, the return is higher for corn production. So, farmers that are located within OE distance to market should produce vegetables and those located within distance ED should produce corn.

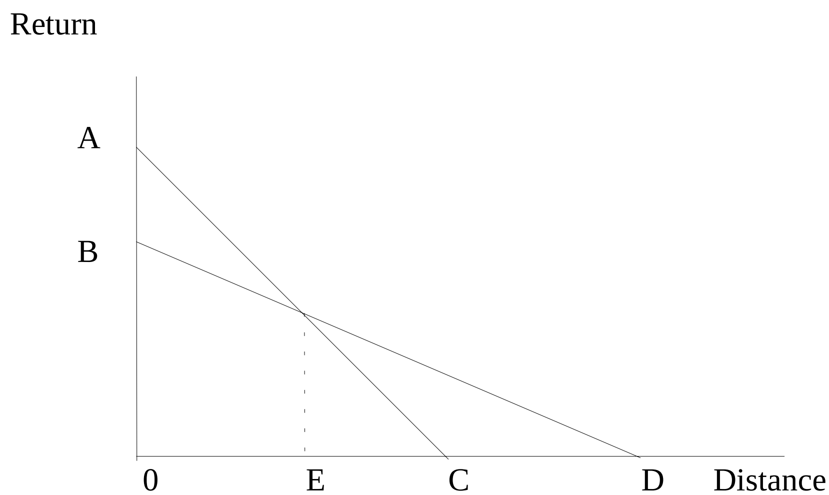


Figure 2.1 Relationship Between the Return from an Agricultural Enterprise and the Distance of the Farm to the Market Place

Greenhut, Norman and Hung (1987) summarize the literature on firm location theories . They classify these theories into groups according to their emphasis. Theories based on cost minimization are represented by Von Thünen and Weber. They assume defined geographic borders for each firm. These theories are developed based on the characteristics of agricultural production. It is assumed that there is no competition to take over a particular location. This limitation led to the development of other theories that are based on oligopoly competition such as the Hotelling model, in which the producers or sellers are located close to each other in the middle of the market. These two theories are integrated into a new theory represented by Lösch, which is based on the aggregate demand and the average cost of a product. A market area is the area within which the marketing of a product remains profitable. The equilibrium market areas that are formed are shown to have hexagonal shapes. A firm location model developed by Greenhut, assuming profit maximization, explains why there is room for relatively high-cost firms in the industry. A few big firms occupy low-cost locations. The demand in high-cost locations pushes the price higher than in low cost locations. High-cost locations are then occupied by many small firms.

Norman and Castle (1967) tested the hypothesis that farm income is lower in the areas that have more choices of what to produce given their natural endowments than in those areas that have few alternatives. The intuition behind this model is that where more alternatives are available, farmers are more risk averse and the opportunity cost of not specializing is lower. So, they are more reluctant to specialize and to introduce a new technology. The potential range of alternatives is quantified by climatic variables, which include the moisture index of the county during the growing season, the potential evapotranspiration of the county during the growing season, the length of growing season and the interaction of the moisture index with the potential evapotranspiration. This study added a new variable to farm income analysis literature, which is the number of available possible choices.

Berry (1994), in a case study, presents a model that addresses the question of how to solve land use discords in Botany Bay, St. Thomas, U.S Virgin Islands. The potential land uses are for conservation, ecological research and residential development. The land for each potential use should have its own characteristics. After matching the land characteristics and required characteristics for each potential use, a map of three potential uses is produced. Since the boundaries of potential uses overlap, a solution is needed given competing uses. This problem is approached in three ways. The first way is to rank the importance of different land uses in overlapping areas. The second method is to show the possibility of multiple uses. The third is to show the trade-off among potential uses of the overlapping areas. The conclusion is that GIS and all other computer methods do not have the power to substitute for the human decision maker. They provide a great deal of help but in the end the decision maker should decide.

Papajorgji, Zazueta, Xin and Moore (1995) present a simulation model using GIS to assess the amount of water required for irrigation in Florida counties. Results of this analysis may be useful for farmers in deciding about establishing an irrigation system for their farm and for water suppliers to analyze the demand for water. The GIS component of the model includes layers for rainfall, land use, soil types, evapotranspiration, temperatures and county boundaries. Monthly water budgets for different crops are compared with the water balance in the soil. Any negative difference gives the amount of water that should come from irrigation. The model is run for different scenarios of water efficiency and parameter variability.

GIS network applications in optimal routing are widely known. Hart (1996) gives an example of using GIS in evaluating the optimal ways to transport fluid milk from dairy farms to processing centers in Virginia.

2.5 Farm Level Diversification

Diversification is often promoted to reduce risk. Heady and Jensen (1954) explain that diversification to reduce risk after the most profitable combination of enterprises and the most appropriate rotations are established could result in a lower income level. This is often the cost of having a low income or net revenue variability.

Delgado and Siamwalla (in Food Security, Diversification and Resource Management: Refocusing the Role of Agriculture?, 1999) show that specialization can increase farm income but that it can also increase income variability and make the agricultural sector more market dependent. Specialization is very risky or may not be possible if output markets, factor markets, financial markets, and markets for insurance are not well developed. They note that from the development perspective, farm diversification is seen as an “objective” in developing economies and as an “outcome” in a commercialized agriculture (p. 127-128).

Johnson examined the farm diversification problem and pointed out that economic literature has treated farm diversification in the same way as portfolio diversification in investment analysis, following Markowitz’ (1952) work on portfolio diversification (Johnson 1967). In his article, Johnson uses the portfolio approach and an application of the separation theorem[1] to find a general solution for the problem of alternative farm enterprise combinations.

Portfolio theory is based on the mean-standard deviation (or variance) rule which means that portfolio A is preferred to portfolio B if:

1) the expected return of portfolio A is higher than the expected return of portfolio B and the standard deviation of expected return of portfolio A is less than or equal to the standard deviation of expected return of portfolio B, or
2) portfolio A has a lower standard deviation of expected return compared to portfolio B and portfolio A has an expected return equal to or higher than the expected return of portfolio B.

This model can easily be adopted to farm management by adjusting the existing constraints or adding new constraints.

Anderson, Dillon and Hardaker (1977) show how the distribution of farm returns is affected by the correlation between individual enterprise returns. Returns from agricultural enterprises depend on price and yield. If returns of different agricultural enterprises are correlated, it may be because their components, prices and/or yields are correlated. Yields could be correlated if crops have similar requirements for soil characteristics, moisture and temperatures, and have the same growing season. Prices of different agricultural products could be correlated if they are substitutes in consumption. A farm with a set of two enterprises, A and B, is being considered. This set of enterprise mix is called a portfolio. Assume that weights of individual enterprises in the portfolio (amount of money invested or acreage occupied) are respectively α and $(1-\alpha)$. The portfolio variance is calculated:

$$Var[\alpha A+(1-\alpha)B]=\alpha^2 Var(A)+(1-\alpha)^2 Var(B)+2\alpha(1-\alpha)Cov(AB)$$

The variance of a portfolio or an enterprise mix depends on the variances of individual enterprises and their covariance. The correlation coefficient is often viewed as a better

[1] The separation theorem states that the decision to invest or to choose a point on the efficient expected return-standard deviation frontier is made separately from the decision to borrow or to lend.

measurement of return interaction between enterprises than covariance. Covariance is an absolute measure and depends on the units of measurement. The correlation coefficient is bounded in the range from -1 to 1. It is therefore more simple to interpret. So, covariance is often referred to by the relationship:

$$Cov(AB) = \rho(AB)s(A)s(B)$$

where:

ρ is the correlation of enterprises' returns, and

s is the standard deviation.

The portfolio variance can now be written:

$$Var[\alpha A + (1-\alpha)B] = \alpha^2 Var(A) + (1-\alpha)^2 Var(B) + 2\alpha(1-\alpha)\rho(AB)s(A)s(B)$$

From the above formula it can be shown that adding a new enterprise in the farm portfolio can reduce the portfolio's risk without decreasing the expected returns of the portfolio. This may happen as long as the new enterprise's expected income has a correlation less than one with other portfolio enterprises. As the correlation approaches -1, it is possible to have a portfolio with risk that approaches zero.

Expected return of the portfolio is the weighted average of enterprises' expected returns. Substituting for ρ=1, ρ= -1, and ρ= 0, a portfolio's standard deviation is calculated. Operating in an expected return-standard deviation space, all possible combinations of returns from enterprises A and B described by mean and standard deviation can be sketched out for various correlation coefficients (Figure 2.2).

In Figure 2.2:

Ea and Eb are the expected returns from portfolio respectively when α =1, and when α =0;

Ep is the expected portfolio return when $0 < \alpha < 1$;

CD (straight line) is the line along which portfolio returns are distributed when ρ(AB) = 1;

CD curve depicts the distribution of portfolio returns when ρ(AB) = 0;

The lines EpD and EpC describe the distribution of portfolio returns in the case of ρ(AB) = -1; and

s(A) and s(B) are portfolio standard deviations respectively when α =1, and when α =0.

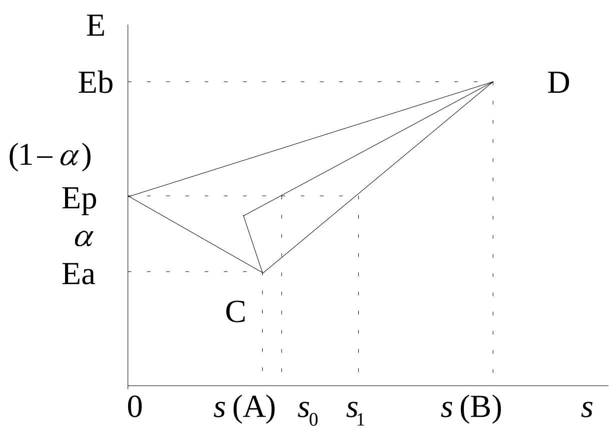


Figure 2.2 Distribution of Portfolio Returns for Various Correlation Coefficients.
Adopted from Anderson, Dillon and Hardaker 1977 (p. 193)

A portfolio with only enterprise A is a low risk portfolio, and a portfolio that is composed only of enterprise B is a high risk portfolio. A mixed portfolio will produce a combination of risk-returns depending on the correlation between expected returns of the individual enterprises. The expected return (Ep) of portfolio with α share of enterprise A and (1-α) share of enterprise B have zero risk in the case of perfectly negative correlation between enterprise returns. The risk corresponding to Ep, in the case of no correlation between enterprise returns, would be s_0 and in the case of perfectly positively correlated returns between individual enterprises, would be s_1.

Heady and Jensen (1954) calculated the correlation coefficients of annual prices for pairs of agricultural products for the period 1910-1950 and concluded that prices were highly positively correlated, although none of them were perfectly positively correlated. None of the correlation coefficients was negative, which could contribute to significant reductions in income variability. These results suggest that diversification cannot reduce income risk coming from price variations very much. However, diversification can do better in reducing income risk resulting from yield variations. The authors show that it is possible to construct an enterprise mix with crops that have different growing seasons and different resistance levels against pests and adverse climatic conditions, such as extreme levels of moisture and temperatures.

2.6 Summary of Literature Review

The purpose of reviewing the literature was to learn how other researchers have approached the problem of evaluating alternative agricultural enterprises and the current status of the research in this area. This work serves as a broad foundation for developing a model.

A number of research projects have been conducted in Virginia in order to develop or adopt new crops in the state. The implementation of these projects requires more research from the economics perspective. Exploiting niche market opportunities may be a successful effort for a limited number of farmers. Niche markets are not likely to be a solution for a large region, however.

Studies that deal directly with the process of evaluating alternative agricultural enterprises present information that helps to understand the problem and potential ways to approach it. Suggestions given include linear programming techniques, market window analysis, product profile analysis or the use of index numbers.

Literature on land evaluation shows how to evaluate the land based on its characteristics and potential uses. The evaluation of agricultural land is conducted based on the profitability of a conventional crop, often corn. In this study the formulation of the problem is placed in a reverse order. The optimal enterprise mix is evaluated based on soil and climate characteristics and management levels. These two approaches are the opposites of each other. The lesson learned from this literature is that a multidisciplinary procedure should be applied to assess soil quality and other technical parameters. Sophisticated economic analysis is missing in land evaluation literature.

Work done in farm management research includes the spatial dimension of agriculture. Techniques that are employed in these studies include distance-return lines, firm location theories, spatial dimensions of soil characteristics and rainfall patterns using a GIS framework. There are also GIS applications in transportation problems.

Literature about farm level diversification gives information that leads to the evaluation of alternative agricultural enterprises in the context of an enterprise mix. Most of the work done in this area has followed a portfolio management approach.

Studying the previous research in evaluating the alternative agricultural enterprises will help in building a model, searching for the appropriate data and finding the tools to conduct an analysis. Understanding the validity and/or insufficiency of prior work will save time and will lead this research effort in the right direction.

Chapter 3

CONCEPTUAL FRAMEWORK

3.1 Introduction

In order to evaluate agricultural alternatives a rigorous analytical framework is required. The methods should describe the algorithm, which selects among the universe of enterprises specific enterprises, which form the optimal mix. This algorithm should screen alternative enterprises one by one and also become a part of a whole farm planning approach.

Figure 3.1 describes the conceptual model of agricultural enterprise evaluation. Individual enterprise screening is done by a method that embodies agronomic, economic and geographic constraints, such as soil, climatic conditions, and enterprise budgets. This screening process is accomplished with a GIS Model. Enterprises that pass this initial screening stage are selected as candidates for finding an optimal mix. Evaluating multiple enterprises involves a method similar to “portfolio management”. This method is called “whole farm planning” and generally incorporates mathematical programming methods.

The following sections examine the economic theory that supports enterprise selection and enterprise combination in order to maximize farm profits. These concepts and principles are used in constructing the empirical model. A general description of the ArcView GIS theoretical model is also presented.

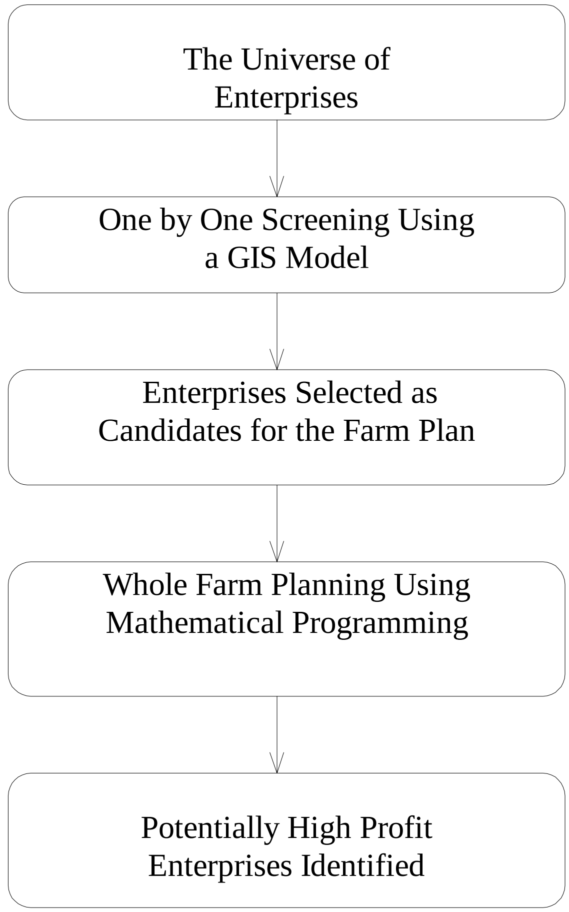


Figure 3.1 Conceptual Model of Agriculture Enterprise Evaluation

3.2 Relationships Between Agricultural Enterprises

Questions of what to produce, how much to produce and how to produce may be addressed by production and market economics. These are also the basic decisions the farmer should make. This study is focused on the first question, what to produce, or more precisely, what combination of enterprises should be chosen. Given the objective function of the farm, which is assumed to be profit maximization, the farmer should choose from feasible enterprises that combination of enterprises which maximizes overall farm profit. According to the relationship that possible enterprises may have to each other, given the limited factors of production, they may be competitive, supplementary or complementary enterprises (Heady and Jensen, 1954).

A production possibility frontier (PPF) describes all possible acreage combinations of crop A and crop B from a total of X acres of land. A set of optimal enterprises or an optimal enterprise “portfolio” is valid within the possible range of production combinations of enterprises. Economics of enterprise mix is constrained by physical relationships of enterprises.

Enterprises are competitive if an increase in the input used by one enterprise results in a decrease in the output of the other enterprise which uses the same input (Figure 3.2).

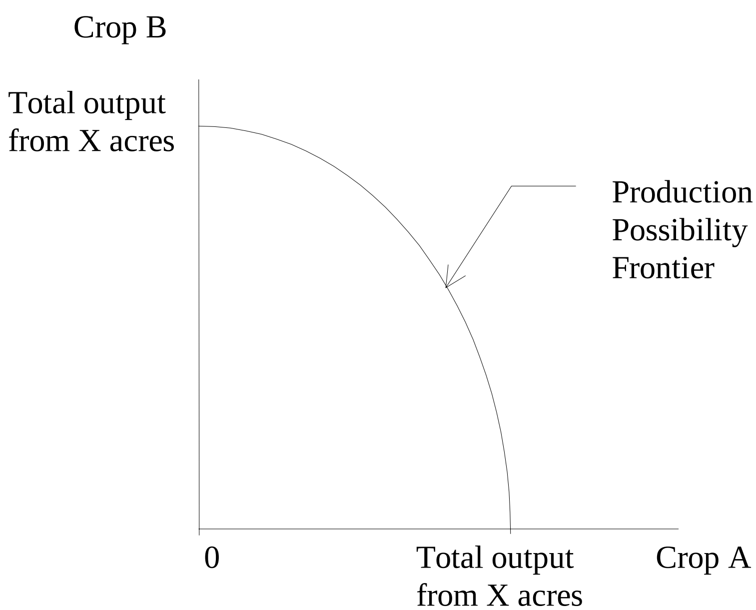


Figure 3.2 Production Possibility Frontier Describing Competitive Enterprises
Source: Adapted from Ronald D. Kay and William M. Edwards

From Figure 3.2 it is clear that going from the origin to the maximum of land acres that can be used in the direction of crop A (B) reduces the output of crop B (A). The profit maximizing combination of these two crops is where:

$$MRPT_{AB} = \frac{P_B}{P_A}, \qquad (3.1)$$

Where: $MRPT_{AB}$ is the marginal rate of product transformation between crop A and B.

P_A and P_B are the respective unit selling prices of products A and B.

An enterprise is supplementary if an increase within some range of its production does not affect the production of the other enterprise which shares the same input. (Figure 3.3). The relationship beyond the supplementary range is a competitive one. A supplementary relationship is one sided which means that, in a two enterprise case, only one enterprise is a supplementary enterprise and the other one is the principal enterprise. The profit maximizing condition remains the same as in the competitive case (equation 3.1), which means that the maximum profit cannot be reached within the supplementary range but within the competitive range.

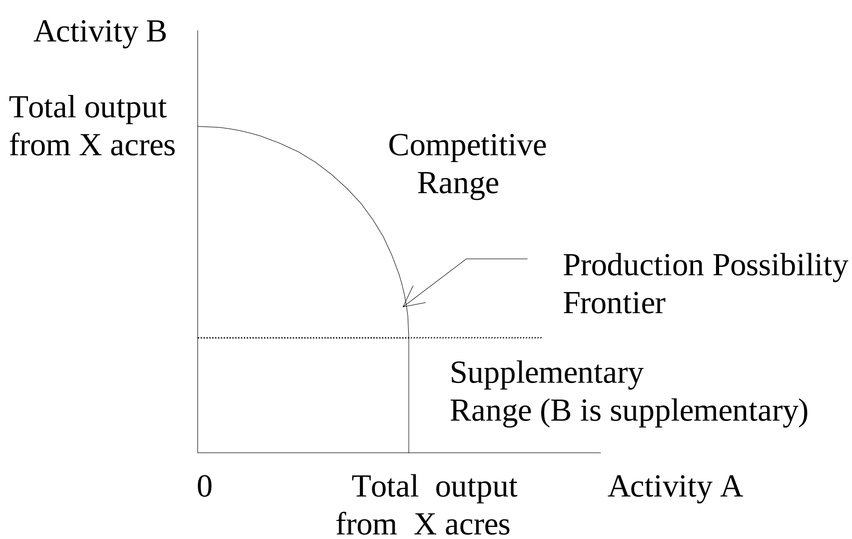


Figure 3.3 Production Possibility Frontier Describing Supplementary Enterprises
Source: Adapted from Ronald D. Kay and William M. Edwards

Enterprises are complementary if their production levels within some range are positively related. A complementary relationship may be one sided or two sided. A one sided complementary relationship means that one enterprise is a complementary one and the other enterprise is a principal one. Both enterprises are complementary within the complementary range in a two-sided complementary case (Figure 3.4).

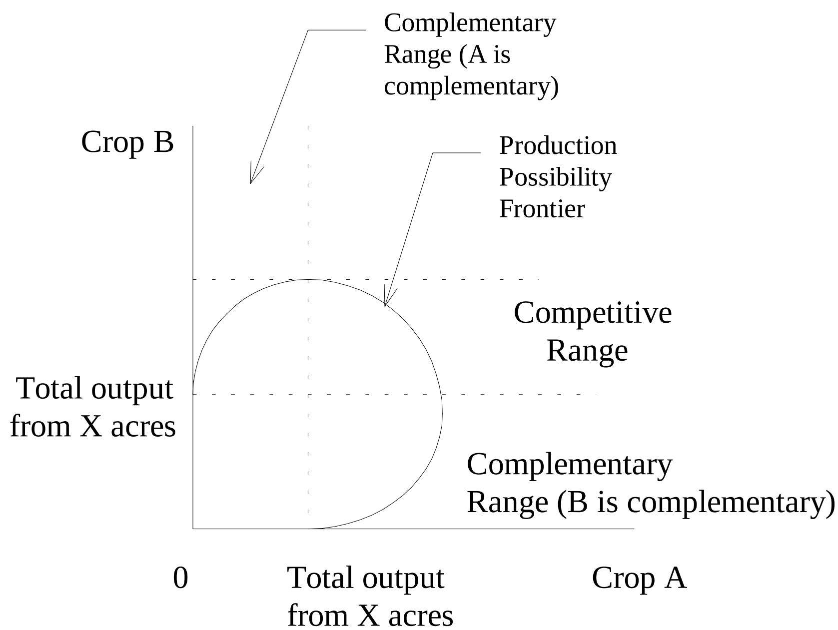


Figure 3.4 Production Possibility Frontier Describing Complementary Enterprises
Source: Adapted from Ronald D. Kay and William M. Edwards

Again, the profit maximizing condition (3.1) holds for this case. The best combination of these enterprises will be found in the competitive range of their technical relationship.

3.3 The Principle of Comparative Advantage in Agricultural Economics

Deciding what to produce is related to both the supply and demand sides of the market. The basic concept, which is the bridge between the geography of agricultural production and agricultural economics, is the comparative advantage principle. This is the reason why different regions specialize in different agricultural enterprises.

Economic literature is abundant with writings about the principle of comparative advantage, but very few of these writings are concerned with local agricultural production. This principle has been and continues to be the domain of international trade. Almost all international trade textbooks, including agricultural international trade literature, treat this principle as the basis for country specialization and trade between nations. David Ricardo (1977), who first formulated this principle in 1817, suggested that each country should produce and export that commodity which it can produce in the most technically efficient manner. He compared two ratios:

$$\frac{a_{11}}{a_{12}} \quad \text{and} \quad \frac{a_{21}}{a_{22}}$$

Where:

> a_{11} and a_{12} are the output of good one and good two per one unit of the same input, produced in country I respectively, and a_{21} and a_{22} are, respectively, the output of good one and good two per one unit of the same input (also the same input as used in country I), produced in country II.

Ricardo only considered labor as an input based on his conception that labor is the only source of value.

If the first ratio is higher than the second, then country I should produce and export good one and country II should specialize in good two. From the above example, it is clear that relative costs of two goods within a country are taken into account. There is only relative advantage that matters in this case, not absolute advantage (Samuelson, 1958). Relative advantage or comparative advantage is the case when the opportunity cost of producing a product in a country is lower than the opportunity cost of producing that product in another country. Absolute advantage is the case when a product costs less in a country compared to another country, including the exchange rates effects.

Heady and Jensen (1954) examine this principle in an agricultural economics setting. They see comparative advantage as a “percentage advantage” (p. 47) in profit margin. The opportunity cost here is considered the foregone profit from the other best alternative. That is why although a farm can profitably produce two or more products, it specializes in producing the product that has the biggest profit per acre in order to achieve the highest profit. This perspective of the comparative advantage principle integrates the concepts of cost, yield and output price.

Farm management literature considers the principle of comparative advantage in strategic decision making (Kadlec, 1985). A farm has a comparative advantage in producing a certain product if its opportunity cost is lower compared to another farm. This means that if the farm wants to produce anything, it should consider the most profitable alternative. From this perspective, the comparative advantage principle is a decision criterion for choosing between alternative enterprises.

Comparative advantage is given to a farm enterprise from farm soils, climatic conditions, and proximity to the market. Most factors of production cannot be moved to other areas. Soil type and climate greatly influence productivity, which is the ratio in physical terms of output units per one unit of input used. Proximity to the market contributes to the cost of transportation. Farms located close to each other share the same climate conditions and proximity to the market, but a farm may have advantage over another farm located in the same area because of the soil types of the land that it controls.

In a perfectly competitive economy, the Pareto efficiency principle requires efficiency in consumption and production. Efficiency in production means that each firm should select an output combination that makes the Marginal Rate of Product Transformation (MRPT) equal for all firms. Firms have incentives to specialize in their relatively more efficient product until MRPT’s are made equal over all firms (Nicholson, 1989).

The Ricardian model of explaining trade flows says nothing about why relative costs are different in different countries. Later research in international trade developed more sophisticated, and also more realistic, models based on factors that determine trade such as factor endowments, technology, preferences and income. For example, the well known Heckscher-Ohlin-Samuelson model is based on factor endowments as determinants of trade (Jones and Kenen, 1984).

International trade is influenced by national currencies and exchange rates, and comparative advantage does not indicate the real pattern of trade. Regional trade within a country is based on the same currency, and the exchange rate impact does not exist. The principle of comparative advantage cannot be used, however, to explain the direction and intensity of trade in the presence of market distortions. Government programs in the agricultural sector, for example, make some crops more competitive in the market than they would be in the absence of the intervention. In this case, the farm does not have an economic incentive to allocate resources to enterprises with real comparative advantage, because it does not compete in a free market. Government influence is very important for farm decision making.

In order to evaluate the comparative advantage or disadvantage of an enterprise, the opportunity cost theory should be considered (Houck 1992). According to this theory, a farm, a region or a specific location has a comparative advantage in producing a certain agricultural product compared to another farm, region or location if it gives up less units of this product for releasing resources to produce an additional unit of another product (Figure 3.5).

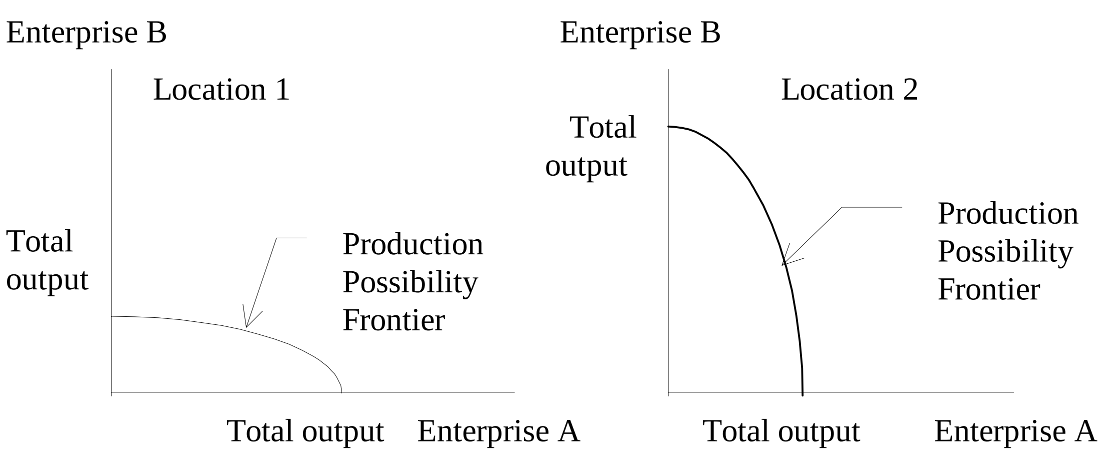


Figure 3.5 Production Possibility Frontier Describing Comparative Advantage of Enterprises

In Figure 3.5 location 1 has a comparative advantage in producing product A, and location 2 has a comparative advantage in producing product B. So, location 1 farms should specialize in producing A and location 2 farms should specialize in producing B. Putting things in a more applicable framework, producers should be guided by the market prices. If the market price for product A is higher than the opportunity cost of producing one additional unit of A in location 1, this is a signal that location 1 farms should produce and market product A.

Comparative advantage is symmetric. If a country or a region has a comparative advantage in producing good one over good two, it has a comparative disadvantage in producing good two over good one.

In order to judge the agricultural enterprise that has a comparative advantage over other potential agricultural enterprises for a single farm, it is not necessary to compare this farm with other farms. Some production alternatives have to exist on a farm. Based on the concept of opportunity cost, farm resources have the least opportunity cost if they are used in the most profitable alternative. This general approach is used in this study for assessing the comparative advantage of one enterprise over other enterprises in a particular area.

3.4 The Price Effect of a Supply Shock

Finding alternative agricultural enterprises that have a good chance to be profitable is a problem for each and every farm. A particular enterprise in some cases may not be a solution for all farms in a region. Individual farms may benefit from niche markets, but more widespread regional specialization may influence market price through a shift in the aggregate market supply curve. This depends on the price flexibility, which is the inverse of the own price elasticity of market demand (Goodwin 1994). The more elastic the demand, the less effect an increase in supply will have on price. In the case of an inelastic demand, a small increase in quantity supplied, will prompt a large decrease in the market price.

Price elasticity of demand for a given product can be estimated using econometric methods. Quantity demanded is a function of own price of that good, prices of other goods, and income. Following Varian (1992), a demand function for a single good is:

$$q = f\left(\frac{p_0}{p_1}, \frac{k}{p_1}\right),$$

where:

p_0 is own price,

p_1 is a price index for all other goods, and

k is income.

Demand functions can be found by estimating the above relationship. A regression equation that could be estimated is:

$$q = \beta_0 + \beta_1 p + \beta_2 y + e,$$

where:

β's are the regression coefficients,

p is the relative price ($\frac{p_0}{p_1}$),

y is the relative income ($\frac{k}{p_1}$), and

e is the error term.

Given the demand function, own price elasticity can be calculated as:

$$\varepsilon = \frac{\partial q}{\partial p}\frac{p}{q}$$

If elasticity is less than -1.0, then demand is elastic. This means that for a percentage change in own price, the quantity demanded will change at a higher percentage in the opposite direction of the price change. If elasticity is equal to -1.0, then demand is unitary elastic, which means that quantity demanded will respond equi-proportionally in the opposite direction to a change in price. Finally, if elasticity is greater than -1.0, then demand is said to be inelastic. In this case, the magnitude of change in quantity demanded is very small for a given change in price.

Since this study is interested in the response of market price to a change in the quantity supplied rather than in the response of the quantity demanded for a change in the market price, the focus is the price flexibility rather than price elasticity. Price flexibility is calculated as the inverse of price elasticity:

$$f = \frac{1}{\varepsilon}$$

It shows the percentage decrease in the price for one percent increase in the market supply. It is clear from the above expression that the more elastic the market demand is, the bigger in absolute value is ε and the less flexible the price is.

Estimation of price elasticity of demand for potential agricultural alternatives is not an objective of this study. Instead, elasticities found in the literature will be used to determine if the market may be quickly saturated and prices decreased significantly through increasing supply.

3.5 The GIS Approach to Agricultural Enterprise Evaluation

The GIS model used in this study is a “cartographic model” (DeMers, 1997,p. 353). Cartographic models are those that use maps as the basic tools for modeling the real world, conducting analysis and displaying results. This is basically a feasibility analysis. The goal is to determine whether a specific site is suitable for stated purposes. A site could be a point or a set of points, a line or some lines, a polygon or some polygons, or a buffer zone around points. In our case, it is a collection of polygons of land that best fit a certain agricultural activity. The required attributes of a specific site in this study are composed of two categories. First, there are the soil characteristics that consist of soil depth, soil texture, slope, and flood potential. Second, there are the climatic conditions, which are represented by average summer temperature.

Some factors can be managed to increase crop yields, but this action could influence crop budgets. These factors are natural drainage of soil, pH, natural fertility, the content of organic matter, and average rainfall. Crop budgets are adjusted according to the cost of intervention. Prices are given and it is assumed that they are the same for all farms of this small area. This accurately reflects the "price taker" status of a farming operation too small to influence overall supply and market price.

This feasibility analysis could generate a unique solution, or no solution. A unique solution is found if a non-empty site is found as the intersection of all sets of required attributes of the given site. There is no solution to this problem if an intersection of all required attributes of the specific site does not exist. It should be emphasized that since there are management options for some attributes, not all required attributes are fixed. Also the importance of these limitations is not uniformly distributed. These observations can lead to some adjustments in the required attributes. In the case of no solution, flexible and not very important attributes can be loosened to the lower bound of the tolerance range to facilitate generation of a solution.

The ArcView GIS model uses the spatial dimensions of soil and climate characteristics and crop requirements to identify borders of sites suitable for each enterprise. The spatial features of the model are only polygons. The enterprise reference units (ERU) are the soil map unit symbols used in the soil survey such as 3a, 4b, 23c and so forth. The output of the ArcView GIS model are maps and attribute tables of those ERU selected as suitable for the specific enterprise.

Figure 3.6 shows a simplified sketch of a unique solution denoted by area "ab". It is derived from polygon overlays by intersection operations. The procedure used is the same as in the theory of sets. Areas that satisfy all required attributes are denoted by one

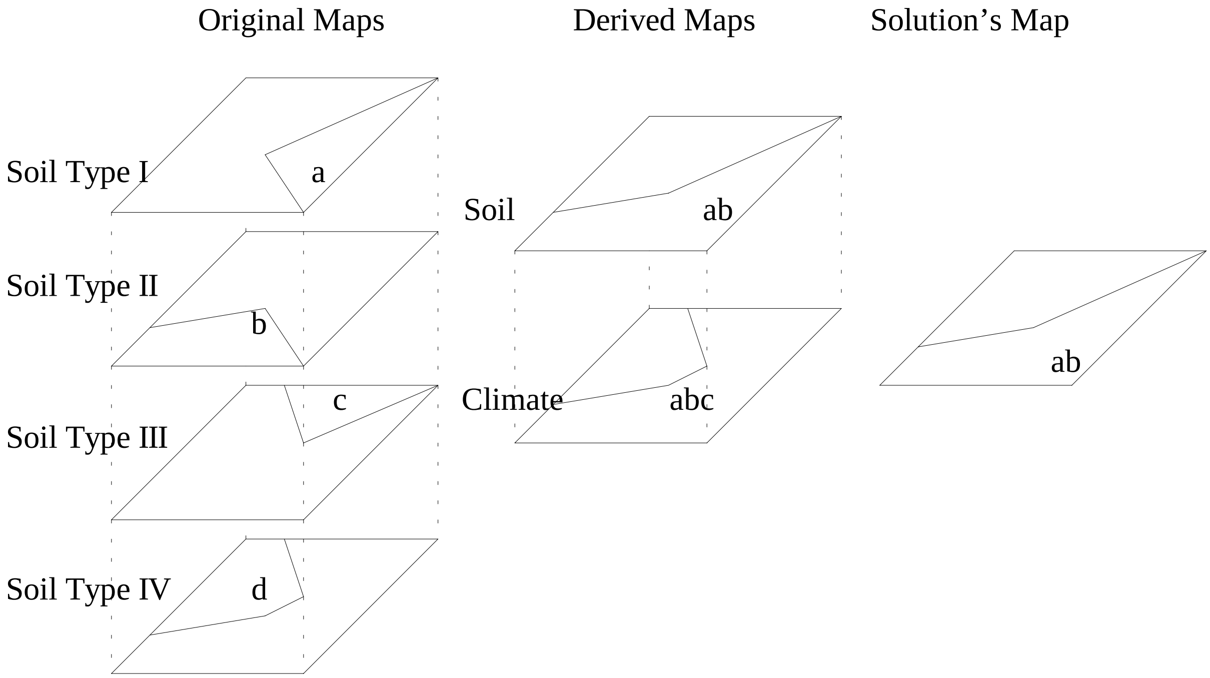


Figure 3.6 A simplified GIS Model for Corn Cultivating Site Selection

or "true", and areas that do not satisfy at least one required attribute are denoted by zero or "false". The result of overlay is the area marked as one or "true". There are several types of polygon overlays. A simple overlay is a binary overlay that can distinguish only yes and no features of the polygons. A more realistic overlay is a multiple factor overlay that can distinguish between the impacts that each feature has on the objective. Other polygon overlay types exist as combinations and automated overlays (DeMers, 1997).

The objective in this example is to find the site that is best for cultivating corn with a given yield level. Required attributes are the features of the site that should be satisfied. They are the suitable soil and appropriate climatic conditions, respectively "ab" and "abc". In this example, only soils in fields "a" and "b" are suitable for the given corn yield. It is assumed that there are two climatic zones. There is a climatic zone that covers soil fields "a", "b", and "c" and another one that covers soil field "d". Only climatic zone “abc” is suitable for this particular corn yield. In Figure 3.6, only area “ab” satisfies both soil and climatic attributes that are required.

A binary overlay is used to show this simplified model. The original maps are data stored as representatives of map images associated with respective tables that contain data describing each independent polygon. The derived maps are obtained by reclassifying base maps according to required attributes. Several intermediate derived maps may be needed to develop the final derived maps because each attribute has some requirements that should be met.

3.6 The Nature of Decision Making and Whole Farm Planning

Decision making in farm management is based on microeconomic theory. Such concepts as marginal cost, marginal revenue, profit, opportunity cost, diminishing returns, marginal rate of substitution, elasticity, risk, and information are the corner stones of the decision process. Farm managers have to choose one or more of available alternatives in order to achieve goals, because farms are constrained by limited resources. Choosing among alternatives is not always easy because most of the time it is a complex evaluation process.

Economic decisions may be strategic or operative. Strategic decisions have to do with the overall organization of the farm. They include choosing among alternative enterprises, specialization versus diversification, borrowing capital, buying land, building facilities, or establishing an irrigation system and so forth. These decisions are very complex and risky. They are long-term decisions that often involve large amounts of investment and, once they are executed, they can not be modified without a huge cost. Complexity comes from the number of available alternatives, complex information and a large number of objectives, which in many cases are in conflict with each other. These types of decisions require a rigorous analysis to be rational and often require a multidisciplinary approach.

Operative decisions are made to implement the operational plan of the farm. In this case, decision variables are more clearly defined. An example is the acreage of land that should be allocated to some given enterprises. Optimization methods are often used to support operative decisions. These decisions are less complex and less risky than strategic decisions, because they cover a shorter period of time and a smaller amount of money is at stake. Some of these kinds of decisions can easily be reversed with a small marginal cost.

Managing means making and executing decisions. There is a goal or some goals that one wants to meet using the smallest possible amount of resources for a given level of revenue or maximizing the revenue per unit of resources employed. In the presence of alternatives, the aim is to choose the optimum way to achieve them. Actually, there is a problem that needs a solution and related actions. That is why the literature emphasizes that economic decision making process should be considered as “a problem solving process” (Hicks, 1991, p. 29) or a process that “always involves a problem or an opportunity” (Castle, Becker and Nelson, 1987, p. 5).

In order to make a decision, a decision rule is required. This rule or criteria is needed to discriminate between alternatives. The decision rule is selected according to the goals and the preferences of decision makers (Moore and Thomas, 1976). The agricultural economics literature has developed a set of decision rules for risky and non-risky situations. They include profit maximization, cost minimization, expected profit maximization, expected utility maximization, mean-variance criteria, maximin criteria, minimax criteria, safety first rules, and the maximum regret rule.

Finding the feasible crops or other farm activities is the first step in making the farm decision about what to produce. Selected enterprises individually may possess high potential but they must be integrated in the whole farm plan. Therefore, the result of interaction of enterprises is needed to be known. In a risky situation, the decision is made in a risk-return framework. As shown earlier in Chapter 2, Section 2.1, adding a new enterprise may increase or decrease farm net income and risk. An ideal desirable new enterprise, assuming that farmers are risk averse, would be one which would increase the farm net income and reduce farm risk. Figure 3.7 provides a framework.

In Figure 3.7, E (r) is the expected farm return, $\sigma(r)$ is the standard deviation of farm return, U is the farmer's expected utility level. The optimal choice is the point of tangency, "A", which is a combination of agricultural activities.

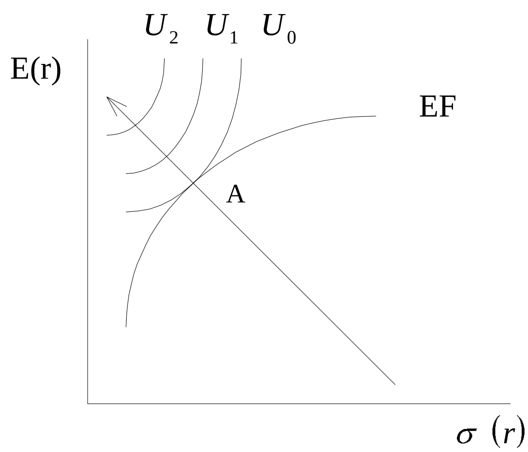


Figure 3.7 An Optimal Choice of Farm Plan Which Maximizes Farmer's Expected Utility.

The efficient expected return - standard deviation frontier is the "EF" line. The arrow shows the direction of preferred portfolio of farm enterprises.

Selecting an optimal farm plan is, conversely, a risky decision. Risk exists in both returns and resource constraints. To make things easy for using known methods of mathematical programming, the variability in resource constraints is considered to be incorporated in the variability of enterprise returns. Furthermore, the time variable is ignored and it is assumed that the decision is a non-consecutive process. This is a strong assumption because in reality the farmer decomposes the initial decision into some partial decisions separated in time (Anderson, Dillon, and Hardaker, 1977).

With the above assumptions the problem of selecting an optimal portfolio of agricultural enterprises could be approached using a quadratic mathematical programming method.

$$Max[C'X - sX'\Sigma X]$$

Subject to:

$$AX \leq b$$

$$X \geq 0$$

Where:

C is the vector of average net returns per acre,

X is the vector of activity levels (acres),

s is the objective function slope,

Σ is the variance covariance matrix of net returns per acre,

A is the matrix of technical coefficients, and

b is the resource limit vector,

The quadratic term is $X'\Sigma X$. The objective function slope is given:

$$s = \frac{\alpha}{2}$$

Where:

α is the Pratt coefficient of absolute risk aversion.

Efficient outcomes of quadratic programming are consistent with those obtained by Expected Utility Model if it is assumed normally distributed returns and constant absolute risk aversion (Barry,1984).

The efficient frontier may be identified by parametrically varying the objective function slope in a risk-return space.

Hazell and Norton (1986) present a simplification of this model and made it suitable for using linear programming. The method is called Minimization Of Total Absolute Deviations (MOTAD). The expected net revenue is assumed to be normally distributed. It can be stated as following:

$$Min \sum_{k=1}^{n} Z_k$$

Subject to:

$$\sum_{i=1}^{n} x_i E(r_i) = \theta$$

$$\sum_{i=1}^{n} a_{ti} x_i \leq b_t$$

$$Z_k + (r_{ik} - E(r_i) x_i \geq 0$$

$$r_{ik} - E(r_i) x_i - \gamma_k + \delta_k = 0$$

$$x_i \geq 0 \text{ for all i}$$

Where:

Z_k is the negative deviation of expected net farm income in year k,

x is activity level (acres),

$E(r_i)$ is the average net return of activity i,

θ is a level of farm income,

a_{ti} are technical coefficients,

b_t is the resource limit of constraint t,

r_{ik} is the return of activity i in year k,

γ is the positive deviation, and

δ is the negative deviation.

The resource constraint may also consist of equal to and greater than or equal to constraints. Rotation constraints and other constraints could easily be added to the model. Solving the MOTAD problem for X for different values of the parameter θ through parametrizing farm income level, the θ_j - σ_j^2 frontier can be presented. The indicator “j” is to show different levels of parameter θ. Variance is calculated by:

$$\sigma_j^{\ 2} = \frac{\sum_{k=1}^{m} \gamma_k^{\ 2} + \sum_{j=1}^{m} \delta_k^{\ 2}}{k-1}$$

Farm enterprise portfolios can be selected from the frontier based on the farmer’s attitude to risk.

Since this study deals with assessing alternative enterprises, which means it introduces some other enterprises to the current farm plan, time series data, necessary for risk programming, are not available. A standard linear programming (LP) model is used instead. In this case, the objective function is assumed to be linear.

LP including MOTAD, which is a linear approximation of quadratic risk programming is not based on economic theory. LP is a pure mathematical method. Unlike LP, quadratic programming traces its roots in economic theory because it is based on a quadratic objective function, which is grounded on a negative exponential utility function. A quadratic function is a second order expansion of Taylor Series approximation of any function.

3.7 Summary of Conceptual Framework

This chapter deals with the theoretical issues related to the modeling of the site - specific evaluation of alternative agricultural enterprises. Most factors of agricultural production are unique and cannot be transferred to other locations. These immobile site-specific factors are the basis of comparative advantage for the particular location. The comparative advantage principle alone, however, cannot explain regional specialization and cannot be used as a practical tool in farm decision making. Market interventions may change the competitiveness of enterprises. Farm resources should be used in those activities that have the least opportunity cost. These activities are the most profitable alternatives. Studying the physical relationships between agricultural enterprises is a starting point in understanding the enterprise mix and the impact of enterprises on each other in the presence of limited resources. The process of selecting enterprises as candidates for the farm plan is based on technical and economic factors. An ArcView GIS model serves as an enterprise screening device. This model uses the spatial dimensions of soil and climate characteristics and crop requirements to identify borders of sites suitable for each enterprise. The spatial features of the model are only polygons. Soil map unit symbols, such as 3a, 4b, 23c and so forth used in the soil survey represent the ERU's. The output of the ArcView GIS model are maps and attribute tables of those ERU selected as suitable for the specific enterprise.

The nature of decision making, in the case of finding an optimal set of enterprises for the study area, involves whole farm planning techniques. These methods are similar to the portfolio management approach. Based on economic theory, quadratic risk programming would be appropriate to address the problem. A standard LP model is used since data available do not support quadratic risk programming.

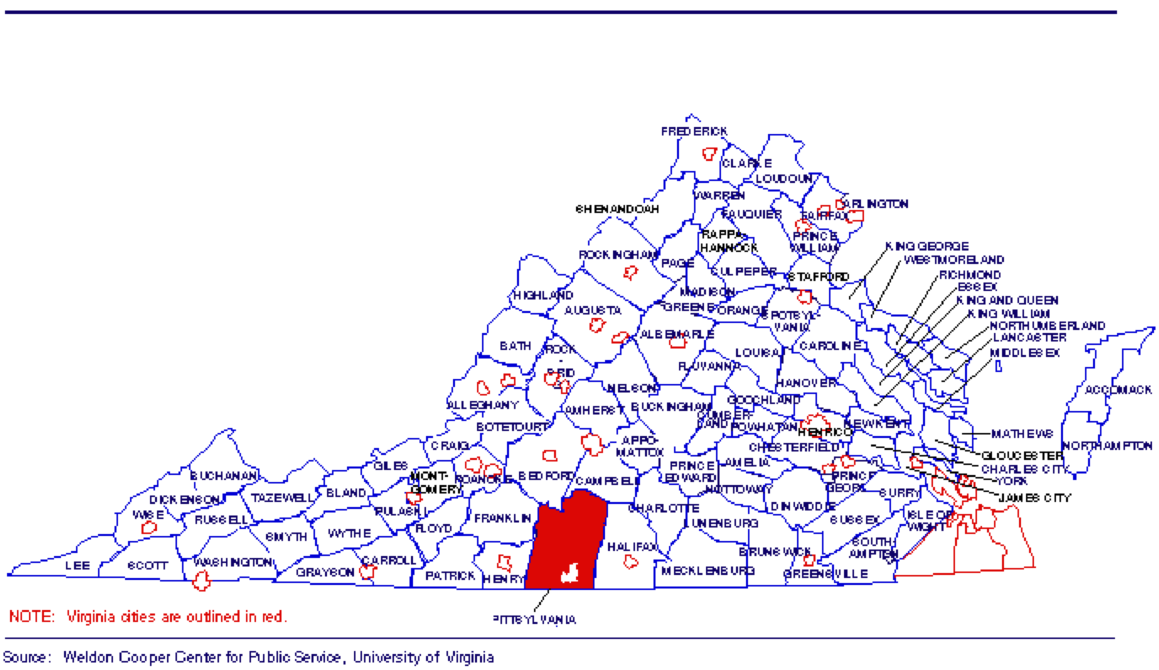
Own price elasticity parameters of demand are used to calculate the price effect of any significant increase in production. This information will prevent farmers from making mistakes by choosing alternatives that look profitable, but cannot maintain profitability, if they are expanded beyond some point that is to be found using elasticity parameters.

Chapter 4

PROCEDURES

<u>4.1 The Study Area</u>

Pittsylvania County is located in the south-central part of the state of Virginia and it is the largest County of the state (Figure 4.1).



Source: Modified from Virginia Tech libraries maps, GIS and cartographic data web page. URL: http://www.lib.vt.edu/subjects/maps/gis.html

<u>Figure 4.1 Map of Virginia's Counties and Independent Cities.</u>

One of the main sources of employment and income is agriculture. Pittsylvania is included in the top 10 Virginia counties that have the highest farm income (Virginia Agricultural Statistics Bulletin 1997). Pittsylvania County is ranked first in the state of Virginia with 2,872 hired farm workers in 1997, followed by Rockingham County with 2,827 hired farm workers (U. S. Department of Agriculture, National Agricultural Statistics Service. *1997 Census of Agriculture*). Washington County, Halifax County and Augusta County had respectively 2,729, 2,458 and 2,057 hired farm workers in 1977.

Based on 1997 census data, Pittsylvania County has 1,235 farms, which have 266,879 acres. This county is ranked sixth in the state in total cash receipts from farm activities with more than $56 million in gross receipts annually. Flue-cured tobacco production of 23,672,000 pounds ranks Pittsylvania the number one county in the state for this crop (Table 4.1).

Table 4.1 Estimated Acres and Production of Tobacco in Top Five Tobacco Counties of Virginia, 1997

Counties	Acres Harvested (% of Virginia Total)	Production (% of Virginia Total)
Pittsylvania	27.32	24.94
Halifax	20.39	18.85
Mecklenburg	13.73	13.93
Brunswick	6.95	9.51
Lunenburg	6.21	6.43
Subtotal Top five	74.60	73.66
Total Virginia	100.00	100.00

Source: Virginia agricultural statistics bulletin 1997, Virginia agricultural statistics service 1998, p.42

The main crops grown in Pittsylvania County besides tobacco are corn for grain, wheat for grain, soybeans for beans, and hay. The acreage of principle crops has changed over time (Table 4.2).

Table 4.2 Acreage of Main Crops Harvested in Pittsylvania County, Virginia

CROPS	1982		1987		1992		1997	
	Acres	% of the top 6 crops	Acres	% of the top 6 crops	Acres	% of the top 6 crops	Acres	% of the top 6 crops
Corn for grain or seed	8,300	11.90	3,816	6.82	3,458	5.95	2,757	4.84
Wheat for grain	14,077	20.18	8,872	15.85	10,807	18.64	8,708	15.28
Tobacco	11,682	16.75	8,926	15.95	11,597	20.01	11,132	19.54
Soybeans	14,892	21.35	8,597	15.36	4,649	8.02	2,565	4.50
Hay-all	20,680	29.65	25,651	45.82	27,359	47.20	31,746	55.72
Land in orchards	123	0.18	114	0.20	99	0.17	67	0.12
Total	69,754	100.0	55,976	100.0	57,969	100.0	56,975	100.0

Source: USDA, 1997 and 1992 Census of Agriculture, Pittsylvania County, Virginia
http://www.nass.usda.gov/

The average size of farms according to acreage is relatively small. The smallest are tobacco farms with 17.62 acres on average in 1992 and 24.79 acres in 1997. This small size is explained by the intense labor requirements and the relatively high profitability of this crop. There is a trend toward increasing the average size of the farm for all crops.

This research is focused on a particular part of Pittsylvania County, half of area 65 of the Soil Survey (Figure A 1 in the Appendix A). This area, which consists of 7,925.99 acres, is located near the city of Danville (Figure 4.2).

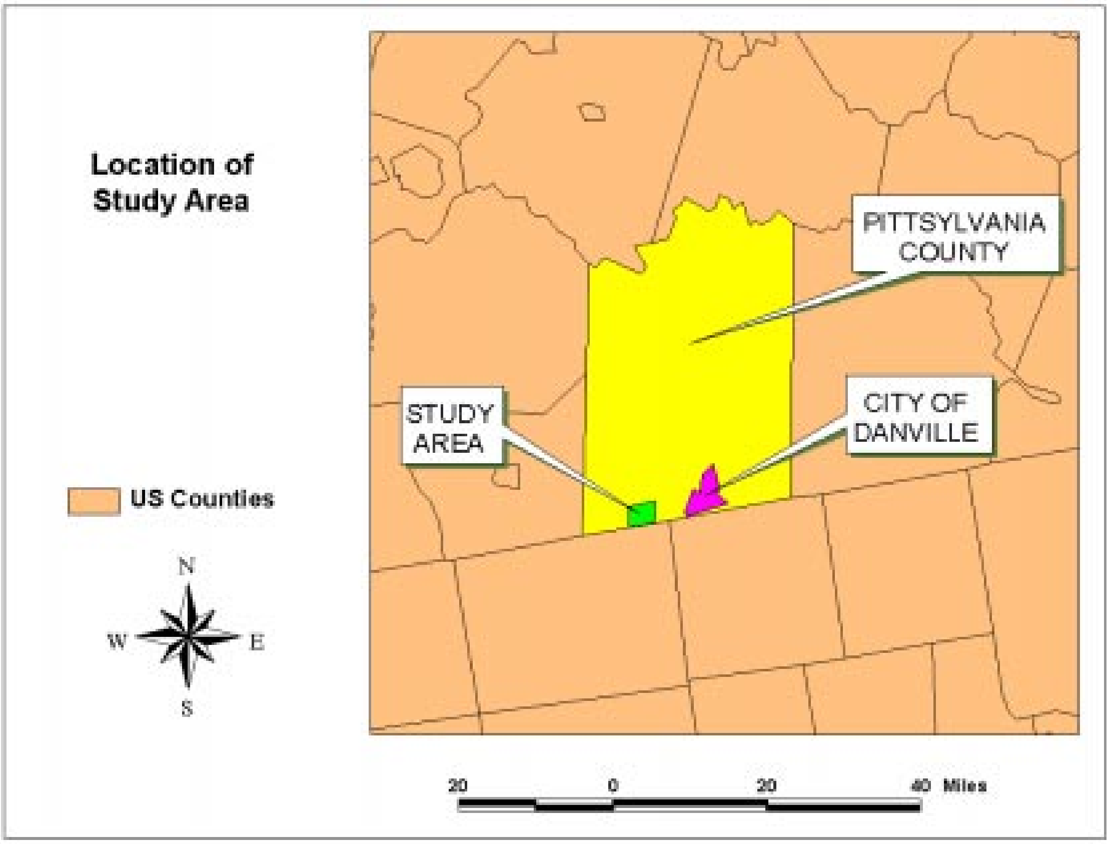


Figure 4.2 Location of Study Area

The reasons for choosing this area are:

1) It is part of Pittsylvania County, where income from the agricultural sector and particularly income from tobacco are high. This means that this area will have a significant impact from tobacco production adjustments.

2) It contains more types of soils, which are included in soil capability classes 1 to 4 and more types of "prime farmland" soil, than other areas of this size in Pittsylvania County. Soil capability classes 1 to 4 in this area consists of 5,471.67 acres or about 69 percent of the total study area. Prime farmland is represented by 10 soil types from 13 types that are present in this County. The study area includes 2,059.43 acres of prime farmland or 37.64 percent of the area of soil capability classes 1 to 4, which are considered in this study. There are no digital data about current vegetation coverage of the study area. It is assumed that soil capability classes 1 to 4 are currently used for

cultivated crops. Other classes that are excluded are supposed to be covered with forest, low productivity pasture, water, or may be residential or commercial areas. Excluded areas consist of 2,454.32 acres or 30.97 percent of the study area.

3) Weather data, especially rainfall data, are more relevant because the Danville weather station is close to the area.

Limiting the research to this area reduces the volume of work and resources allocated for this pilot study. Similar research can be replicated in any other area using the analytical procedures developed and demonstrated here. The primary purpose of this study was to develop and demonstrate a complex "filtering" analytical framework, not to cover the entire county or any broader area.

4.2 Data Description

This research requires data about soil types and properties of each type, detailed soil maps, precipitation and water availability, temperatures, frost dates, potential yields of a wide variety of crops according to land capability given the level of management and modern technology. All these data for area 65 are available in the publication "Soil Survey of Pittsylvania County and the City of Danville, Virginia", 1994. This survey is conducted by the Soil Conservation Service and Virginia Polytechnic Institute and State University.

Soil maps of area 65 and attributes of soil types and climate data are not found in a computerized form. It was necessary to digitize them.

Terminal market prices are found at the University of Florida website (Market Information System, University of Florida. URL: http://mis.ifas.ufl.edu/). This information service is called "Market Information System" and distributes agricultural market information received from USDA Agricultural Marketing Service (AMS). Access to localized price data is a problem, but terminal market price data can be adopted to the model needs. In future applications, more refined and localized prices would be helpful. Price elasticity of demand for vegetables is found in the most recent literature.

Crop and livestock enterprise budgets are modified from Virginia Cooperative Extension publications. Since the study area is close to North Carolina, some enterprise budgets are modified from publications of the Department of Agricultural and Resource Economics, North Carolina State University, Raleigh, North Carolina. These publications are available via the World Wide Web (Department of Agricultural and Resource Economics, North Carolina State University. URL: http://www.ag-econ.ncsu.edu/publications/publications.htm). Crop requirements for soil and climatic conditions are found in "A Handbook of Agronomy" (1984), a publication of Virginia Cooperative Extension Service, and consultations with Southside Virginia counties extension agents. Parameters for yield factors and budget adjustments according to soil characteristics and specific crop requirements are based on the Virginia Tech publication "The Development and Implementation of the Virginia Agronomic Land Use Evaluation System (VALUES)" (Simpson, T. W., et al., 1993) and "Practical Handbook of Agricultural Science, (Hanson, 1990).

4.3 The GIS and LP Models Specification

Given the information about the resources of the farm and market conditions, a final decision is required about what to produce on a particular farm. The inputs and the nature of outputs are known. What is missing is a processing device, which translates the inputs into specific outputs. The device in this study as explained and demonstrated in earlier chapters is a combination of ArcView GIS with Mathematical Programming.

4.3.1 The ArcView GIS Model Specification

The ArcView GIS method is a well established program referred to as a "full featured desktop GIS software" that "continues to set the standard for desktop GIS functionality and performance" (Arc News, 1998,Vol. 20, No. 2, p. 2). Another reason for choosing ArcView GIS to accomplish this study is that it has an interface that is user friendly and map printing is easier than in other GIS programs.

In this study, intermediate themes or derived themes from original themes and theme overlay are widely used. Databases are the foundations of this method. That is why this is the starting point of the model. Establishing the databases requires clear objectives and sequential steps of analysis. This process is very time consuming, therefore using ready made databases wherever possible is highly recommended. Unfortunately, soil survey data are typically not computerized. A soil database was needed for this study. It was developed as documented below.

First, a base map was created in order to define the borders of thematic maps. Performing overlays requires an exact match of coordinates. Therefore, real-world coordinates converted to decimal degrees were registered in a separate file. They were used as marks or reference points and are called “tics”. Tics are points for which coordinates are known. Detailed soil survey maps show longitude and latitude of the corners of each map sheet. They are used as coordinate references during the digitizing process. After digitizing, ArcView is able to show the coordinates of every point within the digitized area. This is necessary for locating the borders of crop enterprise fields. Table 4.3 shows the locations of tics that were used for digitizing every theme. They are the coordinates of corner points of the study area.

Table 4.3 Tic Locations Used for Digitizing all Themes

Tic Number	X Coordinate (longitude)	Y Coordinate (latitude)
1	-79.62500	36.54160
2	-79.62500	36.58330
3	-79.56250	36.58330
4	-79.56250	36.54160

The calculation of decimal degree coordinates from standard latitude and longitude coordinates was done according to this formula:

$$d, m, s = d + \frac{m}{60} + \frac{s}{3600}$$

Where:

d are the degrees, m are the minutes and s are the seconds.

The decimal degree coordinate -79.625 is calculated from the longitude $-79^0 37^' 30''$ in the following way:

$$-79^0 37^' 30^{''} = -79 + \frac{37}{60} + \frac{30}{3600} = -79.625$$

Other decimal coordinates were calculated in a similar way.

The maximum allowable error was set at 0.05, which for the scale 1:24,000 means 100 feet of ground error. Actual error was 0.032, which corresponds to 64 feet error in the ground.

A layer (which is called a theme in ArcView) was formed for each type of soil which is included in land capability classes 1 to 4. Other land classes are of no interest for this study. Hence, a database for soil types is prepared. The types of soils found in the study area according to the Soil Survey of Pittsylvania County and the City of Danville, Virginia, (1994) which are digitized for this study, are listed in the Table 4.4. Along with the maps for each soil, tables that contain characteristics of each soil and climatic data for the region are constructed (See Appendix A).

Table 4.4 Soil Type Layers of the Study Area

No	Soil Name	Soil Map Unit Symbol	Area (acres)
1	Appling sandy loam, 7 to 15 percent slopes	1C	0.17
2	Ashlar fine sandy loam, 7 to 15 percent slopes	2C	5.62
3	Bolling fine sandy loam, 0 to 2 percent slopes	3A	39.50
4	Bolling fine sandy loam, 2 to 7 percent slopes	3B	117.94
5	Cecil sandy loam, 2 to 7 percent slopes	4B	83.06
6	Cecil sandy loam, 7 to 15 percent slopes	4C	41.57
7	Cecil sandy clay loam, 2 to 7 percent slopes	5B3	103.22
8	Cecil sandy clay loam, 7 to 15 percent slopes	5C3	81.40
9	Chenneby loam, 0 to 2 percent slopes	7A	499.09
10	Creedmoor fine sandy loam, 2 to 7 percent slopes	9B	230.66
11	Cullen loam, 2 to 7 percent slopes	10B	3.39
12	Cullen clay loam, 7 to 15 percent slopes	11C3	51.07
13	Hiwassee loam, 2 to 7 percent slopes	17B	158.35
14	Hiwassee cobbly sandy loam, 7 to 15 percent slopes	19C	0.33
15	Madison fine sandy loam, 15 to 25 percent slopes	21D	65.54
16	Mattaponi sandy loam, 2 to 7 percent slopes	22B	104.79
17	Mayodan fine sandy loam, 2 to 7 percent slopes	23B	1078.54
18	Mayodan fine sandy loam, 7 to 15 percent slopes	23C	1308.19
19	Mayodan fine sandy loam, 15 to 25 percent slopes	23D	388.68
20	Pacolet fine sandy loam, 15 to 25 percent slopes	26D	106.20
21	Pinkston cobbly sandy loam, 7 to 15 percent slopes	28C	90.00
22	Rion fine sandy loam, 7 to 15 percent slopes	32C	10.00
23	Riverview silt loam, 0 to 2 percent slopes	33A	209.10
24	Sheva fine sandy loam, 2 to 7 percent slopes	34B	189.36
25	Sheva fine sandy loam, 7 to 15 percent slopes	34C	93.89
26	State sandy loam, 0 to 4 percent slopes	35B	15.04
27	Stoneville silt loam, 2 to 7 percent slopes	36B	79.59
28	Stoneville silt loam, 7 to 15 percent slopes	36C	103.06
29	Toccoa fine sandy loam, 0 to 2 percent slopes	38A	185.20
30	Wickham sandy loam, 2 to 7 percent slopes	42B	29.18

Poor soil and climatic conditions have their impact on agricultural enterprises. The effect could be:

1) A decrease in yield,
2) A decrease in product quality, which influences the selling price, or
3) An increase in the cost of production.

Data were classified according to three group constraints or enterprise requirements for soil attributes, climate and factors for adjusting enterprise budgets.

<u>I Soil Requirements</u>

In this group are included soil factors that affect productivity. These factors are considered as they are without accounting for their improvement, because they cannot be improved with a reasonable cost. They are:

1. Soil depth,
2. Soil series,
3. Soil texture,
4. Slope, and
5. Flood potential.

<u>II Climatic conditions</u>

The climatic constraint that can not be changed but should be addressed is:

The average summer temperature.

<u>III Crop budget adjustments</u>

Limitations due to slope, organic matter content, natural fertility, moisture deficit or surplus, and soil pH have an impact on the yield and quality of product. The same crops that have different yield or different quality product are considered different enterprises. Part of the yield effect can be corrected but since this may cause an increase in costs so, it is embodied in the budget effect. Assuming that input prices are the same for all local farmers, the crop budget for different areas can be different due to these factors:

1. Natural drainage,
2. Soil reaction (pH),
3. Natural fertility,
4. Organic matter content, and
5. Rainfall.

The selection of the suitable enterprises for different land may be approached based on yield factors. Factors that affect yield and yield levels are based on “The Development and Implementation of the Virginia Agronomic Land Use Evaluation System (VALUES)”, Tables A1 and A10 (Simpson, T. W., et al., 1993,) and “Practical Handbook of Agricultural Science, (Hanson, 1990). Crop yields are grouped in three category; high, average and low. Once the fields are identified as suitable for certain enterprises according to yield classification, the corresponding factors that are used for adjusting the enterprise budget are attached.

Figure 4.3 summarizes the steps taken to reach the solution in the GIS model. First, soil fields are digitized as independent working units. An identification number (ID) is assigned to each field in the attributes table. Then, characteristics of each field, such as soil depth, soil series, soil texture, slope and so forth are saved as a database IV file in Excel. This database is joint with the attributes table based on respective ID’s. A new theme is created by joining all individual soil type themes. Each field still remains an independent working unit. This new theme is converted into a grid theme in order to conduct overlays. Overlay with intersection means that maps are overlaid using the “intersection” operator. An “intersected area” is the common area of all maps that have the characteristics of interest. More detailed explanation is given in Chapter 3, Section 3.5. Overlays are used for finding the suitable fields for each enterprise based on climatic and soil requirements. Finally, factors that influence enterprise budget costs are attached to each respective field.

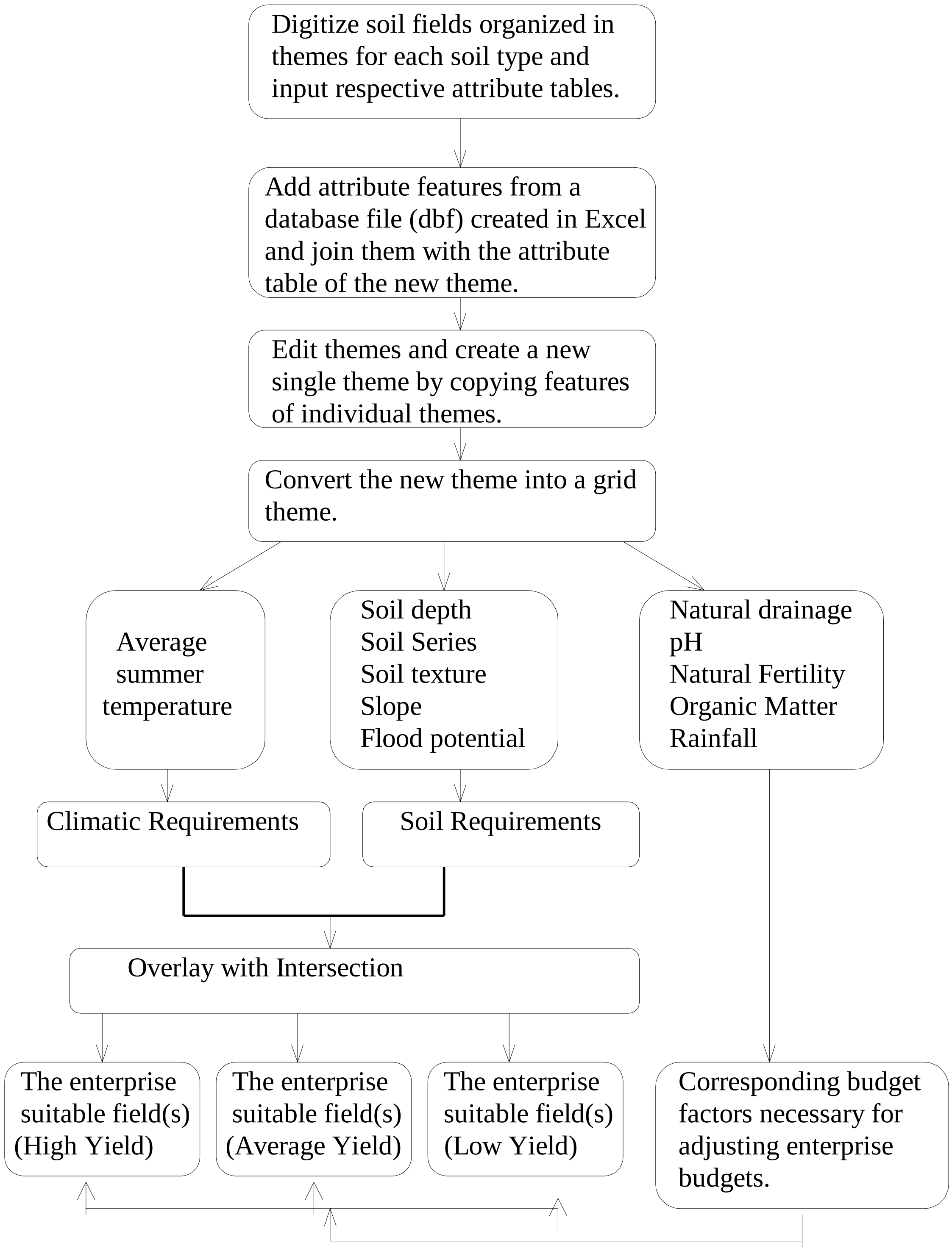


Figure 4.3 The Flowchart of GIS Model for One Enterprise

Results obtained in this phase of the study indicate crops with the highest physical efficiency for each parcel of land. High physical efficiency is a necessary but not a sufficient condition for an enterprise to be included in the farm plan. The issues that still need to be evaluated are market availability and expected price. In order to determine when products should be marketed, cost and price marginal analyses are performed and market windows for different products are identified.

Finally, since resources are limited, enterprises compete with each other in order to find the best solution for the farm plan. This evaluation is accomplished using linear programming.

4.3.2 Linear Programming Model Specification

The GIS approach using combinations of enterprise requirements and natural resource endowments is a method to determine enterprise feasibility in terms of production efficiency. After determining feasible options, whole farm planning is addressed based on LP models and algorithms to find an optimal farm portfolio or enterprise mix. Figure 4.4 describes the procedure of LP model. Objective function and constraints are modified to accommodate the features of 10 scenarios.

Enterprises

Activities considered in this study are a sample of enterprises to be used for demonstrations in the study area. They were selected in consultation with farm management specialists of Virginia Cooperative Extension Service (Sturt and Snodgrass, personal communication). The GIS component of this study will find the best sites for each enterprise and exclude those enterprises that are not feasible for reasons of soil quality, water inadequacies and so forth. Enterprises considered are tobacco, corn, barley, wheat and soybeans double cropped, cotton, wheat, soybeans, broccoli, tomatoes, beef cows calving in the spring, and contract swine production. The selected enterprises were intended to be an exhaustive listing of different types of enterprises that could be suitable for the study area.

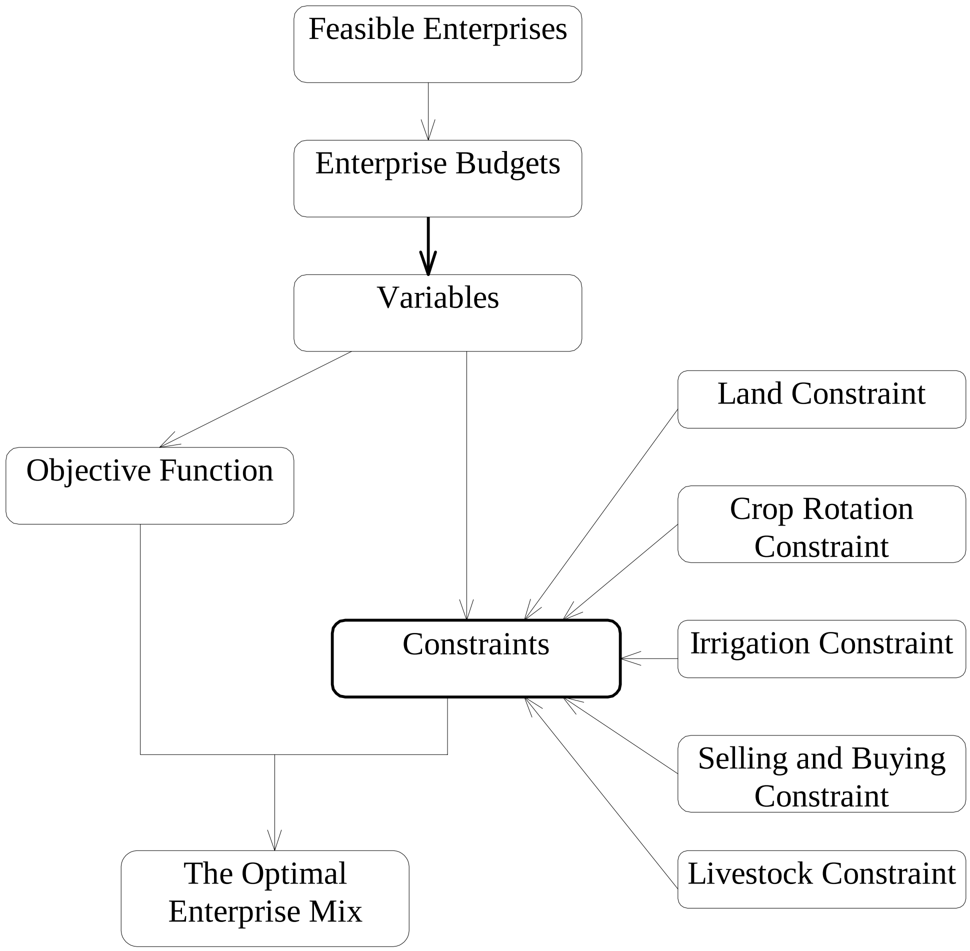


Figure 4.4 The Flowchart of LP Model

Enterprise Budgets

Enterprise budgets are needed in order to specify the LP parameters. Budgets prepared by sources cited at end of each budget are modified, based on characteristics and limitations of soil types, topography and climate conditions. Prices received, except for vegetables, are the averages observed in the last five years. They are found in the Virginia Agricultural Statistics Bulletin 1997. Prices of broccoli and tomatoes are calculated as five year averages and represent the most profitable terminal markets identified for the study area using market window analysis. Trade or brand names are used in the budgets to make the presented information easy to understand. Using these names does not mean the approval of the product to the exclusion of other similar products and does not assure the standard of the product. An example of such budgets is given in Table 4.5. Budgets of all enterprises considered in the LP model appear in Appendix B.

Table 4.5 Budget Example for Fall Broccoli With Sprinkler Irrigation (1999)

	Budget for 1 acre, expected yield, 370 boxes 20 lb each			
Item	Unit	Quantity(units)	Price ($)	Total ($)
Receipts	20 lb box	370	10.18	3766.60
Operating Costs				
Seed	lb	1.00	160.00	160.00
Lime	ton	0.20	25.00	5.00
Fertilizer: Nitrogen	lb	145.00	0.24	34.80
Phosphate	lb	100.00	0.24	24.00
Potash	lb	145.00	0.15	21.75
Spreading	acre	1.00	6.00	6.00
Herbicides	acre	1.00	30.06	30.06
Insecticides	acre	5.00	13.55	67.75
Fungicides	acre	1.00	9.81	9.81
Fuel, Oil, Lube,Repairs	acre	1.00	80.02	80.02
Labor	hour	20.00	6.25	125.00
Supplies: Boxes	each	370	1.00	370.00
Hauling, Grading	box	370.00	1.00	370.00
Harvest Labor	box	370.00	1.00	370.00
Cooling	box	370.00	0.50	185.00
Interest on 6 month Operating Capital	$	1364.19	9.00%	61.39
Total Operating Costs				1920.58
Variable Cost per box				5.19
Fixed Costs: Irrigation	acre	3324.00	20.46%	680.09
Other Fixed Costs				315.27
Total Fixed Costs				995.36
Total Costs				2915.94
Total Cost per box (except land & Mgmt.)				7.88

Source: Modified from “Virginia Cooperative Extension, 1999 Crop Enterprise Cost Analysis for the Eastern Shore of Virginia”.

Objective Function

The goal of the optimization model is to find levels of activities represented by acres that should be allocated to each crop, or number of animals in the case of livestock enterprises, that produce the highest net return for the whole farm. It is assumed that farmers as economic agents seek to maximize net revenue or profits. Thus, the objective function of the LP model is to maximize net revenue as returns to land, management and capital. Variables of this problem are the number of acres, the number of livestock and buying and selling variables. Net revenue is an estimated net revenue because yields, output prices, input prices and quantity of inputs to be used are all estimates. The objective function is stated as follows:

$$MaxR = \sum_{i=1}^{n} p_1 * s_i - \sum_{i=1}^{n} c_i * a_i + \sum_{j=1}^{m} p_2 * s_j - \sum_{j=1}^{m} c_j * a_j$$
$$+.........+\sum_{l=1}^{k} p_9 * s_l - \sum_{l=1}^{k} c_l * a_l + p_{10} * Bec + p_{11} * Cos$$

Where:

R is the net revenue,

$p_1, p_2, ... p_9$ are market prices of sold products (weighted average price for wheat double cropped with soybeans),

$s_i, s_j, ... s_l$ are the sales of products from each enterprise,

$c_i, c_j, ... c_l$ are operating expenses for each enterprise,

$a_i, a_j, ... a_l$ are acres of each crop enterprise,

p_{10} is the net revenue per cow, and

p_{11} is the net revenue per pig placed on the farm.

The notation of variables show that not all crops have high, average, and low yields. Some yield levels are excluded for some crops based on production feasibility analysis. Variables are specified as following:

Ptob1, Ptob2, Ptob3 are sales from respectively high-, average-, and low-yield tobacco.

Pcor1, Pcor2, Pcor3 are sales from respectively high-, average-, and low-yield corn.

Pbar2 and Pbar3 are sales from respectively high-, and average-yield barley.

Pwds1, Pwds2, Pwds3 are sales from respectively high-, average-, and low-yield wheat double cropped with soybean.

Pwhe1, Pwhe2, Pwhe3 are sales from respectively high-, average-, and low-yield wheat.

Psoy1, Psoy2, Psoy3 are sales from respectively high-, average-, and low-yield soybeans.

Pcot2 and Pcot3 are sales from respectively high-, and average-yield cotton.

Pbroc2 is the sale of average-yield broccoli.

Ptom2 is the sale of average-yield tomatoes.

Tob1, Tob2, Tob3 are acres of respectively high-, average-, and low-yield tobacco.

Cor1, Cor2, Cor3 are acres of respectively high-, average-, and low-yield corn.

Bar2 and Bar3 are acres of respectively average -, and low-yield barley.

Wds1, Wds2, Wds3 are acres of respectively high-, average-, and low-yield wheat double cropped with soybean.

Whe1, Whe2, Whe3 are acres of respectively high-, average-, and low-yield wheat.

Soy1, Soy2, Soy3 are acres of respectively high-, average-, and low-yield soybeans.

Cot2 and Cot3 are acres of respectively average -, and low-yield cotton.

Broc2 is the acreage of average-yield broccoli.

Tom2 is the acreage of average-yield tomatoes.

Bec is the number of cows.

Cos is the number of pigs placed in contract production programs per year.

Buying and selling variables are:

Scor1 is the amount of high-yield corn to be sold.

Scor2 is the amount of average-yield corn to be sold.

Scor3 is the amount of low-yield corn to be sold.

Bcor is the amount of corn to be bought for feeding livestock.

Constraints

Not all resources needed for accomplishing farm activities specified in this study are available in an unlimited amount. The following constraints are therefore considered in solving the LP model:

1) Land Constraint.

Land that may be allocated to a given enterprise is limited to areas where land characteristics fit the requirements of the crop. This constraint is decomposed in several constraints according to soil types, climate, and rainfall patterns of the area selected for each enterprise using GIS analysis. Potential acres are precisely located and shown in the maps developed in Chapter 5, Section 5.1.1.

2) Crop Rotation Constraint

Developing a sustainable farming system requires crop rotations. Not planting the same crop or the same family of crops on the same field in consecutive years contributes to preserving the soil structure and improves nutrient balance. Crop rotation protects soil from excessive erosion by alternating crops like tobacco, corn, soybeans and cotton, with crops that have more plants per square inch such as small grains. Rotation helps in controlling plant diseases, insects and weeds. In Pittsylvania County the most dominant rotation is tobacco alternated with wheat on a one-year basis. Rotations are set on land that is suitable for that specific crop. In order for the rotation to be possible crops must share the same suitable soil fields. Some crops share all their fields. This is the case of Cor2, Bar2, Soy2, Cot2, Cor3, Bar3, Soy3, Cot3, Broc2, and Tom2. Other enterprises share their fields with two or more other enterprises. Therefore rotations are set up on a ERU by ERU basis. For example Tob1 grown on ERU 4B (denoted by tob14b) is rotated with Whe2 grown on ERU 4B (denoted by whe24b) and so forth. It is not possible to set up rotations for whe135b, cor17a, cor133a, cor138a, whe210b, whe217b, whe236b, whe31c, whe311c3, and whe336c. The acreage constraints for Whe1, Cor1, Whe2 and Whe3 that are partially rotated in some scenarios are formulated based on Table 4.6.

Table 4.6 LP Acreage Constraints for High-Yield Wheat and Corn, Average-Yield Wheat, and Low-Yield Wheat According to Rotation Possibilities.

Enterprises	GIS generated acreage constraints	Rotated area	Not rotated area	Fallow	LP acreage constraint
whe1	54.54	39.50	15.04	7.52	47.02
cor1	932.89	39.50	893.39	446.70	486.20
whe2	2074.86	1833.53	241.33	120.67	1954.20
whe3	1595.46	1441.16	154.3	77.15	1518.31
whe1, Scenario 7 and 10	54.54	0.00	54.54	27.27	27.27
whe2, Scenario 7	2074.86	217.03	1857.83	928.92	1145.95
whe2, Scenario 10	2074.86	0.00	2074.86	1037.43	1037.43
whe3, Scenario 7 and 10	1595.46	0.00	1595.46	797.73	797.73

Rotation constraints for tobacco and other crops are set up in table 4.7.

Table 4.7 The Matrix of Rotation Constraints Used in the LP Model

	Rotation Number																
Activity	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV	XVI	XVII
tob14b	1																
whe24b	-1																
tob122b		1															
whe222b		-1															
tob142b			1														
whe242b			-1														
tob23a				1													
whe13a				-1													
tob23b					1												

Table 4.7 (continued)

whe23b					-1												
tob29b						1											
whe29b						-1											
tob223b							1										
whe223b							-1										
tob234b								1									
whe234b								-1									
tob34c									1								
whe34c									-1								
tob35c3										1							
whe35c3										-1							
tob332c											1						
whe332c											-1						
soy13a												1					
cor13a												-1					
cor2													1				
bar2													-1				
soy2														1			
cot2														-1			
cor3															1		
bar3															-1		
soy3																1	
cot3																-1	
broc2																	1
tom2																	-1
RHS	=0	=0	=0	=0	=0	=0	=0	=0	=0	=0	=0	=0	=0	=0	=0	=0	=0

3) Selling and Buying Constraint

Corn will be sold or will be used on the farm to feed livestock. The total amount of corn used and sold should be equal to the amount produced. Feeding livestock can either be done by using own farm production or by purchasing corn. Again, the total amount of corn bought and used should be equal to the total consumption. These options and respective transfer row are illustrated in Table 4.8:

Table 4.8 The Description of Selling and Buying Corn Constraint.

	Activities						RHS
	Bec	Cor1	Cor2	Cor3	Scor	Bcor	
Corn Balance	3.965	-90	-80	-60	1	-1	=0

The coefficient 3.965 is taken from the Cow's budget (see Appendix B, Table B 22). It represents corn consumption needs for one cow. Yields in bushels per acre for Cor1, Cor2 and Cor3 are respectively 90, 80 and 60.

4) Irrigation Constraint[2]

There are 55,200 acre inches of water available for irrigation in a typical year in Pittsylvania County (Britt, S. J., Virginia Cooperative Extension Agent, Pittsylvania County Office, personal communication). This means that for each acre of harvested cropland, 0.95 acre inches of water is available. This figure translates to 5,198.1 acre inches of irrigation water capacity for the area of study, which is a small part of Pittsylvania County. Water comes from farm ponds. Creek and river sources are available only to a few producers and are not included here. In order to relax the irrigation constraint, more ponds could be built. This depends on the investment possibilities and the feasibility of building more ponds. Expanding the irrigated area as potentially feasible is taken into account in the LP scenarios. Tobacco is the crop that actually uses the most stored water. Tobacco typically represents 90 percent of the total number of irrigated acres. Typical irrigation water use during the season in Pittsylvania County are 6 acre inches for tobacco, 3 acre inches for broccoli and 9.5 acre inches for tomatoes. Assuming that there is no recharge of ponds during the irrigation season and the rainfall follows the normal pattern, an irrigation constraint can be written (Table 4.9):

Table 4.9 The Description of Irrigation Constraint

Activities	Tob1	Tob2	Tob3	Broc2	Tom2	RHS
Water Limit	6	6	6	3	9.5	<= 5,198.1

[2] Information used in this section is obtained by personal communication with Stephen J. Britt, Extension Agent, Agricultural and Natural Resources, Virginia Cooperative Extension, Pittsylvania County Office.

5) Livestock Constraint

The number of cows is limited to 100 and the number of pigs placed in contract production is constrained to 1,500. It is assumed that there is only one facility in the study area with 500 pigs capacity at a time and a possibility to have 3 groups in a year. The limitations are set just to consider the profitability of these enterprises and do not represent any technical constraint. If cows and contract swine come up in the solutions, sensitivity analysis will suggest whether more facilities could be put in place if such activity levels of these enterprises are allowed from environmental constraints perspective.

It is assumed that there is no constraint on labor, capital and machinery. That is, the farmer can acquire more labor, capital or machinery at reasonable costs. Objective function, constraints and transfer rows are described in full detail in the LP matrix and mathematically formulated LP model, which are shown in Appendix C.

Market prices, variable costs, yields and net returns for cows and contract swine used are shown in Table 4.10. The yield of tomatoes and broccoli represents what goes to the market for fresh tomatoes and broccoli. It is assumed that the small quantity of culled tomatoes and broccoli is not feasible for processing.

Table 4.10 Prices, Variable Costs and Yields Used in LP Model.

Enterprises	Market Price	Per Acre Variable Costs	Yields
Tob1	1.78/lb.	2453.91	2700lb.
Tob2	1.78/lb.	2367.6	2400lb.
Tob3	1.78/lb.	2314.92	1800lb.
Cor1	2.5/bu.	236.33	100bu.
Cor2	2.5/bu.	223.60	90bu.
Cor3	2.5/bu.	212.38	70bu.
Bar2	2.07/bu.	135.67	80bu.
Bar3	2.07/bu.	125.11	70bu.
Wds1	3.77/bu.(weighted average)	235.19	80bu.(combined yield)
Wds2	3.72/bu.(weighted average)	236.91	70bu.(combined yield)
Wds3	3.66/bu.(weighted average)	225.30	60bu.(combined yield)
Whe1	2.78/bu.	181.35	75bu.
Whe2	2.78/bu.	177.53	65bu.
Whe3	2.78/bu.	161.98	50bu.
Soy1	5.41/bu.	125.34	35bu.
Soy2	5.41/bu.	130.70	30bu.
Soy3	5.41/bu.	116.40	25bu.

Table 4.10 (continued)			
Enterprises	Market Price	Per Acre Variable Costs	Yields
Cot2	0.60/lb.	347.00	650lb.
Cot3	0.60/lb.	347.15	600lb.
Broc2	10.18/20lb.crtn.	1966.04	370crtn.(20lb.each)
Tom2	7.99/25lb.crtn.	10005.96	1600crtn.(25lb.each)
Bec	1.66/cow (net return per cow)		
Cos	5.65/pig (net return per pig)		

Scenarios

Ten scenarios are conducted as variations of the basic model. The goal is to show the optimal plan under different plausible situations. First, a baseline scenario is specified with very limited acreage of broccoli and tomatoes (less than or equal to 3 acres and 4 acres, respectively) and limited irrigation water availability. The purpose of this scenario is to represent the current picture of a farm plan in the region, where very few acres are planted in broccoli and tomatoes.

The second scenario differs from the baseline scenario by limiting the tobacco acreage of the baseline scenario by one third. The tobacco acreage constraint is set to half of acres of the baseline scenario in the third scenario.

The fourth scenario goes further in tightening the tobacco acreage constraint to the limits of one third of the baseline scenario. The acreage reductions of one third, one half and two thirds reflect the respective decreases in tobacco quota.

Scenario five is a combination of a reduction in half of the tobacco acreage limit and a relaxation of the broccoli and tomatoes acreage constraints from 3 to 6 acres and from 4 to 8 acres, respectively. The relaxed constraint assumes that the study area might produce the same acreage of tomatoes and broccoli as Pittsylvania County is currently producing.

Scenario six has a distinguishing feature that increases the limits of irrigation water capacity by 10 percent. The presence of tobacco is limited to the half acres of baseline scenario. It is supposed that water could be a limitation. The objective of this is twofold: to show the importance of irrigation in increasing farm income, and to see what happens with the enterprise mix.

The seventh scenario differs from the baseline scenario in broccoli and tomato acreage limits, which are 6 and 8 respectively, and tobacco is limited to the high-yield areas. Irrigation constraint is relaxed by 10 percent.

Scenario eight has a two thirds reduction in tobacco acreage limit. Acres of broccoli and tomatoes are relaxed from 3 to 15 acres and from 4 to 20 acres, respectively. This five times increase of broccoli and tomato acreage is to see the revenue impact of a substantial increase in vegetable production.

The ninth scenario has similar features as scenario eight except the irrigation constraint that is ten percent relaxed.

Scenario 10 has the same characteristics as scenario nine, but assumes that tobacco is no longer produced. All scenarios and their distinguishing characteristics from the baseline scenario are summarized in the following table (Table 4.11)

Table 4.11 Distinguishing Features and Intentions of LP Scenarios

Scenario number	Broccoli acreage limit (≤)	Tomatoes acreage limit (≤)	Presence of tobacco	Irrigation constraint (≤ acre inch)	Intention
1	3	4	yes	5,198.1	Describe current situation (Baseline).
2	3	4	1/3 acreage reduction	5,198.1	Reflect the respective decrease in tobacco quota.
3	3	4	1/2 acreage reduction	5,198.1	Reflect the respective decrease in tobacco quota.
4	3	4	2/3 acreage reduction	5,198.1	Reflect the respective decrease in tobacco quota.
5	6	8	1/2 acreage reduction	5,198.1	Determine the optimal enterprise mix in presence of more vegetables.

Table 4.11 (continued)					
Scenario number	Broccoli acreage limit (≤)	Tomatoes acreage limit (≤)	Presence of tobacco	Irrigation constraint (≤ acre inch)	Intention
6	6	8	1/2 acreage reduction	5,717.91	Determine the optimal enterprise mix in presence of more irrigation.
7	6	8	only tob1	5,717.91	Determine the optimal enterprise mix in presence of only high-yield tobacco.
8	15	20	2/3 acreage reduction	5,198.1	Determine the optimal enterprise mix in presence of more vegetables.
9	15	20	2/3 acreage reduction	5,717.91	Determine the optimal enterprise mix in presence of more vegetables and irrigation.
10	15	20	no tobacco	5,717.91	Determine the optimal enterprise mix in absence of tobacco.

Shadow prices originating from different scenarios are used to show the contribution of limited resources in generating farm revenue. Sensitivity analysis displays the boundaries of prices, operational costs and resources under which the optimal plan holds for each scenario.

Chapter 5

RESULTS

This chapter begins with a presentation of the results of the GIS analysis. ArcView GIS results section presents the results of an approach that uses factors that influence yield as a starting point for identifying boundaries of enterprises suitable for a given site. Maps of fields suitable for each enterprise are displayed in this section. Section 5.2 displays market window analysis for enterprises that have seasonal prices. Section 5.3 presents LP results. The implications of price flexibility are discussed in Section 5.4.

5.1 ArcView GIS Results

The objective of the GIS analysis was to screen enterprises according to their requirements for soil and climatic conditions. The output is a map of suitable sites for each enterprise. Area in acres was determined for each enterprise in order to use it later in the linear programming (LP) modeling. Since the ArcView computer program only calculates the number of cells in the mapped area, a coefficient was entered to multiply the cell numbers in order to convert them to area in acres. This coefficient depends on the selected cell size. A 20 yard cell size was chosen, which made the area of a cell 400 square yards. Since one acre is equal to 4,840 square yards, the coefficient is 0.082645 (400/4,840).

5.1.1 The Production Feasibility Approach

This approach uses yield factors as a starting point for identifying enterprise boundaries. Soil and climatic requirements are different for different expected crop yields. This observation led to specifying requirements for three yield levels, high, average and low (Table 5.1).

In Table 5.1 enterprise names are:

Tob is tobacco, Cor is corn, Bar is barley, Wds is wheat doubled with soybeans, Whe is wheat, Soy is soybeans, Cot is cotton, Broc is broccoli and Tom is tomatoes. Numbers 1, 2 or 3 in enterprise names are for high, average, and low yields respectively. Broccoli and tomatoes were excluded from fields with slopes over 7 percent because broccoli and tomatoes need irrigation. Soils that have slopes higher than 7 percent are considered to be vulnerable to erosion (Soil Survey of Pittsylvania County and the City of Danville, Virginia, 1994, p. 96.).

Table 5.1 Factors Affecting Yields Used to Identify Enterprise Boundaries

Enterprise	Soil Depth	Soil Texture	Slope (%)	Flood Potential	Mean Summer Temperature (F)
Tob1	high	sandy	2-7	none, rare	70-80
Tob2	high, medium	fine sandy	0-2, 0-4, 2-7	none, rare	70-80
Tob3	high	sandy, fine sandy, sandy clay	7-15	none, rare	70-80
Cor1	high	sandy, fine sandy, silt, loam	0-2	none, rare, occasionally	75-77
Cor2	high	sandy, fine sandy, silt, loam	0-4, 2-7	none, rare, occasionally	75-77
Cor3	high	sandy, fine sandy, silt, loam, clay, cobbly sandy, sandy clay	7-15	none, rare, occasionally	75-77
Bar1	high	sandy, silt, loam	0-2	none, rare	70-75
Bar2	high	sandy, fine sandy, silt, loam	0-4, 2-7	none, rare	70-75
Bar3	high	sandy, fine sandy, silt, loam, clay, cobbly sandy, sandy clay	7-15	none, rare	70-75
Wds1	high	sandy, fine sandy, silt, loam	0-2	none, rare	75-80

Table 5.1 (continued)					
Enterprise	Soil Depth	Soil Texture	Slope (%)	Flood Potential	Mean Summer Temperature (F)
Wds2	high	sandy, fine sandy, silt, loam	0-4, 2-7	none, rare	75-80
Wds3	high	sandy, fine sandy, silt, loam, clay, cobbly sandy, sandy clay	7-15	none, rare	75-80
Whe1	high	sandy, fine sandy, silt, loam	0-2	none, rare	70-80
Whe2	high, medium	sandy, fine sandy, silt, loam	0-4, 2-7	none, rare	70-80
Whe3	high	sandy, fine sandy, silt, loam, clay, cobbly sandy, sandy clay	7-15	none, rare	70-80
Soy1	high	sandy, fine sandy, silt, loam	0-2	none, rare	75-77
Soy2	high	sandy, fine sandy, silt, loam	0-4, 2-7	none, rare	75-77
Soy3	high	sandy, fine sandy, silt, loam, clay, cobbly sandy, sandy clay	7-15	none, rare	75-77
Cot1	high	sandy, loam	0-2	none, rare	>77
Cot2	high	sandy, fine sandy, silt, loam	0-4, 2-7	none, rare	>77
Cot3	high	sandy, fine sandy, silt, loam, clay, cobbly sandy, sandy clay	7-15	none, rare	>77
Broc1	high	appling sandy, cecil sandy, cecil sandy clay, mayodan fine sandy	0-2	none, rare	75-77
Broc2	high	appling sandy, cecil sandy, cecil sandy clay, mayodan fine sandy	0-4, 2-7	none, rare	75-77
Tom1	high	appling sandy, cecil sandy, cecil sandy clay, mayodan fine sandy	0-2	none, rare	75-77
Tom2	high	appling sandy, cecil sandy, cecil sandy clay, mayodan fine sandy	0-4, 2-7	none, rare	75-77

The fields of each enterprise were found using an overlay approach and identifying the intersections of factors specified in Table 5.1. For example Tob1 fields were found by using the following expression in a query across the layers of maps:

([SoilDepth] = “high”) and ([SoilTexture] = “sandy”) and ([Slope] = “2-7”) and ([FloodPotential] <> “occasionally”).

Where:

The operator “<>” means “not equal to”.

Mean summer temperature is not included in the above expression and in the subsequent expressions because it has only one value in this particular database and it applies to all fields. This requirement is met for all enterprises except for barley and cotton. In the case of barley and cotton, mean summer temperature requirements are 70-75 and higher than 77 respectively, which are very close to the observed value (76.37), which is considered satisfactory. In some instances, instead of requesting a number of factors, it is easy to exclude the few factors that do not apply. The result of these requests is the intersection of the areas that have the qualities denoted in the expression.

Results show the maps and tables of identified enterprises, soil types and areas associated with each enterprise. Results with detailed data are shown in Table 3, Appendix D. High-yield tobacco was identified on three types of soils with a total of 217.03 acres (Figure 5.1). This figure starts a sequence of figures that show maps of soils suitable for specific enterprises of varying yield potentials.

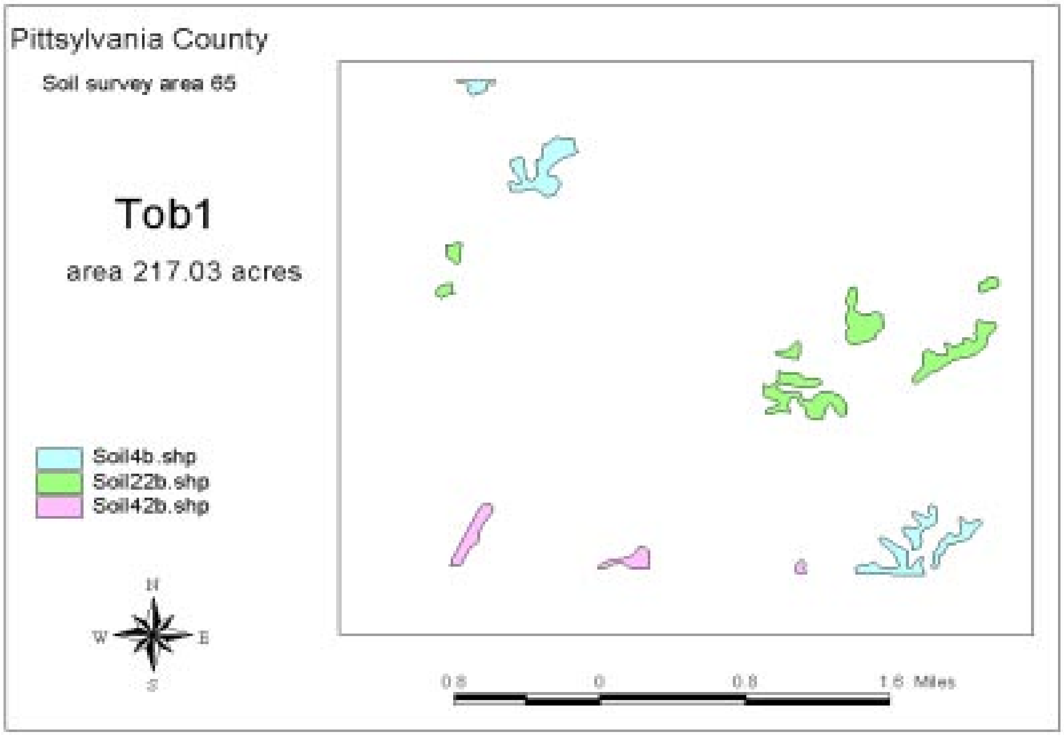


Figure 5.1 Map of Fields Having High-Tobacco Yield Potential

The map legend in this map and in subsequent maps shows the ERU's for the particular enterprise. The suffix "shp" is a technical detail that means "shape" and is a reference to the vector mode of themes printed in ArcView GIS. This is in contrast with the raster mode. Vector mode organizes the map data for the given area based on real world coordinates. Raster mode contains the map data representing the area as a mosaic, divided in cells that are of the same shape and equal size.

Average-yield tobacco is expected on five soil types, which total an area of 1,656 acres (Figure 5.2). They were found by combining factors, which are shown in Table 5.1, that determine an average yield for tobacco. The query expression used in this case was:

([SoilTexture] = "fine sandy") and ([Slope] <>"7-15") and ([Slope] <>"15-25") and ([FloodPotential] <> "occasionally")

SoilDepth was not included in the above expression because it did not make any difference. Both categories, high and medium soil depth, were acceptable in this case.

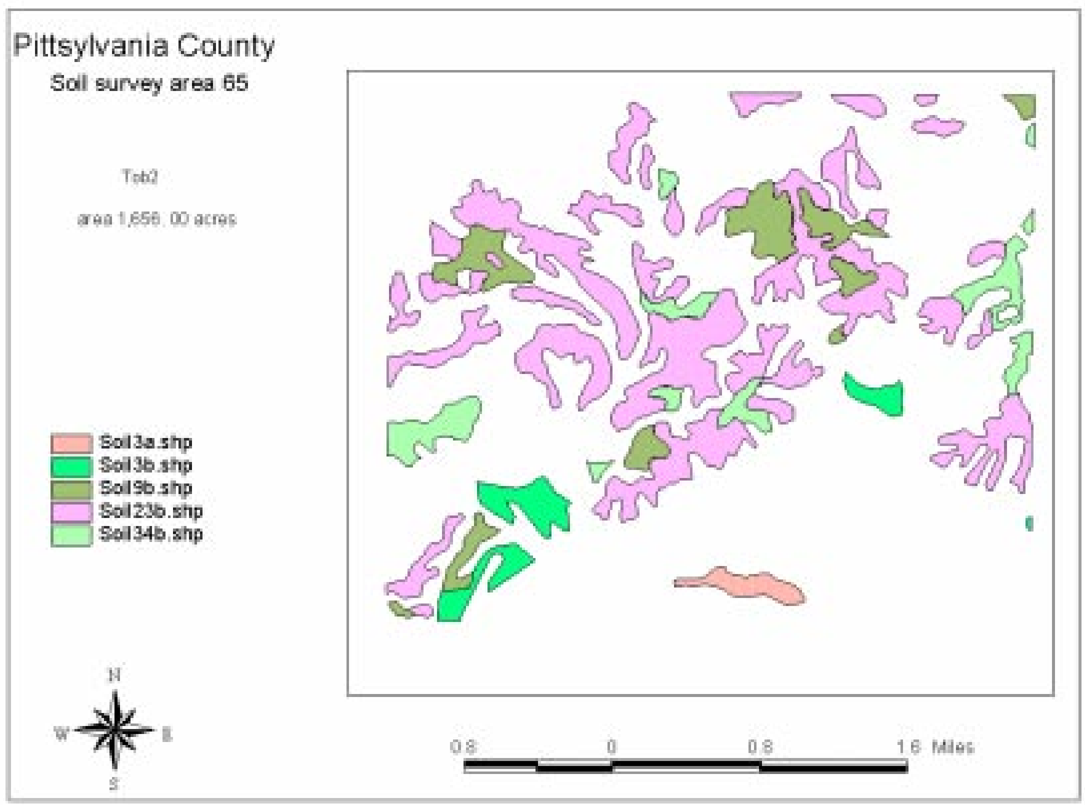


Figure 5.2 Map of Fields Having Average-Tobacco Yield Potential

Low-yield tobacco is expected on fields that make up an area of 1,441.16 acres. Figure 5.3 shows the location of these soils. They were found by using the following expression:

> ([SoilDepth] = "high") and ([SoilTexture] <> "clay") and ([SoilTexture] <> "cobbly sandy") and ([SoilTexture] <> "loam") and ([SoilTexture] <> "silt") and([Slope] = "7-15") and ([FloodPotential] <> "occasionally")

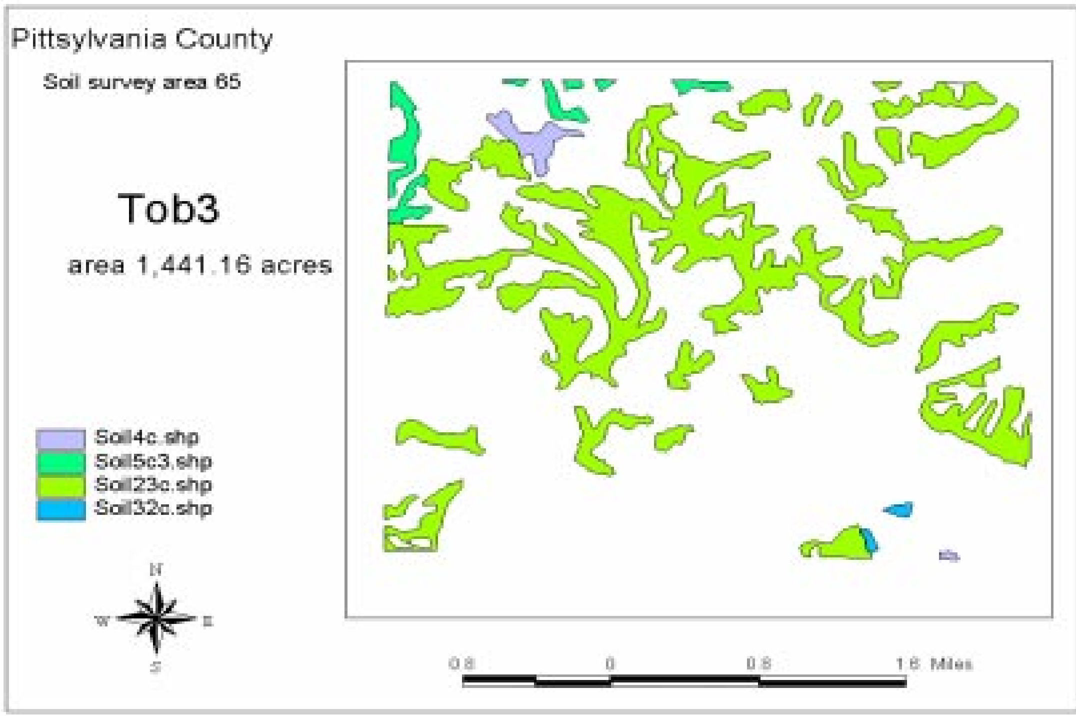


Figure 5.3 Map of Fields Having Low-Tobacco Yield Potential

High-yield corn fields were identified as having the qualities given in the following query expression:

([SoilDepth] = “high”) and ([SoilTexture] <> “clay”) and ([SoilTexture] <> “cobbly sandy”) and ([SoilTexture] <> “sandy clay”) and([Slope] = “0-2”)

They represent high potential yield because the above expression is derived from the technical parameters shown in Table 5.1. The location of these soils is found mainly on the two sides of Dan River that are almost flat (Figure 5.4).

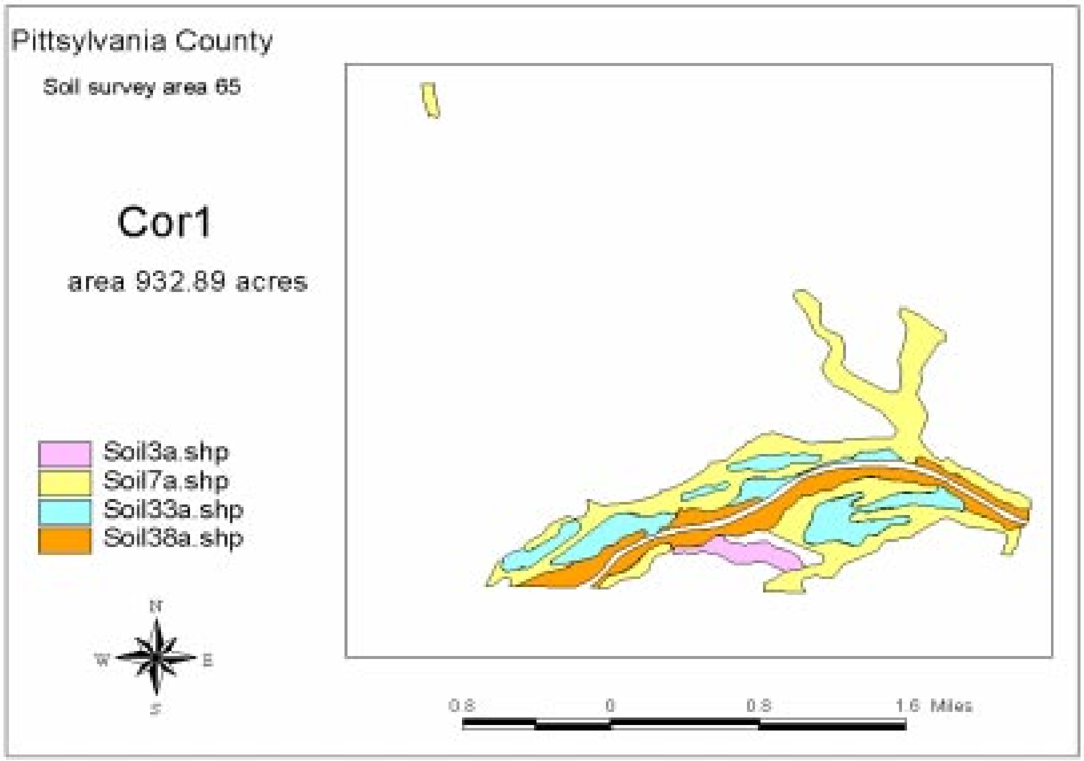


Figure 5.4 Map of Fields Having High-Corn Yield Potential

Average-yield corn, barley, wheat double cropped with soybeans, cotton and soybeans share the same fields (Figure 5.5). The query expression is the same for these enterprises except that in the case of corn it allows for occasional flooding. For corn it appears like this:

> ([SoilDepth] = "high") and ([SoilTexture] <> "clay") and ([SoilTexture] <> "cobbly sandy") and ([SoilTexture] <> "sandy clay") and ([Slope] <> "0-2") and ([Slope] <> "7-15") and ([Slope] <> "15-25")

Cotton and soybeans are more sensitive than corn to excessive soil moisture. The following is added as part of the above expression for barley, cotton, soybeans and wheat double cropped with soybeans:

([FloodPotential] <> “occasionally”)

However, this factor did not make any difference. The result was the same as in the case of corn.

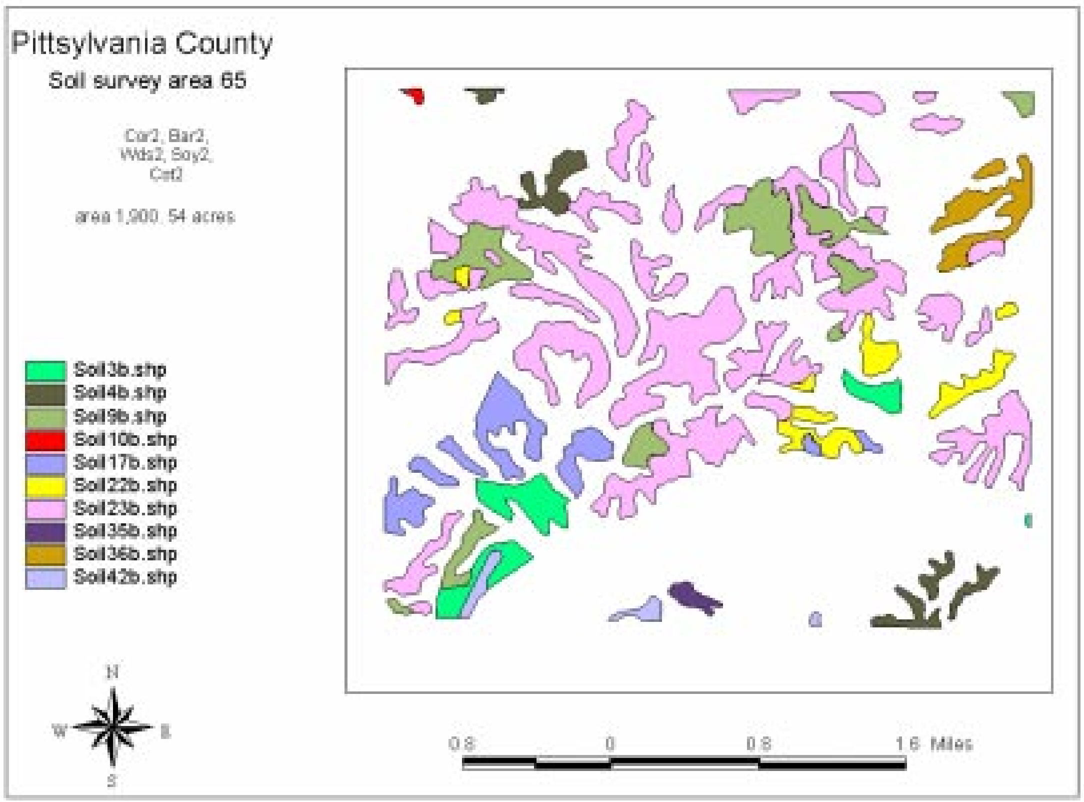


Figure 5.5 Map of Fields Having Average-Corn, Barley, Soybeans, Cotton and Wheat Double Cropped With Soybeans Yield Potential

Low-yield corn, barley, wheat double cropped with soybeans, cotton, wheat, and soybeans share the same fields (Figure 5.6). Again, as in the case of average yields, the query expression is the same, allowing only occasional flooding for corn. It is as follows for all enterprises but corn:

([SoilDepth] = “high”) and ([Slope] = “7-15”) and ([FloodPotential] <> “occasionally”)

The last part, ([FloodPotential] <> “occasionally”), did not apply for corn, but excluding this from the above expression did not have any impact on the result.

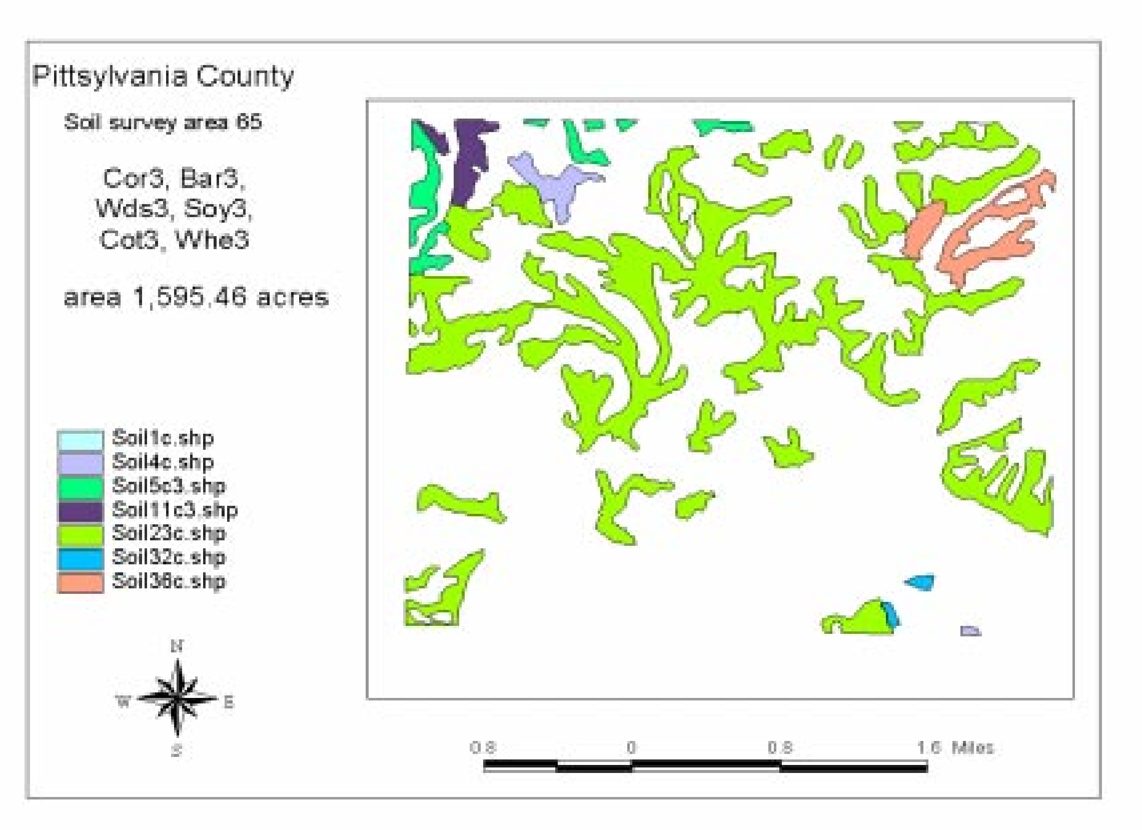


Figure 5.6 Map of Fields Having Low-Corn, Barley, Wheat, Soybeans, Cotton and Wheat Double Cropped With Soybeans Yield Potential

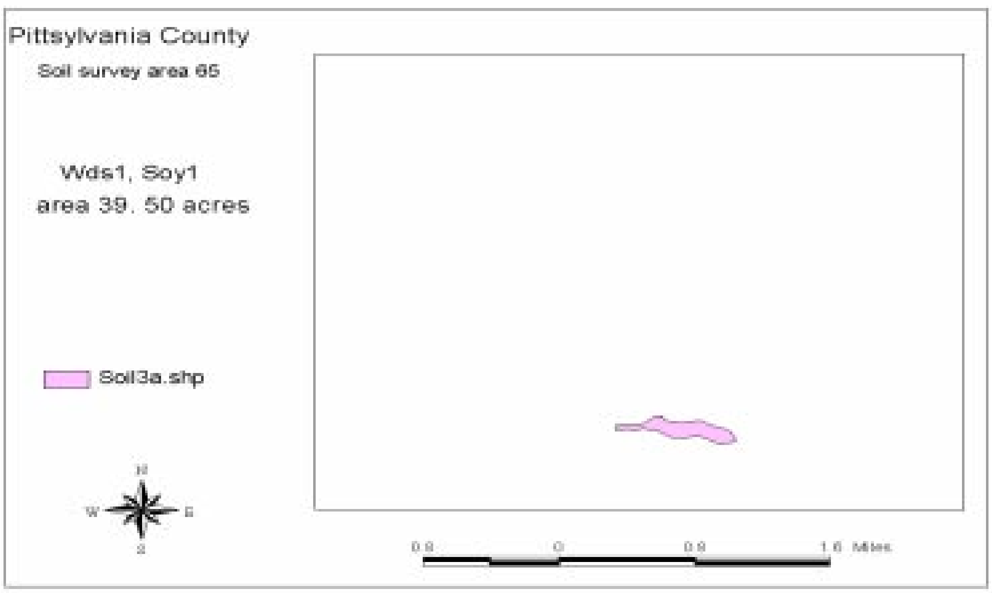
No fields were identified for high-yield barley. The expression used is:

([SoilDepth] = “high”) and ([SoilTexture] <> “clay”) and ([SoilTexture] <> “cobbly sandy”) and ([SoilTexture] <> “fine sandy”) and ([SoilTexture] <> “sandy clay”) and ([Slope] = “0-2”) and ([FloodPotential] <> “occasionally”)

This limitation comes from the combination of slope (0%-2%) and the exclusion of occasionally flooded areas. Such combinations exist only in one area, but are constrained by the soil texture.

High-yield soybeans and wheat double cropped with soybeans share the same soils (Figure 5.7). This result came from the expression:

> ([SoilDepth] = “high”) and ([SoilTexture] <> “clay”) and ([SoilTexture] <> “cobbly sandy”) and ([SoilTexture] <> “sandy clay”) and ([Slope] = “0-2”) and ([FloodPotential] <> “occasionally”)



<u>Figure 5.7 Map of Fields Having High-Soybeans and Wheat Double Cropped With Soybeans Yield Potential</u>

The limited area shown in the above picture was due to the combination of slope (0%-2%) and non-occasionally flooded areas.

High-yield wheat areas (Figure 5.8) were located by using the following statement:

([SoilDepth] = “high”) and ([SoilTexture] <> “clay”) and ([SoilTexture] <> “cobbly sandy”) and ([SoilTexture] <> “sandy clay”) and ([Slope] <> “2-7”) and ([Slope] <> “7-15”) and ([Slope] = “15-25”) and ([FloodPotential] <> “occasionally”)

More soil fields could have been identified if the slope constraint was relaxed from 0%-2% to 0%-7%.

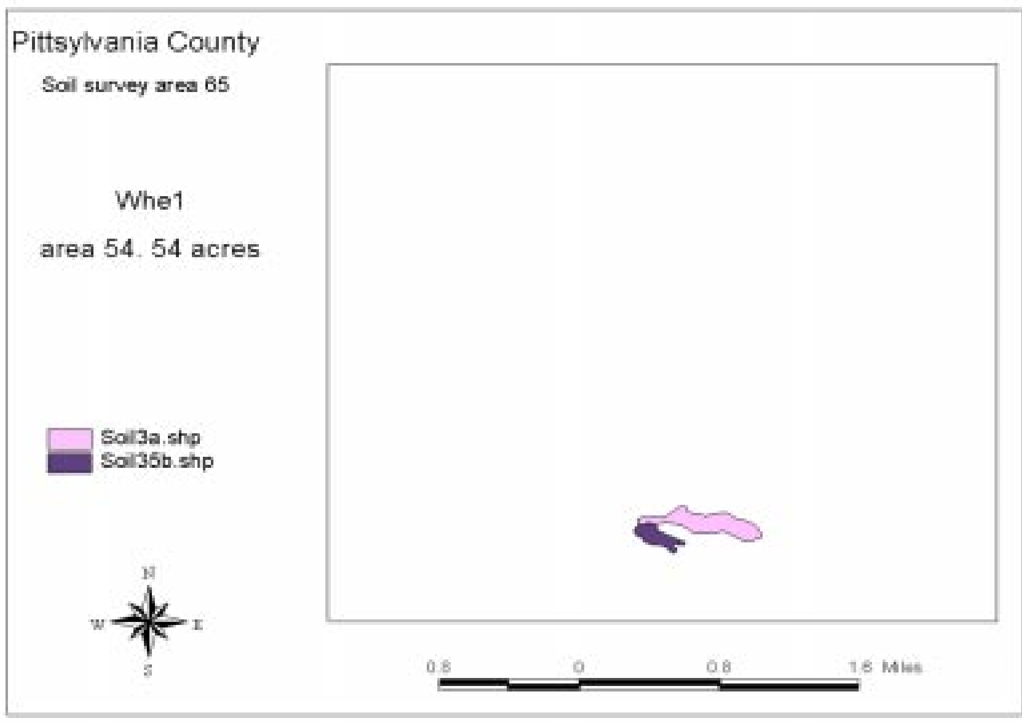


Figure 5.8 Map of Fields Having High-Wheat Yield Potential

Fields that have the potential for average-yield wheat total an area of 2,074.86 acres (Figure 5.9). Compared to high-yield wheat areas, these fields have a higher slope and allow for medium depth soils along with high depth soils. The expression used is:

([SoilTexture] <> “clay”) and ([SoilTexture] <> “cobbly sandy”) and ([SoilTexture] <> “sandy clay”) and ([Slope] <> “0-2”) and ([Slope] <> “7-15”) and ([Slope] <> “15-25”) and ([FloodPotential] <> “occasionally”)

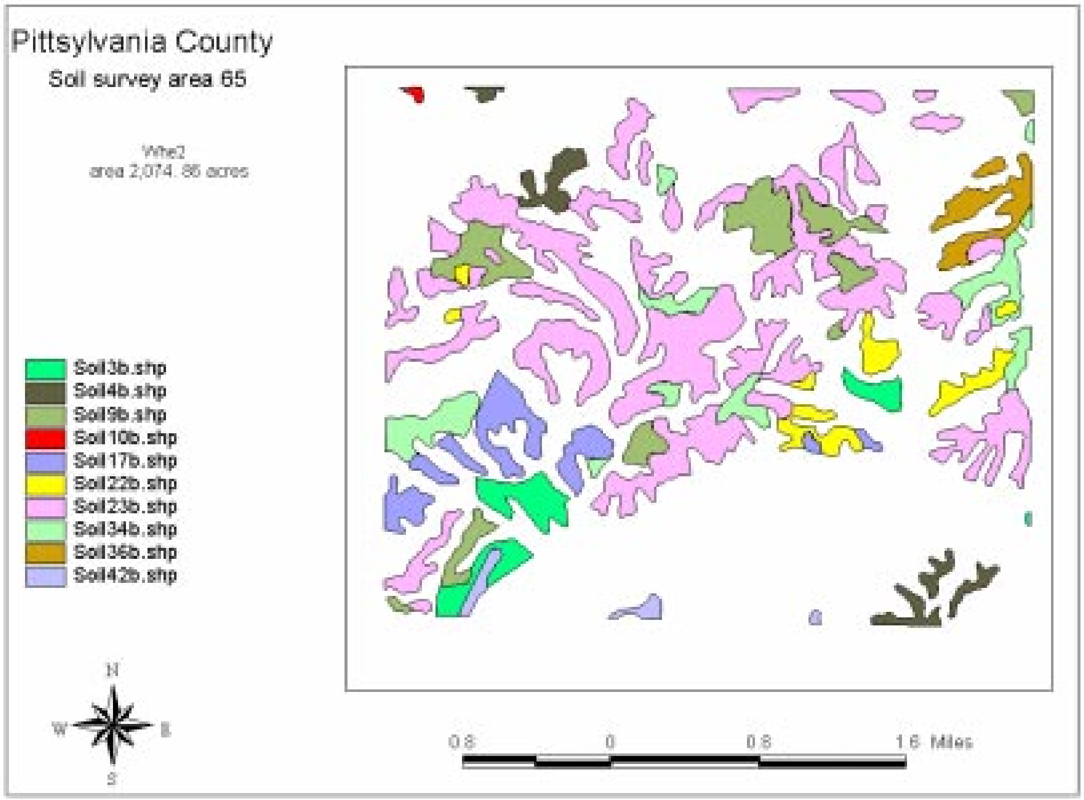


Figure 5.9 Map of Fields Having Average-Wheat Yield Potential

No fields were identified for high-yield broccoli and tomatoes. This limitation was due to the combination of slope 0%-2% and non-occasionally flooded areas. Average-yield broccoli and tomatoes share the same soil fields (Figure 5.10). The statement used to locate the fields of average-yield tomato and broccoli is:

> ([SoilDepth] = “high”) and ([SoilTexture] = “appling sandy”) or ([SoilTexture] = “cecil sandy”) or ([SoilTexture] = “cecil sandy clay”) or ([SoilTexture] = “mayodan fine sandy”) and ([Slope] <> “0-2”) and ([Slope] <> “7-15”) and ([Slope] <> “15-25”) and ([FloodPotential] <> “occasionally”)

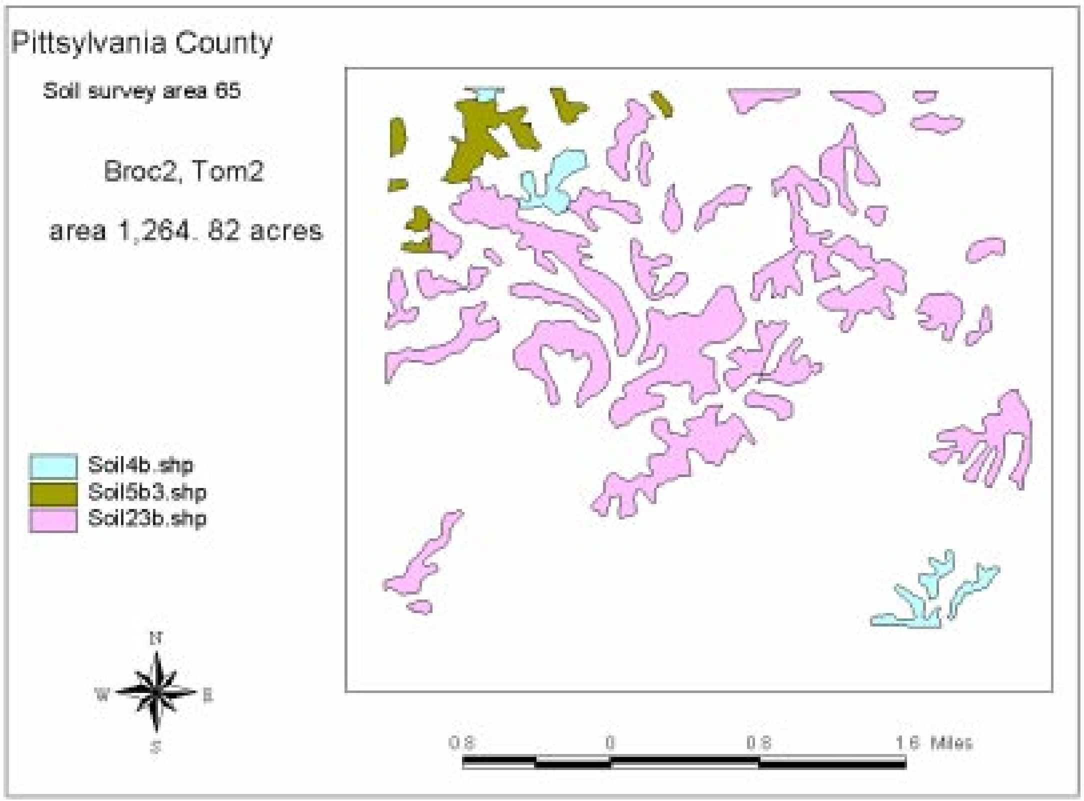


Figure 5.10 Map of Fields Having Average-Broccoli and Tomatoes Yield Potential

In many cases, areas identified for different enterprises overlap with each other. Average-yield corn, barley, wheat double cropped with soybeans and cotton that share the same fields, overlap with some fields of high and average yield tobacco, most fields of average-yield wheat, and some fields of average-yield broccoli and tomatoes. High-yield corn fields overlap with some fields of average-yield tobacco, high-yield wheat doubled with soybeans, high-yield soybeans and high-yield wheat. Low-yield corn, barley, wheat doubled with soybeans, soybeans, cotton and wheat share the same fields. These fields overlap with some fields of low-yield tobacco. Overlapping areas are documented according to the soil symbol. Their identification in acres is important in specifying land constraints in the LP model.

Factors that affect the budgets of identified possible enterprises, which were used to adjust crop budgets, are given in the Table 5.2. Budget adjustments were made based on parameters given in the literature (Hanson, A. A, 1990, and Simpson, T. W., et al.,1993).

Table 5.2 Factors Affecting the Budgets of the Identified Enterprises

Enterprise	Natural drainage	pH	Natural Fertility	Organic Matter	Rainfall (in)
Tob1	good, very good	4.5-5.5, 4.5-6	low	low	43.13
Tob2	good, very good	3.6-5.5, 4.5-5.5, 4.5-7.3	medium, low	low	43.13
Tob3	very good	4.5-5.5	low	low	43.13
Cor1	poor, good, very good	4.5-6, 4.5-7.3, 5.1-6.5	medium, low	medium, low	43.13
Cor2	good, very good	3.6-5.5, 4.5-5.5, 4.5-6, 4.5-7.3	medium, low	low	43.13
Cor3	very good	4.5-5.5	low	low	43.13
Bar2	good, very good	3.6-5.5, 4.5-5.5, 4.5-6, 4.5-7.3	medium, low	low	43.13
Bar3	very good	4.5-5.5	low	low	43.13
Wds1	good	4.5-7.3	medium	low	43.13
Wds2	good, very good	3.6-5.5, 4.5-5.5, 4.5-6, 4.5-7.3	medium, low	low	43.13
Wds3	very good	4.5-5.5	low	low	43.13
Whe1	good, very good	4.5-5.5, 4.5-7.3	medium, low	low	43.13
Whe2	good, very good	3.6-5.5, 4.5-5.5, 4.5-6, 4.5-7.3	medium, low	low	43.13
Whe3	very good	4.5-5.5	low	low	43.13
Soy1	good	4.5-7.3	medium	low	43.13
Soy2	good, very good	3.6-5.5, 4.5-5.5, 4.5-6, 4.5-7.3	medium, low	low	43.13
Soy3	very good	4.5-5.5	low	low	43.13

Table 5.2 (continued)					
Enterprise	Natural drainage	pH	Natural Fertility	Organic Matter	Rainfall (in)
Cot2	good, very good	3.6-5.5, 4.5-5.5, 4.5-6, 4.5-7.3	medium, low	low	43.13
Cot3	very good	4.5-5.5	low	low	43.13
Broc2	very good	4.5-5.5	low	low	43.13
Tom2	very good	4.5-5.5	low	low	43.13

5.2 Market Window Analysis

Timing of the marketing decision is very important in marketing agricultural products that have seasonal prices. These products are generally perishable, particularly fruits and vegetables. Defining the marketing season according to historical prices received and estimated cost of production involves a procedure called "market window analysis". A market window is identified when the average historical prices are above the estimated total cost of production. The market window is then a guide for production planning. In this study, market window analysis is demonstrated only for tomatoes and broccoli. This analysis had limitations that are grounded in the availability of data. First, prices considered are only those observed at terminal markets, ignoring other potentially important more nearby local markets. An attempt is made to incorporate local market data by introducing Columbia, SC terminal market. Local farmer's markets often quote prices quoted at Columbia market (Semones, personal communication). Second, the average price is not a weighted average because of the lack of data about the quantities sold. Another limitation, which comes from using historical prices to conduct market window analysis is that historical prices show only a general trend or general tendency and they may not be observed in the future.

Four terminal markets were identified for the study area; Atlanta, Baltimore, Boston, and New York, for both tomatoes and broccoli. Columbia, SC is also identified for tomatoes. Tomatoes are expected to be harvested during the period August 10 to October 25, reaching a quantity peak from the last week of August to the first week of

October. This means that the planting dates are June 10 to July 15. Historical prices for weeks 33 to 43 of the calendar year are considered for five consecutive years (1994-1998) for each terminal market except Columbia market. Since data were missing for the particular tomato color and size in 1994, Columbia market includes prices only for the time period 1995 to 1998. The price is for a 25 lb. carton, the size of tomatoes is medium to large, and the color designation in describing or "grading" the tomatoes is mature greens and light pink to pink. The minimum and maximum price levels for each week are found and a five year average is calculated for each week for each market (See Appendix E).

Prices paid by terminal markets are not the net prices received by the farmer. A brokerage fee and transportation costs must be deducted from terminal market prices in order to arrive at net farm prices. The brokerage fee is typically 20% of the terminal market price and is deducted in generating the prices used. Transportation costs are calculated based on distances to the markets, the cost per mile, and the truck load. Distances to the markets are found using GIS Network Analyst, which calculates the best way to travel from one location to another. The cost per mile is $1 and the truck load is 1,500 cartons (25 lb. each) for tomatoes and 1,000 cartons (20 lb. each) for broccoli (Semones K., personal communication). The best location for connection with the highway network for going to the identified terminal markets is at Burlington, NC. Results are presented in Table 5.3.

Table 5.3 The Calculation of Transportation Costs per Carton for Tomatoes and Broccoli

Market	Distance From the Study Area (mi)			Total Cost	Tomatoes Cost/Carton	Broccoli Cost/Carton
	Highway	Road	Total Distance	($1/mile)	(1500ctn/truck)	(1000ctn/truck)
Atlanta	343.61	57	400.61	400.61	0.27	0.40
Baltimore	329.99	57	386.99	386.99	0.26	0.39
Boston	727.10	57	784.10	784.10	0.52	0.78
Columbia	202.25	57	259.25	259.25	0.17	n/a
New York	516.65	57	573.65	573.65	0.38	0.57

The minimum, maximum and average net prices are then compared to the total cost (TC) of production to reveal if an opening in time or a “window” exists to sell tomatoes and receive a price above the TC of production. Figure 5.11 shows that the average price received for tomatoes in Atlanta market is higher than TC throughout the marketing season. The minimum price is below TC in weeks 35 and 36. This is important if the farmer is very risk averse.

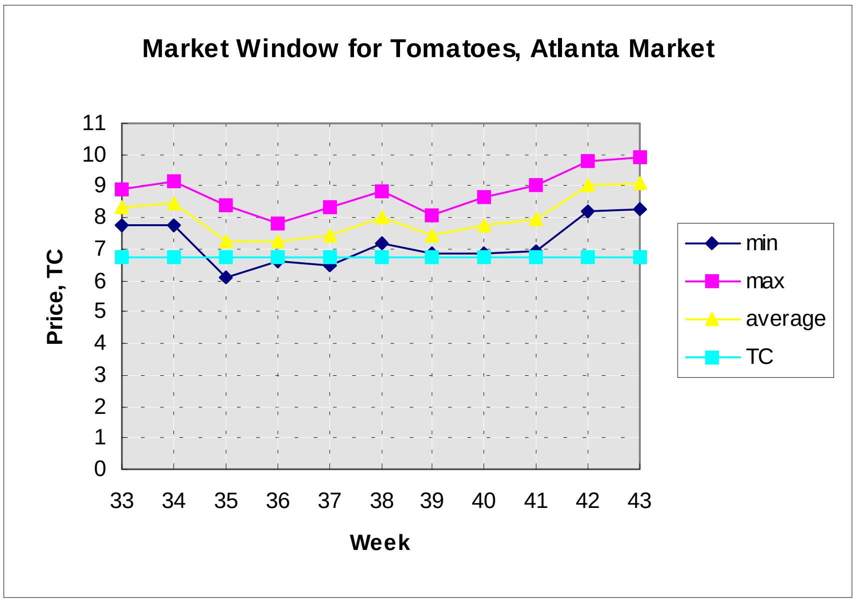


Figure 5.11 Market Window for Tomatoes, Atlanta Market

Baltimore Market data (Figure 5.12) indicate that the best period of time to sell tomatoes in this market is during weeks 39 to 43, where the historical minimum price is above total cost of production. TC is very close to the maximum price during weeks 35 to 37.

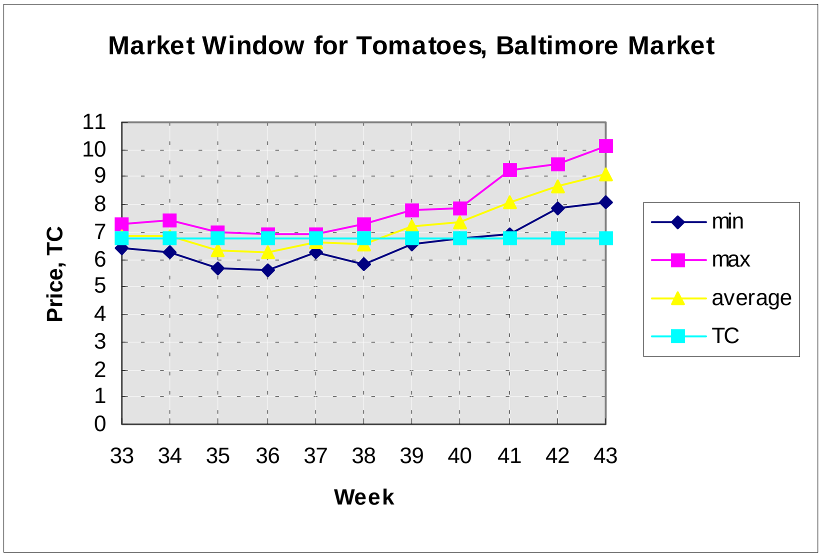


Figure 5.12 Market Window for Tomatoes, Baltimore Market

Figure 5.13 shows a market windows for tomatoes in Boston market in weeks 33 to 35, 37, and 41 to 43. Following a conservative approach by considering minimum prices, only week 42 appears to be a market window in Boston market. Other weeks, especially weeks 35, 36, 38 and 39 are discouraging to market tomatoes from the study area.

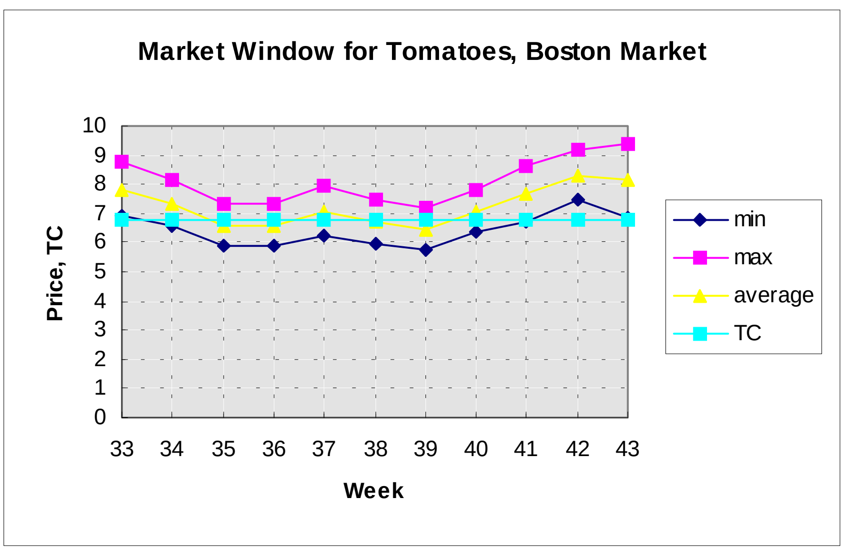


Figure 5.13 Market Window for Tomatoes, Boston Market

The Columbia market is the closest market to the study area. Two windows are identified for marketing tomatoes in this market. First, during the weeks 36 and 37 and second, beyond week 39 to week 43.

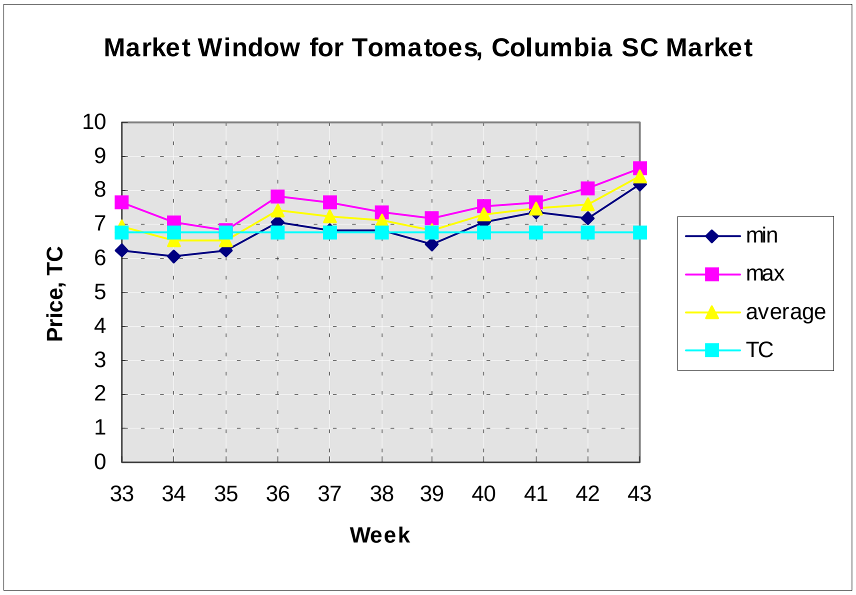


Figure 5.14 Market Window for Tomatoes, Columbia Market

Figure 5.15 represents market windows for tomatoes in the New York market during the weeks 33, 34, 38, and 40 to 43. The worst scenario for this market could be to sell tomatoes during weeks 35 to 37, where TC is close to maximum historical price.

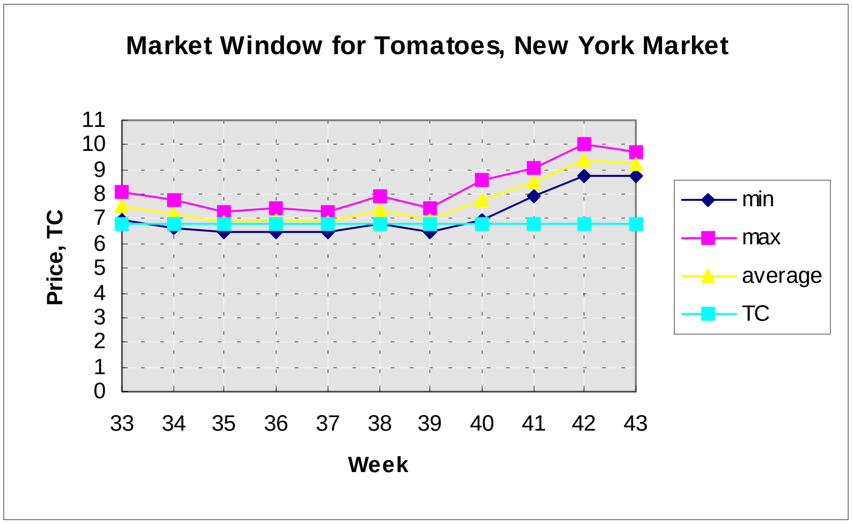


Figure 5.15 Market Window for Tomatoes, New York Market

Findings of this section indicate that tomatoes could be a profitable enterprise if marketed in a timely fashion according to market windows, but the data limitations need to be considered before drawing strong conclusions. The most profitable market could be the Atlanta market.

The same procedure is followed for broccoli. Prices refer to a 20 lb. carton with loose crown-cut broccoli. Four terminal markets and five years are considered (See Appendix E). The harvesting period is expected to be September 10 through December 5 or weeks 38 to 49 of the year. Terminal prices are adjusted for the brokerage fee and transportation costs. TC per carton is graphed along with the minimum, maximum and average price levels showing when a market window exists for selling broccoli in each market. Figure 5.16 shows a market window in Atlanta market throughout the marketing season. The closest levels of TC to the minimum price levels are in weeks 40, 41, and 46.

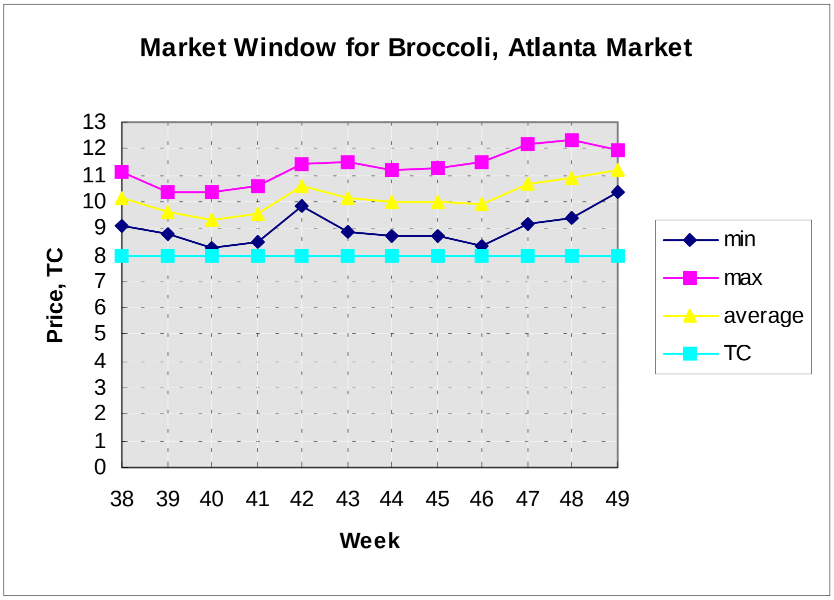


Figure 5.16 Market Window for Broccoli, Atlanta Market

The Baltimore market offers a wide market window for broccoli (Figure 5.17). All weeks considered are open periods for marketing broccoli. The most profitable periods could be weeks 42, 43, 48, and 49.

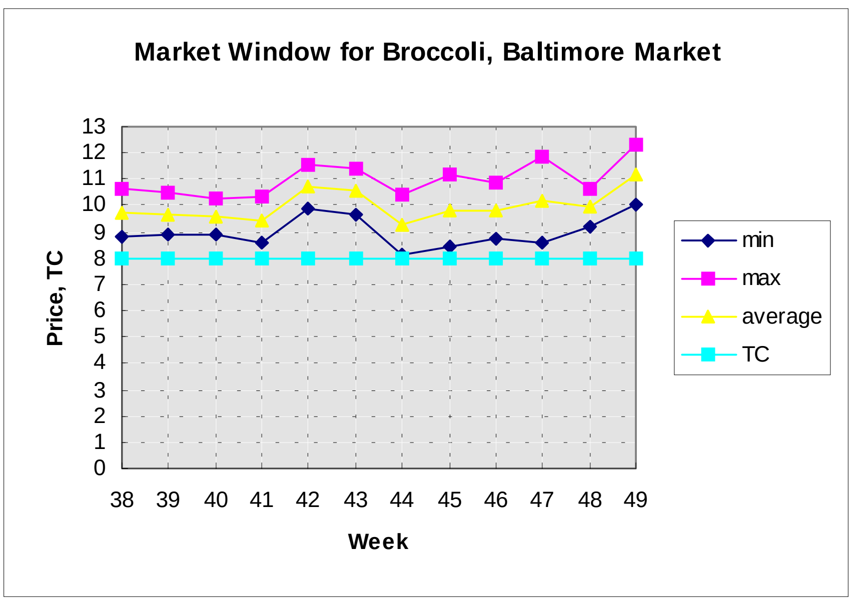


Figure 5.17 Market Window for Broccoli, Baltimore Market

There are two market windows for broccoli in Boston market for the study area, one in week 38 and another one in weeks 45 to 49 (Figure 5.18). If broccoli is marketed in this market, the worst situation could be during weeks 39 to 44.

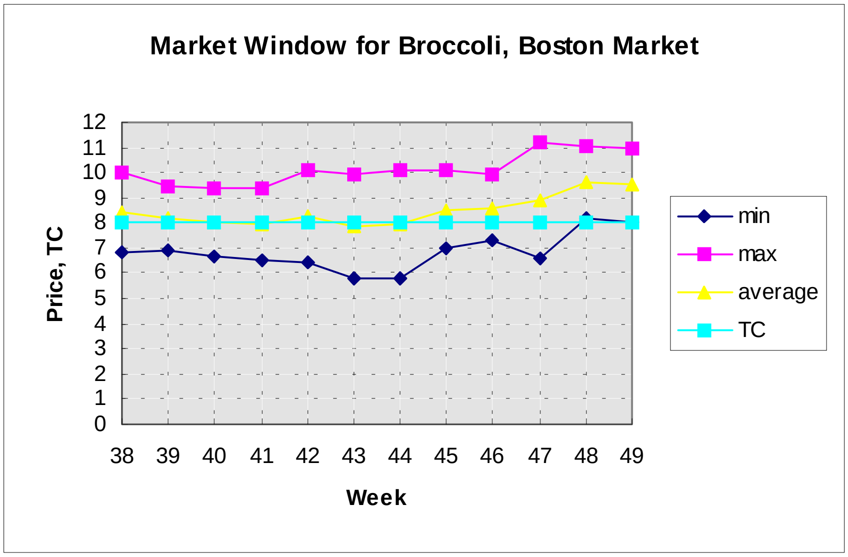


Figure 5.18 Market Window for Broccoli, Boston Market

The large distance to the Boston market from the study area increases the cost of transportation and influences the TC to be high.

The New York market offers a market window for the entire marketing season (Figure 5.19). This market window exists even if minimum prices were considered. Weeks 41, 47 and 49 have TC close to minimum historical prices offered at this market.

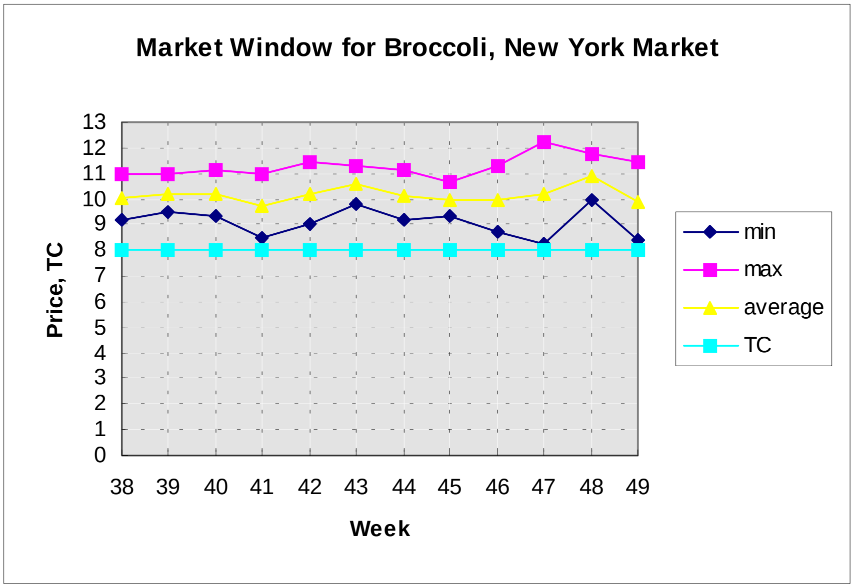


Figure 5.19 Market Window for Broccoli, New York Market

The difference between the minimum historical price at New York, Atlanta, and Baltimore markets and TC of production makes this enterprise appear to be viable. Killing frost could be a potential problem during weeks 47 to 49. The New York market appears to be the most profitable broccoli market for the study area.

In summary, market window analysis, despite the limitations, suggests that both tomatoes and broccoli have high potential and should be considered in defining the optimal farm plan.

5.3 Linear Programming Results

Since the programming model is linear, all ten scenarios were solved using LINDO. The algebraic set up of the baseline scenario is shown in Appendix C. The whole area was treated as one farm, and results are therefore valid for the region.

Analyzing the alternative enterprises is done by using the variable costs. The rationale for this is that fixed costs depend on individual farm conditions, and there is a large variability in fixed costs among farms. Fixed costs are important factors to be considered on a case by case basis for each farm. For example, labor costs are high, but if harvesting of tomatoes is mechanized, the fixed costs associated with mechanization may keep farmers out of this enterprise. The level of fixed costs depend on the machines and equipment used for the given activity, how often the machinery and equipment may need to be replaced, and whether the machinery and equipment to be purchased are new or used.

The optimal enterprise mix changed in different scenarios (Table 5.4). Results from the baseline scenario (scenario 1) contained tobacco at the three yield levels, high-yield corn, wheat double cropped with soybeans at high-yield, high-yield and average -yield wheat, average-yield and low-yield soybeans and cotton, broccoli, tomatoes and contract swine.

Scenario two reduced the acreage limits on tobacco by one third, and resulted in the same enterprise mix as scenario one with less acres of tobacco. High-yield and average-yield tobacco were selected at the maximum possible acres. Only average-yield tobacco was selected at a lower acreage level than the constraint allows. The acreage of remaining enterprises changed in favor of average-yield wheat, and low-yield soybeans and cotton, decreasing acres of average -yield soybeans and cotton.

In scenarios three and four, acreage of tobacco was further decreased. Again, average-yield tobacco did not utilize all possible acres in scenario three. The optimal plan still selected the same enterprises as the baseline scenario, but the acreage is changed. Scenario three followed the same trend of acreage changes as scenario two with larger changes. This trend changed in scenario four. Average-yield wheat, low-yield soybeans and cotton, average -yield soybeans and cotton, all had greater acreage in scenario four.

Scenario five indicated that with a reduction in half of the tobacco quota, introducing more tomatoes and broccoli without relaxing the irrigation constraint did not contribute very much in farm revenues. In this case, adding more vegetables resulted in less tobacco acres.

In scenario six, where the irrigation constraint was relaxed by 10 percent, the selected enterprises were the same as the baseline scenario. However, tobacco acreage was increased, compared to scenario five, in presence of more vegetable acres.

Table 5.4 Optimal Farm Plans

	VALUE									
	Scen I	Scen II	Scen III	Scen IV	Scen V	Scen VI	Scen VII	Scen VIII	Scen IX	Scen X
Obj F	3,107,687.00	2,653,571.00	2,426,517.00	1,758,523.00	2,428,544.00	2,583,160.00	652,414.30	1,813,390.00	1,813,390.00	183,778.60
Var										
Tob1	217.03	144.69	108.52	72.34	108.52	108.52	217.03	72.34	72.34	n/a
Tob2	643.07	715.41	751.58	552	745.33	828	n/a	552	552	n/a
Tob3	1441.16	960.77	720.58	480.39	720.58	720.58	n/a	480.39	480.39	n/a
Cor1	486.20	486.20	486.20	486.20	486.20	486.20	486.20	486.20	486.20	486.20
Cor2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cor3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bar2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bar3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wds1	39.50	39.50	39.50	39.50	39.50	39.50	39.50	39.50	39.50	39.50
Wds2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wds3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Whe1	15.04	15.04	15.04	15.04	15.04	15.04	15.04	15.04	15.04	15.04
Whe2	463.6	608.28	680.62	517.22	668.37	751.04	43.39	493.22	493.22	242.41
Whe3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Soy1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Soy2	743.16	706.99	688.90	788.7	692.03	650.7	950.27	788.7	788.7	950.27
Soy3	77.15	317.34	437.44	557.53	437.44	437.44	797.73	557.53	557.53	797.73
Cot2	743.16	706.99	688.90	788.7	692.03	650.7	950.27	788.7	788.7	950.27
Cot3	77.15	317.34	437.44	557.53	437.44	437.44	797.73	557.53	557.53	797.73
Broc2	3.00	3.00	3.00	3.00	6.00	6.00	6.00	15.00	15.00	15.00
Tom2	3.00	3.00	3.00	3.00	6.00	6.00	6.00	15.00	15.00	15.00
Bec	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cos	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500
Bcor	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Scenario seven was designed to limit tobacco production only in high-yield areas. The acreage reduction from tobacco went mostly to average-yield soybeans and cotton, and to low-yield soybeans and cotton. In Table 5.4 and subsequent tables, the notation "n/a" means not applicable.

Scenarios eight and nine generated the same results. With a two thirds of tobacco acreage reduction, irrigation constraint did not have any impact.

The tenth scenario was an indication of the large impact of tobacco on farm revenues. Average-yield wheat was dependent on tobacco. When tobacco was excluded from the optimal solution, average-yield wheat acres were decreased drastically. The conclusion is that average-yield wheat is included in the optimal plan mostly for its use in rotation requirements. Specialty crops are far for being a viable alternative for tobacco. They could serve as supplementary enterprises. Contract swine appears to be a profitable enterprise. It may be a close alternative to tobacco but its expansion is limited due to environmental concerns.

Table 5.5 shows the acres utilized from the optimal plans of each scenario and net revenue per acre for each scenario.

Table 5.5 Total Area Utilized and Net Revenue per Acre for Each Scenario

	Scen I	Scen II	Scen III	Scen IV	Scen V
Area utilized	4,952.22	5,024.55	5,060.72	4,861.15	5,054.48
Net revenue/acre	627.53	528.12	479.48	361.75	480.47
	Scen VI	Scen VII	Scen VIII	Scen IX	Scen X
Area utilized	5,137.16	4,309.16	4,861.15	4,861.15	4,309.15
Net revenue/acre	502.84	151.40	373.04	373.04	42.65

Scenarios six, three, five and two utilized more acres than other scenarios. The top five scenarios according to net revenue per acre ranked in a descending order are scenarios one, two, six, five and three. Net revenue per acre (above variable costs) generated by the first scenario was the highest level compared to other scenarios. Limitations on tobacco acreage resulted in lower net revenues. The introduction of more acres of broccoli and tomatoes combined with a 10 percent relaxed irrigation constraint led to higher net revenue per acre in scenario six, compared to the case of not relaxed irrigation constraint in scenario five. Limiting tobacco to one third of baseline scenario acreage, in the case of irrigation limit (scenario eight), resulted in the same level of net revenue per acre as in the case of relaxing irrigation limits by 10 percent (scenario nine). The lowest level of net revenue per acre was attained in scenario ten where tobacco was no longer produced. In the case where tobacco was left out of consideration, net revenue was decreased from $627.53 per acre in the baseline scenario to $42.65 per acre. This result was achieved, however, by increasing tomato and broccoli acreage to 15 acres. A reduction in half of tobacco acreage could be offset to some extent by an increase in broccoli and tomato acreage from 3 acres in the baseline scenario to 6 acres, and a 10 percent increase in irrigation capacity. If tobacco would no longer be produced in the study area, farmers would not be able to continue their farming activity, unless they modify their farm plan to accommodate new enterprises.

Shadow price indicates the change in net revenue, if a constraint is relaxed by one unit. In other words, it reveals what the farmer could pay to make another unit of a constraining resource available. The effects of shadow prices must be evaluated individually. Shadow prices generated from all scenarios provide useful information about the opportunity cost of products and resources.

Shadow prices of all products were positive (Table 5.8) which make sense, because for each unit increase of products sold, the net revenue is increased by the per unit price. All shadow prices of products were equal to the market price, except for three cases. First, the shadow price of average-yield barley in all scenarios was 54 cents greater than the selling price, except for the scenarios seven and ten. Second, the shadow price of average-yield wheat double cropped with soybeans was 20 cents higher than the market price in all scenarios. Third, the shadow price of high-yield soybeans was 7 cents greater than the selling price in all scenarios.

The shadow price of land was positive for high-yield and low-yield tobacco in scenarios two to six, eight and nine, for average-yield tobacco in scenarios four, six, eight and nine, for high-yield corn and for broccoli in all scenarios.

The highest shadow price of one acre of land for tobacco was $2,348.92 in scenarios four to six, eight and nine for high-yield tobacco. The shadow price of one acre land for corn was $13.67 in all scenarios. One added acre in broccoli resulted in the highest shadow price $4,572.26 in scenarios four and six to 10. If fixed costs were taken into account, the results would look different. Vegetables have higher fixed costs than other crops. The shadow price of one acre of broccoli would be lower than $4,572.26 in scenarios four and six to 10. The average shadow price of land per acre in different scenarios is given in the Table 5.6.

The estimated market value of land including buildings in Pittsylvania County in 1997 was $1,273 as an average per acre (USDA. 1997 Census of Agriculture, Virginia State and County Data). The closest figure from table 5.6 to this value was generated from scenario six.

Table 5.6 The Average[3] Shadow Price of Land per Acre

	Scen I	Scen II	Scen III	Scen IV	Scen V
Average shadow price of land per acre	17.73	574.98	523.29	1,030.26	523.29
	Scen VI	Scen VII	Scen VIII	Scen IX	Scen X
Average shadow price of land per acre	1,147.72	69.24	1,056.73	1,056.73	150.10

Scenarios one, seven and 10 produced the lowest shadow prices of land because the net revenue does not change very much if more land is acquired. The market value of land was higher than the shadow price of land in all scenarios. Farmers can pay less than the market price per acre, which means that they will not expand their agricultural activity beyond the land that they currently control.

The shadow price of the irrigation constraint showed how much the net revenue would have been increased if one more acre inch of irrigation water was made available. The increase in net revenue was $311.71 in scenarios one, two and five, and $626.4 in

[3] The average shadow price of land is calculated as a weighted average of shadow prices of individual enterprises, using their acreage in optimal mix as weights.

scenario three. There was no change in net revenue if one more acre inch of irrigation water was made accessible in scenarios four and six to 10. A list of all shadow prices generated by each scenario is given in the Table 5.7.

Table 5.7 Shadow Prices Generated by Each Scenario

	Scen I	Scen II	Scen III	Scen IV	Scen V	Scen VI	Scen VII	Scen VIII	Scen IX	Scen X
Yield Transfers										
Ptob1	1.78	1.78	1.78	1.78	1.78	1.78	1.78	1.78	1.78	n/a
Ptob2	1.78	1.78	1.78	1.78	1.78	1.78	n/a	1.78	1.78	n/a
Ptob3	1.78	1.78	1.78	1.78	1.78	1.78	n/a	1.78	1.78	n/a
Pbar2	2.61	2.61	2.61	2.61	2.61	2.61	2.07	2.61	2.61	2.07
Pbar3	2.07	2.07	2.07	2.07	2.07	2.07	2.07	2.07	2.07	2.07
Pwds1	3.77	3.77	3.77	3.77	3.77	3.77	3.77	3.77	3.77	3.77
Pwds2	3.92	3.92	3.92	3.92	3.92	3.92	3.92	3.92	3.92	3.92
Pwds3	3.66	3.66	3.66	3.66	3.66	3.66	3.66	3.66	3.66	3.66
Pwhe1	2.78	2.78	2.78	2.78	2.78	2.78	2.78	2.78	2.78	2.78
Pwhe2	2.78	2.78	2.78	2.78	2.78	2.78	2.78	2.78	2.78	2.78
Pwhe3	2.78	2.78	2.78	2.78	2.78	2.78	2.78	2.78	2.78	2.78
Psoy1	5.48	5.48	5.48	5.48	5.48	5.48	5.48	5.48	5.48	5.48
Psoy2	5.41	5.41	5.41	5.41	5.41	5.41	5.41	5.41	5.41	5.41
Psoy3	5.41	5.41	5.41	5.41	5.41	5.41	5.41	5.41	5.41	5.41
Pcot2	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
Pcot3	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
Pbroc2	10.18	10.18	10.18	10.18	10.18	10.18	10.18	10.18	10.18	10.18
Ptom2	7.99	7.99	7.99	7.99	7.99	7.99	7.99	7.99	7.99	7.99
Acreage Limits										
Tob1	0.00	478.65	478.65	2,348.92	478.65	2,348.92	0.00	2,348.92	2,348.92	n/a
Tob2	0.00	0.00	0.00	1,870.27	0.00	1,870.27	n/a	1,870.27	1,870.27	n/a
Tob3	0.00	873.23	873.23	873.23	873.23	873.23	n/a	873.23	873.23	n/a
Cor1	13.67	13.67	13.67	13.67	13.67	13.67	13.67	13.67	13.67	13.67
Cor2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cor3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bar2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bar3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wds1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 5.7 (continued)										
Wds2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wds3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Whe1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Whe2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Whe3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Soy1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Soy2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Soy3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cot2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cot3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Broc2	675.86	675.86	675.86	4,572.26	675.86	4,572.26	4,572.26	4,572.26	4,572.26	4,572.26
Tom2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Livestock Limits										
Bec	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cos	5.65	5.65	5.65	5.65	5.65	5.65	5.65	5.65	5.65	5.65
Corn Transfer										
Scor	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50
IrrigLim	311.71	311.71	626.4	0.00	311.71	0.00	0.00	0.00	0.00	0.00

Sensitivity analysis produced ranges of prices, costs and right hand sides[4] (RHS) beyond which the particular enterprise move out of the optimal plan or enterprises left out enter the optimal plan, if the optimal solution is unique and no slack in the optimal solution is related to the specific enterprise. This is done for each of the 10 scenarios (Tables 5.8 and 5.9). If a slack variable in the optimal solution is related to the particular enterprise, then that enterprise is not leaving the optimal solution. Instead, the slack variable is moving out of the optimal solution and the acreage constraint becomes binding. Other changes take place in optimal solution if an enterprise leaves or enters the optimal mix. The LP program must be run for each individual case in order to see these changes.

[4] Right hand sides are values in the right hand side of the constraints' equations or non-equations.

Table 5.8 Prices and Operational Costs Ranges (Scen I to V)

		Scen I		Scen II		Scen III		Scen IV		Scen V	
Variables	Current Value	Lower Bound	Upper Bound	Lower Bound	Upper Bound	Lower Bound	Upper Bound	Lower Bound	Upper Bound	Lower Bound	Upper Bound
Ptob1	1.78	1.60	infinity	1.60	infinity	1.60	infinity	0.91	infinity	1.60	infinity
Tob1	2,453.91	infinity	2,932.56	infinity	2,932.56	infinity	2,932.56	infinity	4,802.83	infinity	2,932.56
Ptob2	1.78	1.001	1.92	1.001	1.92	1.001	1.92	1.001	infinity	1.001	1.92
Tob2	2,367.60	2,043.19	4,237.87	2,043.19	4,237.87	2,043.19	4,237.87	infinity	4,237.87	2,043.19	4,237.87
Ptob3	1.78	1.30	infinity	1.30	infinity	1.30	infinity	1.30	infinity	1.30	infinity
Tob3	2,314.92	infinity	3,188.15	infinity	3,188.15	infinity	3,188.15	infinity	3,188.15	infinity	3,188.15
Scor	2.5	2.363	2.98	2.363	2.98	2.363	2.98	2.363	2.98	2.363	2.98
Cor1	236.33	infinity	250	infinity	250	infinity	250	infinity	250	infinity	250
Cor2	223.6	180.33	infinity	180.33	infinity	180.33	infinity	180.33	infinity	180.33	infinity
Cor3	212.38	163.09	infinity	163.09	infinity	163.09	infinity	163.09	infinity	163.09	infinity
Bcor	3	infinity	3.5	infinity	3.5	infinity	3.5	infinity	3.5	infinity	3.5
Pbar2	2.07	infinity	2.61	infinity	2.61	infinity	2.61	infinity	2.61	infinity	2.61
Bar2	135.67	92.4	infinity	92.4	infinity	92.4	infinity	92.4	infinity	92.4	infinity
Pbar3	2.07	infinity	2.77	infinity	2.77	infinity	2.77	infinity	2.77	infinity	2.77
Bar3	125.11	75.82	infinity	75.82	infinity	75.82	infinity	75.82	infinity	75.82	infinity
Pwds1	3.77	3.74	infinity	3.74	infinity	3.74	infinity	3.74	infinity	3.74	infinity
Wds1	235.19	infinity	237.61	infinity	237.61	infinity	237.61	infinity	237.61	infinity	237.61
Pwds2	3.72	infinity	3.917	infinity	3.917	infinity	3.917	infinity	3.917	infinity	3.917
Wds2	236.91	223.1	infinity	223.1	infinity	223.1	infinity	223.1	infinity	223.1	infinity
Pwds3	3.66	infinity	4.019	infinity	4.019	infinity	4.019	infinity	4.019	infinity	4.019
Wds3	225.3	203.75	infinity	203.75	infinity	203.75	infinity	203.75	infinity	203.75	infinity
Pwhe1	2.78	2.418	3.305	2.418	3.305	2.418	3.305	2.418	3.305	2.418	3.305
Whe1	181.35	142.09	208.49	142.09	208.49	142.09	208.49	142.09	208.49	142.09	208.49
Pwhe2	2.78	2.293	3.305	2.293	3.305	2.293	3.305	2.293	3.305	2.293	3.305
Whe2	177.53	143.4	180.7	143.4	180.7	143.4	180.7	143.4	180.7	143.4	180.7
Pwhe3	2.78	infinity	3.56	infinity	3.56	infinity	3.56	infinity	3.56	infinity	3.56
Whe3	161.98	123.15	infinity	123.15	infinity	123.15	infinity	123.15	infinity	123.15	infinity
Psoy1	5.41	infinity	5.48	infinity	5.48	infinity	5.48	infinity	5.48	infinity	5.48
Soy1	125.36	122.94	infinity	122.94	infinity	122.94	infinity	122.94	infinity	122.94	infinity

Table 5.8 Scen I to V (continued)											
		Scen I		Scen II		Scen III		Scen IV		Scen V	
Variables	Current Value	Lower Bound	Upper Bound	Lower Bound	Upper Bound	Lower Bound	Upper Bound	Lower Bound	Upper Bound	Lower Bound	Upper Bound
Psoy2	5.41	4.49	130.09	4.49	130.09	4.49	130.09	4.49	130.09	4.49	130.09
Soy2	130.7	-3609.84	158.32	-3609.84	158.32	-3609.84	158.32	-3609.84	158.32	-3609.84	158.32
Psoy3	5.41	4.14	75.26	4.14	75.26	4.14	75.26	4.14	75.26	4.14	75.26
Soy3	116.4	-1630.06	148.1	-1630.06	148.1	-1630.06	148.1	-1630.06	148.1	-1630.06	148.1
Pcot2	0.6	0.56	6.35	0.56	6.35	0.56	6.35	0.56	6.35	0.56	6.35
Cot2	347	-3393.54	374.62	-3393.54	374.62	-3393.54	374.62	-3393.54	374.62	-3393.54	374.62
Pcot3	0.6	0.55	3.51	0.55	3.51	0.55	3.51	0.55	3.51	0.55	3.51
Cot3	347.15	-1399.31	378.85	-1399.31	378.85	-1399.31	378.85	-1399.31	378.85	-1399.31	378.85
Pbroc2	10.18	8.35	infinity	8.35	infinity	8.35	infinity	-2.18	infinity	8.35	infinity
Broc2	1,966.04	infinity	2,641.90	infinity	2,641.90	infinity	2,641.90	infinity	6,538.30	infinity	2,641.90
Ptom2	7.99	7.57	infinity	7.57	infinity	7.57	infinity	5.132	infinity	7.57	infinity
Tom2	10,005.96	infinity	10,681.82	infinity	10,681.82	infinity	10,681.82	infinity	14,578.22	infinity	10,681.82
Bec	1.66	infinity	9.91	infinity	9.91	infinity	9.91	infinity	9.91	infinity	9.91
Cos	5.65	0	infinity	0	infinity	0	infinity	0	infinity	0	infinity

Table 5.9 Prices and Operational Costs Ranges (Scen VI to X)

Variables	Current Value	Scen VI Lower Bound	Scen VI Upper Bound	Scen VII Lower Bound	Scen VII Upper Bound	Scen VIII Lower Bound	Scen VIII Upper Bound	Scen IX Lower Bound	Scen IX Upper Bound	Scen X Lower Bound	Scen X Upper Bound
Ptob1	1.78	0.91	infinity	0.91	infinity	0.91	infinity	0.91	infinity	n/a	n/a
Tob1	2,453.91	infinity	4,802.83	infinity	4,802.83	infinity	4,802.83	infinity	4,802.83	n/a	n/a
Ptob2	1.78	1.001	infinity	n/a	n/a	1.001	infinity	1.001	infinity	n/a	n/a
Tob2	2,367.60	infinity	4,237.87	n/a	n/a	infinity	4,237.87	infinity	4,237.87	n/a	n/a
Ptob3	1.78	1.30	infinity	n/a	n/a	1.30	infinity	1.30	infinity	n/a	n/a
Tob3	2,314.92	infinity	3,188.15	n/a	n/a	infinity	3,188.15	infinity	3,188.15	n/a	n/a
Scor	2.5	2.363	2.98	2.363	2.98	2.363	2.98	2.363	2.98	2.363	2.98
Cor1	236.33	infinity	250	infinity	250	infinity	250	infinity	250	infinity	250
Cor2	223.6	180.33	infinity	180.33	infinity	180.33	infinity	180.33	infinity	180.33	infinity
Cor3	212.38	163.09	infinity	163.09	infinity	163.09	infinity	163.09	infinity	163.09	infinity
Bcor	3	infinity	3.5	infinity	3.5	infinity	3.5	infinity	3.5	infinity	3.5
Pbar2	2.07	infinity	2.61	infinity	2.61	infinity	2.61	infinity	2.61	infinity	2.61
Bar2	135.67	92.4	infinity	92.4	infinity	92.4	infinity	92.4	infinity	92.4	infinity
Pbar3	2.07	infinity	2.77	infinity	2.77	infinity	2.77	infinity	2.77	infinity	2.77
Bar3	125.11	75.82	infinity	75.82	infinity	75.82	infinity	75.82	infinity	75.82	infinity
Pwds1	3.77	3.74	infinity	3.74	infinity	3.74	infinity	3.74	infinity	3.74	infinity
Wds1	235.19	infinity	237.61	infinity	237.61	infinity	237.61	infinity	237.61	infinity	237.61
Pwds2	3.72	infinity	3.917	infinity	3.917	infinity	3.917	infinity	3.917	infinity	3.917
Wds2	236.91	223.1	infinity	223.1	infinity	223.1	infinity	223.1	infinity	223.1	infinity
Pwds3	3.66	infinity	4.019	infinity	4.019	infinity	4.019	infinity	4.019	infinity	4.019
Wds3	225.3	203.75	infinity	203.75	infinity	203.75	infinity	203.75	infinity	203.75	infinity
Pwhe1	2.78	2.418	3.305	2.418	3.305	2.418	3.305	2.418	3.305	2.418	3.305
Whe1	181.35	142.09	208.49	142.09	208.49	142.09	208.49	142.09	208.49	142.09	208.49
Pwhe2	2.78	2.293	3.305	2.293	3.305	2.293	3.305	2.293	3.305	2.293	3.305
Whe2	177.53	143.4	180.7	143.4	180.7	143.4	180.7	143.4	180.7	143.4	180.7
Pwhe3	2.78	infinity	3.56	infinity	3.56	infinity	3.56	infinity	3.56	infinity	3.56
Whe3	161.98	123.15	infinity	123.15	infinity	123.15	infinity	123.15	infinity	123.15	infinity
Psoy1	5.41	infinity	5.48	infinity	5.48	infinity	5.48	infinity	5.48	infinity	5.48
Soy1	125.36	122.94	infinity	122.94	infinity	122.94	infinity	122.94	infinity	122.94	infinity
Psoy2	5.41	4.49	130.09	4.49	infinity	4.49	130.09	4.49	130.09	4.49	infinity

Table 5.9 Scen VI to X (continued)

Variables	Current Value	Scen VI Lower Bound	Scen VI Upper Bound	Scen VII Lower Bound	Scen VII Upper Bound	Scen VIII Lower Bound	Scen VIII Upper Bound	Scen IX Lower Bound	Scen IX Upper Bound	Scen X Lower Bound	Scen X Upper Bound
Soy2	130.7	-3609.84	158.32	infinity	158.32	-3609.84	158.32	-3609.84	158.32	infinity	158.32
Psoy3	5.41	4.14	75.26	4.14	infinity	4.14	75.26	4.14	75.26	4.14	infinity
Soy3	116.4	-1630.06	148.1	infinity	148.1	-1630.06	148.1	-1630.06	148.1	infinity	148.1
Pcot2	0.6	0.56	6.35	0.56	infinity	0.56	6.35	0.56	6.35	0.56	infinity
Cot2	347	-3393.54	374.62	infinity	374.62	-3393.54	374.62	-3393.54	374.62	infinity	374.62
Pcot3	0.6	0.55	3.51	0.55	infinity	0.55	3.51	0.55	3.51	0.55	infinity
Cot3	347.15	-1399.31	378.85	infinity	378.85	-1399.31	378.85	-1399.31	378.85	infinity	378.85
Pbroc2	10.18	-2.18	infinity	-2.18	infinity	-2.18	infinity	-2.18	infinity	-2.18	infinity
Broc2	1,966.04	infinity	6,538.30	infinity	6,538.30	infinity	6,538.30	infinity	6,538.30	infinity	6,538.30
Ptom2	7.99	5.132	infinity	5.132	infinity	5.132	infinity	5.132	infinity	5.132	infinity
Tom2	10,005.96	infinity	14,578.22	infinity	14,578.22	infinity	14,578.22	infinity	14,578.22	infinity	14,578.22
Bec	1.66	infinity	9.91	infinity	9.91	infinity	9.91	infinity	9.91	infinity	9.91
Cos	5.65	0	infinity	0	infinity	0	infinity	0	infinity	0	infinity

Table 5.10 is a small excerpt and serves as an illustration for understanding the results.

Table 5.10 Boundaries of Prices and Variable Costs (Excerpt from tables 5.8 and 5.9)

Variables	Scenario I		
	Current Value	Lower Bound	Upper Bound
Ptob1	1.78	1.60	infinity
Tob1	2,453.91	infinity	2,932.56
Pwhe1	2.78	2.418	3.305
Whe1	181.35	142.09	208.49
Pbar2	2.07	infinity	2.61
Bar2	135.67	92.4	infinity

Scenario one generated a unique solution. Tob1 is in the optimal solution of scenario one with 217.03 acres. There are no slack acres left out of this variable. If the price of Tob1 were lower than $1.60 (Lower Bound) then high-yield tobacco would have fallen out of the optimal enterprise mix. Scenario one was modified with the price of Tob1 equal to $1.55. As a result Tob1 left the optimal solution and the acreage of other variables in the optimal solution changed in favor of average-yield tobacco and wheat, decreasing acres of average-yield soybeans and cotton. Had the variable costs of average-yield tobacco been higher than 2,932.56 per acre, this enterprise would have been excluded from the optimal mix.

Whe1 was selected in the optimal solution of scenario one with 15.04 acres. There is a slack variable in the optimal solution for 31.98 acres related to Whe1 acres. If the price of Whe1 were greater than $3.305 (Upper Bound) then Whe1 would have been selected with all possible acres, without having slack acres in the optimal solution. The slack variable would leave the optimal solution. Scenario one was rerun with the Whe1 price $3.35. Results indicated that the slack variable moved out of the optimal solution and Whe1 entered the optimal solution with 47.02 acres. Acres of high-yield wheat double cropped with soybeans were decreased by 31.98 in the new optimal solution. The same results would have been shown if the variable costs per acre of Whe1 would have been less than $142.09. If the price of Whe1 were less than $2.418 or the variable costs were greater than $208.49 per acre then high-yield wheat would have been left out of the optimal enterprise mix.

In the case of average-yield barley, this was an enterprise excluded from the optimal set of enterprises. To have been included, the price of Bar2 would have to increase to higher than $2.61. Variable costs in the case of Bar2 would need to be below $92.4 per acre in order for average-yield barley to have been included in the optimal enterprise mix. Scenario one was modified by setting the price of Bar2 equal to $2.62. Bar2 entered the optimal solution with 743.16 acres. Cor2 also entered the optimal solution with the same acreage as Bar2. There were no other changes in the optimal enterprise mix and in the acreage of other enterprises.

Other results presented in the Table 5.9 and in the Table 5.10 can be interpreted in a similar way. The interesting thing here is to see how sensitive the optimal enterprise sets are. In some cases, if the market pushes the price down a very small percentage, the particular enterprise will leave the optimal mix. The most sensitive enterprises are Tob1 in scenario one, Bar2, Wds1, Soy1, Cot2 and Cot3 in all scenarios, Tom2 in scenarios one to three and five.

Every optimal solution will hold not only for the stated constraints but also within a given range of constraints. Table 5.11 presents the current "right hand sides", the lower bound and upper bound of the acreage constraints and other physical or technical limitations. The optimal plan was most sensitive to the acreage constraints of broccoli in scenarios one, seven and 10, high-yield tobacco, and broccoli in scenarios two, four, six, eight and nine, high-yield tobacco, broccoli and the acre inches of available irrigation water in scenarios three and five. This conclusion is drawn from the relatively narrow range of these limits.

Table 5.11 Acreage, Livestock and Irrigation Water Ranges

	Scen I			Scen II			Scen III			Scen IV		
Constraint	Current RHS	Lower Bound	Upper Bound	Current RHS	Lower Bound	Upper Bound	Current RHS	Lower Bound	Upper Bound	Current RHS	Lower Bound	Upper Bound
Tob1	217.03	217.03	infinity	144.69	83.06	187.85	108.52	83.06	187.85	72.34	0	83.06
Tob2	1656	643.07	infinity	1104	715.41	infinity	828	751.59	infinity	552	388.1	577.46
Tob3	1441.16	1441.16	infinity	960.77	10	1318.19	720.58	10	1318.19	480.39	10	1318.19
Cor1	486.2	0	893.39	486.2	0	893.39	486.2	0	893.39	486.2	0	893.39
Cor2	1900.54	0	infinity	1900.54	0	infinity	1900.54	0	infinity	1900.54	0	infinity
Cor3	1595.46	0	infinity	1595.46	0	infinity	1595.46	0	infinity	1595.46	0	infinity
Bar2	1900.54	0	infinity	1900.54	0	infinity	1900.54	0	infinity	1900.54	0	infinity
Bar3	1595.46	0	infinity	1595.46	0	infinity	1595.46	0	infinity	1595.46	0	infinity
Wds1	39.5	39.5	infinity	39.5	39.5	infinity	39.5	39.5	infinity	39.5	39.5	infinity
Wds2	1900.54	0	infinity	1900.54	0	infinity	1900.54	0	infinity	1900.54	0	infinity
Wds3	1595.46	0	infinity	1595.46	0	infinity	1595.46	0	infinity	1595.46	0	infinity
Whe1	47.02	15.04	infinity	47.02	15.04	infinity	47.02	15.04	infinity	47.02	15.04	infinity
Whe2	1954.2	463.6	infinity	1954.2	608.28	infinity	1954.2	680.62	infinity	1954.2	517.22	infinity
Whe3	1518.31	0	infinity	1518.31	0	infinity	1518.31	0	infinity	1518.31	0	infinity
Soy1	39.5	0	infinity	39.5	0	infinity	39.5	0	infinity	39.5	0	infinity
Soy2	1900.54	743.17	infinity	1900.54	707	infinity	1900.54	688.91	infinity	1900.54	788.7	infinity
Soy3	1595.46	77.15	infinity	1595.46	317.35	infinity	1595.46	437.44	infinity	1595.46	557.54	infinity
Cot2	1900.54	743.17	infinity	1900.54	707	infinity	1900.54	688.91	infinity	1900.54	788.7	infinity
Cot3	1595.46	77.15	infinity	1595.46	317.35	infinity	1595.46	437.44	infinity	1595.46	557.54	infinity
Broc2	3	0	4	3	0	4	3	0	4	3	0	4
Tom2	4	3	infinity	4	3	infinity	4	3	infinity	4	3	infinity
Bec	100	0	infinity	100	0	infinity	100	0	infinity	100	0	infinity
Cos	1500	0	infinity	1500	0	infinity	1500	0	infinity	1500	0	infinity
Irrigation	5198.1	4804.44	8221.17	5198.1	4370.4	7529.64	5198.1	4153.38	5656.62	5198.1	3783.54	infinity

Table 5.11 (continued)												
	Scen V			Scen VI			Scen VII			Scen VIII		
Constraint	Current RHS	Lower Bound	Upper Bound	Current RHS	Lower Bound	Upper Bound	Current RHS	Lower Bound	Upper Bound	Current RHS	Lower Bound	Upper Bound
Tob1	108.52	83.06	187.85	108.52	83.06	112.48	217.03	217.03	infinity	72.34	0	83.06
Tob2	828	745.33	infinity	828	577.46	831.96	n/a	n/a	n/a	552	388.1	577.46
Tob3	720.58	10	1318.19	720.58	10	1318.19	n/a	n/a	n/a	480.39	10	1318.19
Cor1	486.2	0	893.39	486.2	0	820.72	486.2	0	893.39	486.2	0	893.39
Cor2	1900.54	0	infinity	1900.54	0	infinity	1900.54	0	infinity	1900.54	0	infinity
Cor3	1595.46	0	infinity	1595.46	0	infinity	1595.46	0	infinity	1595.46	0	infinity
Bar2	1900.54	0	infinity	1900.54	0	infinity	1900.54	0	infinity	1900.54	0	infinity
Bar3	1595.46	0	infinity	1595.46	0	infinity	1595.46	0	infinity	1595.46	0	infinity
Wds1	39.5	39.5	infinity	39.5	39.5	infinity	39.5	39.5	infinity	39.5	39.5	infinity
Wds2	1900.54	0	infinity	1900.54	0	infinity	1900.54	0	infinity	1900.54	0	infinity
Wds3	1595.46	0	infinity	1595.46	0	infinity	1595.46	0	infinity	1595.46	0	infinity
Whe1	47.02	15.04	infinity	47.02	15.04	infinity	27.27	15.04	infinity	47.02	15.04	infinity
Whe2	1954.2	668.37	infinity	1954.2	751.04	infinity	1145.95	43.39	infinity	1954.2	517.22	infinity
Whe3	1518.31	0	infinity	1518.31	0	infinity	797.73	0	infinity	1518.31	0	infinity
Soy1	39.5	0	infinity	39.5	0	infinity	39.5	0	infinity	39.5	0	infinity
Soy2	1900.54	692.04	infinity	1900.54	650.7	infinity	1900.54	950.27	infinity	1900.54	788.7	infinity
Soy3	1595.46	437.44	infinity	1595.46	437.44	infinity	1595.46	797.73	infinity	1595.46	557.54	infinity
Cot2	1900.54	692.04	infinity	1900.54	650.7	infinity	1900.54	950.27	infinity	1900.54	788.7	infinity
Cot3	1595.46	437.44	infinity	1595.46	437.44	infinity	1595.46	797.73	infinity	1595.46	557.54	infinity
Broc2	6	0	8	6	0	7.9	6	0	8	15	0	20
Tom2	8	6	infinity	8	6	infinity	8	6	infinity	20	15	infinity
Bec	100	0	infinity	100	0	infinity	100	0	infinity	100	0	infinity
Cos	1500	0	infinity	1500	0	infinity	1500	0	infinity	1500	0	infinity
Irrigation	5198.1	4190.88	5694.12	5717.91	5694.12	infinity	5717.91	1377.18	infinity	5198.1	3933.54	infinity

Table 5.11 (continued)						
	Scen IX			Scen X		
Constraint	Current RHS	Lower Bound	Upper Bound	Current RHS	Lower Bound	Upper Bound
Tob1	72.34	0	83.06	n/a	n/a	n/a
Tob2	552	388.1	577.46	n/a	n/a	n/a
Tob3	480.39	10	1318.19	n/a	n/a	n/a
Cor1	486.2	0	893.39	486.2	0	893.39
Cor2	1900.54	0	infinity	1900.54	0	infinity
Cor3	1595.46	0	infinity	1595.46	0	infinity
Bar2	1900.54	0	infinity	1900.54	0	infinity
Bar3	1595.46	0	infinity	1595.46	0	infinity
Wds1	39.5	39.5	infinity	39.5	39.5	infinity
Wds2	1900.54	0	infinity	1900.54	0	infinity
Wds3	1595.46	0	infinity	1595.46	0	infinity
Whe1	47.02	15.04	infinity	27.27	15.04	infinity
Whe2	1954.2	517.22	infinity	1037.43	242.42	infinity
Whe3	1518.31	0	infinity	797.73	0	infinity
Soy1	39.5	0	infinity	39.5	0	infinity
Soy2	1900.54	788.7	infinity	1900.54	950.27	infinity
Soy3	1595.46	557.54	infinity	1595.46	797.73	infinity
Cot2	1900.54	788.7	infinity	1900.54	950.27	infinity
Cot3	1595.46	557.54	infinity	1595.46	797.73	infinity
Broc2	15	0	20	15	0	20
Tom2	20	15	infinity	20	15	infinity
Bec	100	0	infinity	100	0	infinity
Cos	1500	0	infinity	1500	0	infinity
Irrigation	5717.91	3933.54	infinity	5717.91	187.5	infinity

5.4 Price Flexibility Implications

Price flexibility is the inverse of price elasticity and shows percentage change in price if the quantity supplied is changed by one percent. The own price elasticity of demand for agricultural products depends partially on the length of marketing season. The shorter the period that the product can be stored, the less elastic is the demand for that product. This is especially true for fresh vegetable production. An inelastic demand may produce a high impact in price reduction, if an increase in quantity supplied is significant.

Results of this research suggested that producing large quantities of broccoli and tomatoes appears to be profitable. The estimation of price elasticity for fresh vegetables is found in the literature (Goodwin, J. W. 1994, p.218). Using data for the period 1947-1979, it is estimated that fresh vegetables have a price elasticity -0.347. It is not specified if the data belong to the farm level or retail level. Price flexibility of fresh vegetables is -2.88. This means that for each 1 percent increase in the U.S. production of tomatoes (broccoli) and offered to the market, the price of tomatoes (broccoli) will decrease by 2.88 percent.

The price effect of the increased quantities according to different scenarios, is given in the Table 5.12. This is an illustration, assuming that Virginia farmers will behave in the same way like farmers of the study area. The calculations are done based on 1996 Virginia tomato production for fresh market, which was 1,008,000 cwt (Virginia Agricultural Statistics Bulletin, 1996) and the United States fresh market tomato production in 1996, which was 30,854,000 cwt (USDA, NASS, *Statistical Highlights of U.S Agriculture 1996/97*). The baseline scenario production represents the current situation. The tomato production of Virginia is assumed to be increased by the same rate as the tomato production of the study area in different scenarios compared to the baseline scenario. Then, the percentage increase in national tomato production is calculated, assuming that other states are producing the same quantity as in 1996. The decrease in the market price is calculated by multiplying the percentage increase in quantity sold in the national market with the price flexibility.

Table 5.12 Illustration of the Price Effect of a Significant Increase in Tomato Supply.

Scenario	Tomato Acres	Tomato Quantity (cwt)	Tomato Quantity Over Baseline Scenario (times)	Increase in VA Tomato Production (cwt)	Percentage Increase in U.S. Tomato Production	Percentage Decrease in Tomato Price	Final Tomato Price per 25 lb. Carton
1	3	1,200	0.00	n/a	n/a	n/a	7.99
2	3	1,200	0.00	0.00	0.00	0.00	7.99
3	3	1,200	0.00	0.00	0.00	0.00	7.99
4	3	1,200	0.00	0.00	0.00	0.00	7.99
5	6	2,400	1.00	1,008,000.00	3.27	9.41	7.24
6	6	2,400	1.00	1,008,000.00	3.27	9.41	7.24
7	6	2,400	1.00	1,008,000.00	3.27	9.41	7.24
8	15	6,000	4.00	4,032,000.00	13.07	37.64	4.98
9	15	6,000	4.00	4,032,000.00	13.07	37.64	4.98
10	15	6,000	4.00	4,032,000.00	13.07	37.64	4.98

The most dramatic price reduction would occur in the case of scenarios eight to 10, where the increased output of Virginia's tomatoes represents an increase of 13.07 percent of U.S production. With the lower prices, tomatoes will continue to be part of the optimal enterprise mix only in scenarios six and seven, where the price $7.24 is still above the lower boundary of $5.132. LP results are based on the variable costs. Fixed costs in the case of tomatoes are estimated to be about 50 cents per carton. This means that the lower bound of the price could be higher. It should be noted that the irrigation constraint is relaxed 10 percent in these scenarios. Making more irrigation water available requires investments for building more ponds, which further increases fixed costs. Taking into account assumptions made in this illustration, planting more tomatoes in the study area seems to be reasonable in scenarios six and seven, where tomato acreage is doubled compared to the baseline scenario (increased from 3acres to 6 acres).

Price impacts are calculated using only one price elasticity parameter. Results hold only if the demand curve exhibits a constant elasticity. This is the case if demand function is assumed to be an exponential function. In the case of a linear demand curve, these results are not accurate. As the quantity increases, demand becomes less elastic and the price elasticity becomes a smaller negative number. The price flexibility of demand increases. As farmers move to larger volumes of tomato production, for each 1 percent increase in the tomatoes produced and offered to the market, the price of tomatoes will decrease by more than 2.88 percent.

Chapter 6

SUMMARY AND CONCLUSIONS

This chapter contains a short summary of the study with emphasis on the analytical framework. Conclusions part shows how the methods used in this research worked. During the course of the work many questions were raised and related issues were identified, not all of which were stated in the objectives of the study. These new issues suggest possible extensions of this research and are included in this chapter as suggestions for further research.

6.1 A Summary of the Study

The overall objective of this research was to develop and demonstrate an analytical framework which would be able to filter technical and economic information regarding alternative agricultural enterprises in order to enable farmers to make more informed diversification and adjustment decisions. Rural areas need to consider a wide range of alternative enterprises to maintain or enhance income and standards of living. This is particularly important for areas that need to adjust the structure of income sources as a result of dramatic changes in market demand or/and agricultural policy.

Tobacco producing regions are currently facing such a problem in the United States. Traditionally, farm planning is approached starting from the available technical information. This research attempts to integrate the technical side with the economics of farm management. The method used was a combination of GIS with Linear Programming. This combination was imposed by the nature of the problem, which involved both strategic economic decisions and operational economic decisions. A GIS database of technical parameters, linked with the real world location of the land, was adopted. These parameters were related to the soils and climatic conditions of the farm fields and agronomic requirements of the enterprises considered in the study.

Procedures developed in an analytical setting were demonstrated using a part of Pittsylvania County as a case study example. Data for the study area were found in the Soil Survey of Pittsylvania County. Since the soil maps and other data were not in a digital format, digitizing was part of this research. Enterprise budgets were modified from the publications of Virginia Cooperative Extension and North Carolina State University. Information from “A Handbook of Agronomy” (1984), published by Virginia Cooperative Extension Service, parameters developed in “The Development and Implementation of the Virginia Agronomic Land Use Evaluation System (VALUES)” (Simpson, T. W., et al., 1993), published by Virginia Tech, and consultations with extension agents of Virginia Cooperative Extension, were very helpful. The soil database was created in an ArcView GIS platform. This included maps and attribute tables. A layer was created for each type of soil which belongs to land capability classes 1 to 4.

Based on the factors that limit yield and cannot be corrected at a reasonable cost, the fields suitable for each enterprise were found using overlays that demonstrates the intersection of limiting factors. Soil depth, soil series, soil texture, slope, flood potential and average summer temperature were factors that affect productivity and cannot be fixed. Natural drainage, soil pH, natural fertility, content of organic matter and rainfall were factors that influenced the cost of production.

GIS analysis was completed using yield factors. Yield factors were very discriminating across varying soil characteristics. Results of GIS analysis are displayed in maps accompanied by attribute tables for each enterprise.

Timing of the marketing decision is very important in marketing agricultural products that have seasonal prices. Defining the marketing season according to historical prices received and the estimated cost of production involves a procedure called market window analysis. When the average historical prices were still above the total cost of production, a market window was identified. Results for each identified market were summarized in tables and were illustrated by graphs.

Finally, since resources were limited, all technical parameters were used in a linear programming procedure in order to define the optimal enterprise mix. This was done for 10 scenarios according to various tobacco, vegetable enterprise activity levels, and irrigation availability. For each scenario, results presented include the optimal enterprise mix, net revenue (above variable costs), shadow prices and sensitivity analysis.

Since all constraints were "less than or equal", the shadow price indicates the change in net revenue if the constraint is relaxed by one unit. In other words, it reveals the ability of the farmer to pay for making available another unit of same constrained resource. Shadow prices must be interpreted individually. This means that relaxing all constraints by one unit does not change the net revenue by the sum of respective shadow prices. Shadow prices generated from all scenarios provide useful information about the opportunity cost of resource use.

The average shadow price of land per acre in each scenario was generated. They were compared with the average value of land in Pittsylvania County in 1997. In all scenarios the market value of land was higher than its shadow price. Farmers would be willing to pay less than the market price per acre, which means that they would not expand their agricultural production by buying land.

The shadow price of the irrigation constraint showed how much the net revenue would have been increased if one more acre inches of irrigation water was made available. A list of all shadow prices generated by each scenario was presented.

Sensitivity analysis produced ranges of prices, costs and resource limits beyond which the optimal plan would change. This analysis is presented for each scenario in tables. The sensitivity of optimal enterprise sets was different in different scenarios. In some cases, if the market pushes the price down even slightly, the particular enterprise may leave the optimal mix. Every optimal solution holds not only for the stated constraints but also within a given range of constraints. In separate tables the "right hand sides", the lower bound and upper bound of the acreage constraints and other physical or technical limitations were presented. In cases when optimal enterprise mix suggested that production of any enterprise was substantially increased, compared to the current situation, price elasticity analysis showed how much the selling price would go down and what would happen to the optimal mix.

The sensitivity analysis is an important guide to farmers in the area. For example, barley is not in the optimal solution, but farmers in the area believe it could be profitable and have started to look at the investments in equipment needed to grow barley. Results showing the sensitivity analysis indicate that, in the first scenario, selling price of average-yield barley must increase 26.09 percent per bushel, or the variable cost of producing average-yield barley must come down 31.89 percent per acre for average-yield barley to be competitive. This is important information because it may prevent a serious mistake by the study area farmer(s).

6.2 Conclusions

The evaluation of agricultural enterprises is very important for farmers and farm management specialists of the Counties. The need for change in farm income sources in tobacco producing regions of Virginia gave an impetus for this research.

Soil survey data have served in the past and still serve the farming community today as a reference in the decision making process. This information and other technical expertise is becoming available in a digital format using GIS methods. It is vital for economic analysis in agriculture to capture all this production information along with market information. Therefore, a combination of GIS with quantitative methods of analysis is important.

Some conclusions could be deducted from a case study example, which was used as a demonstration for the procedures developed in this research. First, methods used in this study include production feasibility analysis, market window analysis, and whole farm planning. Integrated in a single process, “the evaluation of agricultural enterprises”, these methods served as filtering devices for a limited list of enterprises. Methods used in this research were not tested against traditional methods, but there is an indication that these methods produce more accurate results than traditional methods. This conclusion is based on the procedures used to define land constraints, which involve a detailed analysis of properties of soil and climate for a specific location, the detailed rotation constraints and the link of optimal enterprise mix with the specific enterprise reference unit.

Second, results of the case study example were not surprising, compared to the current situation in Southside Virginia. Results showed that tobacco is a very important enterprise for generating revenue in the study area. Average -yield soybeans and cotton may contribute to farm revenues. Wheat and corn may be used mostly for rotations. Beef cows appear not to be profitable. Tomatoes and broccoli could add to farm revenues, but they are likely to be very limited in acreage, at least in the near term. Contract swine could be a profitable alternative to tobacco, but its expansion is limited due to environmental concerns.

Third, reductions in tobacco acreage resulted in less farm revenue. Farm revenue would be decreased dramatically if tobacco acreage would be reduced by more than half. A reduction in half of tobacco acreage could be offset to some extent by an increase in broccoli and tomato acreage from 3 acres in the baseline scenario to 6 acres, and a 10 percent increase in irrigation capacity. If tobacco were no longer produced in the study area, farmers would not be able to continue their farming activity, unless they modify their farm plan to accommodate new enterprises. Specialty crops are far for being a viable alternative for tobacco. They could serve as supplementary enterprises. Developing a diversified farm plan could help farmers to make a smooth transition to other alternatives.

6.3 Limitations of the Study and Suggestions for Further Research

Building a GIS database starting from scratch is a very time consuming process. The best way to address this problem is to find digitized data. Hopefully, future soil surveys will be presented in a digitized format. This will help researchers focus more on analysis rather than on making the data ready for analysis.

Soil survey data, especially those related to the budget adjustment factors such as soil pH and organic matter content in the soil, are not very accurate. These parameters change after each crop. Improvement in these data would help research be more relevant.

Farmers usually keep records about rainfall and temperatures. If this information were available, climatic micro-zones would have been useful for GIS analysis.

Only terminal market prices were used in the Market Window Analysis, leaving other potentially important more nearby direct - to - consumer markets out of consideration. Unavailability of data on other markets was a limitation in this case. It would also be better to use a weighted average price instead of a simple average price, but data on quantities sold were inadequate. Historical prices should be interpreted carefully because they show a general tendency and they may not be observed in the future.

Enterprises were analyzed based on operational or variable costs. Fixed costs are important factors to be considered on a case by case basis for each farm because there is a large variability in fixed costs among individual farms. The optimal mix may change when fixed costs are considered.

This study could be extended in two ways. First, the analytical framework could be further refined. GIS analysis could include ordinal overlays. These types of overlays need regression analysis of yield factors prior to overlays. If data were available about yield, as the dependent variable, and factors that affect yield, as independent variables, the impact of yield factors could be estimated. Then, overlays would take into account the coefficients of independent variables, giving to each factor their relative importance. LP could incorporate more constraints, based on the specific situation. A more rigorous LP model could include a bi-weekly machinery schedule, labor constraints in time periods, timing of irrigation constraint versus irrigation water availability. If farm and parcel boundaries were available, this information could go into the model. Soil variability within the parcel and among parcels could be analyzed with the purpose of maximizing soil homogeneity within a parcel. The degree of soil variability could provide information about the costs and benefits of variable rate application of inputs within a parcel. LP models could be run for each farm taking into account fixed costs and farm specific constraints.

Second, it would be helpful if all parts of this work would be integrated into an expert system, which would provide a powerful tool to farmers for guiding them in their decision making process. The ArcView GIS program needs to be customized in order to control the sequence of procedures in the import of external data and the export of final data to a mathematical optimization program. Hopefully, GIS programs in the future will provide more access to statistical and Mathematical Programming tools. Overlay analysis is not the final step of overall analysis. Therefore, the analytical attribute data should associate maps derived from overlays.

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APPENDIX A

ArcView GIS Database

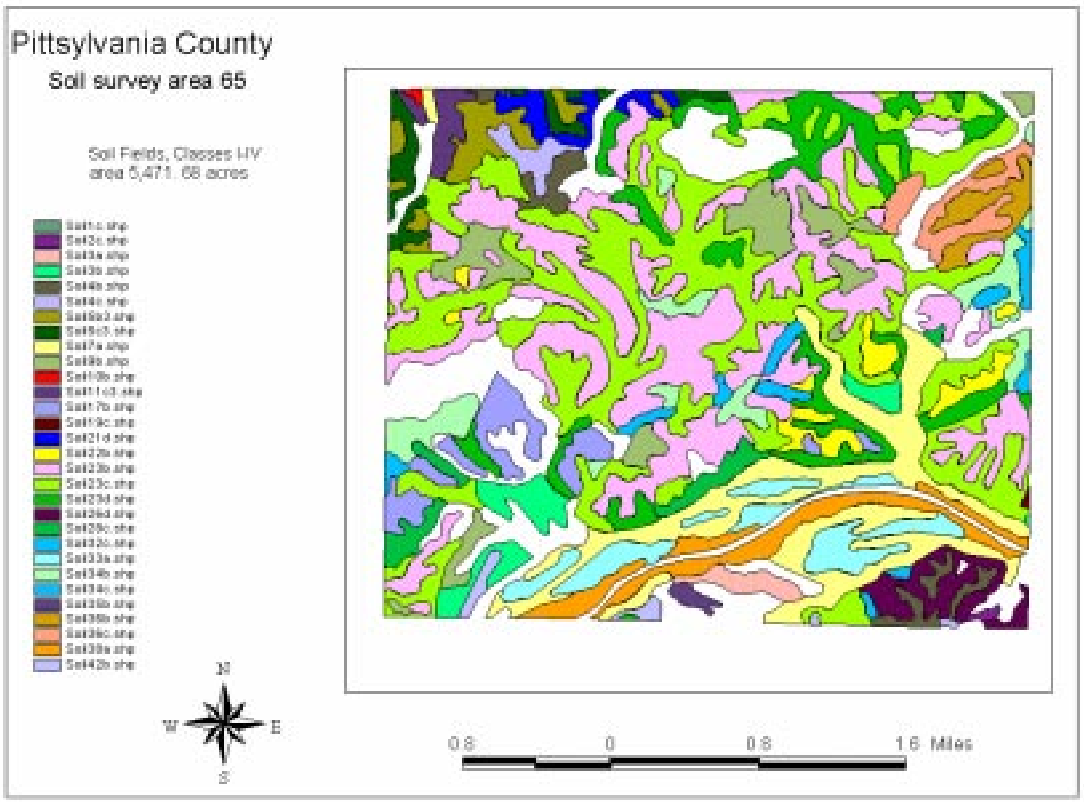

Figure A1 The Study Area

Table A 1 Attributes Table of the Study Area

Area ID	NoCells	Area (acres)	SoilDepth	SoilSeries	SoilTexture	Slope (%)	FloodPoten	AvSmerT (F)	NatDrainage	pH	NatFertal	OrgMatter	Rainfall (in)
1013001	2	0.17	high	Appling	sandy	7-15	none	76.37	very good	4.5-5.5	low	low	43.13
1023001	68	5.62	medium	Ashlar	fine sandy	7-15	none	76.37	excessive	4.5-5.5	low	low	43.13
1031001	478	39.50	high	Bolling	fine sandy	0-2	rare	76.37	good	4.5-7.3	medium	low	43.13
1032001	483	39.92	high	Bolling	fine sandy	2-7	none	76.37	good	4.5-7.3	medium	low	43.13
1032002	671	55.45	high	Bolling	fine sandy	2-7	none	76.37	good	4.5-7.3	medium	low	43.13
1032003	267	22.07	high	Bolling	fine sandy	2-7	none	76.37	good	4.5-7.3	medium	low	43.13
1032004	6	0.50	high	Bolling	fine sandy	2-7	none	76.37	good	4.5-7.3	medium	low	43.13
1042001	227	18.76	high	Cecil	sandy	2-7	none	76.37	very good	4.5-5.5	low	low	43.13
1042002	151	12.48	high	Cecil	sandy	2-7	none	76.37	very good	4.5-5.5	low	low	43.13
1042003	157	12.98	high	Cecil	sandy	2-7	none	76.37	very good	4.5-5.5	low	low	43.13
1042004	410	33.88	high	Cecil	sandy	2-7	none	76.37	very good	4.5-5.5	low	low	43.13
1042005	60	4.96	high	Cecil	sandy	2-7	none	76.37	very good	4.5-5.5	low	low	43.13
1043001	32	2.64	high	Cecil	sandy	7-15	none	76.37	very good	4.5-5.5	low	low	43.13
1043002	471	38.93	high	Cecil	sandy	7-15	none	76.37	very good	4.5-5.5	low	low	43.13
1052301	64	5.29	high	Cecil	sandy clay	2-7	none	76.37	very good	4.5-5.5	low	low	43.13
1052302	88	7.27	high	Cecil	sandy clay	2-7	none	76.37	very good	4.5-5.5	low	low	43.13
1052303	35	2.89	high	Cecil	sandy clay	2-7	none	76.37	very good	4.5-5.5	low	low	43.13
1052304	105	8.68	high	Cecil	sandy clay	2-7	none	76.37	very good	4.5-5.5	low	low	43.13
1052305	784	64.79	high	Cecil	sandy clay	2-7	none	76.37	very good	4.5-5.5	low	low	43.13
1052306	121	10.00	high	Cecil	sandy clay	2-7	none	76.37	very good	4.5-5.5	low	low	43.13
1052307	52	4.30	high	Cecil	sandy clay	2-7	none	76.37	very good	4.5-5.5	low	low	43.13
1053301	202	16.69	high	Cecil	sandy clay	7-15	none	76.37	very good	4.5-5.5	low	low	43.13
1053302	407	33.64	high	Cecil	sandy clay	7-15	none	76.37	very good	4.5-5.5	low	low	43.13
1053303	24	1.98	high	Cecil	sandy clay	7-15	none	76.37	very good	4.5-5.5	low	low	43.13
1053304	171	14.13	high	Cecil	sandy clay	7-15	none	76.37	very good	4.5-5.5	low	low	43.13
1053305	35	2.89	high	Cecil	sandy clay	7-15	none	76.37	very good	4.5-5.		low	43.13
1053306	30	2.48	high	Cecil	sandy clay	7-15	none	76.37	very good	4.5-5.5	low	low	43.13
1053307	116	9.59	high	Cecil	sandy clay	7-15	none	76.37	very good	4.5-5.5	low	low	43.13
1071001	188	15.54	high	Chenneby	loam	0-2	occasionally	76.37	poor	4.5-6	medium	medium	43.13

low

Table A 1 (continued)

1071002	1845	152.48	high	Chenneby	loam	0-2	occasionally	76.37	poor	4.5-6	medium	medium	43.13
1071003	85	7.02	high	Chenneby	loam	0-2	occasionally	76.37	poor	4.5-6	medium	medium	43.13
1071004	103	8.51	high	Chenneby	loam	0-2	occasionally	76.37	poor	4.5-6	medium	medium	43.13
1071005	3818	315.54	high	Chenneby	loam	0-2	occasionally	76.37	poor	4.5-6	medium	medium	43.13
1092001	46	3.80	high	Creedmoor	fine sandy	2-7	none	76.37	good	3.6-5.5	low	low	43.13
1092002	299	24.71	high	Creedmoor	fine sandy	2-7	none	76.37	good	3.6-5.5	low	low	43.13
1092003	770	63.64	high	Creedmoor	fine sandy	2-7	none	76.37	good	3.6-5.5	low	low	43.13
1092004	200	16.53	high	Creedmoor	fine sandy	2-7	none	76.37	good	3.6-5.5	low	low	43.13
1092005	41	3.39	high	Creedmoor	fine sandy	2-7	none	76.37	good	3.6-5.5	low	low	43.13
1092006	409	33.80	high	Creedmoor	fine sandy	2-7	none	76.37	good	3.6-5.5	low	low	43.13
1092007	96	7.93	high	Creedmoor	fine sandy	2-7	none	76.37	good	3.6-5.5	low	low	43.13
1092008	264	21.82	high	Creedmoor	fine sandy	2-7	none	76.37	good	3.6-5.5	low	low	43.13
1092009	666	55.04	high	Creedmoor	fine sandy	2-7	none	76.37	good	3.6-5.5	low	low	43.13
1110201	41	3.39	high	Cullen	loam	2-7	none	76.37	very good	5.1-6	low	low	43.13
1111331	106	8.76	high	Cullen	clay	7-15	none	76.37	very good	5.1-6	low	low	43.13
1111332	512	42.31	high	Cullen	clay	7-15	none	76.37	very good	5.1-6	low	low	43.13
1117201	349	28.84	high	Hiwassee	loam	2-7	none	76.37	very good	5.1-6.5	low	low	43.13
1117202	142	11.74	high	Hiwassee	loam	2-7	none	76.37	very good	5.1-6.5	low	low	43.13
1117203	133	10.99	high	Hiwassee	loam	2-7	none	76.37	very good	5.1-6.5	low	low	43.13
1117204	772	63.80	high	Hiwassee	loam	2-7	none	76.37	very good	5.1-6.5	low	low	43.13
1117205	399	32.98	high	Hiwassee	loam	2-7	none	76.37	very good	5.1-6.5	low	low	43.13
1117206	57	4.71	high	Hiwassee	loam	2-7	none	76.37	very good	5.1-6.5	low	low	43.13
1117207	64	5.29	high	Hiwassee	loam	2-7	none	76.37	very good	5.1-6.5	low	low	43.13
1119301	4	0.33	high	Hiwassee	cobbly sandy	7-15	none	76.37	very good	5.1-6.5	low	low	43.13
1121401	582	48.10	high	Madison	fine sandy	15-25	none	76.37	very good	4.5-5.5	low	low	43.13
1121402	211	17.44	high	Madison	fine sandy	15-25	none	76.37	very good	4.5-5.5	low	low	43.13
1122201	39	3.22	high	Mattaponi	sandy	2-7	none	76.37	good	4.5-6	low	low	43.13
1122202	56	4.63	high	Mattaponi	sandy	2-7	none	76.37	good	4.5-6	low	low	43.13
1122203	293	24.21	high	Mattaponi	sandy	2-7	none	76.37	good	4.5-6	low	low	43.13
1122204	336	27.77	high	Mattaponi	sandy	2-7	none	76.37	good	4.5-6	low	low	43.13
1122205	443	36.61	high	Mattaponi	sandy	2-7	none	76.37	good	4.5-6	low	low	43.13

Table A 1 (continued)													
1122206	48	3.97	high	Mattaponi	sandy	2-7	none	76.37	good	4.5-6	low	low	43.13
1122207	53	4.38	high	Mattaponi	sandy	2-7	none	76.37	good	4.5-6	low	low	43.13
1123201	48	3.97	high	Mayodan	fine sandy	2-7	none	76.37	very good	4.5-5.5	low	low	43.13
1123202	354	29.26	high	Mayodan	fine sandy	2-7	none	76.37	very good	4.5-5.5	low	low	43.13
1123203	194	16.03	high	Mayodan	fine sandy	2-7	none	76.37	very good	4.5-5.5	low	low	43.13
1123204	37	3.06	high	Mayodan	fine sandy	2-7	none	76.37	very good	4.5-5.5	low	low	43.13
1123205	1424	117.69	high	Mayodan	fine sandy	2-7	none	76.37	very good	4.5-5.5	low	low	43.13
1123206	284	23.47	high	Mayodan	fine sandy	2-7	none	76.37	very good	4.5-5.5	low	low	43.13
1123207	126	10.41	high	Mayodan	fine sandy	2-7	none	76.37	very good	4.5-5.5	low	low	43.13
1123208	90	7.44	high	Mayodan	fine sandy	2-7	none	76.37	very good	4.5-5.5	low	low	43.13
1123209	330	27.27	high	Mayodan	fine sandy	2-7	none	76.37	very good	4.5-5.5	low	low	43.13
1123210	188	15.54	high	Mayodan	fine sandy	2-7	none	76.37	very good	4.5-5.5	low	low	43.13
1123211	175	14.46	high	Mayodan	fine sandy	2-7	none	76.37	very good	4.5-5.5	low	low	43.13
1123212	46	3.80	high	Mayodan	fine sandy	2-7	none	76.37	very good	4.5-5.5	low	low	43.13
1123213	398	32.89	high	Mayodan	fine sandy	2-7	none	76.37	very good	4.5-5.5	low	low	43.13
1123214	140	11.57	high	Mayodan	fine sandy	2-7	none	76.37	very good	4.5-5.5	low	low	43.13
1123215	127	10.50	high	Mayodan	fine sandy	2-7	none	76.37	very good	4.5-5.5	low	low	43.13
1123216	309	25.54	high	Mayodan	fine sandy	2-7	none	76.37	very good	4.5-5.5	low	low	43.13
1123217	1674	138.35	high	Mayodan	fine sandy	2-7	none	76.37	very good	4.5-5.5	low	low	43.13
1123218	262	21.65	high	Mayodan	fine sandy	2-7	none	76.37	very good	4.5-5.5	low	low	43.13
1123219	354	29.26	high	Mayodan	fine sandy	2-7	none	76.37	very good	4.5-5.5	low	low	43.13
1123220	1221	100.91	high	Mayodan	fine sandy	2-7	none	76.37	very good	4.5-5.5	low	low	43.13
1123221	855	70.66	high	Mayodan	fine sandy	2-7	none	76.37	very good	4.5-5.5	low	low	43.13
1123222	150	12.40	high	Mayodan	fine sandy	2-7	none	76.37	very good	4.5-5.5	low	low	43.13
1123223	63	5.21	high	Mayodan	fine sandy	2-7	none	76.37	very good	4.5-5.5	low	low	43.13
1123224	87	7.19	high	Mayodan	fine sandy	2-7	none	76.37	very good	4.5-5.5	low	low	43.13
1123225	853	70.50	high	Mayodan	fine sandy	2-7	none	76.37	very good	4.5-5.5	low	low	43.13
1123226	469	38.76	high	Mayodan	fine sandy	2-7	none	76.37	very good	4.5-5.5	low	low	43.13
1123227	1670	138.02	high	Mayodan	fine sandy	2-7	none	76.37	very good	4.5-5.5	low	low	43.13
1123228	304	25.12	high	Mayodan	fine sandy	2-7	none	76.37	very good	4.5-5.5	low	low	43.13
1123229	176	14.55	high	Mayodan	fine sandy	2-7	none	76.37	very good	4.5-5.5	low	low	43.13

Table A 1 (continued)													
1123230	221	18.26	high	Mayodan	fine sandy	2-7	none	76.37	very good	4.5-5.5	low	low	43.13
1123231	237	19.59	high	Mayodan	fine sandy	2-7	none	76.37	very good	4.5-5.5	low	low	43.13
1123232	184	15.21	high	Mayodan	fine sandy	2-7	none	76.37	very good	4.5-5.5	low	low	43.13
1123301	84	6.94	high	Mayodan	fine sandy	7-15	none	76.37	very good	4.5-5.5	low	low	43.13
1123302	23	1.90	high	Mayodan	fine sandy	7-15	none	76.37	very good	4.5-5.5	low	low	43.13
1123303	385	31.82	high	Mayodan	fine sandy	7-15	none	76.37	very good	4.5-5.5	low	low	43.13
1123304	359	29.67	high	Mayodan	fine sandy	7-15	none	76.37	very good	4.5-5.5	low	low	43.13
1123305	82	6.78	high	Mayodan	fine sandy	7-15	none	76.37	very good	4.5-5.5	low	low	43.13
1123306	211	17.44	high	Mayodan	fine sandy	7-15	none	76.37	very good	4.5-5.5	low	low	43.13
1123307	76	6.28	high	Mayodan	fine sandy	7-15	none	76.37	very good	4.5-5.5	low	low	43.13
1123308	72	5.95	high	Mayodan	fine sandy	7-15	none	76.37	very good	4.5-5.5	low	low	43.13
1123309	40	3.31	high	Mayodan	fine sandy	7-15	none	76.37	very good	4.5-5.5	low	low	43.13
1123310	448	37.02	high	Mayodan	fine sandy	7-15	none	76.37	very good	4.5-5.5	low	low	43.13
1123311	155	12.81	high	Mayodan	fine sandy	7-15	none	76.37	very good	4.5-5.5	low	low	43.13
1123312	563	46.53	high	Mayodan	fine sandy	7-15	none	76.37	very good	4.5-5.5	low	low	43.13
1123313	469	38.76	high	Mayodan	fine sandy	7-15	none	76.37	very good	4.5-5.5	low	low	43.13
1123314	330	27.27	high	Mayodan	fine sandy	7-15	none	76.37	very good	4.5-5.5	low	low	43.13
1123315	1193	98.60	high	Mayodan	fine sandy	7-15	none	76.37	very good	4.5-5.5	low	low	43.13
1123316	340	28.10	high	Mayodan	fine sandy	7-15	none	76.37	very good	4.5-5.5	low	low	43.13
1123317	796	65.79	high	Mayodan	fine sandy	7-15	none	76.37	very good	4.5-5.5	low	low	43.13
1123318	401	33.14	high	Mayodan	fine sandy	7-15	none	76.37	very good	4.5-5.5	low	low	43.13
1123319	137	11.32	high	Mayodan	fine sandy	7-15	none	76.37	very good	4.5-5.5	low	low	43.13
1123320	212	17.52	high	Mayodan	fine sandy	7-15	none	76.37	very good	4.5-5.5	low	low	43.13
1123321	248	20.50	high	Mayodan	fine sandy	7-15	none	76.37	very good	4.5-5.5	low	low	43.13
1123322	450	37.19	high	Mayodan	fine sandy	7-15	none	76.37	very good	4.5-5.5	low	low	43.13
1123323	8338	689.09	high	Mayodan	fine sandy	7-15	none	76.37	very good	4.5-5.5	low	low	43.13
1123324	417	34.46	high	Mayodan	fine sandy	7-15	none	76.37	very good	4.5-5.5	low	low	43.13
1123401	16	1.32	high	Mayodan	fine sandy	15-25	none	76.37	very good	4.5-5.5	low	low	43.13
1123402	194	16.03	high	Mayodan	fine sandy	15-25	none	76.37	very good	4.5-5.5	low	low	43.13
1123403	355	29.34	high	Mayodan	fine sandy	15-25	none	76.37	very good	4.5-5.5	low	low	43.13
1123404	125	10.33	high	Mayodan	fine sandy	15-25	none	76.37	very good	4.5-5.5	low	low	43.13

Table A 1 (continued)													
1123405	273	22.56	high	Mayodan	fine sandy	15-25	none	76.37	very good	4.5-5.5	low	low	43.13
1123406	191	15.79	high	Mayodan	fine sandy	15-25	none	76.37	very good	4.5-5.5	low	low	43.13
1123407	254	20.99	high	Mayodan	fine sandy	15-25	none	76.37	very good	4.5-5.5	low	low	43.13
1123408	220	18.18	high	Mayodan	fine sandy	15-25	none	76.37	very good	4.5-5.5	low	low	43.13
1123409	848	70.08	high	Mayodan	fine sandy	15-25	none	76.37	very good	4.5-5.5	low	low	43.13
1123410	234	19.34	high	Mayodan	fine sandy	15-25	none	76.37	very good	4.5-5.5	low	low	43.13
1123411	145	11.98	high	Mayodan	fine sandy	15-25	none	76.37	very good	4.5-5.5	low	low	43.13
1123412	45	3.72	high	Mayodan	fine sandy	15-25	none	76.37	very good	4.5-5.5	low	low	43.13
1123413	210	17.36	high	Mayodan	fine sandy	15-25	none	76.37	very good	4.5-5.5	low	low	43.13
1123414	40	3.31	high	Mayodan	fine sandy	15-25	none	76.37	very good	4.5-5.5	low	low	43.13
1123415	215	17.77	high	Mayodan	fine sandy	15-25	none	76.37	very good	4.5-5.5	low	low	43.13
1123416	1338	110.58	high	Mayodan	fine sandy	15-25	none	76.37	very good	4.5-5.5	low	low	43.13
1126401	151	12.48	high	Pacolet	fine sandy	15-25	none	76.37	very good	4.5-5.5	low	low	43.13
1126402	1134	93.72	high	Pacolet	fine sandy	15-25	none	76.37	very good	4.5-5.5	low	low	43.13
1128301	158	13.06	medium	Pinkston	cobbly sandy	7-15	none	76.37	excessive	4.5-5.5	low	low	43.13
1128302	60	4.96	medium	Pinkston	cobbly sandy	7-15	none	76.37	excessive	4.5-5.5	low	low	43.13
1128303	497	41.07	medium	Pinkston	cobbly sandy	7-15	none	76.37	excessive	4.5-5.5	low	low	43.13
1128304	374	30.91	medium	Pinkston	cobbly sandy	7-15	none	76.37	excessive	4.5-5.5	low	low	43.13
1132301	58	4.79	high	Rion	fine sandy	7-15	none	76.37	very good	4.5-5.5	low	low	43.13
1132302	63	5.21	high	Rion	fine sandy	7-15	none	76.37	very good	4.5-5.5	low	low	43.13
1133101	320	26.45	high	Riverview	silt	0-2	occasionally	76.37	very good	5.1-6.5	medium	low	43.13
1133102	961	79.42	high	Riverview	silt	0-3	occasionally	76.37	very good	5.1-6.5	medium	low	43.13
1133103	582	48.10	high	Riverview	silt	0-4	occasionally	76.37	very good	5.1-6.5	medium	low	43.13
1133104	79	6.53	high	Riverview	silt	0-5	occasionally	76.37	very good	5.1-6.5	medium	low	43.13
1133105	234	19.34	high	Riverview	silt	0-6	occasionally	76.37	very good	5.1-6.5	medium	low	43.13
1133106	354	29.26	high	Riverview	silt	0-7	occasionally	76.37	very good	5.1-6.5	medium	low	43.13
1134201	60	4.96	medium	Sheva	fine sandy	2-7	none	76.37	very good	3.6-5.5	low	low	43.13
1134202	113	9.34	medium	Sheva	fine sandy	2-7	none	76.37	very good	3.6-5.5	low	low	43.13
1134203	681	56.28	medium	Sheva	fine sandy	2-7	none	76.37	very good	3.6-5.5	low	low	43.13
1134204	86	7.11	medium	Sheva	fine sandy	2-7	none	76.37	very good	3.6-5.5	low	low	43.13
1134205	278	22.98	medium	Sheva	fine sandy	2-7	none	76.37	very good	3.6-5.5	low	low	43.13

Table A 1 (continued)													
1134206	211	17.44	medium	Sheva	fine sandy	2-7	none	76.37	very good	3.6-5.5	low	low	43.13
1134207	32	2.64	medium	Sheva	fine sandy	2-7	none	76.37	very good	3.6-5.5	low	low	43.13
1134208	259	21.41	medium	Sheva	fine sandy	2-7	none	76.37	very good	3.6-5.5	low	low	43.13
1134209	36	2.98	medium	Sheva	fine sandy	2-7	none	76.37	very good	3.6-5.5	low	low	43.13
1134210	535	44.22	medium	Sheva	fine sandy	2-7	none	76.37	very good	3.6-5.5	low	low	43.13
1134301	112	9.26	medium	Sheva	fine sandy	7-15	none	76.37	good	3.6-5.5	low	low	43.13
1134302	88	7.27	medium	Sheva	fine sandy	7-15	none	76.37	good	3.6-5.5	low	low	43.13
1134303	131	10.83	medium	Sheva	fine sandy	7-15	none	76.37	good	3.6-5.5	low	low	43.13
1134304	196	16.20	medium	Sheva	fine sandy	7-15	none	76.37	good	3.6-5.5	low	low	43.13
1134305	161	13.31	medium	Sheva	fine sandy	7-15	none	76.37	good	3.6-5.5	low	low	43.13
1134306	88	7.27	medium	Sheva	fine sandy	7-15	none	76.37	good	3.6-5.5	low	low	43.13
1134307	141	11.65	medium	Sheva	fine sandy	7-15	none	76.37	good	3.6-5.5	low	low	43.13
1134308	219	18.10	medium	Sheva	fine sandy	7-15	none	76.37	good	3.6-5.5	low	low	43.13
1135201	182	15.04	high	State	sandy	0-4	rare	76.37	very good	4.5-5.5	low	low	43.13
1136201	877	72.48	high	Stoneville	silt	2-7	none	76.37	very good	4.5-6	low	low	43.13
1136202	86	7.11	high	Stoneville	silt	2-7	none	76.37	very good	4.5-6	low	low	43.13
1136301	311	25.70	high	Stoneville	silt	7-15	none	76.37	very good	4.5-6	low	low	43.13
1136302	936	77.36	high	Stoneville	silt	7-15	none	76.37	very good	4.5-6	low	low	43.13
1138101	440	36.36	high	Toccoa	fine sandy	0-2	occasionally	76.37	very good	5.1-6.5	low	low	43.13
1138102	1335	110.33	high	Toccoa	fine sandy	0-2	occasionally	76.37	very good	5.1-6.5	low	low	43.13
1138103	212	17.52	high	Toccoa	fine sandy	0-2	occasionally	76.37	very good	5.1-6.5	low	low	43.13
1138104	254	20.99	high	Toccoa	fine sandy	0-2	occasionally	76.37	very good	5.1-6.5	low	low	43.13
1142201	135	11.16	high	Wickham	sandy	2-7	none	76.37	very good	4.5-6	low	low	43.13
1142202	23	1.90	high	Wickham	sandy	2-7	none	76.37	very good	4.5-6	low	low	43.13
1142203	195	16.12	high	Wickham	sandy	2-7	none	76.37	very good	4.5-6	low	low	43.13

APPENDIX B

Enterprise Budgets

Table B 1 Flue-Cured Tobacco (Tob1) 1999

Budget for 1 acre, expected yield 2700 lb

Item	Unit	Quantity(units)	Price ($)	Total ($)
Receipts	lb	2700	1.78	4806
Operating Costs				
Plant Bed				
Seed	oz	0.12	67.00	8.04
Fumigant	lb	7.50	2.48	18.60
Plastic Cover	yds	75.00	0.10	7.50
Remay Cover (2 Years)	yds	75.00	0.14	5.25
Straw	bales	0.50	2.00	1.00
Fertilizer: 12-6-6	cwt	0.60	9.85	5.91
16-0-0	cwt	0.04	13.00	0.52
Fungicide	oz	0.50	1.14	0.57
Insecticide	oz	6.75	0.10	0.68
Field				
Lime	ton	0.56	25.00	14.00
PPI:Herbicide	pts	1.35	3.15	4.25
PPI:Fungicide	qts	1.13	36.37	41.10
PPI:Nematicide	qts	2.25	11.23	25.27
PPI:Nematicide	gal	2.25	66.55	149.74
Frow Fertilizer	cwt	6.50	12.80	83.20
TPW: Insecticide	lb	1.00	10.16	10.16
Sidedress	cwt	1.50	14.25	21.38
Insecticide	lb	0.50	11.10	5.55
Insecticide	lb	2.00	10.16	20.32
Sucker Control	gal	3.60	10.90	39.24
Sucker Control	gal	1.50	13.31	19.97
Federal Crop and Hail Ins.	acre	1.00	165.00	165.00
Cover Crop:Rye Seed	bu	2.00	8.50	17.00
Tobacco Curing Fuel	cwt	27.00	8.01	216.27
Building Ins. & Electricity	acre	1.00	32.50	32.50
Marketing Charges	cwt	27.00	6.79	183.33
Tractor, Equip., Fuel & Repairs	acre	1.00	385.33	385.33
Hired Labor	hours	120.00	7.36	883.20
Interest on 6 month Operating Capital	$	1978.78	9.00%	89.05
Total Operating Costs				2453.91
Variable Cost per lb. (except land & Mgmt.)				0.91
Fixed Costs: Irrigation	$/acre	3324	20.46%	680.09
Other Fixed Costs				743.09
Total Fixed Costs				1423.18
Total Costs				3877.09
Total Cost per lb. (except land & Mgmt.)				1.44

Source: Modified from “Virginia Cooperative Extension, Virginia Flue-Cured Tobacco Budget, Jan. 1998”.

Table B 2 Flue-Cured Tobacco (Tob2) 1999

Budget for 1 acre, expected yield 2400 lb

Item	Unit	Quantity(units)	Price ($)	Total ($)
Receipts	lb	2400	1.78	4272
Operating Costs				
Plant Bed				
Seed	oz	0.12	67.00	8.04
Fumigant	lb	7.50	2.48	18.60
Plastic Cover	yds	75.00	0.10	7.50
Remay Cover (2 Years)	yds	75.00	0.14	5.25
Straw	bales	0.50	2.00	1.00
Fertilizer: 12-6-6	cwt	0.60	9.85	5.91
16-0-0	cwt	0.04	13.00	0.52
Fungicide	oz	0.50	1.14	0.57
Insecticide	oz	6.75	0.10	0.68
Field				
Lime	ton	0.60	25.00	15.00
PPI:Herbicide	pts	1.35	3.15	4.25
PPI:Fungicide	qts	1.25	36.37	45.46
PPI:Nematicide	qts	2.25	11.23	25.27
PPI:Nematicide	gal	2.25	66.55	149.74
Frow Fertilizer	cwt	6.00	12.80	76.80
TPW: Insecticide	lb	1.00	10.16	10.16
Sidedress	cwt	1.50	14.25	21.38
Insecticide	lb	0.50	11.10	5.55
Insecticide	lb	2.00	10.16	20.32
Sucker Control	gal	3.60	10.90	39.24
Sucker Control	gal	1.50	13.31	19.97
Federal Crop and Hail Ins.	acre	1.00	165.00	165.00
Cover Crop:Rye Seed	bu	2.00	8.50	17.00
Tobacco Curing Fuel	cwt	24.00	8.01	192.24
Building Ins. & Electricity	acre	1.00	32.50	32.50
Marketing Charges	cwt	24.00	6.79	162.96
Tractor, Equip., Fuel & Repairs	acre	1.00	385.33	385.33
Hired Labor	hours	120.00	7.36	883.20
Interest on 6 month Operating Capital	$	1070.52	9.00%	48.17
Total Operating Costs				2367.60
Variable Cost per lb. (except land & Mgmt.)				0.99
Fixed Costs: Irrigation	$/acre	3324	20.46%	680.09
Other Fixed Costs				743.09
Total Fixed Costs				1423.18
Total Costs				3790.78
Total Cost per lb. (except land & Mgmt.)				1.58

Source: Modified from “Virginia Cooperative Extension, Virginia Flue-Cured Tobacco Budget, Jan.1998”.

Table B 3 Flue-Cured Tobacco (Tob3) 1999

Budget for 1 acre, expected yield 1800 lb

Item	Unit	Quantity(units)	Price ($)	Total ($)
Receipts	lb	1800	1.78	3204
Operating Costs				
Plant Bed				
Seed	oz	0.12	67.00	8.04
Fumigant	lb	7.50	2.48	18.60
Plastic Cover	yds	75.00	0.10	7.50
Remay Cover (2 Years)	yds	75.00	0.14	5.25
Straw	bales	0.50	2.00	1.00
Fertilizer: 12-6-6	cwt	0.60	9.85	5.91
16-0-0	cwt	0.04	13.00	0.52
Fungicide	oz	0.50	1.14	0.57
Insecticide	oz	6.75	0.10	0.68
Field				
Lime	ton	0.80	25.00	20.00
PPI:Herbicide	pts	1.35	3.15	4.25
PPI:Fungicide	qts	1.25	36.37	45.46
PPI:Nematicide	qts	2.25	11.23	25.27
PPI:Nematicide	gal	2.25	66.55	149.74
Frow Fertilizer	cwt	5.50	12.80	70.40
TPW: Insecticide	lb	1.00	10.16	10.16
Sidedress	cwt	1.50	14.25	21.38
Insecticide	lb	0.50	11.10	5.55
Insecticide	lb	2.00	10.16	20.32
Sucker Control	gal	3.60	10.90	39.24
Sucker Control	gal	1.50	13.31	19.97
Federal Crop and Hail Ins.	acre	1.00	165.00	165.00
Cover Crop:Rye Seed	bu	2.00	8.50	17.00
Tobacco Curing Fuel	cwt	18.00	8.01	144.18
Building Ins. & Electricity	acre	1.00	32.50	32.50
Marketing Charges	cwt	18.00	6.79	122.22
Tractor, Equip., Fuel & Repairs	acre	1.00	385.33	385.33
Hired Labor	hours	120.00	7.36	883.20
Interest on 6 month Operating Capital	$	1904.26	9.00%	85.69
Total Operating Costs				2314.92
Variable Cost per lb. (except land & Mgmt.)				1.29
Fixed Costs (New Mach. & Equip.)				743.09
Total Costs				3059.29
Total Cost per lb. (except land & Mgmt.)				1.70

Source: Modified from “Virginia Cooperative Extension, Virginia Flue-Cured Tobacco Budget, Jan.1998”.

Table B 4 Corn for Grain (Cor1) 1999

Budget for 1 acre, minimum till, expected yield 100 bu

Item	Unit	Quantity(units)	Price ($)	Total ($)
Receipts	bu	100	2.5	250
Operating Costs				
Preharvest Expenses				
Corn Seed	unit	0.25	89.13	22.28
Rye Seed	bu	1.50	0	0.00
Nitrogen	lb	110.00	0.24	26.40
Phosphate	lb	45.00	0.24	10.80
Potash	lb	65.00	0.15	9.75
Fertilizer Application	acre	1.00	5.25	5.25
Lime	ton	0.66	25.00	16.50
Herbicides	acre	1.00	32.62	32.62
Insecticides	acre	1.00	20.87	20.87
Fungicides	acre	1.00	0.00	0.00
Chemical Application	acre	1.00	5.61	5.61
Fuel, Oil, Lube	acre	1.00	7.94	7.94
Repairs	acre	1.00	25.02	25.02
Preharvest Labor	hour	1.74	6.25	10.88
Cash Rent or Land Cost	acre	1.00	0.00	0.00
Crop Insurance				0.00
Interest on 6 month Operating Capital	$	193.92	9.00%	8.73
Harvest Expenses				
Fuel, Oil, Lube	acre	1.00	1.74	1.74
Repairs	acre	1.00	14.51	14.51
Harvest Labor	hour	0.39	6.25	2.44
Hauling	bu	100.00	0.15	15.00
Storage	bu	100.00	0.00	0.00
Drying	bu	100.00		0.00
Total Operating Costs				236.33
Variable Cost per bu. (except Mgmt.)				2.36
Fixed Costs (New Mach. & Equip.)				68.33
Total Costs				304.66
Total Cost per bu. (except Mgmt.)				3.05

Source: Modified from “Virginia Cooperative Extension, Virginia Farm Management, Crop and livestock enterprise budgets, 1997”.

Table B 5 Corn for Grain (Cor2) 1999

Budget for 1 acre, minimum till, expected yield 90 bu

Item	Unit	Quantity(units)	Price ($)	Total ($)
Receipts	bu	90	2.5	225
Operating Costs				
Preharvest Expenses				
Corn Seed	unit	0.25	89.13	22.28
Rye Seed	bu	1.50	0	0.00
Nitrogen	lb	100.00	0.24	24.00
Phosphate	lb	30.00	0.24	7.20
Potash	lb	60.00	0.15	9.00
Fertilizer Application	acre	1.00	5.25	5.25
Lime	ton	0.50	25.00	12.50
Herbicides	acre	1.00	32.62	32.62
Insecticides	acre	1.00	20.87	20.87
Fungicides	acre	1.00	0.00	0.00
Chemical Application	acre	1.00	5.61	5.61
Fuel, Oil, Lube	acre	1.00	7.94	7.94
Repairs	acre	1.00	25.02	25.02
Preharvest Labor	hour	1.74	6.25	10.88
Cash Rent or Land Cost	acre	1.00	0.00	0.00
Crop Insurance				0.00
Interest on 6 month Operating Capital	$	183.17	9.00%	8.24
Harvest Expenses				
Fuel, Oil, Lube	acre	1.00	1.74	1.74
Repairs	acre	1.00	14.51	14.51
Harvest Labor	hour	0.39	6.25	2.44
Hauling	bu	90.00	0.15	13.50
Storage	bu	90.00	0.00	0.00
Drying	bu	90.00		0.00
Total Operating Costs				223.60
Variable Cost per bu. (except Mgmt.)				2.48
Fixed Costs (New Mach. & Equip.)				68.33
Total Costs				291.93
Total Cost per bu. (except Mgmt.)				3.24

Source: Modified from "Virginia Cooperative Extension, Virginia Farm Management, Crop and livestock enterprise budgets, 1997".

Table B 6 Corn for Grain (Cor3) 1999

Budget for 1 acre, minimum till, expected yield 70 bu

Item	Unit	Quantity(units)	Price ($)	Total ($)
Receipts	bu	70	2.5	175
Operating Costs				
Preharvest Expenses				
Corn Seed	unit	0.25	89.13	22.28
Rye Seed	bu	1.50	0	0.00
Nitrogen	lb	80.00	0.24	19.20
Phosphate	lb	25.00	0.24	6.00
Potash	lb	45.00	0.15	6.75
Fertilizer Application	acre	1.00	5.25	5.25
Lime	ton	0.50	25.00	12.50
Herbicides	acre	1.00	32.62	32.62
Insecticides	acre	1.00	20.87	20.87
Fungicides	acre	1.00	0.00	0.00
Chemical Application	acre	1.00	6.00	6.00
Fuel, Oil, Lube	acre	1.00	7.94	7.94
Repairs	acre	1.00	25.02	25.02
Preharvest Labor	hour	1.74	6.25	10.88
Cash Rent or Land Cost	acre	1.00	0.00	0.00
Crop Insurance				0.00
Interest on 6 month Operating Capital	$	175.31	9.00%	7.89
Harvest Expenses				
Fuel, Oil, Lube	acre	1.00	1.74	1.74
Repairs	acre	1.00	14.51	14.51
Harvest Labor	hour	0.39	6.25	2.44
Hauling	bu	70.00	0.15	10.50
Storage	bu	70.00	0.00	0.00
Drying	bu	70.00		0.00
Total Operating Costs				212.38
Variable Cost per bu. (except Mgmt.)				3.03
Fixed Costs (New Mach. & Equip.)				68.33
Total Costs				280.71
Total Cost per bu. (except Mgmt.)				4.01

Source: Modified from “Virginia Cooperative Extension, Virginia Farm Management, Crop and livestock enterprise budgets, 1997”.

Table B 7 Barley (Bar2) 1999

Budget for 1 acre, expected yield 80 bu

Item	Unit	Quantity(units)	Price ($)	Total ($)
Receipts	bu	80	2.07	165.6
Operating Costs				
Preharvest Expenses				
Barley seed	bu	2.00	7.02	14.04
Other seed/Inoculant	bu	0.00	0.00	0.00
Nitrogen	lb	80.00	0.24	19.20
Phosphate	lb	40.00	0.24	9.60
Potash	lb	40.00	0.15	6.00
Fertilizer Application	acre	2.50	5.25	13.13
Lime	ton	0.80	25.00	20.00
Herbicides	acre	1.00	6.76	6.76
Insecticides	acre	1.00	0.00	0.00
Fungicides	acre	1.00	0.00	0.00
Chemical Application	acre	1.00	5.61	5.61
Fuel, Oil, Lube	acre	1.00	4.15	4.15
Repairs	acre	1.00	6.59	6.59
Preharvest Labor	hour	1.00	6.25	6.25
Cash Rent or Land Cost	acre	1.00	0.00	0.00
Crop Insurance				0.00
Interest on 6 month Operating Capital	$	111.33	9.00%	5.01
Harvest Expenses				
Fuel, Oil, Lube	acre	1.00	1.54	1.54
Repairs	acre	1.00	3.98	3.98
Harvest Labor	hour	0.29	6.25	1.81
Hauling	bu	80.00	0.15	12.00
Storage	bu	80.00	0.00	0.00
Drying	bu	80.00	0.00	0.00
Total Operating Costs				135.67
Variable Cost per bu. (except Mgmt.)				1.70
Fixed Costs (New Mach. & Equip.)				110.24
Total Costs				245.91
Total Cost per bu. (except Mgmt.)				3.07

Source: Modified from “Virginia Cooperative Extension, Virginia Farm Management, Crop and livestock enterprise budgets, 1997”.

Table B 8 Barley (Bar3) 1999

Budget for 1 acre, expected yield 70 bu

Item	Unit	Quantity(units)	Price ($)	Total ($)
Receipts	bu	70	2.07	144.9
Operating Costs				
Preharvest Expenses				
Barley seed	bu	2.00	7.02	14.04
Other seed/Inoculant	bu	0.00	0.00	0.00
Nitrogen	lb	70.00	0.24	16.80
Phosphate	lb	35.00	0.24	8.40
Potash	lb	35.00	0.15	5.25
Fertilizer Application	acre	3.00	5.25	15.75
Lime	ton	0.50	25.00	12.50
Herbicides	acre	1.00	6.76	6.76
Insecticides	acre	0.50	0.00	0.00
Fungicides	acre	1.00	0.00	0.00
Chemical Application	acre	1.00	5.61	5.61
Fuel, Oil, Lube	acre	1.00	4.30	4.30
Repairs	acre	1.00	7.00	7.00
Preharvest Labor	hour	1.00	6.25	6.25
Cash Rent or Land Cost	acre	1.00	0.00	0.00
Crop Insurance				0.00
Interest on 6 month Operating Capital	$	102.66	9.00%	4.62
Harvest Expenses				
Fuel, Oil, Lube	acre	1.00	1.54	1.54
Repairs	acre	1.00	3.98	3.98
Harvest Labor	hour	0.29	6.25	1.81
Hauling	bu	70.00	0.15	10.50
Storage	bu	70.00	0.00	0.00
Drying	bu	70.00	0.00	0.00
Total Operating Costs				125.11
Variable Cost per bu. (except Mgmt.)				1.79
Fixed Costs (New Mach. & Equip.)				110.24
Total Costs				235.35
Total Cost per bu. (except Mgmt.)				3.36

Source: Modified from "Virginia Cooperative Extension, Virginia Farm Management, Crop and livestock enterprise budgets, 1997".

Table B 9 Wheat grain, Soybeans Double Crop (Wds1) 1999

Budget for 1 acre, expected yields, 50 bu wheat, 30 bu soybeans

Item	Unit	Quantity(units)	Price ($)	Total ($)
Receipts from wheat	bu	50	2.78	139
Receipts from soybeans	bu	30	5.41	162.3
Total Receipts				301.3
Operating Costs				
Preharvest Expenses				
Wheat seed	bu	2.00	13.98	27.96
Soybean seed/Inoculant	bu	1.25	15.75	19.69
Nitrogen	lb	70.00	0.24	16.80
Phosphate	lb	75.00	0.24	18.00
Potash	lb	90.00	0.15	13.50
Fertilizer Application	acre	2.00	5.25	10.50
Lime	ton	0.66	25.00	16.50
Herbicides	acre	1.00	38.82	38.82
Insecticides	acre	1.00	0.00	0.00
Fungicides	acre	1.00	0.00	0.00
Chemical Application	acre	2.00	5.61	11.22
Fuel, Oil, Lube	acre	1.00	7.98	7.98
Repairs	acre	1.00	18.10	18.10
Preharvest Labor	hour	1.75	6.25	10.94
Cash Rent or Land Cost	acre	1.00	0.00	0.00
Crop Insurance				0.00
Interest on 6 month Operating Capital	$	210.01	9.00%	9.45
Harvest Expenses				
Fuel, Oil, Lube	acre	1.00	3.31	3.31
Repairs	acre	1.00	8.55	8.55
Harvest Labor	hour	0.62	6.25	3.88
Hauling	bu	80.00	0.00	0.00
Storage	bu	80.00	0.00	0.00
Drying	bu	80.00	0.00	0.00
Total Operating Costs				235.19
Fixed Costs (New Mach. & Equip.)				206.14
Total Costs				441.33

Source: Modified from "Virginia Cooperative Extension, Virginia Farm Management, Crop and livestock enterprise budgets, 1997".

Table B 10 Wheat grain, Soybeans Double Crop (Wds2) 1999

Budget for 1 acre, expected yields, 45 bu wheat, 25 bu soybeans

Item	Unit	Quantity(units)	Price ($)	Total ($)
Receipts from wheat	bu	45	2.78	125.1
Receipts from soybeans	bu	25	5.41	135.25
Total Receipts				260.35
Operating Costs				
Preharvest Expenses				
Wheat seed	bu	2.00	13.98	27.96
Soybean seed/Inoculant	bu	1.25	15.75	19.69
Nitrogen	lb	70.00	0.24	16.80
Phosphate	lb	75.00	0.24	18.00
Potash	lb	90.00	0.15	13.50
Fertilizer Application	acre	2.00	5.25	10.50
Lime	ton	0.70	25.00	17.50
Herbicides	acre	1.00	38.62	38.62
Insecticides	acre	1.00	0.00	0.00
Fungicides	acre	1.00	0.00	0.00
Chemical Application	acre	2.00	5.61	11.22
Fuel, Oil, Lube	acre	1.00	8.00	8.00
Repairs	acre	1.00	18.50	18.50
Preharvest Labor	hour	1.75	6.25	10.94
Cash Rent or Land Cost	acre	1.00	0.00	0.00
Crop Insurance				0.00
Interest on 6 month Operating Capital	$	211.23	9.00%	9.51
Harvest Expenses				
Fuel, Oil, Lube	acre	1.00	3.50	3.50
Repairs	acre	1.00	8.80	8.80
Harvest Labor	hour	0.62	6.25	3.88
Hauling	bu	70.00	0.00	0.00
Storage	bu	70.00	0.00	0.00
Drying	bu	70.00	0.00	0.00
Total Operating Costs				236.91
Fixed Costs (New Mach. & Equip.)				206.14
Total Costs				443.05

Source: Modified from "Virginia Cooperative Extension, Virginia Farm Management, Crop and livestock enterprise budgets, 1997".

Table B 11 Wheat grain, Soybeans Double Crop (Wds3) 1999

Budget for 1 acre, expected yields, 40 bu wheat, 20 bu soybeans

Item	Unit	Quantity(units)	Price ($)	Total ($)
Receipts from wheat	bu	40	2.78	111.2
Receipts from soybeans	bu	20	5.41	108.2
Total Receipts				219.4
Operating Costs				
Preharvest Expenses				
Wheat seed	bu	2.00	13.98	27.96
Soybean seed/Inoculant	bu	1.25	15.75	19.69
Nitrogen	lb	50.00	0.24	12.00
Phosphate	lb	55.00	0.24	13.20
Potash	lb	80.00	0.15	12.00
Fertilizer Application	acre	2.00	5.25	10.50
Lime	ton	0.66	25.00	16.50
Herbicides	acre	1.00	38.62	38.62
Insecticides	acre	1.00	0.00	0.00
Fungicides	acre	1.00	0.00	0.00
Chemical Application	acre	2.00	5.61	11.22
Fuel, Oil, Lube	acre	1.00	8.10	8.10
Repairs	acre	1.00	18.70	18.70
Preharvest Labor	hour	1.80	6.25	11.25
Cash Rent or Land Cost	acre	1.00	0.00	0.00
Crop Insurance				0.00
Interest on 6 month Operating Capital	$	199.74	9.00%	8.99
Harvest Expenses				
Fuel, Oil, Lube	acre	1.00	3.70	3.70
Repairs	acre	1.00	9.00	9.00
Harvest Labor	hour	0.62	6.25	3.88
Hauling	bu	60.00	0.00	0.00
Storage	bu	60.00	0.00	0.00
Drying	bu	60.00	0.00	0.00
Total Operating Costs				225.30
Fixed Costs (New Mach. & Equip.)				206.14
Total Costs				431.44

Source: Modified from "Virginia Cooperative Extension, Virginia Farm Management, Crop and livestock enterprise budgets, 1997".

Table B 12 Wheat for grain (Whe1) 1999

Budget for 1 acre, expected yield 75 bu

Item	Unit	Quantity(units)	Price ($)	Total ($)
Receipts	bu	75	2.78	208.5
Operating Costs				
Preharvest Expenses				
Wheat seed	bu	2.15	13.98	30.06
Other seed/Inoculant	bu	0.00	0.00	0.00
Nitrogen	lb	125.00	0.24	30.00
Phosphate	lb	45.00	0.24	10.80
Potash	lb	60.00	0.15	9.00
Fertilizer Application	acre	3.00	5.25	15.75
Lime	ton	0.50	25.00	12.50
Herbicides	acre	1.00	6.76	6.76
Insecticides	acre	0.50	12.28	6.14
Fungicides	acre	0.33	10.56	3.48
Growth Regulator	acre	1.00	6.10	6.10
Chemical Application	acre	1.00	5.61	5.61
Fuel, Oil, Lube	acre	1.00	4.68	4.68
Repairs	acre	1.00	7.81	7.81
Preharvest Labor	hour	1.13	6.25	7.06
Cash Rent or Land Cost	acre	1.00	0.00	0.00
Crop Insurance				0.00
Interest on 6 month Operating Capital	$	155.75	9.00%	7.01
Harvest Expenses				
Fuel, Oil, Lube	acre	1.00	1.54	1.54
Repairs	acre	1.00	3.98	3.98
Harvest Labor	hour	0.29	6.25	1.81
Hauling	bu	75.00	0.15	11.25
Storage	bu	75.00	0.00	0.00
Drying	bu	75.00	0.00	0.00
Total Operating Costs				181.35
Variable Cost per bu. (except Mgmt.)				2.42
Fixed Costs (New Mach. & Equip.)				110.24
Total Costs				291.59
Total Cost per bu. (except Mgmt.)				3.89

Source: Modified from "Virginia Cooperative Extension, Virginia Farm Management, Crop and livestock enterprise budgets, 1997".

Table B 13 Wheat for grain (Whe2) 1999

Budget for 1 acre, expected yield 65 bu

Item	Unit	Quantity(units)	Price ($)	Total ($)
Receipts	bu	65	2.78	180.7
Operating Costs				
Preharvest Expenses				
Wheat seed	bu	2.15	13.98	30.06
Other seed/Inoculant	bu	0.00	0.00	0.00
Nitrogen	lb	100.00	0.24	24.00
Phosphate	lb	35.00	0.24	8.40
Potash	lb	50.00	0.15	7.50
Fertilizer Application	acre	3.00	5.25	15.75
Lime	ton	0.80	25.00	20.00
Herbicides	acre	1.00	6.76	6.76
Insecticides	acre	0.50	12.28	6.14
Fungicides	acre	0.33	10.56	3.48
Growth Regulator	acre	1.00	6.10	6.10
Chemical Application	acre	1.00	5.61	5.61
Fuel, Oil, Lube	acre	1.00	4.70	4.70
Repairs	acre	1.00	7.90	7.90
Preharvest Labor	hour	1.13	6.25	7.06
Cash Rent or Land Cost	acre	1.00	0.00	0.00
Crop Insurance				0.00
Interest on 6 month Operating Capital	$	153.46	9.00%	6.91
Harvest Expenses				
Fuel, Oil, Lube	acre	1.00	1.60	1.60
Repairs	acre	1.00	4.00	4.00
Harvest Labor	hour	0.29	6.25	1.81
Hauling	bu	65.00	0.15	9.75
Storage	bu	65.00	0.00	0.00
Drying	bu	65.00	0.00	0.00
Total Operating Costs				177.53
Variable Cost per bu. (except Mgmt.)				2.73
Fixed Costs (New Mach. & Equip.)				110.24
Total Costs				287.77
Total Cost per bu. (except Mgmt.)				4.43

Source: Modified from “Virginia Cooperative Extension, Virginia Farm Management, Crop and livestock enterprise budgets, 1997”.

Table B 14 Wheat for grain (Whe3) 1999

Budget for 1 acre, expected yield 50 bu

Item	Unit	Quantity(units)	Price ($)	Total ($)
Receipts	bu	50	2.78	139
Operating Costs				
Preharvest Expenses				
Wheat seed	bu	2.15	13.98	30.06
Other seed/Inoculant	bu	0.00	0.00	0.00
Nitrogen	lb	85.00	0.24	20.40
Phosphate	lb	30.00	0.24	7.20
Potash	lb	40.00	0.15	6.00
Fertilizer Application	acre	3.00	5.25	15.75
Lime	ton	0.50	25.00	12.50
Herbicides	acre	1.00	6.76	6.76
Insecticides	acre	0.50	12.28	6.14
Fungicides	acre	0.33	10.56	3.48
Growth Regulator	acre	1.00	6.10	6.10
Chemical Application	acre	1.00	5.61	5.61
Fuel, Oil, Lube	acre	1.00	5.00	5.00
Repairs	acre	1.00	8.10	8.10
Preharvest Labor	hour	1.13	6.25	7.06
Cash Rent or Land Cost	acre	1.00	0.00	0.00
Crop Insurance				0.00
Interest on 6 month Operating Capital	$	140.16	9.00%	6.31
Harvest Expenses				
Fuel, Oil, Lube	acre	1.00	1.90	1.90
Repairs	acre	1.00	4.30	4.30
Harvest Labor	hour	0.29	6.25	1.81
Hauling	bu	50.00	0.15	7.50
Storage	bu	50.00	0.00	0.00
Drying	bu	50.00	0.00	0.00
Total Operating Costs				161.98
Variable Cost per bu. (except Mgmt.)				3.24
Fixed Costs (New Mach. & Equip.)				110.24
Total Costs				272.22
Total Cost per bu. (except Mgmt.)				5.44

Source: Modified from “Virginia Cooperative Extension, Virginia Farm Management, Crop and livestock enterprise budgets, 1997”.

Table B 15 Soybeans (Soy1) 1999

Budget for 1 acre, expected yield 35 bu

Item	Unit	Quantity(units)	Price ($)	Total ($)
Receipts	bu	35	5.41	189.35
Operating Costs				
Preharvest Expenses				
Soybean seed	bu	0.66	15.75	10.40
Other seed/Inoculant	bu	0.00	0.00	0.00
Nitrogen	lb	0.00	0.24	0.00
Phosphate	lb	40.00	0.24	9.60
Potash	lb	60.00	0.15	9.00
Fertilizer Application	acre	1.00	5.25	5.25
Lime	ton	0.50	25.00	12.50
Herbicides	acre	1.00	27.93	27.93
Insecticides	acre	1.00	0.00	0.00
Fungicides	acre	1.00	0.00	0.00
Chemical Application	acre	1.00	5.61	5.61
Fuel, Oil, Lube	acre	1.00	6.71	6.71
Repairs	acre	1.00	11.26	11.26
Preharvest Labor	hour	1.38	6.25	8.63
Cash Rent or Land Cost	acre	1.00	0.00	0.00
Crop Insurance				0.00
Interest on 6 month Operating Capital	$	106.88	9.00%	4.81
Harvest Expenses				
Fuel, Oil, Lube	acre	1.00	1.77	1.77
Repairs	acre	1.00	4.57	4.57
Harvest Labor	hour	0.33	6.25	2.06
Hauling	bu	35.00	0.15	5.25
Storage	bu	35.00	0.00	0.00
Drying	bu	35.00	0.00	0.00
Total Operating Costs				125.34
Variable Cost per bu. (except Mgmt.)				3.58
Fixed Costs (New Mach. & Equip.)				115.08
Total Costs				240.42
Total Cost per bu. (except Mgmt.)				6.87

Source: Modified from "Virginia Cooperative Extension, Virginia Farm Management, Crop and livestock enterprise budgets, 1997".

Table B 16 Soybeans (Soy2) 1999

Budget for 1 acre, expected yield 30 bu

Item	Unit	Quantity(units)	Price ($)	Total ($)
Receipts	bu	30	5.41	162.3
Operating Costs				
Preharvest Expenses				
Soybean seed	bu	0.66	15.75	10.40
Other seed/Inoculant	bu	0.00	0.00	0.00
Nitrogen	lb	0.00	0.24	0.00
Phosphate	lb	35.00	0.24	8.40
Potash	lb	55.00	0.15	8.25
Fertilizer Application	acre	1.00	5.25	5.25
Lime	ton	0.80	25.00	20.00
Herbicides	acre	1.00	27.93	27.93
Insecticides	acre	1.00	0.00	0.00
Fungicides	acre	1.00	0.00	0.00
Chemical Application	acre	1.00	5.61	5.61
Fuel, Oil, Lube	acre	1.00	6.80	6.80
Repairs	acre	1.00	11.40	11.40
Preharvest Labor	hour	1.38	6.25	8.63
Cash Rent or Land Cost	acre	1.00	0.00	0.00
Crop Insurance				0.00
Interest on 6 month Operating Capital	$	112.66	9.00%	5.07
Harvest Expenses				
Fuel, Oil, Lube	acre	1.00	1.81	1.81
Repairs	acre	1.00	4.60	4.60
Harvest Labor	hour	0.33	6.25	2.06
Hauling	bu	30.00	0.15	4.50
Storage	bu	30.00	0.00	0.00
Drying	bu	30.00	0.00	0.00
Total Operating Costs				130.70
Variable Cost per bu. (except Mgmt.)				4.36
Fixed Costs (New Mach. & Equip.)				115.08
Total Costs				245.78
Total Cost per bu. (except Mgmt.)				8.19

Source: Modified from “Virginia Cooperative Extension, Virginia Farm Management, Crop and livestock enterprise budgets, 1997”.

Table B 17 Soybeans (Soy3) 1999

Budget for 1 acre, expected yield 25 bu

Item	Unit	Quantity(units)	Price ($)	Total ($)
Receipts	bu	25	5.41	135.25
Operating Costs				
Preharvest Expenses				
Soybean seed	bu	0.66	15.75	10.40
Other seed/Inoculant	bu	0.00	0.00	0.00
Nitrogen	lb	0.00	0.24	0.00
Phosphate	lb	20.00	0.24	4.80
Potash	lb	40.00	0.15	6.00
Fertilizer Application	acre	1.00	5.25	5.25
Lime	ton	0.50	25.00	12.50
Herbicides	acre	1.00	27.93	27.93
Insecticides	acre	1.00	0.00	0.00
Fungicides	acre	1.00	0.00	0.00
Chemical Application	acre	1.00	5.61	5.61
Fuel, Oil, Lube	acre	1.00	6.90	6.90
Repairs	acre	1.00	11.50	11.50
Preharvest Labor	hour	1.38	6.25	8.63
Cash Rent or Land Cost	acre	1.00	0.00	0.00
Crop Insurance				0.00
Interest on 6 month Operating Capital	$	99.51	9.00%	4.48
Harvest Expenses				
Fuel, Oil, Lube	acre	1.00	1.90	1.90
Repairs	acre	1.00	4.70	4.70
Harvest Labor	hour	0.33	6.25	2.06
Hauling	bu	25.00	0.15	3.75
Storage	bu	25.00	0.00	0.00
Drying	bu	25.00	0.00	0.00
Total Operating Costs				116.40
Variable Cost per bu. (except Mgmt.)				4.66
Fixed Costs (New Mach. & Equip.)				115.08
Total Costs				231.48
Total Cost per bu. (except Mgmt.)				9.26

Source: Modified from "Virginia Cooperative Extension, Virginia Farm Management, Crop and livestock enterprise budgets, 1997".

Table B 18 Cotton (Cot2) 1999

Budget for 1 acre, expected yield, 650 lb

Item	Unit	Quantity(units)	Price ($)	Total ($)
Receipts from cotton lint	lb	650	0.60	390
Operating Costs				
Preharvest Expenses				
Cotton seed	lb	10.00	0.80	8.00
Lime	ton	0.80	25.00	20.00
Nitrogen	lb	65.00	0.24	15.60
Phosphorus	lb	40.00	0.24	9.60
Potassium	lb	120.00	0.15	18.00
Boron	lb	0.50	0.37	0.19
Fertilizer Application	acre	1.00	5.25	5.25
PPI Herbicide	acre	1.00	5.77	5.77
Pre-Emerg Herbicides	acre	1.00	19.18	19.18
Post-Emerg Herbicides	acre	1.00	10.73	10.73
Systematic Insecticide	acre	1.00	12.80	12.80
Insect Scouting	acre	1.00	7.50	7.50
Insecticide	acre	1.00	22.03	22.03
Eradication Fee	acre	1.00	2.75	2.75
Growth Regulator	acre	1.00	6.38	6.38
Defoliant	acre	1.00	7.88	7.88
Machinery & Equip.Fuel, Oil, Lube, Repairs				58.23
Preharvest Labor	hour	8.50	6.25	53.13
Interest on 6 month Operating Capital	$	283.01	9.00%	12.74
Harvest Expenses				
Fuel, Oil, Lube	acre	1.00	1.50	1.50
Repairs	acre	1.00	3.50	3.50
Harvest Labor	hour	1.00	6.25	6.25
Hauling				40.00
Total Operating Costs				347.00
Fixed Costs (New Mach. & Equip.)				96.39
Total Costs				443.39

Source: Modified from “Department of Agricultural and Resource Economics, North Carolina State University. URL: http://www.ag-econ.ncsu.edu/publications/publications.htm”.

Table B 19 Cotton (Cot3) 1999

Budget for 1 acre, expected yield, 600 lb

Item	Unit	Quantity(units)	Price ($)	Total ($)
Receipts from cotton lint	lb	600	0.60	360
Operating Costs				
Preharvest Expenses				
Cotton seed	lb	10.00	0.80	8.00
Lime	ton	0.50	25.00	12.50
Nitrogen	lb	60.00	0.24	14.40
Phosphorus	lb	35.00	0.24	8.40
Potassium	lb	100.00	0.15	15.00
Boron	lb	0.50	0.37	0.19
Fertilizer Application	acre	1.00	5.25	5.25
PPI Herbicide	acre	1.00	5.77	5.77
Pre-Emerg Herbicides	acre	1.00	19.18	19.18
Post-Emerg Herbicides	acre	1.00	10.73	10.73
Systematic Insecticide	acre	1.00	12.80	12.80
Insect Scouting	acre	1.00	7.50	7.50
Insecticide	acre	1.00	22.03	22.03
Eradication Fee	acre	1.00	2.75	2.75
Growth Regulator	acre	1.00	6.38	6.38
Defoliant	acre	1.00	7.88	7.88
Machinery & Equip.Fuel, Oil, Lube, Repairs				66.00
Preharvest Labor	hour	9.00	6.25	56.25
Interest on 6 month Operating Capital	$	281.01	9.00%	12.65
Harvest Expenses				
Fuel, Oil, Lube	acre	1.00	2.00	2.00
Repairs	acre	1.00	5.00	5.00
Harvest Labor	hour	2.00	6.25	12.50
Hauling				34.00
Total Operating Costs				347.15
Fixed Costs (New Mach. & Equip.)				96.39
Total Costs				443.54

Source: Modified from “Department of Agricultural and Resource Economics, North Carolina State University. URL: http://www.ag-econ.ncsu.edu/publications/publications.htm”.

Table B 20 Fall Broccoli (sprinkler irrigation), (Broc2) 1999

Budget for 1 acre, expected yield, 370 boxes 20 lb each

Item	Unit	Quantity(units)	Price ($)	Total ($)
Receipts	20 lb box	370	10.18	3766.60
Operating Costs				
Seed	lb	1.00	160.00	160.00
Lime	ton	0.20	25.00	5.00
Fertilizer: Nitrogen	lb	145.00	0.24	34.80
Phosphate	lb	100.00	0.24	24.00
Potash	lb	145.00	0.15	21.75
Spreading	acre	1.00	6.00	6.00
Herbicides	acre	1.00	30.06	30.06
Insecticides	acre	5.00	13.55	67.75
Fungicides	acre	1.00	9.81	9.81
Fuel, Oil, Lube,Repairs	acre	1.00	80.02	80.02
Labor	hour	20.00	6.25	125.00
Supplies: Boxes	each	370	1.00	370.00
Hauling, Grading	box	370.00	1.00	370.00
Harvest Labor	box	370.00	1.00	370.00
Cooling	box	370.00	0.50	185.00
Interest on 6 month Operating Capital	$	1364.19	9.00%	61.39
Total Operating Costs				1920.58
Variable Cost per box				5.19
Fixed Costs: Irrigation	acre	3324.00	20.46%	680.09
Other Fixed Costs				315.27
Total Fixed Costs				995.36
Total Costs				2915.94
Total Cost per box (except land & Mgmt.)				7.88

Source: Modified from "Virginia Cooperative Extension, 1999 Crop Enterprise Cost Analysis for the Eastern Shore of Virginia".

Table B 21 Tomatoes, fresh market, staked (sprinkler irrigation), (Tom2) 1999

Budget for 1 acre, expected yield, 1600 cartons 25 lb each

Item	Unit	Quantity(units)	Price ($)	Total ($)
Receipts	25 lb crtn	1,600	7.99	12784
Operating Costs				
Nylon twine	lb	35.00	1.25	43.75
Custom harvest	crtn	1600.00	0.80	1280.00
Lime	ton	0.70	25.00	17.50
Cartons	each	1600.00	1.00	1600.00
Tomato grade/pack	crtn	1600.00	1.70	2720.00
Harvest buckets	each	30.00	1.50	45.00
Bulk bin	each	20.00	14.00	280.00
Tomato plants, Mtn.	hrd	55.00	9.30	511.50
Fumigation	acre	1.00	950.00	950.00
Post-emrg. herbicide	acre	1.00	12.53	12.53
Post-emrg. herbicide	acre	1.00	26.31	26.31
Contact insecticide	acre	5.00	8.63	43.15
Contact insecticide	acre	3.00	7.38	22.14
Contact insecticide	acre	2.00	9.35	18.70
Fungicide	acre	18	11.55	207.90
Fungicide	acre	2.00	23.10	46.20
Stakes	hundred	27.50	4.00	110.00
8-24-24, dry bulk	cwt	10.00	9.70	97.00
Boron	lb	12.00	0.37	4.44
13-0-44, bagged	cwt	2.00	9.00	18.00
Machinery fuel, lube, repair	acre	1.00	323.58	323.58
Labor	hour	176.00	7.50	1320.00
Interest on 6 month Operating Capital	$	7822.45	9.00%	352.01
Total Operating Costs				10005.96
Variable Cost per carton				6.25
Fixed Costs: Irrigation	$/acre	3324.00	20.46%	680.09
Other Fixed Costs				125.29
Total Fixed Costs				805.38
Total Costs				10811.34
Total Cost per crtn (except land & Mgmt.)				6.76

Source: Modified from "Department of Agricultural and Resource Economics, North Carolina State University. URL: http://www.ag-econ.ncsu.edu/publications/publications.htm".

Table B 22 Beef cows Calving in Spring (hay ration), (Bec) 1999

Budget for 100 cows, 90% calf crop, 15% replacement left as a % of cow herd, 15% annual culling rate and 1% annual cow death loss.

Item	Unit	Quantity(units)	Price ($)	Total ($)
Receipts				
Steers (45 @ 5cwt)	cwt	225.00	61.00	13725.00
Heifers (30 @ 4.5cwt)	cwt	135.00	48.00	6480.00
Cull Cows (14 @ 10cwt)	cwt	140.00	30.00	4200.00
Cull Bull (1 @ 16cwt)	cwt	16.00	38.00	608.00
Total Receipts				25013.00
Operating Costs				
Grass Hay, 5% feed waste	ton	179.67	40.00	7186.80
Corn grain, 2% feed waste	bu	396.50	3.00	1189.50
Salt and Mineral	cwt	68.00	22.00	1496.00
Vet and Medicine	head	100.00	15.33	1533.00
Supplies	head	100.00	2.00	200.00
Replacement Bull	head	1.00	1200.00	1200.00
Pasture	acre	250.00	18.00	4500.00
Haul Cull Cattle	head	15.00	5.20	78.00
Market Cull Cattle	head	15.00		141.16
Haul Calves	head	75.00	3.75	281.25
Market Calves	head	75.00		666.60
Building and Fence Repair				250.00
Utilities				125.00
Machinery (non-crop)	head	100.00	10.00	1000.00
Labor	hours	800.00	6.25	5000.00
Total Operating Costs				24847.31
Annual Debt payment				0.00
Total Costs				24847.31

Source: Modified from "Virginia Cooperative Extension, Virginia Farm Management, Crop and livestock enterprise budgets, 1997".

Table B 23 Contract Swine (Cos) 1999

Pigs Placed	500			
Mortality	2%			
Pigs Sold	490			
Net Feed Conversion	2.8			
Groups Per Year	3			
Starting Weight (lb)	50			
Selling Weight (lb)	240			
Weight Gain Per Hog (lb)	190			
Facility Investment $90per head capacity	45000			

Item	Unit	Quantity(units)	Price ($)	Total ($)
Receipts				
Weight Gain Payment	lb	93100	0.03	2793.00
Feed Conversion Bonus Payment	lb f. conv	588.00	3.00	1764.00
Total Receipts Per Group				4557.00
Total Annual Receipts	groups	3.00	4557.00	13671.00
Operating Costs				
Utilities	head	1500.00	0.65	975.00
Supplies	head	1500.00	0.08	120.00
Repairs	head	1500.00	0.50	750.00
Labor (plus 7.65% FICA)	hours	497.30	6.25	3345.90
Total Operating Costs				5190.90
Fixed Costs				
Debt Payment (10 year period)				7560.00
Property Taxes				202.50
Insurance				270.00
Total Fixed Costs				8032.50
Total Costs				13223.40

Source: Developed based on Kenyon (1997), Swinton and Martin (1997), and Carroll's Foods (1992).

APPENDIX C

Mathematically stated LP model

SCENARIO 1 (BASELINE SCENARIO)

```
MAX      1.78 PTOB1 - 2453.91 TOB1 + 1.78 PTOB2 - 2367.6 TOB2
       + 1.78 PTOB3 - 2314.92 TOB3 + 2.5 SCOR - 236.33 COR1 - 223.6 COR2
       - 212.38 COR3 - 3 BCOR + 2.07 PBAR2 - 135.67 BAR2 + 2.07 PBAR3
       - 125.11 BAR3 + 3.77 PWDS1 - 235.19 WDS1 + 3.72 PWDS2 - 236.91 WDS2
       + 3.66 PWDS3 - 225.3 WDS3 + 2.78 PWHE1 - 181.35 WHE1 + 2.78 PWHE2
       - 177.53 WHE2 + 2.78 PWHE3 - 161.98 WHE3 + 5.41 PSOY1 - 125.36 SOY1
       + 5.41 PSOY2 - 130.7 SOY2 + 5.41 PSOY3 - 116.4 SOY3 + 0.6 PCOT2
       - 347 COT2 + 0.6 PCOT3 - 347.15 COT3 + 10.18 PBROC2 - 1966.04 BROC2
       + 7.99 PTOM2 - 10005.96 TOM2 + 1.66 BEC + 5.65 COS
  SUBJECT TO
         2)   PTOB1 - 2700 TOB1 =    0
         3)   PTOB2 - 2400 TOB2 =    0
         4)   PTOB3 - 1800 TOB3 =    0
         5)   PBAR2 - 80 BAR2 =    0
         6)   PBAR3 - 70 BAR3 =    0
         7)   PWDS1 - 80 WDS1 =    0
         8)   PWDS2 - 70 WDS2 =    0
         9)   PWDS3 - 60 WDS3 =    0
        10)   PWHE1 - 75 WHE1 =    0
        11)   PWHE2 - 65 WHE2 =    0
        12)   PWHE3 - 50 WHE3 =    0
        13)   PSOY1 - 35 SOY1 =    0
        14)   PSOY2 - 30 SOY2 =    0
        15)   PSOY3 - 25 SOY3 =    0
        16)   PCOT2 - 650 COT2 =    0
        17)   PCOT3 - 600 COT3 =    0
        18)   PBROC2 - 370 BROC2 =    0
        19)   PTOM2 - 1600 TOM2 =    0
        20)   TOB1 <=   217.03
        21)   TOB2 <=   1656
        22)   TOB3 <=   1441.16
        23)   COR1 <=   486.2
        24)   COR2 <=   1900.54
        25)   COR3 <=   1595.46
        26)   BAR2 <=   1900.54
        27)   BAR3 <=   1595.46
        28)   WDS1 <=   39.5
        29)   WDS2 <=   1900.54
        30)   WDS3 <=   1595.46
        31)   WHE1 <=   47.02
        32)   WHE2 <=   1954.2
        33)   WHE3 <=   1518.31
        34)   SOY1 <=   39.5
        35)   SOY2 <=   1900.54
        36)   SOY3 <=   1595.46
        37)   COT2 <=   1900.54
        38)   COT3 <=   1595.46
        39)   BROC2 <=   3
        40)   TOM2 <=   4
        41)   BEC <=   100
        42)   COS <=   1500
        43)   TOB1 + TOB2 + TOB3 + COR1 + COR2 + COR3 + BAR2 + BAR3 + WDS1
       + WDS2 + WDS3 + WHE1 + WHE2 + WHE3 + SOY1 + SOY2 + SOY3 + COT2 + COT3
       + BROC2 + TOM2 <=   5471.68
        44)   WDS1 + SOY1 <=   39.5
        45)   BROC2 + TOM2 <=   1264.82
        46)   TOB1 + WHE2 <=   2074.86
        47)   TOB1 + BROC2 + TOM2 <=   1398.79
        48)   TOB2 + COR1 <=   2549.39
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```
 49)   TOB2 + COR2 + BAR2 + WDS2 + SOY2 + COT2 <=   2129.4
 50)   TOB2 + WDS1 + SOY1 <=   1656
 51)   TOB2 + WHE1 <=   1671.04
 52)   TOB2 + WHE2 <=   2114.36
 53)   TOB2 + BROC2 + TOM2 <=   1842.28
 54)   TOB3 + COR3 + BAR3 + WDS3 + WHE3 + SOY3 + COT3 <=   1595.46
 55)   COR1 + WDS1 + WHE1 + SOY1 <=   947.93
 56)   COR2 + BAR2 + WDS2 + WHE1 + SOY2 + COT2 <=   1940.04
 57)   TOB1 + COR2 + BAR2 + WDS2 + WHE2 + SOY2 + COT2 + BROC2 + TOM2
<=   2172.96
 58)   WDS1 + WHE1 + SOY1 <=   54.54
 59)   SCOR - 100 COR1 - 90 COR2 - 70 COR3 - BCOR + 3.965 BEC =    0
 60)   TOB14B <=   83.06
 61)   TOB122B <=   104.79
 62)   TOB142B <=   29.18
 63)   TOB23A <=   39.5
 64)   TOB23B <=   117.94
 65)   TOB29B <=   230.66
 66)   TOB223B <=   1078.54
 67)   TOB234B <=   189.36
 68)   TOB34C <=   41.57
 69)   TOB35C3 <=   81.4
 70)   TOB323C <=   1308.19
 71)   TOB332C <=   10
 72)   COR13A <=   39.5
 73)   TOB1 - TOB14B - TOB122B - TOB142B =    0
 74)   TOB2 - TOB23A - TOB23B - TOB29B - TOB223B - TOB234B =    0
 75)   TOB3 - TOB34C - TOB35C3 - TOB323C - TOB332C =    0
 76)   TOB14B - WHE24B =    0
 77)   TOB122B - WHE222B =    0
 78)   TOB142B - WHE242B =    0
 79)   TOB23A - WHE13A =    0
 80)   TOB23B - WHE23B =    0
 81)   TOB29B - WHE29B =    0
 82)   TOB223B - WHE223B =    0
 83)   TOB234B - WHE234B =    0
 84)   TOB34C - WHE34C =    0
 85)   TOB35C3 - WHE35C3 =    0
 86)   TOB332C - WHE332C =    0
 87) - COR13A + SOY13A =    0
 88)   COR2 - BAR2 =    0
 89)   SOY2 - COT2 =    0
 90)   COR3 - BAR3 =    0
 91)   SOY3 - COT3 =    0
 92)   BROC2 - TOM2 =    0
 93)   6 TOB1 + 6 TOB2 + 3 BROC2 + 9.5 TOM2 <=   5198.1
END
```

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    P   P   P             P   P   P   P   P   P   P   P   P   P   P   P
    T T T T T T S C C C B B B B B W W W W W W W W W W W W S S S S S S C
    O O O O O O C O O O C A A A A D D D D D D H H H H H H O O O O O O O
    B B B B B B O R R R O R R R R S S S S S S E E E E E E Y Y Y Y Y Y T
    1 1 2 2 3 3 R 1 2 3 R 2 2 3 3 1 1 2 2 3 3 1 1 2 2 3 3 1 1 2 2 3 3 2

 1: A-D A-D A-D A-C-C-C-3 A-C A-C A-C A-C A-C A-C A-C A-C A-C A-C A-C T
 2: 1-D   '     '     '     '     '     '     '     '     '     '     '
 3: '  '1-D  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '
 4:       ' 1-D '     '     '     '     '     '     '     '     '     '
 5:       '     '     '   1-B     '     '     '     '     '     '     '
 6: '  '  '  '  '  '  '  '  ' 1-B '  '  '  '  '  '  '  '  '  '  '  '  '
 7:       '     '     '     '     1-B   '     '     '     '     '     '
 8:       '     '     '     '     '   1-B     '     '     '     '     '
 9: '  '  '  '  '  '  '  '  '  '  '  '  ' 1-B '  '  '  '  '  '  '  '  '
10:       '     '     '     '     '     '     1-B   '     '     '     '
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11:       '     '     '     '     '     '     '   1-B     '     '     '
12: '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  ' 1-B '  '  '  '  '
13:       '     '     '     '     '     '     '     '     1-B   '     '
14:       '     '     '     '     '     '     '     '     '   1-B     '
15: '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  ' 1-B '
16:       '     '     '     '     '     '     '     '     '     '     1
17:       '     '     '     '     '     '     '     '     '     '     '
18: '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '
19:       '     '     '     '     '     '     '     '     '     '     '
20:   1   '     '     '     '     '     '     '     '     '     '     '
21: '  '  1  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '
22:       '   1 '     '     '     '     '     '     '     '     '     '
23:       '     ' 1   '     '     '     '     '     '     '     '     '
24: '  '  '  '  '  '1 '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '
25:       '     '     1     '     '     '     '     '     '     '     '
26:       '     '     '     1     '     '     '     '     '     '     '
27: '  '  '  '  '  '  '  '  '  '1 '  '  '  '  '  '  '  '  '  '  '  '  '
28:       '     '     '     '     ' 1   '     '     '     '     '     '
29:       '     '     '     '     '     1     '     '     '     '     '
30: '  '  '  '  '  '  '  '  '  '  '  '  '  '1 '  '  '  '  '  '  '  '  '
31:       '     '     '     '     '     '     ' 1   '     '     '     '
32:       '     '     '     '     '     '     '     1     '     '     '
33: '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '1 '  '  '  '  '
34:       '     '     '     '     '     '     '     '     ' 1   '     '
35:       '     '     '     '     '     '     '     '     '     1     '
36: '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '1 '
37:       '     '     '     '     '     '     '     '     '     '     '
38:       '     '     '     '     '     '     '     '     '     '     '
39: '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '
40:       '     '     '     '     '     '     '     '     '     '     '
41:       '     '     '     '     '     '     '     '     '     '     '
42: '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '
43:   1   1   1 ' 1 1 1     1   1 ' 1   1   1 ' 1   1   1 ' 1   1   1 '
44:       '     '     '     '     ' 1   '     '     '     ' 1   '     '
45: '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '
46:   1   '     '     '     '     '     '     '     1     '     '     '
47:   1   '     '     '     '     '     '     '     '     '     '     '
48: '  '  1  '  ' 1'  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '
49:       1     '   1 '     1     '     1     '     '     '     1     '
50:       1     '     '     '     ' 1   '     '     '     ' 1   '     '
51: '  '  1  '  '  '  '  '  '  '  '  '  '  '  ' 1'  '  '  '  '  '  '  '
52:       1     '     '     '     '     '     '     1     '     '     '
53:       1     '     '     '     '     '     '     '     '     '     '
54: '  '  '  '1 '  '  1  '  '  '1 '  '  '  '1 '  '  '  '1 '  '  '  '1 '
55:       '     ' 1   '     '     ' 1   '     ' 1   '     ' 1   '     '
56:       '     '   1 '     1     '     1     ' 1   '     '     1     '
57: ' 1'  '  '  '  '1 '  '  1  '  '  '  1  '  '  '  1  '  '  '  1  '  '
58:       '     '     '     '     ' 1   '     ' 1   '     ' 1   '     '
59:       '     1-B-B-B-1   '     '     '     '     '     '     '     '
60: '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '
61:       '     '     '     '     '     '     '     '     '     '     '
62:       '     '     '     '     '     '     '     '     '     '     '
63: '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '
64:       '     '     '     '     '     '     '     '     '     '     '
65:       '     '     '     '     '     '     '     '     '     '     '
66: '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '
67:       '     '     '     '     '     '     '     '     '     '     '
68:       '     '     '     '     '     '     '     '     '     '     '
69: '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '
70:       '     '     '     '     '     '     '     '     '     '     '
71:       '     '     '     '     '     '     '     '     '     '     '
72: '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '
73:   1   '     '     '     '     '     '     '     '     '     '     '
74:       1     '     '     '     '     '     '     '     '     '     '
75: '  '  '  '1 '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '
76:       '     '     '     '     '     '     '     '     '     '     '
77:       '     '     '     '     '     '     '     '     '     '     '
```

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78: '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '
79:       '     '     '     '     '     '     '     '     '     '     '
80:       '     '     '     '     '     '     '     '     '     '     '
81: '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '
82:       '     '     '     '     '     '     '     '     '     '     '
83:       '     '     '     '     '     '     '     '     '     '     '
84: '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '
85:       '     '     '     '     '     '     '     '     '     '     '
86:       '     '     '     '     '     '     '     '     '     '     '
87: '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '
88:       '     '   1 '    -1     '     '     '     '     '     '     '
89:       '     '     '     '     '     '     '     '     '     1     '
90: '  '  '  '  '  '  1  '  ' -1  '  '  '  '  '  '  '  '  '  '  '  '  '
91:       '     '     '     '     '     '     '     '     '     '   1 '
92:       '     '     '     '     '     '     '     '     '     '     '
93: ' 6'  6  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '

                        T T       T T   T T T     W W       W W   W
          P           T O O T T T O O T O O O C W H H W W W H H W H
      P   B B P       O B B O O O B B O B B B O H E E H H H E E H E
    C C C R R T T     B 1 1 B B B 2 2 B 3 3 3 R E 2 2 E E E 2 2 E 3
    O O O O O O O B C 1 2 4 2 2 2 2 3 3 5 2 3 1 2 2 4 1 2 2 2 3 3 5
    T T T C C M M E O 4 2 2 3 3 9 3 4 4 C 3 2 3 4 2 2 3 3 9 3 4 4 C
    2 3 3 2 2 2 2 C S B B B A B B B B C 3 C C A B B B A B B B B C 3

 1:-C T-C B-D A-E A A '     '     '     '     '     '     '     '     '
 2:       '     '     '     '     '     '     '     '     '     '     '
 3: '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '
 4:       '     '     '     '     '     '     '     '     '     '     '
 5:       '     '     '     '     '     '     '     '     '     '     '
 6: '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '
 7:       '     '     '     '     '     '     '     '     '     '     '
 8:       '     '     '     '     '     '     '     '     '     '     '
 9: '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '
10:       '     '     '     '     '     '     '     '     '     '     '
11:       '     '     '     '     '     '     '     '     '     '     '
12: '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '
13:       '     '     '     '     '     '     '     '     '     '     '
14:       '     '     '     '     '     '     '     '     '     '     '
15: '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '
16:-C     '     '     '     '     '     '     '     '     '     '     '
17:   1-C '     '     '     '     '     '     '     '     '     '     '
18: '  '  1-C'  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '
19:       '   1-D     '     '     '     '     '     '     '     '     '
20:       '     '     '     '     '     '     '     '     '     '     '
21: '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '
22:       '     '     '     '     '     '     '     '     '     '     '
23:       '     '     '     '     '     '     '     '     '     '     '
24: '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '
25:       '     '     '     '     '     '     '     '     '     '     '
26:       '     '     '     '     '     '     '     '     '     '     '
27: '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '
28:       '     '     '     '     '     '     '     '     '     '     '
29:       '     '     '     '     '     '     '     '     '     '     '
30: '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '
31:       '     '     '     '     '     '     '     '     '     '     '
32:       '     '     '     '     '     '     '     '     '     '     '
33: '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '
34:       '     '     '     '     '     '     '     '     '     '     '
35:       '     '     '     '     '     '     '     '     '     '     '
36: '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '
37: 1     '     '     '     '     '     '     '     '     '     '     '
38:     1 '     '     '     '     '     '     '     '     '     '     '
39: '  '  ' 1'  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '
40:       '     1     '     '     '     '     '     '     '     '     '
41:       '     ' 1   '     '     '     '     '     '     '     '     '
```

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42: '  '  '  '  '  '1 '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '
43: 1   1 ' 1   1     '     '     '     '     '     '     '     '     '
44:       '     '     '     '     '     '     '     '     '     '     '
45: '  '  ' 1'  1  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '
46:       '     '     '     '     '     '     '     '     '     '     '
47:       ' 1   1     '     '     '     '     '     '     '     '     '
48: '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '
49: 1     '     '     '     '     '     '     '     '     '     '     '
50:       '     '     '     '     '     '     '     '     '     '     '
51: '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '
52:       '     '     '     '     '     '     '     '     '     '     '
53:       ' 1   1     '     '     '     '     '     '     '     '     '
54: '  '1 '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '
55:       '     '     '     '     '     '     '     '     '     '     '
56: 1     '     '     '     '     '     '     '     '     '     '     '
57: 1  '  ' 1'  1  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '
58:       '     '     '     '     '     '     '     '     '     '     '
59:       '     ' A   '     '     '     '     '     '     '     '     '
60: '  '  '  '  '  '  1  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '
61:       '     '     ' 1   '     '     '     '     '     '     '     '
62:       '     '     '   1 '     '     '     '     '     '     '     '
63: '  '  '  '  '  '  '  '  1  '  '  '  '  '  '  '  '  '  '  '  '  '  '
64:       '     '     '     ' 1   '     '     '     '     '     '     '
65:       '     '     '     '   1 '     '     '     '     '     '     '
66: '  '  '  '  '  '  '  '  '  '  1  '  '  '  '  '  '  '  '  '  '  '  '
67:       '     '     '     '     ' 1   '     '     '     '     '     '
68:       '     '     '     '     '   1 '     '     '     '     '     '
69: '  '  '  '  '  '  '  '  '  '  '  '  1  '  '  '  '  '  '  '  '  '  '
70:       '     '     '     '     '     ' 1   '     '     '     '     '
71:       '     '     '     '     '     '   1 '     '     '     '     '
72: '  '  '  '  '  '  '  '  '  '  '  '  '  '  1  '  '  '  '  '  '  '  '
73:       '     '    -1-1-1 '     '     '     '     '     '     '     '
74:       '     '     '    -1-1-1-1-1   '     '     '     '     '     '
75: '  '  '  '  '  '  '  '  '  '  '  -1-1-1-1 '  '  '  '  '  '  '  '  '
76:       '     '     1     '     '     '     '-1   '     '     '     '
77:       '     '     ' 1   '     '     '     '  -1 '     '     '     '
78: '  '  '  '  '  '  '  '1 '  '  '  '  '  '  '  ' -1  '  '  '  '  '  '
79:       '     '     '     1     '     '     '     '-1   '     '     '
80:       '     '     '     ' 1   '     '     '     '  -1 '     '     '
81: '  '  '  '  '  '  '  '  '  '1 '  '  '  '  '  '  '  ' -1  '  '  '  '
82:       '     '     '     '     1     '     '     '     '-1   '     '
83:       '     '     '     '     ' 1   '     '     '     '  -1 '     '
84: '  '  '  '  '  '  '  '  '  '  '  '1 '  '  '  '  '  '  '  ' -1  '  '
85:       '     '     '     '     '     1     '     '     '     '-1   '
86:       '     '     '     '     '     '   1 '     '     '     '     '
87: '  '  '  '  '  '  '  '  '  '  '  '  '  ' -1  '  '  '  '  '  '  '  '
88:       '     '     '     '     '     '     '     '     '     '     '
89:-1     '     '     '     '     '     '     '     '     '     '     '
90: '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '
91:    -1 '     '     '     '     '     '     '     '     '     '     '
92:       ' 1  -1     '     '     '     '     '     '     '     '     '
93: '  '  ' 3'  A  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '  '


    W
    H S
    E O
    3 Y
    3 1
    2 3
    C A

 1:     MAX
 2:     =
 3: '  '=
 4:     =
 5:     =
```

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 6: '  '=
 7:     =
 8:     =
 9: '  '=
10:     =
11:     =
12: '  '=
13:     =
14:     =
15: '  '=
16:     =
17:     =
18: '  '=
19:     =
20:     < C
21: '  '< D
22:     < D
23:     < C
24: '  '< D
25:     < D
26:     < D
27: '  '< D
28:     < B
29:     < D
30: '  '< D
31:     < B
32:     < D
33: '  '< D
34:     < B
35:     < D
36: '  '< D
37:     < D
38:     < D
39: '  '< 3
40:     < 4
41:     < B
42: '  '< D
43:     < D
44:     < B
45: '  '< D
46:     < D
47:     < D
48: '  '< D
49:     < D
50:     < D
51: '  '< D
52:     < D
53:     < D
54: '  '< D
55:     < C
56:     < D
57: '  '< D
58:     < B
59:     =
60: '  '< B
61:     < C
62:     < B
63: '  '< B
64:     < C
65:     < C
66: '  '< D
67:     < C
68:     < B
69: '  '< B
70:     < D
71:     < A
72: '  '< B
```

```
73:      =
74:      =
75: '  '=
76:      =
77:      =
78: '  '=
79:      =
80:      =
81: '  '=
82:      =
83:      =
84: '  '=
85:      =
86:-1   =
87: ' 1'=
88:      =
89:      =
90: '  '=
91:      =
92:      =
93: '  '< D
```

APPENDIX D

ArcView GIS Result Table

Table D 1 GIS Results; Fields of ERU's and Their Areas

Tob1 (high yield)		Area	217.03		
Soil symbol 4B		Soil symbol 22B		Soil symbol 42B	
Field ID	Area (acres)	Field ID	Area (acres)	Field ID	Area (acres)
1042001	18.76	1122201	3.22	1142201	11.16
1042002	12.48	1122202	4.63	1142202	1.90
1042003	12.98	1122203	24.21	1142203	16.12
1042004	33.88	1122204	27.77		
1042005	4.96	1122205	36.61		
		1122206	3.97		
		1122207	4.38		
Total 4B	83.06	Total 22B	104.79	Total 42B	29.18

Tob2 (average yield)			Area		1656.00						
Soil symbol 3A		Soil symbol 3B		Soil symbol 9B		Soil symbol 23B				Soil symbol 34B	
Field ID	Area (acres)	Field ID	Area (acres)	Field ID	Area (acres)	Field ID	Area (acres)	Field ID	Area (acres)	Field ID	Area (acres)
1031001	39.50	1032001	39.92	1092001	3.80	1123201	3.97	1123220	100.91	1134201	4.96
		1032002	55.45	1092002	24.71	1123202	29.26	1123221	70.66	1134202	9.34
		1032003	22.07	1092003	63.64	1123203	16.03	1123222	12.40	1134203	56.28
		1032004	0.50	1092004	16.53	1123204	3.06	1123223	5.21	1134204	7.11
				1092005	3.39	1123205	117.69	1123224	7.19	1134205	22.98
				1092006	33.80	1123206	23.47	1123225	70.50	1134206	17.44
				1092007	7.93	1123207	10.41	1123226	38.76	1134207	2.64
				1092008	21.82	1123208	7.44	1123227	138.02	1134208	21.41
				1092009	55.04	1123209	27.27	1123228	25.12	1134209	2.98
						1123210	15.54	1123229	14.55	1134210	44.22
						1123211	14.46	1123230	18.26		
						1123212	3.80	1123231	19.59		
						1123213	32.89	1123232	15.21		
						1123214	11.57				
						1123215	10.50				
						1123216	25.54				
						1123217	138.35				

Table D 1 (continued**)**

						1123218	21.65				
						1123219	29.26				
Total 3A	39.50	Total 3B	117.94	Total 9B	230.66			Total 23B	1078.54	Total 34B	189.36
Tob3 (low yield)		Area	1441.16								
Soil symbol 4C		Soil symbol 5C3		Soil symbol 23C		Soil symbol 32C					
Field ID	Area (acres)	Field ID	Area (acres)	Field ID	Area (acres)	Field ID	Area (acres)				
1043001	2.64	1053301	16.69	1123301	6.94	1132301	4.79				
1043002	38.93	1053302	33.64	1123302	1.90	1132302	5.21				
		1053303	1.98	1123303	31.82						
		1053304	14.13	1123304	29.67						
		1053305	2.89	1123305	6.78						
		1053306	2.48	1123306	17.44						
		1053307	9.59	1123307	6.28						
				1123308	5.95						
				1123309	3.31						
				1123310	37.02						
				1123311	12.81						
				1123312	46.53						
				1123313	38.76						
				1123314	27.27						
				1123315	98.60						
				1123316	28.10						
				1123317	65.79						
				1123318	33.14						
				1123319	11.32						
				1123320	17.52						
				1123321	20.50						
				1123322	37.19						
				1123323	689.09						
				1123324	34.46						
Total 4C	41.57	Total 5C3	81.40	Total 23C	1308.19	Total 32C	10.00				

Table D 1 (continued**)**

cor1 (high yield)		Area	932.89				
Soil symbol 3A		Soil symbol 7A		Soil symbol 33A		Soil symbol 38A	
Field ID	Area (acres)	Field ID	Area (acres)	Field ID	Area (acres)	Field ID	Area (acres)
1031001	39.50	1071001	15.54	1133101	26.45	1138101	36.36
		1071002	152.48	1133102	79.42	1138102	110.33
		1071003	7.02	1133103	48.10	1138103	17.52
		1071004	8.51	1133104	6.53	1138104	20.99
		1071005	315.54	1133105	19.34		
				1133106	29.26		
Total 3A	39.50	Total 7A	499.09	Total 33A	209.10	Total 38A	185.20

Table D 1 (continued**)**

cor2 (average yield)		Area	1900.54						
Soil symbol 3B		Soil symbol 4B		Soil symbol 9B		Soil symbol 10B		Soil symbol 17B	
Field ID	Area (acres)	Field ID	Area (acres)	Field ID	Area (acres)	Field ID	Area (acres)	Field ID	Area (acres)
1032001	39.92	1042001	18.76	1092001	3.80	1110201	3.39	1117201	28.84
1032002	55.45	1042002	12.48	1092002	24.71			1117202	11.74
1032003	22.07	1042003	12.98	1092003	63.64			1117203	10.99
1032004	0.50	1042004	33.88	1092004	16.53			1117204	63.80
		1042005	4.96	1092005	3.39			1117205	32.98
				1092006	33.80			1117206	4.71
				1092007	7.93			1117207	5.29
				1092008	21.82				
				1092009	55.04				
Total 3B	117.94	Total 4B	83.06	Total 9B	230.66	Total 10B	3.39	Total 17B	158.35

Soil symbol 22B		Soil symbol 23B				Soil symbol 35B		Soil symbol 36B		Soil symbol 42B	
Field ID	Area (acres)	Field ID	Area (acres)	Field ID	Area (acres)	Field ID	Area (acres)	Field ID	Area (acres)	Field ID	Area (acres)
1122201	3.22	1123201	3.97	1123221	70.66	1135201	15.04	1136201	72.48	1142201	11.16
1122202	4.63	1123202	29.26	1123222	12.40			1136202	7.11	1142202	1.90
1122203	24.21	1123203	16.03	1123223	5.21					1142203	16.12
1122204	27.77	1123204	3.06	1123224	7.19						
1122205	36.61	1123205	117.69	1123225	70.50						
1122206	3.97	1123206	23.47	1123226	38.76						
1122207	4.38	1123207	10.41	1123227	138.02						
		1123208	7.44	1123228	25.12						

Table D 1 (continued**)**

		1123209	27.27	1123229	14.55						
		1123210	15.54	1123230	18.26						
		1123211	14.46	1123231	19.59						
		1123212	3.80	1123232	15.21						
		1123213	32.89								
		1123214	11.57								
		1123215	10.50								
		1123216	25.54								
		1123217	138.35								
		1123218	21.65								
		1123219	29.26								
		1123220	100.91								
Total22 B	104.79			Total 23B	1078.54	Total 35B	15.04	Total 36B	79.59	Total 42B	29.18
cor3 (low yield)		Area	1595.46								
Soil symbol 1C		Soil symbol 4C		Soil symbol 5C3		Soil symbol 11C3		Soil symbol 23C		Soil symbol 32C	
Field ID	Area (acres)	Field ID	Area (acres)	Field ID	Area (acres)	Field ID	Area (acres)	Field ID	Area (acres)	Field ID	Area (acres)
1013001	0.17	1043001	2.64	1053301	16.69	1111331	8.76	1123301	6.94	1132301	4.79
		1043002	38.93	1053302	33.64	1111332	42.31	1123302	1.90	1132302	5.21
				1053303	1.98			1123303	31.82		
				1053304	14.13			1123304	29.67		
				1053305	2.89			1123305	6.78		
				1053306	2.48			1123306	17.44		
				1053307	9.59			1123307	6.28		
								1123308	5.95		
								1123309	3.31		
								1123310	37.02		
								1123311	12.81		
								1123312	46.53		
								1123313	38.76		
								1123314	27.27		
								1123315	98.60		
								1123316	28.10		

Table D 1 (continued**)**

								1123317	65.79		
								1123318	33.14		
								1123319	11.32		
								1123320	17.52		
								1123321	20.50		
								1123322	37.19		
								1123323	689.09		
								1123324	34.46		
Total 1C	0.17	Total 4C	41.57	Total 5C3	81.40	Total11C3	51.07	Total 23C	1308.19	Total 32C	10.00
Soil symbol 36C											
Field ID	Area (acres)										
1136301	25.70										
1136302	77.36										
Total36 C	103.06										
Bar2 (average yield)			Same as Cor2								
Bar3 (low yield)			Same as Cor3								
Wds1 (high yield)		Area	39.50	**Wds2 (average yield)**		Same as Cor2		**Whe1 (high yield)**		Area	54.54
Soil symbol 3A				**Wds3 (low yield)**		Same as Cor3		Soil symbol 3A		Soil symbol 35B	
Field ID	Area (acres)							Field ID	Area (acres)	Field ID	Area (acres)
1031001	39.50							1031001	39.50	1135201	15.04
Total 3A	39.50							Total 3A	39.50	Total 35B	15.04
Whe2 (average yield)			Area	2074.86							
Soil symbol 3B		Soil symbol 4B		Soil symbol 9B		Soil symbol 10B		Soil symbol 17B			

Table D 1 (continued**)**

Field ID	Area (acres)	Field ID	Area (acres)	Field ID	Area (acres)	Field ID	Area (acres)	Field ID	Area (acres)
1032001	39.92	1042001	18.76	1092001	3.80	1110201	3.39	1117201	28.84
1032002	55.45	1042002	12.48	1092002	24.71			1117202	11.74
1032003	22.07	1042003	12.98	1092003	63.64			1117203	10.99
1032004	0.50	1042004	33.88	1092004	16.53			1117204	63.80
		1042005	4.96	1092005	3.39			1117205	32.98
				1092006	33.80			1117206	4.71
				1092007	7.93			1117207	5.29
				1092008	21.82				
				1092009	55.04				
Total 3B	117.94	Total 4B	83.06	Total 9B	230.66	Total 10B	3.39	Total 17B	158.35

Soil symbol 22B		Soil symbol 23B		Soil symbol 34B		Soil symbol 36B		Soil symbol 42B	
Field ID	Area (acres)	Field ID	Area (acres)	Field ID	Area (acres)	Field ID	Area (acres)	Field ID	Area (acres)
1122201	3.22	1123201	3.97	1134201	4.96	1136201	72.48	1142201	11.16
1122202	4.63	1123202	29.26	1134202	9.34	1136202	7.11	1142202	1.90
1122203	24.21	1123203	16.03	1134203	56.28			1142203	16.12
1122204	27.77	1123204	3.06	1134204	7.11				
1122205	36.61	1123205	117.69	1134205	22.98				
1122206	3.97	1123206	23.47	1134206	17.44				
1122207	4.38	1123207	10.41	1134207	2.64				
		1123208	7.44	1134208	21.41				

Table D 1 (continued**)**

		1123209	27.27	1134209	2.98				
		1123210	15.54	1134210	44.22				
		1123211	14.46						
		1123212	3.80						
		1123213	32.89						
		1123214	11.57						
		1123215	10.50						
		1123216	25.54						
		1123217	138.35						
		1123218	21.65						
		1123219	29.26						
		1123220	100.91						
		1123221	70.66						
		1123222	12.40						
		1123223	5.21						
		1123224	7.19						
		1123225	70.50						
		1123226	38.76						
		1123227	138.02						
		1123228	25.12						
		1123229	14.55						
		1123230	18.26						
		1123231	19.59						
		1123232	15.21						
Total22 B	104.79	Total 23B	1078.54	Total 34B	189.36	Total 36B	79.59	Total 42B	29.18

Whe3 (low yield)	Same as Cor3
Soy1 (high yield)	Same as Wds1
Soy2 (average yield)	Same as Cor2
Soy3 (low yield)	Same as Cor3

Broc2 (average yield)			Area	1264.82	
Soil symbol 4B		Soil symbol 5B3		Soil symbol 23B	
Field ID	Area (acres)	Field ID	Area (acres)	Field ID	Area (acres)
1042001	18.76	1052301	5.29	1123201	3.97
1042002	12.48	1052302	7.27	1123202	29.26

Table D 1 (continued**)**

Cot2 (average yield)	Same as Cor2	1042003	12.98	1052303	2.89	1123203	16.03
Cot3 (low yield)	Same as Cor3	1042004	33.88	1052304	8.68	1123204	3.06
		1042005	4.96	1052305	64.79	1123205	117.69
				1052306	10.00	1123206	23.47
				1052307	4.30	1123207	10.41
						1123208	7.44
						1123209	27.27
						1123210	15.54
						1123211	14.46
						1123212	3.80
						1123213	32.89
						1123214	11.57
						1123215	10.50
						1123216	25.54
						1123217	138.35
						1123218	21.65
						1123219	29.26
						1123220	100.91
						1123221	70.66
						1123222	12.40
						1123223	5.21
						1123224	7.19
						1123225	70.50
						1123226	38.76
						1123227	138.02
						1123228	25.12
						1123229	14.55
						1123230	18.26
						1123231	19.59
						1123232	15.21
Tom2 (average yield)	Same as Broc2	Total 4B	83.06	Total 5B3	103.22	Total 23B	1078.54

APPENDIX E

Terminal Market Prices

Table E 1 Tomato Prices, Atlanta Market (25 lb. crtns)

	1994		1995		1996		1997		1998		5 year Average		
Week	min	max	min	max	min	max	min	max	min	max	min	max	average
33	12.00	13.50	8.00	10.75	8.50	9.50	10.50	12.00	11.00	11.50	10.00	11.45	10.73
34	12.50	13.50	8.50	9.75	8.50	9.50	10.00	14.50	10.50	11.50	10.00	11.75	10.88
35	7.00	13.00	6.50	8.75	7.00	8.00	9.00	12.75	10.50	11.50	8.00	10.80	9.40
36	9.50	10.00	7.50	9.50	7.00	8.00	9.00	11.75	9.85	11.50	8.57	10.15	9.36
37	9.50	11.00	8.00	10.50	6.75	10.75	9.00	11.75	9.00	9.85	8.45	10.77	9.61
38	9.50	10.50	9.50	12.50	9.00	10.50	9.00	11.75	9.50	11.50	9.30	11.35	10.33
39	8.50	10.50	8.00	8.50	7.75	9.00	8.50	9.50	11.85	14.50	8.92	10.40	9.66
40	7.50	8.50	8.50	9.00	6.75	11.00	9.50	11.50	12.35	15.75	8.92	11.15	10.04
41	7.50	8.75	7.00	9.00	9.00	12.00	9.50	11.50	12.00	16.85	9.00	11.62	10.31
42	9.50	11.00	8.50	9.50	9.00	12.00	9.50	11.50	16.50	18.85	10.60	12.57	11.59
43	13.00	14.50	8.50	9.75	8.00	11.00	9.00	11.50	15.00	17.00	10.70	12.75	11.73

Table E 2 Tomato Prices, Baltimore Market (25 lb. crtns)

	1994		1995		1996		1997		1998		5 year Average		
Week	min	max	min	max	min	max	min	max	min	max	min	max	average
33	9.00	10.00	7.50	8.00	8.00	9.00	9.00	10.00	8.00	10.00	8.30	9.40	8.85
34	9.00	12.00	7.00	8.00	7.00	8.00	10.00	10.00	8.00	10.00	8.20	9.60	8.90
35	8.00	11.00	4.00	6.50	7.00	8.00	9.00	10.00	9.00	10.00	7.40	9.10	8.25
36	8.50	10.00	4.00	7.00	6.00	7.00	9.00	11.00	9.00	10.00	7.30	9.00	8.15
37	8.00	8.00	8.00	9.00	7.00	8.00	9.00	11.00	9.00	9.00	8.20	9.00	8.60
38	8.00	9.00	9.00	11.00	7.00	9.00	7.00	10.00	7.00	8.00	7.60	9.40	8.50
39	9.00	11.00	8.50	10.00	7.00	8.00	7.00	8.50	11.00	13.00	8.50	10.10	9.30
40	6.00	7.00	9.00	12.00	8.00	8.00	9.00	10.00	12.00	14.00	8.80	10.20	9.50
41	6.00	6.50	12.00	13.00	6.00	11.00	9.00	10.00	12.00	19.00	9.00	11.90	10.45
42	7.00	9.00	8.00	12.00	9.00	10.00	9.00	10.00	18.00	20.00	10.20	12.20	11.20
43	11.00	13.00	9.00	12.00	9.00	10.00	9.00	10.00	14.00	20.00	10.40	13.00	11.70

Table E 3 Tomato prices, Boston Market (25 lb. crtns)

	1994		1995		1996		1997		1998		5 year Average		
Week	min	max	min	max	min	max	min	max	min	max	min	max	average
33	10.00	13.00	8.50	10.00	8.00	11.00	10.00	12.00	10.00	12.00	9.30	11.60	10.45
34	11.00	12.00	6.50	9.00	8.00	10.00	10.00	12.00	9.00	11.00	8.90	10.80	9.85
35	9.00	11.00	7.00	8.00	6.00	9.00	10.00	11.00	8.00	10.00	8.00	9.80	8.90
36	8.00	10.00	7.00	9.00	7.00	9.00	10.00	11.00	8.00	10.00	8.00	9.80	8.90
37	8.00	12.00	8.00	10.00	8.00	10.00	10.00	11.00	8.00	10.00	8.40	10.60	9.50
38	8.00	9.00	7.00	10.00	8.00	10.00	9.00	11.00	8.50	10.00	8.10	10.00	9.05
39	6.50	8.00	7.50	9.00	8.00	10.00	8.00	9.00	9.00	12.00	7.80	9.60	8.70
40	6.00	8.00	8.00	9.00	9.00	11.00	10.00	11.00	10.00	13.00	8.60	10.40	9.50
41	7.00	8.00	7.00	9.00	10.00	13.00	9.00	12.00	12.00	15.00	9.00	11.40	10.20
42	8.00	11.00	7.00	9.00	11.00	12.00	9.00	10.50	15.00	18.00	10.00	12.10	11.05
43	10.00	13.00	8.00	9.00	10.00	12.00	8.00	10.00	10.00	18.00	9.20	12.40	10.80

Table E 4 Tomato prices, Columbia, SC Market (25 lb. crtns)

	1995		1996		1997		1998		4 year Average		
Week	min	max	min	max	min	max	min	max	min	max	average
33	8.00	10.50	7.00	8.00	9.00	10.50	8.00	10.00	8.00	9.75	8.88
34	7.00	9.00	7.00	8.00	9.00	10.00	8.00	9.00	7.75	9.00	8.38
35	7.00	8.00	8.00	8.00	8.00	10.00	9.00	9.00	8.00	8.75	8.38
36	7.00	9.00	10.00	10.00	10.00	11.00	9.00	10.00	9.00	10.00	9.50
37	9.00	10.00	10.00	10.00	8.00	10.00	8.00	9.00	8.75	9.75	9.25
38	10.00	11.00	9.00	9.00	8.00	8.75	8.00	9.00	8.75	9.44	9.09
39	7.00	9.00	9.00	9.00	8.00	8.75	9.00	10.00	8.25	9.19	8.72
40	8.00	9.00	9.00	10.00	9.00	9.40	10.00	10.00	9.00	9.60	9.30
41	7.50	9.00	10.00	10.00	10.00	10.00	10.00	10.00	9.38	9.75	9.56
42	7.00	9.00	10.00	11.00	8.75	9.00	11.00	12.00	9.19	10.25	9.72
43	7.00	9.00	11.00	11.00	8.75	9.00	15.00	15.00	10.44	11.00	10.72

Table E 5 Tomato prices, New York Market (25 lb. crtns)

	1994		1995		1996		1997		1998		5 year Average		
Week	min	max	min	max	min	max	min	max	min	max	min	max	average
33	14.00	15.00	6.00	7.00	8.00	10.00	9.00	11.00	9.00	10.00	9.20	10.60	9.90
34	14.00	15.00	4.00	7.00	8.00	9.00	9.00	10.00	9.00	10.00	8.80	10.20	9.50
35	11.00	12.00	4.00	6.00	8.00	9.00	11.00	11.00	9.00	10.00	8.60	9.60	9.10
36	9.00	9.00	6.00	9.00	8.00	10.00	11.00	11.00	9.00	10.00	8.60	9.80	9.20
37	8.00	9.00	9.00	10.00	9.00	10.00	8.00	10.00	9.00	9.00	8.60	9.60	9.10
38	10.00	11.00	8.00	9.00	9.00	10.00	8.00	9.00	10.00	13.00	9.00	10.40	9.70
39	9.00	10.00	8.00	10.00	9.00	10.00	7.00	8.00	10.00	11.00	8.60	9.80	9.20
40	7.00	9.00	8.00	13.00	10.00	11.00	10.00	11.00	11.00	12.00	9.20	11.20	10.20
41	7.00	8.00	9.00	13.00	11.00	12.00	10.00	11.00	15.00	15.00	10.40	11.80	11.10
42	10.00	12.00	9.00	10.00	10.00	13.00	10.00	12.00	18.00	18.00	11.40	13.00	12.20
43	12.00	14.00	9.00	10.00	9.00	11.00	9.00	10.00	18.00	18.00	11.40	12.60	12.00

Table E 6 Broccoli prices, Atlanta Market (20 lb. crtns)

	1994		1995		1996		1997		1998		5 year Average		
Week	min	max	min	max	min	max	min	max	min	max	min	max	average
38	16.00	18.00	10.50	13.00	10.00	12.50	11.00	14.00	12.00	14.50	11.90	14.40	13.15
39	14.00	16.00	10.50	11.00	9.00	11.00	12.00	15.00	12.00	14.50	11.50	13.50	12.50
40	10.00	14.00	10.00	12.00	9.00	11.00	13.50	16.00	11.50	14.50	10.80	13.50	12.15
41	10.00	15.00	9.00	10.50	9.00	11.00	14.00	14.75	13.50	17.25	11.10	13.70	12.40
42	13.50	15.50	9.50	10.50	9.00	11.00	15.50	18.25	16.50	18.50	12.80	14.75	13.78
43	13.00	16.25	8.50	10.50	8.00	11.00	16.50	18.00	12.00	18.50	11.60	14.85	13.23
44	12.50	15.50	9.00	11.75	9.50	14.50	15.00	17.25	11.00	13.50	11.40	14.50	12.95
45	12.00	15.00	9.00	11.50	12.50	15.50	14.00	18.50	9.50	12.50	11.40	14.60	13.00
46	12.00	17.00	8.75	10.75	13.00	16.50	11.00	15.50	10.00	14.50	10.95	14.85	12.90
47	19.00	26.00	8.50	10.00	11.50	16.50	9.50	12.00	11.50	14.00	12.00	15.70	13.85
48	27.00	33.00	8.00	9.75	9.00	12.50	8.25	11.00	9.00	13.50	12.25	15.95	14.10
49	34.00	34.00	8.50	10.00	8.50	10.50	7.00	10.00	9.50	12.50	13.50	15.40	14.45

Table E 7 Broccoli prices, Baltimore Market (20 lb. crtns)

	1994		1995		1996		1997		1998		5 year Average		
Week	min	max	min	max	min	max	min	max	min	max	min	max	average
38	11.00	18.00	11.50	12.00	10.00	12.00	12.00	13.00	13.00	14.00	11.50	13.80	12.65
39	15.50	19.00	9.00	11.00	9.50	10.00	12.00	14.00	12.00	14.00	11.60	13.60	12.60
40	12.00	13.50	10.00	12.00	10.00	11.00	14.00	16.00	12.00	14.00	11.60	13.30	12.45
41	11.00	14.00	9.00	11.00	10.00	11.00	12.00	14.00	14.00	17.00	11.20	13.40	12.30
42	13.00	16.50	10.00	12.00	10.00	11.00	15.00	17.00	16.00	18.00	12.80	14.90	13.85
43	15.00	16.50	9.00	11.00	9.00	11.00	18.00	20.00	12.00	15.00	12.60	14.70	13.65
44	13.50	15.00	9.00	12.00	9.00	13.50	13.00	15.00	9.00	12.00	10.70	13.50	12.10
45	12.00	15.00	10.00	13.00	15.00	17.00	13.00	17.00	5.00	10.50	11.00	14.50	12.75
46	12.00	16.00	9.00	11.00	14.00	16.50	11.00	14.00	11.00	13.00	11.40	14.10	12.75
47	18.00	27.00	8.00	9.50	12.00	17.00	9.00	11.00	9.00	12.00	11.20	15.30	13.25
48	26.00	28.00	8.00	9.00	9.00	11.00	8.00	10.00	9.00	11.00	12.00	13.80	12.90
49	33.00	40.00	8.00	9.50	8.00	10.00	7.00	9.00	9.00	11.00	13.00	15.90	14.45

Table E 8 Broccoli prices, Boston Market (20 lb. crtns)

	1994		1995		1996		1997		1998		5 year Average		
Week	min	max	min	max	min	max	min	max	min	max	min	max	average
38	14.00	18.00	7.50	12.00	7.00	10.50	9.00	12.00	10.00	15.00	9.50	13.50	11.50
39	15.00	18.00	6.00	10.00	8.00	9.00	10.00	13.00	9.00	14.00	9.60	12.80	11.20
40	9.00	14.00	6.50	10.00	8.00	9.50	14.00	16.00	9.00	14.00	9.30	12.70	11.00
41	9.00	11.00	8.50	10.00	8.00	10.50	12.00	16.00	8.00	16.00	9.10	12.70	10.90
42	10.00	16.00	6.00	9.00	7.50	10.00	12.00	17.00	9.50	16.00	9.00	13.60	11.30
43	9.00	16.00	7.00	9.00	7.00	10.00	11.00	18.00	7.00	14.00	8.20	13.40	10.80
44	10.00	16.00	6.00	11.00	9.00	11.00	10.00	16.00	6.00	14.00	8.20	13.60	10.90
45	11.00	15.00	6.50	10.00	12.00	16.00	12.00	15.00	7.00	12.00	9.70	13.60	11.65
46	11.00	15.00	7.50	10.00	12.00	16.00	11.00	13.00	9.00	13.00	10.10	13.40	11.75
47	16.00	29.00	5.00	9.00	9.00	16.00	7.00	10.00	9.00	11.00	9.20	15.00	12.10
48	29.00	32.00	6.00	9.00	8.00	12.00	5.00	9.00	8.00	12.00	11.20	14.80	13.00
49	34.00	37.00	6.00	8.50	5.00	10.00	3.00	8.00	7.00	10.00	11.00	14.70	12.85

Table E 9 Broccoli Prices, New York Market (20 lb. crtns)

	1994		1995		1996		1997		1998		5 year Average		
Week	min	max	min	max	min	max	min	max	min	max	min	max	average
38	17.00	18.00	14.00	15.00	10.00	10.00	8.00	14.00	12.00	15.00	12.20	14.40	13.30
39	17.00	18.00	10.00	14.00	10.00	11.00	14.00	15.00	12.00	14.00	12.60	14.40	13.50
40	15.00	16.00	10.00	15.00	10.00	11.00	15.00	16.00	12.00	15.00	12.40	14.60	13.50
41	13.50	15.00	10.00	14.00	10.00	12.00	15.00	16.00	8.00	15.00	11.30	14.40	12.85
42	12.00	14.00	10.00	11.00	10.00	12.00	12.00	18.00	16.00	20.00	12.00	15.00	13.50
43	14.00	15.00	11.00	12.00	10.00	11.00	18.00	18.00	12.00	18.00	13.00	14.80	13.90
44	12.00	14.00	8.00	13.00	10.00	13.00	17.00	17.00	14.00	16.00	12.20	14.60	13.40
45	14.00	15.00	8.00	12.00	12.00	13.00	16.00	16.00	12.00	14.00	12.40	14.00	13.20
46	12.00	15.00	9.00	12.00	15.00	17.00	10.00	16.00	12.00	14.00	11.60	14.80	13.20
47	15.00	26.00	10.00	12.00	12.00	16.00	8.00	12.00	10.00	14.00	11.00	16.00	13.50
48	24.00	26.00	10.00	12.00	12.00	14.00	10.00	12.00	10.00	13.00	13.20	15.40	14.30
49	24.00	28.00	8.00	10.00	8.00	12.00	8.00	12.00	8.00	13.00	11.20	15.00	13.10

Table E 10 Tomato Net Prices Received by Farmers,
Five Year Average, Atlanta Market (25 lb. crtns)

Week	Min Price	Max Price	Average Price	TC
33	7.73	8.89	8.31	6.76
34	7.73	9.13	8.43	6.76
35	6.13	8.37	7.25	6.76
36	6.59	7.85	7.22	6.76
37	6.49	8.35	7.42	6.76
38	7.17	8.81	7.99	6.76
39	6.87	8.05	7.46	6.76
40	6.87	8.65	7.76	6.76
41	6.93	9.03	7.98	6.76
42	8.21	9.79	9.00	6.76
43	8.29	9.93	9.11	6.76
Average Price			7.99	

Table E 11 Tomato Net Prices Received by Farmers,
Five Year Average, Baltimore Market (25 lb. crtns)

Week	Min Price	Max Price	Average Price	TC
33	6.38	7.26	6.82	6.76
34	6.3	7.42	6.86	6.76
35	5.66	7.02	6.34	6.76
36	5.58	6.94	6.26	6.76
37	6.3	6.94	6.62	6.76
38	5.82	7.26	6.54	6.76
39	6.54	7.82	7.18	6.76
40	6.78	7.9	7.34	6.76
41	6.94	9.26	8.1	6.76
42	7.9	9.5	8.7	6.76
43	8.06	10.14	9.1	6.76
Average Price			7.26	

Table E 12 Tomato Net Prices Received by Farmers,
Five Year Average, Boston Market (25 lb. crtns)

Week	Min Price	Max Price	Average Price	TC
33	6.23	7.63	6.93	6.76
34	6.03	7.03	6.53	6.76
35	6.23	6.83	6.53	6.76
36	7.03	7.83	7.43	6.76
37	6.83	7.63	7.23	6.76
38	6.83	7.38	7.11	6.76
39	6.43	7.18	6.81	6.76
40	7.03	7.51	7.27	6.76
41	7.33	7.63	7.48	6.76
42	7.18	8.03	7.61	6.76
43	8.18	8.63	8.41	6.76
Average Price			7.21	

Table E 13 Tomato Net Prices Received by Farmers,
Four Year Average, Columbia, SC Market (25 lb. crtns)

Week	Min Price	Max Price	Average Price	TC
33	6.23	7.63	6.93	6.76
34	6.03	7.03	6.53	6.76
35	6.23	6.83	6.53	6.76
36	7.03	7.83	7.43	6.76
37	6.83	7.63	7.23	6.76
38	6.83	7.38	7.11	6.76
39	6.43	7.18	6.81	6.76
40	7.03	7.51	7.27	6.76
41	7.33	7.63	7.48	6.76
42	7.18	8.03	7.61	6.76
43	8.18	8.63	8.41	6.76
Average Price			7.21	

Table E 14 Tomato Net Prices Received by Farmers,
Five Year Average, New York Market (25 lb. crtns)

Week	Min Price	Max Price	Average Price	TC
33	6.98	8.1	7.54	6.76
34	6.66	7.78	7.22	6.76
35	6.5	7.3	6.9	6.76
36	6.5	7.46	6.98	6.76
37	6.5	7.3	6.9	6.76
38	6.82	7.94	7.38	6.76
39	6.5	7.46	6.98	6.76
40	6.98	8.58	7.78	6.76
41	7.94	9.06	8.5	6.76
42	8.74	10.02	9.38	6.76
43	8.74	9.7	9.22	6.76
Average Price			7.71	

Table E 15 Broccoli Net Prices Received by Farmers, Five Year Average, Atlanta Market (20 lb. crtns)

Week	Min Price	Max Price	Average Price	TC
38	9.12	11.12	10.12	8.00
39	8.8	10.4	9.6	8.00
40	8.24	10.4	9.32	8.00
41	8.48	10.56	9.52	8.00
42	9.84	11.4	10.62	8.00
43	8.88	11.48	10.18	8.00
44	8.72	11.2	9.96	8.00
45	8.72	11.28	10.00	8.00
46	8.36	11.48	9.92	8.00
47	9.20	12.16	10.68	8.00
48	9.40	12.36	10.88	8.00
49	10.40	11.92	11.16	8.00
Average Price			10.16	

Table E 16 Broccoli Net Prices Received by Farmers, Five Year Average, Baltimore Market (20 lb. crtns)

Week	Min Price	Max Price	Average Price	TC
38	8.81	10.65	9.73	8.00
39	8.89	10.49	9.69	8.00
40	8.89	10.25	9.57	8.00
41	8.57	10.33	9.45	8.00
42	9.85	11.53	10.69	8.00
43	9.69	11.37	10.53	8.00
44	8.17	10.41	9.29	8.00
45	8.41	11.21	9.81	8.00
46	8.73	10.89	9.81	8.00
47	8.57	11.85	10.21	8.00
48	9.21	10.65	9.93	8.00
49	10.01	12.33	11.17	8.00
Average Price			9.99	

Table E 17 Broccoli Net Prices Received by Farmers,
Five Year Average, Boston Market (20 lb. crtns)

Week	Min Price	Max Price	Average Price	TC
38	6.82	10.02	8.42	8.00
39	6.9	9.46	8.18	8.00
40	6.66	9.38	8.02	8.00
41	6.5	9.38	7.94	8.00
42	6.42	10.1	8.26	8.00
43	5.78	9.94	7.86	8.00
44	5.78	10.1	7.94	8.00
45	6.98	10.1	8.54	8.00
46	7.3	9.94	8.62	8.00
47	6.58	11.22	8.9	8.00
48	8.18	11.06	9.62	8.00
49	8.02	10.98	9.5	8.00
Average Price			8.48	

Table E 18 Broccoli Net Prices Received by Farmers,
Five Year Average, New York Market (20 lb. crtns)

Week	Min Price	Max Price	Average Price	TC
38	9.19	10.95	10.07	8.00
39	9.51	10.95	10.23	8.00
40	9.35	11.11	10.23	8.00
41	8.47	10.95	9.71	8.00
42	9.03	11.43	10.23	8.00
43	9.83	11.27	10.55	8.00
44	9.19	11.11	10.15	8.00
45	9.35	10.63	9.99	8.00
46	8.71	11.27	9.99	8.00
47	8.23	12.23	10.23	8.00
48	9.99	11.75	10.87	8.00
49	8.39	11.43	9.91	8.00
Average Price			10.18	

VITA

Rushan Halili was born to Kasem and Sulltana Halili on November 10, 1959 in Skrapar, Albania.

He graduated from Shijak High School in Durres, Albania. Rushan enrolled at Agricultural University of Tirana (AUT) in 1979 and graduated with a Bachelor of Science Degree in Agricultural Economics, majored in Finance in June 1983. In January 1984 he joined the faculty of AUT as an assistant professor. In May 1991 he received a Candidate of Science Degree (equivalent to a Ph.D. Degree) at AUT. He worked at the Department of Agricultural Economics, AUT, until 1995.

In August 1995 he entered Virginia Polytechnic Institute and State University as a Ph.D. student. His doctorate studies were completed in January 2000.

Rushan married Drita Binjaku of Fier, Albania in 1986 and two sons were born to them, Enion and Arbri Halili.