NEW CHALLENGES TO FLORIDA CITRUS: A CAPITAL BUDGETING ANALYSIS OF THE IMPACT OF CITRUS CANKER, GREENING, AND RURAL LAND PRICES ON FLORIDA CITRUS GROWERS

By

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Abstract of Thesis Presented to the Graduate School
of the University of Florida in Partial Fulfillment
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The Florida citrus industry provides over $9.2 billion dollars in direct and indirect expenditures; employs more than 75,000 people, mainly in rural areas; and is an emblematic feature of the landscape and history of Florida. After the disastrous hurricane seasons of 2004 and 2005, Florida citrus acreage is now at its lowest point since the tracking of citrus tree acreage first began in 1966, and may decline further due to the twin challenges of diseases known as citrus canker and citrus greening, and the rapid urbanization of the state. This study conducts an expansive survey of current growing practices and collects available information regarding costs, returns, and yields to create a detailed set of parameters. These parameters are analyzed to determine the economics of an investment in citrus within a net present value framework, and uses scenario analysis to test for effects on the profitability of a citrus investment due to these new challenges.

Parameters and assumptions are defined to reflect average costs and yields of a Florida citrus grove in normal operations and under the scenarios of canker, greening, and increased land prices. An empirical present value model is created which dynamically reflects the changes in costs, yields, and tree loss and replacement (resetting) through a fifteen-year period. The

analysis examines the citrus investment by looking at: tree yields and costs by variety (Valencia orange, Hamlin orange, and red grapefruit), age of the grove (new planting versus mature grove), location (the Central ridge, Southwest Florida flatwoods, and the Indian River regions), the presence of disease in various severities (canker and greening), and changes in land prices.

The effect of these variables is measured through changes in the breakeven price of one unit of production (pound solid for oranges or on-tree box for grapefruit). The breakeven price is defined as the minimum price guaranteeing a positive net present value throughout the fifteen-year analysis period. Results are presented to help understand how the challenges affecting the whole industry may affect the investment decisions faced by the thousands of individual growers, service-providers, and employees who make up this industry and, ultimately, whose livelihood depends on it.

CHAPTER 1
INTRODUCTION

Florida is the largest producer of citrus in the United States, and second only to Brazil in the entire world. Florida is the second largest producer of orange juice in the world, and the largest producer of grapefruit. The 2005-2006 Florida citrus crop was estimated at over $1 billion in value, moreover the Florida citrus industry provided over $9.2 billion dollars in direct and indirect expenditures to the state GDP and employed more than 75,000 people throughout the state (Spreen et al. 2006). Unfortunately, while the 2005-6 crop was the second highest valued crop in Florida history due to high prices, the total acreage of Florida citrus fell 17% from 748,555 to 621,373 acres over the last two years. It is now at its lowest point since the tracking of citrus tree acreage first began in 1966, and may decline further due to the twin challenges of diseases known as citrus canker and citrus greening, and the rapid conversion of agricultural land to residential and commercial uses.

These challenges are unfamiliar to Florida growers and contain the possibility of fundamentally altering the production and cost structure of the Florida citrus industry. Citrus canker is a bacterial disease of citrus that causes lesions (or cankers) on the fruit and leaves of citrus trees, reduces tree productivity, and severely affects the marketability of fresh citrus fruit. Citrus greening is a bacterial disease of citrus that kills trees and is spread by the invasive insect species, the Asian citrus psyllid. Finally, rapidly expanding Florida population and conversion of rural lands to urban use have greatly increased the price of agricultural land suitable for citrus production and is changing the highest and best use of rural land in many traditional citrus production areas. It appears that these challenges are having an effect on citrus growers, but there is a lack of economic analysis focused on the current and projected investment environment for Florida citrus.

This analysis is a continuation of research conducted for a report prepared for the Florida Department of Citrus by the Food and Resource Economics Department of the University of Florida's Institute of Food and Agricultural Sciences (IFAS). The report, *An Economic Assessment of the Future Prospects for the Florida Citrus Industry,* was an in-depth examination of the challenges listed above. This study extends the results co-authored with Ronald Muraro of the University of Florida - Lake Alfred Citrus Education and Research Center (Lake Alfred CREC) and reported in Chapter 5 of the original report summarizing the effects of canker, greening, and urbanization on a citrus investment. The grove operating costs of the investment model presented in the study and this analysis are based on annual citrus production cost budgets assembled by Ronald Muraro from surveys with growers and caretakers around Florida. Yield information is taken from studies by Drs. William Castle and Fritz Roka, *10 Year Rootstock Trials at Avon Park and Indiantown* (Castle 1994), and *High Density Plantings in Southwest Florida* (Roka et al. 1997) plus *Revision to the Rootstock Bulletin* (Castle 1999). Information of grapefruit yields by tree age was obtained from state-wide average production figures from the Florida Agricultural Statistics Survey's 2005-06 Citrus Summary, as no current studies of Florida grapefruit yield by tree age exist. A review was conducted of applicable horticultural, plant pathology, and agricultural engineering literature to create and verify assumptions about costs, cultivation methods, and the effects of canker and greening on a citrus grove. These references are cited appropriately where applicable.

This study attempts to fill a gap in the current analysis of the challenges facing the Florida citrus industry by quantifying current scientific literature on canker and greening with an economic analysis to illustrate the contemporary investment decision of growers planning on continuing to operate in the citrus industry over the next 15 years. Given the importance of the

Florida citrus industry in its economic, social, and historic contributions to the state, an analysis is required that examines the quantitative effects of these challenges on individual growers. Clues to the observed decline of bearing citrus acreage at the state-wide level can be found at the level of the individual growers based on the changing economics of growing citrus and investing in new citrus production in Florida. Since growing citrus is a business activity, this study presents an analysis of the profitability of an investment in citrus within a capital budgeting framework.

Prices, yields, costs, and disease effects vary by variety and grove location, so this analysis creates five hypothetical Florida groves. Grove situations for Valencia and Hamlin sweet oranges in both the Central Florida Ridge and Southwestern Florida Flatwoods production regions are considered. Valencia and Hamlin varieties were selected because of their widespread planting and predominant use for juice processing. A grove situation of colored grapefruit in the Indian River production region was selected because of the popularity of fresh Indian River grapefruit. Therefore, this analysis assumes all Valencia and Hamlin oranges will be utilized for processing and grapefruit is intended for the fresh market.

This study begins with creating parameters and assumptions to reflect average costs and yields of an operating citrus grove. First, costs and start up considerations are examined for establishing a citrus grove, including planting density, grove architecture, irrigation, and land preparation. Second, operating expenses are defined for chemical applications, cultivation, fertilizer, irrigation, tree removal and replacement, property taxes, operating capital, and management costs. Third, the analysis examines citrus tree yields by variety and normal tree loss. Fourth, the analysis quantifies the effects of citrus canker and greening on the grove, and the additional costs, tree loss, and yield effects these diseases entail.

After the assumptions and parameters of the analysis are defined, an empirical present value model of the citrus investment is created. The capital budgeting framework is presented and its application to the citrus grove is explained. Finally, scenarios representing a canker and greening-free grove, the presence of each canker and greening in the grove, increases in land prices, and combinations of all three are examined to quantify changes in the returns to a citrus investment. Results are presented to help understand how the challenges affecting the whole industry may affect the investment decisions faced by the thousands of individual growers, service-providers, and employees who make up this industry and, ultimately, whose livelihood depends on it.

CHAPTER 2
ESTABLISHMENT COST, YIELD, AND INVESTMENT PARAMETERS FOR CITRUS PRODUCTION IN FLORIDA

An important first step in this analysis is to make accurate assumptions and define parameters that reflect the reality of an average citrus grower in Florida. While the individual situation of a grower will vary, the cost and yield assumptions are presented are based on a study of common practices in the citrus industry. Cost parameters are based on observed prices and projections on their future levels, while yield parameters are based on referenced studies. First, a discussion is presented of the factors important in current Florida citrus production and key to the construction of any analysis model for citrus. Second, research of expected yields by variety and tree age is presented, and model yields are constructed for our hypothetical groves. Additional information on considerations for growing citrus in Florida and differences between the ridge and flatwoods citrus production areas is available in Appendix A: *Geographic and Topographic Features of Florida Commercial Citrus Production Areas*.

Modeling Citrus Production

Grove Establishment Considerations

Planting a new grove or removing and replacing an existing grove is referred to as a "solidset". Significant one-time costs are incurred for land preparation and irrigation installation. The number of citrus trees per acre and the spacing of trees must balance productivity, access, and the efficient use of the grove area. Tree spacing is defined by in-row and between-row (or "row middle") spacing. A grove must have enough trees to efficiently utilize soil, light, fertilizer, and sprays but not so many as to crowd each other out and reduce overall productivity. Moreover, the grove must have space to allow access for grove equipment and harvesting. Early citrus plantings in Florida were at large spacings of 25'("in-row") by 25'("between-rows"), or 30' by 30', which gives 70 and 48 trees per acre, respectively. It was even suggested during the

1940s that large grapefruit trees should be spaced 35’ by 35’ or 36 trees per acre. (Ziegler and Wolfe 1975) Modern grove care techniques and a better understanding of an efficient bearing and profit-maximizing grove have pushed tree density much higher over the past two decades.

Current hedging, pruning, fertilization, irrigation, and precision agriculture practices reduce competition for resources between the trees (“crowding-out”) and allow for closer spacing. Higher density plantings have also been shown to provide an earlier return on investment and a more efficient use of equipment, materials, and land (Parsons and Wheaton 2006). The trend towards higher density plantings is illustrated in Figure 2-1.

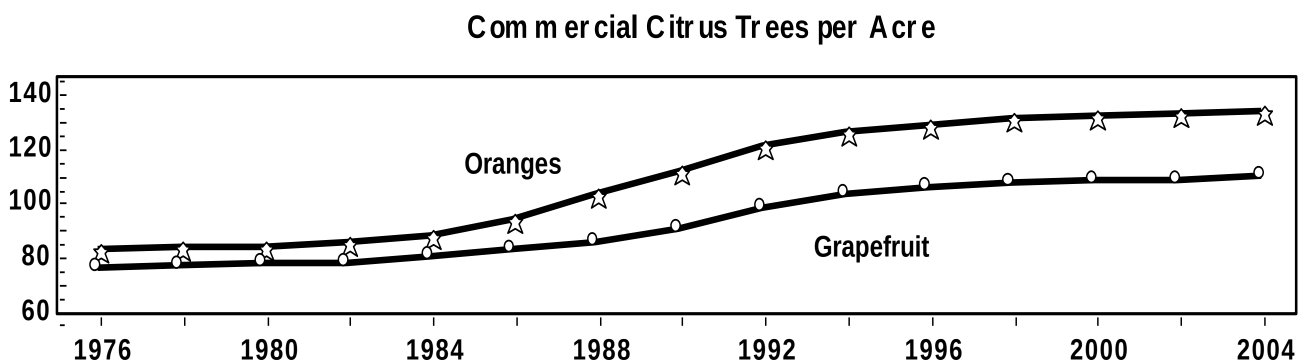

Figure 2-1. Evolution of Florida citrus grove density (source: 2004-05 Florida Citrus Summary)

As illustrated in Figure 2-1, the last large increase in tree density occurred during the late 1980s and early 1990s during a period of intensive replanting of a large number of groves destroyed during the freezes of the 1980s. Currently, there are indications that tree density may increase again due to the extensive losses of trees under the canker eradication program, new precision agriculture practices, and mechanical harvesting. Increasing labor costs and competition from Brazil are making mechanical harvesting of citrus fruit an attractive option for many growers. Mechanical harvesting of citrus trees requires higher density spacing of 22’ X 10’ to 24’ X 15’ for efficient use of the harvesting equipment (Rouse and Futch 2004).

In this analysis, new planting densities are assumed to be 198 trees per acre (22’ by 10’ spacing) for Valencia and Hamlin varieties, and 134 trees per acre (22’ by 13’) for grapefruit. Mature groves tree densities are taken from the 2003-4 IFAS Citrus Production Budgets as common densities for existing groves (Muraro 2005 I, II, III). Mature grove densities are assumed to be 112 trees per acre for Valencia and Hamlin on the Ridge, 145 trees per acre for Valencia and Hamlin on the Flatwoods, and 95 trees per acre for grapefruit.

In the case of a new or replanting of citrus, this analysis uses an irrigation installation and setup cost of $1000 per acre for the ridge and flatwoods production areas. New plantings may require a well to be drilled, which increases the cost of installation, but this is not included in the analysis. A replanted grove is assumed to incur the same cost for irrigation installation due to two observed practices (Muraro and Futch 2006). First, the irrigation system is usually damaged during the process of removing (“pushing”) the previous grove. Second, a new system layout is usually required, especially if there are changes to tree density or other grove architecture.

This analysis does not include the costs of removing or pushing the previous grove, and starts with the assumption that the land is vacant. Preparing open land for citrus varies substantially by topographic area (ridge versus flatwoods). Flatwoods groves incur higher land preparation costs compared to ridge groves. Changes to grove architecture and/or tree density require incurring costs for soil preparation and bed construction all over again. Therefore, this analysis assumes that new plantings and replantings of citrus will incur the same land preparation costs. Average citrus land preparation costs used in this analysis are summarized in Appendix Table B-10.

Grove Care and Operating Cost Considerations

Citrus fruit is utilized either in the fresh processed market, and in both cases must be transported from the tree to the juice processing plant or fresh fruit packing house. This process is currently accomplished in three steps: *picking* the fruit off the tree, *roadsiding* it by transporting it from inside the grove to a central loading point, where the fruit is then *hauled* to its final destination. These costs are influenced by wage rates, equipment/materials costs, and fuel/energy costs. These unit costs are substantial, usually are incurred on a per box basis, and may exceed grove care costs.

Harvesting costs have remained somewhat stable over the past decade, and this enables the grower to project how much it will cost with some certainty. Wage rates, fuel/energy costs (until recently), and equipment/materials costs have remained stable. Unfortunately, there are uncertainties in the supply of agricultural labor, especially for groves located outside of the major Florida production areas and for late season varieties such as Valencia oranges. Grapefruit prices in this analysis are quoted as the industry-standard "on-tree" price meaning the price for pick, roadside, and haul is already subtracted and they do not include a harvesting charge. Orange prices are "delivered-in" to the processing plant, and include a per box harvesting charge. This analysis uses average reported costs from the 2004-05 season of $1.64/box for picking and roadsiding, and $.47/box for transporting the fruit to the juice processing plant for a total of $2.11 (Muraro 2006 II). Details of individual per box costs can be found in Appendix Table B7.

Additionally, the Florida Department of Citrus ("DOC") collects a per box excise tax to fund citrus marketing and industry research. While there have been several legal challenges to the box tax, plus a current proposal to raise the box tax to $0.25, this analysis assumes a rate of $0.185 per box, giving a total per box cost of $2.30.

Due to the special handling requirements for fresh fruit, an extra charge of $1.50 per box is assumed for citrus fruit to be marketed as fresh. Additional handling can include special packaging and transportation from the grove to ensure the visual appeal of the fruit. Moreover, spot picking is a common practice in fresh fruit groves, where pickers identify and ensure only the highest quality fruit is picked and sent for sale as fresh. The assumed pick and haul cost for fresh market fruit is $3.80 per box.

For most growers, agricultural chemical and application costs are the largest production cost after harvest costs. The diverse uses of agricultural chemicals in citrus for pest control, disease control, growth regulation, and nutritional supplementation blur the classifications of fixed-variable costs and range from certain to uncertain. It is the difficult task of the citrus grower to balance the health and productivity of his/her trees while minimizing the cost of materials used. In practice, this is a subjective judgment based on the individual experience of the grower as illustrated by a 2001 survey of spray practices in the Indian River region.

> Research and extension literature on citrus spraying rightly focuses on the complexity of predicting effects of spray practices on distribution of materials within trees, even in controlled experiments. Consequently, recommendations from authorities often provide limited guidance to growers. This forces the industry to explore spraying as an art, in which changes are attempted on an ad-hoc basis and either rejected or continued based on individual experience or reports from peers. The tremendous range of grower spray practices appears to reflect the current status of this ongoing, largely independent, experimentation by individual growers (Stover et al. 2002a).

There are significant differences in spray costs for citrus fruit grown to be consumed fresh, and fruit grown for processing into juice. Fresh market fruit requires a blemish-free peel to enhance its marketability and visual appeal to the consumer. Fresh fruit is delivered to a packinghouse where it is sorted according to size and peel blemishes. The fruit judged unfit for fresh consumption is “eliminated” from the total amount delivered, and sent for processing into juice. The percentage of the total fruit delivered to the packinghouse that is fit for fresh market sale is called the “packout” rate. Often a fresh fruit packinghouse will deduct a fee for the eliminated fruit that passes through its packing line and is transported to a juice processing facility. This fee is deducted (or “charged”) from the total payment to the grower. Fruit sent for processing generally receives a significantly lower price than fresh. Therefore, it is imperative that a grower obtains a high packout rate to maximize the amount of his production receiving the highest price, and minimize the possibility of receiving a lower price for eliminations. This is mostly accomplished through the spray program and spot picking practices as described in the previous section.

Fungal diseases and insect damage are the two most common causes of peel blemishes and reasons for fruit elimination. Fungal infections, such as melanose, citrus scab, alternaria, and greasy spot, are often controlled using fungicidal sprays containing copper and petroleum oil. Some insects, commonly mites, attack the fruit/peel and must be controlled using pesticides to ensure fresh market quality.

Citrus trees are attacked by a number of foliar and root pests and diseases that affect productivity. When balancing lost productivity with the costs of chemical application, the use of chemical control is generally required when a certain level of infestation or infection is reached. Fruit grown for the processing market does not require high external quality. In this case, spray costs appear to be closer to a variable cost of production which increases with yield.

In Florida, most sweet orange varieties, with the exception of Navel oranges, are grown for the processing market (Table 2.1). Grapefruit, tangerines, and other specialty varieties are mostly grown for the fresh market. Due to the factors discussed above, spray costs for the fresh market varieties are significantly higher than oranges for processing. For example, Table 2.2 illustrates the difference in spray costs between the Hamlin orange variety and the red-seedless grapefruit, grown for the processed and fresh markets respectively. The reader should note that these spray programs include micronutrient compounds that are mixed into a solution containing certain pesticides (Lorsban and copper in this case). Chemical costs for specialty fruit will be higher than traditional orange varieties for the processing market.

Table 2-1. Florida citrus marketing by variety, 2005-06 season

	Fresh		Processed		Total
	'000 boxes	%	'000 boxes	%	'000 boxes
Early, Mids, and Navels	4,896	7%	70,104	93%	75,000
Valencia Oranges	2,450	3%	70,450	97%	72,900
Grapefruit-White	1,433	22%	5,067	78%	6,500
Grapefruit-Red	5,481	43%	7,319	57%	12,800

Source: USDA Citrus Fruits 2006 Summary

Table 2-2. Spray budget comparison: fresh versus processed, cost per acre

Hamlin Orange for Processing	
Summer Oil #1	88.02
Summer Oil #2	53.17
Total	141.19
Colored Grapefruit for Fresh Market	
Post Bloom Spray	53.32
Supplemental Post Bloom Spray	83.15
Summer Oil #1	53.32
Summer Oil #2	88.02
Fall Miticide Spray	38.54
Total	316.35

Growth regulating chemicals are applied to certain citrus varieties for the fresh market to control heavy alternate bearing between seasons. These heavy crops can be chemically thinned with Naphthalene Acetic Acid (“NAA”) to reduce crop load and allow more even production between seasons (Stover et al. 2001). Gibberellic acid (“GA”) is sometimes applied to processed orange varieties to delay the time of harvest and increase juice yield and quality, although there appear to be detrimental effects on subsequent cropping (Stover and Davies 2001). The application of growth regulators is expensive with an application cost of approximately $35/acre, and a materials cost of approximately $495/acre and $34/acre, for NAA and GA, respectively (Muraro 2006c). No growth regulating applications are assumed in the analysis presented because of the focus on oranges and grapefruit varieties, however for certain, primarily fresh market citrus varieties, incorporation of these costs is an important component of analysis.

Intuitively, older trees with large canopy volumes should require more amounts of chemicals, however, there is considerable variability between large tree size, high spray volume, and increased chemical costs. A 2001 UF-IFAS survey of spraying practices in the Indian River growing region reported some association between spraying large trees at a high spray volume, but some growers also reported spraying small trees at a high volume (Stover et al. 2002b). Due to the high cost of chemicals and the economics of spray efficiency, Florida citrus has moved quickly to adopt variable rate sprayers that can adjust the amount of chemical material applied to the tree size. Overall, chemical control for pests and disease requires more spray material to cover increased canopy size as trees age; however, spray costs and materials for young, small, and/or non-bearing trees will differ as explained in a following section on young tree care. This analysis assumes that the grove manager or caretaker uses variable rate spraying equipment methods to apply the quantity of spray material appropriate for the tree age. These costs are adjusted according to age as shown in Appendix Table B-8.

A productive citrus grove must maintain a certain level of upkeep during its operation. In the hot and humid Florida environment, other plant species quickly invade a grove and compete with citrus trees for water, sunlight, and soil nutrients. Cultivation includes controlling for these uninvited plants through mechanical mowing and herbicide applications. Labor for general maintenance and upkeep is required to perform a multitude of necessary tasks around the grove. While these costs may vary significantly, a grower is certain that they will be incurred. Estimates of cultivation and grove maintenance costs for the 2005-06 season ranged from $80 to $100 per acre depending on the grove’s location in the state.

The generic term “pruning” generally involves three components in a citrus grove: pruning, hedging, and topping. Pruning refers to removing selected limbs to alter the structure of the tree in order to reduce overcrowding between trees in a row. Crowding has a negative effect on yield, juice, and peel quality. Hedging refers to cutting back the trees from encroaching on the space between the rows (row middles), and allowing grove equipment to pass through. Topping refers to cutting the top off the tree to prevent it from being excessively tall. Topping facilitates harvesting, reduces the amount of spray materials needed, and avoids the shading-out of other trees (Parson and Wheaton 2006).

The frequency of pruning, hedging, and topping depends on the planting density and vigorousness of the citrus variety and rootstock. Planting the trees in a tighter spacing will necessitate more frequent pruning to avoid overcrowding. Accordingly, trees planted on vigorous rootstocks such as Rough Lemon or Volkameriana will encroach on each other faster than Swingle or Cleopatra rootstocks. A grapefruit tree will encroach faster than a Valencia orange tree. The 2004-05 IFAS Citrus Budget reports annualized total costs ranging from $28 to $44 per acre depending on variety and location. This analysis assumes the pruning costs to be incurred from the fourth year of tree age onwards.

An adequate citrus fertilization program is essential to cultivating productive and healthy trees. The fertilization of citrus trees increases yields, growth, and has been shown to aid tree recovery from damage due to weather, disease, or pests (Morgan and Hanlon 2006). Citrus trees require a large amount of macronutrients (nitrogen-N, phosphorous-P, and potassium-K), and smaller amounts of micronutrients (iron-Fe, zinc-Zn, manganese-Mn, boron-B, molybdenum-Mo, and others). Of these nutrients, nitrogen is the most important and is frequently applied in the form of solid fertilizer through multiple soil applications per year (Zekri and Obreza 2003).

Micronutrients are applied as foliar sprays, can be combined with other chemical sprays, and are usually applied as needed when trees exhibit symptoms of micronutrient deficiency.

An individual grove's fertilizer program may vary by soil type, tree age, variety, and specific grove conditions. Moreover, some growers are now using fertigation techniques where macronutrients are applied in a liquid form through the irrigation system. A typical fertilization schedule for oranges requires three annual applications by mechanized fertilizer spreaders of about 210 pounds per acre with grapefruit requiring about three-quarters (150 pounds) of that amount (Jackson and Davies 1999). IFAS estimates for show for the 2005-06 season a range of $50 to $70 per application per acre. This analysis assumes a cost of $205 per acre per year for oranges, and $157 per acre per year for grapefruit. This analysis does not make an allowance for micronutrient sprays.

Most Florida soils used for citrus production are acidic with a low pH in their native state and require infrequent applications of soil amendments to raise their pH. Citrus trees grow best in a pH range of 6.0 to 6.5, and pH values outside of this range affect the absorption of nutrients by the tree and may reduce tree productivity and growth (Obreza and Collins 2002). The most commonly applied amendment to raise soil pH is Dolomite limestone, and this is applied as necessary by the pH level of the soil. Soil and drainage characteristics of the grove determine the behavior of soil pH, but for the purposes of this analysis, one ton per acre is assumed to be applied once every three years for an annualized cost of $13.97.

Horticultural and economic considerations require most commercial citrus in Florida to be irrigated. Many Florida citrus trees are planted on porous and sandy soils that do not retain sufficient moisture for the tree all year. A citrus tree becomes drought-stressed if it does not receive enough water, and this has a negative effect on yields, juice quality, and fruit size (Mongi et al. 2003). Moreover, irrigation can effectively be used for cold protection during freeze events, especially for vulnerable young trees (Parsons and Bohman 2006). Finally, irrigation reduces yield uncertainty and mitigates risk of financial difficulty due to crop failure caused by drought.

Several different irrigation systems exist and require different components and designs, but microsprinkler and micro-jet irrigation have become widely adopted by Florida commercial citrus. This analysis assumes the use of a microsprinkler irrigation system and is comparable in costs to a micro-jet system. Costs for operating a microsprinkler irrigation system vary by location due to additional costs for water management in Flatwoods groves.

In the Florida citrus industry, the process of removing a dead or unproductive tree and replacing it with a new nursery tree is commonly called “resetting”, and the tree itself is called a “reset”. Pests, diseases, freezes, lightning, and many other unpredictable and sometimes unexplainable factors claim the lives of citrus trees. Resetting is an important part of maintaining a citrus grove at maximum bearing efficiency with a full complement of healthy trees. The publicly available Florida Commercial Citrus Tree Inventory is conducted every two years by the FASS, since 1966. Change in commercial citrus acreage is determined by aerial photography, that identifies the number of existing trees by variety and year planted. The average tree loss by age group used for this analysis is 1% for trees aged 1-3 years, 1.5% for trees aged 4-11 years, and 3% for trees 12+ years of age.[1]

[1] This analysis uses an unpublished analysis conducted by Dr. Mark Brown of the Florida Department of Citrus which compared the changes in the tree inventories by tree age from 1994 to 2004, interpolating for between survey years. After subtracting for non-bearing trees to eliminate for newly planted trees and for canker eradications, a linear regression line was fit to account for the increase in losses as trees age. Unfortunately, this data may include some citrus acreage lost to non-agricultural development, and overestimate the actual tree loss suffered in a healthy grove; however, interviews of grove managers conducted by the author confirm that these loss rates are reasonable.

Resetting a new tree in a mature grove requires incurring immediate and continuous costs for up to three years. In the near term, the dead/unproductive tree must be removed and the new tree purchased and planted. This involves additional labor, materials, and equipment time to pull out the dead tree and dispose of it, clear weeds, aerate the soil, apply a soil fumigant, and plant the new tree (Jackson 1994). In the longer term, the newly planted tree requires additional care such as, removing unwanted sprouting, weed control, special fertilization and irrigation programs, and the maintenance of cold-insulating tree wraps. See Appendix B for detailed cost information.

Given the costs involved and the delay for reset trees to come into production, growers attempt to optimize their resetting strategy for maximum economic gain. Nursery trees are usually ordered one or two years in advance, and special equipment and labor must be arranged for planting. IFAS Extension publishes an on-line decision aid for optimal resetting strategy that includes costs, yields, prices, and loss rates (Roka et al. 2000). It is suggested that in high density and new plantings, a program of continuously resetting dead/unproductive trees may increase returns to investment; however, IFAS Citrus Economist Ronald Muraro observes that, under field conditions, most growers only reset trees every other year (biennial resetting) or longer (Muraro 2006d).

In addition to grove care expenses, there are general operating expenses which must be considered. Growers may have fixed costs for buildings, equipment, and other costs that cannot be allocated just to a single grove or on a per acre basis. Since these costs are highly dependent on a grower’s individual situation, this analysis attempts to limit the number of assumptions made about a grower’s fixed expenses. A per acre cash cost is assumed that captures typical fixed expenses such as equipment use, structures, and grove administration by charging a management fee. Property taxes are included on a per acre basis, and a "miscellaneous" cost that accounts for tools, repairs, and additional grove labor.

Citrus production management in Florida is a highly diverse field, with many grove caretaking tasks being contracted to third-party caretakers. The spectrum runs from grove owners who own production equipment (tractors, sprayers, harvesting equipment, etc.) and hire employees, to owners who contract all production work, including harvesting, for a set fee or percentage of revenue. IFAS citrus production budgets designate the former as an "owner-managed" operation, and the latter as a "custom-managed" operation. In the custom-managed production costs, IFAS citrus production budgets incorporate a 10% surcharge on materials cost (chemicals and fertilizer), and use "custom" rates reported by grove caretakers and managers. Many growers fall in between these two extremes, and own some grove equipment, perform some production work themselves, contract for other work, or perform contract work themselves.

In this analysis, costs are reported for an owner-managed operation. Figures given for spray and fertilizer materials costs are reduced by 10% from reported IFAS citrus production budgets. All other grove care costs reflect an owner-managed operation with equipment depreciation incorporated into the costs. A 5% "management" charge is applied to account for other fixed and indirect expenses not directly incorporated into the grove care costs.

Property tax on Florida agricultural land is known as the *millage* rate, and is calculated on a per $1000 of assessed value basis. Reported millage rates range from a low of 11.5 per $1000 of assessed value (1.15% per year) in Collier County to a high of 29.6 per $1000 (2.96% per year) in Pinellas County. Millage rates for the top four citrus producing counties are illustrated in Appendix B - Table B-11 (Hodges et al. 2003).

The land value used for property tax assessment (the assessed value) of agricultural enterprises will usually be lower than the market (just) land value. The tax-assessed value is based on the value of the land derived from the returns to agricultural use. The procedure used to assess agricultural value differs by county and the tax assessed land value varies widely. In this analysis, an average millage rate of 19.5 (1.95%/year) is assumed, with an assessed value of $3,600 per acre for a mature grove, and $1,550 per acre for a new planting or replanting which results in about $70 per year and $30 per year in property taxes, respectively. The values were put into 2003 figures because that is the last publication available with all country agricultural property tax rates collected (Hodges et al. 2003). The just value given for a mature grove and a new/replanted grove is taken from the 2003 IFAS Florida Rural Land Value Survey (Reynolds 2003). The dollar amount of property tax is assumed to increase by 2.5% per year over the 15-year period of analysis reflecting natural growth in the value of agricultural and basic inflation.

A miscellaneous cost of 2% of grove care expenses is added to account for general grove labor and materials. In the base scenario, this cost varies from $14.65 per acre for oranges on the ridge to $19.80 per acre for grapefruit on the flatwoods. This is based on the observation that there are many indirect costs and expenses incurred in grove management for additional labor, tools, and materials.

Cash outflows (expenses) to pay for the previously described expenses are incurred throughout the year. Citrus trees in Florida produce one crop per year that generates a cash inflow (revenue). Many different payment schemes exist where growers contract for delivery of the fruit and receive a portion of the total payment before delivery. One method to value the timing mismatch between cash inflows and outflows due to operations is referred to as working or operating capital. Working capital is an accounting term that is defined as current assets minus current liabilities. It consists for three important components:

Working Capital	=	Inventory	+	Accounts Receivable (Sales Revenue)	-	Accounts Payable (Operating Expenses)

Figure 2-2. Working capital illustration

In the normal course of business, income and expenses are not instantly converted into cash, but credited to or debited from a receivables(income) or payables(expenses) account. Many suppliers of agricultural materials and equipment extend credit or delay payment for a certain period. Inventory is usually considered an asset in working capital because it can quickly be converted into cash to pay expenses. In the case of citrus, the fruit cannot be harvested before maturity, but it can be contracted for delivery and some payment received. Working capital reflects the liquidity of a firm, and changes with the mix of cash inflows and outflows. For example, a larger crop size would increase a grower's accounts receivable if the fruit was already contracted at a specific price per box. Therefore, working capital increases as the grower has more money with which to pay his/her bills. If grove care expenses increase, accounts payable increases and working capital decreases.

	Δ in Working Capital	Cash Inflow	Cash Outflow
Increase in A/R	(+)	(-)	--
Decrease in A/R	(-)	(+)	--
Increase in Estimated Crop	(+)	(+)	--
Decrease in Estimated Crop	(-)	(-)	--
Increase in A/P	(-)	--	(-)
Decrease in A/P	(+)	--	(+)

Figure 2-3. Application of working capital to citrus investment

Although the actual cost of maintaining working capital throughout the season varies significantly by grower circumstance, in this analysis an interest charge of 6% on operating expenses is incurred for a period six months out of each year of analysis. This is assumed to account for the costs of maintaining sufficient working capital for production of that year's crop.

Tree Yields

Yield expectations per tree in generalized Florida growing conditions are summarized from published data. The Florida Agricultural Statistics Service (FASS) division of the USDA has calculated average yield by tree age, variety, and region of Florida (Indian River, North & Central, West, and South) since 1993. The USDA derives the average yield per tree by using the Commercial Citrus Inventory's record of trees by age and end-of-season field samples of production per tree by age (Florida Agricultural Statistics 2006). Appendix Table B13 summarizes the FASS data by tree age and region. At the time of writing, the state average yields by tree age over the 2000-2005 period are available, but were not used because they are lower than previous periods due to the effects of the 2004-5 Atlantic Hurricane Season, especially for the Indian River and Western regions. Since 1960, the Savage yield-tree age study was frequently used by growers to benchmark their own grove's results (Savage 1960). The Savage study may no longer be applicable due to its limitation to ridge groves and low-density plantings (48 to 70 trees per acre). More recent studies by the researchers at the University of Florida-IFAS track box and juice yield by tree age in higher density plantings at both ridge and flatwoods sites. A study of Valencia oranges on twelve rootstocks by Dr. William Castle tracks box and juice yields by tree age over a 15 year period in both ridge (Avon Park) and flatwoods (Indiantown) locations (details in Appendix Table B14, Castle 1994). The findings indicate a trend in high-density plantings in that production per acre reaches a maximum and plateaus earlier, around year 10 or 11 of tree age, than trees with wider spacing. This is due to trees competing with each other for sunlight, water, and nutrients (Parsons and Wheaton 2006). Fortunately, the reduced per tree yield is compensated by a greater number of trees for comparatively more production per acre.

Another study of high density (150+ trees per acre) flatwoods plantings at theUF/IFAS Southwest Florida REC examined Valencia and Hamlin oranges primarily on Carrizo and Swingle rootstocks and confirms the plateau of box yields around 8 to 10 years of age. Moreover, a comparison of the Valencia and Hamlin orange varieties shows that Hamlins produce between 100 and 120 boxes per acre more than Valencias. (Roka et al. 2000). Additionally, while Hamlins produce less pounds-solid per box, Hamlins annually out produce Valencias by 200 to 800 pounds-solid per acre.[2]

Pounds-solid per box varies due to various biological and environmental factors, and also depends on variety and rootstock. In addition to the quantity of pounds-solid per box, the quality of juice is important. Juice with a good color and a sufficiently high sugar to acid ratio (Brix ratio) receives a premium from juice processors. Late-season Valencia oranges usually exhibit better juice quality than early-season Hamlins, and the price per pound-solid for Valencias are generally higher than the price paid for Hamlins (Spreen et al. 2001). Varieties grafted to rootstocks such as Carrizo, Sour Orange, and Swingle tend to give higher pounds-solid than

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[2] Pounds-solid is very important for oranges sold for juice processing because growers are paid on the basis of the pounds-solid measure of juice quantity and not the number of boxes. While a box of oranges always weighs 90lbs, the quantity and quality of juice that can be squeezed from the fruit varies. Orange juice contains water, sugar, and a diverse range of other organic molecules. Sugars constitute about 75% of the dissolved solids in orange juice, and are directly proportional to the quality of the juice. The density of the dissolved solids in the orange juice is measured in degrees Brix, named after the German scientist who discovered how to measure this relationship. Degrees Brix is converted into the percentage of soluble solids in the juice and multiplied by the amount of juice squeezed per box to arrive at the number of pounds of solids (abbreviated to pounds-solid or p.s.) per box of oranges.

Rough Lemon and Volkameriana (Jackson and Davies 1999, Castle 1994). When interpreting the results of this analysis, it is important to remember these differences in breakeven prices.

The preceding sources were used to construct an average box and pounds-solid yield per tree by age for this analysis. Differences in topography, soil, climatic conditions, and grove care all play a role in the yields of a particular grove; however these yields are assumed to control for random effects and represent what a grower can expect from a healthy, well-managed tree. Therefore, the above information was adjusted with the opinion of IFAS experts to reflect the expected average yield of a typical Florida grove using standard grove care techniques (Muraro 2006d). Unfortunately, no detailed studies of grapefruit yields exist; instead an approximation of the state average yields for colored grapefruit is used and adjusted for higher densities. Pounds-solid are not calculated for grapefruit because it is assumed that grapefruit is produced for the fresh market. The analysis yields also incorporate a resetting effect due to the resetting of only half of the total tress lost after year 10 of grove age, which makes more space available for each tree. The maximum yield in year 10 was increased by 10% for years 11-15 due to trees growing out into the wider spacing.

CHAPTER 3
ACCOUNTING FOR THE EFFECTS OF CITRUS CANKER AND GREENING ON FLORIDA COMMERCIAL CITRUS PRODUCTION

The Florida citrus industry currently faces two new disease challenges with unpredictable consequences. Citrus canker is a bacterial disease of citrus that causes unsightly lesions on citrus leaves and affects tree productivity. Citrus greening, or Huanglongbing (HLB), is a bacterial disease of citrus that quickly kills trees.   Both diseases are highly contagious and have the possibility of spreading rapidly through commercial production areas of the state.   Under the canker eradication program, any tree detected with citrus canker was required to be eradicated, along with all other trees within a 1900-foot radius. Growers were compensated by the USDA-Animal and Plant Health Inspection Service (APHIS). This program was halted in January 2006, and the management of canker is now the responsibility of individual growers. In August of 2005, citrus greening was first detected in a residential citrus tree near Homestead in Dade County, and has spread to all of other citrus producing counties. The Florida Department of Agriculture and Consumer Services (FDACS) made it known that there will not be a greening eradication program. Florida commercial citrus production is entering an environment of endemic citrus canker and greening. Due to the novel nature of these challenges to citrus production, this analysis surveys current academic literature on these diseases in order to describe their grove-level effects on citrus.

Citrus Canker

Canker bacteria are spread by windblown rain, human and mechanical contact. It enters the citrus tree through natural openings and wounds in the protective outer tissue of the trees, and is exacerbated by the citrus leafminer insect. Depending on weather conditions, canker symptoms appear from about a week to a couple months after infection, and are especially virulent in hot and humid weather. Severe infections may cause defoliation, badly blemished fruit, premature fruit drop, and tree decline (Schubert and Sun 2001). Studies suggest that the canker bacteria can be spread over two miles from normal wind and rain alone, with longer distances of 10 miles and greater possible due to hurricanes and other severe weather events (Gottwald et al. 2002a).

Florida's first experience with citrus canker was an outbreak around 1910 that was not eradicated until 1933. Canker is hypothesized to have arrived in Florida on plant material imported from Japan (Gottwald et al. 2002 II). After 53 years, canker reappeared in Manatee county in 1986, and after an extensive eradication program, it was declared eradicated in 1994. The next year, canker reappeared in a residential citrus tree near Miami airport, and was the focus of the most recent eradication program. From 1995 onwards, citrus canker was subject to an eradication program which until 1999 destroyed all trees within a 125 ft. radius of an infected tree. In 1999, a new study showed that canker was spread much farther than previously thought, and a 1900 ft. radius of eradication was mandated, plus any cleared land was required to be left fallow for 2 years. The "1900 ft. rule" was statistically determined to eliminate 99% of the bacteria spread within 30 days. According to a USDA study, Hurricane Wilma in 2005 may have exposed 168,000 to 220,000 acres of commercial citrus to canker, in addition to the 80,000 acres already exposed by the 2004 Hurricanes Charley, Francis, and Jeanne (FDACS 2000a).

Approximately 7.5 million commercial trees, 860,000 residential trees, and 4.3 million nursery trees were eradicated from 1995 until the end of the program. Canker finds are now reported in all of the top twelve citrus producing counties. (FDACS 2006 II) With the halt of the citrus canker eradication program, canker will now likely become endemic to Florida for the first time in the history of the industry.

The effects of canker in a citrus grove depend on the susceptibility and market outlet of the fruit. White and colored grapefruit, Persian (Tahiti) limes, and early and midseason oranges (especially Navel and Hamlin varieties) are the most susceptible citrus varieties. Valencia oranges, tangelos, and tangerines appear to be less susceptible to canker (Gottwald et al. 2002b). Canker does not affect the juice quality of fruit, but the unsightly canker peel blemishes and quarantines against fresh fruit shipments from canker infected areas lead to the conclusion that the profitability of fresh market citrus will be impacted more severely than citrus for juice processing. Studies of citrus production in certain areas of Brazil and Argentina where canker is endemic suggest guidelines for specific integrated management programs for the control of canker in a grove (Leite and Mohan 1990, Spreen et al. 2001a, Muraro et al. 2001).

Tree Loss and Yield Reduction Due to Canker

Canker has not been conclusively shown to kill trees in the short and medium term, but a severely infected tree may become unproductive, and serves as a source of inoculum (bacteria) that can be spread to neighboring trees. An integrated management program includes removal of infected trees and some neighboring ones. This analysis assumes an increase of 10% in historical tree loss rates for all age categories.

The hurricane seasons of 2004 and 2005 not only spread canker through commercial groves but affected large numbers of citrus tree nurseries. As of 2004, 70% of Florida citrus nurseries were “field” nurseries where trees are grown outdoors, and are vulnerable to wind and rain spread canker. Canker eradication destroyed nearly two-thirds of the existing nursery tree inventory, and eliminated important sources of budwood for propagating new trees (Spreen et al. 2006). Few nursery trees were available for the next two years, with limited production for the next three to five years. This analysis uses a figure of $7.50 per tree to account for increased price due to decreased supply during the next 2-5 years.

Susceptibility and canker's resulting damage to a tree varies by citrus variety. Infected trees exhibit twig dieback and leaf, flower, and fruit drop (Gottwald 2006 II). Hamlin oranges and grapefruit are considered highly susceptible, and information from Argentina's experience with endemic canker indicates possible yield losses of 10-20% for highly susceptible varieties (Spreen 2001). This analysis assumes a yield penalty of 10% for Hamlin oranges and grapefruit. Valencia oranges are considered moderately susceptible, and are assessed a lower yield penalty of 5%.

Canker Management: Augmented Spray Programs

Canker increases the cost of spray programs for the most susceptible varieties, especially grapefruit for the fresh market. Studies show that copper sprays reduce the canker inoculum (bacteria) build up on the leaf and fruit surfaces of infected trees, with 3-5 annual sprays for moderately susceptible varieties and 4-6 for highly susceptible varieties (Gottwald 2006b). The citrus leafminer insect is currently under somewhat successful biological control, and also is controlled for by oil-based spray applications (Heppner 2003).

For the purposes of this analysis, it is necessary to determine the additional spray material and application costs canker adds to standard spray programs. Copper spray is already widely used as a fungicide/bactericide in Florida to control for melanose, greasy spot, and scab, especially for the fresh market (McCoy et al. 2005). Petroleum-based oil sprays are also used extensively to control for insects such as scales, and other diseases. Many of these sprays can be mixed together, and applied at the same time. Upon consultation with IFAS Lake Alfred CREC experts, additional spray applications, schedules, and costs were determined for canker control (see Appendix Table B-17). Valencia and Hamlin oranges for the processed market, and grapefruit annual spray costs are expected to increase $20.96, $48.17, and $35.26 per acre, respectively.

Canker Management: Field Inspections

Aggressive field inspections and decontamination of workers and grove equipment to identify canker sources and control its spread are a vital part of the canker management program. Three yearly field inspections by trained personnel were estimated at $5.84/acre/inspection (Muraro 2006d). This cost was calculated for a 120-acre grove, using nine inspectors and two vehicles, and may vary depending on the size and location of the grove.

Canker Management: Windbreaks

Windbreaks are densely planted stands of large trees not susceptible to citrus canker planted along the borders of a grove or block of citrus. The intent is that the protection of the trees will stop or deflect the spread of windblown canker for outside sources. This has proved successful in Argentina and Brazil for protecting groves, and is a likely part of an integrated canker management program, especially for fresh market fruit (Leite and Mohan 1990). The annual cost used in this analysis for establishing and maintaining a windbreak is estimated to be $11.47/acre for a 10-acre block over 20 years, and in this analysis is only included for grapefruit. There may be additional costs due to lost production from the reduction in grove area planted in citrus and the shading out of existing trees that are not included in this analysis (see Appendix Table B15 for a detailed breakdown of costs and additional information).

Canker Management: Packinghouse and Export Certification for Fresh Market Citrus

Fresh fruit must be handled in designated packinghouses where fruit is treated with disinfectants, and some processing plants and packinghouses refuse to accept fruit from infected groves. In the future endemic canker environment, packinghouses are expected to pass along the cost of special handling to growers. This analysis assumes $.10 per box (or $40.50/acre @ 450 boxes/acre) based on conversations with industry professionals and academics. Moreover, it is likely that the DPI will require special inspections for groves exporting internationally, and this cost is estimated at $60/acre. In the analysis, these costs are only incurred for fresh market grapefruit after the trees become commercially harvestable at three years of tree age.

Citrus Greening

Citrus greening or Huanglongbin (HLB) is a bacterial disease of citrus native to Asia. Greening (bacteria species name: *Candidatus* Liberibacter) gets its name from the small, green fruit produced by an infected tree. Infection causes the quick decline and death of a tree in about two to four years. After its initial detection in August of 2005 in Homestead, greening has spread throughout the state. Greening is spread by an insect vector named the Asian citrus psyllid which is widely distributed throughout the state and is difficult to control. The exotic nature of greening in Florida and lack of a definitive management program means there is very little information about the effects of greening on the production and costs of a grove. Greening has devastated the citrus industries of other countries, but little is known about how greening will behave in the intensive grove management environment of Florida. Most existing literature on greening is found in scientific journals specializing in virology or plant pathology. As of this writing, there exist only two studies of the economic impact of greening (Grezebach 1994, Roistacher 1996), and both study greening’s effect on the Thai citrus industry. Other countries’ experiences with greening serves as the basis for the assumptions reached below, and may not reflect the realities of greening in Florida.

Literature Survey of International Experiences with Greening

In Taiwan, greening was first discovered in 1951 with significant spread by 1970's. Its transmission was spread by propagation with infected material and the psyllid vector. In a field study with .78 Ha (240 tangerine trees) in a greening endemic area with no control, psyllid infestation was found five months after planting, with 89% of trees infected within eight months after the infestation was discovered (Chen 1998). Trees expressed symptoms of greening and dieback approximately two and one-half years after the initial infection.

A greening-like disease (CVPD) was first discovered in Indonesia in the 1950s, and was present in most major production areas by a 1984 survey (Vichtranada 1998). With an integrated pest management program (IPM), yields increased 200% in certain areas.

A Vietnamese survey conducted in 1995 found greening in all citrus production areas of Vietnam, and it was observed that four to seven year-old trees were particularly damaged. A field study of ten hectares at six sites (tangerines and oranges on trifoliate and volkameriana rootstocks) showed that disease-free trees planted in greening endemic areas, with limited psyllid control suffered a re-infection rate of 16% to 100% (Hong 1998). The lowest rate was attributed to a long proceeding fallow period. Before infection, the orange trees yielded 220 boxes per acre, and after infection only 43 boxes per acre.

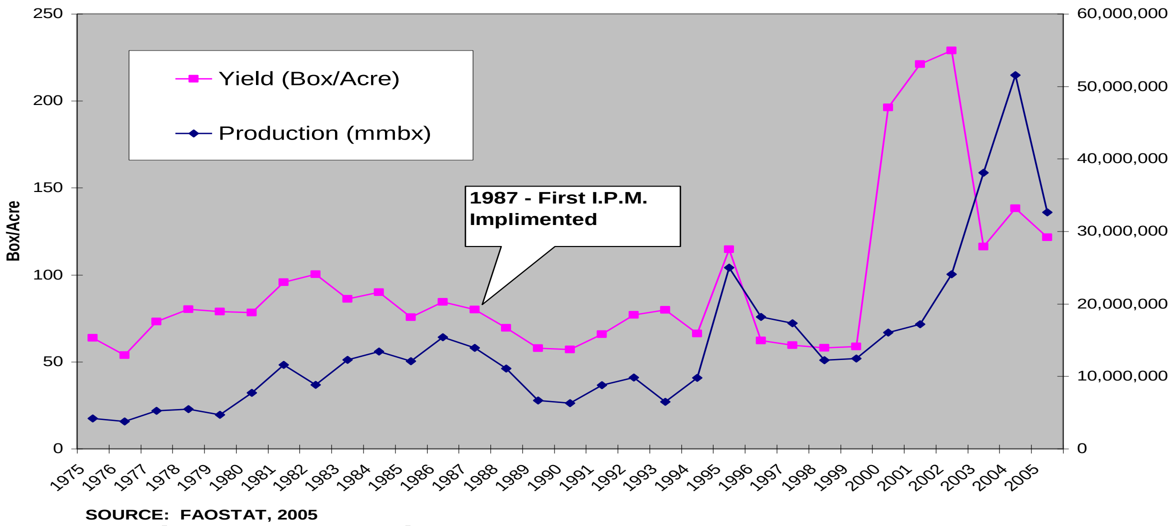


Figure 3-1. Indonesian citrus production, 1975-2005

In Thailand, greening had a devastating impact on commercial tangerine production, and reduced average tree life expectancy from eight to ten years with a 10% to 15% annual death loss. The use of air-layering (marcotting) for propagation and limited insect control programs contributed to greening's spread over all areas of Thailand. The highest tree loss was for one to two year-old trees, with tree death by three to four years. It was observed that newly infected trees were usually found clustered in the front row of the block adjacent to nearest previously infected block of citrus. In a field study with spray program in endemic greening and canker area, spraying at 7-day intervals with copper oxichloride mixed with methamidophos, carbosulfan, imidaclopid, and methomil resulted in no infections (Vichitrananda 1998).

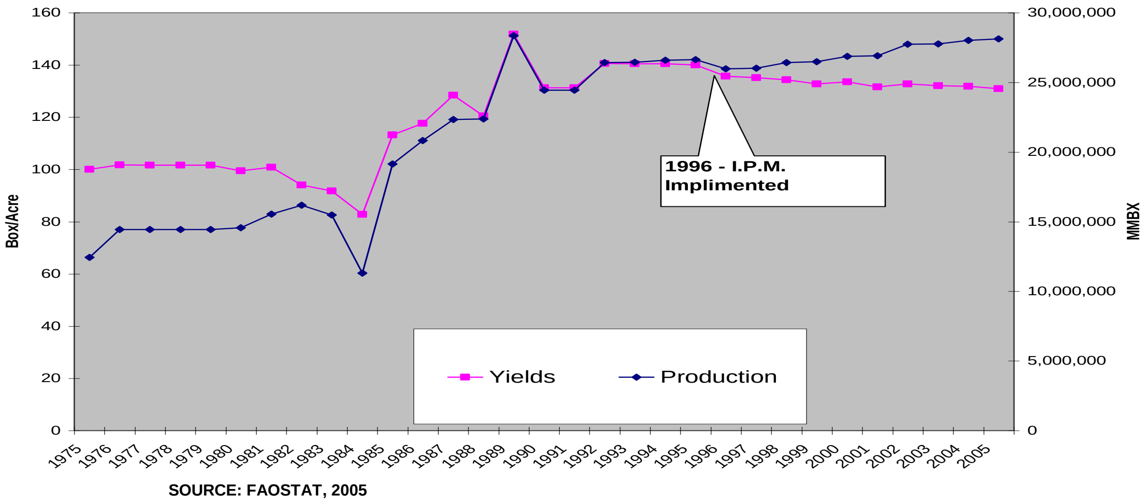


Figure 3-2. Thai citrus production, 1975-2005

The South African strain of greening was first observed in the 1920s, with an estimated 60% of all South African citrus trees infected by 1970. Greening eliminated citrus production in the Transvaal and Natal provinces. Due to the implementation of a successful IPM program, commercial production is returning to some areas previously abandoned because of the effects of greening. Some highlights of South Africa's IPM program are as follows:

- Resetting in mature groves with history of greening is not recommended
- Trees less than five years old are eradicated with any sign of greening
- Trees five to ten years old are eradicated if 75% or more of the canopy shows signs of greening, infected branches are pruned otherwise
- Ten or more year-old trees are not commonly eradicated, but branches with greening are pruned
- Coordinated psyllid spraying among adjacent groves

(Buitendag and Von Broembsen 1995).

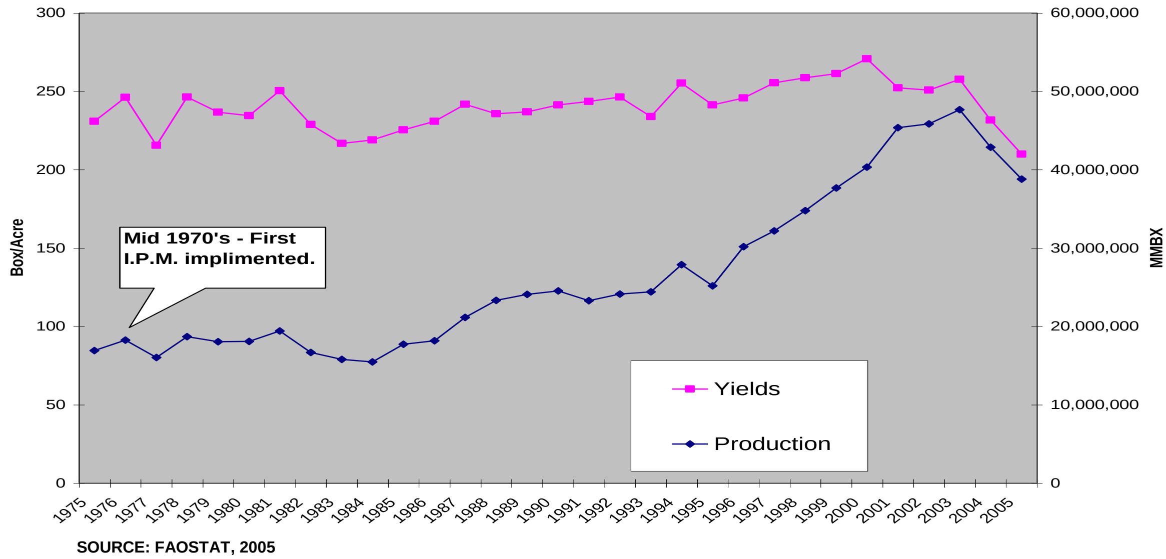


Figure 3-3. South Africa citrus production, 1975-2005

Projected Florida Tree Loss Due to Greening

Given international experiences with greening and the preference of psyllids for new growth, the tree loss rate is expected to be proportionally higher for young trees. While the exact impact of greening on trees by age has not been studied, this analysis assumes a range of possible tree loss due to greening, given by three scenarios: Low, Medium, and High tree loss. The statewide historical loss rate is increased by the following amounts, and the annual tree loss rates are summarized in Table 3-1.

Table 3-1. Tree loss percentages used in analysis

TREE AGE	BASE*	GREENING			CANKER
		Low	Med	High	
1-3	1.00%	2.00%	2.50%	4.00%	1.10%
4-11	1.50%	2.63%	3.00%	4.50%	1.65%
12+	3.50%	5.25%	6.13%	8.75%	3.85%

* Estimated average state historical tree loss (excluding effects of development and eradication)

Greening Management: Psyllid Control

The psyllid insect vector of greening is difficult to control because the psyllid population spikes at certain times of the year, exhibits continuous movement between citrus trees and surrounding host vegetation, and has a wide range of other host plants besides citrus. Moreover, its small size and recent arrival to Florida makes it difficult for growers not familiar with the insect to discover its presence in the grove. Psyllids feed almost exclusively on new growth flushes, and adult psyllids are able to acquire and transmit greening within 24 to 48 hours (Buitendag and Broembsen 1992). The importance of a coordinated psyllid IPM was illustrated in Indian field tests that found that 67% of certified greening-free trees were infected three years after planting if greening was present on adjoining properties (Azzaro et al. 1993). Chinese researchers successfully eliminated all greening incidents by the eradication of all backyard citrus and other host plants in area, the use of windbreaks, the planting of certified greening-free trees, the application of ten to thirteen psyllid-specific sprays per year in flush periods, and the prohibited introduction of any host plants in general area (Ke and Xu 1990). Another Chinese study tested the possibility of rehabilitation of an infected grove by pruning all infected branches and applying 10 to 13 psyllid specific sprays per year. This resulted in reducing new infections from 2.5% to 1% over eleven years in one location, and 7% to 1% over nine years in the other (Xu et al. 1991). Moreover, ten to twenty psyllid-specific sprays per year does not appear to be feasible for both economic and environmental reasons.

From the international experience with greening, a South African study of different psyllid control programs found that:

> Multiple sprays aimed at maintaining low populations of psylla throughout the spring, summer, and autumn periods were impractical and caused pest repercussions. It was then realized that systemic treatments targeted specifically at psylla and applied either to the stem or to the roots would be most effective (Buitendag and Von Broembsen 1992).

Experiments in psyllid control in Florida have shown that foliar applied insecticides such as Danitol, Lorsban, and petroleum oils are useful for short-term control of spikes in psyllid populations, while foliar or soil-applied systemic insecticides such as Provado, Temik, and Admire are useful for long-term control. Admire is used on young, non-bearing trees, and Temik is used on older, productive trees (Rodgers 2006). To augment the standard citrus spray program, this analysis assumes annual Temik or Admire applications in their maximum allowable amounts, plus one additional Danitol and Lorsban application per year. This results in a cost increase of $203.00/acre for oranges on the Ridge, $194.36/acre for oranges on the Flatwoods, and $156.74/acre for grapefruit, added to the existing grove spray program results in the chemical costs shown in Appendix Table B17. The grapefruit for fresh market costs do not increase as much as the oranges for processing because of the ability to combine greening spray applications with the existing spray program.

Greening Management: Grove Inspections

Greening's ease of transmission makes it necessary to scout aggressively for signs of psyllids and infected trees. Infected trees should be eradicated immediately, and psyllid populations controlled promptly to avoid a quick spread throughout the grove (Brlansky 2005). This analysis assumes that growers must inspect six times per year. Using the same cost components as the canker inspection program described above, the annual cost of greening inspections is $35.04/acre.

Combining the Effects of Canker and Greening

To account for the combined effects of canker and greening in a grove, the above cost categories, yield, and tree loss assumptions are added together and overlaps, particularly in the spray programs are subtracted. A comparison of spray programs with different disease scenarios is shown in Appendix B – Table B-17, while a detailed production budget of different groves and varieties with both canker and greening is illustrated in Appendix B – Table B18. Inspection costs are assumed to be the higher figure for eight annual inspections ($35.04/acre) for both canker and greening. The canker yield penalty is included (5% for Valencias and 10% for Hamlins and grapefruit), and the medium greening tree loss rate is assumed.

Table 3-2. Annual per acre spray costs by disease scenario

Scenario	Ridge		Flatwoods		
	Valencia	Hamlin	Valencia	Hamlin	Grapefruit
Base	$137.06	$137.06	$141.19	$141.19	$383.18
Canker	$153.20	$189.36	$153.20	$189.36	$418.43
Greening	$335.55	$335.55	$335.55	$335.55	$539.91
Canker & Greening	$335.55	$371.71	$335.55	$371.71	$539.91

Source: IFAS 2004-5 Citrus Production Budgets adjusted for BMP disease spray programs

CHAPTER 4
A NET PRESENT VALUE MODEL OF A FLORIDA CITRUS GROVE

The definition of an investment used in this analysis is the ownership of an asset that has value. The value of an asset is created by intrinsic value and/or the value of the income it may produce. Unless this asset is inherited or received as a gift, the ownership of the asset must be purchased with another asset of value. In this analysis, value is framed in monetary (dollar) terms. The preferred goal of an investment is to capture a return that is in excess of what it costs to obtain the asset.

In the case of an investment in a citrus grove, initial costs are incurred in the purchase of the land and establishment of the trees. This is based upon the expectation of creating value from the future income from the production of the fruit and the ownership of a productive grove. Due to the long life of a productive grove, it is necessary to determine the value of the future production and ownership currently to compare it to the costs that are incurred now. Net present value analysis is a means of comparing the future expected returns to ownership of a citrus grove to the current cost of acquiring it.

A citrus grove is a dynamic enterprise where yields, revenues, costs, and grove value change through time depending on tree age, tree loss, fruit prices, and input costs. This analysis adapts a mixed-age grove model to reflect grove operating costs and revenues. This mixed-age grove model captures the evolution of costs over time, including the costs of tree loss, resetting, and caring for replacement trees. Both box and pound solids yields increase with tree age, and with resetting it is necessary to capture the effect of a mix of tree ages on total grove yields. Accounting for trees of different ages within a grove becomes even more important when higher tree loss assumptions due to disease are incorporated. Generalized examples of the model's mechanics are given below, but the reader is referred to Appendix C for results generated by the model for a Valencia orange grove in the Central Florida ridge production area.

Net Present Value Theoretical Framework

Net present value (NPV) is a frequently used way of evaluating and comparing investments, also known as capital budgeting in the finance literature. A 2001 survey of 392 chief financial officers for business ranging from small private business to Fortune 500 public corporations found that around 75% use the NPV method of project analysis (Graham and Harvey 2001). Around 50% of firms used sensitivity and scenario analysis methods. This study borrows commonly used investment analysis techniques of NPV and scenario analysis from the corporate finance field, and adapts and applies it to citrus growing in Florida.

Present Value Investment Rule

NPV begins with the assumption that the value of a dollar received today is worth more than a dollar received tomorrow because a dollar today can be used or invested. Determining the present value (PV) of future payments or cash flows requires a method to discount their future value by the perceived opportunity cost of waiting for them.

Cash flows in consecutive future periods that are discounted by the same rate sum up to form the present value. The series of present values are additive and the discount rate compounds in a geometric sequence where it is raised to the power of the future time period. Consider the below case of three yearly cash flows discounted at a rate of 10% per year.

$$\text{4.1)} \quad PV = \frac{100}{(1+.10)^1} + \frac{100}{(1+.10)^2} + \frac{100}{(1+.10)^3}$$

$$= \frac{100}{1.1} + \frac{100}{1.21} + \frac{100}{1.33}$$

$$= 90.91 + 82.64 + 75.13 = 248.68$$

The generalized formula of the sum (Σ) of the present values of the cash flows (CF) in future time periods (t) is represented by the following:

$$(4.2) \quad PV = \sum_{t=0}^{T} \frac{(CF)_t}{(1 + r_t)^t}$$

where CF_t is the current value in period t and r is the interest rate.

Net present value (NPV) adds the initial cash flow to the present values of future cash flows. NPV is used to adapt the present value framework to the reality of most investments. Usually, the initial cash flow is a negative outlay used to acquire an asset assumed to be purchased now, and therefore is not discounted.[3]

$$(4.3) \quad NPV = \sum_{t=0}^{T} \frac{(CF)_t}{(1 + r_t)^t} + CF_0 \quad \text{or} \quad \sum_{t=0}^{T} \frac{(CF)_t}{(1 + r_t)^t} - \text{Initial Investment}$$

When investing in an asset, the investor is foregoing the return available by investing in another asset. The discount rate (r) is a method to incorporate the opportunity cost of choosing an alternative investment, and establish a required rate of return for investing in the asset. This gives two equivalent decision rules for capital investment:

Net Present Value Rule. Accept investments that have positive net present values. In other words, the difference between the present value of future income minus the cost of aquiring the investment is a positive number.

[3] This analysis will use the cash flow sign convention of expenses are negative cash out flows (-) and income is a positive cash out flow (+).

Rate-of-Return Rule. Accept investments that offer rates of return in excess of their opportunity costs of capital, or the rate of return of the investment exceeds the rates of return on similar investments.

Alternative Investment Rules

Three traditional alternatives to the NPV investment decision rule are the book rate of return, payback period, and internal rate of return (or hurdle rate) (Brealey and Meyers 2003). These rules are commonly used and may lead to misleading conclusions and incorrect decisions based on their results. It is important to remember that NPV depends only on forecasted cash flows and the discount rate or opportunity cost of capital.

Book income is another name for accounting income, and it used to determine the book rate of return. Book income is commonly shown on a firm or individual's income statement, and book assets and shareholder's equity are shown on the balance sheet. Both are reported using accrual accounting methods which may not reflect actual cash inflows and outflows. The book rate of return is the basis for ratios such as the return on assets (ROA) or return on equity (ROE).

$$\text{(4.4)} \quad \text{Book rate of return} = \frac{\text{Book Income}}{\text{Book Assets}} \quad \text{or} \quad \frac{\text{Book Income}}{\text{Shareholder's Equity}}$$

Accounting procedures separate cash outflows into capital and operating expenses. Capital expenditures are depreciated and debited against income according to a schedule that may not reflect the actual cash flows; also, the allocation of capital and operating expenditures is usually reported across an entire firm or individual's income and balance sheet, and not on an individual project or investment basis. When evaluating a capital investment decision, it is important to remove the distortive effects of the choice of accounting methods from the actual value of the investment; however, there are benefits to tax, depreciation, and financing choices. Elsewhere, this analysis includes a framework for how to calculate these ancillary benefits.

The payback method is an investment rule which specifies the number of years it should take for the cumulative discounted cash flows (DCF) of an investment to pay back the initial investment expenditure. Graham and Harvey (2001) found that the payback method was predominantly used by smaller firms. The payback method is another way to account for investment risk by limiting one's time exposure to risk. When evaluating competing projects, the project with the shortest payback period is selected. First, this method ignores cash flows after the payback or break-even date. An investment may create significant value after the establishment of an arbitrary cutoff date. Second, the payback method is biased towards investments with large cash flows early in their lives. Longer-lived investments may generate significantly more returns on a DCF basis.

The internal rate of return (IRR or IROR) is an investment rule related to the NPV rule, where the rate of return from discounted cash flows is compared with the discount rate or opportunity cost of capital. The opportunity cost of capital is the "hurdle rate" by which the returns to investment must exceed for a firm to invest. Therefore, if the return of the discounted cash flows is greater than the cost of purchasing the investment, a firm will choose to invest. By definition IRR is the discount rate which makes the NPV equal to zero, and is found by substituting IRR into the NPV formula and solving.

$$(4.5)\ NPV = \sum_{t=0} \frac{(CF)_t}{(1+r)^t} + CF_0 = 0$$

$$\equiv \quad r = \sum_{t=0}^{T} \frac{(CF)_t}{-CF_0} - 1 = IRR$$

Or

$$NPV = CF_0 + \frac{CF_1}{(1+IRR)^1} + \frac{CF_2}{(1+IRR)^2} \ldots \frac{CF_t}{(1+IRR)^t}$$

The IRR illustrates the important aspect of NPV which is its inverse relationship to the discount rate. As the discount rate increases, the present value of future cash flows decreases and NPV becomes smaller. This relationship can be represented by the downward sloping line shown in Figure 4.1. Where the line crosses the discount rate axis is where the NPV of an investment is equal to zero. That rate is the IRR, in this case 35%. The IRR must be compared to the discount rate to either accept or reject the investment. For example, if the discount rate (r) is 20%, the opportunity cost of capital is less than the internal rate of return to the investment (IRR) of 35%, and the NPV is +$1,200. Therefore, the investment will be accepted. If the discount rate (r) is 65%, the opportunity cost of capital is greater than the IRR (35%), and the NPV is -$1,000. Therefore, the investment will be rejected.

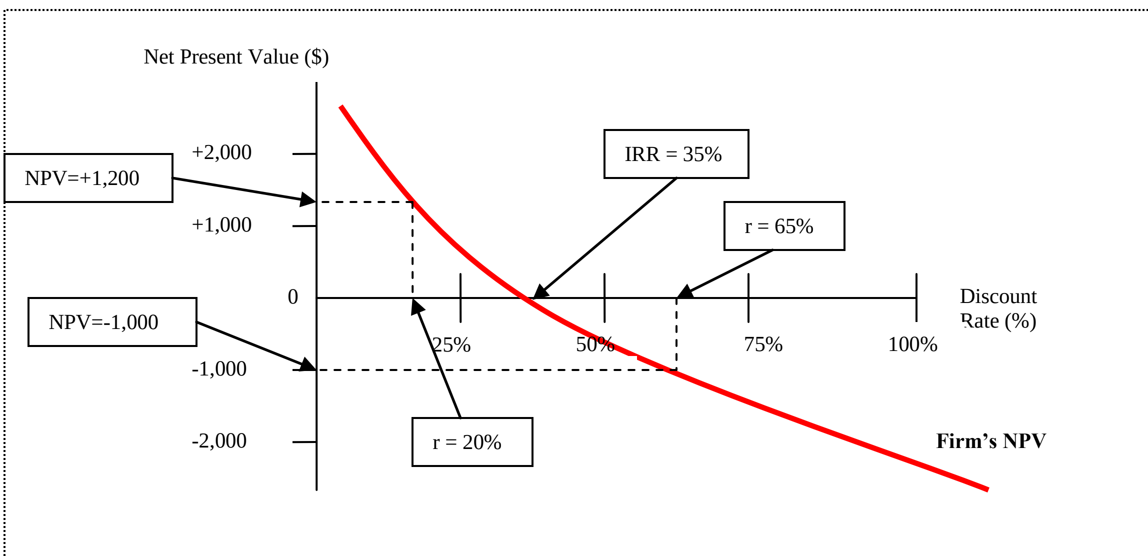


Figure 4-1. Relationship of NPV and IRR

The IRR is a polynomial equation for multiple periods, has no unique solution, and must be solved numerically through interpolation to find an accurate value. Fortunately, this can be done instantly through the use of spreadsheet-based computer programs or financial calculators. Unfortunately, an investment's NPV function is not always as smooth as the line in Figure 4.1. The IRR method will give an inaccurate figure if there are changes of signs in the cash flow, or large positive cash flows early in the investment's life. For instance, if there are many swings where the DCF's go from positive to negative, this may give multiple IRR's if the function crosses the discount rate axis more than one time. The IRR is calculated in citrus grove investment analysis because it can be useful in some situations to compare the profitability of an investment to its opportunity cost, but NPV is a more reliable measure of value over time and an absolute measure of the total value created.

Adapting NPV to Citrus Investment

To adapt the NPV framework to a citrus investment, it is first necessary to construct the cash flows. In its most basic form, the cash flow to growing citrus is a function of yield, price, and cost. In each period there exists a yield of fruit which is multiplied by the price for the fruit minus the operating cost. The first period (period 0) is typically referred to as the initial investment. This is the cash out flow necessary to acquire the grove whether it is the purchase of a mature grove or the cost for establishing a new or replanted grove. In this analysis, it is necessary to distinguish two indexing variables of time (t) and tree age (a). Time is the analysis time which starts in year 0 (present day) and moves forward 15 years or periods. This is distinct from tree age (a) which will change depending on the beginning age distribution of the grove and amount of tree loss incorporated into the model. Yields and costs change with time, tree age, variety (V), tree loss (Ψ), and the presence of disease (θ). In this case, the disease considered is either canker or greening, and is separated from normal tree loss in a grove. Price (P) is treated as an exogenous variable and is used to measure the effects of changes is yield and cost due to disease.

(4.6) $-CF_0$ = Initial Investment

(4.7) $CF_t = P\,Y_t - C_t$, where $Y(t, a, V, \Psi, \theta)$ and $C(t, a, V, \Psi, \theta)$

t = analysis time period
a = tree age
V = tree variety
Ψ = tree loss
θ = disease effect

Exiting the Investment: Bond Valuation, Perpetuities, and Terminal Value

The additive property of present value makes it an attractive method for determining the value of an asset with a long series of future cash flows. Although, one must determine a cash flow for each period of the asset's expected life. This becomes difficult and time consuming when the asset has a very long or indefinite life. A well-maintained citrus grove is usually expected to last at least fifteen years to thirty years, and may last much longer. A grove owner expects that the grove will retain a terminal value as an income producing property after the expected life of the grove due to its suitability to be replanted in citrus. This creates an issue of how to determine the present value of all the future returns accruing to ownership of a grove.

The method of valuing of one of the most basic financial instruments, the bond, illustrates a path to valuing a citrus investment. A fixed-coupon bond is a debt instrument similar to loan where the holder of the bond is entitled to a fixed series of interest payments (coupons) until the bond matures at a specific date and the holder receives the face value (principal) of the bond. The bond can be viewed as two investments, and discounted separately.

(4.8) PV(bond) = PV(coupon payments) + PV(principal)

The value of the bond (or a citrus investment) depends on the coupon payments (income), the principal (value of investment), the time to maturity (expected life of the grove), and the value of other similar bonds (opportunity cost of capital). The total number of coupon payments throughout the time to maturity is discounted at the opportunity cost of capital, plus the final payment of principal at maturity, is also discounted. If the sum of the present values of the coupon payments and the principal is more than the purchase price of the bond, then the NPV is positive. Changes in the purchase price of a bond are related to the rates of return of other assets and perceptions of risk; however, a citrus investment does not pay a fixed income over its life nor will return a fixed amount upon maturity. Therefore, the valuation method must include a way for determining a grove final value.

As previously stated, the present value calculation has the property of being a geometric series which compounds the discount rate by raising it to the power of the time period. This makes the value of future cash flows logarithmically smaller the farther out into the future, up to the present value of $100 at infinity which is zero.

Table 4-1. Discounting example

Discounting $100 @ 10%

Year	Discounted Amount
1	90.91
2	82.64
3	75.13
..	..
15	23.94
..	..
30	5.73

The value of an infinite series of equal future cash flows, called perpetuity, is a useful way of determining an asset of indefinite life. The formula is derived by simplifying the present value series to:

$$\text{(4.9)} \quad \text{PV of perpetuity} = \frac{\text{Annual Cash Flow (CF)}}{\text{Annual Rate of Return}}$$

An extension for a perpetuity with constant growth (g) of cash flows into infinity can be accounted for by the Gordon Growth Model:

$$\text{(4.10)} \quad \text{PV of growing perpetuity} = \frac{\text{Annual Cash Flow (CF)}}{\text{Annual Rate of Return} - \text{Annual Growth Rate}}$$

Valuation of an asset with an indefinite life span is usually calculated by determining the present values of cash flows out to a certain planning horizon, and adding the forecasted value of the asset at the horizon, also discounted back to the present value.

PV of ongoing business as a perpetuity at forecast horizon

$$\text{(4.11) NPV} = CF_0 + \frac{CF_1}{(1+r)^1} + \frac{CF_2}{(1+r)^2} \ldots + \frac{CF_t}{(1+r)^t} + \frac{\left\{ \dfrac{\text{Avg. Annual CF}}{\text{Annual Rate of Return}} \right\}}{(1+r)^t}$$

Determining a Discount Rate for the Citrus Investment

The NPV approach is based on the use of an appropriate discount rate to adjust future cash flows by their opportunity costs. The opportunity cost can be viewed in two ways, a firm-specific and a generalized manner. This analysis uses the generalized case, but the appropriate firm-specific discount rate is explained below.

The weighted average cost of capital (WACC) is defined as the opportunity cost of the financing source for the project being evaluated. WACC is usually a firm-specific measure, and depends on an individual project's financing mix and tax treatment. WACC consists of the two traditional sources of financing, debt and equity, and gives the real cost of financing the given project. The after-tax WACC adjusts the debt component for a firm's ability to deduct the cost of debt (interest expenses) from its taxable income. WACC is usually calculated on a project specific basis, and not firm-wide. The WACC used to discount a specific project should be evaluated for the debt/equity financing mixed used to expand that project.

(4.12) WACC = (% of project financed by debt) * (cost of debt)
+ (% of project financed by equity) * (expected return on equity)

Or = r_d (D/V) + r_e (E/V)

Where r_d = cost of debt, r_e = required return on equity, D = amount of debt,
E = amount of equity, and V = Book Value of project

(4.13) AFTER-TAX WACC = $r_d(1-T_c)(D/V) + r_e(E/V)$ where T_c = marginal tax rate

The generalized risk adjusted discount rate is based on a study of returns to different citrus varieties conducted by Moss, Weldon, and Muraro (1991). That study uses a capital asset pricing model (CAPM) similar to valuing the risk of tradable securities to compare returns of different citrus varieties to an index constructed of the returns from a weighted portfolio of all citrus varieties. The CAPM model is based on the idea that similar factors (such as supply and demand) affect all citrus varieties, but not to the same extent. The CAPM incorporates the risk of a specific citrus variety compared to a diversified portfolio of all other citrus varieties to quantify its performance in relation to other citrus investments. This share of variance a specific variety has in common with other varieties is represented by beta (β_i) in equation 4.4. Beta is then multiplied by the difference between returns to the citrus portfolio and a risk-free rate of return. This captures the relationship of the risk of owning a specific variety of citrus to the returns for all Florida citrus. For instance, if returns to growing oranges for processing increase, prices for Hamlin, Pineapple, and Valencia oranges will all increase, but by different amounts.

This risk adjustment is added to the return on a risk-free alternative investment to arrive at the risk adjusted discount rate (RADR). The variety specific risk adjusted discount rates used in this analysis are shown in Table 4.2.

(4.14) $$\beta_i = \sigma_{i\,f} \;/\; \sigma^2_f$$

Where, $\sigma_{i\,f}$ = Covariance of citrus variety with market portfolio of all varieties
σ^2_f = Variance of market portfolio

(4.15) $$R_i = R_0 + \beta_i * (R_m - R_0)$$

Where, R_i = Risk adjusted rate of return on citrus variety (i)
R_0 = Risk-free rate of return
R_m = Return on market portfolio

Table 4-2. Risk adjusted discount rates by variety

	Beta	**Risk Adjustment***	**RADR**
Early/Midseason Oranges	1.3870	0.0299	0.0824
Valencia Orange	1.9017	0.0409	0.0934
Colored Grapefruit	0.8961	0.0193	0.0718

* Risk adjustment is based on an average return to the market portfolio of .0743 and a risk-free rate of .0525

Source: Moss, Weldon, and Muraro (1991)

In addition to the risk adjusted discount rate, citrus investments are also subject to a liquidity premium, and cost of money management premium. The premiums are taken from an unpublished analysis by Ronald Muraro at IFAS-Lake Alfred CREC (Muraro 2006d). A citrus investment is illiquid in the sense that it cannot be sold quickly without significant transaction fees and reduction in sales price. In this case, the liquidity premium is taken as the difference between a 90-day U.S. Treasure Bill and the 30-year Treasury Bond, 0.55% at the time of writing. The cost for money management premium reflects the additional work and energy required to manage agricultural investments compared to other investments. The overall discount rates by variety used in this analysis are shown in Table 4-3.

Table 4-3. Discount rates used in citrus investment analysis

	Valencia Oranges	Hamlin Oranges	Red Grapefruit
Risk Adjusted Discount Rate	9.34%	8.24%	7.18%
<u>Add:</u>			
Liquidity Premium Difference between 3-Month Treasury Bills and 30-Year Bonds/January 2006	0.55%	0.55%	0.55%
Cost of Money Management Most investments Range from 1% to 2%; Sometimes agriculture is higher.	2.00%	2.00%	2.00%
Total Discount Rate	11.89%	10.79%	9.73%
	Say: 12.0%	Say: 11.0%	Say: 10.0%

Determining an Appropriate Terminal Value for a Citrus Investment

The value of a Florida citrus grove can best be separated into two components: the value of the current and future income from fruit production, and the value of the underlying land. As shown by the bond example for valuing a long-lived asset, any analysis must determine a terminal value for all future returns to the grove after the final period of analysis. The most realistic and accurate ending value would be the sales price of a particular grove at that future point in time given that the sales price reflects agreement between the seller and buyer's expectations on the future income of the grove and the underlying land value. Unfortunately, determining the value of the underlying land depends significantly on the particular characteristics of location, soil, demand, and highest and best use of the land that are beyond the scope of this analysis; however, information exists about grove income and we can arrive at a reasonable approximation of a terminal value to include in this analysis.

The valuation (or appraisal) of land and real estate property is commonly divided into three analysis approaches that are subsequently compared to determine a fair market value for the property (The Appraisal Institute 2001). First, the extraction or cost approach values the replacement or reproduction cost of structures and improvements to land given that the utility of the structures or improvements can be exactly reproduced. For agricultural properties, the cost approach is usually not applicable because of the low percentage of the total value of the property that is attributable to structures and improvements (Muraro 1989). Second, the income approach values a property by its income producing potential and converts the value of all future income accruing to ownership of the property to a present value through the capitalization rate. This is the main approach this analysis will use. Third, the market or comparable sales approach estimates the value of the property by observing the values of like properties, and adjusting for particular aspects of the sale, such as location, transaction date, land characteristics, and the terms of sale. While the comparable sales approach is only applicable to specific properties, this analysis will use that approach to validate an applicable capitalization rate.

The income approach to citrus valuation starts by deriving an average annual expected income from the property, net of grove and operating expenses. This is divided by the sale price of the land to determine a capitalization (or cap) rate. The cap rate can be thought of as the annual return on investment, and is positively related to increases in net income and negatively related to increases in the sales price. Note, the cap rate only includes income, and not changes in the selling price of the land over time (capital gain or loss). Since this analysis is generalized to a variety of grove circumstances, the actual sale price of the grove is unknown, but is assumed to be dependent on a grove's productivity and income generating capability. A dollar amount for annual net income is endogenously generated by the model, and rearranging the capitalization formula to equations 4.11 and 4.12, we need only to estimate a capitalization rate for citrus.

$$(4.16)\quad \text{Capitalization Rate} = \frac{\text{Average Annual Net Income}}{\text{Sale Price of Grove}}$$

Where: Cap Rate ↑ if Net Income ↑
Cap Rate ↓ if Sales Price of Grove ↑

$$(4.17)\quad \text{Sale Price of Grove} = \frac{\text{Average Annual Net Income}}{\text{Capitalization Rate}}$$

Four applicable methods exist for deriving a capitalization rate for citrus (The American Institute of Real Estate Appraisers 1983). First, the band of investment method uses the grove's financing mix (debt to equity ratio) and the required rate of return on both debt and equity to arrive at a cap rate. This method is essentially identical to WACC as explained above. Second, the debt coverage method applies a specified ratio of net operating income to annual debt service (debt coverage ratio) which is usually twice the value of the financed portion of the purchase price to adjust for non-payment risk. This is usually specified by a lender. Third, the yield and change method is an ad hoc modification to the band of investment method to account for the growth in cash flows over time as the grove reaches maturity. This method is not applicable when valuing a fully mature grove. Finally, the built-up cap rate method compares a citrus investment to its alternatives, and starts with a risk-free rate and adds percentage premiums for different types of risk inherent to citrus. The first two methods depend on a specification of the financing mix, and are therefore cannot be generalized. This analysis selects the built-up cap rate method because it enables the comparison of citrus to other investments, and can be generalized to diverse grove settings.

(4.18) Band of Investment
Cap Rate = % Debt * Interest Rate on Debt + % Equity * Required Return on Equity

(4.19) Debt Coverage
Cap Rate = % Debt * Interest Rate on Debt * Debt Coverage Ratio (usually 2)

(4.20) Yield and Change
Cap Rate = Band of Investment Cap Rate + % Chg. in net income + % Chg. in cap gain

(4.21) Built – Up
Cap Rate = Risk Free rate + Price Risk Premium + Liquidity premium + Ag. risk premium + Management premium

The built-up cap rate method requires the estimation of the various premiums described above. The risk-free rate of return used is the rate on a 90-day US Treasury Bill. A variety-specific price risk premium derived from Moss et al. is added. A proxy for credit risk called risk of ownership is added and includes the difference between low risk and medium risk investment grade bonds plus an estimated 2% agricultural risk premium. A cost of money management is added to account for the more intense investment management needed for a citrus investment. The cap rates used in this analysis are shown in Table 4-4.

Table 4-4. Built-up capitalization rate method used in analysis

	Valencia Oranges	Hamlin Oranges	Red Grapefruit
Risk-Free Rate Rate used is 3-Month Treasury Bills/January 2006	4.54%	4.54%	4.54%
Price Risk Premium a/	4.09%	2.99%	1.93%
Risk of Ownership Difference between average of Corporate Aaa And Baa Bonds and the average of 3-Month and 2-Year Treasury Bills Plus 2% additional risk For agricultural operation	3.16%	3.16%	3.16%
Premium for Non-Liquidity Difference between 3-Month Treasury Bills and 30-Year Bonds/January 2006	0.55%	0.55%	0.55%
Cost of Money Management Most investments range from 1% to 2%;	1.50%	1.50%	1.50%
Total Capitalization Rate	13.84%	12.74%	11.68%
	Say: 13.9%	**Say: 12.8%**	**Say: 11.7%**

a/ "The Impact of Risk on the Discount Rate for Different Citrus Varities," Agribusiness, Vol. 7. No4, 327-338 (1991) (Moss, Weldon & Muraro)

The respective cap rates were then compared with comparable sales of real groves throughout the state, and were found to be in line with expectations. Note, the comparable sales were taken from the period 1999 to 2004 because more recent sales may show significantly lower cap rates due to intense non-agricultural demand for citrus land within the last two years. This was done in order to avoid distortions caused by speculative demand, and arrive at a cap rate representative of the value of citrus land, not land for future development.

Table 4-5. Comparable Florida grove sales

Year of Sale	Location	Description	Boxes/acre	Price/acre	Cap Rate
1999	Central	Young/mature grove of early/mids and Valencias	511	7,883	22%
2000	South	10yr grove of early/mids and Valencias	500	8,002	13%
2002	Southwest	12yr grove of Valencias	432	8,096	13%
2003	Central	12yr grove of Valencias	433	8,358	11%
2004	Central	Mature Valencia grove	500	7,704	10%
		Average:	475	8,008	14%

Source: Ronald Muraro, IFAS Extension Economist

This investment model calculates the average net income from the last two years of the analysis, divides the average by the respective cap rate in order to determine the terminal grove value, adds the result back into the year 15 cash flow, and discounts the amount back to the present. The last two years of net income are taken as representative for a stable, mature grove. In certain circumstances under high tree loss scenarios due to disease, the terminal grove value falls below current prices for vacant (pasture) land. To correct for this impossibility, the terminal value defaults to the current price for improved pasture land when this occurs.

Adapting NPV Analysis to the Citrus Grove

Conceptually, the mixed age tree model is based on a study done by Ronald Muraro at the Lake Alfred CREC for citrus grove rehabilitation and two models from the forestry management literature. Muraro (1985) applied a mixed-age grove model to compare rehabilitation of a freeze-damaged grove with solidest replanting. This model compared costs and returns over a 10 year period incorporating different tree ages. Buongiorno and Michie (1980) developed a matrix model of mixed-aged Northern Michigan pine trees in a linear programming model to optimize and test selective cutting methods to maximize NPV. In the model, trees move up diameter classes with time, tree loss due to harvesting is replaced with in-growth of new trees, and a cutting schedule is determined that would result in a sustained yield that maximizes returns in an NPV framework. This model was modified by Boscolo and Vincent (2000) to apply a loss (damage) matrix accounting for young trees damage in the logging process, and tested for NPV maximizing behaviors while overlaying different policy scenarios. The mixed-age grove model is best conceptualized as based on a tree age matrix to describe the evolution of the starting number of trees, the tree loss according to tree age, the resetting of dead/unproductive trees, and the loss of reset trees according to age as the analysis moves forward through time (Figure 4.2). For explanatory purposes, each group of trees of the same age will be referred to as a cohort. The period of analysis is an annual time variable and increases down the columns, and tree age increases along the rows.

AGE DISTRIBUTION MATRIX (A)

Age of Trees (a) →

←Period of Analysis(t)

T00				0
	T11*L1			
R20		T22*L2		
	R31*L1		T33*L3	
		..	..	
Rt,a-2*La-2		Tta*La		

Where: Tta = % of original trees per acre in period(t) of age(a)
Rt,a-2 = % of reset trees per acre in period (t) of age (a-2)*
La = (1 – % tree loss) for trees of age(a)
*note: resets are lagged 2 periods due to the assumption of biennial resetting.

Figure 4-2. Tree age distribution matrix

Each matrix row is a snapshot of the distribution of trees in each age group during that period of analysis, and would sum to 1 (or 100%) if there were zero tree loss. Each cohort of trees planted in period t move diagonally through the period of analysis. In this example, T_{00} represents the starting cohort of trees planted in time zero that are zero years old. As the period of analysis advances one year, the starting cohort of trees (T) becomes one year old, and is now represented by T_{11}. After one year, some percentage of the T trees is expected to be lost as given by the tree loss rate by age of tree or L_1. T_{11} is then multiplied by $1-L_1$ to appropriately reduce the percentage of starting trees.

To incorporate the assumption of biennial resetting (replanting dead/unproductive trees every other year), resets ($R_{t-2,a}$) are included on the matrix diagonals below the center (T) diagonal and lagged two periods. In this example, in analysis period 2, reset trees are planted at age 0 (R_{20}). The resets then follow the same evolution over the analysis periods and are reduced at the appropriate tree loss rate for their age. In the model, 100% of dead/unproductive trees are reset at the end of each 2 year period up until year 12 when only 50% of the trees lost are reset.

Where: t = analysis period, a = tree age, s = starting tree age
T = % of original trees/acre, R = % of reset trees/acre
L = tree loss rate conditional on tree age D = Density of trees/acre
B = tree age distribution of grove

$$(4.22)\quad \sum_{t=1}^{15} \sum_{a=S}^{A} T_{ta} \text{ x } (1-L_a) \text{ x } D \quad + \quad \sum_{t=2}^{15} \sum_{a=S-2}^{A-2} R_{ta} \text{ x } (1-L_a) \text{ x } D$$

$$+ \quad \sum_{t=4}^{15} \sum_{a=S-4}^{A-4} R_{ta} \text{ x } (1-L_a) \text{ x } D$$

…(continues)…

$$+ \quad \sum_{t=12}^{15} \sum_{a=S-12}^{A-12} R_{ta} \text{ x } (1-L_a) \text{ x } (.5)D$$

$$+ \quad \sum_{t=14}^{15} \sum_{a=S-14}^{A-14} R_{ta} \text{ x } (1\text{-}L_a) \text{ x } (.5)D$$

$$= \quad \sum_{t=0}^{15} B_t$$

This is due to the opinion that higher density plantings will be maturing at around 10 years of age, and the older original trees will shade out the young reset trees if spaced too closely together (Muraro 2006 IV).

Calculating Yields for a Mixed-Age Grove

The per-acre yields given by a mixed age grove can be considered an extension of the age distribution equation above. As trees age, box production per tree increases, also, pound solids per box increase with tree age. In equation (2), an additional term for box yield per tree and pound solid per box by tree age is added to each tree age cohort. This captures the differences in yields between trees planted at different times. Appendix B - Table B2 illustrates the yield distribution by tree age for Valencia oranges on the Ridge.

$$(4.23) \quad \sum_{t=0}^{15} \sum_{a=0}^{A} T_{ta} \text{ x } (1\text{-}L_a) \text{ x } D \text{ x } Y_a \text{ x } S_a \quad + \quad \sum_{t=2}^{15} \sum_{a=s-2}^{A-2} R_{ta} \text{ x } (1\text{-}L_a) \text{ x } D \text{ x } Y_a \text{ x } S_a$$

…(continues same as previous equation)…

= Total boxes per acre_t
= Total pounds-solid per acre_t

Where Y_a is boxes per tree for a tree of age a and S_a is pound-solids per box for a tree of age a.

Determining Grove Production Costs

This analysis works with the assumption of the use of precision agriculture in grove management, and applies the tree age matrix to adjusting costs by tree age. First, mature grove costs for a 10+ year old grove are determined for the base and disease scenarios based on IFAS citrus production budgets. Cost categories that vary by tree age are cultivation and herbicide, spraying/chemicals, fertilization, pruning/topping/hedging, and irrigation. The costs are adjusted by tree age according to the schedule in Appendix B, Table B8 – Grove Cost Adjustment by Tree Age.

Solidset grove costs for years 1 through 4 of tree age are determined separately for the base and disease scenarios. If the grove is being solidset, the model charges planting costs for special cultivation and herbicide applications(years 1-4), tree wrap maintenance (years 1-3), labor for cutting sprouts (years 1-2), Ridomil/Aliete application for foot rot (years 1-2), tree cost, and one time charges for staking, planting, tree wrap, and first watering of the tree. Spray/chemical costs are adjusted according to the above schedule (see Appendix B, Table B3 - Solidset Costs by Disease Scenario).

Reset costs for year 1 through 3 are determined separately for the base and disease scenarios. As stated in Chapter 1, reset trees incur supplemental costs in addition to normal grove care costs for about the first three years of life. Supplemental reset costs include maintenance and cultivation (for years 1-3), and one-time planting charges for site preparation, dead/unproductive tree removal, nursery tree cost, staking, planting, and first watering the tree. These costs are in addition to the normal costs incurred for 1 to 3 year old trees.

To incorporate changes in the grove care costs due to tree loss and resetting, a matrix approach is used to provide a simple and dynamic method for adjusting total costs by the number of trees of each age. A grove care budget is created for the grove adjusted by tree age from planting to 15 years of age (see Appendix B, Table B5 - New Planting/Replanting Operating Cost Budget for Valencia Grove).

This budget is used to form a 15x1 vector for each grove cost category (for example, cultivation of grove costs by tree age) that begins with the starting age of the original trees. The tree age matrix of the original planted trees only (the reset trees are separated out and will be used in the next step) is a diagonal matrix with zeros on the off-diagonals that gives the percentage of the original trees by age and by year of analysis. The tree age matrix is multiplied by the cost category vector to give a vector of costs adjusted to tree ages for all the periods of analysis. For example, 90% of the original planted trees exist in year ten, and are ten years old (Notation: $T_{10,10}$). 90% is multiplied by the cost for cultivation and herbicide for ten-year-old trees (C_{10}) which gives the total cost of cultivation and herbicide attributable to the original planted trees in year 10. For simplicity of illustration, Figures 4.3 and 4.4 separate the original trees from reset trees, however, in the actual calculation these two categories are combined in the same matrix following Figure 4-3.

$$\boxed{\begin{array}{llllll} \text{Original Trees} & & & & & \\ T_{00} & & & & & \\ & T_{11} & & & & \\ & & T_{22} & & & \\ & & & .. & & \\ & & & & .. & \\ & & & & & T_{ta} \end{array}} \quad \text{X} \quad \boxed{\begin{array}{l} C_{00} \\ C_{11} \\ C_{22} \\ .. \\ .. \\ C_{ta} \end{array}} \quad = \quad \boxed{\begin{array}{l} W_{0} \\ W_{1} \\ W_{2} \\ .. \\ .. \\ W_{t} \end{array}}$$

Where: T_{ta} = Percent of Trees of age (a) at time (t)
C_{ta} = Total cost per acre for tree age (a) at time (t)
W_t = Adjusted cost per acre for trees T at time (t)

Figure 4-3. Cost calculation by tree age (original trees)

Subsequently, a similar operation is used to determine the costs for reset trees, starting with the reset trees age matrix. The diagonal of this matrix consists of zeros (the original trees were separated and used in the previous step) and the reset trees reside in the lower triangle. Due to the biennial resetting program assumed in this analysis, the resets are planted at two- year intervals (every other year). For example, in year 4 of the analysis, the total number of resets will consist of those planted in year two which are now two years old, plus new resets planted in year 4 which are 0 years old. Therefore, the reset costs incurred in year 4 (Z_4) are the percentage of zero (R_{40}) and two-year-old (R_{42}) resets times the supplemental costs for zero (S_0) and two-year-old (S_2) resets plus the grove care costs for zero (C_1) and two-year-old (C_2) trees.

Reset Trees Age Matrix

$$\begin{bmatrix} 0 & & & & & & \\ R_{20} & 0 & & & & & \\ 0 & R_{31} & 0 & & & & \\ R_{40} & 0 & R_{42} & 0 & & & \\ 0 & R_{51} & 0 & R_{53} & 0 & & \\ .. & .. & .. & .. & .. & & \\ R_{15,9} & 0 & R_{15,11} & 0 & R_{15,13} & 0 & \end{bmatrix} \text{X} \begin{bmatrix} 0 \\ S_0 + C_1 \\ S_1 + C_2 \\ S_2 + C_3 \\ C_3 \\ .. \\ C_{15} \end{bmatrix} = \begin{bmatrix} 0 \\ Z_2 \\ Z_3 \\ Z_4 \\ Z_5 \\ .. \\ Z_{15} \end{bmatrix}$$

Where, $R_{t,a-2}$ = Percent of reset trees in grove lagged two years
S_a = Supplemental reset costs for tree age 1 to 3
C_a = Total cost per acre by tree age
Z_t = Adjusted cost per acre for all resets of all ages in year (t).

Figure 4-4. Reset tree age matrix

Therefore, the total operating cost per acre at analysis period t (C_t) is a combination of the adjusted cost per acre for the original trees at period t (W_t), and the adjusted cost per acre for the reset trees at period t (Z_t). Some operating costs are fixed, and are not adjusted according to tree age. Overhead, maintenance, and miscellaneous are fixed as a percent of mature grove costs, while property taxes follow a fixed-rate schedule of increases as the grove matures. These fixed costs are collected into the term (F), and are added to the adjusted costs for the original and reset trees to form a total cash budget for the 15 year analysis (see Appendix B, Table B6 – Mature Valencia Grove Operating Cost Budget).

(4.24) $C_t = W_t + Z_t + F_t$

Determining Cash Flows

By adjusting yields and costs to the age of the trees, this model creates a realistic portrayal of the dynamic nature of the citrus grove. The basic operating cash in flows are constructed as a function of analysis period (t), tree age (a), number of trees per acre (T), box yield per tree (Y), harvest cost per box (H). Since this analysis presents both processed and fresh market varieties, additional terms must be introduced to calculate price by market outlet, these are: pound solid yield per box for oranges (S), the price per pound solid (P_{PS}), the packout rate for grapefruit as a percentage of harvested fruit saleable as fresh (K), and the price for fresh grapefruit (P_F) and processed grapefruit (P_P), since they are significantly different. Grapefruit prices do not include harvest costs because prices are considered "on-tree" which means net of picking, roadsiding, and hauling charges. The presence of canker is expected to reduce per tree yields; therefore a percentage term for the yield penalty (Q) related to canker is included in the cash-in-flow equation.

Oranges:

$$(4.25) \quad \text{CASH IN FLOW } (CF+)_t = \sum_{a=0}^{A} Y_{ta} \times (1-Q) \times S_{ta} \times T_{ta} \times P_{PSt} - Y_{ta} \times (1-Q) \times H_t$$

Grapefruit:

$$(4.26) \quad \text{CASH IN FLOW } (CF+)_t = \sum_{a=0}^{A} (Y_{ta} \times T_{ta} \times K_t \times P_{Ft}) \times (1-Q)$$

$$+ (Y_{ta} \times T_{ta} \times (1-K_t) \times P_P) \times (1-Q)$$

t = analysis period a = tree age

Cash out flows are considered the same for oranges and grapefruit and are constructed as a function of analysis period (t), tree age (a), the number of trees per acre (T), and the operating costs per acre (C). The presence of canker or greening in the grove is expected to incur additional costs in the term (D), which has variable and fixed components. The variable disease costs (DV) are related to the increases in spray programs which are adjusted according to tree age, while fixed disease costs (DF) are incurred through grove inspections and windbreaks for fresh market grapefruit with canker.

$$(4.27) \quad D_t = DV_{ta} + DF$$

$$(4.28) \quad \text{CASH OUT FLOW } (CF\text{-})_t = C_t + D_t$$

The cash flow in each period is now constructed for the NPV model where the cash inflow and cash outflows for each period are collected into cash flow one term (CF), which may be positive or negative depending on that period's cash flows.

$$(4.29) \quad PV = \sum_{t=0}^{T} \frac{(CF+_t) + (CF-_t)}{(1+r)^t} = \sum_{t=0}^{T} \frac{CF_t}{(1+r)^t}$$

Adding the additional terms for the grove establishment or purchase costs (generally referred to as the initial investment) and the terminal value completes the multiperiod NPV model. All cash flows are considered to be end of period and are discounted from that point, however the initial investment is the period 0 cash flow and will include grove establishment costs plus (if there are existing trees) cash inflows and outflows related to operations in period 0. The terminal value also includes operational cash flows in period 15 plus the terminal grove value.

$$(4.30) \quad PV = CF_0 + \sum_{t=0}^{T} \frac{CF_t}{(1+r)^t} + \frac{CF_T}{(1+r)^T}$$

CHAPTER 5
EMPIRICAL RESULTS

Alternative scenarios are constructed to develop hypothetical situations currently faced by Florida growers. First, investment scenarios are determined based on either new plantings (with and without land costs), or mature plantings without land costs. Then, the production costs and yields detailed in Chapter 2 are established for Hamlin and Valencia sweet oranges grown for the processing (juice) market on both ridge and flatwoods locations, and colored (Red or Pink) grapefruit grown for the fresh fruit market on an Indian River location. Finally, assumptions are applied for additional costs, yield decline, and tree losses due to the different diseases. In Appendix B, detailed cost budgets illustrate the Solidset Costs (Table B-3) of grove care expenses for the first four years of a new Valencia planting. Appendix B tables B-15, B-16, and B-17 show annual mature grove production costs with the canker, greening, and canker and greening diseases scenarios, respectively. Actual production costs are reported in Appendix B (Tables B-5 and B-6) for a Valencia ridge grove, and vary from the annual figures because of adjustments for tree age, tree loss, and resetting.

The return on investment is determined at different price levels for citrus using a net present value framework over a 15 year period of analysis. Price is assumed to remain constant over the analysis period. In this respect, price serves as an indicator of the effects of changing costs and disease scenarios. The breakeven prices reported are the lowest prices where the NPV of the grove is positive over the 15 year period. All calculations are performed on a per-acre basis.

Results of the Mixed-Age Grove Model – Yield and Cost Analysis

For a new planting of citrus, initial planting (solidset) costs are included in grove expenses. These costs include initial tree and planting costs, as well as the previously indicated young tree care, but not irrigation installation and land preparation. Figure 5-1 shows the evolution of yields and expenses for a new or replanted Valencia orange grove on the Ridge over the analysis period, where annual box yields per acre are listed on the left axis and operating costs per acre on the right axis. One can observe in Figure 5-1 that after the initial costs of bringing the trees into production, costs rise as the grove matures, and then level off. The periodicity due to resetting starts to become more apparent at tree ages ten to fifteen. It is interesting to note the periodicity of operating costs due to a biennial resetting policy. This periodicity disappears with either an annual or no resetting policy. It does suggest an ability to manage expenses by putting off resetting in times of low prices or production. This periodicity would be greater with certain blight susceptible rootstocks such as Volkameriana or Rough Lemon, where tree loss due to blight increases after maturity. In the analysis of new plantings, yields peak at year 10 and then decline. Further analysis reveals that the high density planting of Valencia settles into an equilibrium of 450 to 500 boxes per acre. The yields peak at year 10 because of the initial yield data the model is given. Trees on more slowly maturing rootstocks, such as Cleopatra Mandarin, would be expected to peak later.

The analysis continues with projecting the expected yields and costs of a mature Valencia grove on the ridge. Tree density on the ridge is assumed to 112 trees per acre and to start with the tree age distribution in Table 5-1 which was endogenously derived using the analysis model to project the ending tree age distribution (at year 15) after starting with a solidset grove, assuming biennial resetting, and state historical tree loss rates.

As shown in Figure 5-2, production declines slightly from 290 boxes per acre to stabilize around 275 boxes per acre. This reflects the higher loss rates among older (15+ year-old) productive trees, but eventually settling to an equilibrium level.

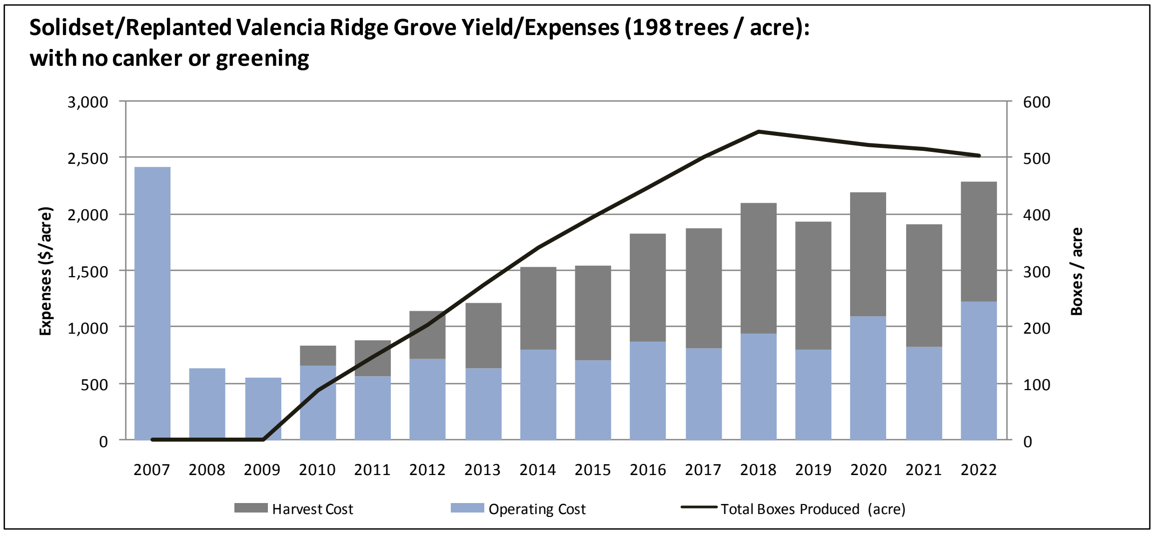


Figure 5-1. Costs and yields for a newly planted Valencia grove on the Ridge

Table 5-1. Beginning tree age distribution for mature Valencia on the Ridge

Mature Valencia Ridge Grove (112 trees/acre spacing):

	Non-bearing	1-3 yrs	4-10yrs	11-15yrs	15+ yrs	Total # of Bearing Trees
Number	3	12	9	4	84	109
Percent	3%	11%	8%	3%	75%	

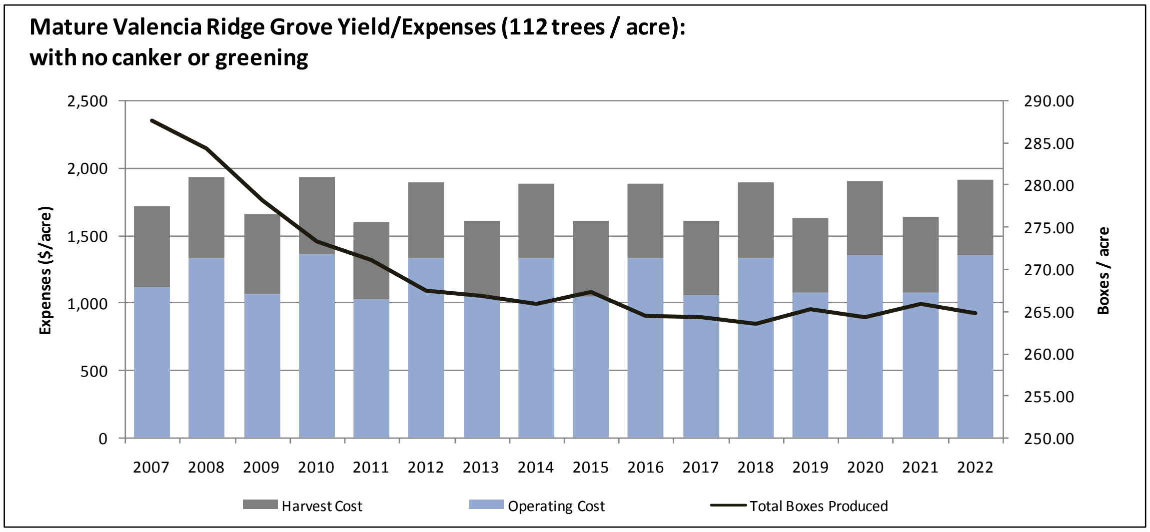


Figure 5-2. Costs and yields for a mature Valencia grove on the Ridge

Citrus Canker's Effects on Yield and Costs

Applying the canker disease scenario to the model results in increases in costs and decreases in yields. Based on the initial assumptions given in Chapter 3, canker acts to simply shift yields down and costs up. As expected, the effect is more pronounced with the level of susceptibility. Valencia oranges show the least effect, followed by Hamlin oranges, while yield decreases and cost increases is most pronounced for colored grapefruit. Canker's effect on a 15-year-old colored grapefruit grove is to shift the equilibrium yields down from approximately 340-350 boxes per acre, to around 300 boxes per acre. Annual operating costs are shifted up from approximately $1,200 per acre to $1,460 per acre.

Citrus Greening's Effects of Yield and Costs

The adverse effects of citrus greening are shared by all three varieties under study. As shown in Figure 5-4, greening's effect on a mature Hamlin orange grove dramatically lowers yields and increases costs. In the severe greening scenario, the increased tree loss acts to drop mature grove yields from approximately 400 boxes per acre to the 300-350 boxes per acre range.

Annual operating costs increase from approximately $1,015 per acre to $1,275 per acre for additional spraying, inspections, and other disease related costs. The reduction in costs observed in Figure 5-4 is attributable to the reduction in harvesting costs due to the reduced yields. Also observable is the higher fluctuation of costs due to increased tree loss and higher resetting expenses.

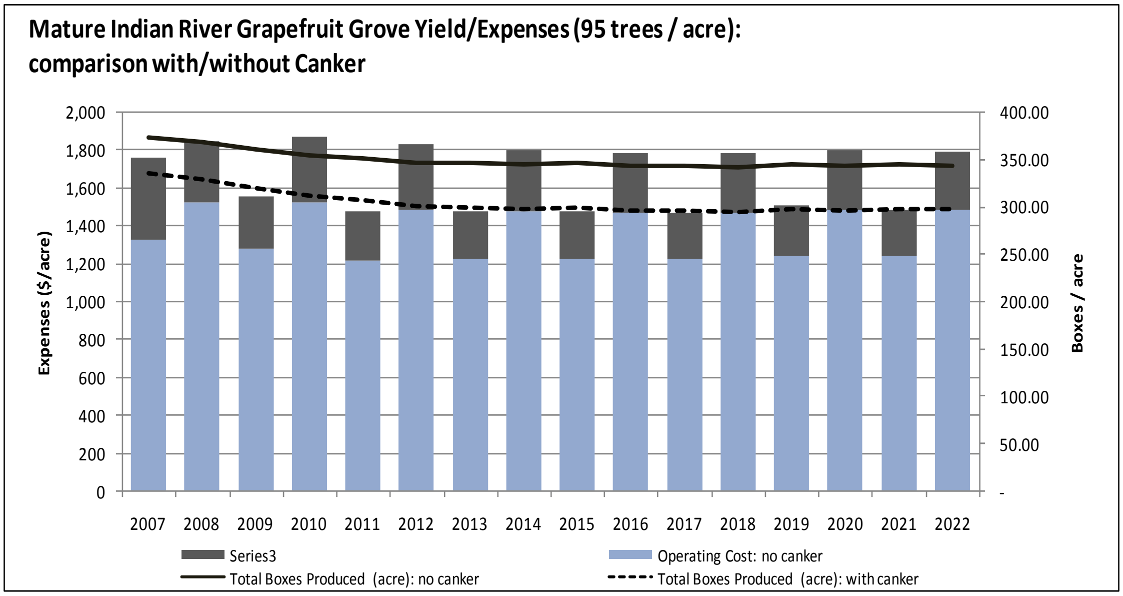


Figure 5-3. Costs and yields for mature Indian River grapefruit grove with canker

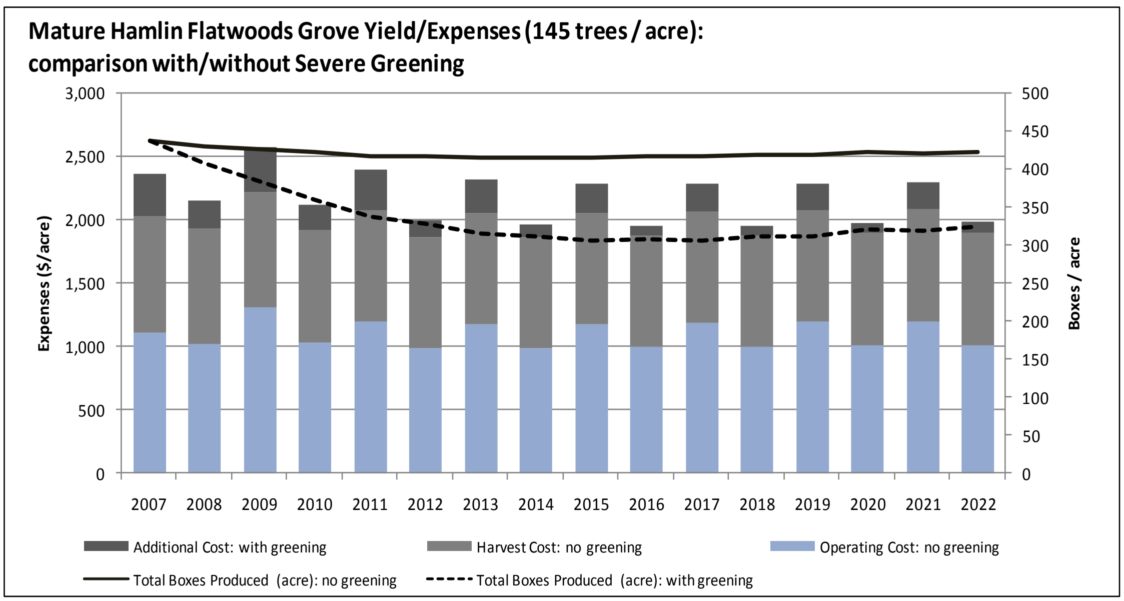


Figure 5-4. Costs and yields for mature Hamlin flatwoods grove with greening

An interesting result is the necessity of an aggressive resetting policy in the presence of greening. Figure 5-5 illustrates the effect with a mature Valencia grove on the ridge, the grove shows a precipitous decline under a no resetting policy with only 44 trees per acre of the original 112 trees per acre remaining at the end of the 15 year analysis period. Biennial resetting maintains 102 bearing trees per acre with of the trees in bearing age. On first glance, it appears that aggressive resetting is necessary to sustain yields with a greening infection the more aggressively a grove is reset, the more trees remain in bearing age. The results of this model may not be validated in an actual grove situation if greening is more severe in young reset trees. There is evidence, as shown in the Chapter 3 survey of scientific literature regarding canker and greening, that resetting individual trees in a grove with a severe greening infection may be unadvisable due to the behavior of the psyllid insect vector which is attracted to the growth flushes of young immature trees.

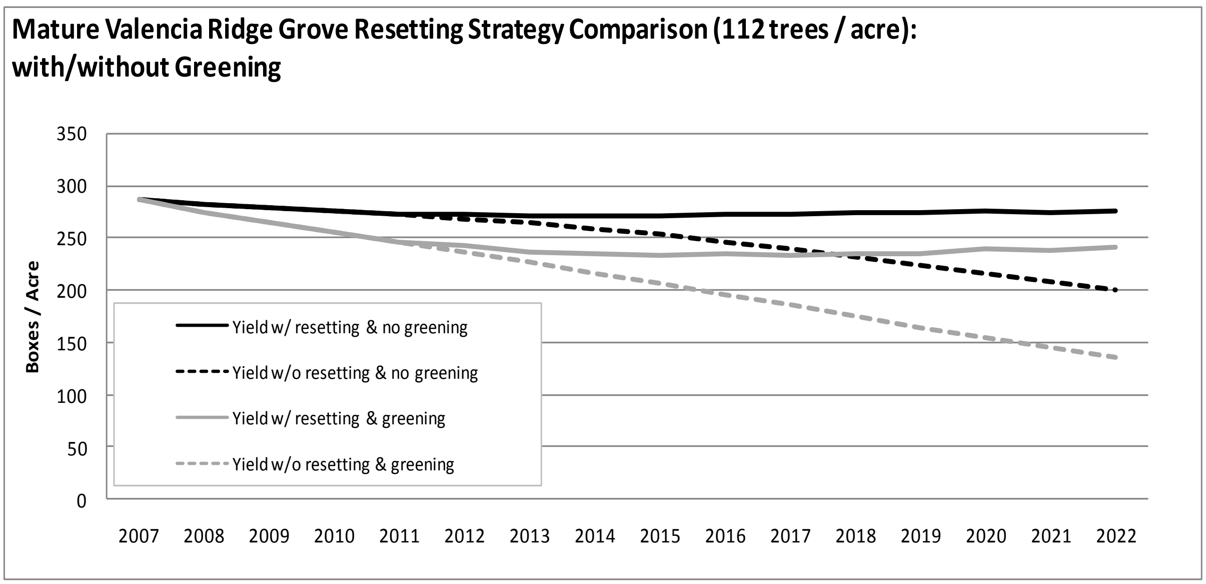


Figure 5-5. Resetting comparison

Investment Scenarios

New Planting Scenario represents the situation of a grower who intends to plant citrus and must purchase land at current market prices. The land cost is assumed to be improved pasture or cropland already zoned for agricultural use as reported in the IFAS 2005 Rural Land Value Survey for the respective areas of the state (Reynolds 2005). This scenario attempts to gauge investment returns for new entrants into the citrus industry or current growers looking to expand their operations. Also, this scenario may apply to investors wishing to speculate in long-term property appreciation while generating income from citrus.

Replanting Scenario is representative of a grower or landowner who already owns land and intends to plant citrus. This land may be new to citrus, the grower may be replacing an unproductive grove, or replanting a grove previously eradicated due to citrus canker. No opportunity costs are assumed for alternative uses for the land, either agricultural or non-agricultural. This scenario would especially apply to large citrus operations with contiguous properties and vacant land due to canker eradication, or those wishing to plant citrus instead of other agricultural operations (i.e., livestock, forestry, sod, etc.). Also, this scenario may apply to investors speculating in long term appreciation in property values, and opportunities for generating income from the land during the interim.

Mature Grove Scenario (without land costs) is based on a grower/landowner who owns a mature (15-year-old) grove at the beginning of the planning horizon. This scenario applies to established growers who did not suffer losses from citrus canker eradication, and seek to examine the long-term profitability of their groves.

Mature Grove Scenario (with land costs) is based on an investor looking to purchase a mature (15-year-old) grove. The purchase price is a set at $10,000 per acre for all varieties and locations.   It is a reasonable estimate given prices for mature orange and grapefruit groves as reported in the 2005 Florida Land Value Survey (Reynolds 2005).

Table 5-2. Initial investment costs by scenario

Grove Scenario	Location	Land Cost	Irrigation Installation	Land Preparation
New Plantings*	Ridge	6,426	1,350	615
	Flatwoods	5,895	1,000	1,422
	Indian River	5,895	1,000	1,422
Replantings	Ridge	-	1,000	615
	Flatwoods	-	1,000	1,251
	Indian River	-	1,000	1,251
Mature Grove (w/o land cost)	Ridge	-	-	-
	Flatwoods	-	-	-
	Indian River	-	-	-
Mature Grove (w/ land cost)	Ridge	10,000	-	-
	Flatwoods	10,000	-	-
	Indian River	10,000	-	-

Source: IFAS Citrus Production Budgets 2005-6

* New planting uses land cost for improved pasture land from IFAS - 2005 Florida Rural Land Value Survey

Disease Assumptions

Base (No canker or greening) uses the production costs listed in Chapter 1, based on actual costs for the 2004-05 season. Tree loss rates reflect an estimated state historical average, excluding the effects of development and eradication. Tree loss rates for all disease scenarios are presented in Table 5-3.

Canker-only uses Chapter 3 estimates for increased costs due to endemic citrus canker within the state. Also following Chapter 3, a yield penalty of 10% is applied to Hamlin orange and Red Grapefruit varieties because of their increased susceptibility, and 5% to Valencia oranges. A slight increase in tree loss (10%) is added across the all varieties and ages.

Greening-only uses Chapter 3 estimates for increased costs due to intensive control of the Asian citrus psyllid insect vector of greening. This incorporates additional spray costs based on IFAS Integrated Pest Management guidelines. This analysis uses the medium rate of tree loss due to greening.

Canker and Greening (low, medium, high) uses combined estimates for costs due to each disease. This reflects some amount of overlap between management programs. Due to a lack of certainty about exactly what effects Greening will have in Florida, the analysis is calculated for three different levels (low, medium, and high) of tree loss.

Table 5-3. Tree loss percentage by scenario

TREE AGE (in years)	BASE*	GREENING			CANKER
		Low	Medium	High	
1-3	1.00%	2.00%	2.50%	4.00%	1.10%
4-11	1.50%	2.63%	3.00%	4.50%	1.65%
12+	3.50%	5.25%	6.13%	8.75%	3.85%

* Estimated average state historical tree loss (excluding effects of development and eradication)

Calculation of Breakeven Prices

After the operation of grove costs and yields is established in the model, price is applied as an exogenous variable to determine the minimum price at which, for a given cost and yield scenario, a grower or investor can expect a positive return on his or her investment. For the purposes of this analysis breakeven prices are defined as the lowest average price over a 15 year analysis where the NPV of the grove is positive. This is analyzed by computing the NPV for a range of prices. The breakeven price is not a measure of year to year profitability, but of the price level received for the grove's production where it earns in excess of its WACC or risk-adjusted discount rate. Prices below the breakeven level signify that the grove will lose money in real terms over the 15-year period, and prices above signify profits in real terms in excess of the discount rate. Due to the focus on oranges for the processing market and grapefruit for the fresh market, processed and fresh market prices are used for oranges and grapefruit, respectively. The price used to calculate gross revenue for oranges for processing is the delivered-in price per pound solid. Then picking, roadsiding, and hauling costs are subtracted to arrive at the net revenue of a box of oranges delivered to a processing plant. The price used to calculate revenue for grapefruit is a combination of the on-tree price per box for fresh and processed sales. The "on-tree price" is the value of a box of fruit already subtracted the costs of picking, roadsiding, and hauling. Grapefruit grown for the fresh market will have a certain number of fruit graded unfit for fresh sale (eliminated) and sent for processing into juice instead. The percentage of the total amount of fruit delivered to the packinghouse and sent to the fresh market is referred to as the "packout" rate, and these receive a much higher price than fruit sent for processing. The packout rate is assumed to be 60%. On-tree fresh prices in dollars per box are reported below, while eliminations sent for processing receive a price of $2/box in all scenarios.

Results of the Mixed-Age Grove Model – Breakeven Price Analysis

Under field conditions, citrus production is not nearly as deterministic as portrayed in this analysis. Citrus trees are biological organisms and thus respond (sometimes unpredictably) to changes in their environment. Climate and individual grove site characteristics have important and widely divergent effects on production and costs. Also, there is evidence that alternate bearing patterns exist for some varieties, and may significantly affect tree yields in a given season. Production costs and technologies change over time and affect operating budgets. Moreover, growers practice a range of cultural care programs, and their individual costs may be different.

Individual growers, landowners, or investors have different asset/liability positions, tax rates, capital gain/loss carry forwards, and risk preferences that change the dynamics and profitability of a citrus investment. All analysis and calculations are conducted on the basis of unleveraged cash flows before income tax in order to focus on cash flows attributable specifically to citrus operations. Also, by excluding land value appreciation through the terminal grove valuation method used, we attempt to remove distortions caused by recent surges in Florida rural land values, and arrive at a true value for growing citrus in Florida.

The scenarios and assumptions presented attempt to illustrate important aspects of the decision-making process faced by those involved in citrus production across Florida. Citrus is an investment where a large upfront cost is incurred (buying and preparing the land and planting the trees) with operating profits delayed several years until the trees become productive, and sunk costs being recouped after that, all depending on volatile fruit prices. Due to the nature of discounted cash flow analysis, changes in the upfront investment costs have a disproportionate effect on a grove's NPV. Breakeven prices for all scenarios analyzed are summarized in Table 5-4.

Table 5-4. Estimated breakeven prices across disease scenarios, varieties, and production regions

(Price* at which NPV of grove cash flows over 15 yr period is positive)

		RIDGE		FLATWOODS		INDIAN RIVER
		Valencia	Hamlin	Valencia	Hamlin	GFT
New Plantings	**Base**	$1.40	$1.30	$1.50	$1.40	$10.00
	Canker	$1.50	$1.40	$1.60	$1.50	$13.00
	Greening-low	$1.60	$1.50	$1.70	$1.60	$13.00
	G&C-low	$1.70	$1.60	$1.80	$1.70	$15.00
	G&C-med	$1.70	$1.70	$1.80	$1.80	$15.00
	G&C-high	$1.90	$1.80	$2.00	$1.90	$17.00
Replantings	**Base**	$1.00	$0.90	$1.00	$1.00	$6.00
	Canker	$1.00	$1.00	$1.10	$1.10	$8.00
	Greening-low	$1.20	$1.10	$1.20	$1.10	$8.00
	G&C-low	$1.20	$1.20	$1.20	$1.20	$10.00
	G&C-med	$1.20	$1.20	$1.30	$1.30	$10.00
	G&C-high	$1.30	$1.30	$1.40	$1.40	$11.00
Mature Grove	**Base**	$0.60	$0.60	$0.50	$0.50	$4.00
(w/o land cost)	**Canker**	$0.60	$0.60	$0.60	$0.60	$7.00
	Greening-low	$0.70	$0.70	$0.60	$0.60	$6.00
	G&C-low	$0.70	$0.80	$0.60	$0.70	$8.00
	G&C-med	$0.70	$0.80	$0.70	$0.70	$9.00
	G&C-high	$0.80	$0.80	$0.70	$0.70	$9.00
Mature Grove	**Base**	$1.00	$0.90	$0.90	$0.90	$11.00
(with land cost)	**Canker**	$1.10	$1.00	$1.00	$1.00	$14.00
	Greening-low	$1.10	$1.10	$1.10	$1.00	$13.00
	G&C-low	$1.20	$1.20	$1.10	$1.10	$15.00
	G&C-med	$1.20	$1.20	$1.10	$1.10	$15.00
	G&C-high	$1.30	$1.30	$1.20	$1.20	$17.00

***Price in $/P.S. for oranges, and $/on tree box (fresh) for GFT**

The Effect of Agricultural Land Prices on Grove Profitability

The land prices used in the new plantings scenario are for improved pasture costing $6,426 per acre for Central Florida ridge plantings, and $5,895 per acre for South West Florida and Indian River flatwoods plantings. For the mature grove with land cost scenario, a price of $10,000 per acre was applied. These prices are representative of agricultural land costs for areas available for expansion of citrus plantings. These prices were reported as of May 2005, and may have significantly appreciated since then, which would understate the negative effects of land costs on new plantings. The current rural land price market in Florida constitutes a relatively large and disproportionate upfront cost for a grower who wishes to purchase land and plant citrus.

In reality, all citrus growers have incurred a land cost at some point, and the assumption of zero land cost in the replanting and mature grove scenarios without land cost is not realistic. Some portion of this land cost should be charged against the returns of a citrus investment. As in any commercial real estate investment, many growers/landowners/investors look not only at the income generated by the property, but also appreciation of the underlying land. Since this analysis values only the returns associated with a citrus investment, and not land price appreciation, these scenarios can be thought of as establishing upper and lower bounds on the profitability of grove investment decisions facing the Florida citrus industry.

At the upper extreme, some growers/landowners/investors may evaluate a citrus grove as an investment in isolation, and only care about the returns to the citrus operation. Therefore, they may apply the entire land cost against the profitability of the grove. This is illustrated by the new plantings scenario, and could represent those growers considering citrus as their primary business. At the lower extreme, some growers/landowners/investors are purely interested in returns from land price appreciation, and view citrus as an interim income producing activity until they opt to realize their gains on the land. These owners would not apply any of the land cost against the profitability of the grove, instead viewing land cost as recouped upon eventual sale of the grove. This is illustrated by the replanting (without land cost) scenario, and could represent investors acquiring land for future non-agricultural development. The replanting scenario (without land cost) also includes growers who may have had sections of groves eradicated due to canker, but do not have the ability to sell the area due to effects on their entire grove.

The reality is that most people involved in growing citrus are somewhere in the middle; neither charging the entire land cost against the citrus investment, nor expecting the entire return on investment to come from land price appreciation. In weighing the results of this analysis, one should view the breakeven prices for new planting and mature groves with land costs against replanting and mature groves without land costs as a range between which one can expect investment or planting of citrus. According to this analysis for a Valencia orange grove on the ridge, even with the presence of endemic canker and a high rate of tree loss due to greening, a citrus investment is profitable in the range of $1.30/P.S. (for replanting without land cost) to $1.90/P.S. (for new planting with land cost). This range incorporates our conservative estimate for the residual value of the grove as explained in Chapter 4.

The Effect of Canker on Grove Profitability

The change in costs from the base scenario is the greatest (+26% and +22%) for new/replanting and a mature grove of grapefruit, respectively, because of significantly increased spray and canker-free certification costs for fresh market citrus. The increase in costs for new/replanting of Hamlin oranges (+11-13%) compared to Valencia oranges (+8-9%) reflects Hamlin's increased susceptibility to canker and required additional sprays.

Yield penalties of 10% for Hamlin oranges and grapefruit, and 5% for Valencia oranges were incorporated into the analysis to estimate canker's effect on per tree production, and tree loss rates were increased 10% over the historical average across varieties to account for the removal of infected trees. Changes in average yields due to canker are slightly higher due to the compounded effect of the yield penalty and higher tree loss.

In this analysis, canker does not dramatically increase the breakeven prices for oranges for processing. Although breakeven prices for new plantings are $1.50 to $1.60 per pound solid, once land costs are excluded, breakeven prices attributable exclusively to canker increase slightly to $1.10 per pound solid for both Hamlin and Valencia oranges. Mature plantings without land costs continue to show profitability down to $0.60 to $0.70 per pound solid for oranges. The effects of canker on oranges for processing, even the more susceptible Hamlin oranges, appears to be negligible.

Replanting of grapefruit for fresh market require a breakeven price of $9.00 per box in the presence of canker, which is historically high compared recent past non-hurricane seasons, but appears reasonably sustainable given recent developments in grapefruit supply statewide. Mature plantings without land cost continue to create significant cash flows even below $0.60-$0.70 per pound solid for sweet oranges and $7.00 per box for grapefruit. A worst-case scenario for grapefruit was performed where the packout rate was set at 40%, and this resulted in a significant effect on profitability, with breakeven prices for worst case scenario grapefruit increasing to $19.00-$11.00 per box for new and replanting, respectively, $19.00 and $9.00 per box for a mature grove with and without land costs, respectively. The worst case scenario shows the dramatic sensitivity of returns to grapefruit from changes in the packout rate.

An alternative assumption was considered with the possibility of spot picking (selective harvesting) fresh grapefruit to raise the packout rate back to 60%. An additional $.40 per box spot picking charge was incorporated for boxes of fresh market fruit. This additional charge brought the breakeven price very close to the original canker scenario (with 60% packout rate), illustrating that spot picking may be necessary to maintain grapefruit profitability in the presence of canker.

Finally, a scenario was tested where all the costs for controlling canker are incurred, but no yield penalty or packout loss is assumed. This is based on the idea that successful canker management may result in no decrease in yields or packout, and applying increased costs and decreased yields at the same time may overstate the effects of canker on an intensively managed grove. Breakeven prices increase moderately, and show the benefit of an effective canker management program in fresh market grapefruit.

Table 5-5. Grapefruit packout price vomparison

Scenario		**Packout Rate**	**Breakeven**
New Plantings	Base	60%	$ 10.00
	with Canker	60%	$ 13.00
	with Canker (worst case)	40%	$ 19.00
	with Canker (spot pick*)	60%	$ 14.00
	with Canker (no yield/packout loss)	60%	$ 12.00
Replantings	Base	60%	$ 6.00
	with Canker	60%	$ 8.00
	with Canker (worst case)	40%	$ 11.00
	with Canker (spot pick)	60%	$ 9.00
	with Canker (no yield/packout loss)	60%	$ 7.00
Mature Grove (without land cost)	Base	60%	$ 4.00
	with Canker	60%	$ 7.00
	with Canker (worst case)	40%	$ 9.00
	with Canker (spot pick)	60%	$ 7.00
	with Canker (no yield/packout loss)	60%	$ 6.00
Mature grove (with land cost)	Base	60%	$ 11.00
	with Canker	60%	$ 14.00
	with Canker (worst case)	40%	$ 19.00
	with Canker (spot pick)	60%	$ 14.00
	with Canker (no yield/packout loss)	60%	$ 12.00

* Spot picking assesses a $.40/box surcharge per box sold fresh

Further sensitivity analysis for Hamlin oranges shows that if yield loss can be controlled, there is no movement in the breakeven price. A “no management” scenario for Hamlin oranges assumes a yield loss of 15%, and illustrates a significant, but not immense, increase in the breakeven price. This suggests that profitability for a Hamlin grove selling to the processing market may not be catastrophically affected by canker.

Table 5-6. Hamlin yield-loss sensitivity

Scenario		Yield Loss	Breakeven
New Plantings	Base	0%	$1.40
	with Canker	10%	$1.50
	with Canker (no yield loss)	0%	$1.40
	with Canker (no management)	15%	$1.60
Replantings	Base	0%	$1.00
	with Canker	10%	$1.10
	with Canker (no yield loss)	0%	$1.00
	with Canker (no management)	15%	$1.20
Mature Grove (without land cost)	Base	0%	$0.50
	with Canker	10%	$0.60
	with Canker (no yield loss)	0%	$0.60
	with Canker (no management)	15%	$0.70
Mature grove (with land cost)	Base	0%	$0.90
	with Canker	10%	$1.00
	with Canker (no yield loss)	0%	$0.90
	with Canker (no management)	15%	$1.10

While increasing production costs and decreasing yields, especially for fresh market grapefruit, canker in isolation appears to have a relatively small effect on the profitability of Florida oranges for juice processing. Canker's effect on fresh market grapefruit is also significant and bordering on catastrophic if canker reduces packout rates. It can be supposed that if adequate control measures are taken, and canker is not allowed to firmly establish itself in a grove, profitability will remain mostly unchanged.

Effects of Greening on Grove Profitability

In the greening-only analysis, we assume greening increases tree loss to 2% per year for trees from 0 to 3 years of age, 2.63% for trees aged 4-11, and 5.25% for trees 12+ years. This is compared to the historic state-wide tree loss rate of 1%, 1.5%, and 3.5%, respectively. Psyllid control, increased resetting, and field inspections for greening result in an increase in production costs across all varieties and grove ages. Production costs for oranges increase (+32%-35%) for new plantings/replanting and (+25%-27%) for mature plantings. Production costs for grapefruit increase (+27%) for new planting/replanting and (+21%) for mature plantings. The difference between new planting/replanting and mature plantings reflect the disproportionate effect of greening on young tree loss, and the need to incur additional reset costs. However, mature groves suffer larger reductions in average per acre yields due to the absolute increase in the loss of older, highly productive trees.

The presence of greening appears to have a greater effect on breakeven prices compared to canker. Breakeven prices for new plantings move into the $1.50-$1.70 per pound solid range for oranges, and $13.00 per box for grapefruit. Breakeven prices for replanting are $1.10-$1.20 per pound solid for oranges, and $8.00 per box for grapefruit. Breakeven prices for mature groves without land costs are less than $.60-$.70 per pound solid for sweet oranges and $6.00 per box for grapefruit. This indicates that while greening by itself does boost production costs significantly, its effect on replanting and mature groves (without land costs) given current price levels shows that citrus remains a profitable investment.

A sensitivity analysis on tree loss rates exhibit that higher tree loss rates has a small effect on breakeven prices. Another effect of greening is that average annual tree maintenance costs actually decline as tree loss rates increase. This result relates to the use of precision agriculture in which greening kills older trees and reduces the amount of materials and labor required for their maintenance, plus harvest costs decline due to reduced yields. This trend may be an artifact of the analysis assumptions and may not reflect actual grove circumstances. Moreover, significant declines in fruit production due to the loss of mature, highly-producing trees more than offset any cost savings.

Table 5-7. Tree loss comparison for a Valencia grove on the Ridge with greening

Scenario		Avg. Expenses*	Yield	Breakeven
New Plantings	Greening-Low	$1,080.45	488	$1.60
	Greening-Medium	$1,090.11	474	$1.60
	Greening-High	$1,124.38	426	$1.70
Replantings	Greening-Low	$1,080.45	488	$1.20
	Greening-Medium	$1,090.11	474	$1.20
	Greening-High	$1,124.38	426	$1.30
Mature Grove without land cost	Greening-Low	$1,101.57	268	$0.70
	Greening-Medium	$1,090.83	258	$0.70
	Greening-High	$1,062.74	231	$0.80
Mature grove with land cost	Greening-Low	$1,101.57	268	$1.10
	Greening-Medium	$1,090.83	258	$1.20
	Greening-High	$1,062.74	231	$1.30

* Avg. Expenses are annual per acre, with yrs 3-15 for new/replantings and yrs 1-15 for mature plantings

Canker and Greening Scenarios

The current reality of citrus growing in Florida appears to be that growers are challenged with both canker and greening. The canker and greening scenarios (listed as "G&C" in Figure 5-4) were conducted for all three greening tree loss rates plus yield losses due to canker. Costs were adjusted to reflect a hypothetical combined management program.

In combination, canker and greening significantly boost production costs, decrease yields, increase breakeven prices, and, therefore, reduce profitability. With even the low rate of tree loss due to greening, breakeven prices in the new plantings scenario move to $1.60-$1.70 per pound solid for oranges, and $15.00 per box for grapefruit. Breakeven prices for the replanting scenario increase to $1.20 per pound solid for oranges and $10.00 per box for grapefruit. A mature grove without land cost increases to $0.60 and $0.80 per pound solid for oranges and $8.00 per box for grapefruit. Finally, the breakeven price for a mature grove with land cost increases to $1.10-$1.20 per pound solid for oranges and $15.00 per box for grapefruit. These prices are high by historical standards, and the possibility of achieving sustained prices above $1.50 per pound solid for oranges or $10.00 per box for grapefruit is questionable. Therefore, canker and greening act to decrease the profitability, especially of new plantings and mature groves where land must be purchased at market prices.

CHAPTER 6
SUMMARY AND CONCLUSIONS

Given the short period that the Florida citrus industry has dealt with greening and canker, it is too soon to conclude that the fundamental economics of growing citrus in Florida have changed. The challenge associated with analyzing the impact of canker, greening, and increasing rural land prices is principally the novelty of these issues to Florida growers, and a lack of historical data regarding their effects. Any economic analysis on disease effects on grove production must make assumptions by quantifying non-linear and highly complex biological phenomena into monetary or production units in order to be measured. Any economic analysis on the effects of land prices on a grove investment's profitability is inherently tied to people's expectations of the value of future income from the land plus appreciation, where assumptions must be made through the discount rate and exit capitalization rate. This analysis uses a NPV framework to evaluate the profitability of a citrus investment, makes assumptions grounded in actual historical data for production costs and yields, and then makes reasonable assumptions about the monetary effects of these new challenges to Florida growers. The value of this examination is to draw conclusions about the attractiveness of investing in citrus for the "average" citrus grower/investor, and any changes that these new challenges may cause. From the conclusions drawn about the economics of a citrus investment, we may be able to predict the future entry and exit of investors in the Florida citrus industry given the behavior of production costs and fruit prices. The limitation of this examination is the unique situation of each grower and grove, which alters any conclusions made which are based on the grove production cost and yield. In addition, the complex and untested nature of the assumptions used to quantify these new challenges introduces uncertainty into the analysis and ultimate future of the Florida citrus industry.

The assumptions about the consequences of a growing environment with endemic canker and greening on grove production were made by looking at production data from other countries and controlled scientific studies, however, the reality of what the true manifestations of these diseases will be in the distinct ecologies of Florida and these diseases' interaction with the infinitely complex biological environment will take time to study and predict. Overall, the development of new production technologies, and the experimentation and adaptation by Florida growers to the manifestations of these diseases will be the true indicator of the long-term success of the Florida citrus industry.

In the first outbreak of canker in Florida in 1910, anecdotal accounts relate many trees became rapidly infected and unproductive, which led to the statewide eradication of a significant portion of Florida citrus trees. At that time groves, however, were not irrigated, fertilizer and pesticide technology was in its infancy, and biological research into the means of infection was rudimentary compared to today. The assumptions made about yield loss and production cost increases are primarily drawn from Argentina's experience with canker, which is shares certain similarities to Florida's climate and environment, but has a significantly lower overall level of production technology. Long-term studies are needed to measure the spread and virility of infection within different Florida grove locations and by variety, the rate of decline and potential rehabilitation of infected trees, and best practices for disease control including sprays, tree-care, and grove sanitary controls. These will be the determinants of the ultimate economic consequences of growing citrus in an endemic canker environment.

Greening has devastated citrus industries in Asia and Africa, but these citrus industries were nowhere near the sophistication of Florida growers in terms of production technology, and had little access to the resources and scientific knowledge available to the Florida citrus industry.

Sprays and systemic insecticides aid in the control of the citrus psyllid insect vector, and there is a mounting body of evidence that drought and disease-stressed trees are more susceptible to infection. Most likely, this will increase the production cost of growing citrus, however, the Florida citrus industry is already moving towards irrigation and regular spray programs for most commercial groves, therefore the marginal increase in production cost of controlling for greening may be lower than the approximately 30% assumed in this analysis.

Large institutions such as the University of Florida's Institute of Food and Agricultural Sciences (IFAS), the USDA Agricultural Research Center at Ft. Pierce (USDA-ARS), the Florida Department of Agriculture and Consumer Services (FDACS), and private industry are investing significant effort into controlling and managing greening. The Florida citrus industry should soon expect results from these research endeavors, including: the establishment of best practices for greening control and management and new methods of biological/chemical control of the psyllid vector. Since greening is fatal to citrus trees, if the spread of greening between and inside groves cannot be controlled, this will have particularly negative effects on the citrus investment because of the time frame necessary for the development and profitability of the grove. If the average life expectancy for citrus trees is shortened to eight years (as was the case in Thailand) the economics of growing citrus in Florida is impractical. Therefore, this author recommends that future research efforts to determine the economic effect of greening must focus on the probability of the spread of greening between groves and control of greening within a grove. This will be the ultimate test of the assumptions used in this analysis.

The effect of land prices on grove profitability is more easily quantified because there exists a market of agricultural land prices and historical information about the behavior of land prices over time. Unfortunately, deriving an assumption for the average value of land and making comparisons between citrus properties is difficult for two reasons. First, every piece of land is unique in that it has a specific physical location which carries specific attributes such as soil, drainage, micro-climate, and distance to packinghouses or processing plants which have a direct impact upon the productivity and profitability of the grove. Second, land prices are subject to people's expectations about the future economic value derived from use or ownership of the land. Expectations about the highest and best use of many Florida citrus groves is changing as the state becomes more urbanized, and a large demand of non-agricultural users for citrus growing land (particularly in the central ridge and east coast production areas) is divorcing the value of citrus land from the value of citrus production.

This analysis attempts to quantify the value of citrus land within the net present value framework where it is assumed that the value of the land equals the present value of the discounted cash flows plus a future sale value (terminal grove value) at the end of the projection period. In this analysis, the terminal grove value is derived from the built-up exit capitalization rate method which makes it a function of citrus prices, grove production, market interest rates, the historical volatility of citrus prices, a premium for the ownership risk and additional effort required to manage an agricultural operation, a liquidity premium, and a cost of money management assumed for the additional financial structure required for the operation of a citrus investment compared to other investment options (i.e. stocks, bonds, and other financial instruments). In this formula, the one determinant more or less common to all growers is the market interest rate. All other premiums are subjective and specific to the preferences of each grower/investor, and therefore lead to different expectations of grove value.

The built-up exit cap method is still based on the NPV framework and therefore the income derived from citrus growing, however, non-agricultural demand for citrus land adds an additional appreciation to the transaction price of citrus land as the potential income from non-agricultural uses is higher than citrus, and has the effect of lowering the exit cap rate for citrus investments. This appreciation is highly property specific and is dependent on the grove's potential for conversion to non-agricultural use. In this analysis, the prices derived for the citrus exit cap rate were similar to actual market transactions from the 1999-2004 period which were taken as a sample which excluded the effects of the strong non-agricultural demand for citrus properties. Overall, this analysis attempts to exclude appreciation due to non-agricultural demand, but this appreciation exists, and may be a significant component of grower/investors subjective valuation of a citrus grove. At the time of writing, macroeconomic factors have slowed the non-agricultural demand for citrus land, however, continued tracking of Florida agricultural land prices, such as done through the IFAS Florida Rural Land Value Survey, is necessary to determine whether citrus land prices will revert to being more closely correlated with the income value of land, or a new price level is established for Florida rural land and will persist.

In this analysis, citrus prices are treated as an exogenous variable; however, they are the ultimate determinate of the profitability of the citrus investment. Analysis of citrus price trends is outside the scope of this analysis, but price is the most important component of this analysis as the effects of citrus canker, greening, and rural land prices are all compared on the basis of the relative change in the breakeven price for the citrus investment within the NPV framework. All results are relative to citrus prices, and the current high price environment makes the citrus investment profitable even with significant increases in production cost, tree loss, and land prices.

The economic model of perfect competition suggests that excess profits or losses are transitory and with no barriers to entry or exit the marginal price of selling a good equals the marginal cost of producing it, and the dynamics of production and competition in the Florida citrus industry exhibit many similarities to this model. Within this model, the NPV of the citrus investment can be considered a proxy for excess profit or losses, while the breakeven price where the NPV equals zero can be considered an equilibrium point. If current prices are expected to be above this breakeven price, then one can expect citrus acreage to expand until the additional supply forces prices down to their equilibrium level, and vice versa in the case of price expectations below the current breakeven price. In the real world, many factors conspire to complicate and cloud this fundamental relationship, such as: imperfect information, different subjective price expectations, different risk expectations (as transmitted through the discount rate), different cost structures, lags in supply response, changes in demand, foreign competition, and personal preferences.

In attempting to construct an average return to the citrus investment, we can begin to draw conclusions about the current and future prospects for the Florida citrus industry. This analysis finds that current price levels (as of Fall 2007) around $1.75 per pound solid, if sustained, make many of the scenarios examined profitable, even in the presence of canker, greening, and high land prices. The major question remaining is if the current high price environment is sustainable and citrus has established a new higher equilibrium price. In the long run, canker, greening, and higher citrus land prices should act to force up the cost of production, and therefore the equilibrium price, however, more research is needed to determine whether other factors, principally US consumer demand for citrus products and Brazilian citrus production costs will allow the price to remain higher.

The three new challenges of canker, greening, and higher citrus land prices will bring change to the Florida citrus industry, and change brings uncertainty. The myriad of other factors interrelated with this uncertainty and their respective feedback loops introduce yet more complexity into the system, and this creates a perception of greater risk in growing citrus in Florida. The Florida citrus industry has experienced and survived other adverse situations such as tristeza, the freezes of the 1980's, the low prices of the late 1990's, and others. With each crisis, there were people who doubted that the industry will ever recover, however, each time it did because Florida growers change and adapt to the new realities forced upon them. The resilience of the industry comes from the fact that there are few places in the world where the beneficial attributes of abundant land, climate, skilled citrus growers and researchers, financial resources, and a stable and consistent political and legal environment have converged to such a great extent as Florida. Once the full effects of these new challenges are felt, growing citrus in Florida will be different, but its prospects look quite good.

APPENDIX A
GEOGRAPHIC AND TOPOGRAPHIC FEATURES OF FLORIDA COMMERCIAL CITRUS PRODUCTION REGIONS

Florida commercial citrus production is generally divided into four major geographical production regions with citrus grown on two topographic features (Muraro 2004). The Central Florida citrus region includes Lake, Polk, and Highlands counties and accounts for about 25% of Florida’s total citrus acreage. The Southwest region includes Charlotte, Collier, Desoto, Glades, Hardee, Hendry, and Lee counties with 35% of total citrus acreage. The Western region includes Hillsborough, Manatee, Pasco, and Sarasota counties with 7% of total citrus acreage. The Indian River region refers to the citrus producing counties on Florida's east coast including Brevard, Indian River, Martin, Palm Beach, and St. Lucie counties with 24% of total citrus acreage (FASS 2005). The remaining citrus acreage is dispersed throughout the state with a general orientation southwards after the disastrous freezes of 1980’s destroyed much of the Northern citrus acreage.

Table A-1. Florida commercial citrus acreage, 2004-5

County	Acres	County	Acres
Hendry	29,607	Glades	3,517
Polk	24,777	Okeechobee	3,480
Highlands	21,338	Lee	2,861
DeSoto	13,578	Pasco	2,732
Collier	10,478	Orange	1,450
Hardee	10,265	Palm Beach	752
Martin	8,348	Brevard	648
St. Lucie	6,310	Sarasota	285
Charlotte	6,119	Seminole	273
Lake	4,862	Marion	267
Manatee	4,723	Hernando	224
Indian River	4,179	Volusia	169
Hillsborough	3,939	Other [1/]	92
Osceola	3,777	**Total [2/]**	**169,050**

[1/] Alachua, Citrus, Pinellas, and Putnam counties

Source: 2004-05 FASS Citrus Summary

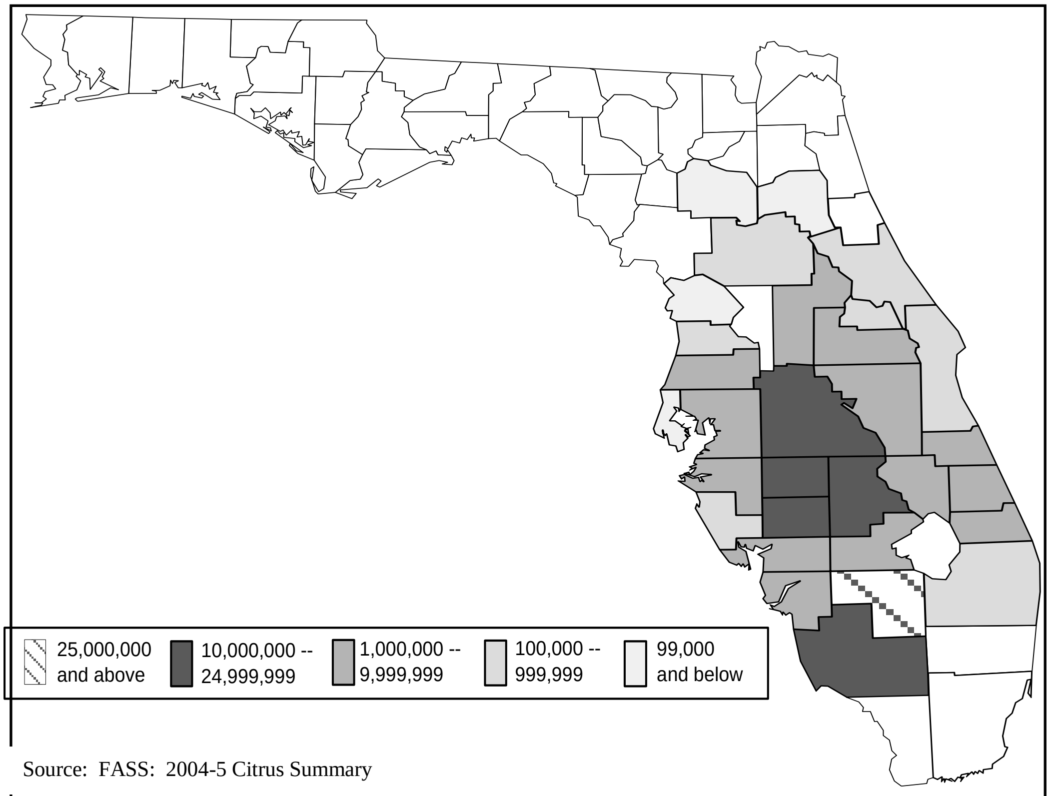
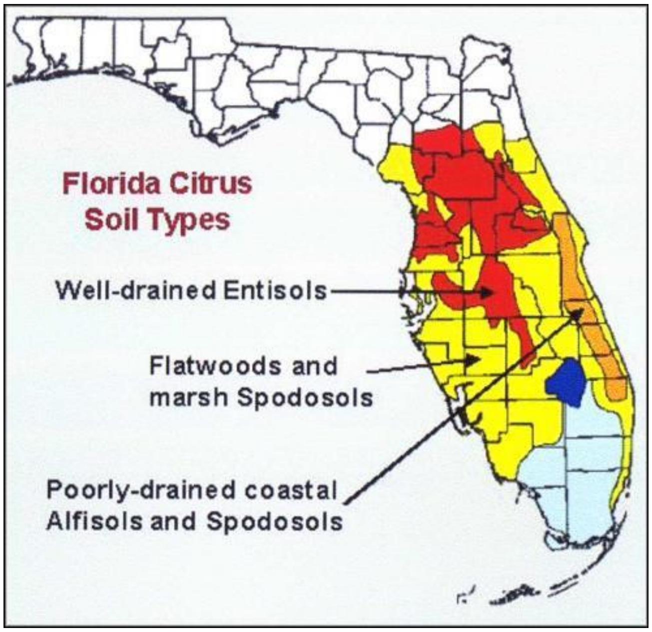


Figure A-1. Florida commercial citrus acreage map, 2005

The “Ridge” topography refers to the well-drained sandy soils (entisols) concentrated in the Central Florida region although the ridge also extends into the Western zone. These soils allow a deep extension of the citrus tree’s root zone, and trees tend to be large and productive due to the access to nutrients that the large root spread provides. The “flatwoods” topography refers to low-lying, poorly-drained soils (alfasols and spodosols) where citrus must be planted on raised furrows to allow for sufficient rooting depth. The Western, Southwest, and Indian River areas are predominantly of the flatwoods-type, but flatwoods groves exist in low lying regions of Central Florida as well. Flatwoods groves tend to grow smaller trees due to the shallower root zone, however, the Indian River region is known for its high quality grapefruit groves which thrive in the poorly drained alfisols of the eastern coast of Florida (Obreza and Collins 2002).



Source: Obreza and Collins 2002
Figure A-2. Florida citrus soil types

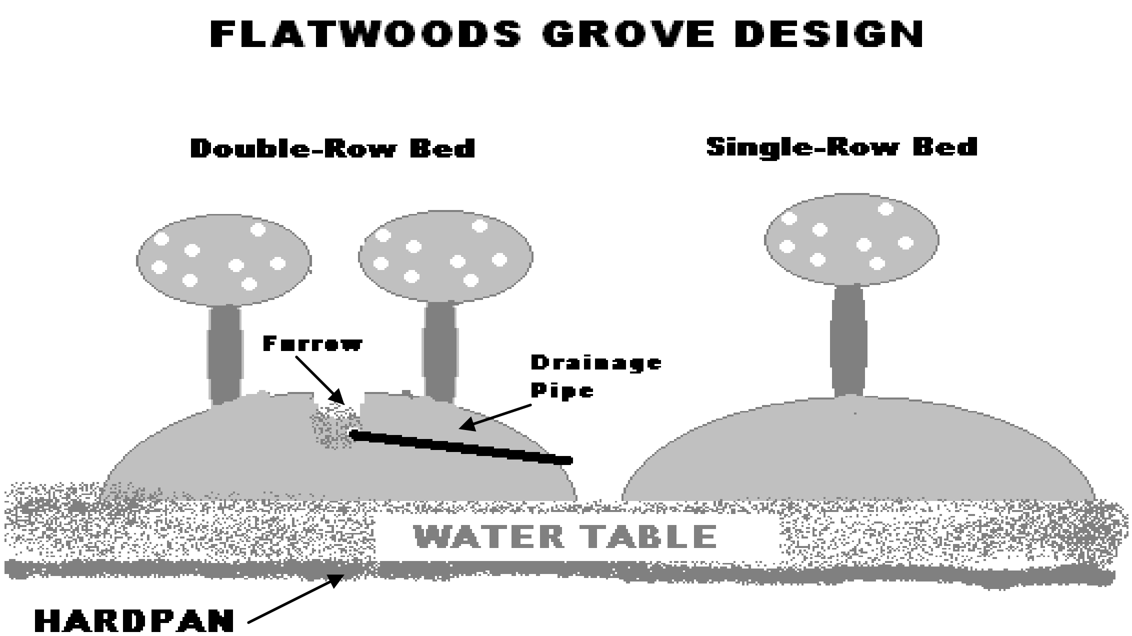


Figure A-3. Illustration of flatwoods grove design

Many flatwoods groves have a “hardpan” of an impermeable layer of clay at 20 to 48 inches of depth that does not allow for drainage of the water table, especially during periods of high rain during the summer. Citrus trees will die if their roots are submerged in water for extended periods of time. The poorly-drained flatwoods land requires the construction of beds (artificially raised rows of soil) where citrus trees may be planted so as to allow for sufficient rooting depth. Commonly, these are double-row beds that transport water away from the root zone through a network of furrows, drainage pipes, ditches, pumps, and retention ponds.

Flatwoods groves incur higher land preparation costs compared to Ridge groves, as shown in Table A-2. Changes to grove architecture and/or tree density require incurring costs for soil preparation and bed construction all over again. Therefore, this analysis assumes that new planting and replanting of citrus will incur the same land preparation costs.

Due to the excess space required by drainage management in the flatwoods, there are correspondingly fewer trees per acre of land area in the flatwoods than on the ridge, as reported in Table A-3. This analysis assumes, however, that new flatwoods and ridge groves will have the same high density tree spacing. In order to make production costs and yields comparable, this analysis reports its results per planted acre of citrus. This becomes important when land prices are factored in because prices are per acre. Land price is adjusted by dividing it by the percentage utilization in citrus, assumed to be 95% for ridge groves and 75% for the flatwoods. This converts the land price into per acre of planted citrus terms.

Table A-2. Average citrus land preparation costs, 2002-03 season

	FLATWOODS	RIDGE
Land Clearing (pasture)	195	350
Laser Leveling	275	n/a
Bedding: 2-row	130	n/a
Soil Amendment: Dolomite (1 ton)	35	35
Soil Amendment: Super K (400lbs)	30	30
Canals, Ditches, Dykes	195	n/a
Reservoirs and Roads	155	n/a
Throw-out pumps	55	n/a
Culverts	85	n/a
Middle Drop Drainage	105	n/a
Drainage Tiles	150	n/a
Soil Fumigation	n/a	330
Cover Crop	12	12
Total:	**$ 1,422**	**$ 757**

Source: Muraro 2004

Table A-3. Land utilization of Florida citrus groves

	Ridge		Flatwoods	
	Range	Average	Range	Average
Planted in Citrus	90-97%	95%	55-85%	71%
Roads and Service Areas	3-10%	5%	3-15%	6%
Canals and Ditches	0	0	5-10%	8%
Water Retention	0	0	10-30%	15%

Source: Muraro 2004

APPENDIX B
PARAMETERS USED IN THE ANALYSIS

In this appendix, input data used in the grove investment analysis is presented. This includes establishment cost for new plantings, reset costs, grove maintenance costs for both a newly established and mature grove. This data is presented in Tables B-1 through B-4

Table B-1. Solidset costs by disease scenario for a Valencia orange grove in the ridge

General Grove Information:	Valencia Ridge Grove w/ No Canker or Greening				Valencia Ridge Grove w/ Canker				Valencia Ridge Grove w/ Greening			
Solidset Planted Trees (cost / acre)	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 1**	**Year 2**	**Year 3**	**Year 4**
Irrigation	83.09	91.39	99.70	108.01	83.09	91.39	99.70	108.01	83.09	91.39	99.70	108.01
Fertilizer	102.39	112.62	122.86	133.10	102.39	112.62	122.86	133.10	102.39	112.62	122.86	133.10
Fertilizer Through Irrigation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Spraying	66.12	72.73	79.34	85.96	76.60	84.26	91.92	99.58	167.78	184.55	201.33	218.11
Tree Wrap	50.00	0.00	0.00	0.00	50.00	0.00	0.00	0.00	50.00	0.00	0.00	0.00
Tree Wrap (annual maintenance)	37.50	37.50	37.50	0.00	37.50	37.50	37.50	0.00	37.50	37.50	37.50	0.00
Sprouting (labor)	30.00	30.00	0.00	0.00	30.00	30.00	0.00	0.00	30.00	30.00	0.00	0.00
Cultivation/Mowing	79.60	79.50	95.40	95.40	79.60	79.50	95.40	95.40	79.60	79.50	95.40	95.40
Herbicide	67.50	67.50	75.00	82.50	67.50	67.50	75.00	82.50	67.50	67.50	75.00	82.50
Ridomil/Aliette	52.50	52.50	0.00	0.00	52.50	52.50	0.00	0.00	52.50	52.50	0.00	0.00
Tree Cost (bare root)	1,485.00	0.00	0.00	0.00	1,485.00	0.00	0.00	0.00	1,485.00	0.00	0.00	0.00
Stake, Plant, and Water Tree	261.36	0.00	0.00	0.00	261.36	0.00	0.00	0.00	261.36	0.00	0.00	0.00
Cold Protection	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Disease-Related Costs (due to Canker and Greening)	0.00	0.00	0.00	0.00	45.24	45.24	45.24	45.24	62.76	62.76	62.76	62.76
Miscellaneous	10.37	10.87	10.20	10.10	11.49	12.01	11.35	11.28	13.66	14.37	13.89	14.00
Supervision and Overhead	26.45	27.73	26.00	25.75	29.29	30.63	28.95	28.76	34.84	36.63	35.42	35.69
Total:	**2,351.88**	**582.36**	**546.00**	**540.82**	**2,411.55**	**643.15**	**607.92**	**603.86**	**2,527.96**	**769.33**	**743.87**	**749.57**

Table B-2. Reset costs by disease scenario for a Valencia located in the ridge

	Without Citrus Canker or Greening			With Citrus Canker			With Citrus Greening			With Citrus Canker & Greening		
	Year 1	**Year 2**	**Year 3**	**Year 1**	**Year 2**	**Year 3**	**Year 1**	**Year 2**	**Year 3**	**Year 1**	**Year 2**	**Year 3**
Supplemental Maintenance Costs	3.59	2.96	2.34	4.85	4.71	4.63	4.83	4.69	4.6	5.67	6.24	7.07
Site Preparation	4.18	0	0	4.18	0	0	4.18	0	0	4.18	0	0
Tree Cost (bare root)	7.5	0	0	7.5	0	0	7.5	0	0	7.5	0	0
Stake, Plant, and Water Tree	2.55	0	0	2.55	0	0	2.55	0	0	2.55	0	0
Tree Removal Cost	4.45	0	0	4.45	0	0	4.45	0	0	4.45	0	0
Other Costs	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL:	**22.27**	**2.96**	**2.34**	**23.53**	**4.71**	**4.63**	**23.51**	**4.69**	**4.6**	**24.35**	**6.24**	**7.07**

Table B-3. New planting/replanting operating costs for a Valencia grove (without canker or greening)

Grove Care Costs	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
Cultivation and Herbicide	0.00	177.10	177.00	170.40	177.90	132.42	141.88	151.34	160.79	170.25	189.17	189.17	189.17	189.17	189.17	189.17
Spraying	0.00	118.62	125.23	79.34	85.96	92.57	99.18	105.79	112.40	119.02	132.24	132.24	132.24	132.24	132.24	132.24
Fertilization	0.00	102.39	112.62	122.86	133.10	143.34	153.58	163.82	174.05	184.29	204.77	204.77	204.77	204.77	204.77	204.77
Pruning/Hedging	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	204.77	204.77	204.77	204.77	204.77	204.77	204.77	204.77
Irrigation	0.00	83.09	91.39	99.70	108.01	116.32	124.63	132.94	141.24	149.55	166.17	166.17	166.17	166.17	166.17	166.17
Heating/Cold Protection Costs	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Disease-Related Costs	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other Costs	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Miscellaneous	0.00	10.37	10.87	10.20	10.10	9.69	10.39	11.08	15.87	16.56	17.94	17.94	17.94	17.94	17.94	17.94
Supervision and Overhead	0.00	26.45	27.73	26.00	25.75	24.72	26.48	28.25	40.46	42.22	45.75	45.75	45.75	45.75	45.75	45.75
Total Grove Care Costs:	**0.00**	**518.02**	**544.86**	**508.50**	**540.82**	**519.05**	**556.13**	**593.21**	**849.59**	**886.66**	**960.82**	**960.82**	**960.82**	**960.82**	**960.82**	**960.82**
Planting Costs:																
Solidset	0.00	1,833.86	37.50	37.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Reset/Rehab. Tree Removal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Planting Costs:	**0.00**	**1,833.86**	**37.50**	**37.50**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Property Taxes	30.00	30.75	31.52	32.31	33.11	33.94	34.79	35.66	36.55	37.47	38.40	39.36	40.35	41.36	42.39	43.45
Interest on Operating Expenses	0.90	71.48	18.42	17.35	17.22	16.59	17.73	18.87	26.58	27.72	29.98	30.01	30.03	30.07	30.10	30.13
Total Operating Costs (Acre):	**30.90**	**2,454.11**	**632.29**	**595.66**	**591.15**	**569.59**	**608.65**	**647.73**	**912.73**	**951.85**	**1,029.19**	**1,030.18**	**1,031.20**	**1,032.24**	**1,033.30**	**1,034.39**

Table B-4. Operating costs for a mature (15+ year old)Valencia grove located on the ridge (without canker or greening)

Grove Care Costs:	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
Cultivation and Herbicide	189.17	182.55	176.16	169.99	164.04	158.30	152.76	147.42	142.26	137.28	132.47	127.84	123.36	119.04	114.88	110.86
Spraying	132.24	127.61	123.15	118.84	114.68	110.66	106.79	103.05	99.44	95.96	92.61	89.36	86.24	83.22	80.31	77.49
Fertilization	204.77	197.60	190.69	184.01	177.57	171.36	165.36	159.57	153.99	148.60	143.40	138.38	133.53	128.86	124.35	120.00
Hedging	204.77	197.60	190.69	184.01	177.57	171.36	165.36	159.57	153.99	148.60	143.40	138.38	133.53	128.86	124.35	120.00
Irrigation	166.17	160.35	154.74	149.33	144.10	139.06	134.19	129.49	124.96	120.59	116.37	112.29	108.36	104.57	100.91	97.38
Heating Costs/Cold Protection	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Disease-related Costs	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other Costs	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Miscellaneous	17.94	17.31	16.71	16.12	15.56	15.01	14.49	13.98	13.49	13.02	12.56	12.12	11.70	11.29	10.90	10.51
Supervision and Overhead	45.75	44.15	42.61	41.12	39.68	38.29	36.95	35.65	34.41	33.20	32.04	30.92	29.84	28.79	27.78	26.81
Grove Care Costs (original trees):	**960.82**	**927.19**	**894.74**	**863.42**	**833.20**	**804.04**	**775.90**	**748.74**	**722.53**	**697.25**	**672.84**	**649.29**	**626.57**	**604.64**	**583.48**	**563.05**
Planting Costs:																
Solidset	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Reset Tree Costs	0.00	0.00	229.74	30.23	242.17	62.69	267.22	93.41	292.37	126.64	333.86	175.43	285.08	211.54	368.05	248.59
Planting Costs (Reset trees):	**0.00**	**0.00**	**229.74**	**30.23**	**242.17**	**62.69**	**267.22**	**93.41**	**292.37**	**126.64**	**333.86**	**175.43**	**285.08**	**211.54**	**368.05**	**248.59**
Property Taxes	30.00	30.75	31.52	32.31	33.11	33.94	34.79	35.66	36.55	37.47	38.40	39.36	40.35	41.36	42.39	43.45
Interest on Operating Expenses	0.90	28.74	34.68	27.78	33.25	27.02	32.34	26.33	31.54	25.84	31.35	25.92	28.56	25.73	29.82	25.65
Total Operating Costs (Acre):	**991.72**	**986.68**	**1,190.68**	**953.74**	**1,141.74**	**927.69**	**1,110.25**	**904.14**	**1,083.00**	**887.20**	**1,076.46**	**890.01**	**980.56**	**883.26**	**1,023.73**	**880.75**

The costs for original trees are shown under "Grove Care Costs (original trees)" and costs for resetting an maintaining reset trees is shown under "Planting Costs (Reset Trees)".

Table B-5. Harvest and other per box costs

Picking & Roadsiding		$1.64
Transportation to processing plant		0.47
DOC box assessment		0.185
Additional Cost for Fresh Market/Spot Picking:		1.50
	Total Processed Market Cost	$2.30
	Total Fresh Market Cost	$3.80

Table B-6. Adjustment factors for grove care cost by tree age

Grove Care Cost Category	**Cost Adjustment (Yes/No)**	**Age of Trees in Analysis**	**COST ADJUSTMENT PERCENTAGE as % of Mature Grove Costs**
Cultivation and Herbicide	Yes	**1**	50%
Spray/Chemical Costs	Yes	**2**	55%
Fertilization	Yes	**3**	60%
Pruning/Hedging	Yes	**4**	65%
Irrigation and Ditch Maintenance	Yes	**5**	70%
Heating Cost for Cold Protection:	Yes	**6**	75%
Disease-Related Costs due to Canker/Greening	Yes	**7**	80%
Other Costs	Yes	**8**	85%
Supervision and Overhead	No	**9**	90%
Miscellaneous	No	**10**	100%
-		**11**	100%
		12	100%
		13	100%
		14	100%
		15+	100%

Table B-7. Annual irrigation expense (ridge/flatwoods comparison)

		($/Acre)
Variable Operating Expense (Diesel)		59.44
Annual Maintenance		50.17
Fixed-Depreciation Expense (non-cash)		56.56
	"Ridge" Total:	**166.17**
(Additional for Flatwoods)		
Clean Ditches (Weed Control)		14.19
Ditch and Canal Maintenance		15.06
Water Control (Pump water in/out of Ditches and Canals)		13.21
	"Flatwoods" and "Indian River" Total:	**208.63**

Source: 2004-5 IFAS Citrus Production Budgets

Table B-8. Average per acre citrus land preparation costs (ridge/flatwoods comparison)

	FLATWOODS	RIDGE
Land Clearing (pasture)	195	350
Laser Leveling	275	n/a
Bedding: 2-row	130	n/a
Soil Amendment: Dolomite (1 ton)	35	35
Soil Amendment: Super K (400lbs)	30	30
Canals, Ditches, Dykes	195	n/a
Reservoirs and Roads	155	n/a
Throw-out pumps	55	n/a
Culverts	85	n/a
Middle Drop Drainage	105	n/a
Drainage Tiles	150	n/a
Soil Fumigation	n/a	330
Cover Crop	12	12
Total:	**1,422**	**757**

Source: 2004-5 IFAS Citrus Production Budgets

Table B-9. Property tax levy for top five citrus producing counties, 2003

County	Millage Rate	A.P.R. (%)*
Polk	17.322	1.73%
Hendry	21.062	2.11%
St. Lucie	20.855	2.09%
Highlands	18.477	1.85%

***A.P.R. is annual percentage rate of the millage rate converted into a percent**

source: Hodges et al. 2003

Table B-10. Property tax analysis assumptions

	Mature Grove	New Planting/Replanting
Market Value*	$ 5,721.00	$ 2,934.00
Assessment Value ($/acre)	$ 3,600.00	$ 1,550.00
Millage Rate ($/$1000 of value)	19.5	19.5
Effective A.P.R.(%)	1.95%	1.95%
Annual Property Tax ($/acre)	$ 70.20	$ 30.23

* Market value is 2003 value for Central Florida mature oranges and improved pasture for new/replanting

Source: Hodges et al. (2003) and 2003 IFAS Florida Rural Land Value Survey

Table B-11. USDA average yields by variety and production district, 1999-2004 average

VALENCIA ORANGES

	3-5 Years	6-8 Years	9-13 Years	14-23 Years	24+ Years
Indian River	0.8	1.3	1.75	2.03	2.68
North&Central	1.03	1.72	2.45	3.59	5.67
Western	1.5	2.22	2.89	3.28	4.26
Southern	0.94	1.67	2.1	2.45	4.07
Statewide	1.09	1.73	2.28	2.83	4.33

EARLY/MIDSEASON ORANGES

	3-5 Years	6-8 Years	9-13 Years	14-23 Years	24+ Years
Indian River	0.65	1.51	1.87	2.49	3.03
North&Central	1.36	2.3	3.46	4.75	6.4
Western	1.27	1.74	3.33	4.58	5.32
Southern	1.14	1.9	2.82	3.62	4.11
Statewide	1.16	1.96	3.1	4.13	4.94

COLORED GRAPEFRUIT

	3-5 Years	6-8 Years	9-13 Years	14-23 Years	24+ Years
Indian River	1.41	2.18	3.14	4.37	5.01
North&Central	2.67	3.2	4.68	7.35	8.36
Western	2.43	1.64	4.27	2.68	7.18
Southern	2.96	4.1	4.11	4.72	5.67
Statewide	1.86	2.8	3.62	4.58	5.24

Source: 2003-4 Florida Citrus Summary

Table B-12. Rootstock study for Valencia oranges on ridge and flatwoods sites

		AVON PARK (145 Trees/Acre)				INDIANTOWN (102 Trees/Acre)			
		SWINGLE		CARRIZO		SWINGLE		CARRIZO	
SEASON	TREE AGE	Box/Tree	P.S./Box	Box/Tree	P.S./Box	Box/Tree	P.S./Box	Box/Tree	P.S./Box
1980/81	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1981/82	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1982/83	3	0.24	6.56	0.26	6.57	0.00	0.00	0.00	0.00
1983/84	4	0.97	4.96	1.26	4.81	0.20	5.03	0.30	4.63
1984/85	5	1.04	5.92	1.57	5.82	0.40	5.03	0.80	4.63
1985/86	6	1.36	6.04	1.85	5.70	1.00	5.03	1.70	4.63
1986/87	7	1.58	6.14	2.93	6.22	1.60	7.68	2.20	8.04
1987/88	8	1.69	6.26	1.95	6.22	2.20	6.89	3.00	6.75
1988/89	9	3.25	5.98	5.62	5.89	3.60	5.94	4.60	6.21
1989/90	10	2.67	6.51	2.98	6.06	2.10	7.05	4.00	7.30
1990/91	11	4.06	6.54	6.00	6.44	3.00	7.15	4.60	7.60
1991/92	12	3.89	6.59	4.59	6.30	2.30	7.65	4.00	7.45
1992/93	13	3.75	6.56	5.65	6.37	4.50	6.94	6.70	6.69
1993/94	14	4.01	7.65	7.22	6.92	4.70	7.01	6.40	7.08
1994/95	15	3.91	7.18	6.53	6.78	3.00	6.77	5.30	6.91

Source: Dr. William Castle, IFAS Lake Alfred CREC

Table B-13. Fruit and juice yield by variety used in the analysis

	Hamlin Orange		Valencia Orange		Colored Grapefruit
Spacing:	22' x 10'		22' x 10'		25' x 13'
Trees/Acre:	198		198		134
Tree Age	Boxes Per Tree	P.S. Per Tree	Boxes Per Tree	P.S. Per Tree	Boxes Per Tree
1	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00
3	0.55	5.00	0.46	5.00	0.68
4	0.91	5.25	0.77	5.50	1.14
5	1.28	5.50	1.08	6.00	1.60
6	1.73	6.00	1.47	6.50	2.17
7	2.19	6.25	1.85	7.00	2.73
8	2.55	6.25	2.16	7.00	3.19
9	2.92	6.25	2.47	7.00	3.65
10	3.28	6.25	2.78	7.00	4.10
11	3.61	6.25	3.06	7.00	4.51
12	3.61	6.25	3.06	7.00	4.51
13	3.61	6.25	3.06	7.00	4.51
14	3.61	6.25	3.06	7.00	4.51
15	3.61	6.25	3.06	7.00	4.51

Table B-14. Mature grove production costs with canker by production region

	RIDGE		FLATWOODS		
	VALENCIA	HAMLIN	VALENCIA	HAMLIN	GFT
Cultivation and Herbicide	189.17	189.17	189.17	189.17	189.17
Spray Program	132.24	132.24	141.19	141.19	383.17
Fertilization	204.77	204.77	204.77	204.77	157.00
Pruning	40.06	40.06	40.06	40.06	52.13
Irrigation and Ditch Maintenance	166.17	166.17	208.63	208.63	208.63
Miscellaneous	14.65	14.65	15.68	15.68	19.80
Supervision and Overhead	36.62	36.62	39.19	39.19	49.51
Water-drainage Tax	-	-	-	-	60.00
Total Grove Care (before canker)	783.68	783.68	838.69	838.69	1,119.41
Additional Disease Related Costs					
Canker Field Inspections	17.52	17.52	17.52	17.52	17.52
Additional Spray Program	20.96	57.12	12.01	48.17	35.26
Citrus Canker Decontamination Costs	27.72	27.72	27.72	27.72	27.72
Yearly Cost to Establish & Maintenance for Windbreak	-	-	-	-	11.47
DPI Fresh Market Citrus Certification Costs*	-	-	-	-	60.00
Additional Packhouse Certification Costs*	-	-	-	-	40.50
Additional Supervision/Misc. Costs	4.63	7.17	4.01	6.54	13.47
Total Grove Care (after greening)	**854.51**	**893.20**	**899.94**	**938.64**	**1,325.35**
% Change from Base	9%	14%	7%	12%	18%

* Only incurred for fresh market fruit once trees reach commerical production age

Table B-15. Mature grove production costs with greening by production region

	RIDGE		**FLATWOODS**		
	VALENCIA	HAMLIN	VALENCIA	HAMLIN	GFT
Cultivation and Herbicide	189.17	189.17	189.17	189.17	189.17
Spray Program	132.24	132.24	141.19	141.19	383.17
Fertilization	204.77	204.77	204.77	204.77	157.00
Pruning	40.06	40.06	40.06	40.06	52.13
Irrigation and Ditch Maintenance	166.17	166.17	208.63	208.63	208.63
Miscellaneous	14.65	14.65	15.68	15.68	19.80
Supervision and Overhead	36.62	36.62	39.19	39.19	49.51
Water-drainage Tax	-	-	-	-	60.00
Total Grove Care (before greening)	783.68	783.68	838.69	838.69	1,119.41
Additional Disease Related Costs					
Greening Field Inspections	35.04	35.04	35.04	35.04	35.04
Additional Spray Program	203.31	203.31	194.36	194.36	156.74
Additional Supervision/Misc. Costs	16.68	16.68	16.06	16.06	13.42
Total Grove Care (after greening)	**1,038.71**	**1,038.71**	**1,084.15**	**1,084.15**	**1,324.61**
% Change from Base	33%	33%	29%	29%	18%

Table B-16. Mature grove production costs with canker and greening

	RIDGE		FLATWOODS		
	VALENCIA	HAMLIN	VALENCIA	HAMLIN	GFT
Cultivation and Herbicide	189.17	189.17	189.17	189.17	189.17
Spray Program	132.24	132.24	141.19	141.19	383.17
Fertilization	204.77	204.77	204.77	204.77	157.00
Pruning	40.06	40.06	40.06	40.06	52.13
Irrigation and Ditch Maintenance	166.17	166.17	208.63	208.63	208.63
Miscellaneous	14.65	14.65	15.68	15.68	19.80
Supervision and Overhead	36.62	36.62	39.19	39.19	49.51
Water-drainage Tax	-	-	-	-	60.00
Total Grove Care (before canker & greening)	783.68	783.68	838.69	838.69	1,119.41
Additional Disease Related Costs					
Canker/Greening Field Inspections	35.04	35.04	35.04	35.04	35.04
Additional Spray Program	203.31	203.31	194.36	194.36	156.74
Citrus Canker Decontamination Costs	27.72	27.72	27.72	27.72	27.72
Yearly Cost to Establish & Maintenance for Windbreak	-	-	-	-	11.47
DPI Fresh Market Citrus Certification Costs*	-	-	-	-	60.00
Additional Packhouse Certification Costs*	-	-	-	-	40.50
Additional Supervision/Misc. Costs	18.62	18.62	18.00	18.00	23.20
Total Grove Care (after greening)	**1,068.37**	**1,068.37**	**1,113.81**	**1,113.81**	**1,474.08**
% Change from Base	36%	36%	33%	33%	32%

* Only incurred for fresh market fruit once trees reach commercial production age

Table B-17. Spray schedule and costs by variety and disease scenario

	Base		Canker			Greening		Canker & Greening		
Type/Purpose	**Oranges***	**GFT**	**Valencia**	**Hamlin**	**GFT**	**Oranges***	**GFT**	**Valencia**	**Hamlin**	**GFT**
Winter-Early Spring						118.63	118.63	118.63	118.63	118.63
Systemic Insecticide (Temik/Admire)										
Psyllid control										
Spring-Post Bloom (at first flush)		99.58		36.16	36.16		36.16		36.16	36.16
Oil/Copper										
Rust mite/Leafminer/Fungicide										
Spring-Post Bloom (3-weeks after petal fall)	83.43	37.86	54.5	54.5	54.5	54.5	54.5	54.5	54.5	54.5
Copper/Micronutrients/Lorsban										
Leafminer/Rust mite/ Scale										
Spring-Post Bloom (6-weeks after petal fall)		37.86			59.06		59.06			59.06
Copper/Micromite										
Scab/Melanose/Rust mite										
Summer (late May)		96.6			109.14		109.14			109.14
Oil/Miticide										
Rust mite/Scale										
Summer (late May/early June)	53.63	53.82	49.35	49.35	49.35	49.35	49.35	49.35	49.35	49.35
Copper/Oil/Miticide										
Rust mite/Scale/Fungicide										
Summer (early July/ mid August)			49.35	49.35	49.35	70.69	70.69	70.69	70.69	70.69
Oil/Copper/Lorsban/Micronut.										
Rust mite/Scale/Fungicide/Psyllid										
Fall (mid November)		57.46			60.87	42.38	42.38	42.38	42.38	42.38
Vendex or Danitol										
Rust mite/psyllid control										
TOTAL ($/acre)	**137.06**	**383.18**	**153.20**	**189.36**	**418.43**	**335.55**	**539.91**	**335.55**	**371.71**	**539.91**

* Oranges not separated by variety because of identical spray programs. All orange costs representative of ridge
source: IFAS 2004-5 Citrus Production Budgets adjusted by Ronald Muraro for recommended spray programs by disease

APPENDIX C
SELECTED RESULTS

Results from various scenarios are shown in Tables C-1 through C-6.

Table C-1. Tree age distribution of a solidset Valencia grove, base scenario

Period of Analysis

	Age of Original Planted Trees															
PERIOD	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
0	0															
1	0	1.000														
2	0	0.000	0.990													
3	0	0.020	0.000	0.980												
4	0	0.000	0.020	0.000	0.970											
5	0	0.025	0.000	0.020	0.000	0.956										
6	0	0.000	0.025	0.000	0.019	0.000	0.941									
7	0	0.029	0.000	0.024	0.000	0.019	0.000	0.927								
8	0	0.000	0.029	0.000	0.024	0.000	0.019	0.000	0.913							
9	0	0.029	0.000	0.029	0.000	0.024	0.000	0.018	0.000	0.900						
10	0	0.000	0.029	0.000	0.029	0.000	0.023	0.000	0.018	0.000	0.886					
11	0	0.015	0.000	0.029	0.000	0.028	0.000	0.023	0.000	0.018	0.000	0.873				
12	0	0.000	0.015	0.000	0.028	0.000	0.028	0.000	0.023	0.000	0.018	0.000	0.842			
13	0	0.039	0.000	0.014	0.000	0.028	0.000	0.027	0.000	0.022	0.000	0.017	0.000	0.813		
14	0	0.000	0.038	0.000	0.014	0.000	0.028	0.000	0.027	0.000	0.022	0.000	0.017	0.000	0.784	
15	0	0.050	0.000	0.038	0.000	0.014	0.000	0.027	0.000	0.026	0.000	0.022	0.000	0.016	0.000	0.757

Example: In year 7 of the analysis, 92.7% of the 7 year-old originally planted trees remain. Additionally, 1.9% of 5-year-old reset trees remain, plus 3-year-old and 1-year-old reset trees, with 2.5% and 2.9% remaining, respectively.

Table C-2. Yields for a solidset Valencia grove- base scenario

Period of Analysis

		Age of Original Planted Trees															Total	Pound
PERIOD	**Boxes/Age**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**Boxes**	**Solids**
0	0.00																0	0.00
1	0.00																0	0.00
2	0.00																0	0.00
3	0.46			89													89	446.34
4	0.77			0.0	148												148	813.62
5	1.08			1.8	0.0	204											206	1236.92
6	1.47			0.0	2.9	0.0	274										277	1800.18
7	1.85			2.2	0.0	4.1	0.0	340									346	2421.59
8	2.16			0.0	3.7	0.0	5.5	0.0	391								400	2798.23
9	2.47			2.6	0.0	5.1	0.0	6.8	0.0	440							454	3181.09
10	2.78			0.0	4.4	0.0	6.8	0.0	7.8	0.0	488						507	3546.90
11	3.06			2.6	0.0	6.0	0.0	8.4	0.0	8.8	0.0	529					554	3880.25
12	3.06			0.0	4.3	0.0	8.1	0.0	9.7	0.0	9.7	0.0	510				542	3794.99
13	3.06			1.3	0.0	6.0	0.0	10.0	0.0	10.9	0.0	10.5	0.0	492			531	3718.47
14	3.06			0.0	2.2	0.0	8.0	0.0	11.5	0.0	12.1	0.0	10.2	0.0	475		519	3634.40
15	3.06			3.5	0.0	3.0	0.0	10.0	0.0	13.0	0.0	13.1	0.0	9.8	0	459	511	3576.40

Example: In year 7 of the analysis, the originally planted trees are seven years old, and produce 1.85 boxes per tree totaling 340 boxes. Additionally, there are 5 year-old reset trees producing 1.08 boxes/tree totaling 4.1 boxes, and 3 year-old resets producing .46 boxes per tree totaling 2.2 boxes. The total production for year 7 is 346 boxes per acre, or 2422 pound solids per acre.

Table C-3. Reset strategy beginning/ending tree distributions under disease scenarios

	Non-bearing/ Empty Spaces	1-3 yrs	4-10yrs	11-15yrs	15+ yrs	Total # of Bearing Trees
Mature Grove Beginning Tree Age Distribution - Valencia on Ridge						
Number	3	12	9	4	84	109
Percent	3%	11%	8%	3%	75%	
Mature Grove Ending Tree Age Distribution - Valencia on Ridge						
With resetting & without greening						
Number	6	12	17	11	66	106
Percent	6%	11%	15%	10%	59%	
Without resetting & without greening						
Number	46	-	-	-	66	66
Percent	41%	0%	0%	0%	59%	
With resetting & with greening						
Number	10	19	25	13	44	102
Percent	9%	17%	23%	12%	40%	
Without resetting & with greening						
Number	68	-	-	-	44	44
Percent	60%	0%	0%	0%	40%	

Table C-4. Estimated breakeven price by scenario

(Price* at which NPV of grove cash flows over 15-year period is positive)

		RIDGE		FLATWOODS		INDIAN RIVER
		Valencia	Hamlin	Valencia	Hamlin	GFT
New Plantings	Base	$1.40	$1.30	$1.50	$1.40	$10.00
	Canker	$1.50	$1.40	$1.60	$1.50	$13.00
	Greening-low	$1.60	$1.50	$1.70	$1.60	$13.00
	G&C-low	$1.70	$1.60	$1.80	$1.70	$15.00
	G&C-med	$1.70	$1.70	$1.80	$1.80	$15.00
	G&C-high	$1.90	$1.80	$2.00	$1.90	$17.00
Replantings	Base	$1.00	$0.90	$1.00	$1.00	$6.00
	Canker	$1.00	$1.00	$1.10	$1.10	$8.00
	Greening-low	$1.20	$1.10	$1.20	$1.10	$8.00
	G&C-low	$1.20	$1.20	$1.20	$1.20	$10.00
	G&C-med	$1.20	$1.20	$1.30	$1.30	$10.00
	G&C-high	$1.30	$1.30	$1.40	$1.40	$11.00
Mature Grove (w/o land cost)	Base	$0.60	$0.60	$0.50	$0.50	$4.00
	Canker	$0.60	$0.60	$0.60	$0.60	$7.00
	Greening-low	$0.70	$0.70	$0.60	$0.60	$6.00
	G&C-low	$0.70	$0.80	$0.60	$0.70	$8.00
	G&C-med	$0.70	$0.80	$0.70	$0.70	$9.00
	G&C-high	$0.80	$0.80	$0.70	$0.70	$9.00
Mature Grove (with land cost)	Base	$1.00	$0.90	$0.90	$0.90	$11.00
	Canker	$1.10	$1.00	$1.00	$1.00	$14.00
	Greening-low	$1.10	$1.10	$1.10	$1.00	$13.00
	G&C-low	$1.20	$1.20	$1.10	$1.10	$15.00
	G&C-med	$1.20	$1.20	$1.10	$1.10	$15.00
	G&C-high	$1.30	$1.30	$1.20	$1.20	$17.00

*****Price in $/P.S. for oranges, and $/on tree box (fresh) for GFT

Table C-5. Average grove production costs by scenario and disease

TYPE OF PLANTING/GROVE	VARIETY	LOCATION	BASE	CANKER		GREENING-LOW		CANKER&GREENING LOW		CANKER&GREENINGMED		CANKER&GREENING HIGH	
			Cost/ Acre	Cost/ Acre	% Δ from Base	Cost/ Acre	% Δ from Base	Cost/ Acre	% Δ from Base	Cost/ Acre	% Δ from Base	Cost/ Acre	% Δ from Base
NEW PLANTINGS/REPLANTINGS*	VALENCIA	RIDGE	\873	873	9%	1,080	35%	1,080	35%	1,090	36%	1,124	41%
NEW PLANTINGS/REPLANTINGS	HAMLIN	RIDGE	906	906	13%	1,080	35%	1,113	39%	1,122	40%	1,155	44%
NEW PLANTINGS/REPLANTINGS	VALENCIA	FLATWOODS	912	912	8%	1,118	32%	1,118	32%	1,127	33%	1,160	37%
NEW PLANTINGS/REPLANTINGS	HAMLIN	FLATWOODS	945	945	11%	1,118	32%	1,151	36%	1,159	37%	1,190	40%
NEW PLANTINGS/REPLANTINGS	GRAPEFRUIT	INDIAN RIVER	1,268	1,268	26%	1,284	27%	1,394	38%	1,392	38%	1,387	38%
MATURE PLANTINGS**	VALENCIA	RIDGE	932	932	8%	1,102	27%	1,105	28%	1,095	26%	1,068	23%
MATURE PLANTINGS	HAMLIN	RIDGE	966	966	12%	1,102	27%	1,137	31%	1,126	30%	1,097	27%
MATURE PLANTINGS	VALENCIA	FLATWOODS	999	999	6%	1,175	25%	1,179	26%	1,173	25%	1,157	23%
MATURE PLANTINGS	HAMLIN	FLATWOODS	1,033	1,033	10%	1,175	25%	1,211	29%	1,204	28%	1,186	26%
MATURE PLANTINGS	GRAPEFRUIT	INDIAN RIVER	1,340	1,340	22%	1,327	21%	1,432	30%	1,409	28%	1,347	22%

* New Plantings/Replantings production costs exclude year 1 establishment costs

** Mature grove averages production costs from 15-30 year-old trees

Table C-6. Average gove yields by scenario and disease

TYPE OF PLANTING/GROVE	VARIETY	LOCATION	BASE	CANKER		GREENING-LOW		C & G* LOW		C &G MED		C & G HIGH	
			Boxes/ Acre	Boxes/ Acre	% Δ from Base	Boxes/ Acre	% Δ from Base	Boxes/ Acre	% Δ from Base	Boxes/ Acre	% Δ from Base	Boxes/ Acre	% Δ from Base
NEW PLANTINGS/REPLANTINGS**	VALENCIA	RIDGE	527	495	-6%	488	-7%	464	-12%	450	-15%	405	-23%
NEW PLANTINGS/REPLANTINGS	HAMLIN	RIDGE	622	553	-11%	576	-7%	518	-17%	503	-19%	453	-27%
NEW PLANTINGS/REPLANTINGS	VALENCIA	FLATWOODS	527	495	-6%	488	-7%	464	-12%	450	-15%	405	-23%
NEW PLANTINGS/REPLANTINGS	HAMLIN	FLATWOODS	622	553	-11%	576	-7%	518	-17%	503	-19%	453	-27%
NEW PLANTINGS/REPLANTINGS	GRAPEFRUIT	INDIAN RIVER	526	468	-11%	487	-7%	438	-17%	425	-19%	383	-27%
MATURE PLANTINGS***	VALENCIA	RIDGE	290	271	-7%	268	-8%	255	-12%	245	-16%	220	-24%
MATURE PLANTINGS	HAMLIN	RIDGE	342	303	-11%	316	-8%	285	-17%	274	-20%	246	-28%
MATURE PLANTINGS	VALENCIA	FLATWOODS	375	351	-6%	347	-7%	330	-12%	317	-15%	285	-24%
MATURE PLANTINGS	HAMLIN	FLATWOODS	443	392	-12%	409	-8%	368	-17%	355	-20%	318	-28%
MATURE PLANTINGS	GRAPEFRUIT	INDIAN RIVER	362	321	-11%	335	-7%	302	-17%	290	-20%	260	-28%

* “C & G” indicates situations where both canker and greening are present in the grove.

** New Plantings/Replantings yield averages for tree age 4 to 15

*** Mature plantings assume 119 trees/acre for ridge, 145 trees/acre for flatwoods, 95 trees/acre for GFT on flatwoods.

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BIOGRAPHICAL SKETCH

Jordan Malugen is a native of the state of California and completed his Bachelor of Arts in International Political Economy at the Colorado College in Colorado Springs, Colorado. Prior to entering the University of Florida's Food and Resource Economics Master's program, he held positions at the First National Bank in San Diego as an intern in both the foreign exchange and corporate lending areas, U.S. Foreign Commercial Service in Buenos Aires, Argentina as an intern, The Bank of New York, New York as an international banking associate, DSF Global as head of finance and Peruvian market development manager, and Garuda Thai Corporation as office manager. During his time at the University of Florida, he was the recipient of the Ross Travel Award for research into the Brazilian citrus industry in conjunction with the International Agricultural Trade and Policy Center (IATPC). Upon leaving the program, Mr. Malugen began working for Prudential Real Estate Investors Latin America where he is an associate portfolio manager. Currently, Mr. Malugen resides in Rio de Janeiro, Brazil.