An Economic Assessment of the Future Prospects for the Florida Citrus Industry

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An Economic Assessment of the Future Prospects for the Florida Citrus Industry

Executive Summary

This study provides an overview of the current status and future prospects of the Florida citrus industry. The industry currently faces two relatively new diseases: citrus canker and citrus greening. It also must compete with increasing urbanization in the state which has resulted in increasing land values. Citrus canker has also impacted the citrus tree nursery industry in the state. New regulations will likely result in major changes in how nursery trees are produced in the state.

The Florida citrus industry remains an important supplier of citrus products to both the U.S. and world market. Florida is the world's second largest producing region for orange juice. Along with São Paulo, Brazil, these two regions account for over 80% of world orange-juice production. Despite a major loss in bearing grapefruit trees, Florida is the world's largest producer of both fresh and processed grapefruit products.

The study consists of four major parts that address various aspects of Florida's citrus industry. These parts are (1) analysis of the economic impact of the industry on the Florida economy, (2) assessment of the future structure of the Florida citrus tree nursery industry, (3) analysis of the future prospects for new investment in Florida citrus, and (4) long-run production and price forecasts for Florida citrus under varying assumptions that relate to supply issues including the impact of canker and greening, higher undeveloped land prices, supply issues confronting São Paulo, Brazil and alternative future demand assumptions.

The citrus varieties that are explicitly analyzed are early and midseason oranges, Valencia oranges, and red and white seedless grapefruit. For the orange varieties, the analysis focuses on fruit used for processing. For the grapefruit varieties, both the fresh and processed markets are considered.

The Florida citrus industry is a major economic force in the state. Using the *IMPLAN* input-output model, the total estimated economic impact of the citrus industry on the economy of Florida in the 2003-04 season was $9.3 billion and generated over 76,000 jobs in the state. The citrus industry is a prime driver of the economy of many counties in central and south-central Florida.

The analysis of the Florida citrus tree nursery industry is preliminary in that the Division of Plant Industry (DPI) of the Florida Department of Agriculture and Consumer Services (FDACS) will ultimately establish regulations regarding the production of nursery trees in the state. Based upon preliminary discussions, however, it is estimated that new regulations will increase the cost of new trees by $2.00 to $2.50 per tree. With the large number of trees destroyed as a part of the canker eradication effort, new citrus trees will be in short supply for the next two to three years. The new regulations are tentatively not slated to take effect until January 1, 2008.

The investment analysis considered three situations: new grove development including the purchase of land, replanting of property that does not include land costs, and returns to existing mature groves. With the large increase in the price of undeveloped land, if an investor needs to purchase land to expand citrus production, inclusion of a land charge increases the breakeven price for processed oranges by $.40 per pound solids (PS). The effects of citrus canker do not have a large effect on returns to processed orange production but add

approximately $2.00 per box on-tree to the breakeven price for grapefruit. The economic costs associated with greening are estimated in three scenarios in which the death loss resulting from greening is varied. A high rate of death loss resulting from greening substantially affects the breakeven price in all land ownership arrangements. All estimated breakeven prices for processed orange production across all scenarios, however, are $2.00 per PS or less.

In the long run price/production forecast section, processed oranges are evaluated in a framework that encompasses the world orange-juice market including supply responses in Brazil. The results suggest that greening under a high-death-loss assumption has strong negative implications for Florida, with production in Florida decreasing, but stabilizing, at 123 million boxes. With increased death loss in both Brazil and Florida, however, processed orange prices would rise substantially. Brazilian citrus growers must not only deal with greening but also face competition for farmland in São Paulo from sugarcane used for ethanol. Simultaneous imposition of greening, canker, high Florida land values, and higher sugar prices in São Paulo suggests that Florida orange production may be around 152 million boxes at the end of the 15-year projection period considered with São Paulo production at approximately 300 million boxes. This level of production results in FOB FCOJ prices in Florida exceeding $2.00 per single-strength-equivalent (SSE) gallon (1.029 PS per SSE gallon). With higher prices more than offsetting lower production levels in this scenario, the estimated total economic impact of the citrus industry on the economy of Florida in 2020-21 is $10.8 billion, 16% greater than the 2003-04 level. The citrus industry, however, will likely account for a smaller percentage of the overall Florida economy in upcoming years with the state economy expected to grow relatively rapidly.

It is acknowledged that high prices may well stimulate processed orange production in other regions, but it would take at least 20 years for other regions to develop sufficient infrastructure to allow them to become a major supplier of orange juice to the world market. Weaker demand assumptions were also considered. No demand growth for orange juice has little effect on production over the projection period but does result in the buildup of inventories and decreases Florida FOB FCOJ prices by about $.14 per SSE gallon. With the various supply constraints in this study, consumption of orange juice and other citrus products is limited, and the impact of demand is largely reflected by price as opposed to the quantity consumed. Lower demand results in lower prices, a factor that becomes important for the present situation where production costs are increasing as a result of canker, greening and higher land costs— weak demand may result in prices that do not cover cost increases. Under all scenarios considered, survival of the Florida citrus industry is suggested although its equilibrium size is affected by assumptions regarding canker and greening, high land prices, the impact of higher sugar prices in São Paulo, and demand growth.

An Economic Assessment of the Future Prospects For the Florida Citrus Industry

<u>Section I</u>
Introduction

Florida is the largest citrus-producing state in the United States and the second largest citrus-producing region in the world following the state of São Paulo, Brazil. Florida has historically accounted for over 40% of world grapefruit production and dominates the world market in the trade of both fresh and processed grapefruit ("Citrus Summary," Florida Agricultural Statistics Service (FASS), and Food and Agriculture Organization (FAO) of the United Nations). Florida and São Paulo collectively account for over 80% of world orange-juice production with São Paulo dominating world trade, but Florida being the primary supplier to both the United States and Canada (FAO). Florida is also an important supplier to the U.S. domestic fresh market of specialty varieties including navel oranges, and early and late tangerines.

Given Florida's importance as a supplier of fresh and processed citrus products to the world market, challenges facing the Florida citrus industry on several fronts will have major implications for both the production and price of a number of citrus products. The objective of this document is to evaluate the implications of both diseases and increases in costs of factors of production that now confront the industry.

The Florida citrus industry has faced major challenges in the past, most notably, the series of freezes that struck the industry in the 1980s. Both bearing tree numbers and production declined by 40% between 1975 and 1986 as freezes destroyed a large portion of the industry in

Lake, Orange, and Pasco counties. The industry recovered, however, moving south, adopting micro-sprinkler irrigation, and planting new varieties and rootstocks. As a result, in the 1997-98 season, 13.7 million tons of citrus was produced, easily breaking the old production record of 11.8 million tons established in the 1979-80 season (FASS).

The 2003-04 season saw the second largest citrus crop produced in Florida. With demand issues affecting orange-juice consumption, grower prices fell to levels not seen since the 1960s. A malaise affected the industry as producers were concerned about their economic survival. The late summer of 2004 witnessed hurricane Charley, the first hurricane to strike the main citrus-producing area of the state since 1962. This storm was followed by hurricanes Frances and Jeanne in September. These three storms served to spread Asian citrus canker into a large portion of the commercial citrus-producing region of the state.

Citrus canker has been a periodic problem affecting Florida citrus since the early 20th century. A new infestation found its way to Dade County in 1995 and had spread into southwest and southeast Florida by 2004. The Florida Department of Agriculture and Consumer Services (FDACS) had initiated an eradication program in an attempt to rid the state of the disease. The hurricanes served to thwart the efforts of FDACS. With the spread of citrus canker into new areas by 2006, the number of acres slated for eradication grew dramatically reaching 90,180 acres or about 12% of the total production area. Additionally, it has been estimated that, as a result of hurricane Wilma in October 2005, canker may further spread to more than twice this amount. In early 2006, the Animal and Plant Health and Inspection Service of the United States Department of Agriculture (APHIS-USDA) elected to halt its compensation program to growers whose trees had been eradicated due to the presence of citrus canker. At present, it is unclear what policy FDACS will implement in its efforts to either eliminate or suppress citrus canker in Florida.

In August of 2005, citrus greening was detected in dooryard exotic tropicals near Homestead, Florida. Citrus greening (also known as Huanglongbing) is a destructive disease that until 2002 was confined to Asia. In the Western Hemisphere, it was first found in São Paulo, Brazil. Two years later it surfaced in Florida and has now moved into the commercial citrus-producing area of the state. Given the powerful effect that citrus greening has had on Asian citrus production, it represents another threat to the viability of commercial citrus production in Florida.

Citrus canker and citrus greening have also affected the production of new citrus trees in Florida. The main source of budwood for citrus nursery growers in the state has been destroyed after citrus canker was found. It is estimated that 62% of citrus nursery trees found in Florida in the late summer of 2005 were eradicated due to exposure to citrus canker. The presence of citrus canker and greening will require new greenhouse investments and practices to ensure disease-free nursery trees.

Collectively, citrus canker and citrus greening are major challenges to citrus producers in the state. Another issue has, however, surfaced which will also serve to increase the cost of producing citrus in the state. Land values in the state have risen dramatically in response to low interest rates and population growth. A recent report by John Reynolds, Professor Emeritus, Food and Resource Economics, University of Florida, indicates that undeveloped land values in South and Central Florida increased by roughly 80% from 2004 to 2005. This rapid increase in factor prices has major implications for agricultural production in the state.

In this study, three issues are analyzed: (1) the impact of citrus canker, (2) the impact of citrus greening, and (3) the impact of increased raw-land values on the economics of producing citrus in Florida. These threats are evaluated from three perspectives: (1) future directions for the

Florida citrus nursery industry, (2) analysis of replant/new grove investment, and (3) long-run price and production forecasts.

In the analysis of future directions for the Florida citrus nursery, this study is preliminary in that FDACS will issue new regulations related to citrus-nursery-tree production in Florida after this report has been released. In this study, alternative solutions for the Florida citrus nursery are discussed and their possible implications on citrus growers are evaluated.

The collective impact of citrus canker and citrus greening is to reduce per-tree yields, increase cost of production, and increase tree mortality. These effects combined with increased raw-land costs will adversely affect the profitability of citrus production in the state. An analysis is conducted to evaluate individually and collectively the effect of canker, greening, and increased land values on the rate of return on new grove development and replanting.

Both citrus canker and citrus greening will affect the volume of fruit produced in Florida. Increased raw-land values will also affect the willingness of investors to commit capital to citrus production in Florida. With both canker and greening present in Brazil, its orange production will also be impacted. In Section VII of the study, each of the three factors are incorporated into long-run models of the world, following previous work on the orange-juice market (Spreen, Muraro and Fairchild; Spreen, Brewster and Brown) and the market for Florida grapefruit (Busby and Spreen). The output of these models provides estimates of long-run production and price impacts. In the orange-juice analysis, the competitive position of Florida vis-α-vis São Paulo is also considered.

Section II
Historical Perspective of Citrus Production in Florida

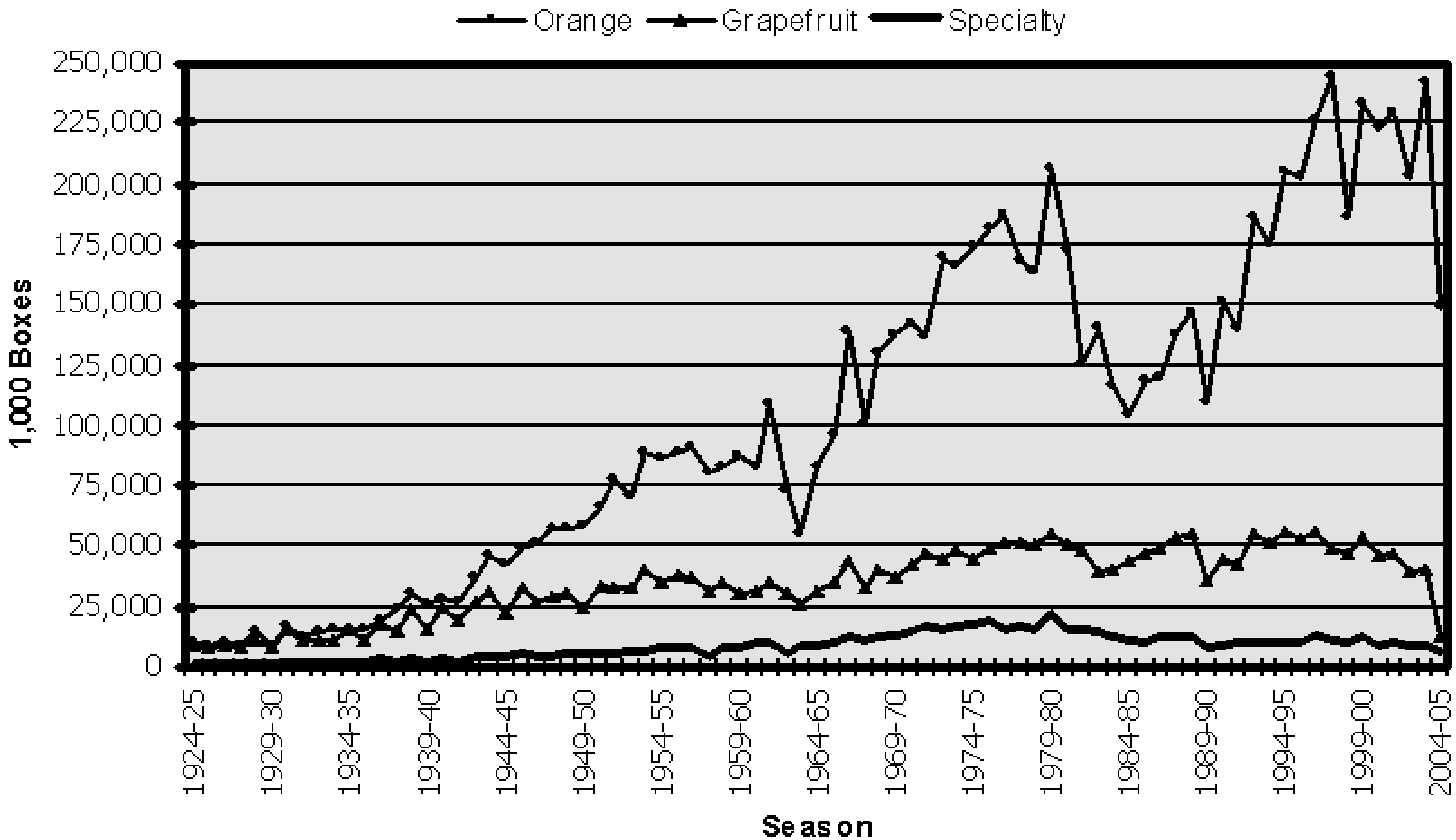
by
Thomas H. Spreen

Citrus production in Florida dates back to the colonization of the state by the Spaniards in the 15th century. Issues related to transportation served to restrain the size of the industry until the early 20th century when railroads provided a means to ship fresh citrus from Florida to destinations in the Northeast and Midwest regions of the United States. In 1935, the Florida Department of Citrus was created through a state marketing order and initiated advertising programs to expand the demand for orange juice and other citrus products in the United States. By 1950, orange production was 66 million boxes with total citrus production at 105 million boxes. The advent of frozen concentrated orange juice (FCOJ) after World War II provided a new impetus for the industry. FCOJ provided a means to (1) store orange juice from the harvest season into other time periods, (2) provided a way to produce a product with a consistent taste, and (3) offered new modes of transport and new retail package alternatives to the consumer. By 1970, orange production had grown to 142 million boxes, more than double 20 years earlier, and with increasing grapefruit production, total citrus production was nearly 200 million boxes. (See Figure 2-1).

By 1970, however, other factors had surfaced which ultimately would impact the industry. Retail consumption of orange juice began shifting from purchase of FCOJ towards ready-to-serve reconstituted orange juice (known as RECON). After the devastating freeze of 1962, Florida citrus interests helped initiate FCOJ production in São Paulo, Brazil. The decade of the 1970s, however, saw increasing citrus production in the State of Florida with orange

Figure 2-1.

Total Florida Citrus Production, by Variety



production peaking at 206.7 million boxes in the 1979-80 season and all citrus production setting a new production record of 283.6 million boxes in that same season.

The decade of the 1980s saw successive freezes in 1981 and 1982, followed by the massive freezes of December 1983 and January 1985. As recovery began from those freezes, another destructive freeze came again in December 1989. Citrus production plummeted. The orange crop in 1989-90 was 110.2 million boxes and total citrus production was 154.2 million boxes. Given Florida's dominance in world citrus production at that time, the freezes of the 1980s were followed by an extended period of high prices for all citrus varieties. Florida saw its industry shift south into the Flatwoods area of southwest Florida. Consequently, tree numbers rebounded and production recovered. In the 1997-98 season, a new production record was established at 244 million boxes of oranges and 304 million boxes of all citrus varieties.

During this same period, citrus production in other countries expanded as well. Production in the state of São Paulo, Brazil grew rapidly. By the mid-1990s, São Paulo replaced Florida as the largest producing region for orange juice. Rapid growth in production was also observed in Mexico, Belize, Costa Rica, and Cuba among others. Belize and Costa Rica benefited from the signing of the Caribbean Basin Economic Recovery Act (also known as the Caribbean Basin Initiative or CBI) which eliminated the tariffs imposed on imports of orange juice, other fresh and processed citrus products, among other goods, from CBI countries. According to data from the Food and Agriculture Organization (FAO) of the United Nations, world orange production increased from an annual average of 40 million metric tons (MT) over the 1986-88 period to over 58 million MT over the 1996-98 period.

With rapid growth in world orange production, prices declined. These lower prices served to slow the tree planting process in all major citrus-production regions including Florida

and São Paulo. With a near record Florida orange crop of 242 million boxes in the 2003-04 season, prices fell to levels not seen in Florida since the 1970s. The hurricanes that visited Florida in 2004 caused a rapid shift in the opposite direction in the supply-demand balance. These hurricanes were also responsible for the spread of citrus canker throughout much of the commercial citrus-producing region of the state. With another hurricane crossing peninsular Florida again in 2005, prices increased to higher levels with the cash market for processed oranges reaching levels comparable to the freeze-affected years of the 1980s. The combined effects of hurricanes and citrus canker reduced the Florida grapefruit crop to levels not seen since the Great Depression and consequently resulted in record high prices.

Section III
Diseases and Other Factors Affecting Florida Citrus Production

by
Thomas H. Spreen and Ronald P. Muraro

With its humid climate, Florida citrus growers have long dealt with several diseases that affect citrus trees. Among the more prominent diseases are blight (also known as decline), greasy spot, and phytophthora (also known as root rot). All of these diseases serve to reduce yields, and blight and phytophthora can result in tree death. Additionally, citrus tristeza, a viral disease that affects sour orange rootstock trees and results in rapid decline and tree death, is present in Florida. The brown citrus aphid, the main vector for spreading citrus tristeza, found its way to Florida in the late 1990s. The aphid allowed efficient transmission of citrus tristeza resulting in the death of millions of trees.

The two new diseases, citrus canker and citrus greening, represent new threats to the viability of citrus production in the state. The state fought a long battle against citrus canker in the first half of the 20th century, eventually eradicating the disease in 1933. Citrus canker was re-introduced into Florida in 1995.

Citrus Canker

Citrus canker is a bacterial disease which is mainly spread by human contact and wind driven rain. After it is introduction into Dade County, Florida, the disease remained undetected until it found its way into the lime-producing area near Homestead. Through primarily human contact, the disease was spread sporadically into the commercial-citrus-production area, and FDACS initiated a policy of eradication in an attempt to eliminate the disease from the state.

Eradication efforts met resistance in urban areas especially in Broward County. A focal point of the controversy was the policy of eradicating all citrus trees in a 1,900-foot radius around any positive (infected) tree. In a rural setting, this meant that approximately 260 acres of citrus trees could be destroyed if canker was found in a solid-set area. In a residential setting, the 1,900-foot rule meant that backyard citrus trees up to 1/3 mile away from a positive tree needed to be destroyed. Homeowners in Broward County elected to pursue legal means to force changes to or stoppage of the eradication program. In 2004, the Florida Legislature enacted a law requiring that the 1,900-foot rule be enforced if a tree infected with citrus canker was found.

The hurricanes of 2004 thwarted the efforts of FDACS. The hurricanes served to spread the disease throughout much of the commercial-citrus-production area. Over 90,000 acres of commercial citrus were slated to be eradicated in early January 2006 when APHIS-USDA, announced that they were discontinuing the compensation to growers whose trees were destroyed due to the citrus canker eradication program. This announcement resulted in FDACS halting tree eradication. At the time this paper was being prepared, FDACS had not determined its new policy regarding the citrus canker eradication program.

Citrus canker attacks citrus trees through its fruit and leaves. Lesions form which serve to cause premature fruit drop. Disfigurement of the fruit makes it unsuitable for the fresh market. Quarantines imposed by other citrus-producing regions on fruit imported from canker-endemic production regions impose additional costs on fresh fruit growers. In addition to lowering yields, there is likely some increase in tree mortality as canker may open pathways for other diseases. In order to suppress canker, copper spray is generally considered the best policy. Planting of windbreaks likely serves to slow the spread of the disease via wind-driven rain. Additional copper sprays and windbreaks are the two main management interventions observed in

citrus-production regions with endemic citrus canker (Muraro, et al.). In order to stem the spread of the disease via human contact and equipment, citrus groves are fenced and security is established so that all people and equipment are sprayed with copper sulfate upon entry and exit from the property. These measures impose additional production costs.

Yield impacts resulting from endemic citrus canker are not known. Scientists acknowledge that the humid conditions found in Florida are conducive to the spread of citrus canker. Yet, the consensus is that yields will be moderately affected. In this study, it is assumed that Valencia orange trees will incur yield losses of 5% and all other varieties will experience losses of 10%. Packout, however, should see a larger effect with packout percentages decreasing by 1/3. For example, varieties which currently show packout percentages of 60% will decrease to 40% with citrus canker.

Although increased tree mortality is not the major concern with endemic citrus canker, it is expected that death losses will increase with the presence of the disease. In this study, it is assumed that citrus canker will increase tree mortality by 10% above historical loss rates across all citrus varieties and all age groups.

In the analysis, the incidence and spread of canker is assumed to vary across regions of the State. Four regions are specified in the model: South, West, Indian River, and the North & Central. These regions are roughly the same as those for which FASS reports yields per tree.[1]

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[1] The regions included the following counties—South: Charlotte, Collier, Glades, Hendry, Lee and Okeechobee; West: DeSoto, Hardee, Hillsborough, Manatee, and Sarasota; Indian River: Indian River, St. Lucie, Martin, Palm Beach, Brevard, Volusia, and Flagler (parts of some counties are not included, as defined by FASS); North & Central: all other counties.

Initially, the Indian River region is assumed to have the highest incidence of canker, followed by lower incidences in the South and West regions, and in the North & Central region. See Table 3-1 for the assumptions across regions and upcoming seasons.

Table 3-1. Assumed incidence of citrus canker in Florida citrus groves.

Season	Region[a]			
	Southern	West	Indian River	North & Central
	- - - - - - - - - - - - - - - - - - % of acreage with canker - - - - - - - - - - - - - - - - - -			
2005-06	10	10	75	8
2006-07	25	25	100	15
2007-08	50	50	100	25
2008-09	75	75	100	40
2009-10	100	100	100	60
2010-11	100	100	100	80
2011-12 & after	100	100	100	100

[a]The regions included the following counties—South: Charlotte, Collier, Glades, Hendry, Lee and Okeechobee; West: DeSoto, Hardee, Hillsborough, Manatee, and Sarasota; Indian River: Indian River, St. Lucie, Martin, Palm Beach, Brevard, Volusia, and Flagler (parts of some counties are not included, as defined by FASS); North & Central: all other counties.

Citrus Greening

Citrus greening is a disease which had been confined to Asia. The disease was found in the state of São Paulo, Brazil in 2003. In August of 2005, it was found near Homestead, Florida in a farm growing exotic tropical fruit. A survey conducted in November and December of 2005 found greening in a commercial grove in DeSoto County. The disease has since been found in

several of the commercial-production areas of Florida. In 2005, APHIS-USDA announced it would not pursue an eradication program similar to that attempted to eradicate citrus canker.

The main vector for citrus greening is a leaf feeding insect known as the psyllid. Psyllids were present in Florida before the greening inoculum arrived in 2005. Since psyllids appear to prefer new growth for feeding, citrus greening will likely have a larger affect on young trees. Previous experience with citrus greening in Asia suggests that this is a potentially devastating disease for citrus.

In this study, it is assumed that the presence of greening will have several effects. First, grove care costs will increase due to increased scouting, removal of all positive trees, reset of lost trees, and additional insecticide costs as growers actively suppress the psyllid population. At the present time, it appears that Admire is the most effective agent against psyllids for young trees and Temik offers the best protection for older trees. Even with an active program of psyllid suppression, two scenarios are analyzed with respect to increased tree mortality. One scenario considered is that tree mortality increases by 100% compared to base levels in nonbearing trees, by 75% in trees ages 4 though 11, and 50% in trees 12 years and older. The second scenario is that tree mortality increases by 2-2/3 to 3 times those of Scenario 1, depending on tree age. This approach is taken because so little is known regarding the impact of greening on tree mortality in Florida. The range of tree mortality being considered is less than the levels observed in areas of Asia that have endemic greening.

Because of the large increases in death loss being considered, no yield effect is factored in for greening. This is because it is assumed that any tree found with symptoms of greening will be immediately removed. Therefore, the tree will not be allowed to go through a period of decline.

In this study, a logistic function was used to model the spread of greening. In the immediate upcoming years, the incidence of greening is assumed to be relatively low. The spread of this disease is then assumed to be relatively rapid, leveling off as the incidence approaches 100%. See Table 3-2 for the assumptions on the spread of greening over the projection period.

Table 3-2. Assumed incidence of greening in Florida citrus groves.

Season	Percent of Acreage with Greening
2005-06	0.0
2006-07	0.0
2007-08	0.2
2008-09	1.0
2009-10	4.4
2010-11	17.7
2011-12	50.0
2012-13	82.3
2013-14	95.6
2014-15	99.0
2015-16	99.8
2016-17 & after	100.0

The presence of greening in an area does not mean all trees are in the same symptom-reflecting stage or that all trees necessarily have the disease, but that the Asia citrus psyllid, an insect vector that spreads the disease, is present and tree-loss rates can be expected to increase as subsequently discussed.

Urban Development and Increasing Land Values

Since the hurricanes of 2004, the state of Florida has witnessed a rapid increase in the value of both undeveloped and agricultural land in the state. While one might argue that such a run-up in land values is a perverse response to hurricanes, it has occurred and has been documented by Reynolds. In a rural land value survey conducted annually by the University of Florida, Reynolds reported that agricultural land in South and Central Florida increased in value between $1,866 per acre and $4,633 per acre from May 2004 to May 2005, depending on the land use. Since this report, further increases in land values have likely occurred. Cost increases of this magnitude will have an impact on the economics of agricultural use of that land including citrus. Grove investment analysis is conducted in this paper to document the effect on the rate of return associated with new grove investment. Given the impact of urbanization on the location of citrus production in southern California, it is known that increasing underlying land values have profound impacts on the location of agricultural production.

A more complicated question relates to the desire of development interests to "inventory" large tracts of land for future development. There is a belief that a portion of the land price inflation that has been accruing in Florida is a result of such activity by speculators. There is a question regarding the planning horizon of these individuals and how best to manage that land until it is suitable for conversion to development. Given the agricultural use property assessment in place in Florida, one means to reduce the holding costs of such land is to keep it in agricultural production. An interesting question arises: is it more profitable to place the land in a more intensive use, e.g. citrus production and its associated risks or to use the land for cattle grazing? Answering that question is beyond the scope of this study. It is clear, however, that the approach

taken by land speculators with respect to management of large land tracts placed in inventory for future development will affect the supply of land available for citrus production.

<u>Section IV</u>
The Economic Impacts of the Florida Citrus Industry in 2003-04

by
Alan W. Hodges, Mohammad Rahmani and W. David Mulkey

Methods

The total economic impacts of the Florida citrus industry in 2003-04 were evaluated using published values for citrus fruit, processed juices and by-products, together with a regional input-output model for Florida. Data for citrus fruits were taken from reports by the USDA-National Agricultural Statistics Service, and the Florida Department of Citrus, while data on the value of processed citrus juices and by-products were available from Florida Citrus Mutual.

The *IMPLAN Pro* economic impact and social accounting software package, licensed to the University of Florida by the Minnesota Implan Group, Inc. (MIG) was used to develop a regional input-output model of the Florida economy with adjustments for the citrus industry. *IMPLAN*, which is an acronym for *Impact Analysis for Planning*, is an input-output modeling software package that enables the estimation of the overall effects of changes in final demand for one or more industries in a defined region through the use of economic multipliers. Multipliers measure total changes in output, income, employment, or value added, for a given change in direct output or employment, and estimate three components of total change within the local area: direct effects represent the initial change in the industry in question; indirect effects represent changes in inter-industry transactions as supplying industries respond to changes in demands from the directly affected industries; and induced effects reflect changes in local

spending that result from income changes in the directly and indirectly affected industry sectors. Social Accounting Matrix (SAM) multipliers in *IMPLAN* also account for transfer payments such as social security, welfare, and retirement pensions, income taxes, and savings by households. Total effects multipliers usually range from 1.5 to 2.5, meaning that there will be a total change of 1.5 to 2.5 times for a given unit change.

Regional models may be constructed with *IMPLAN* for a single county, groups of contiguous counties, or for an entire state or region. In this case, the region of interest was defined as the state of Florida. Regional data for the model represent 2003, the most recent information available from the United States National Accounts and Regional Economic Information System maintained by the U.S. Commerce Department. Information used in the model is specific to the state for industry output, employment, income, and trade, while national averages are used for transactions between industries. The model was constructed with all social accounts endogenous, including households, governments (state/local, federal), and capital investment.

Three industry sectors in *IMPLAN* were used to analyze the Florida citrus industry: fruit farming (#5), frozen foods (#60), and canned fruit and vegetable juices (#61). These industry sectors are defined based on the primary product or service produced, under the North American Industry Classification System (NAICS). The output value of each major form of product was specified as an impact event in the appropriate industry sector: fresh market citrus fruit in the fruit farming sector, frozen citrus juices in the frozen foods sector, and chilled citrus juices in the canned juices sector. The value of processed by-products were entered as impact events to the two processing sectors in proportion to their primary product values. Also, the export and local consumption values of citrus juice and by-products were treated separately; only the direct

impacts were considered for local consumption, since these values do not necessarily represent a change in overall regional economic activity.

Several adjustments were made to the *IMPLAN* model to reflect the special characteristics of the Florida citrus industry, as distinguished from the national economy for fruit farming and frozen/canned food processing, which includes a variety of other food commodities. The set of inputs purchased by these industries, known as production functions, are what drives the estimates of indirect and induced impacts. The production functions for the two processing sectors were adjusted such that purchases from the fruit farming sector represented 38% of output, and other agricultural sectors were removed from the model. The production function for the fruit farming sector was adjusted based on budgeted production costs reported by Muraro, et al. (2004). Production expenditures for the major types of citrus and various production regions in Florida are shown in Table 4-1, including both fresh and processed Valencia and Hamlin oranges, white and red grapefruit, in the Central, Southern and Indian River regions. Weighted average expenditures in relation to production volume were assigned to appropriate *IMPLAN* sectors as indicated in Table 4-2. Industry purchases from other sectors included financial lenders, fertilizers, agricultural chemicals, greenhouse and nursery products, plastic pipes and fittings, other state and local government enterprises, and government-non education. Many of the cultural operations were treated as labor inputs to production, and as such represent value added rather than industry purchases. Finally, the regional purchase coefficient for fruit farming was set to the maximum allowable level (0.88), in order to force the processing sectors to purchase all available fruit from local (in-state) sources. Industry information on value added, including employee compensation, proprietor income, other property income, and indirect business taxes, were left at default levels.

Table 4-1. Florida citrus production expenditures, by type and region, 2003-04 season.

Expense	Central		Indian River		Southern			
	Processed	Fresh	Processed	Fresh	Processed		Fresh	
	Valencia		White Grapefruit		Hamlin	Red GF	Hamlin	Red GF
	$ per box							
Tree replacement: prepare & plant	0.056	0.056	0.134	0.134	0.092	0.064	0.092	0.064
Mechanical mow middles (4/year)	0.086	0.086	0.067	0.076	0.044	0.041	0.044	0.041
Weed control: discing (2/year)	0.042	0.042	0.025	0.025	0.021	0.020	0.021	0.020
Weed control, gen. grove work (2 hr/A)	0.056	0.056	0.057	0.057	0.049	0.046	0.049	0.046
Herbicide application	0.059	0.059	0.082	0.082	0.050	0.046	0.050	0.046
Weed control: spot treatment (appl + material)	0.032	0.032	0.000	0.000	0.000	0.000	0.000	0.000
Spray summer oil #1 application	0.048	0.048	0.064	0.064	0.000	0.000	0.047	0.043
Spray summer oil #2 application	0.048	0.062	0.064	0.064	0.047	0.043	0.047	0.043
Supplemental fall miticide application	0.000	0.048	0.064	0.064	0.047	0.043	0.047	0.043
Fertilizer application	0.055	0.055	0.049	0.049	0.030	0.028	0.030	0.028
Dolomite, material & application	0.020	0.020	0.028	0.028	0.023	0.022	0.023	0.022
Pruning/topping	0.030	0.030	0.031	0.031	0.021	0.020	0.021	0.020
Pruning/hedging	0.036	0.036	0.037	0.037	0.024	0.022	0.024	0.022
Chop/mow brush after hedging	0.009	0.009	0.013	0.013	0.008	0.008	0.008	0.008
Raise skirt of trees	0.000	0.000	0.015	0.015	0.000	0.012	0.000	0.012
Tree replacement, remove trees	0.030	0.030	0.053	0.053	0.037	0.026	0.037	0.026
Clean ditches (weed control)	0.000	0.000	0.029	0.029	0.025	0.024	0.025	0.024
Ditch & canal maintenance	0.000	0.000	0.033	0.033	0.029	0.027	0.029	0.027
Water control	0.000	0.000	0.029	0.029	0.025	0.023	0.025	0.023
Supplemental post-bloom spray, application	0.000	0.000	0.000	0.111	0.000	0.000	0.047	0.044
Fall miticide application	0.000	0.056	0.000	0.055	0.000	0.000	0.016	0.014
Management costs	0.101	0.101	0.108	0.108	0.093	0.086	0.093	0.086
Harvesting costs: pick/spot pick, roadside & haul, & canker decontamination	2.190	2.190	1.885	2.086	2.217	1.885	2.217	2.086
Fruit drenching	0.000	0.000	0.000	0.170	0.000	0.000	0.000	0.170
Fertilizer material	0.295	0.295	0.182	0.226	0.233	0.165	0.233	0.165
Weed management: herbicide material	0.156	0.156	0.200	0.200	0.157	0.146	0.157	0.146
Spray summer oil #1 material	0.127	0.128	0.128	0.128	0.000	0.000	0.051	0.047
Spray summer oil #2 material	0.062	0.138	0.141	0.141	0.110	0.102	0.110	0.102
Supplemental fall miticide material	0.000	0.020	0.046	0.046	0.052	0.048	0.036	0.034
Supplemantal post-bloom spray, material	0.000	0.000	0.000	0.042	0.000	0.000	0.098	0.092
Fall miticide material	0.000	0.069	0.000	0.070	0.000	0.000	0.055	0.051
Canker decontamination costs	0.012	0.012	0.014	0.010	0.009	0.011	0.009	0.011
Irrigation, microsprinkler system	0.319	0.319	0.342	0.342	0.295	0.274	0.295	0.274
Interest on operating (cultural) costs	0.045	0.048	0.047	0.117	0.074	0.032	0.074	0.043
Interest on average capital investment costs	0.675	0.675	0.722	0.722	0.623	0.579	0.623	0.579
Water drainage district tax	0.000	0.000	0.142	0.135	0.000	0.000	0.000	0.099
Fly protocol cost	0.000	0.000	0.123	0.117	0.000	0.000	0.000	0.000
FDOC assessment	0.150	0.150	0.240	0.250	0.150	0.240	0.150	0.250
Property tax & water management tax	0.130	0.130	0.106	0.101	0.118	0.092	0.118	0.092
TOTAL	4.928	5.217	5.402	6.155	4.773	4.224	5.071	4.992

Source: Muraro, et al., 2004.

Table 4-2. Industry purchases for Florida citrus fruit production, by *IMPLAN* sector, 2003-04.

IMPLAN Sector (number)	Total Expenditures	Output
	- - - $ - - -	- - % - -
Greenhouse & nursery products (6)	21,589,880	1.22
Fertilizer mixing, manufacturing (158)	87,820,996	4.97
Pesticides & agricultural chemicals (159)	98,360,748	5.57
Plastic pipes & fittings (173)	84,838,081	4.80
Financial lenders (430)	195,331,379	11.06
Other state & local government enterprises (499)	49,354,411	2.79
State & local government non-education (504)	33,311,668	1.89
Total industry purchases	500,607,163	32.31

Results and Discussion

The value of citrus fruit production was estimated separately for fresh market fruit and processed fruit, by citrus variety, as shown in Table 4-3. In the 2003-04 season, total citrus fruit production in Florida was 291.8 million boxes, including 242.0 million boxes of early, midseason, Naval and Valencia oranges, 40.9 million boxes of grapefruit, and 8.9 million boxes of specialty citrus (tangelos, tangerines, temples). Some 32 million boxes were produced for the fresh market and 260 million boxes were utilized for processing, which represented 11% and 89%, of the citrus crop, respectively. About 53% of the red seedless grapefruit was produced for the fresh market, while 80% of white seedless grapefruit and 96% of oranges were processed for juice. Average free-on-board (F.O.B.) prices for fresh market fruit sold from packinghouses ranged from $13.20 per box for Valencia oranges to $24.50 for tangelos and tangerines. Average delivered-in prices for processed fruit were $4.14 per box for early, midseason and Naval oranges, $5.82 for Valencia oranges, and $2.84 to $3.02 for grapefruit. The total value of Florida citrus fruit in 2003-04 was $1.778 billion, including fresh fruit shipments from packinghouses valued at $548 million, and fruit delivered to processing plants valued at $1.230 billion. Red seedless grapefruit and tangerines accounted for 41% and 20%, respectively, of fresh market value. Valencia oranges represented 53% of the processed fruit market value, while early, midseason and Naval oranges accounted for 41%.

The value of Florida processed citrus juice product shipments in the 2003-04 season are shown in Table 4-4. The total value of citrus juice products was $3.00 billion, including $1.93 billion for chilled (canned) juice, and $1.08 billion for frozen concentrate juice. The vast majority of juice shipments, $2.85 billion or 95%, were for processed orange juice. More than

Table 4-3. Production volume, price and value of fresh and processed Florida citrus fruit, 2003-04 season.

Variety	Fresh Market Fruit			Processed Fruit			All Fruit	
	Production	F.O.B. Price	Total Output	Production	Delivered-In Price	Total Output	Production	Total Output
	1,000 boxes	$/box	mil. $	1,000 boxes	$/box	mil. $	1,000 boxes	mil. $
Early, Midseason, & Navel Oranges	5,615	15.00	84.2	120,385	4.14	498.4	126,000	582.6
Valencia Oranges	4,287	13.20	56.6	111,722	5.82	650.2	116,000	706.8
White Seedless Grapefruit	3,273	17.00	55.6	12,627	2.84	35.9	15,900	91.5
Red Seedless Grapefruit	13,384	16.80	224.9	11,616	3.02	35.1	25,000	260.0
Tangelos	545	24.50	13.4	455	2.56	1.2	1,000	14.6
Tangerines	4,440	24.50	108.8	2,060	3.04	6.3	6,500	115.1
Temples	342	14.30	4.9	1,058	2.69	2.8	1,400	7.7
TOTAL	31,886		548.3	259,923		1,229.8	291,800	1,778.1

Sources: Citus Fruits, 2005 Summary, September 2005, U.S. Department of Agriculture, National Agricultural Statistics Service, and Florida Department of Citrus, Economic and Market Research Department, Gainesville, Florida, February 2006.

Table 4-4. Value of Florida frozen and canned citrus juice for local consumption and export, 2003-04 season.

Product	Export Shipments (out of state)	Local Consumption (in state)	Total Value
	- - - - - - - - - - - - - - - - - million $	- - - - - - - - - - - - - - - - -	
Frozen concentrated orange juice	969.3	31.5	1,000.8
Chilled & canned orange juice	1,805.2	39.7	1,844.9
Frozen concentrated grapefruit juice	73.9	1.7	75.6
Chilled & canned grapefruit juice	82.8	0.9	83.6
Total frozen concentrated citrus juice	1,043.1	33.3	1,076.4
Total chilled & canned citrus juice	1,887.9	40.6	1,928.5
TOTAL	2,931.1	73.8	3,004.9

Source: Florida Citrus Mutual, *Annual Statistical Report, 2003-04 Season*.

97% of citrus juice products were exported outside of Florida to other states or foreign countries, while only 3% was consumed in the state. The share of juice consumed locally in Florida was estimated based on the Florida population and U.S. average per-capita consumption.

In addition to orange and grapefruit juices, the citrus processing industry produces several other important by-products, including citrus pulp and dried meal, molasses and D-limonene. The essential oil D-limonene, recovered from the distilled extracts of fruit peel and seeds, is used for a variety of chemical products such as cleaners, disinfectants, flavors and fragrances. Citrus pulp, meal and molasses are sold as livestock feed ingredients. During the 2003-04 season, Florida citrus processors produced more than 1.1 million tons of citrus pulp and meal, 38,000 tons of molasses, and nearly 36 million pounds of D-limonene, and the total value of these by-

products was about $136 million (Table 4-5). Citrus pulp and meal represented about 66% of the total by-product value.

Table 4-5. Volume and value of processed Florida citrus by-products, 2003-04 season.

By-product	Production	Units	Price	Value
			$/unit	million $
Citrus Pulp & Meal	1,130,601	tons	80.00	90.5
Molasses	38,337	tons	55.00	2.1
D-Limonene	35,782,731	pounds	1.20	42.9
TOTAL				135.5

Sources: Florida Citrus Processors Association, 2003-04 Statistical Summary (production volumes); *Feedstuffs* magazine, *Chemical Market Reporter*, Florida Distillers, Inc. (prices).

Total economic impacts estimated for the Florida citrus industry in 2003-04 are summarized in Table 4-6. The direct output or sales revenue produced by the citrus industry in 2003-04 was $3.69 billion. The total output impact of the industry was $9.29 billion, including $8.01 billion from processed citrus juice and by-products, and $1.28 billion from fresh market citrus fruit sales. The indirect output impacts resulting from purchases of inputs from other industry sectors, including the purchase of round fruit from growers by the processing sector, were $1.93 billion. The induced output impacts resulting from consumer spending by employee households were $3.67 billion. The ratio between the total output impact and direct output implies an overall multiplier effect of 2.52. These multiplier effects are significant because the export-based nature of the Florida citrus industry brings new money into the state economy.

Total employment impacts of the Florida citrus industry were 76,336 jobs, with 61,307 jobs from the processing sector and 15,029 jobs from fresh fruit. These employment impacts

Table 4-6. Summary of economic impacts of the Florida citrus industry, 2003-04 season.

Industry Sector	Impact Measure	Output	Employ-ment	Value Added	Labor Income	Indirect Business Taxes
		- mil. $ -	- jobs-	- - - - - - - - - - million $	- - - - - - - - - -	
Citrus Juice & By-products	Direct-Local Cons.	77.2	212	25.8	12.6	0.6
	Direct-Exports	3,063.2	8,085	1,022.3	495.4	25.4
	Indirect	1,804.6	19,775	1,106.3	539.4	66.5
	Induced	3,061.1	33,235	1,912.0	1,248.3	147.7
	TOTAL	**8,006.1**	**61,307**	**4,066.3**	**2,295.6**	**240.2**
Fresh Market Citrus Fruit	Direct	547.3	7,566	350.5	145.4	16.3
	Indirect	127.5	865	77.1	41.9	1.9
	Induced	608.0	6,599	379.3	248.4	29.1
	TOTAL	**1,282.7**	**15,029**	**806.8**	**435.8**	**47.3**
All Sectors	Direct	3,687.7	15,863	1,398.6	653.4	42.3
	Indirect	1,932.0	20,640	1,183.3	581.3	68.4
	Induced	3,669.1	39,833	2,291.3	1,496.7	176.8
	TOTAL	**9,288.8**	**76,336**	**4,873.2**	**2,731.4**	**287.5**

represent both full-time and part-time jobs, and are not adjusted to a full-time equivalent basis. Total value added impacts were $4.87 billion. Value added is a broad measure of total personal and business net income generated, and is equivalent to industry output less industry purchases. The value added impact of the citrus industry represented 0.9% of the gross state product of Florida in 2003 ($548 billion). Labor income impacts amounted to $2.73 billion, which represents all wages and salary earnings by industry employees and proprietor's income to business owners. Indirect business tax impacts were $288 million, which includes most forms of local and state taxes, such as property tax, sales tax, water management district levies, intangible taxes, motor fuel and vehicle taxes, excise taxes, etc., but does not include federal income taxes.

Total economic impacts of Florida citrus are shown by major industry group in Table 4-7. Naturally, the largest impacts occurred in the agriculture and manufacturing groups, where the direct impacts occurred from fruit farms and citrus processing. Output impacts in manufacturing and agriculture were $3.54 billion and $1.58 billion, respectively. Large output impacts also occurred in government enterprises ($769 million), construction ($478 million), finance and insurance ($419 million), health and social services ($369 million), retail trade ($335 million), wholesale trade ($289 million), professional-scientific and technical services ($288 million), and real estate and rentals ($225 million). Employment impacts in agriculture (21,814 jobs) were greater than for manufacturing (9,836 jobs) due to the labor-intensive nature of agriculture, particularly for fruit harvesting in the citrus industry. Important employment impacts also occurred in retail trade (5,945 jobs), health and social services (4,897 jobs), and construction (4,281). These impacts in other industries indicate the significant linkages of the citrus industry throughout the Florida economy.

Table 4-7. Economic impacts of the Florida citrus industry, by industry group, 2003-04 season.

Industry Group	Output	Employ -ment	Value Added	Labor Income	Indirect Business Taxes
	- mil. $ -	- jobs-	- - - - - - - million $	- - - - - - - -	
Agriculture, forestry, fisheries & hunting	1,577.1	21,814	1,012.0	420.0	46.7
Mining	9.6	37	2.2	0.9	0.2
Utilities	88.3	163	60.3	18.5	8.8
Construction	478.4	4,281	205.4	168.6	2.5
Manufacturing	3,540.2	9,836	1,172.2	589.0	28.7
Wholesale trade	288.7	2,184	219.6	123.1	47.4
Transportation & warehousing	159.4	1,712	88.4	65.0	3.4
Retail trade	334.7	5,945	249.6	155.5	47.6
Information	131.2	538	61.0	32.1	5.2
Finance & insurance	418.8	2,496	264.6	130.4	8.5
Real estate & rental	224.7	1,537	149.9	39.4	23.5
Professional, scientific & technical services	288.1	2,808	172.0	144.4	2.8
Management of companies	92.5	578	55.2	42.5	0.9
Administrative & waste services	110.6	2,031	67.6	54.9	1.7
Educational services	32.9	684	19.1	18.6	0.4
Health & social services	368.6	4,897	228.2	199.7	2.5
Arts, entertainment & recreation	43.5	741	27.7	19.0	2.9
Accommodations & food services	170.3	3,371	88.0	60.3	9.6
Other services	162.8	3,066	85.1	66.0	6.7
Government & non-NAICS	768.5	7,616	645.1	383.6	37.6
TOTAL	**9,288.8**	**76,336**	**4,873.2**	**2,731.4**	**287.5**

The economic impacts of the Florida citrus industry presented here for the 2003-04 season are consistent with those reported in a previous study for the 1999-00 season (Hodges, et al., 2001), in which total output impacts were estimated at $9.13 billion, total employment impacts were 89,778 jobs, and total value-added impacts were $4.18 billion. This would suggest that the industry grew during the 1999-2003 period. In fact, however, total sales of fresh and processed citrus juice and by-products have actually declined from $4.07 billion to $3.55 billion. Although the impact estimates in both studies were made using similar data sources and analytic procedures, there are important differences that account for this discrepancy. Notably, the earlier study was done using a previous version of the *IMPLAN* software, which used the Standard Industrial Classification (SIC) system, rather than the NAICS. Also, it is possible that the structure of the Florida economy has become more integrated, leading to greater multiplier effects. If we use the current (2003) *IMPLAN* model to evaluate the direct output of fresh and processed citrus for the 1999-00 period, we get a total output impact of $9.80 billion (in 2003 dollars). This restated result would suggest that the total economic impact of the Florida citrus industry has declined by about 5% during this period in real terms.

These economic impact estimates are based on well-documented values for citrus products, however, there are certain limitations of the analysis that should be borne in mind when interpreting the results. First, the budget information for citrus fruit production was aggregated into a relatively small number of *IMPLAN* sectors, which may lead to an underestimate of the linkages to other sectors of the state's economy. Secondly, there was no specific information available for the citrus processing sector, other than purchases from the fruit farming sector, that would enable adjustment of the production function for this sector. To more accurately estimate

the economic impacts of this large sector would require further details on processing expenditures.

Section V
Economic Assessment of the Florida Citrus Nursery Industry

by
Fritz M. Roka and Robert E. Rouse

Current Situation

The Florida citrus nursery industry has been shut down since early summer of 2005. Positive citrus canker finds at seven large nursery operations led to the destruction of more than 4 million trees, two-thirds of the industry's existing inventory. Growers, uncertain as to the canker status of the remaining nursery stock, either canceled their orders or refused shipment of the remaining trees.

Simultaneous to the canker finds in nursery operations, crews from the Florida Division of Plant Industries (DPI) located numerous canker-infected trees spread throughout the commercial-citrus-production area. Many of these finds were directly attributable to the three hurricanes that pushed across the citrus belt during August and September of 2004 (Charley, Francis, and Jeanne). More than 60,000 acres of citrus had been pushed between August 12, 2004 and December 31, 2005. In total, the canker-eradication program had destroyed nearly 80,000 acres and 10 million commercial citrus trees between 1998 and the end of 2005.

On January 11, 2006, the USDA declared an end to the eradication program, fearing that canker had spread to a point where eradication was no longer feasible. Punctuating the concerns for tree health was the confirmation by DPI officials in late 2005 that citrus greening (Huanglongbing) had infected trees in a Southwest Florida commercial grove. While suspension of the eradication program eased concerns about moving the remaining inventory of nursery

trees, orders for newly propagated nursery trees dropped to zero as the nursery and production sectors of the citrus industry grappled with how to cope with the increasing spread of citrus canker and other exotic disease threats.

The Florida Citrus Plant Protection Committee (FCPPC) was formed in November 2005 to develop guidelines for the propagation of "clean," disease- and virus-free plant material. Six nurserymen and six production managers comprised the FCPPC, with IFAS and USDA-ARS scientists providing technical support. Discussions within the FCPPC centered around three core issues:

1. Producing plant material within protected structures.
2. Determining if a minimum distance of citrus-free buffer zone surrounding a nursery facility was necessary, and if so, what distance.
3. Developing sanitary production procedures within the nursery facility.

Protected Stuctures

A strong consensus developed around the concept of a protected structure in which scion trees, seedlings, liners, increase blocks, and nursery trees would be grown.[2] The FCPPC unanimously agreed that:

> *"The minimum for structures growing citrus plants shall be fully enclosed, insect proof, and with double entrances with positive pressure displacement."* (FCPPC minutes, January 6, 2006).

FCPPC agreed in concept that DPI officials would regularly inspect the facility. The Committee further recommended that the nursery operation stock extra screening material to

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[2]Scion trees are budwood sources and considered "mother" trees. Increase blocks allow the rapid propagation of budwood material. As of January 1, 2006, all budwood scion trees are required to be grown in screen houses.

readily repair breeches in the facility's screen and develop a plan to chemically protect the plant material ahead of an anticipated storm event that could potentially breech the screen house.

FCPPC developed a generic design for a screen house facility. The facility encompassed 47,040 ft^2 and included three areas:

1. Production area for seedlings, liners, and budded trees: 6 gcs (gutter connected structures) * (35 x 144 ft)/gcs = 30,240 ft^2.

2. Vestibule area for receiving soil, pots, other supplies, and gathering of trees for transport: 2 gcs * (35 x 96 ft)/gcs = 6,720 ft^2.

3. Scion area for increase blocks and/or foundation budwood: 2 gcs * (35 x 144 ft)/gcs = 10,080 ft^2.

The investment into approved structures is estimated to increase production costs of citrus nursery trees by more than $2.00 per tree over field-grown (unprotected) nursery operations. This cost estimate is based on the following assumptions:

1. Construction costs - $7.75 per ft^2. (Initial cost estimates range between $7.50 and $8.00 per ft^2. This cost does not include architectural drawings, permits, site prep, electrical, irrigation, concrete work, benches, and internal thermostats or controllers. Further, it was assumed that an irrigation well is currently in place with enough capacity for anticipated irrigation needs.)

2. Tree/plant capacity – 77,000 (4-inch) pots for liners and propagated trees.

3. 85% of all budded trees are sold (15% tree loss).

4. Production cycle – 18 months from seed to saleable tree.

5. Assumptions for estimating annual ownership costs of a structure:

   a. Service life – 10 years
   b. Interest on average investment – 10%
   c. Repairs – 5% of original investment
   d. Taxes – 1.5% of original investment
   e. Insurance – 1% of original investment
   f. Electrical power to run facility – 1% of original investment.

At \$7.75 ft^2 , the initial investment in this facility would be \$364,560. Annual ownership costs, including depreciation, interest, repairs, taxes, insurance, and electrical power, would be \$85,672. Given an 18-month production cycle (seed to saleable tree) and a tree-loss rate of 15%, the number of trees sold per year is estimated to be 42,633 trees. On an annual per-tree basis, transferring nursery production from open-field conditions to protected screen-house structures would increase production costs by \$1.96 per tree. Pots (4 in.) and soil mix add another 30¢ to 40¢ per tree. Prior to August 2004, budwood "eyes" from screen enclosures at state-owned facilities in Immokalee and Dundee sold for 15¢. However, whether 15¢ fully captures all costs if grown within a commercial nursery remains unclear. Another cost factor that would be hard to quantify would be learning how to grow nursery trees under screen enclosures versus under open-field conditions. Growing inside will require coordination and mixing of soil material, different irrigation procedures, and new house maintenance routines to name a few management adjustments a grower would have to make (Jamison, March 8, 2006).

Setback Distance

As a practical reality, the best-engineered facility can be breeched during a violent storm event. In addition, a "pest-free" structure depends on regular and long-term maintenance routines. Therefore, the FCPPC concluded that some minimum "setback" distance would add an additional margin of safety against storms and management lapses. Neither IFAS nor ARS scientists could provide precise recommendations of setback distances; only to say that greater distance provides greater security.

The challenge of establishing a minimum setback distance is balancing safety from disease and pests against the practical realities of relocating nursery operations. Canker eradication protocol required quarantine areas of 3,800 feet around an infected tree. A 3,800-foot citrus-free buffer zone would require a nursery operation to be located in the middle of a 1,000-acre block. Initial recommendations within the FCPPC were to extend a citrus-free buffer to two miles. The recommendation was later revised to 1/8 mile, or 660 feet. In all likelihood, the final setback distance, if any, will not be resolved until the DPI rule-making process is complete.

Any buffer, whether 660 feet or two miles, requires a nursery operation to be in the middle of a citrus-free area. Of the 50 nursery operations in business prior to August 2004, at most only 10 would comply with the 660-feet buffer proposal. The prospect of having to relocate a nursery to a new location has generated considerable concern among nursery growers. Finding suitable property and uprooting the entire operation could be the single most significant delay to restarting an operation. Areas in north and north-central Florida, outside the main commercial-citrus-production region, have been discussed as likely areas for relocation. Personal issues beyond the nursery business become entangled with the setback provisions. If a nursery has to relocate, typically a family has to move as well.

One alternative to owning all the land in a buffer area, would be to sign agreements with all surrounding neighbors in the buffer zone to have existing citrus trees removed and assurances that citrus will not be replanted within the buffer zone. Such agreements may be difficult to achieve without some form of compensation to the neighboring property owners. Further, even if an agreement is reached at a particular nursery site, long-term enforcement could be a challenge, especially when property ownership changes. Whether existing nurseries physically relocate to

new property or work toward securing compliance agreements with its neighbors, creating an eighth-mile buffer zone would add to the costs of protected facility structures.

Sanitation

Developing a sanitary protocol for nursery operations was the third charge of the FCPPC. Most of the sanitary procedures are common sense recommendations and emphasize how to decontaminate workers, vehicles, and equipment that enter the facility compound. Many nurserymen indicate that they already follow most of these recommendations, and it is not clear if a formalized set of sanitary protocols would increase overall production costs.

The FCPPC will finish developing its production guidelines sometime during spring 2006. The Florida Division of Plant Industries (DPI) will use the FCPPC guidelines as the basis of new rules that would “certify” citrus nursery operations. After DPI drafts the new rules, there will be a period for public comment. At the earliest, the new rules will be adopted during fall 2006. The projected implementation of these guidelines will be January 1, 2008.

While canker and citrus greening have accelerated the process, the citrus nursery industry has been undergoing increasing regulations and moving toward protected facilities. The mandatory budwood registration program became effective on January 1, 1997. The rule required all citrus tree propagations to use registered budwood sources. Budwood production regulations tightened on January 1, 2006, when all scion trees had to be grown in protected screen houses.

Future Supply and Demand for Citrus Nursery Trees

The new round of regulations stemming from the FCPPC guidelines will dramatically change the operational demographics within the citrus nursery industry. Before August 2004, more than 70% of the industry's capacity resided in "field" nurseries. The consensus within the nursery industry is that whatever the final rules turn out to be, field nurseries will not be allowed to continue. For these nursery operations to continue, they will have to invest in a screen structure and transfer growing operation inside the structure. Undoubtedly, some percentage of the existing field nurseries will choose not to make this investment, and consequently, to go out of business prior to January 2008.

Capacity within the citrus nursery industry has been declining since 1998 (DOACS). According to statistics from the Budwood Registration Office, 75 nursery operations propagated 6.0 million trees in 1998. By August of 2002, the number of nurseries had fallen to 65 and total propagations to 5.2 million trees. During the fiscal year ending June 30, 2004, 50 nurseries produced 4.0 million trees. For the year ending June 30, 2005, the Budwood Registration Office reported only 2.1 million propagations and an estimated inventory of 6 million trees. Canker eradication destroyed nearly two-thirds of the inventory, or 4.1 million trees. More significantly, the eradication actions and the general cloud of uncertainty hanging over the citrus industry, suspended the propagation of any new nursery trees.

Once the existing tree inventory (~ 2 million trees) has been depleted, leaders within the nursery industry predict few if any new trees being available for the next two years and limited production for the next three to five years. Existing nursery operations have to decide whether to remain in business. That decision will be strongly influenced by the final rules that will emerge

from the DPI rule making process. Given the significant investments for protected structures and possible relocation requirements, nursery operations are not likely to restart their operations until DPI rules are finalized. How fast the DPI rule making process can proceed is uncertain, but officials believe that final rules can be established sometime during the fall of 2006. Once the rules are in place, nursery growers who choose to continue in the business can start their investment plans. Relocating nursery operations and building protected structures will likely require at least a year to complete. Once the facility has been reestablished, the propagation process will require another 18 to 20 months before a new crop of nursery trees is ready to be planted in commercial groves.

Budwood supplies are likely to be scarce for the next three years. Commercial nursery operations were responsible for at least 93% of all budwood material. The eradication program eliminated at least two-thirds of the budwood material in commercial nurseries. Commercial nurseries maintained both scion trees and increase blocks. Increase blocks are planted with budwood from certified scion trees. Under the existing DPI protocol, a nursery can cut budwood from an increase block for up to 24 months. The block can be re-certified to continue cutting for a third year. Under the proposed regulations, a nursery will be able to cut budwood within a screen structure for up to 36 months, and if re-inspected, for an additional 12 months.

State-owned foundation groves have also been affected, limiting budwood availability. Hurricanes destroyed the screen house structures at the DPI Budwood office in Dundee, Florida. DPI officials elected not to cut budwood until a new protected facility can be rebuilt. The DPI Dundee facility is being relocated to state land near Chiefland, Florida. If the state legislature appropriates the money, a facility could be completed by the end of 2006. Another two years would be required, however, before budwood would be available in substantial quantities. The

Foundation Budwood Grove at the Southwest Research and Education Center near Immokalee, Florida, is another state-owned certified budwood source. This site has been under screen protection since 1999 and the nearest canker finds to date have been more than 2 miles away. However, the screen houses are adjacent to existing citrus trees and would be out of compliance if any setback requirements were established.

The decline in nursery tree propagations has mirrored the level of commercial grove acreage. Following the freezes in the 1980s, bearing-citrus acreage in Florida peaked at 815,000 acres during the 1996-97 season. By 2004 total bearing acreage had fallen to less than 680,000 (FASS, *Citrus Summary 2003-04*). Prior to August 2004, acreage declines were attributable to diseases, notably blight and the citrus tristeza virus, and land conversion from citrus to urban development. In addition, low market prices forced growers to abandon less productive groves and limit planting to resets in more highly productive areas. The canker eradication program was not a major factor in overall acreage decline. Between 1995 and August 12, 2004, less than 16,000 total citrus acres were destroyed as part of the eradication program.

From August 12, 2004 to the lifting of the eradication program in early January 2006, nearly 64,000 acres and 10 million commercial trees were destroyed (DOACS). Nearly one-third of the canker eradicated area occurred in the rapidly urbanizing Treasure Coast region of Florida. The percentage of this acreage that will be replanted to citrus will depend on the robustness of the real estate market. There are some early signals that the real estate market is beginning to cool down. With delivered-in prices for processed oranges at more than $1.20 per PS and fresh grapefruit commanding more than $15 per box, interest in replanting lost citrus acreage is likely to accelerate. Adding pressure on depleted tree supplies is the annual demand for resets. Annual

attrition rates of mature commercial trees average 3%, creating an annual, ongoing demand for resets of nearly 3 million trees (700,000 ac * 130 trees/ac * 3%).

Summary

Hurricanes and the canker-eradication program have depressed Florida citrus production to its lowest levels in the past 15 years. With the suspension of the canker-eradication program and the presence of the citrus greening disease, the citrus industry is in a state of turmoil as it collectively tries to chart a course into the future. Citrus prices, however for both processed oranges and fresh grapefruit, have pushed higher and are beginning to encourage growers to replant lost acreage. A significant constraint to replanting efforts over the next three to five years will be the availability of citrus nursery trees. As of January 1, 2006, the citrus nurseries were closed down as new rules and guidelines were being developed to insure the propagation of "clean" plant material. The rules should be in place by the end of 2006 with full implementation expected by January 2008.

The cost of new citrus trees is likely to increase by more than $2.00 over current levels ($4.50 to $5.50 per tree) to cover added costs of growing within a screen-house facility. Availability of trees will depend on the number of nursery operations that choose to make the necessary investments under the new rules.

Section VI
CITRUS PRICE/RETURN ANALYSIS:
An Examination of Investment Returns to Citrus in a Citrus Canker and Greening Environment

by
Ronald P. Muraro and Jordan C. Malugen

Introduction

This analysis attempts to determine the relationship between citrus prices and grove profitability for new and mature plantings, and illustrate the effects of historically high land prices, endemic citrus canker, and citrus greening on investment returns. These scenarios attempt to quantify investment decisions faced by citrus growers and landowners across the state.

First, investment scenarios are determined based on either new plantings (with and without land costs), or mature plantings without land costs. Then, base production costs 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.[3] Finally, assumptions are applied for additional costs, yield decline, and tree losses due to the different diseases. The return on investment is determined at different price levels for citrus using a net present value (NPV) framework over a 15-year planning horizon. The breakeven prices reported are the lowest prices where the NPV of

[3]Ridge refers to the well-drained and sandy soils of Central Florida and encompasses citrus production in Polk, Highlands, Lake, Orange, Hardee, and Hillsborough counties. Flatwoods refers to the wet and/or muck soils of Southwestern and South Central Florida and encompasses citrus production in Charlotte, Collier, Hendry, Glades, Lee, DeSoto, Okeechobe, and Sarasota counties. Indian River refers to parts of citrus-producing counties on Florida's east coast, such as: Brevard, Indian River, Palm Beach, and St. Lucie counties. These classifications are general and individual grove characteristics in these geographic areas may differ.

the investment is positive over the 15 year period of analysis. All calculations are performed on a per-acre basis.

Investment Scenarios

- **New Plantings Scenario**: Represents the situation of a grower who intends to plant a new citrus grove and must purchase land at current market prices. The land cost is assumed to be improved pasture already zoned for agricultural use as reported in the IFAS 2005 Rural Land Value Survey for the respective areas of the state. This scenario attempts to gauge investment returns for new entrants into the citrus industry or current growers looking to expand their operations by purchasing additional land.

- **Replantings Scenario:** 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 continuous properties and vacant land due to canker eradication, or those wishing to replace other agricultural operations (i.e., livestock, forestry, sod, etc.) with citrus.

- **Mature Grove Scenario:** 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 want to examine the long-term profitability of their groves.

Disease Assumptions

- **Base (No Canker or Greening):** Uses actual production costs by geographical area for the 2004-05 season as reported in the IFAS Citrus Budgets collected by Muraro, et al. It reflects common cultural practices in different areas of the state for a custom managed operation. Tree loss rates reflect an estimated state historical average, excluding the effects of development and eradication (Table 6-1).

Table 6-1. Tree-loss percentages.

Tree Age	Base[a]	Greening			Canker
		Low	Medium	High	
- years -	- % -				
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

[a]Estimated average state historical tree loss (excluding effects of development and eradication).

- **Canker-Only:** Uses estimates for increased costs due to endemic citrus canker within the state. A yield penalty of 10% is applied to Hamlin orange and colored grapefruit varieties because of their increased susceptibility, and 5% to Valencia oranges. A slight increase in tree loss (10%) is added to base loss rates across all varieties and ages.

- **Greening-Only:** Uses estimates for increased costs due to intensive control of the Asian citrus psyllid insect vector of citrus greening. This incorporates additional spray costs based on IFAS Integrated Pest Management guidelines. This analysis uses the low 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.

Investment Model Assumptions

For numerical data used in the investment model assumptions, please consult

Appendix A.

- **Citrus Varieties:** Valencia and Hamlin sweet oranges grown for the processing market. Colored (pink and red) grapefruit grown for the fresh market.

- **<u>Location</u>:** Scenarios were run for Valencia and Hamlin groves on the Ridge area (Northern & Central Florida), and on the Flatwoods (Southern Florida). Grapefruit is assumed to be located on the Flatwoods (Indian River). Geographical differences in costs and returns were incorporated into the investment model.

- **<u>Area</u>:** All costs and returns are on a one-acre-of-planted-citrus basis. This adjusts for the different uses of space between Ridge and Flatwoods plantings. Ridge plantings assume 95% planted in citrus. Flatwoods plantings assume 75%. Per acre land costs are then divided by the percent planted in citrus to establish a comparable cost per acre of planted citrus.

- **<u>Tree Density</u>:** For new plantings, densities are assumed to be 198 trees per acre (22' X 10' spacing) for Valencia and Hamlin varieties, and 134 trees per acre (25' X 13') for grapefruit. For mature groves, 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. While the new planting densities used in this analysis are higher than the historical averages, we believe they reflect an apparent trend towards higher density plantings.

- **<u>Resetting</u>:** All scenarios use a bi-annual resetting policy (replacing dead/unproductive trees every other year) until year ten, and bi-annual resetting of 50% of tree loss for years 11 to 15. This reflects two realities of resetting: (1) when pursuing a continuous reset policy, under field conditions, growers do not always have the opportunity to reset every season, and may wait until there is enough tree loss to justify the expense of removing and replacing trees, and (2) with the higher density plantings in this model, a grower most likely would reset at a lower density (space trees farther apart) after the original trees are mature (about 10 years old) to avoid shading-out the young trees.

- **<u>Yields</u>:** Yield estimates were calculated by assuming a box yield per tree according to the age of the tree. This illustrates the impact of tree loss rates on production by adjusting the total per acre yield by the mix of trees of different ages. Peak boxes per acre production occurs when the trees are at 11 years of age, and peak pound solids for processing oranges is reached at year 7. Table 6-2 reflects yield per acre, adjusted for the number of planted trees per acre and the age distribution of the trees due to the tree loss rates of the different scenarios. For example, while a mature grove of Valencia oranges on the Ridge with 100% of its original trees may produce about 550 boxes per acre, because of tree loss, resetting, and the resulting number of non-bearing and immature young trees, it will produce about 416 boxes per acre under base rates, and only about 329 boxes with the highest tree loss rates of an endemic canker and greening environment.

Table 6-2. Average grove yields by scenario and disease.

Type	Variety	Location	Base	Canker		Greening-Low		Canker & Greening: Low		Canker & Greening: Medium		Canker & Greening: High	
			boxes/ acre	boxes/ acre	% change from base	boxes/ acre	% change from base	boxes/ acre	% change from base	boxes/ acre	% change from base	boxes/ acre	% change from base
New Plantings/ Replant- ings[a]	Valencia	Ridge	416	392	-6	390	-6	370	-11	361	-13	329	-21
	Hamlin	Ridge	491	438	-11	460	-6	414	-16	403	-18	369	-25
	Valencia	Flatwoods	416	392	-6	390	-6	370	-11	361	-13	329	-21
	Hamlin	Flatwoods	491	438	-11	460	-6	414	-16	403	-18	369	-25
	Grapefruit	Indian River	416	371	-11	390	-6	350	-16	341	-18	312	-25
Mature Plantings[b]	Valencia	Ridge	290	271	-7	268	-8	255	-12	246	-15	220	-24
	Hamlin	Ridge	342	303	-11	317	-7	285	-17	275	-20	246	-28
	Valencia	Flatwoods	376	351	-7	347	-8	330	-12	318	-15	285	-24
	Hamlin	Flatwoods	443	393	-11	410	-7	369	-17	355	-20	319	-28
	Gapefruit	Indian River	363	321	-12	335	-8	302	-17	291	-20	261	-28

[a]New plantings/replantings yield averages for tree age 4 to 15.
[b]Mature orange plantings assume 112 trees per acre for Ridge, 145 trees per acre for Flatwoods, and 95 trees per acre for grapefruit in the Indian River.

- **<u>Orange Prices</u>:** Grove profitability was evaluated using price ranges to determine at what price level a grove is profitable given the different cost scenarios. The price used to calculate a gross revenue for oranges for processing is the delivered-in price per pound solid.[4] Then picking, roadsiding, and hauling costs are subtracted to arrive at the net revenue. The price range for oranges is $1.00 to $2.50 per PS, evaluated in 10¢ increments.

- **<u>Grapefruit Prices</u>:** The price used to calculate revenue for grapefruit is an on-tree price for all methods of sale. The "on-tree price" is the value of a box of fruit net of the costs of picking, roadsiding, and hauling. "All methods of sale" is the combined average of grapefruit destined for the fresh and processed markets. Grapefruit grown for the fresh market will have a certain number of fruit graded unfit for fresh sales (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. This model makes no assumptions about an individual grove's packout rate. The price range for grapefruit is $5.00 to $20.00 per box evaluated in $1.00 intervals.

- **<u>Base Scenario Production Costs</u>:** Production costs for the base scenario (no canker or greening present) use the IFAS 2004-05 Citrus Budgets by Ronald Muraro, adjusted for the respective grove locations. However, all scenarios use a $7.50 per new tree price to reflect a general shortage of nursery citrus trees over the next couple years. Spray programs reflect historic costs for citrus production (Table 6-3).

- **<u>Canker-Only Scenario Production Costs</u>**: In addition to the base scenario production costs, costs are assumed for citrus leafminer control, field inspections, and fresh market canker-free certification for grapefruit. Spray programs reflect additional costs for two additional sprays for leafminer on Hamlin oranges, one additional spray for Valencia oranges, and five additional sprays for fresh market grapefruit (Table A-10).

- **<u>Greening-Only Scenario Production Costs</u>:** In addition to the base scenario production costs, costs are assumed for psyllid control and greening inspections. A psyllid control program assumes the maximum use as permitted by law of Temik systemic insecticide for 5+ year-old trees (Admire for 1 to 4 year-old trees). Also, two additional psyllid control sprays for processing oranges, and three additional psyllid control sprays for grapefruit (Table A-11).

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[4]Pound solid (abbreviated P.S.) is the weight of sugar solids extracted from orange juice. For example, 1 gallon of single-strength orange juice has about 1 pound solid (1.029lbs.). Oranges destined for the processing market are paid by the pound solid, and a box of oranges will have a certain amount of pounds solid that varies by environment, tree age, and variety.

Table 6-3. Base scenario grove costs.

General Grove Information	Valencia Ridge	Valencia Flatwoods	Hamlin Ridge	Hamlin Flatwoods	Grapefruit Indian River
Total Land Acres	1	1	1	1	1
Percent Land Planted to Citrus	95%	75%	95%	75%	75%
Effective Age of Mature/Original Trees	15	15	15	15	15
Mature/Original Tree Density (trees per acre)	112	145	121	145	95
Reset/Solid-set Tree Density (trees per acre)	198	198	198	198	134
Land/Grove Purchase Price/Acre (per planted acre of citrus)	6,764	7,860	6,764	7,860	7,860
Irrigation Cost - New Plantings (with well)	1,350	1,000	1,350	1,000	1,000
Irrigation Cost - Replantings (without well)	1,000	1,000	1,000	1,000	1,000
Land Preparation (per acre) for New Plantings	615	1,422	615	1,422	1,422
Land Preparation (per acre) for Replantings	615	1,251	615	1,251	1,251
New Planting/Replanting Beginning Annual Property Tax (acre)	30	30	30	30	30
Mature Grove Beginning Annual Property Tax (acre)	70	70	70	70	70
Expected Interest Rate on Operating Expenses	6.0%	6.0%	6.0%	6.0%	6.0%
Interest Rate for Calculation of New Present Value	11.0%	11.0%	10.0%	10.0%	9.0%
Capitalization Rate for 15-Year Grove Value	13.3%	13.3%	12.2%	12.2%	11.2%
Miscellaneous Costs Percentage Rate	2.0%	2.0%	2.0%	2.0%	2.0%
Supervision and Overhead Costs Percentage Rate	5.0%	5.0%	5.0%	5.0%	5.0%
Year Analysis Begins	2006	2006	2006	2006	2006
Grove Care Costs for a Mature Grove (15+ Years Old)					
Cultivation and Herbicide	189.17	189.17	189.17	189.17	189.17
Spraying	132.24	141.19	132.24	141.19	383.17
Fertilization	204.77	204.77	204.77	204.77	157.00
Hedging and Pruning	40.06	40.06	40.06	40.06	52.13
Irrigation and Ditch Maintenance	166.17	208.63	166.17	208.63	208.63
Miscellaneous	14.65	15.68	14.65	15.68	19.80
Supervision and Overhead	36.62	39.19	36.62	39.19	49.51
Total Grove Care Costs	**783.68**	**838.69**	**783.68**	**838.69**	**1,059.41**

- **Canker & Greening Scenario Production Costs**: In addition to the base scenario production costs, costs are assumed for psyllid control, leafminer control, canker and greening inspection costs, and fresh market certification for grapefruit. Some overlap of psyllid and leafminer control spray programs is recognized (Table A-12) .

- **Young & Reset Tree Establishment Costs:** Adjustments were made to certain production costs for the first nine years of a solid-set (replanted) grove, and the first three years of reset trees. These adjustments reflect additional care costs for young trees, such as staking, planting, tree wraps, Ridomil treatments for foot/root rot, and additional cultivation maintenance. These adjustments also reflect a reduction in other care costs for an immature grove, such as reducing hedging and topping costs, and materials costs for spray and fertilization programs (Tables A-6 and A-7).

Investment Model Description

- **Investment Period**: Scenarios are evaluated over a 15-year (period) planning horizon, where mature plantings are assumed to be in production in the first year, and new plantings are assumed to require one year for regulatory approval and land preparation, with planting at the beginning in year two. For example, at the end of year two of the analysis, the trees are one-year old. Returns to mature plantings are assumed to accrue at the end of the first period.

- **Net Present Value:** The model uses the returns-to-assets net present value (NPV) technique of adding together the discounted cash flows over the investment period, plus a discounted terminal grove value, minus the non-discounted initial investment. The end of period cash flows are discounted using discount rates specific to each variety of citrus (Table 6-4) derived from previously published research (Table A-2).

- **Net Cash Flows:** Operating revenues minus operating costs. This investment model calculates cash flows as earnings before interest, taxes, depreciation, and amortization (EBITDA). The returns are a cash return per acre of planted citrus.

Table 6-4. Discount and capitalization rates.

Rate	Valencia	Hamlin	Grapefruit
	- - - - - - - - - - - - - - - - - - - -	%	- - - - - - - - - - - - - - - - - - - -
Discount	11.00	10.00	9.00
Capitalization	13.30	12.20	11.20

- **<u>Terminal Grove Value</u>:** In addition to the above cash flows, a final grove value is calculated by dividing the average cash flow of the last two periods by the capitalization rate, adding this back to the last period cash flow, and discounting to the present value.[5] The capitalization rate is specific to each variety of citrus and derived from previously published research (Table A-3). This values the grove on an income-producing basis, does not include land price appreciation, and may reflect a conservative estimate of grove value. In some disease scenarios ,the average last two period cash flow is dramatically reduced, and when the terminal value is calculated on an income producing basis, it is significantly smaller than the original purchase price. To correct for this unlikely outcome, the terminal grove value is assumed to never fall below the beginning per acre price for cropland/improved pasture.

- **<u>Breakeven Prices</u>:** The breakeven price is the lowest delivered-in price ($ per PS) for oranges, or on-tree ($ per box) for grapefruit at which the NPV of the 15-year investment period is positive A higher average price would mean the grove would break even in less time. For example, while a new planting of Valencia on the Ridge in the base scenario requires an average price of $1.30 per PS over 15 years to break even, an average price of $1.80 per PS would mean the grove breaks even within 13 years.

Investment Model Results Summary

<u>Scope of Analysis</u>

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, strong evidence shows 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.

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[5] See Appendix A for discussion.

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. This analysis follows common practices and standards across the Florida citrus industry. This information was gathered through publicly available data and extensive consultations with growers, other industry professionals, and citrus scientists and academics. We observe earnings before interest, taxes, depreciation, and amortization (EBITDA) in order to focus on cash flows attributable specifically to citrus operations. Also, by excluding land value appreciation we attempt to remove distortions caused by 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 an up-front 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. The NPV framework discounts these uncertain future returns using discount rates dependent upon the historical variability in citrus returns.[6] Due to the discounting factor, cash flows become smaller the farther out they are in an uncertain future. Therefore, changes in the up-front investment costs have a disproportionate effect on a grove's NPV.

Accounting for the Effect of Rural Land Prices on the Profitability of Citrus

According to the IFAS *2005 Florida Land Value Survey*, rural land prices increased from 50% to 88% in one year across the state, depending on their use (Reynolds 2005). Due to

[6] For a discussion of the discount rates and capitalization rates used in this analysis, please see Appendix A.

commercial development and related speculation, strong non-agricultural demand for rural properties appears not to be focusing on the income producing potential of agricultural activities. The prices used in this analysis for improved pasture were $6,426 per acre for Central Florida Ridge plantings, and $5,895 per acre for Southwestern and Indian River Flatwoods plantings (Reynolds). These prices are proxies 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, the assumption of zero land cost is not realistic, and 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 establish upper and lower bounds on the profitability of the replanting 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. This is illustrated by the replantings (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 plantings (with land costs) and replantings (without land costs) as a price range between which one can expect some planting of citrus. According to this analysis for a Valencia orange grove on the Ridge soil type, 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 per PS (for replantings without land cost) to $1.80 per PS (for new plantings with land cost) (Table 6-5). This range incorporates our conservative estimate for the residual value of the grove.[7]

Effects of Endemic Citrus Canker on Grove Profitability

With the end of the government-mandated citrus canker eradication program, Florida citrus is now entering an environment where citrus canker is likely to become endemic, and control is in the hands of the individual grower. Canker may be managed by grove sanitation

[7]Please refer to the "Terminal Grove Value" section of the Investment Model Description for a discussion of the method of incorporating an ending grove value into the NPV analysis.

Table 6-5. Breakeven citrus prices (net cash flow + final value) (Price[a] at which NPV of grove cash flows over 15-year period is positive).

Type	Scenario	Ridge		Flatwoods		Indian River
		Valencia	Hamlin	Valencia	Hamlin	Grapefruit
		$				
New Plantings	Base	1.30	1.20	1.30	1.30	7.00
	Canker	1.40	1.40	1.60	1.50	9.00
	Greening-low	1.50	1.40	1.60	1.50	9.00
	G&C-low	1.60	1.60	1.70	1.70	9.00
	G&C-med	1.70	1.60	1.80	1.70	10.00
	G&C-high	1.80	1.70	1.90	1.90	11.00
Replantings	Base	<1.00	<1.00	<1.00	<1.00	<5.00
	Canker	<1.00	1.00	1.00	1.10	6.00
	Greening-low	1.10	1.10	1.20	1.10	6.00
	G&C-low	1.20	1.20	1.20	1.20	7.00
	G&C-med	1.20	1.20	1.30	1.30	8.00
	G&C-high	1.30	1.30	1.40	1.40	9.00
Mature Grove	Base	<1.00	<1.00	<1.00	<1.00	<5.00
	Canker	<1.00	<1.00	<1.00	<1.00	<5.00
	Greening-low	<1.00	<1.00	<1.00	<1.00	<5.00
	G&C-low	<1.00	<1.00	<1.00	<1.00	<5.00
	G&C-med	<1.00	<1.00	<1.00	<1.00	<5.00
	G&C-high	<1.00	1.00	<1.00	<1.00	<5.00

[a]Price in $/PS for oranges, and $/on-tree box for grapefruit.
Threshold price for profitability less than scenario range, i.e., profitable at lower price than $1.00.

practices, removal of infected trees, and control of the citrus leafminer insect, which causes damage to citrus leaf tissue where the canker bacteria might enter. This analysis estimates the effect of canker in two ways: (1) increased production costs for managing canker, and (2) decreased yields due to infected trees. The degree and cost of canker management practices will mostly vary by the destination of the fruit. Because of canker's negative effect on the peel and visual desirability, a higher level of control, and therefore higher costs, is anticipated for fresh market fruit. Fruit destined for processing is not affected as much, due to the fact that canker has little effect on internal juice quality.

The marketing of the fruit and differing levels of susceptibility to canker across varieties results in the production costs being proportionally higher for grapefruit grown for the fresh market than oranges grown for the processing market (Table 6-6). The change in costs from the base scenario is the greatest (+25%) for grapefruit because of significantly increased spray and canker-free certification costs. The increase in costs for Hamlin oranges (+12% to 14%) compared to Valencia oranges (+9% to 10%) reflects Hamlin's increased susceptibility to canker and need for more intense management. Yield decreases 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 base rates across varieties to account for the removal of infected trees.

In our analysis, canker does not dramatically increase the breakeven prices for citrus. Although breakeven prices for new plantings are high ($1.40 to $1.60 per PS for oranges, and $9.00 per box for grapefruit), once land costs are excluded, the breakeven prices attributable exclusively to canker increase slightly for the susceptible varieties, Hamlin oranges and grapefruit, and less for Valencia oranges. Replanting of grapefruit for the fresh market requires a

Table 6-6. Average grove production costs by scenario and disease.

Type	Variety	Location	Base	Canker		Greening-Low		Canker & Greening					
								Low		Medium		High	
			cost/ acre	cost/ acre	% change from base	cost/ acre	% change from base	cost/ acre	% change from base	cost/ acre	% change from base	cost/ acre	% change from base
New Plantings/ Replantings[a]	Valencia	Ridge	811.48	893.45	10	1,085.38	34	1,104.85	36	1,116.37	38	1,155.18	42
	Hamlin	Ridge	811.48	924.44	14	1,085.38	34	1,134.56	39	1,145.49	41	1,182.39	46
	Valencia	Flatwoods	853.15	927.13	9	1,117.54	31	1,137.01	33	1,147.84	35	1,184.38	39
	Hamlin	Flatwoods	853.15	958.12	12	1,117.54	31	1,166.71	37	1,176.96	38	1,211.59	42
	Grapefruit	Indian River	1,008.25	1,256.15	25	1,365.72	35	1,378.90	37	1,375.46	36	1,364.89	35
Mature Plantings[b]	Valencia	Ridge	898.10	980.38	9	1,170.93	30	1,193.06	33	1,194.21	33	1,198.77	33
	Hamlin	Ridge	898.10	1,014.70	13	1,170.93	30	1,225.65	36	1,225.82	36	1,227.67	37
	Valencia	Flatwoods	974.88	1,055.36	8	1,260.23	29	1,283.10	32	1,290.23	32	1,311.89	35
	Hamlin	Flatwoods	974.88	1,089.68	12	1,260.23	29	1,315.69	35	1,321.83	36	1,340.79	38
	Gapefruit	Indian River	1,133.47	1,393.81	23	1,503.77	33	1,520.82	34	1,508.90	33	1,477.73	30

[a]New plantings/replantings production costs exclude year 1 establishment costs.
[b]Mature grove averages production costs for 15- to 30-year-old trees.

breakeven on-tree price of $6.00 per box, which is high for the recent past, but appears reasonably sustainable given recent events in grapefruit supply. Mature plantings continue to create significant cash flows even below $1.00 per PS and $5.00 per box for grapefruit. While increasing production costs and decreasing yields, canker in isolation does not require high prices in order to break even.

Effects of Greening on Grove Profitability

The effects of the citrus greening bacteria, or Huanglongbing (HLB), in Florida are still largely uncertain. Other countries' experiences with greening are extremely negative, but none of the other locations where greening is established practice the intense degree of grove management and advanced cultural techniques of the Florida citrus industry.[8] Also, many other countries did not implement greening control and integrated pest management programs until long after the disease was established and pervasive. Greening is spread by the vector of the Asian citrus psyllid insect. The psyllid feeds on the growth flushes put out by citrus trees as they grow. Citrus trees will die within a 1- to 4-year period after infection. In the greening-only analysis, we assume greening increases tree loss to 2% per year for trees aged 1 to 3, 2.63% for trees aged 4 to 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. Since young trees have more growth flushes, we expect greening to have a disproportionate effect on younger, vigorous trees. Note: these results are based on assumptions formed from greening's effects on other countries citrus industries and the current body of scientific literature, and may not reflect the reality of the disease in Florida.

[8] Although Greening has been present in Brazil, the world's largest producer of citrus, longer than Florida and is the subject of extensive scientific research, results from Brazil are still inconclusive.

Controlling for psyllids, resetting more trees, and field inspections for greening increase production costs significantly across all varieties and grove age. Production costs for oranges increase 31% to 34% for new plantings/replantings and 29% to 30% for mature plantings. Production costs for grapefruit increase 35% for new plantings/replantings and 33% for mature plantings. The difference between new plantings/replantings 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.

Greening appears to increase breakeven prices significantly more than canker. Breakeven prices for new plantings move into the range of $1.40 to $1.60 per PS for oranges, and $9.00 per box for grapefruit. Breakeven prices for replantings are $1.10 to $1.20 per PS for oranges, and $6.00 per box for grapefruit. Breakeven prices for mature groves are still less than $1.00 per PS and $5.00 per box for grapefruit. This indicates that while greening by itself does boost production costs significantly, its effect on replantings (without land cost) and mature groves given current price levels shows that citrus remains a profitable investment.

Conclusions

The Florida citrus industry faces significant barriers to entry. Increasing commercial and residential development of rural lands and Florida's expanding population are resulting in high land prices that increase up-front costs to establishing new citrus groves. The NPV analysis shows that disproportionate up-front costs make it difficult for a citrus investment to recoup the purchase price for vacant agricultural land. Citrus is currently in a high price environment, but, unlike the period following the freezes of the 1980s, investment in citrus by new entrants who do

not already own land is not expected. Most expansion in citrus acreage may come from existing growers and landowners converting land to citrus from other agricultural uses.

Increased risks due to canker and greening also act as a barrier to entry. Uncertainty about exactly what effects these diseases will have raises the return required to compensate for this additional risk. In our analysis, canker does not significantly alter the risk/return profile for processed citrus. Also, the expected future prices for grapefruit are favorable, and even with higher production costs, the expected returns appear to compensate risks due to canker.

Unfortunately, there is much uncertainty about what risks growers will face from greening. It is known that greening may significantly raise costs, but by how much depends on psyllid control, tree loss rates, and the effectiveness of the management program. Greening appears to have less of an effect on the profitability of mature groves and replantings for growers who already own their land.

The assumptions and scenarios in this analysis use the current body of information and opinions available to predict the future direction of Florida citrus. This includes high density plantings and constant resetting because of higher tree loss rates due to greening. This analysis adopts the strategy of pushing as many trees as possible through the vulnerable immaturity period, although this is yet to be scientifically validated. Also, the high tree loss rates may result in a lack of uniformity in groves which may create difficulties for mechanical harvesting. At this time, not enough is known about the way greening kills trees to effectively project what a future Florida citrus grove will look like.

We determine price ranges in order for citrus to be profitable. The predicted prices in other sections of this report indicate that, for certain participants, citrus may be highly profitable over the next decade. Barring significant changes in the price environment, assumed effects of

diseases, or rural property values, preexisting citrus may remain profitable because of the constraints on production. Those who own citrus groves or agricultural land will stay in the business and may even expand plantings, however, Florida citrus may not expand in response to high prices as it once did.

Section VII
Long-run Production and Price Forecasts for Processed Oranges and Fresh and Processed Grapefruit

by
Mark G. Brown and Thomas H. Spreen

In this section of the paper, long-run production and price forecasts for Florida processed oranges and fresh and processed grapefruit are presented. This is accomplished through two quantitative models: one that relates to the world orange-juice market and another model of the market for Florida grapefruit.

Model simulations are conducted to provide input to answering key questions about the Florida citrus industry. Will prices be high enough to cover costs? What will be the size of the Florida citrus industry in the future? What will be the impact on the Florida economy? Answers to these questions are critical for planning, but such answers can only be provided in a probabilistic sense. The future of a complex industry such as Florida citrus simply can not be reliably predicted. Thus, in this context, a range of scenarios are examined here based on current industry expectations on spread of citrus diseases, costs, land development and other factors.

A Model of the World Orange-Juice Market

A model of the world orange-juice market was originally developed by McClain in 1989. Since that time it has been modified and updated several times including Spreen, et al. (1992) in an analysis of the impact of the North American Free Trade Agreement (NAFTA) on U.S. citrus growers and Spreen, et al. (2003) who analyzed the effects of the proposed Free Trade Area of the Americas (FTAA).

That model is modified and adapted for this study. The world OJ model is comprised of general relationships between OJ supply, demand and prices in the world. Econometric estimates of these relationships are then used to simulate the model. The model includes explicit supply relationships for orange juice produced in Florida and São Paulo, Brazil.

The model used herein is a modification of the Spreen, et al. (2003) model in that it does not explicitly consider not-from-concentrate orange juice as a distinct product from reconstituted-from-concentrate orange juice. Aggregation of these two products into a single product greatly simplifies the calculation of a price equilibrium. Demand for orange juice in the United States and the rest of the world are included in the model as well as inventory adjustments (juice inventories represent a demand for the present season and supply to the next season). Prices in the model are based on aggregate world supply and demand relationships. The current price is determined by (1) calculating the change in aggregate supply from the previous to current period, (2) calculating the assumed shift in aggregate demand (price constant) from the previous to current period, and (3) adjusting price to equate these supply and demand changes: if the supply change equals the demand change, price is unchanged; if the supply change is greater than (less than) the demand change, price is decreased (increased) until quantity demanded increases (decreases) sufficiently to eliminate the excess supply (excess demand), using demand elasticities across markets to determine the quantity responses to price. Although the model is based on one OJ price (the Florida FOB for bulk FCOJ), other OJ prices across markets and product forms would generally be expected to differ from the Florida FOB price, depending on transportation costs, tariffs, quality premiums and other factors. The margins between the Florida FOB price and the other prices, however, are assumed to be constant, and a change in the Florida FOB price results in the same change in the other OJ prices. This modeling approach is the same as taken

by McClain. Prices are dollars per single-strength-equivalent (SSE) gallon (1.029 pound solids per SSE gallon).

The model takes as input the existing tree inventory in Florida and uses yields on a per-acre basis and by tree age to predict the Florida orange crop for the present season. Fresh utilization is deducted and using historical juice yields, the remaining orange production is converted to juice. A similar process is used to predict orange and orange-juice production in São Paulo, Brazil. Brazilian juice is allocated between the United States and the rest of the world (ROW) (primarily the European Union). Juice from Florida and São Paulo constitute the bulk of the supply to the U.S. market. Orange-juice production from Mexico, Costa Rica, Belize and other countries are part of aggregate world supply and some of this supply may be imported to the U.S. market, although not specifically tracked here—U.S. imports are calculated as a residual: U.S. consumption minus Florida beginning inventory minus U.S. production (from Florida and other U.S. citrus-producing states) plus U.S. exports plus Florida ending inventory.

Based on demand relationships estimated by Brown, et al. (including updates), current year U.S. supply is allocated between current-year consumption and inventory. The demand equations include a 1% annual increase in U.S. orange-juice demand and 2% annual increase in demand in the ROW. In recent years, U.S. demands for OJ and a number of foods have been adversely impacted by low-carb diet concerns of consumers. With these concerns having strong impacts over several years, the demands for OJ and various other foods declined. Historically, U.S. demand for OJ, however, has grown with support from advertising (see "Generic Promotions of Florida Citrus," by a Panel of Citrus Economists). Over the projection period, generic and brand advertising is assumed to occur and support a growth rate of 1% in U.S. demand for OJ. An alternative assumption of zero growth in U.S. demand is also considered.

Once an FOB price for FCOJ in the United States is determined, this price is used to predict new plantings in Florida in the next season. The tree inventory is aged one year and adjusted for death loss. A similar set of calculations is conducted for São Paulo. A major distinction between new plantings in Florida and São Paulo is that in the São Paulo equation, a ratio of orange prices and sugar prices is used to predict new plantings to account for the strong competition between oranges and sugarcane for agricultural land in São Paulo.

After the tree inventory has been adjusted, the model moves to the next season and the process outlined above is repeated. Inventory accumulated from the previous season represents supply to the following season.

To account for the presence of citrus canker and greening, modifications to the model were made to per-acre yields (canker) or death loss (greening). The new tree planting equation is also modified to reflect shifts in the revenue stream resulting from the presence of these diseases. Increases in grove care costs due to canker and greening are subtracted from grower prices to obtain net prices for predicting new planting levels. This adjustment can be viewed as a shift in the intercept of the new planting equation (Appendix B). Likewise, increased prices for undeveloped land are handled through a shift in the new tree planting equation.

A Model of the World Market for Florida Grapefruit

In 1988, Pana completed the first attempt to construct a model of the world market for Florida grapefruit. The grapefruit market differs from the orange-juice market in three fundamental ways. First, Florida is the dominant supplier to the world fresh and processed grapefruit market. Before the production decline in Florida following the hurricanes of 2004, Florida accounted for over 40% of world grapefruit production. Therefore, it is not necessary to

consider alternative suppliers of grapefruit. Second, there is fungibility between grapefruit sent to the fresh versus the processed market. A market model of grapefruit should take into consideration that a market allocation process takes place that establishes the proportion of the crop processed and sold fresh. Third, there are two main varieties of grapefruit: red seedless and white seedless.

In this study, a modification of Pana's model is used. Pana used a spatial equilibrium approach. In this study, a deterministic simulation model that is similar to the Pana model is developed. It begins in a fashion similar to the world orange-juice model. The grapefruit tree inventory for Florida is input to the model. Using average yields on a per-acre basis, the number of acres in an age category is multiplied by average per-acre yields and summed across age categories to generate the total production of white seedless and red seedless grapefruit. Total production is allocated between the fresh and processed markets. Equilibrium prices are determined in each market using demand equations estimated by Lee (2004), Brown (2004), Brown and Lee (2002). No growth in demand is assumed for both fresh and processed grapefruit. The model also deals with domestic versus export fresh sales. After packing costs and processing costs are deducted, delivered-in prices for both fresh and processed sales are established. Subtracting pick and haul costs gives on-tree prices. On-tree prices are then used to predict new plantings. The existing tree inventory is aged and adjusted for tree mortality. The model is then solved for the next season.

Empirical Results

Eleven scenarios are presented as outlined below.

1. A base run of the model with citrus-canker yield and acre-loss penalties.

2. No citrus-canker yield and acre-loss penalties are imposed.

3. Imposition of citrus canker with higher yield losses (30% for early-mid varieties and 15% for Valencia).

4. Imposition of citrus canker plus citrus greening assuming a low rate of tree mortality (100% increase in nonbearing death loss, 75% increase in death loss for trees ages 4 through 11, and 50% increase in death loss for trees 12 years and older).

5. Imposition of citrus canker plus citrus greening at a high rate of tree mortality (300% increase in death loss for nonbearing trees, 200% increase in death loss for trees ages 4 through 11, and a 150% increase in death loss for trees 12 years and older).

6. Imposition of citrus canker plus an increase in raw-land values (cost of raw land is assumed to increase by $3,500 per acre and impact tree planting levels).

7. Imposition of citrus canker plus a high development impact (cost of raw land is assumed to increase by $3,500 per acre and impact tree planting levels; in addition, an annual loss of orange acreage of 2% and an annual loss of grapefruit acreage of 4% are assumed).

8. Imposition of citrus canker plus an adjustment in the sugar price in Brazil to reflect increased prices.

9. Simultaneous imposition of citrus canker (Scenario 1), citrus greening (Scenario 4), higher raw-land prices (Scenario 6), and high sugar prices in Brazil (Scenario 8).

10. Simultaneous imposition of citrus canker citrus (Scenario 1), greening (Scenario 4), higher raw-land prices (Scenario 6), and high sugar prices in Brazil (Scenario 8), plus no demand growth in the United States.

11. Simultaneous imposition of citrus canker citrus (Scenario 1), greening (Scenario 4), higher raw-land prices (Scenario 6), and high sugar prices in Brazil (Scenario 8), plus pessimistic assumptions regarding future worldwide orange-juice demand.

Base-Run Results

A base run of the orange-juice model was completed in order to (1) validate the model for the 2005-06 marketing years and (2) provide a reference point for the other scenarios to be evaluated. In this run, the FASS citrus inventory has been updated by adjusting for the 2005 hurricane losses, acres lost due to canker eradication and other factors. The yields used in the model are a weighted average of 11 seasons (1993-94 through 2003-04) which excludes hurricane affected years. A separate set of yields were estimated based on the 2004-05 hurricane season. Future production is based upon the assumption that a hurricane will strike the Florida peninsula once every 10 years. It should be noted that historically, relatively large variations in yields have occurred. In this report, future production is based on average yields, and indicates trends in production over time, as opposed to actual production in any given season which may vary substantially from the trend. The 95% confidence intervals based on yield variation alone indicate orange and grapefruit production could vary roughly plus/minus 20% and plus/minus 10% around their trends, respectively. Similarly, assumed trends in acres lost over time may also be smoother than will actually occur, as acres lost in a given season may vary from the assumed acre-loss trend due to unforeseen events such as hurricanes, freezes, and the rapid spread of diseases such as canker .

Planting levels over the next two seasons, 2005-06 and 2006-07, are assumed to be 1/6 the level of plantings in the 2003-04 season and zero in 2007-08 due to the limited availability of nursery stock. In 2008-09 and after, constraints on nursery trees are removed and planting levels are determined by the model's planting equations.

Given the current level of citrus canker found in the four main citrus-production areas, it is assumed that the disease will not disperse evenly throughout the state. The disease will not be

present in 100% of all production regions until the 2011-12 season. In the base model, the presence of citrus canker is assumed to reduce per-acre yields by 5% in Valencias and 10% for all other varieties. These yield penalties are adjusted by the percentages of assumed infected acres noted earlier. The other impacts of canker, increased tree mortality and increased cost of production are also adjusted in a similar manner.

The base scenario does not include the effects of greening, increases in Florida land values and increases in sugar prices in Brazil (before the oil-price spike).

The results of the base run are shown in Tables 7-1, 7-2, and 7-3. The simulation period is 15 years beginning in 2006-07 through 2020-21. Note the projected production levels. Based upon adjustments in the existing tree inventory, the projected crop in the 2006-07 season, assuming average yields, is 196 million boxes, a level considerably higher than the 2004-05 and 2005-06 seasons which were adversely affected by hurricanes. At this level of production, prices are expected to ease from present levels with all processed oranges averaging $3.98 per box on-tree. With the lack of new trees for the next three seasons, total acres (bearing and non-bearing) are projected to decline to less than 500,000 by the 2008-09 season. Loss rates reported in the tables reflect acre losses (bearing and non-bearing) from the previous to current seasons, and do not include newly planted trees in the current season. Florida orange production is projected to decline to 175 million boxes by 2014-15, at which point it stabilizes and increases to 181 million boxes by the 2020-21 season. Over this same period, production in São Paulo is projected to steadily increase, exceeding 400 million boxes in 2013-14 season and reaching 468 million boxes in 2020-21. Despite increasing production in São Paulo, bulk FCOJ prices

Table 7-1. Scenario 1: Long-run projections of Florida and São Paulo orange production, U.S. and ROW OJ consumption and U.S. OJ prices, **Base assumptions**.[1]

Season	ORANGE							
	Florida Production	Total Acreage	Acre Loss Rate	São Paulo Production	Price		OJ Consumption	
					Florida Bulk FCOJ	Processed On-Tree	U.S.	ROW
	million boxes	1,000 acres	- % -	million boxes	$/SSE gal.	- $/box -	- million SSE gallons -	
2006-07	196	523	-3.9	360	1.19	3.98	1,391	2,167
2007-08	194	504	-3.5	360	1.18	3.95	1,408	2,217
2008-09	191	498	-3.4	365	1.20	4.08	1,412	2,237
2009-10	187	504	-3.4	371	1.23	4.26	1,414	2,249
2010-11	183	509	-3.4	377	1.26	4.41	1,418	2,267
2011-12	179	515	-3.4	384	1.28	4.57	1,422	2,286
2012-13	178	521	-3.3	392	1.30	4.66	1,430	2,315
2013-14	176	527	-3.3	401	1.31	4.73	1,440	2,349
2014-15	175	534	-3.3	409	1.31	4.77	1,452	2,389
2015-16	175	541	-3.2	419	1.32	4.80	1,464	2,432
2016-17	175	548	-3.2	428	1.32	4.81	1,479	2,480
2017-18	176	555	-3.1	438	1.32	4.80	1,494	2,531
2018-19	177	562	-3.1	448	1.31	4.77	1,511	2,586
2019-20	179	569	-3.1	458	1.31	4.74	1,528	2,643
2020-21	181	576	-3.0	468	1.30	4.71	1,545	2,702

[1] Assumes (a) presence of canker will increase acre-loss rates by 10%, and decrease acre yields for Valencia oranges and other citrus varieties by 5% and 10%, respectively; (b) acre yields are weighted averages of historical yields: 90% times non-hurricane yields (averages from 1993-94 through 2003-04) plus10% times hurricane yields (2004-05), (c) U.S. and ROW OJ demands grow by 1% and 2% annually, respectively; and (d) ROW OJ supplies grow by 1% annually.

Table 7-2. Scenario 1: Long-run projections of Florida grapefruit production, fresh and processed prices, U.S. GJ consumption, and Florida fresh grapefruit shipments, **Base assumptions**.[1]

Season	GRAPEFRUIT							
	Florida Production	Total Acreage	Acre Loss Rate	Price			U.S. GJ Consump-tion	Florida Certified Fresh Grapefruit Utiliza-tion
				Florida Fresh FOB	Florida Bulk FCGJ (White)	Fresh/ Processed On-Tree		
	million boxes	1,000 acres	- % -	- $/box -	- $/PS -	- $/box -	million SSE gallons	million boxes
2006-07	24	57	-9.0	19.85	2.34	7.09	52.3	9.9
2007-08	23	53	-6.0	20.84	2.22	7.26	53.1	9.4
2008-09	22	53	-4.2	21.54	2.28	7.74	52.6	9.2
2009-10	21	54	-3.4	22.21	2.39	8.32	51.9	8.9
2010-11	21	56	-3.1	22.80	2.52	8.90	51.1	8.7
2011-12	20	58	-3.0	23.29	2.63	9.40	50.3	8.5
2012-13	20	60	-2.9	23.46	2.69	9.62	50.0	8.5
2013-14	20	63	-2.8	23.45	2.71	9.68	49.9	8.5
2014-15	20	66	-2.6	23.30	2.69	9.56	50.0	8.5
2015-16	21	69	-2.5	22.87	2.62	9.17	50.4	8.7
2016-17	21	73	-2.4	22.29	2.50	8.62	51.1	8.9
2017-18	22	76	-2.3	21.50	2.34	7.86	52.1	9.2
2018-19	23	79	-2.2	20.58	2.16	7.00	53.3	9.6
2019-20	24	82	-2.2	19.64	1.97	6.10	54.7	10.0
2020-21	25	84	-2.2	18.70	1.78	5.20	56.2	10.4

[1] Assumes (a) presence of canker will increase acre-loss rates by 10%, and decrease acre yields by10%; (b) acre yields are weighted averages of historical yields: 90% times non-hurricane yields (averages from 1993-94 through 2003-04) plus10% times hurricane yields (2004-05), and (c) no growth in domestic and export demands for GJ and fresh grapefruit.

Table 7-3. Scenario 1: FOB Revenues – **Base assumptions**.[1]

Season	FOB Revenue						
	Fresh				Processed		
	Orange	Grapefruit	Specialty	Total	OJ	GJ	Total
	- million $				- -		
2006-07	137	196	85	418	3,027	207	3,234
2007-08	137	197	82	416	3,072	201	3,274
2008-09	137	197	79	414	3,095	204	3,330
2009-10	137	198	77	412	3,105	209	3,314
2010-11	137	199	74	410	3,115	214	3,329
2011-12	137	199	72	408	3,120	218	3,338
2012-13	137	199	69	405	3,133	220	3,353
2013-14	137	199	67	403	3,148	221	3,370
2014-15	137	199	65	401	3,166	221	3,386
2015-16	137	199	63	398	3,185	218	3,402
2016-17	137	198	61	396	3,206	213	3,419
2017-18	137	197	59	393	3,230	206	3,436
2018-19	137	197	57	391	3,258	198	3,456
2019-20	137	196	55	388	3,288	188	3,476
2020-21	137	195	54	386	3,322	177	3,499

[1] Assumes (a) presence of canker will increase acre-loss rates by 10%, and decrease acre yields for Valencia oranges and other citrus varieties by 5% and 10%, respectively; (b) acre yields are weighted averages of historical yields: 90% times non-hurricane yields (averages from 1993-94 through 2003-04) plus10% times hurricane yields (2004-05), (c) U.S. and ROW OJ demands grow by 1% and 2% annually, respectively; (d) no growth in domestic and export demands for GJ and fresh grapefruit, and (e) ROW OJ supplies grow by 1% annually.

exhibit an upward to flat trend over the forecast period, reaching $1.32 per SSE gallon in 2015-16. On-tree prices show a similar pattern, exceeding $4.00 per box over all but two years of the forecast period. These results are based on the assumption that OJ demands in the United States and the rest of the world grow annually by 1% and 2%, respectively. (A 1% growth rate in U.S. demand would keep per capita consumption relatively constant, with the U.S. population growing at about 1%; a 2% growth rate in the rest of the world is based on estimates of growth in world demand in recent years made by the Florida Department of Citrus; China and Russia have been experiencing the largest growth; Brown, Staff Report 2004-6.)

Projections for grapefruit are shown in Table 7-2. With the large decrease in bearing acres due to the canker eradication program, Florida grapefruit production is projected to be 24 million boxes in 2006-07. While this level is higher than the depressed production levels of 2004-05 and 2005-06, it is far below the levels realized in the past decade. Production is projected to decline to 20 million boxes by the 2011-12 season, stabilize and recover to 25 million boxes by 2020-21. With Florida being the largest supplier of grapefruit to the world market, production at these levels translates to exceedingly high prices for grapefruit, assuming the demand for fresh grapefruit and grapefruit juice remain stable. FOB fresh grapefruit prices are projected to exceed $20.00 per box ($10.00 per carton) over nearly all of the forecast horizon. Frozen-concentrated-grapefruit-juice (FCGJ) prices are also projected at high levels of over $2.00 per PS over the most of the forecast horizon.

At these persistent high price levels, it is possible that other production regions will respond by increasing production. In Florida's marketing window, possible competing regions are Mexico, Cuba, Israel, and Turkey. Each of these regions, however, face other issues (e.g., the

Mexican fruit fly is endemic in Mexico) that may constrain their ability to significantly expand production.

In Table 7-3, projected FOB revenue is presented for the base run of the models. As a point of reference FOB revenue from fresh citrus sales was $159 million in the 2003-04 season and from processed sales was $2,846 million for a total of $3,005 million. Compared to these figures, FOB revenue is projected to be higher throughout the forecast horizon with processed FOB revenue increasing from $3,234 million in 2006-07 to $3,499 million in 2020-21. Processed FOB revenue includes a premium for NFC sales and adjustments for product sold in bulk versus retail packages. Higher FOB revenue results from lower production and proportionately higher prices due to the inelastic nature of demand for citrus products at the FOB level. Based purely upon FOB revenue, this industry is not facing a dire future. FOB revenue, however, can be misleading if production costs substantially increase. The presence of citrus canker will increase production costs for growers and packinghouses.

Results from Other Scenarios

Ten alternative scenarios were analyzed. The intent of these scenarios is to evaluate the incremental effect of greening and high raw-land prices in Florida on production and prices. Another scenario is analyzed which is intended to account for the competition between sugarcane and citrus for agricultural land in Brazil. Alternative assumptions related to demand growth for citrus products are also evaluated.

No Canker Effect - Scenario 2 Results

In this scenario, yield penalties of 5% for Valencias and 10% for all other varieties are removed. A 10% increase in tree-death loss is also removed. Projected orange production and prices under these assumptions are shown in Table 7-4. Compared to the base run, Florida orange production is consistently higher with the increase ranging from 4 million boxes in the 2006-07 season to 23 million boxes in 2020-21. Higher production results in a modest decrease in prices of about 1¢ to 7¢ per SSE gallon. On-tree prices are decreased by a similar proportional magnitude. These results provide a rough estimate of the impact of citrus canker on the processing sector over the next 15 years. Lower prices in Florida also affect adversely São Paulo orange production, although the magnitude of the production decrease is relatively small.

Projected Florida grapefruit production and prices under no canker effect is shown in Table 7-5. The impact on grapefruit production is modest, averaging about 11% per year over the forecast horizon. Florida production in 2020-21 is projected at 27 million boxes in this scenario compared to 25 million boxes in the base run. Both fresh and processed prices decrease modestly.

In Table 7-6, projected FOB revenue for fresh and processed citrus products is shown. It is assumed that pack-out rates are the same as in the base scenario, and the FOB revenue from fresh sales for the base scenario and this scenario are similar. FOB revenue from processed sales shows a small increase reflecting increased market share for Florida versus Brazil.

Table 7-4. Scenario 2: Long-run projections of Florida and São Paulo orange production, U.S. and ROW OJ consumption and U.S. OJ prices, base assumptions **EXCEPT no canker yield and acre losses**.[1]

Season	ORANGE							
	Florida Produc-tion	Total Acreage	Acre Loss Rate	São Paulo Produc-tion	Price		OJ Consumption	
					Florida Bulk FCOJ	Processed On-Tree	U.S.	ROW
	million boxes	1,000 acres	- % -	million boxes	$/SSE gal.	$/SSE gal.	- million SSE gallons -	
2006-07	200	523	-3.8	360	1.17	3.89	1,397	2,182
2007-08	201	506	-3.3	360	1.16	3.78	1,419	2,246
2008-09	201	501	-3.2	365	1.16	3.83	1,429	2,281
2009-10	201	508	-3.1	371	1.18	3.92	1,437	2,310
2010-11	199	516	-3.1	377	1.19	4.02	1,445	2,337
2011-12	197	523	-3.1	384	1.21	4.14	1,451	2,363
2012-13	196	531	-3.0	392	1.23	4.23	1,459	2,393
2013-14	195	539	-3.0	399	1.24	4.29	1,469	2,429
2014-15	195	547	-3.0	407	1.25	4.35	1,480	2,468
2015-16	195	556	-2.9	415	1.25	4.38	1,493	2,510
2016-17	196	564	-2.9	424	1.26	4.41	1,506	2,555
2017-18	197	573	-2.9	432	1.26	4.42	1,520	2,604
2018-19	199	582	-2.8	441	1.26	4.42	1,536	2,657
2019-20	202	591	-2.8	449	1.26	4.41	1,551	2,712
2020-21	204	599	-2.8	458	1.25	4.40	1,568	2,768

[1] Same as base scenario, Table 7-1, except no decrease in acre yields and no increase in acre-loss rates are assumed.

Table 7-5. Scenario 2: Long-run projections of Florida grapefruit production, fresh and processed prices, U.S. GJ consumption, and Florida fresh grapefruit shipments, base assumptions **EXCEPT no canker yield and acre losses**.[1]

Season	GRAPEFRUIT							
	Florida Production	Total Acreage	Acre Loss Rate	Price			U.S. GJ Consump-tion	Florida Certified Fresh Grapefruit Utiliza-tion
				Florida Fresh FOB	Florida Bulk FCGJ (White)	Fresh/ Processed On-Tree		
	million boxes	1,000 acres	- % -	- $/box -	- $/PS -	- $/box -	million SSE gallons	million boxes
2006-07	25	57	-8.8	18.32	2.06	5.69	55.5	10.6
2007-08	24	53	-5.8	19.00	1.87	5.55	57.1	10.3
2008-09	24	54	-3.9	19.39	1.87	5.72	57.2	10.1
2009-10	24	55	-3.1	19.71	1.91	5.99	56.7	9.9
2010-11	23	56	-2.8	20.10	1.98	6.34	56.1	9.8
2011-12	23	58	-2.8	20.38	2.05	6.63	55.5	9.6
2012-13	23	60	-2.7	20.46	2.08	6.75	55.2	9.6
2013-14	23	62	-2.6	20.41	2.09	6.77	55.1	9.6
2014-15	23	64	-2.5	20.28	2.08	6.68	55.2	9.7
2015-16	23	67	-2.4	19.96	2.03	6.40	55.6	9.8
2016-17	24	69	-2.3	19.56	1.96	6.03	56.3	10.0
2017-18	24	71	-2.2	19.00	1.86	5.53	57.2	10.3
2018-19	25	73	-2.2	18.38	1.74	4.95	58.3	10.6
2019-20	26	75	-2.1	17.73	1.62	4.35	59.5	10.9
2020-21	27	77	-2.1	17.09	1.50	3.76	60.8	11.3

[1] Same as base scenario, Table 7-2, except no decrease in acre yields and no increase in acre-loss rates are assumed.

Table 7-6. Scenario 2: FOB Revenues – Base assumptions **EXCEPT no canker yield and acre losses.**[1]

Season	FOB Revenue						
	Fresh				Processed		
	Orange	Grapefruit	Specialty	Total	OJ	GJ	Total
	- - - - - - - - - - - -	- - - - - - - - -	- - - - - - - - -	- - - - million $	- - - - - - - - - - - -	- - - - - - - - -	- - - - - - - - -
2006-07	137	194	85	417	3,041	192	3,232
2007-08	137	195	82	415	3,099	182	3,281
2008-09	137	196	80	412	3,138	182	3,320
2009-10	137	196	77	410	3,166	184	3,350
2010-11	137	196	75	408	3,186	188	3,374
2011-12	137	196	73	406	3,202	191	3,392
2012-13	137	197	70	404	3,221	192	3413
2013-14	137	196	68	402	3,242	193	3,435
2014-15	137	196	66	400	3,267	192	3,459
2015-16	137	196	64	397	3,293	190	3,483
2016-17	137	196	62	395	3,321	186	3,507
2017-18	137	195	61	393	3,353	181	3,534
2018-19	137	195	59	391	3,389	175	3,563
2019-20	137	194	57	388	3,427	168	3,594
2020-21	137	193	56	386	3,467	160	3,627

[1] Same as base scenario, Tables 7-1 and 7-2, except no decrease in acre yields and no increase in acre-loss rates are assumed.

Higher Negative Yield Effect from Canker - Scenario 3 Results

In Scenario 3, yield penalties associated with citrus canker are increased to 15% for Valencias and 30% for other varieties. Yield penalties of this magnitude are more consistent with those realized in China where citrus canker has been present for many years. While the climate in China is more humid than other production regions with endemic citrus canker (e.g. Argentina), the intensity of management in Florida is generally higher compared to China. There is some belief that yield effects from citrus canker on the order of 5% to 10% is too low for Florida's climatic conditions.

Projected production and prices assuming larger citrus canker yield penalties are shown in Table 7-7. In this scenario, production is lower compared to the base run throughout the forecast horizon with production decreasing from 188 million boxes in 2006-07 to 145 million boxes in 2015-16. At that point, production stabilizes and recovers slightly to 148 million boxes in the 2020-21 season. With these levels of production, FOB FCOJ prices are generally higher than the base run, increasing from $1.22 per SSE gallon in 2006-07 to $1.42 per SSE gallon in 2012-13. The price increase, however, is tempered by increased production in São Paulo. São Paulo orange production is projected to reach 485 million boxes in 2020-21 compared to 468 million boxes in the base run.

Decreased yields also have a strong effect on grapefruit production as shown in Table 7-8. Projected grapefruit production is 20 million boxes in 2006-07 and decreases to 15 million boxes in 2013-14. Production recovers modestly to 19 million boxes in 2020-21. At these production levels, prices remain exceedingly high over the forecast horizon, with FOB prices for fresh fruit

Table 7-7. Scenario 3: Long-run projections of Florida and São Paulo orange production, U.S. and ROW OJ consumption and U.S. OJ prices, base assumptions **PLUS increased canker yield losses.**[1]

Season	ORANGE							
	Florida Production	Total Acreage	Acre Loss Rate	São Paulo Production	Price		OJ Consumption	
					Florida Bulk FCOJ	Processed On-Tree	U.S.	ROW
	million boxes	1,000 acres	- % -	million boxes	$/SSE gal.	- $/box -	- million SSE gallons -	
2006-07	188	523	-3.9	360	1.22	4.16	1,380	2,140
2007-08	180	504	-3.5	360	1.23	4.27	1,387	2,164
2008-09	171	498	-3.4	365	1.28	4.56	1,381	2,156
2009-10	161	501	-3.4	371	1.34	4.91	1,372	2,139
2010-11	156	505	-3.4	377	1.37	5.14	1,371	2,145
2011-12	150	509	-3.4	385	1.41	5.34	1,373	2,156
2012-13	148	513	-3.4	394	1.42	5.42	1,381	2,186
2013-14	147	518	-3.4	403	1.42	5.45	1,393	2,225
2014-15	146	523	-3.3	414	1.42	5.45	1,407	2,270
2015-16	145	528	-3.3	425	1.42	5.42	1,423	2,321
2016-17	145	533	-3.2	437	1.41	5.37	1,441	2,375
2017-18	145	537	-3.2	449	1.40	5.30	1,459	2,433
2018-19	146	542	-3.2	461	1.39	5.22	1,479	2,495
2019-20	146	547	-3.1	473	1.37	5.15	1,499	2,559
2020-21	148	551	-3.1	485	1.36	5.07	1,519	2,623

[1] Same as base scenario, Table 7-1, except canker is assumed to decrease acre yields for Valencia oranges and other citrus varieties by 15% and 30%, respectively.

Table 7-8. Scenario 3: Long-run projections of Florida grapefruit production, fresh and processed prices, U.S. GJ consumption, and Florida fresh grapefruit shipments, base assumptions **PLUS increased canker yield losses**.[1]

Season	GRAPEFRUIT							
	Florida Production	Total Acreage	Acre Loss Rate	Price			U.S. GJ Consump-tion	Florida Certified Fresh Grapefruit Utiliza-tion
				Florida Fresh FOB	Florida Bulk FCGJ (White)	Fresh/ Processed On-Tree		
	million boxes	1,000 acres	- % -	- $/box -	- $/PS -	- $/box -	million SSE gallons	million boxes
2006-07	20	57	-9.0	23.67	2.89	10.21	46.0	8.4
2007-08	19	53	-6.0	25.44	2.99	11.27	45.5	7.9
2008-09	18	53	-4.2	27.02	3.23	12.59	44.5	7.5
2009-10	17	53	-3.4	28.74	3.52	14.10	43.3	7.1
2010-11	16	55	-3.1	29.79	3.77	15.21	42.5	6.8
2011-12	16	57	-3.1	30.81	4.00	16.23	41.7	6.6
2012-13	16	59	-3.0	31.20	4.11	16.70	41.4	6.6
2013-14	15	62	-2.8	31.37	4.17	16.91	41.2	6.5
2014-15	15	65	-2.7	31.34	4.17	16.88	41.2	6.5
2015-16	16	69	-2.5	30.90	4.08	16.45	41.5	6.6
2016-17	16	73	-2.4	30.18	3.93	15.74	41.9	6.8
2017-18	17	77	-2.3	29.10	3.72	14.71	42.6	7.0
2018-19	18	81	-2.2	27.80	3.46	13.48	43.4	7.3
2019-20	18	85	-2.1	26.39	3.19	12.16	44.4	7.6
2020-21	19	88	-2.1	24.96	2.90	10.81	45.5	8.0

[1] Same as base scenario, Table 7-2, except canker is assumed to decrease acre yields by 30%.

exceeding $30.00 per box ($15.00 per carton) for several years before declining to $24.96 per box ($12.48 per carton) in 2020-21. FCGJ prices also remain extremely high over the forecast period.

Projected FOB revenue for fresh and processed citrus products is shown in Table 7-9. Imposition of larger yield penalites for citrus canker negatively affects FOB revenue, but the effects are not large. FOB revenue for processed sales decreases as São Paulo production increases and Florida loses market share. FOB revenue from fresh sales increases modestly.

Inclusion of Effects from Greening - Scenario 4 Results

In this scenario, the impact of greening is incorporated into the base scenario. Greening is assumed to increase tree mortality in Florida. Tree mortality for nonbearing trees increases by 150% compared to the base, 100% for trees ages 4 through 11 and 75% for all older trees. The assumed spread of greening in Florida is described in Section III of this paper. It is assumed in the greening scenarios of this study that means will be developed to identify this disease, control the psyllid and growers will aggressively remove infected trees. Projected processed orange production and prices associated with this scenario are shown in Table 7-10.

One can clearly see the effect of greening on bearing acreage and hence production and prices. In this scenario, total acres decline to just under 500,000 acres, but recover slowly in spite of persistently high prices. Increased death loss associated with greening results in higher overall death loss; the base level of tree death has increased from approximately 3% per year to over 4% annually. As a result, Florida orange production declines to 155 million boxes by 2018-19, at which time production stabilizes.

Table 7-9. Scenario 3: FOB Revenues – Base assumptions **PLUS increased canker yield losses.**[1]

Season	FOB Revenue						
	Fresh				Processed		
	Orange	Grapefruit	Specialty	Total	OJ	GJ	Total
	- million $ -						
2006-07	137	199	85	422	3,000	229	3,229
2007-08	137	201	82	420	3,019	233	3,252
2008-09	137	202	79	418	3,011	241	3,252
2009-10	137	203	77	417	2,985	250	3,235
2010-11	137	204	74	415	2,977	257	3,234
2011-12	137	204	72	413	2,966	262	3,228
2012-13	137	204	69	411	2,973	265	3,238
2013-14	137	205	67	409	2,983	266	3,249
2014-15	137	204	65	406	2,993	266	3,259
2015-16	137	204	63	404	3,004	264	3,268
2016-17	137	204	60	401	3,016	260	3,277
2017-18	137	203	59	399	3,032	255	3,286
2018-19	137	202	57	396	3,050	247	3,297
2019-20	137	201	55	393	3,071	238	3,309
2020-21	137	200	53	391	3,094	227	3,321

[1] Same as base scenario, Tables 7-1 and 7-2, except canker is assumed to decrease acre yields for Valencia oranges and other citrus varieties by 15% and 30%, respectively.

Table 7-10. Scenario 4: Long-run projections of Florida and São Paulo orange production, U.S. and ROW OJ consumption and U.S. OJ prices, base assumptions **PLUS low-greening-loss rates.**[1]

Season	ORANGE							
	Florida Produc-tion	Total Acreage	Acre Loss Rate	São Paulo Produc-tion	Price		OJ Consumption	
					Florida Bulk FCOJ	Processed On-Tree	U.S.	ROW
	million boxes	1,000 acres	- % -	million boxes	$/SSE gal.	- $/box -	- million SSE gallons -	
2006-07	196	523	-3.9	350	1.19	3.98	1,391	2,167
2007-08	194	504	-3.5	342	1.24	4.31	1,383	2,151
2008-09	191	497	-3.4	337	1.31	4.71	1,370	2,125
2009-10	186	499	-3.5	334	1.37	5.14	1,356	2,097
2010-11	183	501	-3.7	332	1.44	5.54	1,345	2,076
2011-12	177	502	-4.2	331	1.50	5.96	1,333	2,053
2012-13	172	502	-4.7	332	1.57	6.34	1,324	2,039
2013-14	167	502	-4.8	335	1.62	6.68	1,318	2,032
2014-15	163	503	-4.8	338	1.67	6.97	1,316	2,033
2015-16	160	506	-4.7	343	1.70	7.20	1,316	2,043
2016-17	157	511	-4.6	350	1.73	7.37	1,320	2,062
2017-18	156	516	-4.5	357	1.75	7.47	1,328	2,090
2018-19	155	522	-4.4	366	1.75	7.50	1,340	2,128
2019-20	155	528	-4.3	375	1.75	7.49	1,354	2,172
2020-21	156	535	-4.2	385	1.74	7.44	1,370	2,222

[1] Same as base scenario, Table 7-1, except greening is assumed to increase base-scenario, Florida acre-loss rates by 100% for non-bearing trees, by 75% for 4 through 11 year old trees, and 50% for trees over 11 years old; and increase tree-loss rates in São Paulo by 50% (5% to 7.5%).

Prices for processed oranges show an upward trend over the forecast horizon with FOB bulk FCOJ prices reaching $1.70 per SSE gallon in 2015-16 and leveling off at $1.75 per SSE gallon in 2017-18. Prices exhibit this upward trend because the impact of greening is also proportionately imposed on Brazil. The underlying tree-death loss in Brazil in this scenario is 7.5% compared to 5% in the base run (the increase in this death-loss rate is imposed over the entire projection period with greening having apparently spread relatively widely in São Paulo). Higher death loss also limits production growth in São Paulo although Brazilian orange production increases from a low point of 331 million boxes in 2011-12 to 385 million boxes in 2020-21.

The combination of lower production in Florida and São Paulo impacts consumption in both the United States and the rest of the world. In 2020-21, consumption in these two markets decreases 175 million and 480 million SSE gallons, respectively, compared to the base run.

Florida grapefruit production is also impacted by greening. Projected production declines to 19 million boxes by 2012-13 and recovers only slightly to 22 million boxes in 2020-21 as shown in Table 7-11. Projected prices are high throughout the forecast horizon. FOB prices for fresh grapefruit exceed $20.00 per box ($10.00 per carton) over nearly all of the forecast horizon and FOB FCGJ prices range from $2.22 to $3.05 per PS.

Projected FOB revenue associated with this scenario is shown in Table 7-12. Because of higher prices associated with decreased production, FOB revenue for both fresh and processed products is only minimally affected. Total processed FOB revenue is estimated to be $3,580 million in 2020-21 compared to $3,499 million in the base run.

Table 7-11. Scenario 4: Long-run projections of Florida grapefruit production, fresh and processed prices, U.S. GJ consumption, and Florida fresh grapefruit shipments, base assumptions **PLUS low-greening-loss rates**.[1]

Season	GRAPEFRUIT							
	Florida Production	Total Acreage	Acre Loss Rate	Price			U.S. GJ Consump-tion	Florida Certified Fresh Grapefruit Utiliza-tion
				Florida Fresh FOB	Florida Bulk FCGJ (White)	Fresh/ Processed On-Tree		
	million boxes	1,000 acres	- % -	- $/box -	- $/PS -	- $/box -	million SSE gallons	million boxes
2006-07	24	57	-9.0	19.85	2.34	7.09	52.3	9.9
2007-08	23	53	-6.1	20.84	2.22	7.26	53.1	9.4
2008-09	22	53	-4.2	21.54	2.28	7.74	52.6	9.2
2009-10	21	53	-3.5	22.23	2.40	8.34	51.9	8.9
2010-11	21	54	-3.4	22.89	2.53	8.98	51.0	8.7
2011-12	20	55	-3.8	23.65	2.68	9.70	50.0	8.4
2012-13	19	57	-4.1	24.29	2.81	10.33	49.2	8.2
2013-14	19	58	-4.1	24.85	2.93	10.88	48.5	8.1
2014-15	19	61	-4.0	25.26	3.02	11.29	48.1	7.9
2015-16	19	64	-3.7	25.35	3.05	11.38	47.9	7.9
2016-17	19	67	-3.5	25.18	3.02	11.24	48.1	8.0
2017-18	19	70	-3.4	24.65	2.93	10.78	48.5	8.1
2018-19	20	74	-3.2	23.86	2.80	10.08	49.2	8.4
2019-20	21	77	-3.1	22.89	2.63	9.22	50.2	8.7
2020-21	22	80	-3.0	21.82	2.44	8.25	51.4	9.1

[1] Same as base scenario, Table 7-2, except greening is assumed to increase base-scenario, acre-loss rates by 100% for non-bearing trees, by 75% for 4 through 11 year old trees, and 50% for trees over 11 years old.

Table 7-12. Scenario 4: FOB Revenues – Base assumptions **PLUS low-greening-loss rates.**[1]

Season	FOB Revenue						
	Fresh				Processed		
	Orange	Grapefruit	Specialty	Total	OJ	GJ	Total
	- million $ -						
2006-07	137	196	85	418	3,027	207	3,234
2007-08	137	197	82	416	3,134	202	3,335
2008-09	137	197	79	414	3,179	204	3,383
2009-10	137	198	77	412	3,210	209	3,419
2010-11	137	199	74	410	3,239	215	3,454
2011-12	137	199	71	407	3,255	220	3,475
2012-13	137	200	67	404	3,269	225	3,494
2013-14	137	200	64	401	3,280	229	3,508
2014-15	137	200	61	399	3,289	231	3,520
2015-16	137	200	58	396	3,298	232	3,530
2016-17	137	200	55	393	3,307	231	3,538
2017-18	137	200	53	390	3,319	228	3,547
2018-19	137	199	51	387	3,334	224	3,558
2019-20	137	199	49	384	3,351	218	3,568
2020-21	137	198	46	381	3,371	210	3,580

[1] Same as base scenario, Tables 7-1 and 7-2, except greening is assumed to increase base-scenario, Florida acre-loss rates by 100% for non-bearing trees, by 75% for 4 through 11 year old trees, and 50% for trees over 11 years old; and increase tree-loss rates in São Paulo by 50% (5% to 7.5%).

High Greening Impact - Scenario 5 Results

Given the uncertainty regarding the impact of greening on tree mortality in Florida, a second scenario was evaluated in which tree mortality rates were increased. In this scenario, tree mortality for non-bearing trees are increased by 300% compared to the base. Tree mortality is increased by 200% for trees ages four through eleven, and by 150% for all trees age 12 and older. The tree-death loss in Brazil in this scenario is 9%. Projected processed orange production and prices for this scenario are shown in Table 7-13.

Florida orange production shows a downward trend throughout the forecast horizon decreasing to 123 million boxes by 2020-21. It is worth noting that production does appear to be stabilizing by 2020-21 suggesting that the industry would survive under these conditions, assuming greening can be controlled. High tree mortality assumptions such as considered here, however, implies that the psyllid, the vector that spreads this disease, has become widespread, decreasing the likelihood of suppressing the disease. At some level of incidence, greening may become uncontrollable.

Decreasing production in Florida results in increasing prices with average on-tree prices exceeding $5.00 per box in the 2008-09 season and increasing to over $9.50 per box over the last five years of the forecast horizon. Orange-juice consumption in both the United States and the rest of the world is negatively impacted and declines by approximately 19% and 29% in 2020-21, respectively, compared to the base run.

Florida grapefruit production is impacted by higher tree mortality. Production declines to 16 million boxes in 2015-16 and shows modest recovery as shown in Table 7-14. Note also that grapefruit production begins to increase toward the end of the forecast horizon suggesting that

Table 7-13. Scenario 5: Long-run projections of Florida and São Paulo orange production, U.S. and ROW OJ consumption and U.S. OJ prices, base assumptions **PLUS high-greening-loss rates**.[1]

Season	ORANGE							
	Florida Produc-tion	Total Acreage	Acre Loss Rate	São Paulo Produc-tion	Price		OJ Consumption	
					Florida Bulk FCOJ	Processed On-Tree	U.S.	ROW
	million boxes	1,000 acres	- % -	million boxes	$/SSE gal.	- $/box -	- million SSE gallons -	
2006-07	196	523	-3.9	344	1.19	3.98	1,391	2,167
2007-08	194	504	-3.5	331	1.28	4.53	1,368	2,113
2008-09	191	497	-3.4	321	1.37	5.09	1,345	2,061
2009-10	186	499	-3.6	313	1.46	5.67	1,323	2,011
2010-11	181	500	-4.2	307	1.55	6.24	1,302	1,967
2011-12	172	496	-5.8	303	1.65	6.89	1,278	1,915
2012-13	162	486	-7.2	300	1.76	7.55	1,256	1,867
2013-14	153	477	-7.6	300	1.86	8.19	1,235	1,826
2014-15	144	472	-7.5	302	1.95	8.75	1,220	1,798
2015-16	137	470	-7.2	305	2.02	9.20	1,211	1,784
2016-17	132	471	-6.9	311	2.07	9.53	1,208	1,784
2017-18	128	475	-6.6	318	2.11	9.72	1,211	1,799
2018-19	125	480	-6.4	327	2.12	9.79	1,220	1,829
2019-20	124	487	-6.1	338	2.11	9.74	1,235	1,870
2020-21	123	495	-5.9	350	2.09	9.60	1,253	1,922

[1] Same as base scenario, Table 7-1, except greening is assumed to increase base-scenario, Florida acre-loss rates by 300% for non-bearing trees, by 200% for 4 through 11 year old trees, and 150% for trees over 11 years old; and increase tree-loss rates in São Paulo by 50% (5% to 9%).

Table 7-14. Scenario 5: Long-run projections of Florida grapefruit production, fresh and processed prices, U.S. GJ consumption, and Florida fresh grapefruit shipments, base assumptions **PLUS high-greening-loss rates**.[1]

Season	GRAPEFRUIT							
	Florida Production	Total Acreage	Acre Loss Rate	Price			U.S. GJ Consump-tion	Florida Certified Fresh Grapefruit Utiliza-tion
				Florida Fresh FOB	Florida Bulk FCGJ (White)	Fresh/ Processed On-Tree		
	million boxes	1,000 acres	- % -	- $/box -	- $/PS -	- $/box -	million SSE gallons	million boxes
2006-07	24	57	-9.0	19.86	2.34	7.10	52.3	9.9
2007-08	23	53	-6.1	20.84	2.22	7.27	53.1	9.4
2008-09	22	53	-4.2	21.55	2.29	7.75	52.6	9.2
2009-10	21	53	-3.6	22.28	2.40	8.38	51.8	8.9
2010-11	20	54	-3.9	23.08	2.56	9.13	50.8	8.6
2011-12	19	54	-5.2	24.27	2.77	10.21	49.4	8.2
2012-13	18	54	-6.4	25.66	3.02	11.47	48.0	7.8
2013-14	17	55	-6.6	27.11	3.28	12.80	46.7	7.4
2014-15	17	57	-6.3	28.42	3.52	13.98	45.6	7.1
2015-16	16	60	-5.8	29.29	3.68	14.78	44.9	6.9
2016-17	16	63	-5.4	29.70	3.76	15.17	44.5	6.9
2017-18	16	67	-5.0	29.47	3.75	15.02	44.6	6.9
2018-19	17	72	-4.7	28.68	3.64	14.40	45.0	7.1
2019-20	17	77	-4.4	27.45	3.47	13.39	45.7	7.4
2020-21	18	81	-4.2	25.91	3.23	12.08	46.8	7.8

[1] Same as base scenario, Table 7-2, except greening is assumed to increase base-scenario, acre-loss rates by 300% for non-bearing trees, by 200% for 4 through 11 year old trees, and 150% for trees over 11 years old.

the Florida grapefruit industry may survive even under high tree mortality associated with greening, again assuming the disease can be controlled.

Grapefruit prices associated with these low production levels remain high throughout the forecast horizon. FOB prices for fresh grapefruit range from $20.00 to nearly $30.00 per box ($10.00 to $15.00 per carton). FOB FCGJ prices exceed $3.00 per PS beginning in 2012-13.

Projected FOB revenue associated with this scenario is shown in Table 7-15. FOB revenue from both fresh citrus and processed citrus decreases slightly compared to the base run.

Development and High Land Prices - Scenario 6 Results

In Scenario 6, the effect of greening is suppressed. The purpose of this scenario to evaluate the impact of higher land costs associated with urban development in Florida and accompanying land speculation. According to a recent study by Reynolds, unimproved land in South and Central Florida has increased in price by about 80% depending upon region of the state. In this scenario, the new planting equation used in both the processed orange and world grapefruit models is shifted so that higher on-tree prices are required to effect the same level of plantings.[9] The magnitude of this relationship is based upon the work presented in Section VI of this paper. It is assumed that land costs increase by $3,500 per acre. When annualized this translates into an increase in land charge by $245 per acre per year.

The results from this scenario are shown in Tables 7-16 through 7-18. Increased land costs in isolation do not have a large effect on citrus production in Florida. As shown in Table 7-16, production is negatively affected but the impact is less than 10 million boxes of production per year (compared to the base run). The grapefruit production impact is comparable.

[9]In economic jargon, the demand for new plantings is shifted left.

Table 7-15. Scenario 5: FOB Revenues – Base assumptions **PLUS high-greening-loss rates**.[1]

Season	FOB Revenue						
	Fresh				Processed		
	Orange	Grapefruit	Specialty	Total	OJ	GJ	Total
	- million $						- -
2006-07	137	196	85	418	3,027	207	3,234
2007-08	137	197	82	416	3,170	202	3,371
2008-09	137	197	79	414	3,226	204	3,431
2009-10	137	198	77	412	3,269	209	3,479
2010-11	137	199	73	409	3,305	216	3,520
2011-12	137	200	69	406	3,313	223	3,536
2012-13	137	201	64	402	3,306	231	3,537
2013-14	137	202	59	398	3,289	238	3,526
2014-15	137	203	55	395	3,268	243	3,511
2015-16	137	203	51	391	3,247	246	3,493
2016-17	137	203	47	388	3,230	247	3,477
2017-18	137	203	44	385	3,217	247	3,464
2018-19	137	203	41	381	3,210	245	3,456
2019-20	137	202	39	378	3,209	241	3,450
2020-21	137	201	36	375	3,213	235	3,448

[1] Same as base scenario, Tables 7-1 and 7-2, except greening is assumed to increase base-scenario, Florida acre-loss rates by 300% for non-bearing trees, by 200% for 4 through 11 year old trees, and 150% for trees over 11 years old; and increase tree-loss rates in São Paulo by 50% (5% to 9%).

Table 7-16. Scenario 6: Long-run projections of Florida and São Paulo orange production, U.S. and ROW OJ consumption and U.S. OJ prices, base assumptions **PLUS increased land values impacting planting rates**.[1]

Season	ORANGE							
	Florida Produc-tion	Total Acreage	Acre Loss Rate	São Paulo Produc-tion	Price		OJ Consumption	
					Florida Bulk FCOJ	Processed On-Tree	U.S.	ROW
	million boxes	1,000 acres	- % -	million boxes	$/SSE gal.	- $/box -	- million SSE gallons -	
2006-07	196	523	-3.9	360	1.19	3.98	1,391	2,167
2007-08	194	504	-3.5	360	1.18	3.95	1,408	2,217
2008-09	191	497	-3.4	365	1.20	4.08	1,412	2,237
2009-10	187	499	-3.4	371	1.23	4.26	1,414	2,249
2010-11	183	502	-3.4	377	1.26	4.41	1,418	2,267
2011-12	179	505	-3.4	384	1.28	4.57	1,422	2,285
2012-13	177	508	-3.4	392	1.30	4.67	1,429	2,313
2013-14	175	512	-3.4	401	1.31	4.75	1,439	2,346
2014-15	174	516	-3.4	409	1.32	4.81	1,449	2,383
2015-16	173	520	-3.3	419	1.33	4.85	1,461	2,423
2016-17	172	524	-3.3	428	1.33	4.88	1,474	2,467
2017-18	172	529	-3.2	438	1.33	4.88	1,488	2,515
2018-19	173	534	-3.2	448	1.33	4.88	1,503	2,566
2019-20	173	538	-3.2	458	1.33	4.87	1,519	2,620
2020-21	175	543	-3.1	468	1.33	4.85	1,536	2,675

[1] Same as base scenario, Table 7-1, except land values are assumed to increase by $3,500 and negatively impact planting rates.

Table 7-17. Scenario 6: Long-run projections of Florida grapefruit production, fresh and processed prices, U.S. GJ consumption, and Florida fresh grapefruit shipments, base assumptions **PLUS increased land values impacting planting rates.**[1]

Season	GRAPEFRUIT							
	Florida Production	Total Acreage	Acre Loss Rate	Price			U.S. GJ Consump-tion	Florida Certified Fresh Grapefruit Utiliza-tion
				Florida Fresh FOB	Florida Bulk FCGJ (White)	Fresh/ Processed On-Tree		
	million boxes	1,000 acres	- % -	- $/box -	- $/PS -	- $/box -	million SSE gallons	million boxes
2006-07	24	57	-9.0	19.85	2.34	7.09	52.3	9.9
2007-08	23	53	-6.0	20.84	2.22	7.26	53.1	9.4
2008-09	22	53	-4.2	21.54	2.28	7.74	52.6	9.2
2009-10	21	53	-3.5	22.21	2.39	8.32	51.9	8.9
2010-11	21	54	-3.2	22.80	2.52	8.90	51.1	8.7
2011-12	20	55	-3.1	23.36	2.64	9.46	50.3	8.5
2012-13	20	57	-3.0	23.69	2.72	9.81	49.8	8.4
2013-14	20	59	-2.9	23.88	2.77	10.03	49.5	8.3
2014-15	20	62	-2.8	23.96	2.79	10.11	49.4	8.3
2015-16	20	65	-2.6	23.76	2.76	9.93	49.6	8.4
2016-17	20	68	-2.5	23.38	2.68	9.57	50.0	8.5
2017-18	21	71	-2.4	22.74	2.56	8.97	50.7	8.7
2018-19	22	74	-2.3	21.92	2.41	8.21	51.7	9.0
2019-20	22	77	-2.2	21.01	2.23	7.36	52.8	9.4
2020-21	23	80	-2.2	20.06	2.05	6.47	54.1	9.8

[1] Same as base scenario, Table 7-2, except land values are assumed to increase by $3,500 and negatively impact planting rates.

Table 7-18. Scenario 6: FOB Revenues – Base assumptions **PLUS increased land values impacting planting rates.**[1]

Season	FOB Revenue						
	Fresh				Processed		
	Orange	Grapefruit	Specialty	Total	OJ	GJ	Total
	- million $ -						
2006-07	137	196	85	418	3,027	207	3,234
2007-08	137	197	82	416	3,072	201	3,274
2008-09	137	197	79	414	3,095	204	3,300
2009-10	137	198	77	412	3,105	209	3,314
2010-11	137	199	74	410	3,115	214	3,329
2011-12	137	199	72	408	3,120	219	3,338
2012-13	137	199	69	406	3,131	222	3,353
2013-14	137	199	67	403	3,144	223	3,368
2014-15	137	199	65	401	3,159	224	3,383
2015-16	137	199	62	399	3,174	223	3,397
2016-17	137	199	60	397	3,192	220	3,412
2017-18	137	198	58	394	3,212	216	3,427
2018-19	137	198	57	392	3,235	209	3,444
2019-20	137	197	55	389	3,261	201	3,462
2020-21	137	196	53	386	3,290	192	3,482

[1] Same as base scenario, Tables 7-1 and 7-2, except land values are assumed to increase by $3,500 and negatively impact planting rates.

It is plausible that the full impact of higher land prices has not been adequately quantified in this analysis. Given the high level of investment associated with citrus production and the annual out-of-pocket expenses associated with grove care, the analysis herein probably has not fully captured the intentions of citrus producers. The inherent risks associated with agricultural production (including citrus) are not easily quantifiable.

Increased Land Pressure from Development - Scenario 7 Results

Given the results from Scenario 6, another scenario was created - Scenario 7. In this scenario, land costs are still assumed to increase by $3,500 per acre. In addition, acre-loss rates are increased by 2% per year for oranges and 4% per year for grapefruit. These loss rates stem from the encroachment of urban areas into to agricultural properties. A higher loss rate is assumed for grapefruit compared to oranges to represent the expected population increase in the Indian River area.

Projected orange production and prices under this scenario are shown in Table 7-19. Higher acre-loss rates have the expected negative impact on orange production. Orange production shows a downward trend over the forecast horizon falling to under 150 million boxes in 2013-14 and further declining to 136 million boxes by 2020-21. Note that with the increased prices associated with these assumptions, however, production appears to stabilize around 136 million boxes suggesting industry survival. Production in São Paulo is positively affected by decreased production in Florida. It increases throughout the forecast horizon and exceeds 400 million boxes in 2013-14 and reaches 481 million boxes in 2020-21.

In spite of increasing Brazilian production, grower prices for oranges are high over most of the forecast period. On-tree prices exceed $5.50 per box beginning in 2014-15 and remain

Table 7-19. Scenario 7: Long-run projections of Florida and São Paulo orange production, U.S. and ROW OJ consumption and U.S. OJ prices, base assumptions **PLUS increased land values impacting planting and acre-loss rates**.[1]

Season	ORANGE							
	Florida Produc-tion	Total Acreage	Acre Loss Rate	São Paulo Produc-tion	Price		OJ Consumption	
					Florida Bulk FCOJ	Processed On-Tree	U.S.	ROW
	million boxes	1,000 acres	- % -	million boxes	$/SSE gal.	- $/box -	- million SSE gallons -	
2006-07	192	512	-5.9	360	1.20	4.08	1,385	2,153
2007-08	186	484	-5.5	360	1.21	4.14	1,395	2,185
2008-09	179	468	-5.4	365	1.25	4.37	1,394	2,188
2009-10	172	462	-5.4	371	1.29	4.64	1,389	2,184
2010-11	165	458	-5.4	377	1.33	4.88	1,388	2,188
2011-12	158	455	-5.4	385	1.37	5.11	1,387	2,193
2012-13	153	453	-5.3	393	1.40	5.28	1,390	2,210
2013-14	149	452	-5.3	402	1.42	5.41	1,396	2,233
2014-15	145	451	-5.2	412	1.43	5.50	1,404	2,263
2015-16	142	452	-5.2	422	1.44	5.56	1,415	2,299
2016-17	140	452	-5.1	433	1.45	5.59	1,427	2,340
2017-18	138	453	-5.0	445	1.45	5.59	1,441	2,387
2018-19	137	455	-5.0	457	1.44	5.57	1,457	2,439
2019-20	136	456	-4.9	469	1.44	5.53	1,474	2,494
2020-21	136	458	-4.9	481	1.43	5.48	1,492	2,551

[1] Same as base scenario, Table 7-1, except land values are assumed to increase by $3,500 and negatively impact planting rates, and acre-loss rates increase by 2% for oranges as a result of land development.

above this level until 2020-21. Given the stabilization of production that occurs in the last four years of the forecast horizon, these results suggests that a long-run on-tree price of $5.50 per box is needed to sustain long-term orange production in Florida under these assumptions.

Higher acre-loss rates for grapefruit result in a steep decline in grapefruit production as shown in Table 7-20. Production is projected to decrease from 23 million boxes in 2006-07 to 14 million boxes in 2014-15. Production, however, does stabilize at this point and begins to increase reaching 20 million boxes in 2020-21. With declining production, grower prices rise sharply from nearly $8.00 per box to over $18.00 per box in 2013-14. The results suggest that at prices exceeding $15.00 per box, new plantings are sufficient to overcome the assumed increase of 4% in acre loss and higher land costs.

Projected FOB revenues under this scenario are shown in Table 7-21. Both fresh and processed revenues decrease relative to the base run. Fresh revenues are adversely affected by decreased production while processed producers lose market share relative to São Paulo.

Supply Effects in São Paulo - Scenario 8 Results

Other than greening impacts, the analysis up to this point has focused on issues affecting fruit supply in Florida. In Scenario 8, attention is focused on a supply issue in São Paulo. Since the oil-price spike of the 1970s, the government of Brazil has invested heavily in a sugarcane-to-ethanol program. This process has included subsidies to encourage the construction of ethanol-production facilities and restrictions on the minimum amount of ethanol that must be included in fuel used for automobiles.[10] The relevance of this program to citrus production is

[10] As ethanol use also has positive implications for air quality in urban areas, the minimum ethanol requirement varies by region of the country.

Table 7-20. Scenario 7: Long-run projections of Florida grapefruit production, fresh and processed prices, U.S. GJ consumption, and Florida fresh grapefruit shipments, base assumptions **PLUS increased land values impacting planting and acre-loss rates**.[1]

Season	GRAPEFRUIT							
	Florida Production	Total Acreage	Acre Loss Rate	Price			U.S. GJ Consump-tion	Florida Certified Fresh Grapefruit Utiliza-tion
				Florida Fresh FOB	Florida Bulk FCGJ (White)	Fresh/ Processed On-Tree		
	million boxes	1,000 acres	- % -	- $/box -	- $/PS -	- $/box -	million SSE gallons	million boxes
2006-07	23	54	-13.0	20.86	2.51	7.97	50.4	9.4
2007-08	21	49	-10.0	22.97	2.57	9.09	50.0	8.6
2008-09	19	47	-8.2	24.88	2.82	10.60	48.5	8.0
2009-10	18	47	-7.4	26.89	3.14	12.31	46.8	7.5
2010-11	17	47	-7.0	28.91	3.48	14.09	45.2	7.0
2011-12	16	50	-6.9	30.92	3.81	15.84	43.8	6.6
2012-13	15	53	-6.6	32.48	4.07	17.20	42.9	6.3
2013-14	15	57	-6.4	33.58	4.26	18.16	42.2	6.1
2014-15	14	63	-6.1	34.06	4.34	18.57	42.0	6.1
2015-16	15	68	-5.9	33.61	4.28	18.20	42.2	6.1
2016-17	15	75	-5.8	32.41	4.10	17.18	42.7	6.3
2017-18	16	81	-5.6	30.48	3.81	15.56	43.7	6.7
2018-19	17	86	-5.5	28.18	3.44	13.60	45.1	7.2
2019-20	19	92	-5.5	25.81	3.04	11.53	46.8	7.8
2020-21	20	96	-5.4	23.54	2.64	9.52	48.7	8.5

[1] Same as base scenario, Table 7-2, except land values are assumed to increase by $3,500 and negatively impact planting rates, and acre-loss rates increase by 4% for grapefruit as a result of land development.

Table 7-21. Scenario 7: FOB Revenues – Base assumptions **PLUS increased land values impacting planting and acre-loss rates**.[1]

Season	FOB Revenue						
	Fresh				Processed		
	Orange	Grapefruit	Specialty	Total	OJ	GJ	Total
	- million $ -						
2006-07	137	197	85	419	3,013	215	3,228
2007-08	137	199	80	416	3,040	217	3,258
2008-09	137	200	76	413	3,045	227	3,271
2009-10	137	202	72	411	3,036	237	3,272
2010-11	137	203	68	408	3,026	245	3,272
2011-12	137	204	65	406	3,012	252	3,265
2012-13	137	205	61	403	3,005	257	3,262
2013-14	137	206	58	401	3,000	260	3,260
2014-15	137	206	55	398	2,997	261	3,258
2015-16	137	206	52	395	2,995	260	3,255
2016-17	137	205	49	392	2,996	257	3,253
2017-18	137	204	47	388	3,001	251	3,252
2018-19	137	202	45	384	3,009	242	3,251
2019-20	137	201	42	380	3,020	230	3,250
2020-21	137	199	40	377	3,035	215	3,250

[1] Same as base scenario, Tables 7-1 and 7-2, except land values are assumed to increase by $3,500 and negatively impact planting rates, and acre-loss rates increase by 2% for oranges as a result of land development.

that São Paulo state is the largest sugarcane production state in Brazil. Citrus and sugarcane compete directly for agricultural land. Therefore, increased returns to sugarcane production will negatively affect the supply of land available for citrus production.

The new planting relationship used for São Paulo in the processed orange model is based upon the relative price of oranges to sugar. While this relationship only indirectly captures the potential impact of the ethanol program, it still demonstrates the importance of the sugarcane industry in São Paulo in analyzing the orange industry of that region.[11] Citrus and sugarcane compete for land in some areas of São Paulo, but elsewhere in Brazil the competition may be less and the impact of sugar prices on planting levels may be less or not a factor. Recent sugar prices (New York futures) have been up about 8¢ per pound from last year's level and about 10¢ per pound from two years ago. In the present scenario, sugar prices are assumed to be 5¢ per pound greater over the projection period compared to last year's price. Since this change only affects the processed orange market, no results for grapefruit are presented.

Projected production and prices under this scenario are shown in Table 7-22. This scenario includes no effect from greening and no effect from higher land prices in Florida. Increasing the price of sugar has a large impact on the orange supply from São Paulo. Compared to the base run, there is no material effect on Florida orange production. Orange production in São Paulo, however, is substantially lower and relatively flat to moderately increasing over the 15-year projection period. São Paulo orange production is projected at 382 million boxes in 2020-21.

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[11] The price ratio between oranges and sugar was used because a longer time series for sugar prices was found compared to prices paid for sugarcane. There is evidence that given Brazil's importance in the world sugar market, the ethanol program does affect world sugar prices. See Schmitz, et al. for further discussion.

Table 7-22. Scenario 8: Long-run projections of Florida and São Paulo orange production, U.S. and ROW OJ consumption and U.S. OJ prices, base assumptions **PLUS high-sugar-prices impacting São Paulo orange planting rates.**[1]

Season	ORANGE							
	Florida Produc-tion	Total Acreage	Acre Loss Rate	São Paulo Produc-tion	Price		OJ Consumption	
					Florida Bulk FCOJ	Processed On-Tree	U.S.	ROW
	million boxes	1,000 acres	- % -	million boxes	$/SSE gal.	- $/box -	- million SSE gallons -	
2006-07	196	523	-3.9	360	1.19	3.98	1,391	2,167
2007-08	194	504	-3.5	360	1.18	3.95	1,408	2,217
2008-09	191	498	-3.4	365	1.20	4.08	1,412	2,237
2009-10	187	504	-3.4	371	1.23	4.26	1,414	2,249
2010-11	183	509	-3.4	374	1.27	4.47	1,415	2,258
2011-12	179	515	-3.4	377	1.31	4.73	1,412	2,258
2012-13	178	522	-3.3	378	1.35	4.98	1,409	2,260
2013-14	176	529	-3.3	379	1.39	5.23	1,407	2,263
2014-15	175	537	-3.3	379	1.43	5.49	1,405	2,267
2015-16	175	546	-3.2	379	1.47	5.74	1,403	2,271
2016-17	175	556	-3.2	380	1.51	5.99	1,402	2,277
2017-18	176	566	-3.1	380	1.55	6.23	1,402	2,287
2018-19	178	578	-3.0	380	1.58	6.43	1,404	2,302
2019-20	180	590	-3.0	381	1.61	6.62	1,407	2,320
2020-21	183	603	-2.9	382	1.64	6.79	1,412	2,342

[1] Same as base scenario, Table 7-1, except higher sugar prices are assumed to negatively impact São Paulo orange planting rates. The New York future sugar price is assumed to increase by about 5¢ per pound over the 2004 price.

With decreased Brazilian orange production, prices in Florida are substantially higher. On-tree prices exceed $5.00 per box beginning in the 2013-14 season and are estimated to be $6.79 per box in 2020-21. If the forecast horizon was extended, it is expected that Florida production would increase at an increasing rate with this high level of grower prices.

Projected FOB revenue from fresh and processed citrus production in Florida associated with Scenario 8 is shown in Table 7-23. Since São Paulo does not participate in Florida's fresh markets, there is no effect on Florida fresh citrus FOB revenue. Processed FOB revenue increases substantially, ending up over 7% higher than in the base scenario in 2020-21.

The Joint Effect of Canker, Greening, Higher Land Costs,and Higher Sugar Prices - Scenario 9 Results

In this scenario, all four of the main factors thought to affect citrus production in Florida and São Paulo are imposed on the two models: canker in Florida, greening in Florida and São Paulo, higher land costs in Florida, and higher sugar prices in São Paulo. The greening assumptions incorporated in this scenario are identical to Scenario 4 (lower greening impact). The land and development assumptions are identical to Scenario 6 (land price effect only).

Projected processed orange production and prices associated with this scenario are shown in Table 7-24. Florida orange production is projected to trend downward over the forecast horizon to 152 million boxes in 2020-21. Production in São Paulo also trends downward to 301 million boxes in 2020-21. With production in the two major orange-juice-producing regions declining by this magnitude, prices skyrocket with Florida bulk FCOJ prices exceeding $2.00 per SSE gallon in 2017-18 and reaching $2.21 per SSE gallon in 2020-21. Grower prices also rise substantially increasing from an average on-tree price of $3.98 per box in 2006-07 to $10.39 per box in 2020-21. These are real prices, adjusted for the effects of inflation.

Table 7-23. Scenario 8: FOB Revenues – Base assumptions **PLUS high-sugar-prices impacting São Paulo orange planting rates**.[1]

Season	FOB Revenue						
	Fresh				Processed		
	Orange	Grapefruit	Specialty	Total	OJ	GJ	Total
	- million $ -						
2006-07	137	196	85	418	3,027	207	3,234
2007-08	137	197	82	416	3,072	201	3,274
2008-09	137	197	79	414	3,095	204	3,300
2009-10	137	198	77	412	3,105	209	3,314
2010-11	137	199	74	410	3,124	214	3,338
2011-12	137	199	72	408	3,143	218	3,361
2012-13	137	199	69	405	3,174	220	3,394
2013-14	137	199	67	403	3,210	221	3,432
2014-15	137	199	65	401	3,252	221	3,472
2015-16	137	199	63	398	3,296	218	3,514
2016-17	137	198	61	396	3,343	213	3,556
2017-18	137	197	59	393	3,395	206	3,601
2018-19	137	197	57	391	3,451	198	3,649
2019-20	137	196	55	388	3,509	188	3,697
2020-21	137	195	54	386	3,571	177	3,748

[1] Same as base scenario, Tables 7-1 and 7-2, except higher sugar prices are assumed to negatively impact São Paulo orange planting rates. The New York future sugar price is assumed to increase by about 10¢ per pound over the 2004 price.

Table 7-24. Scenario 9: Long-run projections of Florida and São Paulo orange production, U.S. and ROW OJ consumption and U.S. OJ prices, base assumptions **PLUS low-greening-loss rates, increased land values impacting Florida planting rates, and high-sugar-prices impacting São Paulo orange planting rates**.[1]

Season	ORANGE							
	Florida Produc-tion	Total Acreage	Acre Loss Rate	São Paulo Produc-tion	Price		OJ Consumption	
					Florida Bulk FCOJ	Processed On-Tree	U.S.	ROW
	million boxes	1,000 acres	- % -	million boxes	$/SSE gal.	- $/box -	- million SSE gallons -	
2006-07	196	523	-3.9	350	1.19	3.98	1,391	2,167
2007-08	194	504	-3.5	342	1.24	4.31	1,383	2,151
2008-09	191	495	-3.4	337	1.31	4.71	1,370	2,125
2009-10	186	495	-3.5	334	1.37	5.14	1,356	2,097
2010-11	183	494	-3.7	329	1.45	5.60	1,342	2,067
2011-12	177	492	-4.3	324	1.53	6.14	1,323	2,027
2012-13	172	489	-4.8	319	1.62	6.70	1,304	1,987
2013-14	167	488	-4.9	314	1.72	7.28	1,285	1,949
2014-15	162	488	-4.9	310	1.81	7.86	1,267	1,914
2015-16	158	491	-4.8	306	1.90	8.42	1,251	1,884
2016-17	155	496	-4.7	303	1.98	8.94	1,238	1,860
2017-18	153	504	-4.6	301	2.06	9.41	1,228	1,845
2018-19	151	513	-4.4	300	2.12	9.81	1,222	1,840
2019-20	151	524	-4.3	300	2.17	10.14	1,220	1,842
2020-21	152	537	-4.2	301	2.21	10.39	1,221	1,853

[1] Combined assumptions for base scenario, Table 7-1; greening scenario, Table 7-10; high-land-value scenario, Table 7-16; and high-sugar-price scenario, Table 7-22.

With decreasing production in both of the major orange-juice-producing regions, consumption plummets. Projected U.S. orange-juice consumption in 2020-21 declines by 324 million SSE gallons or about 21% compared to the base estimate. Consumption in the rest of the world in 2020-21 decreases by 849 million SSE gallons, a decline of nearly one-third (see Brown, Spreen and Lee for earlier estimates of world OJ consumption by market).

At this juncture, it is relevant to discuss production in the rest of the world. Orange-juice production in regions outside of Florida and São Paulo currently account for approximately 430 million SSE gallon or about 10% of world supply including inventories in Florida and Brazil, based on data published by the Food and Agricultural Organization of the United Nations and the USDA, Foreign Agricultural Service. This production is distributed across Mexico, Spain, Cuba, Belize, Costa Rica, Argentina, Italy, and Australia with several other countries supplying smaller amounts. Each of these other production areas face other challenges to significantly expand production. For example, the Mexican citrus industry is highly vulnerable to the tristeza virus with its dependence on sour orange rootstock. It also has a land tenure policy that is not conducive to large-scale citrus production (Mondragon, et al.). Spain is primarily a fresh fruit production area with high production costs and a limited area suitable for citrus production. Cuba, Belize, and Costa Rica all possess tropical climates which tend to produce low-color-high-ratio juice. Canker is endemic in most of Argentina. Citrus production in Argentina is mainly geared to the fresh market. The Italian industry has been in a long period of decline due to high production costs and import competition. Australia is currently a net importer of orange juice. Its main production area is arid and therefore not conducive to juice-fruit production.

The country in the rest of the world with the greatest potential to increase orange and OJ production may be China. There are areas in China presently free of greening, and high world OJ prices could possibly stimulate a significant OJ supply response in China.

With these observations, it would naive to argue that FCOJ prices approaching $2.00 per SSE gallon would not tend to result in supply responses in regions that currently supply orange juice or even from new production areas. It is the collective judgement of the authors of this report, however, that supply in the rest of the word could not respond on a scale to have a large effect on price in the next 15 years. Another scenario was evaluated in which the rest of world increased its output by about 62% over the forecast horizon. If this were to occur, the projected FOB bulk FCOJ price in 2020-21 is $2.03 per SSE gallon.

The collective effect of canker, greening, and high land costs on projected Florida grapefruit production and prices is shown in Table 7-25. Grapefruit production is projected to range from a high of 24 million boxes in 2006-07 to a low of 18 million boxes beginning in 2014-15 and then increase to 20 million boxes in 2020-21. Both FOB and grower prices are high over the forecast price horizon with grower prices ranging from $7.09 per box in 2006-07 to $12.36 per box in 2016-17 and declining to $9.76 per box in 2020-21. These results suggest that under the assumptions incorporated into this scenario, the Florida grapefruit industry needs prices in the range of $8.00 per box on-tree to maintain long-term viability.

Projected FOB revenue from fresh and processed citrus products associated with Scenario 9 is shown in Table 7-26. The collective impact of canker, greening, and high land values on fresh FOB revenue is small. The projections for processed FOB revenue are quite different as the combined effect of greening and high sugar prices in São Paulo results in relatively high OJ

Table 7-25. Scenario 9: Long-run projections of Florida grapefruit production, fresh and processed prices, U.S. GJ consumption, base assumptions **PLUS low-greening-loss rates and increased land values impacting Florida planting rates**.[1]

Season	GRAPEFRUIT							
	Florida Production	Total Acreage	Acre Loss Rate	Price			U.S. GJ Consump-tion	Florida Certified Fresh Grapefruit Utiliza-tion
				Florida Fresh FOB	Florida Bulk FCGJ (White)	Fresh/ Processed On-Tree		
	million boxes	1,000 acres	- % -	- $/box -	- $/PS -	- $/box -	million SSE gallons	million boxes
2006-07	24	57	-9.0	19.85	2.34	7.09	52.3	9.9
2007-08	23	53	-6.1	20.84	2.22	7.26	53.1	9.4
2008-09	22	52	-4.2	21.54	2.28	7.74	52.6	9.2
2009-10	21	52	-3.5	22.23	2.40	8.34	51.9	8.9
2010-11	21	52	-3.5	22.89	2.53	8.98	51.0	8.7
2011-12	20	53	-3.9	23.73	2.69	9.76	50.0	8.4
2012-13	19	53	-4.3	24.54	2.85	10.52	49.0	8.1
2013-14	19	55	-4.3	25.32	3.00	11.26	48.2	7.9
2014-15	18	57	-4.1	26.02	3.13	11.90	47.5	7.7
2015-16	18	59	-3.9	26.41	3.20	12.25	47.1	7.6
2016-17	18	62	-3.7	26.52	3.22	12.36	47.0	7.6
2017-18	18	66	-3.5	26.22	3.18	12.10	47.2	7.7
2018-19	19	70	-3.3	25.57	3.08	11.54	47.7	7.8
2019-20	19	73	-3.2	24.64	2.93	10.75	48.5	8.1
2020-21	20	77	-3.0	23.51	2.74	9.76	49.5	8.5

[1] Combined assumptions for base scenario, Table 7-2; greening scenario, Table 7-11; and high-land-value scenario, Table 7-17.

Table 7-26. Scenario 9: FOB Revenues – Base assumptions **PLUS low-greening-loss rates, increased land values impacting Florida planting rates, and high-sugar-prices impacting São Paulo orange planting rates**.[1]

Season	FOB Revenue						
	Fresh				Processed		
	Orange	Grapefruit	Specialty	Total	OJ	GJ	Total
	- -			million $	- -		
2006-07	137	196	85	418	3,027	207	3,234
2007-08	137	197	82	416	3,134	202	3,335
2008-09	137	197	79	414	3,179	204	3,383
2009-10	137	198	77	412	3,210	209	3,419
2010-11	137	199	74	410	3,248	215	3,462
2011-12	137	199	71	407	3,277	220	3,498
2012-13	137	200	67	404	3,309	226	3,535
2013-14	137	200	64	402	3,339	230	3,570
2014-15	137	201	61	399	3,370	234	3,604
2015-16	137	201	58	396	3,401	236	3,637
2016-17	137	201	55	394	3,434	237	3,670
2017-18	137	201	53	391	3,469	235	3,705
2018-19	137	201	50	388	3,509	233	3,742
2019-20	137	200	48	385	3,551	228	3,779
2020-21	137	199	46	382	3,596	221	3,817

[1] Combined assumptions for base scenario, Tables 7-1 and 7-2; greening scenario, Tables 7-10 and 7-11; high-land-value scenario, Tables 7-16 and 7-17; and high-sugar-price scenario, Table 7-22.

prices and allows Florida processed orange producers to gain market share. The result is that processed FOB revenue increases by more than 9% in 2020-21compared to the base run.

No U.S. Demand Growth – Scenario 10 Results

In this scenario, all factors affecting supply in Florida and São Paulo are maintained. The assumption of a 1% annual growth in U.S. orange-juice demand is modified to no growth in U.S. demand. With increasing population in the United States, this suggestion implies that per capita consumption in the United States would erode.

Projected processed orange production and prices are shown in Table 7-27. In this scenario, the production forecast for both Florida and São Paulo is similar to Scenario 9. In Florida, production is projected to follow a downward trend until 2019-20 at which time production stabilizes at 149 million boxes. São Paulo follows a similar pattern with the production estimated at 296 million boxes in 2020-21. The main impact of no U.S. OJ demand growth is on price. Florida orange-juice prices follow an upward trend, but prices are consistently lower compared to Scenario 9 with total orange-juice production from Florida and São Paulo slightly lower but with Florida inventories up. From the middle to the end of the 15-year projection period, the difference in the FOB bulk FCOJ price ranges from 10¢ to 14¢ per SSE gallon with the spread widening over the forecast horizon.

These results suggest that continuation of the generic advertising for orange juice would still provide an economic benefit in face of short supplies for orange juice. Maintaining the underlying demand growth for orange juice does provide a benefit through higher prices.

FOB revenue associated with Scenario 10 is shown in Table 7-28.

Table 7-27. Scenario 10: Long-run projections of Florida and São Paulo orange production, U.S. and ROW OJ consumption and U.S. OJ prices, base assumptions **PLUS low-greening-loss rates, increased land values impacting Florida planting rates, high-sugar-prices impacting São Paulo orange planting rates, and no U.S. demand growth only**.[1]

Season	ORANGE							
	Florida Produc-tion	Total Acreage	Acre Loss Rate	São Paulo Produc-tion	Price		OJ Consumption	
					Florida Bulk FCOJ	Processed On-Tree	U.S.	ROW
	million boxes	1,000 acres	- % -	million boxes	$/SSE gal.	- $/box -	- million SSE gallons -	
2006-07	196	523	-3.9	350	1.17	3.88	1,371	2,185
2007-08	194	504	-3.5	342	1.22	4.16	1,352	2,179
2008-09	191	495	-3.4	337	1.27	4.50	1,330	2,163
2009-10	186	494	-3.5	334	1.33	4.86	1,306	2,144
2010-11	183	493	-3.7	329	1.39	5.25	1,282	2,123
2011-12	177	490	-4.3	324	1.47	5.72	1,254	2,092
2012-13	172	486	-4.8	319	1.54	6.20	1,226	2,060
2013-14	166	483	-5.0	314	1.62	6.71	1,198	2,029
2014-15	162	482	-5.0	309	1.71	7.22	1,171	2,000
2015-16	158	483	-4.9	305	1.78	7.71	1,146	1,976
2016-17	154	486	-4.7	301	1.86	8.18	1,123	1,958
2017-18	152	492	-4.6	298	1.93	8.59	1,104	1,947
2018-19	150	499	-4.5	297	1.98	8.95	1,088	1,945
2019-20	149	507	-4.4	296	2.03	9.24	1,075	1,950
2020-21	149	517	-4.3	296	2.07	9.47	1,065	1,964

[1] Combined assumptions for base scenario, Table 7-1; greening scenario, Table 7-10; high-land-value scenario, Table 7-16; and high-sugar-price scenario, Table 7-22, except no growth is assumed in U.S. demand for OJ.

Table 7-28. Scenario 10: FOB Revenues – Base assumptions **PLUS low-greening-loss rates, increased land values impacting Florida planting rates, high-sugar-prices impacting São Paulo orange planting rates, and no U.S. demand growth only**.[1]

Season	FOB Revenue						
	Fresh				Processed		
	Orange	Grapefruit	Specialty	Total	OJ	GJ	Total
	million $						
2006-07	137	196	85	418	2,990	207	3,197
2007-08	137	197	82	416	3,074	202	3,275
2008-09	137	197	79	414	3,095	204	3,299
2009-10	137	198	77	412	3,102	209	3,311
2010-11	137	199	74	410	3,115	215	3,330
2011-12	137	199	71	407	3119	220	3,340
2012-13	137	200	67	404	3,125	226	3,351
2013-14	137	200	64	402	3,129	230	3,359
2014-15	137	201	61	399	3,133	234	3,367
2015-16	137	201	58	396	3,136	236	3,373
2016-17	137	201	55	394	3,141	237	3,378
2017-18	137	201	53	391	3,148	235	3,384
2018-19	137	201	50	388	3,159	233	3,392
2019-20	137	200	48	385	3,172	228	3,400
2020-21	137	199	46	382	3,188	221	3,410

[1] Combined assumptions for base scenario, Tables 7-1 and 7-2; greening scenario, Tables 7-10 and 7-11; high-land-value scenario, Tables 7-16 and 7-17; and high-sugar-price scenario, Table 7-22, except no growth is assumed in U.S. demand for OJ.

No Demand Growth in the United States and the Rest of the World - Scenario 11 Results

In this scenario, demand growth for orange juice in the United States was maintained at zero as in Scenario 10. Orange-juice demand growth in the rest of the world was also reduced from an annual rate of 2% to zero. The results of this scenario are shown in Table 7-29. With no demand growth and the collective effects of canker, greening, high Florida land prices, and high sugar prices in Brazil negatively affecting orange production in both Florida and São Paulo, production follows a downward trend in Florida reaching 142 million boxes in 2020-21. This level of production results in on-tree prices of $6.63 per box in 2020-21. Since the rate of production decline is slowing, it appears that price levels of approximately $6.00 per box are sufficient to sustain the industry. In São Paulo, production begins to stabilize at around 280 million boxes at the end of the forecast horizon. A Florida bulk FCOJ price of $1.61 per SSE gallon is not sufficient to stimulate plantings at a level to outweigh the other negative supply factors built into this scenario.

The large decrease in price between Scenario 10 and Scenario 11 suggests the importance of demand in the rest of the world on Florida orange-juice prices. Even though most Florida product is sold in the United States and Canada, there is a linkage between the North American market and the rest of the world.

FOB revenue associated with Scenario 11 is shown in Table 7-30.

Table 7-29. Scenario 11: Long-run projections of Florida and São Paulo orange production, U.S. and ROW OJ consumption and U.S. OJ prices, base assumptions **PLUS low-greening-loss rates, increased land values impacting Florida planting rates, high-sugar-prices impacting São Paulo orange planting rates, and no U.S. and ROW demand growth**.[1]

Season	ORANGE							
	Florida Produc-tion	Total Acreage	Acre Loss Rate	São Paulo Produc-tion	Price		OJ Consumption	
					Florida Bulk FCOJ	Processed On-Tree	U.S.	ROW
	million boxes	1,000 acres	- % -	million boxes	$/SSE gal.	- $/box -	- million SSE gallons -	
2006-07	196	523	-3.9	350	1.13	3.60	1,391	2,155
2007-08	194	504	-3.5	342	1.14	3.70	1,384	2,137
2008-09	191	495	-3.4	337	1.17	3.85	1,373	2,109
2009-10	186	492	-3.5	334	1.19	4.02	1,361	2,078
2010-11	183	489	-3.7	329	1.22	4.21	1,349	2,046
2011-12	177	483	-4.3	324	1.27	4.47	1,332	2,002
2012-13	171	476	-4.9	318	1.31	4.74	1,314	1,957
2013-14	166	469	-5.1	312	1.36	5.03	1,296	1,911
2014-15	161	463	-5.1	307	1.40	5.32	1,278	1,865
2015-16	156	459	-5.0	301	1.45	5.62	1,261	1,823
2016-17	152	456	-4.9	296	1.49	5.89	1,245	1,784
2017-18	148	455	-4.8	291	1.53	6.13	1,231	1,751
2018-19	146	455	-4.7	287	1.56	6.33	1,220	1,724
2019-20	144	456	-4.7	284	1.59	6.50	1,211	1,702
2020-21	142	458	-4.6	281	1.61	6.63	1,204	1,686

[1] Combined assumptions for base scenario, Table 7-1; greening scenario, Table 7-10; high-land-value scenario, Table 7-16; and high-sugar-price scenario, Table 7-22, except no growth is assumed in U.S. and ROW demand for OJ.

Table 7-30. Scenario 11: FOB Revenues – Base assumptions **PLUS low-greening-loss rates, increased land values impacting Florida planting rates, high-sugar-prices impacting São Paulo orange planting rates, and no U.S. and ROW demand growth**.[1]

Season	FOB Revenue						
	Fresh				Processed		
	Orange	Grapefruit	Specialty	Total	OJ	GJ	Total
	million $						
2006-07	137	196	85	418	2,929	207	3,136
2007-08	137	197	82	416	2,988	202	3,190
2008-09	137	197	79	414	2,987	204	3,192
2009-10	137	198	77	412	2,973	209	3,183
2010-11	137	199	74	410	2,965	215	3,180
2011-12	137	199	71	407	2,950	220	3,170
2012-13	137	200	67	404	2,936	226	3,162
2013-14	137	200	64	401	2,921	230	3,151
2014-15	137	201	61	399	2,906	234	3,140
2015-16	137	201	57	396	2,891	236	3,127
2016-17	137	201	55	393	2,877	237	3,114
2017-18	137	201	52	390	2866	235	3,101
2018-19	137	201	50	387	2,857	233	3,089
2019-20	137	200	47	384	2,849	228	3,076
2020-21	137	199	45	381	2,843	221	3,064

[1] Combined assumptions for base scenario, Tables 7-1 and 7-2; greening scenario, Tables 7-10 and 7-11; high-land-value scenario, Tables 7-16 and 7-17; and high-sugar-price scenario, Table 7-22, except no growth is assumed in U.S. and ROW demand for OJ.

Forecast Economic Impacts of the Florida Citrus Industry in 2003-04[12]

Methods

The total economic impacts of the Florida citrus industry in 2020-21 were evaluated using forecast values for Scenario 9 developed in this report, which represents the anticipated effects of citrus canker and greening diseases, increasing land values in Florida, and competition between sugar and citrus for agricultural land in Brazil. Values for 2020-21 were given in deflated 2003-04 dollar terms. Data sources and methods for impact analysis were previously described in Section 4 of this report. Revenues for byproducts were assumed to be proportional to levels in 2003-04. Also, the split between export (out-of-state) shipments versus local (in-state) consumption was assumed to remain constant. Additional adjustments were made to the *IMPLAN* model of the Florida citrus industry to reflect the higher cost of citrus fruit purchased by the processing sector (48% of total output value), and the regional purchase coefficient for fruit farming was adjusted downward to 0.74 to represent the increased imports of citrus juice that are anticipated. All other parameters in the model were left as previously indicated. Importantly, labor costs and all other input costs were assumed to remain constant in relation to industry revenues.

Results and Discussion

The total production volume of citrus fruit was forecast to decline from 292 million boxes in 2003-04 to 175 million boxes in 2020-21. In spite of this decline in fruit production volume,

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[12]By Alan W. Hodges, Mohammad Rahmani and W. David Mulkey, University of Florida, Institute of Food and Agricultural Sciences, Food and Resource Economics Department, Gainesville, FL.

total industry revenues (FOB) were forecast to increase to $4.37 billion, including $3.99 billion for processed juices and byproducts, and $382 million for fresh market citrus fruit. Revenues for juice would be greater than currently, while revenues for fresh fruit would be decreased.

Total economic impacts of the Florida citrus industry in 2020-21 are summarized in Table 7-31. The total output impact of the industry is estimated at $10.79 billion, including $9.89 billion from processed citrus juice and byproducts, and $895 million from fresh market citrus fruit sales. The indirect output impacts resulting from purchases of inputs from other industry sectors, including the purchase of round fruit from growers by the processing sector, were $2.23 billion, while the induced output impacts resulting from consumer spending by employee households were $4.18 billion. These forecast output impacts represented a 16% increase over 2003-04 levels. Total employment impacts forecast for the Florida citrus industry in 2020-21 were 86,208 jobs, or 13% higher than in 2003-04, and total value-added impacts were $5.57 billion, 14% higher.

These results suggest that the Florida citrus industry may continue to grow in terms of value and economic impacts, in spite of reduced production levels, due to strong demand and substantially higher prices. In the forecast scenario here, lower production volumes are more than offset by higher prices and greater expenditures on production inputs. At the same time, the general economy of Florida is expected to continue growing very rapidly, so the citrus industry will likely become relatively smaller in relation to the overall state economy.

Table 7-31. Summary of forecast economic impacts of the Florida citrus industry, 2020-21 season.

Industry Sector	Impact Measure	Output	Employ-ment	Value Added	Labor Income	Indirect Business Taxes
		- mil. $ -	- jobs-	- - - - - - - - - - million $ - - - - - - - - - -		
Citrus Juice & By-products	Direct-Local Cons.	105.4	284	35.2	17.1	0.9
	Direct-Exports	3,883.7	10,187	1,295.9	627.4	32.2
	Indirect	2,143.4	24,478	1,327.1	626.6	72.5
	Induced	3,758.3	40,769	2,345.6	1,531.7	181.3
	TOTAL	**9,890.8**	**75,719**	**5,003.8**	**2,802.7**	**286.9**
Fresh Market Citrus Fruit	Direct	382.0	5,281	244.6	101.5	11.4
	Indirect	89.0	604	53.8	29.2	1.3
	Induced	424.3	4,605	264.7	173.4	20.3
	TOTAL	**895.3**	**10,489**	**563.1**	**304.1**	**33.0**
All Sectors	Direct	4,371.1	15,752	1,575.7	746.0	44.5
	Indirect	2,232.4	25,082	1,380.9	655.8	73.8
	Induced	4,182.6	45,374	2,610.3	1,705.0	201.5
	TOTAL	**10,786.1**	**86,208**	**5,566.9**	**3,106.9**	**319.9**

Concluding Remarks

In this section, 11 scenarios related to the possible impacts of citrus canker, citrus greening, high land prices in Florida, higher sugar prices in São Paulo, and weaker demand assumptions for orange juice were analyzed. A model with 15-year planning horizon beginning in 2006-07 and validated for the 2004-05 season was developed separately for processed oranges and fresh and processed grapefruit.

The empirical results suggest that the Florida citrus industry should be concerned about the possible impacts of new diseases especially citrus greening. The current state of knowledge with respect to greening is limited. Sensitivity analysis was conducted on increased tree mortality associated with greening. At a high level of tree mortality, Florida orange production is projected to decrease to 123 million boxes at the end of the forecast horizon. Of the 11 scenarios considered in this study, this projected production level is the lowest.

The projected effects of citrus canker are not as large compared to the projected effects of greening. As reported in Zansler et al., citrus canker has more profound impacts on fresh fruit production relative to processed production. Citrus canker adversely affects per-acre fruit yields, and has a potentially large effect on packout. If quarantines continue to be imposed on groves with citrus canker, the impact of citrus canker could be the destruction of the fresh citrus industry in Florida. It is imperative that protocols be established that allow the marketing of fresh citrus from regions within Florida with canker as has been accomplished in Argentina and Uruguay.

High prices for undeveloped land in Florida have implications for the ability of the industry to recover from the collective impacts of hurricanes and efforts to eradicate citrus canker. In the long-run production and price analysis, it is difficult to separate those growers

who already own land and have a much lower price threshold to stimulate new planting versus those who must purchase land to undertake new grove investment.

Citrus growers in Brazil must also deal with citrus greening. Sugarcane production offers a strong alternative to citrus in São Paulo. The recent run-up in world oil prices will likely result in an increased demand for agricultural land by sugar cane producers and sugar/ethanol companies in São Paulo. Imposition of higher sugar prices in São Paulo had a negative effect on new plantings in São Paulo. This suggests an important effect on citrus growers in Florida. In Scenario 9, the simultaneous imposition of canker, greening, high land prices in Florida, and high sugar prices in Brazil resulted in decreased citrus production in both Florida and São Paulo and consequently high prices for processed oranges. This result hinges on the relationship established between the relative prices of citrus and sugar and new plantings in São Paulo.

A 1% annual increase in demand in the United States for orange juice and a 2% annual increase in the rest of the world is used in all Scenarios except 10 and 11. An assumption of no demand growth in the United States results in a 14¢ per SSE gallon decrease in FOB FCOJ prices in year 15. No demand growth in the United States and the rest of the world has a larger negative effect on wholesale prices. These results suggest that even though Florida and São Paulo are entering a period of limited orange juice supplies, ignoring demand factors would be a mistake. Demand promotion programs would still offer good returns through higher juice prices.

Throughout this analysis, it is assumed that supply responses in the rest of the world will not materially change world OJ supply-demand conditions. At the high prices indicated in several scenarios, this assumption may not be realistic. Given that other regions that currently produce orange juice have other issues constraining supply, it is not clear what region could step

forward and significantly increase orange-juice output. China is the likely candidate, but it faces major obstacles in that it lacks the infrastructure needed to become a large scale exporter of orange juice.

The future of the Florida grapefruit industry depends directly on the establishment of protocols to allow out-of-state shipment of fresh fruit and the development of production practices that minimizes the impact of citrus canker on external appearance. The results presented herein suggest that Florida grapefruit production will not recover to levels seen in the 1990s. Low forecasted production results in consistently high grower and wholesale prices in nearly all scenarios considered. Supply response in other regions has not been considered given Florida's dominance in world grapefruit production. It is possible that other regions including Cuba, Mexico, and Turkey will expand output given this outlook for Florida. Each of these regions, however, face challenges.

In closing, it is clear that the outlook for the Florida citrus industry over the next 15 years is for lower levels of production but higher prices compared to the 10 years preceding the hurricanes of 2004. Florida's major orange competitor, the state of São Paulo, Brazil faces challenges of its own, however, that limits its ability to take market share from Florida. Florida's grapefruit industry also faces great challenges as it deals with the consequences of canker and greening. Despite the challenges, it is likely that Florida will remain a major player in the market for both processed oranges and fresh and processed grapefruit.

Appendix A
CITRUS PRICE/RETURN ANALYSIS

Operating Costs Used in Analysis

Historical production cost estimates are based on “Citrus Production Budgets” by Ron Muraro, University of Florida, Institute of Food and Agricultural Sciences, Citrus Research and Education Center, Lake Alfred, Florida.

Historical production costs for Valencia and Hamlin orange varieties grown for processing are assumed to be identical, within their geographic area. Grapefruit grown for the fresh market has higher production costs because of additional sprays used to control rust mite and other pests that cause blemishes to the grapefruit peel and reduce appeal to the consumer.

Historical production costs are assumed to differ between geographic areas (the Ridge and the Flatwoods) because of differences in grove architecture and irrigation methods.

Operating costs added to grove production costs include a miscellaneous cost, management cost, property tax, and interest on operating expenses.

- **Miscellaneous Costs:** A 2% miscellaneous charge is applied to grove production costs to account for additional labor and materials used.

- **Management Costs:** A 5% management charge is applied to all grove production costs. This includes a cost for overhead and other fixed capital expenses, depreciation of grove machinery or expenses for grove caretaking.

- **Property Taxes:** A base agricultural property tax of $30 per acre per year for new plantings/replantings is included. This tax is expected to increase with the maturity of the grove and assessed value of the property as follows: +5% per year for years 1 to 3, +7.5% per year for years 4 to 7, +10% per year for years 8 to 11, and remains at $71.14 per acre for years 12+. For mature groves, a base property tax of $70 per acre is assumed to increase by 2.5% per year.

- **Interest on Operating Expenses:** A 6% A.P.R. interest charge is placed on one half of the season's grove production costs (6 months). This accounts for the cash flow pattern of citrus investments which may accrue interest expenses related to materials and supplies paid for before fruit is harvested.

See Table A-1 for details.

Investment Model Assumptions

The following is a further discussion of various assumptions made in the investment model.

Net Present Value Analysis

This model uses a Returns-to-Assets (RTA) model for calculating the net present value (NPV) of the citrus investment. Cash inflows and outflows are calculated at the end of the period and discounted before interest, taxes, depreciation, and amortization (EBITDA).

The initial investment in period 0 includes land cost (for the new-planting scenario only), the installation and materials cost for a micro-sprinkler irrigation system, land preparation costs (building beds, service roads, and drainage), permitting and licensing costs, and property taxes. It is assumed that the first year (in the case of new plantings) is devoted to planning and preparing the grove, with the actual trees being planted at the beginning of period 1.

Discount and Capitalization Rates

The rate used to discount future cash flows to their NPV varies between the citrus varieties analyzed because it is based on a risk-adjusted discount rate by variety, a non-liquidity premium, and a cost of money management. First, the risk-adjusted discount rates come from

"The Impact of Risk on the Discount Rate for Different Citrus Varieties," (Moss, Weldon, & Muraro 1991), and uses a derivation of the Capital Asset Pricing Model (CAPM) to establish a risk premium for each variety based on historical returns. Then, a liquidity premium is added, based on the difference between the yields of a 3-month U.S. Treasury Bill and the 30-year U.S. Treasury Bond (.03% at the time of writing). Finally, a cost of money management (1.5%) is added that compensates for the additional, "hands-on" effort required by a citrus grove compared to other investments. This figure may be higher for smaller, non-specialized growers/landowners/investors, and lower for large grove operations (Table A-2).

In this analysis, the capitalization rate (or cap rate) is used to determine the terminal grove value as an income producing property. The cap rate is derived using a built up discount rate method. This is illustrated by Table A-3. In addition to the liquidity and cost of money management premiums discussed above, the built-up cap rate takes a risk-free rate of return and adds price and ownership of agricultural property risk premiums. The risk-free rate of return is the yield on a 3-month U.S. Treasury Bill. The price risk is determined by comparing the volatility of the price of each variety of citrus to the risk-free rate. The ownership of agricultural property premium is based on the inherently risky nature of agricultural assets, their production of one crop per year, and their susceptibility to unpredictable weather and biological events.

<u>Breakeven Prices with Terminal Grove Value Versus Cumulative Discounted Cash Flows Only</u>

A citrus investment requires land for planting, and the land must be obtained by either purchase or preexisting ownership. Even if the citrus investment has no value, the underlying land still retains some value (especially in Florida). Additionally, planting a citrus grove creates

an income generating asset. Therefore, the value of an acre of planted citrus consists of two components, the value of the income generating asset plus the value of the underlying land.

Although historically land prices trend upward, this analysis does not make assumptions about the appreciation in value of the underlying land in the calculation of NPV. However, the NPV of cash flows plus the terminal grove value does capture the value created by taking a piece of open land (improved pasture or cropland), and planting an income producing citrus grove. This value does not disappear after the 15-year period of analysis. We incorporate it by taking the average income of the final two periods (14-15), dividing the average income by the capitalization rate, adding it to the final period cash flow, and discounting back to the present. The average income of the final two periods represents a level of income that a grower/landowner/investor could reasonably expect from a mature grove. The capitalization rate is derived for a citrus investment. This follows the standard income-approach of property appraisal.

Although some growers/landowners/investors may look only at cumulative cash flows from operations, this may underestimate the true value of the citrus investment. A parallel example is the value of a bond. One purchases a bond by paying the face value, subsequently the purchaser is entitled to the coupon (the interest paid) over the life of the bond. Upon maturity, the purchaser could receive his/her money back. In the case of our citrus grove, one purchases a citrus grove by paying money for the establishment and land costs (face value). Then, the grove owner is entitled to the income (coupon) for the 15 years of analysis. At the end of 15 years, the grove owner can get his/her money back by selling the grove or continue to hold on to the grove. In this analysis, it does not matter whether the owner sells the grove or not, because the terminal

value only captures the value of the income produced by the asset. In reality, this estimate may be conservative because it ignores the value of the underlying land.

In this analysis, there are a few scenarios where we do incorporate the value of the underlying land. This is when the average income divided by the capitalization rate is less than the initial purchase price of the improved pasture. This occurs infrequently at the lowest price ranges ($1.00 per PS and $5.00 per box) combined with the canker and high greening disease assumptions. In this case, we assume the terminal value can never fall below the initial purchase price, and we simply add the initial purchase price to the final period.

Accounting for Uneven Aged Trees in a Grove

The reality of the grove situation is that few groves have trees of a uniform age, and most growers pull out dead or unproductive trees and replant with young trees. Young reset trees incur additional costs above mature, older trees, and trees differ in yields according to their ages.

In order to capture the effects of the uneven aged trees, this investment model uses an age matrix accounting for the different percentages of trees by age. An example of solid-set Valencias is provided in Tables A-4 and A-5. In Table A-4, the physical age of the trees increases across the top row, while the period of analysis increases down the left column. The cells along the downward sloping diagonal are the percentages of the original solid-set planted trees, and the other cells are the percentage of reset trees by age. For example, in year 5 of the analysis, 95.6% of the original trees are remaining and they are 5-years old. Two percent of trees are 3-years old. These trees were reset in year 2 of the analysis. Two and one-half percent of trees are 1-year old, and are reset in that year of analysis. These percentages change with tree

loss assumptions, and as tree loss rates increase, the percentage of original trees decreases more rapidly.

The tree-age matrix is then used to determine a yield matrix (Table A-5), which accounts for the different yields per tree by tree age. The tree-age matrix is also applied to the grove costs, so the additional costs of young, reset trees can be incorporated into the total grove costs.

Resetting and Young-Tree Establishment Costs

All scenarios use a bi-annual resetting policy (replacing dead/unproductive trees every other year) until year ten, and semi-annual resetting of 50% of tree loss for years 11 to 15. This reflects two realities of resetting: (1) when pursuing a continuous reset policy, under field conditions, growers do not always have the opportunity to reset every season, and may wait until there is enough tree loss to justify the expense of removing and replacing trees; (2) with the higher density plantings in this model, a grower most likely would reset at a lower density (space trees farther apart) after the original trees are mature (about 10-years old) to avoid shading-out the young trees. In our analysis, a cyclical fluctuation could be noticed in grove operating costs due to the semi-annual resetting policy. Every other year, the grower incurs extra costs due to resetting trees within a mature grove. The higher the tree loss rates, the more pronounced these cyclical fluctuations become. Therefore, in the greening scenarios with high tree loss, there is a substantial difference in costs from year to year.

Moreover, there are still unanswered questions about the role of resetting in an environment with endemic citrus greening. It is suggested by some studies that the psyllid vector prefers the tender growth flushes of young trees. If there are some infected trees within proximity of young, reset trees, these reset trees may attract psyllids and have a higher incidence of greening infection.

Costs for years 1 to 3 of reset trees were incorporated into the model. These costs differ for canker and greening environments (Table A-6). After year 3, they are assumed to follow the grove care plan of the rest of the grove.

Costs for years 1 to 4 of a newly planted grove (solid-set) were applied to account for extra cultivation and labor required for planting and caring for the young trees (Table A-7).

Additional costs for spray programs for solid-set trees are also incorporated into the model (Table A-8).

Tree Yields

Yield estimates were calculated by assuming a box yield per tree according to the age of the tree. These data were collected from averages of results of experiments with high density planting yields conducted by IFAS-Lake Alfred researchers. All trees are assumed to follow this average progression as shown in Table A-9 of the analysis. Total grove yields are then adjusted using tree loss and yield penalties due to disease.

This illustrates the impact of tree loss rates on production by adjusting the total per acre yield by the mix of trees of different ages. Peak boxes per acre production occurs when the trees are at 11 years of age, and peak pound solids for processing oranges is reached at year 7.

Disease Assumptions

Both citrus canker and citrus greening are assumed to add on to the base citrus production costs due to additional spraying, inspection costs, and cultural practices. However, much uncertainty still exists because of the recent appearance of greening in Florida, the new endemic canker environment, voluntary or mandatory disease control programs that are not currently in

place, and integrated pest management recommendations from state, federal, or industry organizations that are subject to frequent revision. Therefore, we attempt to accurately quantify the impact of these diseases using the current scientific literature, University of Florida, Institute of Food and Agricultural Sciences, and the Florida Department of Agriculture and Consumer Services, Division of Plant Industry experts in plant pathology and horticulture, industry professionals, and other countries experiences with citrus greening and canker.

Detailed descriptions of the assumptions are below. Please refer to Tables A-10 through A-13 for further information.

Citrus Canker

Many assumptions about the impact of endemic canker on the Florida citrus industry are based on studying the effect of canker on the Argentine citrus industry, as summarized in "An Overview of Argentina's Citrus Canker Control Program and Grower Costs of Having Citrus Canker in Florida," by Muraro, et al., available online at http://edis.ifas.ufl.edu/pdffiles/FE/FE28500.pdf.

- **Yield Penalty:** In this model, canker is assumed to have a yield penalty of 10% for more susceptible varieties of citrus (Hamlin oranges and grapefruit) and 5% for less susceptible varieties (Valencia oranges). This yield penalty is due to increased fruit drop, which is a common symptom of canker. Also, canker is assumed to increase the tree loss rate by 10% across all age groups to account for a higher percentage of trees becoming economically unproductive. For fresh fruit (grapefruit in this analysis), canker is assumed to lower the pack-out rate to 60% due to the appearance of unsightly peel blemishes. This does not affect fruit for processing.

- **Additional Costs:** Production for the fresh citrus market incurs the most additional costs. Costs for additional sprays for citrus leaf-miner control and copper sprays, increased grove sanitation practices, including disinfecting equipment, other cultural practices such as skirting trees, planting windbreaks, canker inspections, and fresh market certification are also included.

Citrus Greening

Despite its dramatic effects, greening has received little study in the scientific literature, and almost no assessment of its economic impacts. Although Brazil is starting to feel the effects of greening on its citrus industry, the disease was discovered there only about a year before its arrival in Florida. Most published information and research comes from countries such as South Africa, Thailand, Vietnam, India, China, and the Philippines. In many of these countries, greening has had a devastating impact on local citrus industries. For example, greening is credited with decreasing the average life expectancy of a citrus tree to eight years in Thailand. However, the citrus industries in many of these countries use less intensive grove management than Florida. Spread of the disease continues through propagation with infected plant material, and ineffective or inefficiently implemented integrated pest management programs. For the purposes of economic analysis, assumptions are made regarding the two main effects of greening: (1) increased tree loss; and (2) increased pesticide costs due to control of the psyllid insect vector.

- **Increased Tree Loss:** Through a literature review and conversations with experts, it appears that greening may infect young trees more readily than older trees due to the fact that the psyllid prefers to feed on tender growth flushes and these are more present on young trees. Studies show that 100% of a newly planted grove of disease-free trees can become infected within a few years with no psyllid control. However, it also appears that one can dramatically reduce the spread by removing the infected trees, planting disease-free young trees, and intensively controlling for psyllids.

- **Increased Pesticide Costs:** The psyllid insect is relatively new to Florida, and not traditionally a target of pest management by growers. Based on conversations with growers and citrus specialists, we assume that growers will follow a control program consisting of systemic insecticides and additional sprays for psyllid control. A literature review showed successful experimental attempts to control greening used intensive spray programs (8 to 20 sprays per year), especially during the seasonal peaks in psyllid populations. Anecdotal evidence from the Brazilian citrus industry also points towards intensive spray programs to control psyllids.

Many incidences of greening-infected trees are in residential (dooryard) citrus and ornamentals. Although an exact determination has not been made, it is suggested that the psyllid can fly long distances and has multiple hosts where it can feed and reproduce. This makes the psyllid extremely hard to control, and may require the constant use of pesticides to protect commercial groves.

The need for increased pesticide use to control greening may cause new difficulties in agricultural/residential relations. Systemic insecticides such as Temik, Admire, and Provado appear to be some of the most effective tools for controlling psyllid populations (Rodgers 2005). Temik and Admire are soil applied insecticides and are already subject to restrictions on their usage because of concerns about groundwater infiltration. Previously, due to restrictions on usage and cost, Temik and Admire were not widely used by growers. Currently, signals from Integrated Pest Management Programs (IPM's) both here and abroad point toward more growers using these systemics more frequently. Also, intensive spraying of other pesticides during growth flushing periods may result in large amounts of chemicals being used by many growers within a short time period.

Limits on pesticide use may create difficulties for citrus growers due to an expanding population in Florida. Already many groves face increasing urban encroachment. This may limit the tools available for growers to control psyllid populations and the spread of greening. Biological control measures are already underway, and this may increase the importance of these measures. Given the current tools available to combat greening, growers may find themselves in a situation where the most effective tools may not be available to them.

Table A-1. Base production costs used in analysis (per acre).

Production/Cultural Costs (mature 10-year-old grove)	Oranges		Grapefruit
	Ridge	Flatwoods	Indian River
	- - - - - - - - - - - - $ per acre	- - - - - - - - - - - -	
Weed Management/Control			
Mechanical Mow Middles (3 times/year)			
Chemical Mow Middles (3 times/year)			
General Grove Work (2 labor hours/year)			
Herbicide (50% grove area covered)			
Application			
Materials			
TOTAL	189.17	189.17	189.17
Spray (applications & material)			
TOTAL	132.24	141.19	240.12
Fertilizer & Dolomite (applications & material)			
TOTAL	204.77	204.77	157.00
Pruning			
Topping			
Hedging			
Skirting			
TOTAL	40.06	40.06	52.13
Irrigation and Ditch Maintenance			
Type of Irrigation System: Micro Sprinkler			
For Flatwoods:			
Clean Ditches (weed control)			
Ditch and Canal Maintenance			
Water Control (pump water in/out of ditches & canals			
TOTAL	187.40	208.63	208.60
TOTAL GROVE PRODUCTION COSTS	**810.76**	**783.32**	**847.02**
Miscellaneous Charges (2%)	14.65	15.68	16.94
Management Charges (5%)	36.62	39.19	42.35
Property Taxes:	70.00	70.00	70.00
TOTAL GROVE OPERATING COSTS	**937.51**	**908.69**	**976.31**

Table A-2. Discount rates for citrus investment analysis.

Item	Valencia Oranges	Hamlin Oranges	Red Grapedruit
	- - - - - - - - - - - - -	% - - - - - - - - - - - -	
Risk adjusted discount rate[a]	9.34	8.24	7.18
Add:			
Premium for non-liquidity	0.03	0.03	0.03
Difference between 3-month Treasury Bills and 30-year Bonds, January 2006			
Cost of money management	1.50	1.50	1.50
Most investments range from 1% to 2%; sometimes agriculture is higher.			
Total Discount Rate	10.87	9.77	8.71

[a]Moss, Weldon, & Muraro. "The Impact of Risk on the Discount Rate for Different Citrus Varieties." *Agribusiness*, Vol. 7, No. 4, pp. 327-338. 1991.

Table A-3. Built-up capitalization rate method.

Item	Valencia Oranges	Hamlin Oranges	Red Grapedruit
	- - - - - - - - - - - - - %	- - - - - - - - - - - -	
Alternate use/safe rate	4.54	4.54	4.54
Rate used is 3-month Treasury Bills, January 2006.			
Price risk premium[a]	4.09	2.99	1.93
Risk of ownership	3.16	3.16	3.16
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.			
Premium for non-liquidity	0.03	0.03	0.03
Difference between 3-month Treasury Bills and 30-year Bonds, January 2006			
Cost of money management	1.50	1.50	1.50
Most investments range from 1% to 2%.			
Total Capitalization Rate	13.32	12.22	11.16

[a]Moss, Weldon, & Muraro. "The Impact of Risk on the Discount Rate for Different Citrus Varieties." *Agribusiness*, Vol. 7, No. 4, pp. 327-338. 1991.

Table A-4. Tree-age distribution of solid-set Valencia – base scenario.

Period	Age of Original Planted Trees															
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	% of trees by age															
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

Table A-5. Grove yields for solid-set Valencia – base scenario.

Period	Boxes Per Tree	Age of Original Planted Trees													Total Boxes Per Acre	Pound Solids Per Acre
		3	4	5	6	7	8	9	10	11	12	13	14	15		
		- - - boxes per acre, by age - - -														
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	1,236.92
6	1.47	0.0	2.9	0.0	274										277	1,800.18
7	1.85	2.2	0.0	4.1	0.0	340									346	2,421.59
8	2.16	0.0	3.7	0.0	5.5	0.0	391								400	2,798.23
9	2.47	2.6	0.0	5.1	0.0	6.8	0.0	440							454	3,181.09
10	2.78	0.0	4.4	0.0	6.8	0.0	7.8	0.0	488						507	3,546.90
11	3.06	2.6	0.0	6.0	0.0	8.4	0.0	8.8	0.0	529					554	3,880.25
12	3.06	0.0	4.3	0.0	8.1	0.0	9.7	0.0	9.7	0.0	510				542	3,794.99
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	3,718.47
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	3,634.40
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	3,576.40

Table A-6. Reset tree costs by disease.

Establishment Costs for Reset Planted Trees (cost per tree)	Year		
	1	2	3
	- - - - - - - - - - - - - $ per tree - - - - - - - - - - - -		
Without Citrus Canker or Greening			
Supplemental maintenance costs	3.59	2.96	2.34
Site preparation	4.18	0.00	0.00
Tree cost (bare root)	7.50	0.00	0.00
Stake, plant, and water tree	2.55	0.00	0.00
Tree removal cost	4.45	0.00	0.00
With Citrus Canker			
Supplemental maintenance costs	4.85	4.71	4.63
Site preparation	4.18	0.00	0.00
Tree cost (bare root)	7.50	0.00	0.00
Stake, plant, and water tree	2.55	0.00	0.00
Tree removal cost	4.45	0.00	0.00
With Citrus Greening			
Supplemental maintenance costs	4.83	4.69	4.60
Site preparation	4.18	0.00	0.00
Tree cost (bare root)	7.50	0.00	0.00
Stake, plant, and water tree	2.55	0.00	0.00
Tree removal cost	4.45	0.00	0.00
With Citrus Canker & Greening			
Supplemental maintenance costs	5.67	6.24	7.07
Site preparation	4.18	0.00	0.00
Tree cost (bare root)	7.50	0.00	0.00
Stake, plant, and water tree	2.55	0.00	0.00
Tree removal cost	4.45	0.00	0.00

Table A-7. Establishment costs for solid-set planted trees, cost per acre.

Item	Year			
	1	2	3	4
	- - - - - - - - - - - - - - - - - - - $ per acre - - - - - - - - - - - - - - - - - - -			
Irrigation/cold protection	49.50	115.50	122.51	134.06
Fertilizer	61.50	91.50	121.50	129.00
Spraying	70.60	77.65	84.71	91.77
Tree wrap	50.00	0.00	0.00	0.00
Tree wrap (annual maintenance)	37.50	37.50	37.50	0.00
Sprouting (labor)	30.00	30.00	0.00	0.00
Cultivation/mowing	79.60	79.50	95.40	95.40
Herbicide	67.50	67.50	75.00	82.50
Ridomil/Aliette	52.50	52.50	0.00	0.00
Tree cost (bare root)	1,485.00	0.00	0.00	0.00
Stake, plant, and water tree	261.36	0.00	0.00	0.00
Miscellaneous	8.97	11.03	10.73	10.65
Supervision and overhead	22.88	28.13	27.37	27.17
TOTAL	2,276.91	590.82	574.72	570.56

Table A-8. Establishment spray costs for solid-set planted trees.

Scenario	Year			
	1	2	3	4
	$ per acre			
ORANGES				
Without citrus canker or greening	66.12	72.73	79.34	85.96
With citrus canker	76.59	84.26	91.91	99.58
With citrus greening	167.78	184.55	201.33	218.11
With citrus canker & greening	167.78	184.55	201.33	218.11
GRAPEFRUIT				
Without citrus canker or greening	191.50	210.65	230.80	248.95
With citrus canker	209.21	230.14	251.06	271.97
With citrus greening	269.95	296.95	323.94	350.94
With citrus canker & greening	269.95	296.95	323.94	350.94

Table A-9. Per-tree yields used for analysis.

Tree Age	Variety:	Hamlin Orange	Valencia Orange	Red Grapefruit
	Spacing:	22' x 10'	22' x 10'	25' x 13'
	Trees/Acre:	198	198	134
- years -		- - - - - - - -	boxes per tree	- - - - - - - -
1		0.0	0.0	0.0
2		0.0	0.0	0.0
3		0.6	0.5	0.7
4		0.9	0.8	1.1
5		1.3	1.1	1.6
6		1.7	1.5	2.2
7		2.2	1.9	2.7
8		2.6	2.2	3.2
9		2.9	2.5	3.7
10		3.3	2.8	4.1
11		3.6	3.1	4.5
12		3.6	3.1	4.5
13		3.6	3.1	4.5
14		3.6	3.1	4.5
15		3.6	3.1	4.5

Table A-10. Citrus canker spray programs.

Spray Program	Processed Hamlin Oranges – With Citrus Canker				Processed Valencia Oranges – With Citrus Canker				Fresh Grapefruit – With Citrus Canker			
	Materials/ Ingredients	Amount per Acre	Price per Unit ($)	Cost per Acre ($)	Materials/ Ingredients	Amount per Acre	Price per Unit ($)	Cost per Acre ($)	Materials/ Ingredients	Amount per Acre	Price per Unit ($)	Cost per Acre ($)
WINTER-EARLY SPRING – Spray Program #1												
# of Applications	0				0				0			
Psyllid Control	Temik 15G	33 lbs.	3.20	105.60	Temik 15G	33 lbs.	3.20	105.60	Temik 15G	33 lbs.	3.20	105.60
Psyllid Control (Yng.)	Admire 2F	0 oz.	4.06	–	Admire 2F	0 oz.	4.06	–	Admire 2F	0 oz.	4.06	–
Total Material Costs				105.60				105.60				105.60
	Temik Application	1 acre		13.03	Temik Application	1 acre		13.03	Temik Application	1 acre		13.03
Young Tree Drench	Hand-Gun Sprayer	2 hours/acre		0.00	Hand-Gun Sprayer	2hours/ace		0.00	Hand-Gun Sprayer	2 hours/acre		0.00
Total Cost Per Application				118.63				118.63				118.63
TOTAL COSTS - Spray #1				0.00				0.00				0.00
SPRING-POST BLOOM – Spray Program #2												
# of Applications	1				0				1			
	Spray Oil (97+%)	3 gals.	2.21	6.63	Spray Oil (97+%)	3 gals.	2.21	6.63	Spray Oil (97+%)	3 gals.	2.21	6.63
	Basic Copper (53%)	4 lbs.	1.40	5.60	Basic Copper (53%)	4 lbs.	1.40	5.60	Basic Copper (53%)	4 lbs.	1.40	5.60
Total Material Costs				12.23				12.23				12.23
	PTO-125	125 gals.		23.93	PTO-125	125 gals.		23.93	PTO-125	125 gals.		23.93
Total Cost Per Application				36.16				36.16				36.16
TOTAL COSTS - Spray #2				36.16				0.00				36.16
SPRING-POST BLOOM – Spray Program #3												
# of Applications	1				1				1			
Leaf Minor Control	Lorsban 4EC	5 pts.	4.27	21.34	Lorsban 4EC	5 pts.	4.27	21.34	Lorsban 4EC	5 pts.	4.27	21.34
	Basic Copper (53%)	4 lbs.	1.40	5.60	Basic Copper (53%)	4 lbs.	1.40	5.60	Basic Copper (53%)	4 lbs.	1.40	5.60
	Zn (Zinc)	3 lbs.	0.83	2.49	Zn (Zinc)	3 lbs.	0.83	2.49	Zn (Zinc)	3 lbs.	0.83	2.49
	Mn (Manganese)	3 lbs.	0.32	0.96	Mn (Manganese)	3 lbs.	0.32	0.96	Mn (Manganese)	3 lbs.	0.32	0.96
	B (Borates)	0.25 lb.	0.70	0.18	B (Borates)	0.25 lb.	0.70	0.18	B (Borates)	0.25 lb.	0.70	0.18
Total Material Costs				30.57				30.57				30.57
	PTO-125	125 gals.		23.93	PTO-125	125 gal.s		23.93	PTO-125	125 gals.		23.93
Total Cost Per Application				54.50				54.50				54.50
TOTAL COSTS - Spray #3				54.50				54.50				54.50
SPRING-POST BLOOM – Spray Program #4												
# of Applications	0				0				2			
	Micromite 80WG	1.25 pts.	10.99	13.74	Micromite 25 WP	1.25 lbs.	9.05	11.31	Micromite 25 WP	0 lbs.	9.05	–
	Basic Copper (53%)	7 lbs.	1.40	9.80	Basic Copper (53%)	7 lbs.	1.40	9.80	Basic Copper (53%)	4 lbs.	1.40	5.60
Total Material Costs				23.54				21.11				5.60
	PTO-125	125 gals.		23.93	PTO-125	125 gals.		23.93	PTO-125	125 gals.		23.93
Total Cost Per Application				47.47				45.04				29.53
TOTAL COSTS - Spray #4				0.00				0.00				59.06
SUMMER – Spray Program #5												
# of Applications	0				0				1			
	Abound	15 oz.	1.70	25.56	Abound	15 oz.	1.70	25.56	Abound	15 oz.	1.70	25.56
(if no mite resistance)	Agrimek	10 oz.	4.40	44.03	Arimek	10 oz.	4.40	44.03	Agrimek	10 oz.	4.40	44.03
	Spray Oil (97+%)	5 gal.s	2.21	11.05	Spray Oil (97+%)	5 gals.	2.21	11.05	Spray Oil (97+%)	5 gals.	2.21	11.05
Total Material Costs				80.64				80.64				80.64
	PTO-250	250 gals.		28.50	PTO-250	250 gals.		28.50	PTO-250	250 gals.		28.50
Total Cost Per Application				109.14				109.14				109.14
TOTAL COSTS - Spray #5				000				0.00				109.14
SUMMER – Spray Program #6												
# of Applications	1				1				1			
	Basic Copper (53%)	7 lbs.	1.40	9.80	Basic Copper (53%)	7 lbs.	1.40	9.80	Basic Copper (53%)	7 lbs.	1.40	9.80
	Spray Oil (97+%)	5 gals.	2.21	11.05	Spray Oil (97+%)	5 gals.	2.21	11.05	Spray Oil (97+%)	5 gals	2.21	11.05
Total Material Costs				20.85				20.85				20.85
	PTO-250	250 gals.		28.50	PTO-250	250 gals.		28.50	PTO-250	250 gals.		28.50
Total Cost Per Application				49.35				49.35				49.35
TOTAL COSTS - Spray #6				49.35				49.35				49.35
SUMMER – Spray Program #7												
# of Applications	1				1				1			
	Spray Oil (97+%)	5 gals.	2.21	11.05	Spray Oil (97+%)	5 gals.	2.21	11.05	Spray Oil (97+%)	5 gals.	2.21	11.05
	Basic Copper (53%)	7 lbs.	1.40	9.80	Basic Copper (53%)	7 lbs.	1.40	9.80	Basic Copper (53%)	7 lbs.	1.40	9.80
	Zn (Zinc)	0 lbs.	0.83	–	Zn (Zinc)	0 lbs.	0.83	–	Zn (Zinc)	0 lbs.	0.83	–
	Mn (Manganese)	0 lbs.	0.32	–	Mn (Manganese)	0 lbs.	0.32	–	Mn (Manganese	0 lbs.	0.32	–
	B (Borates)	0 lbs.	0.70	–	B (Borates)	0 lbs.	0.70	–	B (Borates)	0 lbs.	0.70	–
Total Material Costs				20.85				20.85				20.85
	PTO-250	250 gals.		28.50	PTO-250	250 gals.		28.50	PTO-250	250 gals.		28.50
Total Cost Per Application				49.35				49.35				49.35
TOTAL COSTS - Spray #7				49.35				49.35				49.35
FALL – Spray Program #8												
# of Applications	0				0				1			
	Vendex 50W	2 lbs.	14.86	29.72	Nexter WP	6.6 oz.	5.60	36.94	Nexter WP	6.6 oz.	5.60	36.94
	PTO-125	125 gals.		23.93	PTO-125	125 gals.		23.93	PTO-125	125 gals.		23.93
Total Cost Per Application				53.65				60.87				60.87
TOTAL COSTS - Spray #8				0				0.00				60.87
TOTAL SPRAY PROGRAM COSTS				**189.36**				**153.20**				**418.43**

Table A-11. Citrus greening spray programs.

Spray Program	Processed Hamlin Oranges – With Citrus Greening: Materials/ Ingredients	Amount per Acre	Price per Unit ($)	Cost per Acre ($)	Processed Valencia Oranges – With Citrus Greening: Materials/ Ingredients	Amount per Acre	Price per Unit ($)	Cost per Acre ($)	Fresh Grapefruit – With Citrus Greening: Materials/ Ingredients	Amount per Acre	Price per Unit ($)	Cost per Acre ($)
WINTER-EARLY SPRING – Spray Program #1												
# of Applications	1				1				1			
Psyllid Control	Temik 15G	33 lbs.	3.20	105.60	Temik 15G	33 lbs.	3.20	105.60	Temik 15G	33 lbs.	3.20	105.60
Psyllid Control (Yng.)	Admire 2F	0 oz.	4.06	–	Admire 2F	0 oz.	4.06	–	Admire 2F	0 oz.	4.06	–
Total Material Costs				105.60				105.60				105.60
	Temik Application	1 acre		13.03	Temik Application	1 acre		13.03	Temik Application	1 acre		13.03
Young Tree Drench	Hand-Gun Sprayer	2 hours/acre		0.00	Hand-Gun Sprayer	2 hours/acre		0.00	Hand-Gun Sprayer	2hours/ace		0.00
Total Cost Per Application				118.63				118.63				118.63
TOTAL COSTS - Spray #1				118.63				118.63				118.63
SPRING-POST BLOOM – Spray Program #2												
# of Applications	0				0				1			
	Spray Oil (97+%)	3 gals.	2.21	6.63	Spray Oil (97+%)	3 gals.	2.21	6.63	Spray Oil (97+%)	3 gals.	2.21	6.63
	Basic Copper (53%)	4 lbs.	1.40	5.60	Basic Copper (53%)	4 lbs.	1.40	5.60	Basic Copper (53%)	4 lbs.	1.40	5.60
Total Material Costs				12.23				12.23				12.23
	PTO-125	125 gals.		23.93	PTO-125	125 gals.		23.93	PTO-125	125 gals.		23.93
Total Cost Per Application				36.16				36.16				36.16
TOTAL COSTS - Spray #2				0.00				0.00				36.16
SPRING-POST BLOOM – Spray Program #3												
# of Applications	1				1				1			
	Lorsban 4EC	5 pts.	4.27	21.34	Lorsban 4EC	5 pts.	4.27	21.34	Lorsban 4EC	5 pts.	4.27	21.34
	Basic Copper (53%)	4 lbs.	1.40	5.60	Basic Copper (53%)	4 lbs.	1.40	5.60	Basic Copper (53%)	4 lbs.	1.40	5.60
	Zn (Zinc)	3 lbs.	0.83	2.49	Zn (Zinc)	3 lbs.	0.83	2.49	Zn (Zinc)	3 lbs.	0.83	2.49
	Mn (Manganese)	3 lbs.	0.32	0.96	Mn (Manganese)	3 lbs.	0.32	0.96	Mn (Manganese)	3 lbs.	0.32	0.96
	B (Borates)	0.25 lb.	0.70	0.18	B (Borates)	0.25 lb.	0.70	0.18	B (Borates)	0.25 lb.	0.70	0.18
Total Material Costs				30.57				30.57				30.57
	PTO-125	125 gals.		23.93	PTO-125	125 gals.		23.93	PTO-125	125 gal.s		23.93
Total Cost Per Application				54.50				54.50				54.50
TOTAL COSTS - Spray #3				54.50				54.50				54.50
SPRING-POST BLOOM – Spray Program #4												
# of Applications	0				0				2			
	Micromite 80WG	1.25 pts.	10.99	13.74	Micromite 80 WP	1.25 pts.	10.99	13.74	Micromite 80WG	0 pts.	10.99	–
	Basic Copper (53%)	7 lbs.	1.40	9.80	Basic Copper (53%)	7 lbs.	1.40	9.80	Basic Copper (53%)	4 lbs.	1.40	5.60
Total Material Costs				23.54				23.54				5.60
	PTO-125	125 gals.		23.93	PTO-125	125 gals.		23.93	PTO-125	125 gals.		23.93
Total Cost Per Application				47.47				47.47				29.53
TOTAL COSTS - Spray #4				0.00				0.00				59.06
SUMMER – Spray Program #5												
# of Applications	0				0				1			
	Abound	15 oz.	1.70	25.56	Abound	15 oz.	1.70	25.56	Abound	15 oz.	1.70	25.56
(if no mite resistance)	Agrimek	10 oz.	4.40	44.03	Agrimek	10 oz.	4.40	44.03	Arimek	10 oz.	4.40	44.03
	Spray Oil (97+%)	5 gal.s	2.21	11.05	Spray Oil (97+%)	5 gals.	2.21	11.05	Spray Oil (97+%)	5 gals.	2.21	11.05
Total Material Costs				80.64				80.64				80.64
	PTO-250	250 gals.		28.50	PTO-250	250 gals.		28.50	PTO-250	250 gals.		28.50
Total Cost Per Application				109.14				109.14				109.14
TOTAL COSTS - Spray #5				0.00				0.00				109.14
SUMMER – Spray Program #6												
# of Applications	1				1				1			
	Basic Copper (53%)	7 lbs.	1.40	9.80	Agrimek (if no mite res.)	10 oz.	4.40	44.03	Basic Copper (53%)	7 lbs.	1.40	9.80
	Agrimek (if no mite res.)	10 oz.	4.40	44.03	Basic Copper (53%)	7 lbs.	1.40	9.80				
	Spray Oil (97+%)	5 gals.	2.21	11.05	Spray Oil (97+%)	5 gals	2.21	11.05	Spray Oil (97+%)	5 gals.	2.21	11.05
Total Material Costs				20.85				20.85				20.85
	PTO-250	250 gals.		28.50	PTO-250	250 gals.		28.50	PTO-250	250 gals.		28.50
Total Cost Per Application				49.35				49.35				49.35
TOTAL COSTS - Spray #6				49.35				49.35				49.35
SUMMER – Spray Program #7												
# of Applications	1				1				1			
	Spray Oil (97+%)	5 gals.	2.21	11.05	Spray Oil (97+%)	5 gals.	2.21	11.05	Spray Oil (97+%)	5 gals.	2.21	11.05
	Basic Copper (53%)	7 lbs.	1.40	9.80	Basic Copper (53%)	7 lbs.	1.40	9.80	Basic Copper (53%)	7 lbs.	1.40	9.80
	Lorsban 4EC	5 pts.	4.27	21.34	Lorsban 4EC	5 pts.	4.27	21.34	Lorsban 4EC	5 pts.	4.27	21.34
	Mn (Manganese)	0 lbs.	0.32	–	Mn (Manganese	0 lbs.	0.32	–	Mn (Manganese)	0 lbs.	0.32	–
	B (Borates)	0 lbs.	0.70	–	B (Borates)	0 lbs.	0.70	–	B (Borates)	0 lbs.	0.70	–
Total Material Costs				42.19				42.19				42.19
	PTO-250	250 gals.		28.50	PTO-250	250 gals.		28.50	PTO-250	250 gals.		28.50
Total Cost Per Application				70.69				70.69				70.69
TOTAL COSTS - Spray #7				70.69				70.69				70.69
FALL – Spray Program #8												
# of Applications	1				1				1			
	Danitol	1 pt.	18.45	18.45	Danitol	1 pt.	18.45	18.45	Danitol	1 pt.	18.45	18.45
	PTO-125	125 gals.		23.93	PTO-125	125 gals.		23.93	PTO-125	125 gals.		23.93
Total Cost Per Application				42.38				42.38				42.38
TOTAL COSTS - Spray #8				42.38				42.38				42.38
TOTAL SPRAY PROGRAM COSTS				**335.55**				**335.55**				**539.91**

Table A-12. Citrus canker and greening spray programs.

Spray Program	Processed Hamlin Oranges – With Citrus Canker and Greening				Processed Valencia Oranges – With Citrus Canker and Greening				Fresh Grapefruit – With Citrus Canker and Greening			
	Materials/ Ingredients	Amount per Acre	Price per Unit ($)	Cost per Acre ($)	Materials/ Ingredients	Amount per Acre	Price per Unit ($)	Cost per Acre ($)	Materials/ Ingredients	Amount per Acre	Price per Unit ($)	Cost per Acre ($)
WINTER-EARLY SPRING – Spray Program #1												
# of Applications	1				1				1			
Psyllid Control	Temik 15G	33 lbs.	3.20	105.60	Temik 15G	33 lbs.	3.20	105.60	Temik 15G	33 lbs.	3.20	105.60
Psyllid Control (Yng.)	Admire 2F	0 oz.	4.06	–	Admire 2F	0 oz.	4.06	–	Admire 2F	0 oz.	4.06	–
Total Material Costs				105.60				105.60				105.60
	Temik Application	1 acre		13.03	Temik Application	1 acre		13.03	Temik Application	1 acre		13.03
Young Tree Drench	Hand-Gun Sprayer	2 hours/acre		0.00	Hand-Gun Sprayer	2 hours/acre		0.00	Hand-Gun Sprayer	2hours/ace		0.00
Total Cost Per Application				118.63				118.63				118.63
TOTAL COSTS - Spray #1				118.63				118.63				118.63
SPRING-POST BLOOM – Spray Program #2												
# of Applications	1				0				1			
	Spray Oil (97+%)	3 gals.	2.21	6.63	Spray Oil (97+%)	3 gals.	2.21	6.63	Spray Oil (97+%)	3 gals.	2.21	6.63
	Basic Copper (53%)	4 lbs.	1.40	5.60	Basic Copper (53%)	4 lbs.	1.40	5.60	Basic Copper (53%)	4 lbs.	1.40	5.60
Total Material Costs				12.23				12.23				12.23
	PTO-125	125 gals.		23.93	PTO-125	125 gals.		23.93	PTO-125	125 gals.		23.93
Total Cost Per Application				36.16				36.16				36.16
TOTAL COSTS - Spray #2				36.16				0.00				36.16
SPRING-POST BLOOM – Spray Program #3												
# of Applications	1				1				1			
	Lorsban 4EC	5 pts.	4.27	21.34	Lorsban 4EC	5 pts.	4.27	21.34	Lorsban 4EC	5 pts.	4.27	21.34
	Basic Copper (53%)	4 lbs.	1.40	5.60	Basic Copper (53%)	4 lbs.	1.40	5.60	Basic Copper (53%)	4 lbs.	1.40	5.60
	Zn (Zinc)	3 lbs.	0.83	2.49	Zn (Zinc)	3 lbs.	0.83	2.49	Zn (Zinc)	3 lbs.	0.83	2.49
	Mn (Manganese)	3 lbs.	0.32	0.96	Mn (Manganese)	3 lbs.	0.32	0.96	Mn (Manganese)	3 lbs.	0.32	0.96
	B (Borates)	0.25 lb.	0.70	0.18	B (Borates)	0.25 lb.	0.70	0.18	B (Borates)	0.25 lb.	0.70	0.18
Total Material Costs				30.57				30.57				30.57
	PTO-125	125 gals.		23.93	PTO-125	125 gals.		23.93	PTO-125	125 gal.s		23.93
Total Cost Per Application				54.50				54.50				54.50
TOTAL COSTS - Spray #3				54.50				54.50				54.50
SPRING-POST BLOOM – Spray Program #4												
# of Applications	0				0				2			
	Micromite 80WG	1.25 pts.	10.99	13.74	Micromite 25 WP	1.25 lbs.	9.05	11.31	Micromite 25 WP	0 lbs.	9.05	–
	Basic Copper (53%)	7 lbs.	1.40	9.80	Basic Copper (53%)	7 lbs.	1.40	9.80	Basic Copper (53%)	4 lbs.	1.40	5.60
Total Material Costs				23.54				21.11				5.60
	PTO-125	125 gals.		23.93	PTO-125	125 gals.		23.93	PTO-125	125 gals.		23.93
Total Cost Per Application				47.47				45.04				29.53
TOTAL COSTS - Spray #4				0.00				0.00				59.06
SUMMER – Spray Program #5												
# of Applications	0				0				1			
	Abound	15 oz.	1.70	25.56	Abound	15 oz.	1.70	25.56	Abound	15 oz.	1.70	25.56
(if no mite resistance)	Agrimek	10 oz.	4.40	44.03	Agrimek	10 oz.	4.40	44.03	Arimek	10 oz.	4.40	44.03
	Spray Oil (97+%)	5 gal.s	2.21	11.05	Spray Oil (97+%)	5 gals.	2.21	11.05	Spray Oil (97+%)	5 gals.	2.21	11.05
Total Material Costs				80.64				80.64				80.64
	PTO-250	250 gals.		28.50	PTO-250	250 gals.		28.50	PTO-250	250 gals.		28.50
Total Cost Per Application				109.14				109.14				109.14
TOTAL COSTS - Spray #5				0.00				0.00				109.14
SUMMER – Spray Program #6												
# of Applications	1				1				1			
	Basic Copper (53%)	7 lbs.	1.40	9.80	Basic Copper (53%)	7 lbs.	1.40	9.80	Basic Copper (53%)	7 lbs.	1.40	9.80
	Spray Oil (97+%)	5 gals.	2.21	11.05	Spray Oil (97+%)	5 gals	2.21	11.05	Spray Oil (97+%)	5 gals.	2.21	11.05
Total Material Costs				20.85				20.85				20.85
	PTO-250	250 gals.		28.50	PTO-250	250 gals.		28.50	PTO-250	250 gals.		28.50
Total Cost Per Application				49.35				49.35				49.35
TOTAL COSTS - Spray #6				49.35				49.35				49.35
SUMMER – Spray Program #7												
# of Applications	1				1				1			
	Spray Oil (97+%)	5 gals.	2.21	11.05	Spray Oil (97+%)	5 gals.	2.21	11.05	Spray Oil (97+%)	5 gals.	2.21	11.05
	Basic Copper (53%)	7 lbs.	1.40	9.80	Basic Copper (53%)	7 lbs.	1.40	9.80	Basic Copper (53%)	7 lbs.	1.40	9.80
	Lorsban 4EC	5 pts.	4.27	21.34	Lorsban 4EC	5 pts.	4.27	21.34	Lorsban 4EC	5 pts.	4.27	21.34
	Mn (Manganese)	0 lbs.	0.32	–	Mn (Manganese	0 lbs.	0.32	–	Mn (Manganese)	0 lbs.	0.32	–
	B (Borates)	0 lbs.	0.70	–	B (Borates)	0 lbs.	0.70	–	B (Borates)	0 lbs.	0.70	–
Total Material Costs				42.19				42.19				42.19
	PTO-250	250 gals.		28.50	PTO-250	250 gals.		28.50	PTO-250	250 gals.		28.50
Total Cost Per Application				70.69				70.69				70.69
TOTAL COSTS - Spray #7				70.69				70.69				70.69
FALL – Spray Program #8												
# of Applications	1				1				1			
	Danitol	1 pt.	18.45	18.45	Danitol	1 pt.	18.45	18.45	Danitol	1 pt.	18.45	18.45
	PTO-125	125 gals.		23.93	PTO-125	125 gals.		23.93	PTO-125	125 gals.		23.93
Total Cost Per Application				42.38				42.38				42.38
TOTAL COSTS - Spray #8				42.38				42.38				42.38
TOTAL SPRAY PROGRAM COSTS				**371.71**				**335.55**				**539.91**

Table A-13. Other disease costs.

Item	Canker			Greening			Greening & Canker		
	Hamlin	Valencia	Grapefruit	Hamlin	Valencia	Grapefruit	Hamlin	Valencia	Grapefruit
	- - - - - - - - - - - - - - - - $ per acre - - - - - - - - - - - - - - - -								
Mandatory cirus canker decontamination costs	27.72	27.72	27.72	27.72	27.72	27.72	27.72	27.72	27.72
Field Inspections	17.52	17.52	17.52	35.04	35.04	35.04	35.04	35.04	35.04
Establish windbreak & maintenance (for canker)	0.00	0.00	11.47	0.00	0.00	11.47	0.00	0.00	11.47
DPI fresh market citrus canker certification costs	0.00	0.00	60.0	0.00	0.00	60.00	0.00	0.00	60.00
DPI fresh market packinghouse certification	0.00	0.00	40.50	0.00	0.00	40.50	0.00	0.00	40.50
Water drainage tax	0.00	0.00	60.00	0.00	0.00	60.00	0.00	0.00	60.00
TOTAL	45.24	45.24	217.20	62.76	62.76	234.72	62.76	62.76	234.72

Appendix B
Models Used To Examine Impacts on the Florida Citrus Industry

The models used to examine how citrus canker, greening, land development and cost increases may impact the Florida citrus industry are discussed in this appendix. These factors mainly impact supply, but impacts on demand may also occur through loss of some export and domestic markets (e.g., Europe, California, Texas and Arizona, where citrus is produced locally, could bar imports from areas where canker is present). On the supply side, canker, greening and use of citrus lands for residential and commercial development could significantly reduce Florida citrus production. Living with canker and greening can also be expected to result in higher costs as additional resources will be required to minimize and manage these diseases. Increases in citrus land values resulting from demand for land for development would also impact grower costs. The models here focus on supply and demand changes and the price environment that may occur as a result of the above factors.

Orange-Juice Model

A model for orange juice (OJ), the largest revenue-producing citrus product in Florida, is discussed first, followed by a model for grapefruit. The OJ model is comprised of general relationships between OJ supply, demand and prices in the world. Econometric estimates of these relationships are then used to simulate the model.

Conceptual Model

Let Q(p, t) and q(p, t) be world OJ supply and demand, respectively, where t is time and p is the Florida FOB price for bulk FCOJ. In this model, the Florida FOB price p is used as an approximation of the world price, based on the relatively high correlation between this FOB price and other world OJ prices over time.[13] The variable t is used to indicate changes over time in supply and demand (price constant). Supply may change due to say canker, greening, hurricanes, and use of citrus acreage for alternative uses; while, demand may change due to perhaps consumer income growth, advertising and enhanced preferences.

In equilibrium, price is at a level such that supply equals demand, i.e,

(1) $Q(p, t) = q(p, t)$.

An important part of the model is how changes in supply and demand impact price. If supply Q grows faster than demand q, price p will tend to decrease and vice versa; if supply and demand change by the same amount, price will tend to remain constant. These price tendencies can be formalized by totally differentiating equation (1) and solving for the price change dp (d before a variable is used to indicate a change in that variable; in this case, $dp_t = p_t - p_{t-1}$, where time subscripts have been added), i.e.,

(2) $(\partial Q/\partial p)dp + (\partial Q/\partial t)dt = (\partial q/\partial p)dp + (\partial q/\partial t)dt$

or, rearranging terms,

---

[13] The market for OJ is comprised of a number of differentiated products. OJ is differentiated by product form (FCOJ and NFC) and attributes including ratio, color and viscousity. In principle, separate demands for each differentiated product could be specified as a function of the product’s (own) price and the (cross) prices of all the other differentiated OJ products, as well as other variables such as prices of other goods and consumer income. However, given these OJ products are close substitutes, their prices tend to be highly correlated (multicollinear), and estimation of separate own and cross-price parameters is problematic. Thus, based on the high correlation of prices, OJ is modeled here as a single product with one price as an approximation.

(3) $dp = [(\partial q/\partial t)dt - (\partial Q/\partial t)dt] / (\partial Q/\partial p - \partial q/\partial p)$.

The supply slope is positive or $\partial Q/\partial p > 0$; the demand slope is negative or $\partial q/\partial p < 0$; thus the denominator of equation (3) is positive or $(\partial Q/\partial p - \partial q/\partial p) > 0$. If demand and/or supply grows, contracts or is unchanged, the terms $(\partial q/\partial t)dt$ and/or $(\partial Q/\partial t)dt$ would be positive, negative or zero, respectively. The strengths of these supply and demand changes determine the price change. For example, if there is no change in demand, so that $(\partial q/\partial t)dt = 0$, and supply grows or $(\partial Q/\partial t)dt > 0$, then price will fall, $dp < 0$, according to equation (3). Thus, with growth in supply, growth in demand is needed to prevent price from decreasing.

OJ Supply

World OJ supply in a given year is specified as

(a) beginning OJ inventories in Florida (Florida Citrus Processors Association or FCPA) plus

(b) beginning OJ inventories in Brazil (USDA) plus

(c) Florida OJ production plus

(d) other U.S. OJ production plus

(e) Brazil OJ production plus

(f) rest-of-the-world (ROW) OJ production.

Beginning inventories are predetermined based on previous season supply and demand. Florida OJ production is based on the Florida orange crop which is determined based on Florida bearing orange acreage times boxes of fruit per acre, by tree age (Florida Agricultural Statistics Service or FASS). The part of the model for Florida orange production is an extension of a model used by the Florida Department of Citrus (FDOC) to project production; see “Florida Citrus Production Trends, 2005-06 Through 2014-15,” for discussion of this model. Acreage,

yield and orange production estimates are disaggregated by early and midseason oranges and Valencia oranges. The initial acreage, upon which the future production projections depend, is based on the bearing trees reported by FASS for the 2005-06 season. The bearing acreage in 2006-07 is the surviving 2005-06 bearing acreage plus surviving acreage planted in 2003 (the maturation of non-bearing two year old trees to bearing three year old trees). Acreage in subsequent years is similarly, recursively determined. Acreage losses due to canker, greening, hurricanes and development enter the model through assumed loss rates used in projecting the acreage forward through time. (Cost increases due to these factors also enter the model through planting equations, as subsequently discussed.) Additionally, yields per acre are dependent on assumed acreage infected with canker. For infected acreage, yields for early and midseason oranges and Valencia oranges are assumed to decrease by 10% and 5%, respectively. Yields are also adjusted for the possibility of hurricane losses. Average yields from 1993-94 through 2003-04 are used to represent yields in non-hurricane seasons, while yields in the hurricane-impacted season of 2004-05 are used to represent yields in future hurricane-impacted seasons. For example, if the probability of a future hurricane is set at 10%, the future yields used in the simulation are weighted averages, calculated as 90% of the non-hurricane yields plus 10% of the hurricane yields.

Florida orange planting equations for early and midseason oranges and Valencia oranges were estimated and used in the model to determine acres planted. The planting equations link prices to future supply. The general planting specification for both varieties of oranges used is

(4) $n_t = a+b*p^e_{f,t}$

where n_t is the number of acres planted, $p^e_{f,t}$ is the expected futures price for FCOJ at time t, and a and b are estimated (positive) parameters. An adaptive expectations specification was used to

model the expected price: $p^e_{f,t} = \lambda * p_{f,t-1} + (1-\lambda) * p^e_{f,t-1}$, where $p_{f,t-1}$ is the actual futures price at time t-1, deflated by the consumer price index (CPI), and λ is a parameter between zero and one, estimated at .73 here.

The impacts on planting levels due to cost changes such as the increase in the cost of citrus land related to the demand for land for development are considered by adjusting the intercept in equation (4). It is assumed that the expected delivered-in price differs from the expected futures price by a constant, i.e., $p^e_d = a_1 + p^e_f$, where p^e_d is the expected delivered-in price and a_1 is the constant. An expected net grower price is specified as $p^e_n = p^e_d - c$, where c represents costs. Hence, through substitution, $p^e_n = a_1 + p^e_f - c$. Using this result, the planting equation can also be written as

$$n_t = a_0 + b * p^e_{n,t}$$

or

$$n_t = a_0 + b * (a_1 + p^e_{f,t} - c_t)$$

or

$$n_t = a + b * p^e_{f,t},$$

where

$$a = (a_0 + b * a_1 - b * c_t).$$

The above result implies that if costs change by dc, then the intercept a changes by the amount -b*dc; thus, given b is positive, an increase in costs results in a decline in the planting level of b*dc. Equation (4) is incorporated into the model in difference form:

$$(n_t - n_{t-1}) = b * (p^e_{f,t} - p^e_{f,t-1}) - b * (c_t - c_{t-1})$$

or

$$n_t = n_{t-1} + b * (p^e_{f,t} - p^e_{f,t-1}) - b * (c_t - c_{t-1}).$$

Processed orange utilization is estimated as boxes of Florida oranges produced, as determined above, minus an assumed fresh utilization level (certified and noncertified) of 9 million boxes. An average juice yield per box is then applied to the processed orange utilization estimate to obtain OJ production. Additionally, OJ production from specialty citrus production is estimated by multiplying an average specialty processed utilization rate times specialty citrus production times the average juice yield. Specialty citrus production is assumed to follow the same trend as orange production over the projection period.

Other U.S. OJ production is set at the average level over the five year period from 2000-01 through 2004-05, while ROW OJ production is based on data reported in "Citrus Fruit, Processed and Fresh, Annual Statistics 2003," CCP:CI/ST/2003, by the Food and Agricultural Organization (FAO) of the United Nations. In the model, ROW OJ production is assumed to grow by 1% annually.

Brazil's OJ production is estimated similarly as Florida's. São Paulo's bearing and non-bearing trees (USDA) are projected forward based on an assumed tree-loss rate and planting equation. São Paulo orange production is then estimated as the projected bearing trees times an average yield per tree. São Paulo processed orange boxes are estimated as production minus an assumed fresh utilization level held constant over the projection period. São Paulo OJ production is then estimated as processed orange boxes times an average juice yield. OJ production in Brazil outside of São Paulo is estimated as constant, based on recent levels.

The planting equation for São Paulo is

(5) $$n_{b,t} = e + f*p^{e}_{fs,t}$$

where $n_{b,t}$ is the number of trees planted, $p^{e}_{fs,t}$ is an expected price ratio, the FCOJ futures price divided by the Brazil sugar price, and e and f are estimated parameters. As in the Florida

planting equation above, an adaptive expectations specification was used to model the expected price variable.

Growing sugarcane is an important alternative land use for citrus acreage in Brazil. About half of Brazil's sugarcane is used in producing ethanol. Recent energy price increases have resulted in increases in demand for ethanol, which, in turn, has resulted in increases in ethanol and sugar prices, making sugarcane production more profitable. Based on industry reports, 14 new ethanol refineries will come into operation in Brazil in the upcoming year, in addition to about 50 refineries presently being operated there. The New York futures price for sugar is about $.08 per pound (1/24/2006) or about 80% greater than the 2005 level.

Based on estimates of the above supply components, season-to-season changes in aggregate OJ supply, $(\partial Q/\partial t)dt$ in equation (3), can the be determined. To obtain an estimate of the price change (dp), estimates are needed of the change in world demand with prices constant or $(\partial q/\partial t)dt$, and the world demand slope or $\partial q/\partial p$.

For season-to-season changes, the supply slope, $\partial Q/\partial p$, is assumed to be zero; in the long-run this slope is positive based on planting equations (4) and (5). It takes about three years for a newly planted tree to produce oranges for commercial use. Thus, even though the current price, as well as past prices, impact current planting levels in the model, because of the lag between the planting year and the year in which the newly planted trees bear fruit, the current price does not impact current production in the model. Thus, based on equation (3), the season-to-season change in the price of OJ is calculated as

$$dp = [(\partial Q/\partial t)dt - (\partial q/\partial t)dt] / (\partial q/\partial p). \quad (6)$$

The numerator of this equation indicates excess supply, excess demand or neutral supply and demand shifts, when its sign is positive, negative or zero, respectively. The inverse of the term $\partial q/\partial p$ or $\partial p/\partial q$ transforms the excess supply or demand into a price change.

OJ Demand

Demand growth rates are assumed to determine the volume (gallon) change in world demand, $(\partial q/\partial t)dt$. In the model, world demand is disaggregated into five components. Each of these components, along with a baseline demand growth assumption, is shown below.

U.S. OJ consumption: 1%

U.S. OJ exports: 1%

ROW consumption: 2%

Florida ending OJ inventory: 1%

Brazil ending OJ inventory: 1%

For each component, the growth rate times the previous period demand component level yields an estimate of the volume growth in demand for the component. The sum of these component volumes provides an estimate of $(\partial q/\partial t)dt$.

The last term needed to determine the price change, equation (6), is the world demand slope $\partial q/\partial p$. This term is calculated as the sum of the FOB price slopes for the five world OJ demand components above. World demand can be written as

(7) $q = \sum_{i = 1 \text{ to } 5} q_i (p_i, t),$

where i stands for a component; and $p_i = p + m_i$ or the FOB price for component i, with m_i being the margin between the Florida FOB price p and the FOB price for component i. Differentiating world demand with respect to price p results in $\partial q/\partial p = \sum_{i = 1 \text{ to } 5} \partial q_i/\partial p_i$. The component

quantity-price slopes ($\partial q_i/\partial p_i$) are based on previous research ("Generic Promotions of Florida Citrus," prepared by a Panel of Economists, appointed by the Florida Citrus Commission, Lakeland, Florida; "The Free Trade Area of the Americas and the Market for Processed Orange Products," by T. Spreen, C. Brewster and M. Brown; and "Impacts on U.S. prices of Reducing Orange Juice Tariffs in World Markets," by M. Brown, T. Spreen and J. Lee) and recent preliminary demand estimates. The estimated FOB price elasticities for U.S. OJ consumption, U.S. OJ exports and ROW OJ demand are -.34, -.66 and -.40, respectively. The Florida and Brazil inventory elasticities were estimated at -.56 and -.88, respectively. The five elasticities, defined by $\epsilon_i = (\partial q_i/\partial p_i)(p_i/q_i)$, were transformed to quantity-price slopes based on the relationship $\epsilon_i *(q_i/p_i) = (\partial q_i/\partial p_i)$.

The price based on equation (6) is such that world demand exactly equals world supply. The demand level for each component is calculated based on the differential of the component's demand, i.e., $dq_i = (\partial q_i/\partial p_i)dp + (\partial q_i/\partial t)dt$, or $q_{i,t} = q_{i,t-1} + (\partial q_i/\partial p_i)dp + (\partial q_i/\partial t)dt$. That is, the current-period component demand is the pervious-period component demand plus the component demand slope times the price change from equation (6) plus the assumed volume growth rate for the component times the previous component demand volume.

U.S. Advertising Goals

The above model can also be used to examine the goal of growing U.S. consumption of OJ by some rate, say r%, in face of restricted supplies. Breaking out individual demand components, and setting $\partial Q/\partial p = 0$ for the short run as discussed above with respect to equation (6), aggregate world supply and demand, equation (2), can be written as

(8) $$(\partial Q/\partial t)dt = (\textstyle\sum_{i = 1 \text{ to } 5} \partial q_i/\partial p_i)dp + \sum_{i = 1 \text{ to } 5} (\partial q_i/\partial t)dt$$

or, further breaking out U.S. demand (i=1), as

(9) $(\partial Q/\partial t)dt = (\partial q_1/\partial p_1)dp + (\partial q_1/\partial t)dt + (\sum_{i = 2 \text{ to } 5} \partial q_i/\partial p_i)dp + \sum_{i = 2 \text{ to } 5} (\partial q_i/\partial t)dt.$

The first two terms on the right hand side comprise the change in U.S. demand, i.e., $dq_1 = (\partial q_1/\partial p_1)dp + (\partial q_1/\partial t)dt$. For the goal of an increase in U.S. consumption of r percent, this change can be written as

(10) $dq_1 = r\ q_{1,t-1}$

or

(11) $r\ q_{1,t-1} = (\partial q_1/\partial p_1)dp + (\partial q_1/\partial t)dt,$

or, solving for the growth term,

(12) $(\partial q_1/\partial t)dt = r\ q_{1,t-1} - (\partial q_1/\partial p_1)dp.$

The term $(\partial q_1/\partial t)dt$, in general, indicates a change in demand, prices constant, and, although many factors including changes in income and consumer preferences could underlie this term, it is assumed here to reflect the impact of advertising.

Thus, based on equation (12), the impact of advertising required to ensure an increase in U.S. consumption of r percent can be determined given lagged consumption $q_{1,t-1}$, the U.S. demand slope $\partial q_1/\partial p_1$ and the change in price (dp).

The change in price for this case is found by substituting the left hand side term of equation (11) for the first two terms on the right hand side of equilibrium condition (9), i.e.,

(13) $(\partial Q/\partial t)dt = r\ q_{1,t-1} + (\sum_{i = 2 \text{ to } 5} \partial q_i/\partial p_i)\ dp + \sum_{i = 2 \text{ to } 5} (\partial q_i/\partial t)dt,$

or, solving for the change in price,

(14) $dp = (\ (\partial Q/\partial t)dt - r\ q_{1,t-1} - \sum_{i = 2 \text{ to } 5} (\partial q_i/\partial t)dt\ ) / (\sum_{i = 2 \text{ to } 5} \partial q_i/\partial p_i).$

Result (14) is similar to equation (6) for the unrestricted case, except the growth rate in U.S. consumption is set at r and the world slope, the denominator on the right-hand-side of equation (14), excludes the U.S. component $\partial q_1/\partial p_1$.

Thus, for a growth rate in U.S. consumption of r percent, the change in price is determined according to equation (14) which, in turn, is used in equation (12) to find the impact of advertising to achieve this result.

In elasticity form, equation (12) can be written as—divide both side of equation (12) by q_1 and multiply and divide dp by p where $p = p_1$

(15) $(\partial q_1/\partial t)(1/q_{1,t-1})\, dt = r\, q_{1,t-1}/q_{1,t-1} - (\partial q_1/\partial p_1)(p_1/q_1)\, dp/p$

or

(16) $g = r - \epsilon_p\, dp/p$,

where $g = (\partial q_1/\partial t)(1/q_1)dt$ or the percentage increase in U.S. demand due to advertising and $\epsilon_p = (\partial q_1/\partial p_1)(p_1/q_1)$ is the U.S. price elasticity. Thus, for example, if supplies are constrained $((\partial Q/\partial t)dt < 0)$ and price increases by 10% (dp/p) according to equation (14), the price elasticity is -.34, and the goal is for U.S. consumption to grow by 1% (r), then the growth in demand required is g = 1% + (.34) 10% = 4.4%, based on equation (16).

Grapefruit Model

The model for grapefruit is similar to that for OJ except that it includes parts for both fresh grapefruit and grapefruit juice (GJ), given the relative importance of these two products. The model also focuses on Florida given that historically Florida has been the dominant producer of grapefruit in the world. To the extent reductions in Florida grapefruit occur, however, this dominance will decline. Other suppliers are included in the analysis through assumptions on

U.S. imports — historical import levels of grapefruit products have been largely insignificant, making it difficult to estimate reliable import supply relationships.

Conceptual Model

Florida grapefruit production is projected in upcoming years, following the same approach used to project orange production as discussed above. Grapefruit acres, by tree age, are projected through time based on assumed acre-loss rates and a planting equation; and yields per acre, by tree age, are applied to the projected bearing acres to obtain production estimates. Diseases and development are assumed to impact loss rates and yields. Canker is assumed to reduce yields of infected acres by 10%.

Grapefruit production is allocated to fresh (certified and noncertified) and processed utilization, assuming fresh grapefruit pack-out rates (40% for white grapefruit and 60% for red grapefruit). Florida GJ production is obtained by applying an average juice yield to the boxes allocated to processing. The price of GJ is based on the estimate of GJ production plus beginning GJ inventory, along with GJ demand growth assumptions and GJ price elasticities. Noncertified fresh utilization is assumed to be constant based on recent levels. Certified fresh utilization along with fresh grapefruit demand growth assumptions and fresh grapefruit price elasticities are used to estimate the fresh grapefruit FOB price. An overall grapefruit on-tree price is calculated, based on the above fresh FOB and GJ price estimates, and used to determine planting levels.

Fresh Grapefruit Price

The FOB fresh grapefruit price is set so that the demand for Florida fresh grapefruit equals Florida certified fresh utilization, i.e.,

(17) $Q_t = \alpha * p_t^{\epsilon} * e^{r*t}$,

where now Q is Florida certified fresh utilization (supply), $\alpha * p_t^{\epsilon} * e^{r*t}$ is demand, p is the fresh grapefruit FOB price, ϵ is a domestic-export weighted-average price elasticity (Lee (2004); Brown (2004); Brown and Lee (2002)), r is an assumed growth rate with price constant, and α is a constant (e is the natural logarithm base and approximately equals 2.718).

An equation to estimate the fresh FOB price can be obtained by dividing equation (17) by its lag, i.e.,

(18) $Q_t / Q_{t-1} = (\alpha * p_t^{\epsilon} * e^{r*t}) / (\alpha * p_{t-1}^{\epsilon} * e^{r*(t-1)})$

or, solving for p_t

(19) $p_t = p_{t-1} * ((Q_t / Q_{t-1}) / e^r)^{(1/\epsilon)}$.

Equation (19) is the log version of price equation (6), and the previous discussion on excess supply, excess demand and price responses continues to be applicable, but in terms of percentage changes.

In the base simulations, the growth rate r is assumed to be zero (no growth in domestic and export demands), while the weighted average price elasticity is about -.9.

GJ Price

The GJ price is determined following the same general approach to estimate the OJ price. This approach is summarized by equation (6) which is repeated below with new variable definitions specific to the GJ situation.

(20) $dp = [(\partial Q/\partial t)dt - (\partial q/\partial t)dt] / (\partial q/\partial p)$,

where now p is the FOB price for GJ (the white GJ price is used to measure the GJ price); Q is total availability of GJ, calculated as predetermined beginning Florida GJ inventory plus projected Florida GJ production for the season in question as discussed above plus assumed imports, set at a relatively low level of 2 million SSE gallons per year over the projection period; $(\partial q/\partial t)dt$ is the assumed domestic-export growth in GJ demand, price constant; and $(\partial q/\partial p)$ is a slope for overall GJ demand (domestic movement and exports) based on a weighted average elasticity for these demand components using FDOC elasticity estimates by market (inventories are held at 25 weeks of supply). In the base simulations, the growth rate underlying $(\partial q/\partial t)dt$ is set at zero (no growth in domestic and export demands).

Grapefruit Planting Equation

The Florida grapefruit planting equation is similar to that for Florida oranges, equation (4), except for re-interpretation of the variables. Separate planting equations were estimated for white and red grapefruit. As for oranges, the grapefruit planting equations link prices to future supply. The general planting specification is repeated below followed by new variable definitions:

(21) $n_t = a+b*p^e_t$

where now n_t is the number of white or red grapefruit acres planted; p^e_t is the expected white or red on-tree returns or price per acre, based on the fresh FOB and GJ price estimates discussed above, and a and b are estimated grapefruit-variety-specific (positive) parameters. An adaptive expectations specification was again used to model the expected grapefruit prices; see discussion following equation (4) for the general specification.

Qualifications to Recognize the Uncertainty of the Future

The models above are, of course, a simplification of the real world. Some simplification is necessary to examine the economic complexity underlying the Florida citrus industry. The focus has been on variables considered to be important for the future of the industry. Nevertheless, it is difficult to predict the course that some explanatory variables may take, and estimated relationships may change over time. Additionally, variables that may seem insignificant today and left out of the analysis may become major factors tomorrow.

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