The Feasibility of Including Citrus Greening as a Cause of Loss under Florida Fruit Tree Insurance Program

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Table of Contents

Section I. Executive Summary 1
Section II. Introduction and Overview 4
Section III. Quantitative Risk Assessment 20
Section IV. Citrus Greening Prevention and Eradication Strategies 25
Section V. Citrus Industry Impact Assessment 34
Section VI. Insurance Risk and Mitigation Strategy Assessment 44
Section VII. Feasibility Recommendations 48
Section VIII. Bibliography 53

List of Tables

Table 1. Florida Fruit Tree Citrus Insurance Policies Earning Premium by Variety 1996-2008 ... 6
Table 2. Florida Fruit Tree Insurance Citrus Liability by Variety 1996-2008 7
Table 3. Florida Fruit Tree Citrus Insurance Liability by Variety 1996-2008 7
Table 4. Commercial Florida Acreage 1996-2008 9
Table 5. Changes in Commercial Florida Acreage 1996-2008 9

List of Figures

Figure 1. Transmission Electron Micrograph of *Candidatus* Liberibacter *asiaticus*, Within a Citrus Phloem Sieve Tube 14
Figure 2. Orange Fruits Affected by Citrus Greening 17
Figure 3. Time-course of Development of HLB-symptomatic Populations in Five Florida Orange Production Units during Seven Scouting Cycles 24
Figure 4. Symptomatic and Asymptomatic Trees in Five HLB-infected Blocks in South Florida Showing Infected Trees [PCR(+)] That Are Asymptomatic [Visual(-)] 29
Figure 5. Map Illustrating Areas Potentially Affected by HLB in 2009, HLB-positive Sections, and HLB-positive Counties (inset) 38
Figure 6. Time Course of the Spread of HLB Symptoms in a Taiwanese Citrus Block in an Orchard Planted with Disease-free Stock 40
Figure 7. Time Course of the Spread of HLB Symptoms in Two Florida Citrus Blocks in Five Scounting Cyles over Two Years 41

List of Appendices

Appendix A. Florida Fruit Tree Policy Insurance Experience
Exhibit 1. Historical Experience for Citrus in the Florida Fruit Tree Program
Exhibit 2. 2008 County Level Participation for Citrus in the Florida Fruit Tree Program
Appendix B. APHIS New Pest Response Guidelines: Citrus Greening Disease
Appendix C. DOACS DPI Asiatic Citrus Canker Control Regulations
Appendix D. Citrus Health Response Plan (CHRP), State of Florida, 2006-2007

SECTION I. EXECUTIVE SUMMARY

Citrus Huanglongbing (HLB), also called Citrus Greening disease, is a bacterial disease that is devastating to commercial citrus production. The disease is carried from tree to tree by tiny insects now found in most citrus producing regions around the world. As a result of the prevalence of this vector, HLB is considered a significant threat to commercial citrus production in North America. While HLB infections were not identified in the U.S. until 2005, infections are now common throughout Florida and the industry is mobilizing to deal with the disease.

This report provides an evaluation of the feasibility for Federal Crop Insurance Corporation insurance to play a role in that response. The feasibility study includes a review of the current science concerning the disease; assessments of potential future courses of the disease and mitigation strategies; and a report on the potential impact of HLB on the industry. To the extent possible, an assessment of the potential insurance risks of incorporating HLB as a cause of loss for the FFT insurance policy is provided, and the potential impacts of this inclusion on rating for the FFT insurance are discussed. Finally, a recommendation concerning the feasibility of including HLB as a cause of loss under the policy is presented.

Few data are available to quantify the risks associated with HLB. The disease effects are dramatic and the spread of the disease is rapid. Producers and grove managers dealing with HLB appropriately address more of their energy to crop management practices than to data collection documenting those practices. When data are collected, the types of data collected and data collection protocols vary substantially from grove to grove and from time to time. Most data are from mid-sized to larger operations, and even those datasets rarely cover more than two years of experience. However, smaller operations (fewer than 50 acres) represent almost 70 percent of the units insured under the FFT program. Small groves, abandoned groves, and dooryard production provides substantial pools of inocula that can contribute to the spread of HLB to groves of all sizes.

The FFT policy is essentially a “life insurance” policy for the citrus grove “stock.” To evaluate the risks to the survival of productive citrus trees inherent in HLB, both the frequency of infections and the severity of losses due to infection must be quantified and assessed. There are data to support the contention that the causative agent of HLB is endemic throughout the citrus production regions of Florida. There is a general belief that there are at least as many infected but asymptomatic infected trees in a grove as there are symptomatic trees, with some data to support the contention. The presence of infected, asymptomatic trees means management practices will affect how often new symptomatic trees are observed within a grove.[1] Consequently, a precise determination of frequency for the effects of HLB is challenging.

There are also observations from which the severity of the risk can be inferred. On the one hand, once a tree shows the typical HLB blotchy chlorosis, the productive life of the tree is limited to about three additional years. Best management practices for the long term (as opposed to practices to maximize short term yields) may require removal of trees as soon as the scouts have identified symptoms of HLB. This effectively shortens the life of symptomatic trees to less than a year. There is also the possibility the potential useful life of a grove will drop from

[1] Groves managed aggressively appear to have a lower frequency of new infections than groves managed less aggressively.

approximately 50 years to 15 to 20 years. Under this scenario, the life expectancy has been shortened by more than two thirds of the life expectancy prior to the HLB epidemic.

The causative agent of HLB has been studied extensively. It is a bacteria believed to be in the genus Liberibacter. Since the organism has not been grown in isolation, it has not been possible to establish the causation unequivocally. It is possible the infection involves elaborate symbioses that impact latency, severity, and symptoms. Antibiotic treatment may delay the development of symptoms of HLB, but can not cure an infection.

Management involves extensive scouting to identify infected trees, removal of the infected trees, elimination of sprouts developing from roots or stumps remaining in the groves, and frequent pesticide treatments to limit the populations of the vectors. These practices have slowed, but not eliminated the spread of HLB in infected blocks and into uninfected blocks. An unproven alternative management practice has been proposed for more heavily infected groves. These practices require frequent treatment of the trees with a mixture of micronutrients, salicylic acid, and hydrogen peroxide. No systematic studies have been made of this practice, but producers who are facing the choice of using this or pushing their grove are encouraged by the short term responses of infected trees to the treatment.

Aggressive management practices to limit the effects of HLB increase production costs by 30 to 50 percent. With open market prices in Florida currently depressed by large citrus processor inventories, many producers, academics, and grove managers believe that HLB will effect major changes throughout the industry. It is likely that additional economic abandonment of citrus groves will occur, especially for groves where production is not under contract. Groves with substantial HLB symptom levels (i.e., >25 percent) cannot be managed using traditional replacement practices. Consequently, further industry consolidation, and eventually higher farm-level, wholesale, and retail prices for Florida citrus products are anticipated. These changes will inevitably affect the position of Florida, and consequently of the U.S., in the global market for citrus products. The ripple effect of these changes on the entire economy of the state will be enormous.

HLB has already had a substantial impact on the citrus industry in Florida. Most citrus producers in Florida have operated on thin margins over the last 20 years. Freezes, hurricanes, diseases, and the public policies related to disease management have each led to years with substantial yield reductions. In years when citrus yields are higher, market prices are depressed. One effect of these patterns has been a consolidation of the industry, with the departure of both smaller producers and smaller processors.

This feasibility study examines three broad classes of feasibility criteria:

- Acceptability to producers;
- Responsibility to taxpayers; and
- Market neutrality.

While the introduction of HLB as a cause of loss would almost certainly be acceptable to producers, especially if it were available in all citrus producing regions in the country, these minimal criteria for feasibility cannot be satisfied. The status of HLB in Florida creates a situation where offering the insurance would not be responsible to the taxpayer and where the

possibility of unacceptable market effects is great. In light of the limited data, underwriting risks with including HLB as a cause of loss for the FFT program, and the absence of accepted risk mitigation procedures, the Contractor cannot recommend inclusion of HLB as a cause of loss under the FFT policy at the present time. Furthermore, the Contractor can not currently envision an appropriate mechanism to rate the risks associated with HLB during this transitional period for the Florida citrus industry.

The citrus industry in Florida, and most likely throughout the U.S., is facing an inevitable crisis of far-reaching proportions. HLB will cause substantial additional changes in almost every aspect of citrus farm-level practices and finances. Many of these changes will be costly. The timing of the crisis in Florida, on the heels of weather and disease incidents during the early years of this century, catches the Florida citrus industry in a particularly vulnerable situation. The added impact of precipitously declining land values and tight credit markets limits the responses producers can implement to maintain their markets, market shares, and productivity.

The Government should anticipate requests for identification of the HLB as a "natural disaster." A structure other than insurance to address this catastrophe, a structure that cannot be manipulated by the recipient of disaster aid, may need to be identified and implemented. Yet the industry as a whole has been remarkably resilient. The Florida Citrus Commission has approved 115 research projects, funded primarily from grower assessments and taxes on citrus produced in Florida, to address these challenges. Researchers addressing HLB are also funded by Federal grants and private sources. However, these diverse efforts will require years, or perhaps even decades, before they define the next steps of an industry that has been in Florida for centuries. A bridge to this future is required, but tree insurance is not appropriate at this moment as either the foundation or the principal structure of that bridge.

Yet with the financial challenges facing producers and the rapid changes in both the industry and market, it is important to introduce insurance support as soon as it is both feasible and possible. Consequently, the Contractor recommends ongoing monitoring of the citrus industry, HLB, and data availability. At the minimum, the areas monitored should include:

- CHRP Progress Reports;
- Florida data on the progression of the disease;
- Changes in phytosanitary regulations;
- Abandoned Grove Initiative data;
- Research into HLB resistance; and
- NASS and state annual tree and acreage inventories.

As soon as the annual effects of HLB on changes in Florida citrus tree demographics have stabilized, the question of the feasibility of incorporating Citrus Greening into the FFT program should be revisited.

SECTION II. INTRODUCTION AND OVERVIEW

RMA awarded Contract 0409CT21101/0001[2] to support a review of the disease known as Citrus Greening, Citrus Vein Phloem Degeneration (CVPD), dragon's tongue, Huanglongbing (HLB), yellow shoot, and yellow dragon disease, and to support an analysis of the feasibility of including the disease as a cause of loss for the Florida Fruit Tree (FFT) insurance policy. The report on these efforts includes a discussion of the current science concerning the disease; an assessment of potential future courses of the disease, descriptions of available mitigation strategies, and a report on the potential impact of HLB on the industry. The Contractor also provides an assessment of the potential risks of incorporating HLB as a cause of loss for the FFT insurance policy and, to the extent possible, a discussion of the potential impacts of this inclusion on the rates for the FFT insurance. Finally, this report presents a recommendation concerning the feasibility of including HLB as a cause of loss under the existing FFT policy.

RMA first implemented an FFT pilot insurance program for citrus and other tropical fruit trees in five Florida counties for the 1996 crop year. The program provided an indemnity for trees that were damaged or destroyed during the insurance period by weather perils including freeze, wind, and excess moisture. A policy provided a specified dollar amount of insurance coverage per tree (based on the average productive age of trees in the grove, on acreage, and on a coverage level elected by the insured). Changes in loss adjustment procedures for avocado and mango trees, also insurable under the original FFT provisions, resulted in the development of a separate policy for those crops in 1998. For the 2000-2001 crop year, the FFT pilot program for citrus was expanded to include 29 counties.[3] The insurance was also modified to include tree removal "under public order" resulting from infection by or exposure to Asiatic Citrus Canker (ACC) as an insurable cause of loss.

The FFT pilot was substantially modified for the 2007 crop year. Changes included:

- Development of a single policy to cover tropical fruit and citrus trees;
- Changes in the insurance period;
- Clarification in the language addressing coverage for ACC;
- Addition of flooding due to high groundwater levels and freeze coverage for young trees north of Interstate-4 in central Florida under certain circumstances as insurable causes of loss;
- Revision of the tree stage definitions and the method by which they are applied;
- Development of a new damage appraisal method;
- A revised method for determining percent damage;
- Revised prices;
- Revised rates; and
- Two new coverage options:
  - Occurrence Loss Option (OLO), and
  - Comprehensive Tree Value Endorsement (CTVE).

[2] Determining the Feasibility of Citrus Greening as a Cause of Loss under Florida Fruit Tree Insurance Program

[3] Brevard, Broward, Charlotte, Citrus, Collier, De Soto, Glades, Hardee, Hendry, Hernando, Highlands, Hillsborough, Indian River, Lake, Lee, Manatee, Marion, Martin, Miami-Dade, Okeechobee, Orange, Osceola, Palm Beach, Pasco, Polk, Sarasota, Seminole, St. Lucie, and Volusia counties are also covered under the current policy.

The OLO available under the FFT pilot allows an insured to elect additional coverage on the insured trees where premium rates for the option are established. The option applies to all insurable trees of the crop within the county, is continuous, and must be elected on the application by a new insured or through a contract change form by a carryover insured on or before the sales closing date. The OLO is available only if the insured has not elected coverage under the Catastrophic Risk Protection Endorsement (CAT). An indemnity is due under OLO if the amount of insured damage within all stands of damaged trees (SDT) identified as a result of the most recent cause of loss is at least five percent (5%) of the unit value or as specified in the Special Provisions. This option provides coverage for losses resulting from a single event rather than aggregating losses from events occurring throughout the crop year.

The CTVE provides supplemental coverage in addition to the coverage provided by the FFT pilot crop provisions for fruit trees. This endorsement is available to producers who have purchased buy-up insurance. The amount of additional protection is controlled by an applicable reference price establishing a comprehensive maximum value per tree. CTVE coverage is only available for Stage II or Stage III trees, and a CTVE indemnity is paid only for trees considered fully (100 percent) damaged or destroyed. If an insured elects to purchase both the OLO and the CTVE, the OLO will also apply to the CTVE. Under these circumstances, losses to Stage II and Stage III trees resulting from a single insurable event and exceeding five percent (5%) of the unit value are indemnified at the higher CTVE levels.

The pilot program was modified again for the 2008 crop year to exclude removal due to infection by or exposure to ACC as an insurable cause of loss.[4] This change to the insurance responded to a change in the United States Department of Agriculture (USDA) Animal and Plant Health Inspection Service (APHIS) protocol for ACC, eliminating the requirement to destroy trees under public order. Under the revised provisions, the causes of loss are described in Section 10. Causes of Loss as follows:

(a) In accordance with the provisions of section 12 of the Basic Provisions, insurance is provided only against the following causes of loss that occur within the insurance period:
   (1) Freeze;
   (2) Wind;
   (3) Excess moisture;
   (4) Flooding due to high groundwater levels, if allowed by the Special Provisions; and
   (5) Insects, diseases, and other pathogens, as specifically provided by the Special Provisions.

(b) In addition to the causes of loss excluded in section 12 of the Basic Provisions, we will not insure:
   (1) Any trees for flooding due to high groundwater that do not meet the requirements given in the Special Provisions;
   (2) Any stage I citrus trees that, due to freeze, do not meet the requirements, if provided, in the Special Provisions; and
   (3) Against damage other than actual damage to the tree from an insurable cause specified in this section.[5]

[4] United States Department of Agriculture, Risk Management Agency, 2008, Florida Fruit Tree Pilot Crop Insurance Provisions, http://www.rma.usda.gov/pilots/2008/08_0014.pdf, accessed March 2, 2009.
[5] ibid.

A review of the special provisions for the counties in Florida where FFT coverage for citrus is available did not reveal coverage for "insects, diseases, and other pathogens" as allowed under section 10(a)(5). However, coverage for HLB losses, if feasible, could be implemented through this provision with limited impact on the policy language.

Many factors have contributed to the evolution of the tree insurance program, including:

- Rapid changes in the citrus industry in Florida,
- Environmental factors including insects and diseases,
- Producer demand for coverage, and
- Program performance.

During the pilot periods, participation (Tables 1 and 2) and indemnity payments (Table 3) were affected by both the evolution of the policy and specific natural events, including freezes, hurricanes, and diseases, leading to tree losses. Additional elements of the FFT program experience are documented in Appendix A.

Table 1. Florida Fruit Tree Citrus Insurance Policies Earning Premium by Variety 1996-2008

	FFT Policies Earning Premium				
Year	**Orange**	**Grapefruit**	**Lemon**	**Lime**	**All Other Citrus**
1996	428	225		41	205
1997	581	284		48	257
1998	724	289		54	303
1999	748	247		61	308
2000	2,909	916	2	65	899
2001	3,056	933	2	38	924
2002	3,177	898	2	24	913
2003	3,052	804	3	21	878
2004	2,883	706	2	16	803
2005	3,364	825	2	4	834
2006	3,158	750		2	747
2007	2,737	646	2	3	620
2008	2,858	641	2	3	631
2009	2,848	580	2	3	620

Source: CropData, www.cropdata.com, accessed March 18, 2009

Table 2. Florida Fruit Tree Insurance Citrus Liability by Variety 1996-2008

	FFT Plan Liability (dollars)					
Year	Orange	Grapefruit	Lemon	Lime	All Other Citrus	Total
1996	78,575,525	9,919,525		2,105,593	10,704,603	**101,305,246**
1997	95,983,180	9,488,445		2,366,436	11,895,764	**119,733,825**
1998	118,259,477	10,907,202		2,579,004	12,953,587	**144,699,270**
1999	129,908,869	10,363,235		3,035,458	13,122,375	**156,429,937**
2000	543,254,178	102,094,435	929,426	6,852,092	43,744,611	**696,874,742**
2001	668,735,862	110,532,135	1,689,194	4,136,623	45,056,438	**830,150,252**
2002	900,882,950	129,964,879	1,956,975	3,011,031	56,228,614	**1,092,044,449**
2003	878,521,438	116,990,841	2,061,634	1,341,198	52,058,042	**1,050,973,153**
2004	844,754,975	118,115,912	1,956,975	859,878	49,636,036	**1,015,323,776**
2005	956,158,290	125,945,970	2,022,209	83,012	55,442,954	**1,139,652,435**
2006	1,096,278,794	126,519,782		26,179	54,792,296	**1,277,617,051**
2007	994,254,778	128,396,959	1,066,787	5,974	51,690,066	**1,175,414,564**
2008	970,370,727	111,554,947	1,153,283	51,388	52,984,212	**1,136,114,557**
2009	1,169,623,191	131,275,412	1,447,590	62,247	59,815,266	**1,362,223,706**

Source: CropData, www.cropdata.com, accessed March 18, 2009

Table 3. Florida Fruit Tree Citrus Insurance Indemities by Variety 1996-2008

	FFT Plan Indemnity (dollars)					
Year	Orange	Grapefruit	Lemon	Lime	All Other Citrus	Total
1996	1,070	0		0	0	**1,070**
1997	0	0		0	0	**0**
1998	0	0	0	3,569	0	**3,569**
1999	0	0	0	0	0	**0**
2000	1,380,943	1,306,013	0	3,720,637	7,150	**6,414,743**
2001	2,623,860	301,097	0	678,853	55,573	**3,659,383**
2002	1,442,654	75,294	0	1,237,845	0	**2,755,793**
2003	2,087,116	682,641	0	256,410	91,897	**3,118,064**
2004	7,160,232	1,273,849	0	0	404,567	**8,838,648**
2005	76,754,676	19,606,580	12,425	6,186	4,474,898	**100,854,765**
2006	1,498,222	2,100,787	0	0	50,767	**3,649,776**
2007	627,782	2,389,735	0	0	5,759	**3,023,276**
2008	0	0	0	0	0	**0**

Source: CropData, www.cropdata.com, accessed March 18, 2009

The Florida Citrus Industry

Only a small fraction of Florida oranges are sold into the retail fresh fruit market. Instead, fruit from Florida trees supply the vast majority of the U.S. orange juice. Most of the citrus juice

consumed by Americans is produced in Florida. Yet given the rapid spread of HLB, the high mortality, and the lack of effective treatments, Citrus Greening has the potential to devastate citrus production in the U.S. and to have a major impact on the Florida economy.

International trade in fresh citrus fruits began in the 1800s, though at that time most U.S. production was marketed in the U.S. International trade in citrus juices began after bulk juice processing technologies were developed in the late 1940s. Hard freezes in Florida during the 1960s destroyed substantial Florida citrus acreage. In response, citrus production in Brazil (primarily in the state of Saõ Paulo) increased, providing an alternative source of juice for worldwide markets (including those in North America). During the 1980s, Brazil became the largest citrus producer in the world, with an industry focused on orange juice exports.[6] The citrus industry has become more globally integrated since the 1990s. The timing of this globalization has coincided with both a series of substantial weather events affecting Florida citrus production and the globalization of citrus diseases.

Despite declines in acreage and production due to freezes, hurricanes, pests, and disease, the citrus industry remains an important element of the economy in Florida. The Economic and Market Research Department of the Florida Department of Citrus estimates the on-tree value of Florida oranges for the 2007-2008 season was $1,166,000,000, with almost 60 percent of the revenues derived from sales of Valencia oranges and only about 3 percent of the total revenues derived from sales of fresh fruit.[7, 8] There were 59.6 million bearing orange trees in Florida during the 2007-2008 season.[9] Yet this represented 9.6 percent fewer trees than in the 2005-2006 season and a 25.1 percent decline from the bearing tree numbers in 1998-1999. The number of bearing orange trees is currently at the lowest level since1992-1993. In 2007-2008, there were 576,577 acres of all citrus varieties of which 496,518 acres comprise the orange groves in Florida, with 6 percent (6%) of the orange grove acreage populated by non-bearing trees.[10] (Tables 4 and 5)

[6] United Nations Conference on Trade and Development, 2008, InfoComm – Market Information in the Commodities Area: Citrus, http://www.unctad.org/infocomm/anglais/orange/characteristics.htm, accessed March 1, 2009.

[7] Mark G. Brown, The Florida Department of Citrus, Economic and Market Research Department, 2007, Florida Citrus Outlook 2007-08 Season, http://www.floridajuice.com/pdfs/Outlook2007-08-103107.pdf, accessed January 31, 2009.

[8] The 2007 United States Department of Agriculture (USDA) National Agricultural Statistics Service (NASS) Census of Agriculture reported total fruit and nut revenues in Florida of $2,144,718,000,

[9] USDA, NASS, 2008, Commercial Citrus Inventory Citrus Preliminary Report, http://www.nass.usda.gov/Statistics_by_State/Florida/Publications/Citrus/ccipre/ccipr08.pdf.

[10] Florida Department of Citrus, Economic and Market Research Department, 2007, Florida Citrus Production Trends 2008-09 Through 2017-18 Update, http://www.floridajuice.com/user_upload/files/trends20_4769381f2ac7e.pdf, accessed January 15, 2008.

Table 4. Commercial Florida Acreage 1996-2008*

Year	Oranges	Grapefruit	Specialty Fruit	Total
1996	656,598	144,416	56,673	**857,687**
1998	658,390	132,817	54,053	**845,260**
2000	665,529	118,145	48,601	**832,275**
2002	648,806	105,488	43,009	**797,303**
2004	622,821	89,048	36,686	**748,555**
2006	529,241	63,419	28,713	**621,373**
2008	496,518	56,881	23,178	**576,577**

* NASS data for this acreage is reported every second year.

Source: United States Department of Agriculture, National Agricultural Statistics Service, 2008, Commercial Citrus Inventory Preliminary Report, http://www.nass.usda.gov/Statistics_by_State/Florida/Publications/Citrus/ccipre/ccipr08.pdf, accessed March 18, 2009.

Table 5. Changes in Commercial Florida Acreage 1996-2008

	Two Year Change			
Census Year	Gross Loss	New Plantings	Net Change	Total
1994-1996	35,947	39,892	3,945	**857,687**
1996-1998	49,325	36,898	(12,427)	**845,260**
1998-2000	59,541	46,531	(13,010)	**832,250**
2000-2002	77,197	42,225	(34,972)	**797,303**
2002-2004	88,875	40,127	(48,748)	**748,555**
2004-2006	150,805	23,623	(127,182)	**621,373**
2006-2008	66,924	22,128	(44,796)	**576,577**

Source: United States Department of Agriculture, National Agricultural Statistics Service, 2008, Commercial Citrus Inventory Preliminary Report, http://www.nass.usda.gov/Statistics_by_State/Florida/Publications/Citrus/ccipre/ccipr08.pdf, accessed March 18, 2009.

The bearing grapefruit tree populations in Florida for the 2007-2008 season was just 6.0 million trees, down 8.0 percent since 2005-2006 and down 57.6 percent since its peak in 1996-1997. Similar changes were reflected in the grapefruit acreage reports. (Tables 4 and 5) In fact, the number of grapefruit trees is at the lowest level since the late 1960s.[11]

These decreases reflect economic decisions, changes in citrus production practices, and losses attributable to natural events, including various disease. Economic abandonment of citrus production, leading to abandoned groves, results from factors such as "low prices; shortages of labor, transportation, containers, and packing facilities; marketing order decisions affecting size,

[11] ibid.

grade or cullage; and interruptions of the normal market flow."[12] As land prices rise and weather drives the citrus industry further south, production practices have evolved. One substantial change is higher plant density in newly planted blocks. This practice increases production in the block during the early years. It also requires more aggressive thinning/pruning to control tree size as the block matures and aggressive management of diseases and pests.

Crop Insurance Feasibility

The success of this project rests on an understanding of both the HLB-citrus interactions and the criteria used to assess the feasibility of adding Citrus Greening as a cause of loss to the FFT policy. The definition the Contractor used for feasibility for Government subsidized crop insurance, developed during a number of RMA funded feasibility studies, incorporates three classes of feasibility criteria:

- Acceptability to producers;
- Responsibility to taxpayers; and
- Market neutrality.

These classifications together are defining bounds to identify appropriate recommendations for crop insurance development activities in the broadest terms. However, the classifications themselves are not specific criteria that can be weighed and evaluated. Acceptable risk for an amendment to a policy exists when:

- There is enough interest in the insurance for the risk to be spread over an acceptable number of insureds and geographic areas;
- Peril(s) addressed by the amendment are identifiable;
- Effective loss controls for the peril are available;
- An actuarially-sound premium rate addressing all perils can be determined and charged to customers who are willing to pay the price;
- Customers cannot adversely select against the program;
- Moral hazards are avoidable or controllable; and
- The insurance cannot unduly disrupt local, regional, or national markets.

Specific tests of the feasibility of an amendment to a crop insurance policy, as classified and categorized above are as follows:

- The proposed insurance coverage must comply with the restrictions of the Federal Crop Insurance Act, meaning the cause of loss must be due to a natural event beyond the control of the producer.

  Citrus Greening meets this restriction since it results from an infection by a pathogen for which no effective control has been developed. However, the cause of subsequent spread of the disease within a grove is less clear-cut, since certain management actions can slow the progress of the disease once it is identified.
- There must be enough interest for the risk to be spread over an acceptable pool of insureds. An appropriate pool size is also required to address the need for insurance that is responsible to the taxpayer, since a limited pool could face collective catastrophic loss

[12] Florida Department of Agriculture and Consumer Services, 2007, Florida Agriculture Statistical Highlights, http://www.florida-agriculture.com/pubs/pubform/pdf/Florida_Agriculture_Statistics_Brochure.pdf, accessed February 7, 2009.

not protected by the insurance pool funds. A sufficient number of producers, who are not identically affected by perils, must be willing to buy the insurance as part of their overall farm risk management strategy. Without an appropriate pool of insured enterprises, the insurer faces the risk of catastrophic losses. Indemnities in excess of the realized premiums may occur, increasing the subsidy costs to the taxpayer.

Recent experience (See Appendix A, Exhibit 1) with the FFT program suggests that the critical population size criterion will easily be met if HLB can be incorporated as an insurable cause of loss for policies offered at a price that is acceptable. Most citrus trees in Florida are insured under the FFT program at least at the CAT level.

- There must be an appropriate geographic distribution of production to assure a sound financial basis for the insurance. An appropriate geographic distribution of production is also required to address the need for insurance that is responsible to the taxpayer, since producers operating in a limited geographic area could face collective catastrophic loss not protected by the insurance pool funds.

  Current experience with the FFT program suggests that both the geographic criterion will be met if HLB can be incorporated as an insurable cause of loss for policies offered at a price that is acceptable. (See Appendix A, Exhibit 2) Citrus is currently insured in the 27 counties where the FFT program is offered.

- Producers or their agents must be willing to pay the appropriate price for the insurance.

  Since the study was initiated because of industry concerns, there is a priori evidence of customer interest. The willingness of producers or their agents to pay will be influenced by the added costs associated with incorporating HLB into the insurable peril list.

- Appropriate loss controls must be available so best practices can be defined and required of producers. HLB is currently not controllable, but management practices that limit losses have been identified. Unless controllable losses are managed and excluded from insurance, an insurance program will not have an actuarially-sound basis and will tempt the purchaser to manipulate his profits through fraud or deceptive practices.

  The status of eradication and mitigation efforts is addressed in some detail later in this report.

- It must be possible for an actuarially-sound premium rate to be determined.

  This is fundamentally a question of data availability, either in terms of quantity of statistically valid observations or of quality of non-quantifiable observations but secondarily a question of the nature of perils. For this assessment, the rating process requires sufficient information to assess the frequency and severity of losses associated with HLB. The insurance product must be effective and meaningful in that premiums reflect the actual risk faced by the insured producer and indemnities reflect the actual losses borne by the insured producer.

- Customers must not be able to select insurance only when conditions are adverse. At the time of enrollment the purchaser must be unable to predict the outcome. If the purchaser can predict the outcome at the time of enrollment, not only will adverse selection occur, but unscrupulous purchasers could "farm" the insurance to maximize profits. Only unpredictable outcomes fall into the category of appropriately insurable risks. Predictable outcomes do not include risks, but are characterized by certainty.

  This criterion is addressed in a number of the remaining sections of the report.

- Moral hazards must be avoidable or controllable. There must be a clearly defined outcome or phenomenon to be insured and the outcome must be subject to random variation; the variation in outcome must be separable into that part which can or might be manipulated, and that part which cannot be controlled.

  This criterion is addressed in the section of the report dealing with insurance risks and mitigation strategies.
- The proposed insurance product must have definitive causes of loss that can be observed and quantified. Measurement of the outcomes of the enterprise must be such that the uncontrollable portion of losses can be identified and quantified. If this is not possible, then uninsurable losses may be indemnified to the detriment of the taxpayer.

  Citrus Greening is the cause of loss being considered. It is identifiable. It is less easily quantified at this time.
- There can be no chance of beneficial gain. Should an insured individual benefit unduly from participation in the program, that gain introduces the possibility that the insurance would change the status of the insured within the pool of producers. Insurance should be only a vehicle to manage risk. There should be no possibility that indemnity payments should become a fundamental element of the typical income stream.

  This criterion is addressed in the section of the report dealing with insurance risks and mitigation strategies.
- There must be no unacceptable change in market behavior or unacceptable market distortions in terms of either a change in quantity supplied or shift in the supply curve. The intent of crop insurance is not to manage the market, but to manage risks faced by producers. If the insurance unduly increases production, shifts production to new regions, creates unfair advantages for individual producers or particular production regions, then the market distortions will invalidate the rating developed in a neutral market. This presents a danger to producers, to the market itself, and to the insuring entity.

  Globally, the citrus market is in a state of flux, in part due to HBL and in part to a variety of other operators. Tree insurance in Florida for Citrus Greening is not likely to introduce unacceptable changes in market behavior.

If these minimum criteria are satisfied, a proposed policy change should be feasible, appropriate underwriting should be possible, and adoption of the program will fulfill both the needs of the producer and the requirement of being responsible to taxpayers and to the industry.

It is important to remember that citrus production is different from production of row crops. Row crops are planted anticipating harvest after one (or occasionally two) years. The practices, economics, and business approach for citrus production differ substantially even from those of short-lived perennials. Properly maintained citrus trees can have five or more decades of productive life, with yields from individual trees increasing through approximately ten years and then stabilizing. Consequently, citrus producers face agricultural risks affecting yields for a single year (e.g., mild freeze, wind, disease that attacks the fruit or blossom, or pests) and those that affect both current and future crop years (e.g., fires, hard freezes, hurricanes, and catastrophic diseases). While risks affecting both time frames are important, the financial loss associated with long term losses are far greater than losses to production during a single season.

To address these different timeframes for the risks citrus producers must manage, the USDA Risk Management Agency (RMA) currently offers two approaches to insurance:

- Yield Insurance, including:
  - The Arizona-California Citrus Crop Provisions - 2000-126,
  - The California Citrus Dollar Provisions - 2002-0215 (pilot),
  - The Florida Citrus Fruit Crop Provisions (09-026), and
  - The Texas Citrus Fruit Crop Provisions (00-226).
- Tree Insurance, including:
  - The Florida Fruit Tree Provisions - 2008-0014 (pilot),
  - Florida Fruit Tree Pilot Crop Insurance Comprehensive Tree Value (CTV) Endorsement 2008-0014A, and
  - The Texas Citrus Tree Crop Provisions (99-025).

A pilot for an Actual Revenue History insurance product is anticipated to be offered for Navel Oranges in California in the 2011 crop year.

A complicating issue for both yield and revenue insurance for citrus is the establishment of an appropriate liability level. Yield per acre is the most widely accepted measure of "yield." Yield per acre can be established regardless of the age and density of the trees in the block. However, per acre yields in Florida fluctuate widely between blocks and within a block from year to year. County aggregate yield cannot effectively address differences in yields between blocks within the county. There are too many factors that affect block yields, even if the aggregate county-level yields show less variability. Yet this variability is small compared to the total risk associated with loss of productive trees.

Tree insurance is fundamentally different than crop yield or revenue insurance. The main purpose for citrus tree insurance is to protect the long-term value of the citrus operation. Consequently, a policy like FFT should protect against catastrophic risks such as a major freeze, hurricane, or rapid tree loss from pest or disease. Yet to establish a plan or policy that is acceptable to producers; responsible to taxpayers; and does not disrupt the marketplace, insurable risks, rating structure, and underwriting constraints must address all the criteria described earlier.

The pilot tree insurance in Florida is a dollar plan of insurance, based on a value per tree at specific growth stages. Stage III trees should be able to produce a yield typical for a healthy tree of the "current" tree age.[13] Trees that were set out less than three crop years earlier, were "buckhorned" or "topworked" less than two crop years earlier, or were reset (uprighted) after having been toppled less than one crop year prior to the beginning of the current crop year are considered to be in Stage I. Stage II trees were set out three to five crop years earlier, were buckhorned or topworked two or three crop years earlier, or were reset after having been toppled less than two crop years prior to the beginning of the current crop year. Stage III trees are generally much more productive than the Stage I or Stage II trees.

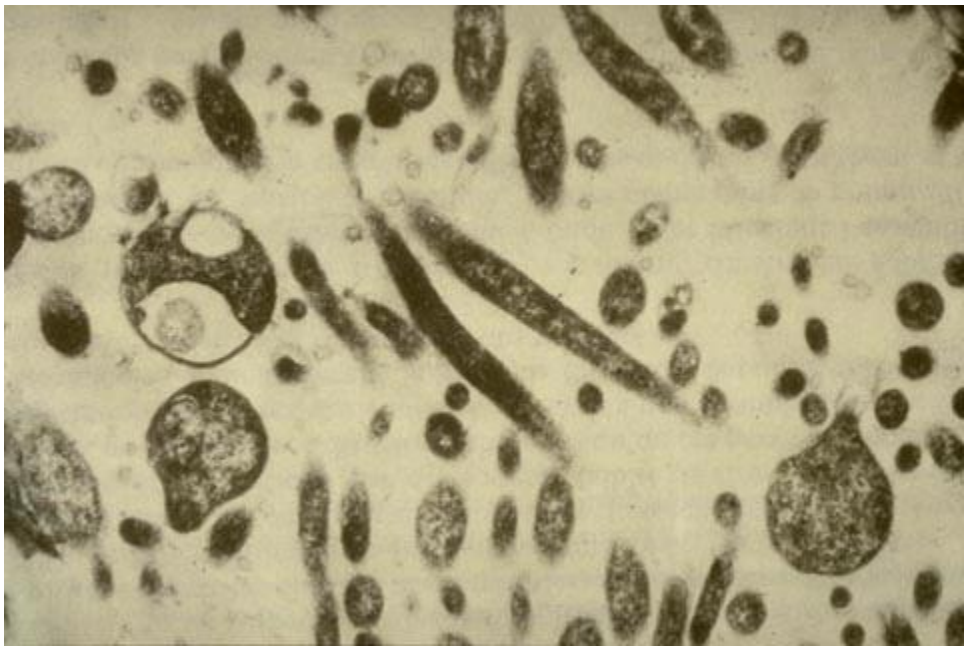
[13] Although trees do not qualify for this stage until after the sixth crop year after set-out or after the fourth crop year after buckhorning/topworking, both involve substantial pruning.

The maximum reference dollar value for a tree in each stage is loosely based on costs of replacing a tree and bringing it back to useful production. Thus, it reflects the cost of budded nursery stock, the costs of planting, and the costs of maintaining the trees for approximately three years. The reference maximum price varies by type of citrus and age. For crop year 2010, the reference maximum price for orange trees (all types) under the base policy ranges from $25 in growth Stage I to $49 in growth Stage III. Consequently, at 75 percent coverage, the amount of insurance per tree under the base policy ranges from $18.75 to $36.75. The 2007 citrus tree inventory for Florida indicates an average of 128 trees per acre, resulting in a maximum average amount of insurance per acre of $4,704 under the base policy. The CTVE increases the value that can be obtained for each tree. The insurable causes of loss are limited by the provisions for this insurance. The current Florida Fruit Tree Provisions, even with the CTVE, does not indemnify for losses caused by HLB.

Huanglongbing

The genus *Candidatus* Liberibacter comprises a group of filamentous bacteria that have been observed primarily in the conductive tissues of citrus trees (Figure 1). Three putative species in the genus, *Candidatus* Liberibacter *asiaticus* (*Ca.* L. *asiaticus*), *Candidatus* Liberibacter *americanus* (*Ca.* L. *americanus*), and *Candidatus* Liberibacter *africanus* (*Ca.* L. *africanus*) cause HLB. The "*Candidatus*" in the scientific name reflects a level of taxonomic uncertainty characteristic of bacterial species that have not been isolated and successfully grown in culture.

Figure 1. Transmission Electron Micrograph of *Candidatus* Liberibacter *asiaticus*, Within a Citrus Phloem Sieve Tube



Source: After a photograph by Monique Garnier

HLB is one of the most severe diseases of citrus in Asia (*Ca.* L. *asiaticus*) and Africa, including the Arabian Peninsula, and the islands of Mauritius, Reunion, and Madagascar (*Ca.* L. africanus).[14] HLB symptomatic citrus trees were identified in 2004 in Brazil[15] (initially, infections were observed to be caused by *Ca.* L. *americanus*, but *Ca.* L. *asiaticus* is currently the predominant cause of damage). HLB symptomatic citrus trees were first observed in the U.S. in 2005 (*Ca.* L. *asiaticus*).[16] In 2007, APHIS reported HLB was observed in 39 countries, including:

> Bangladesh, Bhutan, Brazil, Burundi, Cambodia, Cameroon, Central African Republic, China, Comoros, Ethiopia, Hong Kong, India, Indonesia, Japan, Kenya, Laos, Madagascar, Malawi, Malaysia, Mauritius, Myanmar, Nepal, Pakistan, Papua New Guinea, Philippines, Reunion, Rwanda, Saudi Arabia, Somalia, South Africa, Sri Lanka, Swaziland, Taiwan, Tanzania, Thailand, United States, Vietnam, Yemen, and Zimbabwe.[17]

Although there is a generally held belief that HLB originated in China in the early 1900s, recent changes in the taxonomy of the host citrus species suggests an alternative, much earlier origin.[18]

The severe agronomic and economic effects of HLB have inspired substantial research efforts around the world. An on-line searchable HLB bibliographic database listed 870 citations in December, 2008.[19] The research identified in the database covers the gamut from biochemistry and molecular biology to ecology and from farm-level to global economics. The expectation of the organizers of this site is that the literature will soon encompass more than 1,000 peer-reviewed, invited, trade, and general distribution articles, as well as numerous books and book chapters. The severity of the risks associated with HLB is reflected in the fact the disease is addressed repeatedly in the 2008 NATO Science for Peace and Security Series volume on biosecurity. HLB is first identified in a chapter on diseases with extreme biological and economic effects.[20] The effects of the infection mechanisms on epidemiology are discussed.[21]

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[14] Garnier, M., and J. M. Bové. 1993. Citrus greening disease and the greening bacterium, in P. Moreno, J. V. da Graça, and L. W. Timmer (eds.), Proceedings of the 12th Conference of the International Organization for Citrus Virology. International Organization of Citrus Virologists, Riverside, California, 212-219.
Garnier, M., and J. M. Bové. 1996. Distribution of the greening Liberobacter species in fifteen African and Asian countries, p.. In J. V. da Graça, P. Moreno, and R. K. Yokomi (eds.), Proceedings of the 13th Conference of the International Organization for Citrus Virology. International Organization of Citrus Virologists, Riverside, California, 388-391.

[15] Teixeira, D.C., A.J. Ayres, E.W. Kitajima, F.A.O. Tanaka, J.L. Danet, S. Jagoueix-Eveillard, C. Saillard, and J.M. Bové, 2005, First report of a Huanglongbing-like disease of citrus in São Paulo State, Brazil, and association of a new liberibacter species, "Candidatus Liberibacter americanus",

[16] Halbert, S. 2005. The discovery of huanglongbing in Florida in: Proceedings of the 2nd International Citrus Canker and Huanglongbing Workshop, Orlando, Florida 50. http://www.doacs.state.fl.us/pi/chrp/images/2nd_International_Canker_Huanglongbing_Research_Workshop_2005.pdf accessed 3/1/2009

[17] United States Department of Agriculture, Animal and Plant Health Inspection Service, 2007, Plant Health: Citrus Greening, http://www.aphis.usda.gov/plant_health/plant_pest_info/ citrus_greening/background.shtml, accessed February 2, 2009.

[18] Beattie, G.A.C., P. Holford, D.J. Mabberley, A.M. Haigh and P.Broadbent,2008, On the Origins of Citrus, Huanglongbing, Diaphorina citri and Trioza erytreae , Proceedings of the 2008 International Research Conference on Huanglongbing, pp. 25-57.

[19] Arevalo1, H. A., G. Snyder, and P. A. 2008, Stansly, http://swfrec.ifas.ufl.edu/hlb/database, The Citrus Greening Bibliographical Database, a New Tool for Researchers Students and Growers

[20] Gamliel, A., 2008, High Consequence Plant Pathogens**,** in Crop Biosecurity: Assuring our Global Food Supply, M.L. Gullino, J. Fletcher, A. Gamliel, and J.P. Stack, Springer, Dordrecht, The Netherlands, pp. 25-36.

[21] Gamliel, A., M.L. Gullino, J.P. Stack, 2008, Crop Biosecurity: Local, National, Regional and Global Perspectives, in Crop Biosecurity: Assuring our Global Food Supply, M.L. Gullino, J. Fletcher, A. Gamliel, and J.P. Stack, Springer, Dordrecht, The Netherlands, pp. 37-61.

Then, the logistical and scientific challenges of dealing with the disease across entire continents are considered.[22]

The causative agent of HLB is an alpha-proteobacteria.[23] The alpha-proteobacteria is a group of fastidious[24] filamentous bacteria also associated with bio-film production in water and waste-water systems. *Ca.* Liberibacter attack the phloem of the trees and stimulate the production of a chemical called callose. HLB infection affects expression of 624 genes, including genes associated with sugar metabolism, plant defense, phytohormone, and cell wall metabolism. Anatomical analyses show HLB infections cause plugged sieve pores, phloem disruption, and sucrose accumulation in a variety of tissues. The up-regulation of the pp2 gene may lead to callose deposition in the phloem of HLB-affected plants. Phloem blockage results from sieve pores plugged by callose rather than by the HLB bacteria themselves. Three key starch biosynthetic genes contributed to accumulation of starch in HLB-affected leaves.[25]

HLB causes blotchy chlorosis;[26] twig dieback; and reductions in fruit size, quality, and number. Many of these symptoms are similar to the symptoms of nutrient deficiencies, particularly deficiencies of zinc and iron, and to symptoms of other citrus diseases. Early signs of HLB are difficult to detect in unthrifty trees, with thin canopies and pale foliage.[27]

If the HLB infection occurs soon after saplings are set out, the whole tree may exhibit these symptoms. In mature trees, sectoral chlorosis (yellowing of one branch or one part of the canopy), yellow leaf veins, and blotchy chlorosis are the clearest early indications of HLB infections. In these early stages, chlorotic blotching of leaves, swollen leaf veins, or corky veins are additional diagnostic elements, especially when they occur in combination.

Although HLB infections can quickly move throughout individual citrus trees and expansive groves, trees inoculated with *Ca.* Liberibacter bacteria may not show symptoms for years following the initial exposure. Yet within a year after the first symptoms of HLB are evident, an infected tree may exhibit extensive yellowing of foliage and little or reduced fruit set.[28] The fruit that do form on infected branches is often smaller than previously, lopsided, and contain seeds that do not develop fully. These fruits generally do not color properly, hence the name "Citrus Greening" (see Figure 2). The juice of fruits on infected stems is often bitter, with off flavors,

[22] Tinivella, F., M.L. Gullino, J.P. Stack, 2008, The Need for Diagnostic Tools and Infrastructure, in Crop Biosecurity: Assuring our Global Food Supply, M.L. Gullino, J. Fletcher, A. Gamliel, and J.P. Stack, Springer, Dordrecht, The Netherlands, pp. 71-92.

[23] Jagoueix, S., J.M. Bové, and M. Garnier, 1994, The phloem-limited bacterium of greening disease of citrus is a member of the subdivision of the Proteobacteria. International Journal of Systematic Bacteriology 44: 379-386. accessed 3/1/2009 http://ijs.sgmjournals.org/cgi/reprint/44/3/379.

[24] Bacteria that are difficult to grow in culture and known primarily *in situ*.

[25] Kim J.S., U.S. Sagaram, J.K. Burns, J.L. Li, and N. Wang, 2009, Response of sweet orange (Citrus sinensis) to 'Candidatus Liberibacter asiaticus' infection: microscopy and microarray analyses, Phytopathology: 99, pp. 50-57.

[26] Failure of the chlorophyll to fully develop, causing a yellow appearance.

[27] Richard I. Davis, 2008, Plant and Disease Image Library, Citrus huanglongbing 'Candidatus Liberibacter spp.' a-Proteobacteria, http://www.padil.gov.au/viewPest.aspx?id=494, accessed February 11, 2009.

[28] Davis RI, Gunua TG, Kame MF, Tenakanai D, Ruabete TK (2005) Spread of citrus huanglongbing (greening disease) following incursion into Papua New Guinea. Australasian Plant Pathology 34: 517-524.

although there is some disagreement in the industry about reduction in juice quality.[29] It is likely these effects vary by variety, fruit age, rootstock, and level of infection. In later stages, the chlorotic blotching becomes less obvious, with entire leaf blades showing substantial chlorosis.

Figure 2. Orange Fruits Affected by Citrus Greening

Source: After United States Department of Agriculture, Agricultural Research Service, 2008, Huanglongbing (Citrus Greening): What ARS Is Doing, http://www.ars.usda.gov/citrusgreening, accessed March 14, 2009.

Chronically infected citrus trees have sparse foliage, low fruit yields, and show extensive dieback at the branch tips. In countries where HLB is well established, the average productive lifespan of citrus trees has dropped from 50 or more years to 15 or fewer years.[30] Infected trees in orchards often die three to five years after first showing symptoms. There are no procedures to cure trees once they are infected. Consequently, current practices generally require removal of trees at the first signs of infection. To maintain the productivity of a block, these trees need to be replaced.

The causative agent of HLB is spread by two species of psyllid insects, the Asian citrus psyllid, *Diaphorina citri* (Kuwayama), and the African citrus psyllid, *Trioza erytreae* (del Guercio), two of the most serious citrus pests. *Diaphorina citri* has been found in Florida since 1998. The adults are small (three to four mm) with mottled brown wings. Adults deposit eggs on newly emerging buds. Eggs hatch to produce tiny green or orange nymphs that feed on leaves and stems. The Asian citrus psyllid population increases occur during periods when the citrus are actively growing, especially when the young branches are in the earliest stages of development called the flush.[31] Asian citrus psyllids feed primarily on citrus and closely related plants in the family Rutaceae. The psyllids are now widely distributed in Florida and frequently found on

[29] Baldwin, E., J. Manthey, A. Plotto, G. McCollum, M. Ireyfumosorosea,2008, An Update on the Effect of HLB on Orange Juice Flavor – 1) Chemical Components, Proceedings of the 2008 International Research Conference on Huanglongbing, pp. 234-235.
[30] United States Department of Agriculture, Animal and Plant Health Inspection Service, 2007, Plant Health: Citrus Greening, http://www.aphis.usda.gov/plant_health/plant_pest_info/ citrus_greening/background.shtml, accessed February 2, 2009.
[31] ibid.

Murraya paniculata (Orange Jessamine, Chinese box, "mock orange", Mock lime, Satinwood), an ornamental widely grown in southern Florida.[32]

HLB is a difficult disease to manage due to the of lack of early diagnostic methods. Since the only definitive method of diagnosing HLB is by DNA analysis,[33] even verifying the cause of a decline is costly. Polymerase Chain Reaction (PCR) diagnostic methods are efficient when symptomatic tissue is used for DNA extraction. Analysis of vector nymphs for the presence of *Ca.* Liberibacter may provide a way to identify areas of infection, and identification of *Ca.* Liberibacter in vector adults is one indicator of a disease hotspot.[34] In single psyllid PCR extractions, 0 to 40 percent of the psyllids (depending on collection location) were found to carry *Ca.* Liberibacter. The highest levels of bacteria in the psyllids was in the early fall, and the lowest in the winter, even in samples collected from severely infected areas. The difficulty of identifying the disease early, the ease of transmission, prolonged latency, and decline of symptomatic trees all contribute to the perception that the HLB complex may be the most devastating citrus disease anywhere.[35]

HLB was not identified in the United States until 2005. Survey crews collected HLB infected tissue from plants in Miami-Dade County (Florida) during August of that year.[36] In response to this observation, USDA APHIS Plant Protection and Quarantine (PPQ) program and the Florida Department of Agriculture and Consumer Services deployed a Unified Command and delimiting survey crews to define the extent of the problem. This is a challenging task since new observations of HLB occur from one day to the next. On August 7, 2008, HLB had been identified in 32 counties and 1,118 sections in Florida. By October 29, the number of affected sections had increased to 1,466. Fewer than half of the affected sections include commercial citrus production. However, adult psyllids may transfer HLB in an area exceeding 2.5 square miles.[37] As citrus are commonly used in horticultural plantings throughout the South, there are abundant plants to support the growth of psyllids and transfer of HLB between ornamental and commercial plants. Infections in horticultural specimens pose as great a threat to commercial groves as do infections in commercial blocks, since the horticultural specimens can bridge between commercial blocks, providing an avenue for transmission of HLB by psyllids. There is at least one incidence of HLB in Hendry County when the nearest known infection was 50 miles away.[38]

The relationships between the psyllids and the *Ca.* Liberibacter pathogens are poorly understood. It appears *Ca.* Liberibacter are multiplying in the psyllids as well as in citrus.[39] It is unclear

[32] ibid.
[33] United States Department of Agriculture, Animal and Plant Health Inspection Service, 2007, Plant Health: Citrus Greening, http://www.aphis.usda.gov/plant_health/plant_pest_info/ citrus_greening/background.shtml, accessed February 2, 2009.
[34] Ramadugu, C., Keremane, M.L., Ramos, C., Halbert, S., Lee, R.F., 2007, Incidence of Huanglongbing in Psyllids Under Natural Conditions in Florida. Phytopathology, 97, No7: S96.
[35] Florida Department of Agriculture and Consumer Services, 2007, Pest Alert: Asian citrus psyllid - A serious exotic pest of FL citrus, http://www.doacs.state.fl.us/pi/enpp/ento/dcitri.htm, accessed February 1, 2009.
[36] ibid.
[37] There are numerous references in Government documents to African psyllids having an effective fly radius of 0.9 miles, but W&A was unable to identify the scientific source of this frequently-referred to number.
[38] http://spdn.ifas.ufl.edu/Greening%20management%20for%20homeowners%20HALBERT.ppt#378,12,Asian citrus psyllids may fly longer distances in some cases
[39] Aubert, B., 1987.,Trioza erytreae Del Guercio and Diaphorina citri Kuwayama (Homoptera: Psylloidea), the two vectors of citrus greening disease: Biological aspects and possible control stragegies, Fruits 42:149-162.

whether *Ca. Liberobacter* spp. are passed from adult insects to eggs.[40] When feeding on infected tissues, African psyllids can acquire the bacteria in as little as a day,[41] while the Asian psyllids are reported to have acquisition times as short as half an hour.[42] Fourth and fifth instar Asian citrus psyllid nymphs and adults are only able to transmit the pathogen 8 to 12 days after their initial exposure to the bacteria.[43] A shorter latent period (perhaps as short as a day) has been reported for the African HLB complex.[44] However the latency in the psyllids is short when compared to the asymptomatic period for the citrus trees themselves.

Feasibility Assessment

This feasibility assessment provides an evaluation of the feasibility of adding Citrus Greening as an insurable peril under the FFT plan. The report consists of five additional components: a quantitative risk assessment, a disease prevention and eradication research summary, a citrus industry impact analysis, an underwriting risk and mitigation section, and feasibility recommendations.

[40] Buitendag, C.H. and von Broembsen, L.A., 1993, op. cit.; Roistacher, C.N. 1991., op. cit. ; Van den Berg, M. A., van Vuuren, S. P., and Deacon, V. E. 1992. Studies on greening disease transmission by the citrus psylla, Trioza erytreae (Hemiptera: Triozidae). Israel Journal of Entomology. 25-26:51-56.

[41] Buitendag, C.H. and von Broembsen, L.A., 1993, Living with citrus greening in South Africa. in P. Moreno, J.V. daGraça and L.W. Timmer, eds., Proceedings of the Twelfth Conference of the International Organization of Citrus Virologists, pp. 269-273.

[42] Roistacher, C.N. 1991. Techniques for biological detection of specific citrus graft transmissible diseases, (Greening). FAO, Rome, pp. 35-45.

[43] Roistacher, C.N. 1991., op. cit.

[44] Buitendag, C.H. and von Broembsen, L.A., 1993, op. cit.

SECTION III. QUANTITATIVE RISK ASSESSMENT

One of the primary challenges of assessing feasibility for the addition of Citrus Greening as a peril under the FFT program is quantifying the marginal risk associated with the disease. A logical starting point is the insurance experience for the previous and existing tree policies (Tables 1 and 2). County-level summary information for the FFT plan for 1999 through 2007 is reported in Appendix A, Exhibit 2. The FFT covered another catastrophic citrus disease, ACC, from 2000 through 2007.

PCR testing can provide insight into patterns of infection by *Ca.* L. *asiaticus* and the spread of HLB. The United States Sugar Corporation/Southern Gardens Citrus Corporation diagnostic laboratory has been anylzing samples by real-time PCR testing (RT-PCR) free of-charge to those submitting samples. During the first two years of this program, 64,905 samples were submitted. These represented at least 1,265 groves in 27 Florida counties. Samples were provided by commercial citrus groves, commercial citrus nurseries, homeowners, state and Federal researchers, extension agents, and the Florida Division of Agriculture and Consumer Services Bureau of Budwood Certification program. Analysis of this testing has focused on HLB incidence by county, citrus varietal infection patterns (especially focusing on sweet oranges), percent infection by age category and by season, and the accuracy of HLB diagnosis by professional scouts using visual disease symptoms. As of the date of this report, sample numbers had exceeded 90,000. *Ca.* L. *asiaticus* was identified in samples from every county, with higher incidence in counties with commercial production in the south and east. Highest *Ca.* L. *asiaticus* infection levels were found in Early Gold, Hamlin, Parson Brown and Valencia sweet oranges, and grapefruit while lower infection levels were found in Minneola and other tangelos and in Midsweet, Navel, and Pineapple sweet oranges. The six to nine year old age group of trees had the highest level of infection compared to other age groups. HLB symptoms were least evident from April through July and most evident from August through March. The percentage of *Ca.* L. *asiaticus* positive samples increased in July and declined in March, perhaps reflecting seasonal changes in the bacterial populations or alternatively seasonal differences in the accuracy of identification of *Ca.* L. *asiaticus* infections from visual symptoms.[45] Over time, the success of identification of infection by professional scouts has increased. The most successful scouts can currently identify HLB symptomatic trees with success rates as high as 95 percent (depending on season).[46]

Unfortunately, in spite of the large number of samples tested by RT-PCR, the results do not refect systematic sampling, but rather responses to in-field conditions. In extensive interactions with Florida plant health officials, the UDSA Agricultural Research Service and APHIS, the Contractor found few quantitative data on the progress of the disease are available. The information recorded by plant health programs is designed to serve specific needs and is generally poorly suited to quantitative risk assessment of the type required for development of crop insurance.

[45] Irey, M., Mai, P.; Graham, J. and Johnson, J. 2008. Data trends and results from an HLB testing laboratory that has processed over 64,000 commercial and research samples over a two year period in Florida, Proceedings of the 2008 International Research Conference on Huanglongbing, p. 101.

[46] S. Futch, Florida Citrus Extension Agent, personal communication, February, 2009.

There are several diverse HLB research programs underway in Florida. The Contractor worked with the Florida Department of Citrus, Florida Citrus Mutual, University of Florida personnel, producers, grove managers, and scouting firms to obtain any available quantifiable data relevant to the frequency and severity of HLB damage. These non-traditional data sources were queried and data collected was integrated with plant health and regulatory datasets to develop a picture of the risk posed by Citrus Greening. The Florida Department of Agriculture and Consumer Services recently (October 29, 2008) published a map that depicts the potential spread of HLB in the state within one year. The map is based upon an assumption that the infection could spread within a 15-mile radius of any presently detected infection. All commercial citrus production in the state falls within the zone into which the disease potentially could expand within one year. The 15-mile radius is based on data analyzed from commercial citrus operations in Brazil.[47]

The available data are not sufficient to develop a statistically valid methodology to assess rate requirements should Citrus Greening be included in the coverage under the Crop Provisions. It cannot be known if current observations of the disease are the result of new infections or merely of newly discovered infections, since an infected tree can be asymptomatic for months or perhaps even years.[48] Consequently, the actual number of currently infected trees could be much greater than the number of infected trees currently identified.

However, as long as the producer cannot identify infected, asymptomatic trees on the sales closing date, the inability to identify all infected trees from physical symptoms is not an insurmountable impediment to developing an appropriate premium rate. Rather, it is the inability to identify the numbers of asymptomatic infected trees and the effects of those infections in the actuarial analysis, or to have sufficient data concerning the course of the disease for such analysis, that makes the latency of HLB a substantial barrier to the development of an amendment to the FFT insurance.

This problem with evaluating the quantitative risk is exacerbated by the large numbers of acres of abandoned groves receiving little or no care to control psyllid populations. The USDA reported 129,869 acres of abandoned citrus groves in Florida in 2008.[49] As long as there is live tissue in the trees, these abandoned groves provide a refuge for the psyllids and potential sources of *Ca.* L. *asiaticus* that can be spread to nearby operating groves by the psyllids. These abandoned groves make it more difficult for the managers of active operations to define appropriate control measures for both psyllids and trees exhibiting symptoms of HLB. Managers of large citrus operations can more effectively control the spread of HLB under these conditions than can managers of smaller operations. The managers of the larger operations have much less "edge" to deal with relative to their acreage. Hence, an appropriate premium rating structure would need to incorporate size of operation (in terms of total acres of citrus of all types in a single contiguously managed area) and proximity to abandoned groves as risk factors. It is important to note the abandoned acreage is not uniformly distributed throughout the state; even within counties the distribution of abandoned citrus acreage and the proximity to active groves varies substantially. However, quantitative data concerning the total acreage of citrus of all types

[47] The map can be viewed at http://www.doacs.state.fl.us/pi/chrp/images/CHRP_Dec%2008.pdf.
[48] S. Futch, Florida Citrus Extension Agent, personal communication, February, 2009.
[49] "Disease, storms and development have shrunk Florida's citrus groves to new lows." October 27, 2008. Accessed at http://www.palmbeachpost.com/business/content/business/epaper/2008/10/26/a1f_citrus_1027.html in March 2009.

in a single contiguously managed area and proximity of actively managed acreage to abandoned groves are not readily obtainable.[50]

Section 12(b) of the FFT Crop Provisions defines damage to Florida Fruit Trees of various types. None of these definitions seems to categorize appropriately damage due to HLB. The initial symptoms of *Ca.* L. *asiaticus* infection in a tree is often a characteristic sectoral cholorosis of a single shoot or branch. Although the effect on the current crop of fruit from this level of infection is limited, appearance of this symptom is an indication that the tree will likely cease to be a productive contributor to the grove yield (and therefore the income from the grove) within a few years. Furthermore, even such mild symptoms are an indicator that the infected tree is a source of inoculum for infections of other trees in the grove by *Ca.* L. *asiaticus*. While a manager may wish to replace the tree immediately to limit the exposure of other trees in the grove to the disease, the tree is not considered destroyed under the terms of the FTT Crop Provisions. Therefore, the tree would not qualify for determining the amount of any indemnity.

Appropriate definitions in the Crop Provisions for damage caused by infection with *Ca.* L. *asiaticus* are needed before the severity of losses caused by these infections could be calculated, and these severity calculations are required for determining a premium rate component for insurance of trees losses caused by HLB. As stated earlier, a tree may be unproductive within one year after exhibiting the first obvious signs of HLB. Consequently, it seems reasonable to consider a tree to be 100 percent damaged when it firsts exhibits evidence of the disease. This categorization creates a dilemma in establishing appropriate risk control structures for an FFT program incorporating HLB as an insurable cause of loss. If there were accepted best management practices for the disease, the designation of a symptomatic tree as either 100 percent (100%) damaged (for a regime requiring immediate removal) or undamaged (for a regime focused on maximizing harvested fruit in the early stages of infection) would suffice. However, in the absence of well-defined best management practices established by the industry, any imposed underwriting requirements for incorporation of HLB as a cause of loss for the FFT plan would, in effect, be defining a set of recommended practices the industry itself has been unable to define.

Even if a tree is considered 100 percent (100%) destroyed as soon as there is evidence of the Citrus Greening disease, an average of at least 6.4 symptomatic trees per acre[51] would need to exhibit symptoms of the disease to penetrate the 5 percent (5%) deductible value of the Occurrence Loss Option. In effect, during the period when the infection is established in a grove and aggressive scouting and tree removal limit the total numbers of symptomatic trees, there would be no indemnity payments. Furthermore, when a manager decides it is time to push the grove, only 25 to 30 percent (25% to 30%) of the trees would be symptomatic. Structuring an indemnity payment under these circumstances would be difficult, since a substantial number of unaffected trees would be removed and the costs of identifying the healthy trees and

[50] The State of Florida has initiated a comprehensive plan to destroy abandoned groves. Once this plan is completed, this source of uncertainty will be removed from consideration. See information at http://www.doacs.state.fl.us/pi/chrp/documents/chrp_update_jan_2009.pdf, and Leavitt, M.R., L.M. Young, A.F. Guerrero, and C.L. Weingart, 2008, Abandoned Agricultural Property, http://www.deanmead.com/CM/Articles/o0421861.pdf, accessed March 9, 2009.

[51] Assuming all trees are of the same stage and the density is at the average of 128 trees per acre currently existing in Florida.

asymptomatic infected trees would substantially increase loss adjustment costs or the costs of managing the grove if selective tree removal were required.

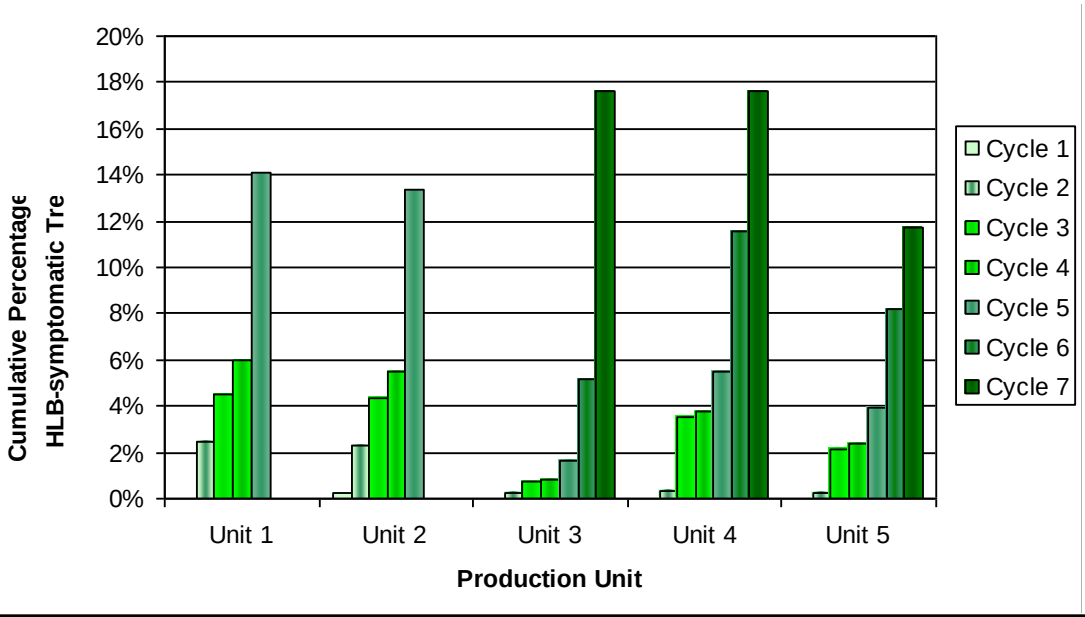
Appropriate quantitative data concerning the numbers of trees infected per year are not currently available; however, the State of Florida conducted a survey of producers for the 2008 crop year (September 1, 2007 to August 31, 2008). The state will compile comprehensive data regarding Citrus Greening and ACC from the producer responses. In particular, the survey instrument asks for specific information about the number of trees showing symptoms for each disease and the number of trees removed during the crop year within a grove name/block number.[52] Participation is voluntary; responses initially were due by January 31, 2009, but the due date was extended to February 28, 2009. These data, once available, may provide a more comprehensive quantitative assessment of the situation regarding HLB in Florida if there is sufficient participation.

Until these survey data are available, any attempt to provide a quantitative assessment of the risk presented by HLB would be largely conjectural. Available evidence clearly indicates the disease has been detected in most, if not all, citrus producing counties. As of February 16, 2009 (the date when this section of the report was prepared), HLB had been detected in 33 counties and 1,891 sections in Florida. However, the number of sections where HLB has been observed may reflect sampling patterns (i.e., the number of sections sampled for HLB) more than infection patterns.[53] There is little comprehensive quantitative evidence beyond these observations.

Patterns of spread within blocks, units, and groves vary substantially. In an aggressively managed grove with professional scouting for both psyllids and HLB symptoms, IPM to control psyllid population, removal of symptomatic trees as soon as symptoms are evident, and replacement of trees that were removed, HLB symptomatic trees increased from 0.01 percent to 0.27 percent in 26 months. The cumulative rate for the appearance of symptomatic trees was just slightly more than 0.7 percent, but the cumulative rate of apperanace of symptomatic trees for units within the grove ranged from 0.015 percent to 2.58 percent.[54] At the unit and grove level, the rate of spread of the disease is highly variable, even under uniform management practices (Figure 3). These disparate results further complicate the development of the quantitative risk assessments required for rating. When the wide range of environmental factors affecting citrus in Florida and of management practices currently being implemented are taken into account, the available data are quite limited. Fortunately, both producers and the state of Florida are engaged in substantial data collection efforts.

[52] The survey instrument is available at http://www.doacs.state.fl.us/pi/chrp/documents/08453.pdf.
[53] S. Futch, Florida Citrus Extension Agent, personal communication, February, 2009.
[54] Anonymous grove managers, personal communications, February, 2009.

Figure 3. Time-course of Development of HLB-symptomatic Populations in Five Florida Orange Production Units during Seven Scouting Cycles*



* Symptomatic trees were removed as soon as they were identified and replaced as stock became available. Consequently, the changes reflect progression of the disease rather than the current phytosanitary status of the unit.

Source: Florida Citrus Researcher, not identified to maintain confidentiality of proprietary production and management data.

SECTION IV. CITRUS GREENING PREVENTION AND ERADICATION STRATEGIES

Citrus Greening is a recent problem in Florida, having first been officially identified in a pummelo tree (and a second tree whose species was not identified) in 2005.[55] Despite its recent discovery in the U.S., the disease has been known for almost 100 years, and researchers in Florida have been actively studying the disease for years. Since the discovery of *Ca.* L. *asiaticus* in Florida, investigators in the U.S. have accelerated their efforts to characterize the disease and develop appropriate management approaches. Current research efforts targeted at prevention and eradication address disease resistance in root stock and scion varieties, prevention and management approaches (including substantial research addressing host/vector/pathogen interactions), as well as treatment and control procedures. Similar research efforts have been underway in other citrus producing countries, especially those with substantial citrus production where HLB is endemic.

Resistance and Tolerance

Pathogens like *Ca.* L. *asiaticus* play an important role in plant evolution because they can reduce plant growth and/or tolerance. Disease resistance limits the impact of a potential pathogen since infections are never established in resistant plants. Consequently, in truly resistant plants there are never any disease symptoms. On the other hand, tolerant plants become infected, but have mechanisms to compensate or limit the effects of the infection. In most natural populations, a range of levels of resistance and tolerance to common pathogens exists. So for example, some plants may become infected by a single exposure to the pathogen and are not at all resistant to the infection; others are only infected after repeated exposures, while still others appear never to become infected. Similarly, some plants succumb to a disease shortly after infection begins; others may show disease symptoms, but survive and even reproduce effectively for years; while still others may "carry" a disease, but never show symptoms.

Ironically, tolerance to pathogens can reduce natural selection for disease resistance and alter the effect of pathogens on the evolution of a plant population. Moreover, these natural evolutionary patterns, which generally operate over centuries or millennia, are being challenged by mono-cultural farming practices and the globalization of diseases. Furthermore, populations that have evolved or have been selected in a disease-free environment are likely to show a more dramatic reaction to a "new" disease than are populations that have co-evolved with the disease-causing pathogen.

In cultivated populations, selection for desirable traits (e.g., yields, nutrient levels, or flavors) may inadvertently affect other traits (e.g., resistance or tolerance to diseases). Coupling of apparently unrelated characteristics like this occurs due to both gene linkages and biochemical interactions in complex metabolic pathways.

If varieties of citrus that are resistant or fully tolerant of HLB can be identified, they can be used to mitigate the effects of the disease in cultivated populations. To date, no complete, natural

[55] Halbert, S. 2005. The discovery of huanglongbing in Florida in: Proceedings of the 2nd International Citrus Canker and Huanglongbing Workshop, Orlando, Florida 50. http://www.doacs.state.fl.us/pi/chrp/images/2nd_International_Canker_Huanglongbing_Research_Workshop_2005.pdf accessed 3/1/2009

resistance to HLB has been identified in commercial citrus species. Initially, infections are randomly distributed among the trees in a block rather than passing uniformly from a tree to its nearest neighbors. This random pattern may give the impression that some trees are resistant to the disease. However, no true resistance is evident in these trees. Trees that are initially asymptomatic may eventually become symptomatic after a period of time if the vector is not effectively controlled. These trees display an initial tolerance to Citrus Greening rather than resistance to infection by *Ca.* L. *asiaticus*.

Nonetheless, efforts to identify resistant individuals, varieties, and species in the citrus family continue. Koizumi *et al*. identified species showing much slower development of physiological symptoms. They found most sweet orange trees show rapid decline following infection, while grapefruit remains asymptomatic much longer.[56] Lee confirmed these observations, reporting that sweet oranges, mandarin oranges, and tangelos are most susceptible to decline caused by *Ca.* Liberibacter; while grapefruit and lemon are slower to develop symptoms; and limes, *Poncirus trifoliate*, and citranges were the most tolerant of infection among the species studied.[57] While this tolerance might be bred into new commercial varieties to buffer some of the economic damage caused by the timing of productivity loss in the groves, it will also contribute to the problems latency introduces, especially the existence of inoculum pools that lead to the spread of infections throughout the groves.

Traditional breeding programs have not yet been successful in developing truly resistant varieties for any commercial citrus species. Efforts in South Africa targeting such development were begun in 1985. They have not produced any resistant varieties,[58] in spite of the fact that *Ca.* L. *africanus* tends to be less infective than *Ca.* L. *asiaticus*, the causative agent of the HLB in Florida.

Two highly technical approaches are currently being used to explore the possibility of developing resistance to *Ca.* Liberibacter infection in citrus. Tissue cultures are being challenged by the *Ca.* Liberibacter to attempt to identify resistant cell lines. Recently these efforts have extended to cultures of psyllid cells, to try to see if there is a mechanism that might break the infection cycle as the *Ca.* Liberibacter moves between vector and host. Even more promising are recent advances in genetic engineering of potentially resistant varieties. Genes coding for antimicrobial peptides have been transferred to citrus genomes in sweet oranges, grapefruit, Key lime and Carrizo citrange.[59] Transgenic plants have been regenerated. Genetically modified plants containing antimicrobial genes from *Arabidopsis* have been produced from some of the engineered cell lines, and some transgenic plants have already been challenged with *Ca.* L. *asiaticus*.[60] Both producers and researchers have expressed optimism that

[56] Koizumi, M., M. Prommintara, G. Linwattana, and T.Kaisuwan. 1993. Field evaluation of citrus cultivars for greening resistance in Thailand, in Proc. 12th Conference of the International Organization of Citrus Virologists, P. Moreno, J.V. da Graça, and L.W. Timmer [eds.], University of California, Riverside, pp. 274-279.

[57] Lee, R.F. 1996. Citrus greening disease and its vectors. Naranja 17: 258-260.

[58] da Graça, J.V., and L. Korsten, 2004, Citrus huanglongbing: Review, present status and future strategies in: Diseases of Fruits and Vegetables, Vol. I, S.A.M.H. Naqvi, ed., Kluwer Academic Press, Dordrecht, The Netherlands 229-245.

[59] Reddy, J.D., and D.W Gabriel, 2008, A transgenic approach to the control of citrus greening, Proceedings of the 2008 International Research Conference on Huanglongbing, pp. 343-348, and Grosser, J.W., M. Dutt, , A. Omar,, V. Orbovic, and G.A Barthe, 2008, Towards the Ultimate Solution: Genetic Resistance to HLB in Commercial Citrus, Proceedings of the 2008 International Research Conference on Huanglongbing, p. 330.

[60] Grosser, J.W., et al., 2008, op. cit.

these efforts will provide new opportunities for grove replacement with resistant varieties. Nonetheless, there are both logistic and political barriers to the incorporation of transgenic citrus products into the American economy. It will be years before the economic benefits from these developments will be quantifiable. It is unproductive at this point to consider the impact of genetically engineered rootstock and scion on grove productivity, longevity, and crop insurance.

Prevention

Disease prevention is any activity which reduces the mortality or morbidity resulting from a disease. Initially, the behavior of the HLB in the host and vector led to the hypothesis that a virus was the causative agent, and efforts to identify prevention strategies for HLB were targeted to viral infections. Eventually, the causative agent of HLB was recognized as a bacterium in the putative genus Liberibacter. Since none of the *Ca.* Liberibacter has been grown in isolation, it has not been possible to establish this causation unequivocally.[61] However, there is no question *Ca.* L. *asiaticus* infection is involved in the development of HLB symptoms. It is likely the infection involves elaborate symbioses that impact latency, the development of symptoms, and the severity of responses. USDA Agricultural Research Service (ARS) scientists have reported sequencing at least 95 percent of the *Ca.* L. *asiaticus* genome.[62] This molecular biological characterization will allow exploration of the potential involvement of plasmids and/or transposable elements in the HLB infections.

Restriction analysis of the bacterial DNA suggests there are variants even within a single putative species.[63] This genetic diversity undoubtedly contributes to the challenges of managing HLB. Common management practices include extensive scouting to identify infected trees, PRC verification of the presence of *Ca.* Liberibacter in the host, removal of the infected trees, integrated pest management (IPM) to limit the spread of the disease by psyllids, and elimination of sprouts developing from roots or stumps remaining in the groves after tree removal.

In Brazil and Florida, these practices have slowed, but not eliminated, the spread of HLB in infected blocks. These approaches are more effective when infections are limited and have little effect in blocks in which >25 percent of the trees are symptomatic. São Paulo, Brazil, has recently enacted a law requiring an entire block of citrus be removed when more than 28 percent of the trees in the block are *Ca.* L. positive. The policy is based on the belief that control of HLB by removal of individual infected trees is ineffective above this level of infection and that even asymptomatic trees are likely infected. Furthermore, the phytosanitation regulations require scouting at least every three months, with an official report every six months to the Centro de Defesa Ambiental (Center of Environmental Protection) of São Paulo on the inspection and eradication efforts. The state of São Paulo has increased staffing by 700 to assist in the inspection and eradication programs monitored by the Centro de Defesa Ambiental.[64]

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[61] A test called Koch's postulates is used to determine causality unequivocally. But the postulates require pure cultures of the causative organism in two stages. Since *Ca.* L. *asiaticus*, *Ca.* L. *africanus* , and *Ca.* L. *americanus* have not been grown outside their hosts and vectors, the postulates cannot be demonstrated to apply to HLB infections.

[62] Dennis O'Brien, 2009, ARS Scientists Sequence Citrus Disease Bacterium, http://www.ars.usda.gov/IS/pr/2009/090212.htm, accessed March 17, 2009.

[63] Bastianel, C., M.Garnier-Semancik, J. Renaudin, J.M. Bové, and S. Eveillard, 2005, Diversity of "Candidatus Liberibacter asiaticus," Based on the omp Gene Sequence, Applied and Environmental Microbiology 71:6473-6478. http://www.pubmedcentral.nih.gov/picrender.fcgi?artid=1287744&blobtype=pdf, accessed 3/1/2009.

[64] Steven Futch, Citrus Crop Expert, personal communication, March, 2009.

The Asian citrus psyllid (*Diaphorina citri* Kuwayama) is the vector of *Ca.* L. *asiaticus* ; it is now considered a serious pest of citrus in Florida. While the African citrus psyllid, (*Trioza erytreae* del Guercio) is the vector of Citrus Greening disease in Africa (caused by *Ca.* L. *africanus*), it will not be considered in this report because it does not play a role in the HLB infections in the U.S. Control of *D. citri* is essential to prevent the spread of *Ca.* L. *asiaticus*. Controlling *D. citri* involves a fully integrated pest management program. Control of psyllids on asymptomatic plants is important both because such control can prevent infection of uninfected trees and prevent infection of the psyllids by infected plants in the latency period. While any psyllids are a problem, as few as three nymphal psyllids and five adults on a twig indicate a lack of control and constitute a serious threat to both the infested grove and neighboring operations.

Both systemic and foliar pesticides have proven effective when applied at appropriate times to reduce psyllid levels. The recent use of low volume pesticide mists has decreased application cost and time to complete an application, thus impacting the control of the psyllids. International recommendations for citrus insecticide regimes in areas affected by HLB range from half a dozen insecticide treatments per year, primarily during the flush periods, to spraying young trees at weekly intervals during the rainy season and every 10 days during the dry season (i.e., approximately 40 treatments per year).[65] Synchronization of pesticide applications throughout a region are recommended.[66] Some Florida producers are using aerial applications to assure that the psyllids are controlled regionally rather than locally.[67]

While trapping may be used to monitor *D. citri* populations in order to determine the timing of pesticide treatments, Halburth and Manjuanth have suggested this method may not identify the most important treatment windows, since the numbers of adult *D. citri* increase very rapidly and without substantial prior increases in the populations of trapped adults. They recommend monitoring nymph populations on shoots as well as sampling of overwintered adults to observe their reproductive status.[68]

Severe pruning has been helpful in managing *Ca.* L. *africanus*,[69] however this approach has not proven effective for management of *Ca.* L. *asiaticus*. The preferred approach for *Ca.* L. *asiaticus* is to remove and destroy any symptomatic tree immediately. Hedging, topping, and fertilization are common grove management processes that impact psyllid control. Promoting synchronized flushes enhances the ability to control psyllid infestations with fewer pesticide applications. Management strategies that limit the duration of flushes, or limit the number of

[65] Gonzales, C. I., and R.C. Viñas, 1981,. Field performance of citrus varieties and cultivars grown under control measures adopted against leaf mottling(greening) disease in the Philippines in Proceedings of the International Society of Citriculture Volume 1, pp. 463-464.

[66] Aubert, B. 1990, High density planting (HDP) of Jiaogan mandarine in the lowland area of Shantou (Guangdong China) and implications for greening control, in Rehabilitation of Citrus Industry in the Asia Pacific Region. Proceedings of the Asia Pacific International Conference on Citriculture, B. Aubert, S. Tontyaporn, and D. Buangsuwon [eds.], Chiang Mai, Thailand, UNDP-FAO, Rome, pp. 149-157.

[67] Name of producer, personal communication, February, 2009.

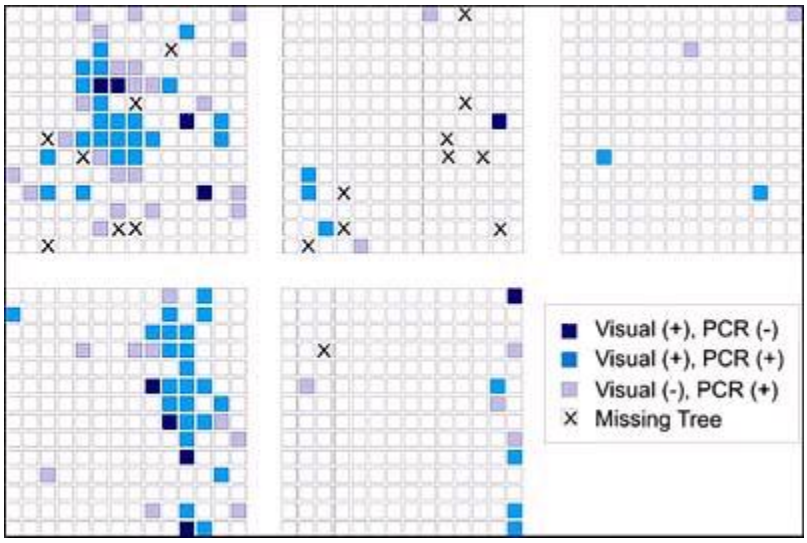
[68] Halbert, S.E., and K.L. Manjunath, 2004, Asian citrus psyllids (Sternorrhyncha: Psyllidae) and greening disease of citrus: A literature review and assessment of risk in Florida. Florida. Entomology. 87:330-353.

[69] Buitendag, C.H. and L.A. von Broembsen, 1993, Living with citrus greening in South Africa. in Proceedings of the Twelfth Conference of the International Organization of Citrus Virologists, P. Moreno, J.V. daGraça and L.W. Timmer, eds., pp. 269-273.

flushes may help to maintain lower psyllid populations and reduce the need for additional pesticide applications.

Computer modeling may allow analysis of the effects of tree removal on disease transmission.[70] Unfortunately these management models generally assume infected trees can be quickly identified, yet the existence of asymptomatic HLB infected trees is well established. In general, it has been estimated about half the infected trees in a Florida grove are asymptomatic in an infected population at any given time (Figure 4).[71] How these asymptomatic trees affect transmission is not clear for groves with moderate numbers of symptomatic trees. In groves with more than about 20 percent symptomatic trees, control efforts may be ineffective. As techniques become available to identify infected asymptomatic trees at lower costs and with less delay, the removal of these asymptomatic infected trees could substantially improve the outcome of this management approach.

Figure 4. Symptomatic and Asymptomatic Trees in Five HLB-infected Blocks in South Florida Showing Infected Trees [PCR(+)] That Are Asymptomatic [Visual(-)]



Source: After Gottwald, T.R., J.V. da Graça, and R.B. Bassanezi, 2007, Citrus Huanglongbing: The pathogen and its impact. Online. Plant Health Progress doi:10.1094/PHP-2007-0906-01-RV.

Southern Gardens Citrus Corporation, one of the largest citrus producers in Florida, has more than 16,000 acres in production in 3 large groves. HLB was detected in the southernmost grove in November, 2005. Seven infected trees were identified on the eastern edge of the property. Six scouting cycles have been completed in the three groves since the first infections were observed. The scouting has included both visual identification of HLB symptomatic trees by trained field scouts and confirmation of the symptoms by senior scouts. In less than 2 1/2 years, HLB-symptomatic trees have increased from 0.1 percent (November, 2005) to 12.6 percent

[70] Supriyanto, A. and A. M. Whittle. 1991. Citrus rehabilitation in Indonesia. pp. 409-413 In Proc.11th Conference of the International Organization of Citrus Virologists, R. H. Brlansky, R. F. Lee, and L. W. Timmer [eds.], Riverside, CA.
[71] Steven Futch, personal communication, February, 2009.

(March, 2008). Higher levels of symptomatic trees were noted in trees which were less than ten years of age. Higher incidences of HLB-symptomatic trees were observed on grove and block "edges," a pattern apparent at various spatial levels. Edge effects were evident along irrigation ditches, around ponds, at interfaces with natural areas, and boundaries between groups of younger and more mature trees.[72]

Experience in Brazil has shown that an aggressive Citrus Greening management program of scouting and identification, prompt tree removal, and spraying to reduce psyllid populations can keep tree loss rates at economically acceptable levels but is not effective in disease eradication.[73] Higher tree density provides added returns to offset higher costs from tree attrition and Citrus Greening management paractices.

The decision not to control Citrus Greening compromises the effectiveness of neighboring growers who implement disease management practices and is the least profitable strategy in an environment with Citrus Greening. Young trees need to be aggressively protected for three to five years to limit insect damage from psyllids and leafminers during establishment. Citrus trees producing more frequent flushes throughout the year are at greater risk of HLB infection than less actively growing mature trees. Systemic insecticides provide long lasting control of psyllids with limited impact on beneficial insects. These are most effective in the spring and fall, when rainfall is less likely to wash away the treatment. Foliar pesticide sprays can be used during the rainy season if psyllids are observed on young trees. Dormant sprays can reduce the over-wintering psyllid populations prior to the spring flushes, thereby reducing yearly population potential. Use of a variety of chemical and physical controls will limit the development of psyllid resistance to control practices.[74]

The current chemical control options for suppressing psyllids on mature trees are broad-spectrum foliar and soil-applied systemic insecticides. Temik® is used in mature citrus groves for the control of psyllid in the spring flush period, although Temik® can only be applied once per year and only between November 15 and April 30. The Florida Citrus Pest Management Guide (Appendix B) identifies recommended products and application regimes. Early season spraying, when temperatures are below 90°F and the tree is in feather leaf flush, are especially effective. After the spring flush, chemical controls of psyllids are less effective due to the short residual effects of the pesticides.[75]

Insecticide applications reduce psyllid populations, but also reduce the populations of predator (ladybeetles) and parasitic species (*Tamarixia radiata*, a parasitic wasp) that contribute to natural control of the psyllids. More than 90 percent of psyllids that hatch in the field do not survive to

[72] Irey, M., Gast, T., Terra, R. and Snively, J. 2008. Observations gleaned from the geospatially referenced and documented spread of HLB in three commercial groves in Florida and the implications of these observations on scouting and management decisions. Proceedings of the 2008 International Research Conference on Huanglongbing, pp. 303-304.
[73] Rogers, M.E., and P.A. Stansly, 2006, Biology and Management of the Asian Citrus Psyllid, *Diaphorina citri* Kuwayama, in Florida Citrus, ENY-739, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida.
[74] ibid.
[75] ibid.

become adults. Excessive sprays could result in resurgence of both psyllids and other pests (scales and mites) currently limited by biological rather than chemical controls.[76]

Where HLB has been confirmed, symptomatic trees are often removed quickly, especially when infections are at a level where control is still an option. Many operations with limited infections try to remove symptomatic trees the day they are identified. However, once infections are well established in a grove, lags as long as six to eight weeks before removal are not uncommon, especially during harvesting season when growers wish to harvest the crop prior to tree removal and when psyllid populations are lower during the winter months. In some groves, the level of symptomatic trees are so high growers may elect not to remove trees for economic reasons. These groves may be kept until the returns are lower than maintenance and harvest costs. Both physical and human resources contribute to these lags as the number of trees that need to be removed grows. Insecticide treatment of infected tree(s) prior to removal may limit spread of the disease by psyllids. Because psyllids are small and travel short distances, trees nearer to infected individuals are at higher risk and often receive additional scouting.

Treatment and Control of *Ca.* L. *asiaticus*

Antibiotic treatments have been generally ineffective at slowing the spread of HLB, although they have been shown to affect development of symptoms in individual trees.[77] While both penicillin and tetracycline have affected the development of Citrus Greening symptoms, neither resulted in long-term suppression of HLB. Most likely the treatments resulted in bacteriostasis (a slowing of bacterial growth) rather than bactericidal (killing bacteria) effects, since antibiotics injected into infected citrus trees does provide temporary remission of some HLB symptoms.[78] Tetracycline has also been used to treat budwood used in nursery stock development, especially in Asia[79] and Africa.[80] Achromycin treatment is currently being studied in China. The benefits of the antibiotic treatment are improved by air-pressured injection. Three annual treatments with Achromycin provided the most effective reduction of symptoms, although initially the treated trees show vein necrosis, reduced leaf size, and defoliation in response to either the antibiotic themselves or the pressure treatment. Antibiotic treatment works best on large trees showing limited effects of the *Ca.* L. *asiaticus* infection.[81] Currently this approach is not used extensively as a management or control practice in the U.S.

Regulation

Regulation is defined as imposition of rules by an agency of the government, backed by the use of penalties intended to modify the behavior of individuals and firms in the private sector.

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[76] ibid.

[77] Buitendag, C.H. and L.A. von Broembsen, 1993, Living with citrus greening in South Africa. in P. Moreno, J.V. daGraça and L.W. Timmer, eds., Proceedings of the Twelfth Conference of the International Organization of Citrus Virologists, pp. 269-273.accesssed 3/1/2009 http://www.via.es/iocv?Proceedings/XII/ Buitendag, C.H. and L.A. von Broembsen

[78] Aubert, B, 2008, Historical perspectives of HLB in Asia, Proceedings of the 2008 International Research Conference on Huanglongbing, pp 16-24.

[79] Zhao, X.-Y., 1996, Citrus Production and the Occurrence of Virus Diseases in the Mainland of China, Proceedings of the 13th Conference of the International Organization for Citrus Virology, J. V. da Graqa P. Moreno R. K. Yokomi, eds., International Organization of Citrus Virologists, Riverside, California, 8-11.accessed March, 1, 2009

[80] Gottwald, T.R., J.V. da Graça, and R.B. Bassanezi, 2007, Citrus Huanglongbing: The pathogen and its impact. Online. Plant Health Progress doi:10.1094/PHP-2007-0906-01-RV.

[81] Su, Hong-Ji, 2008, Research and Health Management of Citrus Huanglongbing in Taiwan, Proceedings of the 2008 International Research Conference on Huanglongbing, pp. 58-93.

Experience in Florida with the attempted control of ACC show the difficulty of plant disease control by regulations. The canker control regulations (now repealed) were relatively comprehensive (Appendix C), but were unable to account for the effects of natural conditions on the spread of the disease. USDA APHIS currently has a Citrus Health Response Program (CHRP) in place (Appendix D).[82] The goals of the CHRP are to sustain the citrus industry in the U.S., to maintain access to export markets, and to safeguard citrus growing states against diseases and pests.

USDA APHIS, working collaboratively with state and Federal agencies, has brought together production and practice guidelines for CHRP providing guidelines for nursery stock product compliance, fruit inspection, treatment, and certification. CHRP is currently comprised of these guidelines rather than official regulations. Even so, in light of their experiences with both ACC and HLB, producers in Florida are not generally enthusiastic about the efficacy of the program. Generally, the program guidelines provide for relatively static responses. With diseases as dynamic as Citrus Greening and ACC, it is challenging for a static plan to address the disease progression. Perhaps the most successful elements are the recommendations on production and movement of nursery stock.[83] Aggressive control of the scion, rootstock, insects, and growth medium has produced disease free planting stock. However, since to date the nursery stock is not resistant to infection by *Ca.* L. *asiaticus*, it is primarily useful as an element of a comprehensive management plan.

Quarantine

Introduction of *Ca.* L. *asiaticus* and *D. citri* to unaffected areas may occur on horticultural host plants. The pathogens are transmitted primarily by vectors or through grafts of diseased tissue used in the production of new trees. Nursery management can limit transmission through grafts, but vector transmission is difficult to control, although is being addressed through regulatory processes requiring all nursery trees to be produced in approved greenhouse structures that limit vector movement. Many dooryard fruit and horticultural species serve as a host for the HLB and the vector. *D. citri* colonized much of south Florida on orange jasmine (*Murraya paniculata*) and distributed state-wide from infested Miami-Dade County nurseries. Because of the wide range of the HLB vector, any quarantine effort would need to apply universally to active and abandoned groves, commercial and dooryard citrus, and nurseries. Such quarantines may be effective at slowing the spread of *Ca.* L. *asiaticus* to other states, but HLB is so prevalent in Florida that quarantine will be ineffective as a management strategy.

Management

In every location where HLB occurs, citrus production losses are significant and the life expectancy of citrus trees is reduced. Yet in Asia and Africa, commercial production of citrus has adapted and continued in the presence of the disease. The most successful management efforts involve use of disease-free planting stock, aggressive psyllid control, and removal and destruction of potential inoculum sources. Yet these practices are costly and cannot maintain

[82] USDA APHIS and FDACS DPI, 2006, Citrus Health Response Plan (CHRP) State of Florida 2006-2007, http://www.aphis.usda.gov/plant_health/plant_pest_info/citrus/index.shtml, accessed February 19, 2009.

[83] United States Department of Agriculture, Animal and Plant Health Services, 2007, Technical Working Group: Commercial Production and Movement of Citrus Nursery Stock from Florida to Non-citrus Producing States: Findings and Recommendations, http://www.aphis.usda.gov/plant_health/plant_pest_info/citrus/downloads/cns-twg-report.pdf, accessed February 13, 2007.

production at levels expected prior to the impact of HLB. The costs and the success of these new management practices are influenced by the extent of the problem. Early detection is essential for successful management; this requires frequent and extensive scouting and removal of infected trees to reduce disease levels and potential infection sources. Once HLB becomes widespread, there is little hope of eradication, particularly if the pathogen has become established in native or ornamental non-citrus hosts.

Given an ideal situation (a limited infection in an isolated citrus population, for example on an island), with early detection it may be possible to eradicate Citrus Greening. However, the situation in Florida is not ideal. The disease has spread over a large area and into a range of commercial and non-commercial plants. Management of HLB in Florida is the most likely outcome for the citrus industry, yet some of the elements of that management are yet to be defined.

An unproven alternative management practice has been proposed by M. Boyd for more heavily infected groves.[84] These practices require frequent treatment of the trees with a mixture of micronutrients, salicylic acid, and hydrogen peroxide. While this management approach has been described in the popular and trade presses, the practices have yet to be reported in the scientific literature. No long-term, systematic studies have been made of this practice, but producers who are facing the choice of using this approach or pushing their groves are encouraged by the short term responses of infected trees to the treatment. Extension agents, grove managers, and producers are concerned the infected trees maintained under this regime will serve as a substantial source of inoculum for less severely affected groves being managed by aggressive tree removal.

[84] Giles, F., 2007, An Alternative Approach, Florida Grower, p. 6-8.

SECTION V. CITRUS INDUSTRY IMPACT ASSESSMENT

This discussion addresses three aspects of the impact of HLB on the citrus industry in Florida. These include:

- The impact of the disease at the state level;
- The impact of the disease at the producer level; and
- The impact of the disease on the FFT program.

There is no doubt the economy of the state of Florida (and other citrus producing states) and of the individual citrus producers has been harmed by the introduction of *Ca.* L. *asiaticus* into the state and by the spread of HLB into commercial groves. Other citrus producing states in the U.S. will be negatively impacted by the spread of the psyllids and of *Ca.* L. *asiaticus*. The industry is in a state of flux and precise predictions of these changes cannot be made. There is also no doubt significant tree deaths have already occurred and will continue to occur as a result of HLB. Federally-subsidized insurance would limit the financial impact on individual producers. As a result of a variety of unrelated factors, it is less clear how an infusion of insurance indemnities at the individual level would impact the industry as a whole, and consequently the economy of the state.

The Impact of HLB on Florida

The subtropical climate and the unique soils in Florida support a citrus industry whose total economic impact exceeds $9 billion. More than 76,000 people are employed in a wide range of occupations and professions linked to the industry. While oranges are the dominant crop in Florida, grapefruit, Temple oranges, tangerines, tangelos, and other specialty crops all contribute to the state economy.[85]

Only a small fraction of Florida oranges are sold into the retail fresh fruit market, but Florida trees supply the vast majority of the U.S. orange juice industry. Historically, more than 90 percent of America's orange juice has been made from Florida-grown oranges. Although foreign competitors have recently gained market share, most of the citrus juice consumed by Americans is produced in Florida with imported juice as required to meet market demand in years of short domestic supply. Yet given the rapid spread of HLB, the high mortality, and the lack of effective treatments, Citrus Greening has the potential to devastate citrus production in the U.S. and to have a major impact on the Florida economy.

The state of Florida and the USDA National Agricultural Statistics Service (NASS) maintain substantial records describing the current and historic status of the citrus industry in Florida. Reports such as the Commercial Citrus Inventories,[86] the Florida Citrus Summary,[87] the Florida Department of Citrus Annual Report,[88] and the Florida Citrus Outlook[89] provide a picture of an

[85] Florida Department of Citrus, 2008 Citrus Facts, http://www.floridajuice.com/juice.php.

[86] United States Department of Agriculture, National Agricultural Statistics Service, 2008, Commercial Citrus Inventory Preliminary Report, http://www.nass.usda.gov/Statistics_by_State/Florida/Publications/Citrus/ccipre/ccipr08.pdf, United States Department of Agriculture, National Agricultural Statistics Service, 1990-2006, Commercial Citrus Inventories, 1996–2008 (preliminary). http://www.aphis.usda.gov/plant_health/plant_pest_info/ citrus_greening/background.shtml /Statistics_by_State/Florida/Publications/Citrus/index, accessed February 7, 2009.

[87] United States Department of Agriculture, National Agricultural Statistics Service, 2008. 2007-08 Florida Citrus Summary, http://www.nass.usda.gov/Statistics_by_State/Florida/ Publications/Citrus/index, accessed February 7, 2009

[88] Florida Department of Citrus, 2007, 2006 – 2007 Annual Report, http://www.floridajuice.com/user_upload/files/annual%20r_486b85a52ed08.pdf, accessed February 1, 2009.

industry that has been challenged by both economic and environmental factors. Nonetheless, it is also a picture of an industry remarkably responsive to those challenges. Virtually all sectors in the Florida citrus industry are assessing the challenges posed by the HLB epidemic and attempting to determine appropriate and effective strategies to counter the threats posed. Both the unusual coalescence of the citrus industry world-wide and the remarkable efforts to address this disease in Florida are reflected in Proceedings of the International Research Conference on Huanglongbing held in Orlando, Florida in December of 2008.[90]

Citrus Greening, although relatively new to the state, is rapidly affecting both the citrus industry and the economy of the state. Citrus producers, processors, managers, laborers, and consumers will all be affected by the changes to the industry caused by HLB, as will the many auxiliary industries that support citrus production and marketing. As supplies of oranges decline, higher prices for citrus products are one likely outcome. However, it is not likely prices will rise enough so the Florida citrus industry as presently structured can remain viable.

The ability of the industry to raise prices will be constrained by competitive offerings of other beverages, competition from other countries to supply the U.S. with orange juice, and limitations on disposable income of the consumers. Orange juice is just one of a number of beverages consumers can choose to purchase. Preferences, price, and marketing all impact the consumer's choices. At the same time that consumer demand has decreased, Florida citrus acreage and production have also experienced declines, reflecting both environmental and market factors. Some of the recent decreases in U.S. production resulting from weather and disease were offset by imports of juice products, primarily from Brazil.[91] Furthermore, even before the current economic crisis in the U.S, the growth in median family income was slow, and the per capita disposable income was declining. Limited financial resources of at least a portion of those who used to drink orange juice may have accounted for part of the recent decline in U.S. consumer demand.[92] This confluence of constrained consumer resources, declining U.S. supplies, changing patterns of exports, and introduction of new diseases into both Brazil and the U.S. created a complicated world-wide production/demand system.

One direct effect of HLB on the state is an increase in regulatory activities both in the field and for citrus nursery tree production. As a result of ACC, production of nursery stock had already been restricted to controlled environments under the Citrus Health Response Program (CHRP). Replacement trees must now be grown in enclosed structures (greenhouses) having extensive environmental control and pest control practices. These requirements have doubled the cost of replacement trees, while the nurseries attempt to meet the expanding demand for replacement trees. Trees for delivery in 2009-10 are priced in the range of $8 to $10 per tree as compared to

[89] Brown, M.G., 2008, The Florida Department of Citrus, Economic and Market Research Department, 2007, Florida Citrus Outlook 2007-08 Season, http://www.floridajuice.com/pdfs/Outlook2007-08-103107.pdf, accessed January 31, 2009.

[90] This conference was organized by Timothy Gottwald (USDA, ARS), Wayne Dixon (Florida Department of Agriculture and Consumer Services Division of Plant Industry), James Graham (Institute of Food and Agricultural Sciences, University of Florida, and Philip Berger (USDA, APHIS), but hundreds of Florida researchers and producers participated, along with industry representatives from around the world.

[91] Florida Department of Citrus, 2007, Florida Citrus Production Trends 2008-09 Through 2017-18 Update, http://www.floridajuice.com/user_upload/files/trends20_4769381f2ac7e.pdf, accessed February 1, 2009

[92] Florida Department of Citrus, 2008, Citrus Crop Utilization, , http://www.floridajuice.com/user_upload/files/0607%20yrb_482d733fdd37f.pdf, accessed March, 2009.

$4 to $5 just 2 years ago. Increased cost of replacement trees and higher production costs are affecting both citrus producers and producers of nursery stock.

These changes also affect the Florida Department of Agriculture and Consumer Services, Division of Plant Industry, which certifies the resulting stock. The state has instituted an Abandoned Grove Initiative. Under this initiative, all abandoned groves are to be categorized and inventoried. An important component of the initiative is to inform "owners that if they take action and eliminate any live citrus trees in abandoned groves, this will be considered a *bona fide* agricultural practice and owners will remain in compliance with CHRP guidelines, thus maintaining their agriculture property tax status."[93] While this program will be costly, it is impossible to quantify the economic effects of either the implementation of the program or the substantial economic benefits to agricultural production resulting from that implementation. Florida also supported an aerial spraying experiment in limited areas from December 1, 2008 through February 1, 2009. The state offered services to scout for pests and disease at grower request (subject to resource availability) and disease recognition training.[94] In December, 2008, the Florida Citrus Commission approved 83 Citrus Greening and ACC-related projects recommended by its Long-range Planning Advisory Council in conjunction with a review panel organized by the National Academy of Sciences. Approximately $20 million of funding was set aside for this research, largely from funds that would in the past have supported marketing and market research. In March of 2009 more than 30 additional HLB projects were funded. The vast majority of these funds are derived from grower assessments and taxes on citrus produced in Florida.

It is evident one impact of Citrus Greening will be greater involvement by the state in promoting collective action by growers to control the disease. However, the full quantitative economic impact of HLB on the state of Florida cannot currently be assessed, in part because of rapid changes resulting from the disease in the U.S., in part because there are similar changes occurring in the Brazilian citrus industry, and in part because other market factors are at work. Consequently, detailed projections of the anticipated changes in the industry structure caused by HLB are not possible.

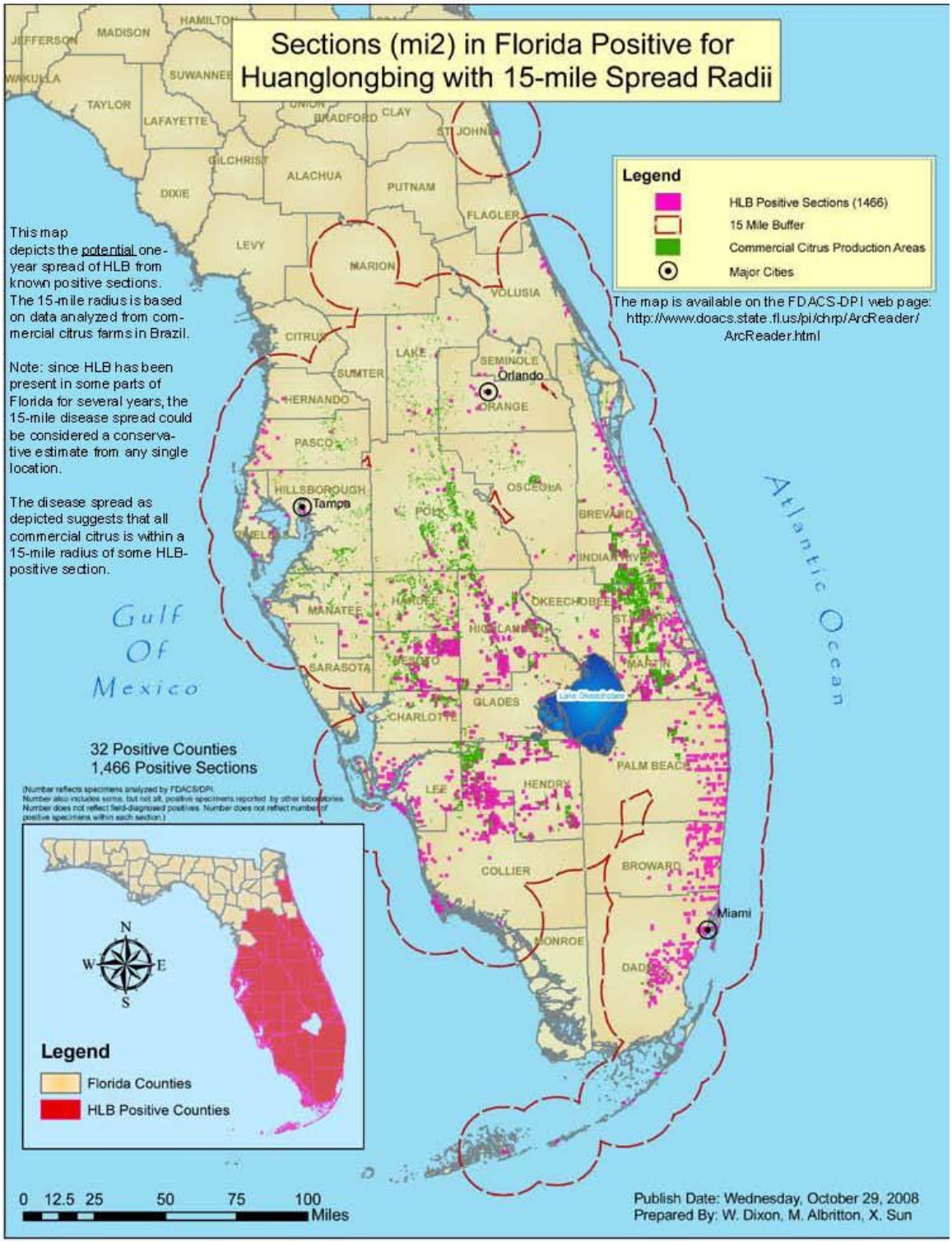
The Impact of HLB on the Producer

One element of the producer-level impact of HLB is to consider the geospatial distribution of the disease and geospatial patterns of the disease progression. In 2008, HLB had been detected in 32 counties, including all the counties where citrus is produced commercially. Moreover, mapping of HLB-positive sections and regions where infection is likely to spread by the end of 2009 (Figure 5) shows that *Ca*. L. *asiaticus* is likely to be endemic throughout most of the state. The State of Florida, Division of Plant Industry publishes frequent updates on the Citrus Health Response Program (http://www.doacs.state.fl.us/pi/chrp/). These data are useful in supplying a "snapshot" of disease conditions. However, no agency has sampled uniformly throughout the state or in all commercial groves. Yet, for the purposes of this economic assessment it is reasonable to assume that every commercial grove is either infected with HLB or at immediate risk of infection.

[93] Florida Department of Agriculture and Consumer Services Division of Plant Industry, 2009, Citrus Health Reponse Program Update, http://www.doacs.state.fl.us/pi/chrp/documents/chrp_update_jan_2009.pdf, accessed March, 2009.
[94] ibid.

A second geospatial issue affecting the producer is the location of abandoned citrus acreage, both within the state and relative to insured groves. It is not possible to quantify either of these patterns at this time. However, the Division of Plant Industry is actively collecting data on the location and ownership of abandoned citrus groves, initially with an emphasis on properties near commercial citrus production areas. Beginning in April, 2008, representatives from the Division of Plant Industry CHRP offices began contacting abandoned grove property owners to determine the current and proposed future disposition of the land. These data are important to the development of appropriate models to address the impact of substantial inoculum pools on insured groves.

Figure 5. Map Illustrating Areas Potentially Affected by HLB in 2009, HLB-positive Sections, and HLB-positive Counties (inset)



Source: After Florida Division of Plant Industry, 2008, Citrus Health Response Program Update December 2008, http://www.doacs.state.fl.us/pi/chrp/documents/chrp_update_dec_2008.pdf, accessed December 30, 2008.

Limited quantitative epidemiological studies have been conducted to characterize the spread of HLB. Tree removal; latency; and the duration of the disease in trees, blocks, and groves, all complicate the collection of suitable epidemiological data.[95] The removal of infected individuals from a population to causes other than death (e.g., tree removal as a management practice) introduces an element of uncertainty into any epidemiological study. The long and poorly understood latency period for HLB requires research over years or even decades to obtain spatial-temporal analyses. Furthermore, variability in the timing of expression of classical disease symptoms limits the understanding of the spread of HLB that can be obtained without molecular biological diagnostic procedures. Consequently, both asymptotic and logistic models have been utilized to evaluate disease progression.[96]

Longer term epidemiological data are available for Reunion Island and mainland China, while preliminary data are also available for Taiwan, the Philippines, Brazil, and Florida. Asymptotic modeling based on these studies suggests the effects of the infections should stabilize after 13 years, while logistic modeling suggests HLB effects should stabilize after 7 to 13 years.[97] Unfortunately, as new technologies (i.e., pesticides, antibiotics, and resistant stock) come into play, the effects of these elements are not easily incorporated into the models based on less technological production areas.

Analysis of the prevalence of and location of symptomatic trees has revealed two spatial patterns for the spread of HLB by the psyllids. Locally, the vector spreads the disease to adjacent and nearby trees. However, there are also clusters of symptomatic trees about 75 to 150 feet from the initial focus of infection.[98] Longer distance vector transmission studies have not been completed, although psyllids have been observed traveling on fruit and nursery plants (both commercial and ornamental species). Trees near roads and in the outer rows of trees in blocks are more likely to show the symptoms of HLB early in the spread of the disease. It is unclear whether this pattern reflects some sort of biological edge effect (for example a different structure or prevalence of flushes in those trees) or implicates the roadways in the spread of the disease. The disease course seems to be influenced by the species of the disease organism (i.e., *Ca. L. asiaticus*, *Ca. L. africanus*, or *Ca. L. americanus*,), the vector, the host species (e.g., sweet orange or grapefruit); by the physiological condition of the host trees, by weather and traffic patterns, and by management practices. This complex system of controlling factors limits the utility of patterns observed outside Florida in the assessment of the impact of HLB in Florida.

Citrus are affected by a variety of environmental and biological agents. Some symptoms of HLB are similar to symptoms from other diseases, mineral deficiencies, and insect pests. These similarities make scouting and identification of all HLB-positive trees a difficult and expensive task. Nonetheless, visual HLB symptoms observed during scouting can be used to illustrate the rapid spread and devastating potential of *Ca*. L. *asiaticus*. In the citrus grove illustrated in

[95] Gottwald, T.R., J.V. da Graça, and R.B. Bassanezi, 2007, Citrus Huanglongbing: The pathogen and its impact. Online. Plant Health Progress doi:10.1094/PHP-2007-0906-01-RV.

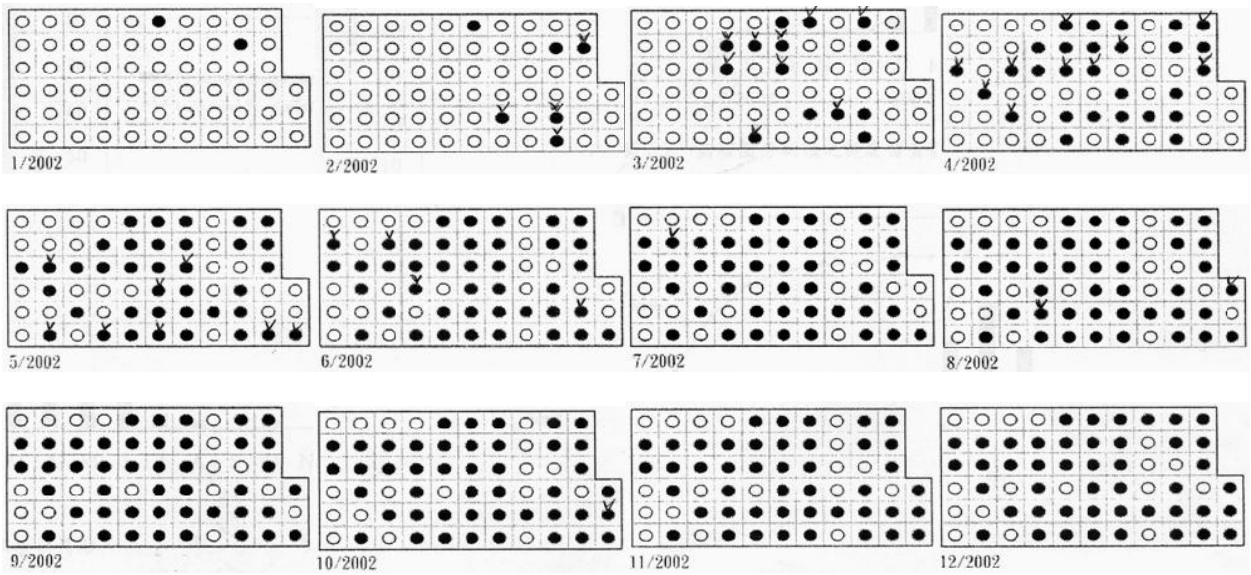
[96] Gottwald, T.R., A. Bergamin-Filho, R. Bassanezi, L. Amorim, M. Irey, X. Zhao, and B. Aubert, 2007, Concepts in Huanglongbing Epidemiology in The International Workshop for Prevention of Citrus Greening Disease in Severely Infested Areas : December 6 and 7, Japan International Research Center for Agricultural Sciences, p. 1-10. http://hdl.handle.net/10113/10003 http://hdl.handle.net/10113/10003, accessed March 5, 2009.

[97] ibid.

[98] ibid.

Figure 6, the number of symptomatic trees increased from 2 (3%) in January to 46 (73%) in October.

Figure 6. Time Course of the Spread of HLB Symptoms in a Taiwanese Citrus Block in an Orchard Planted with Disease-free Stock*

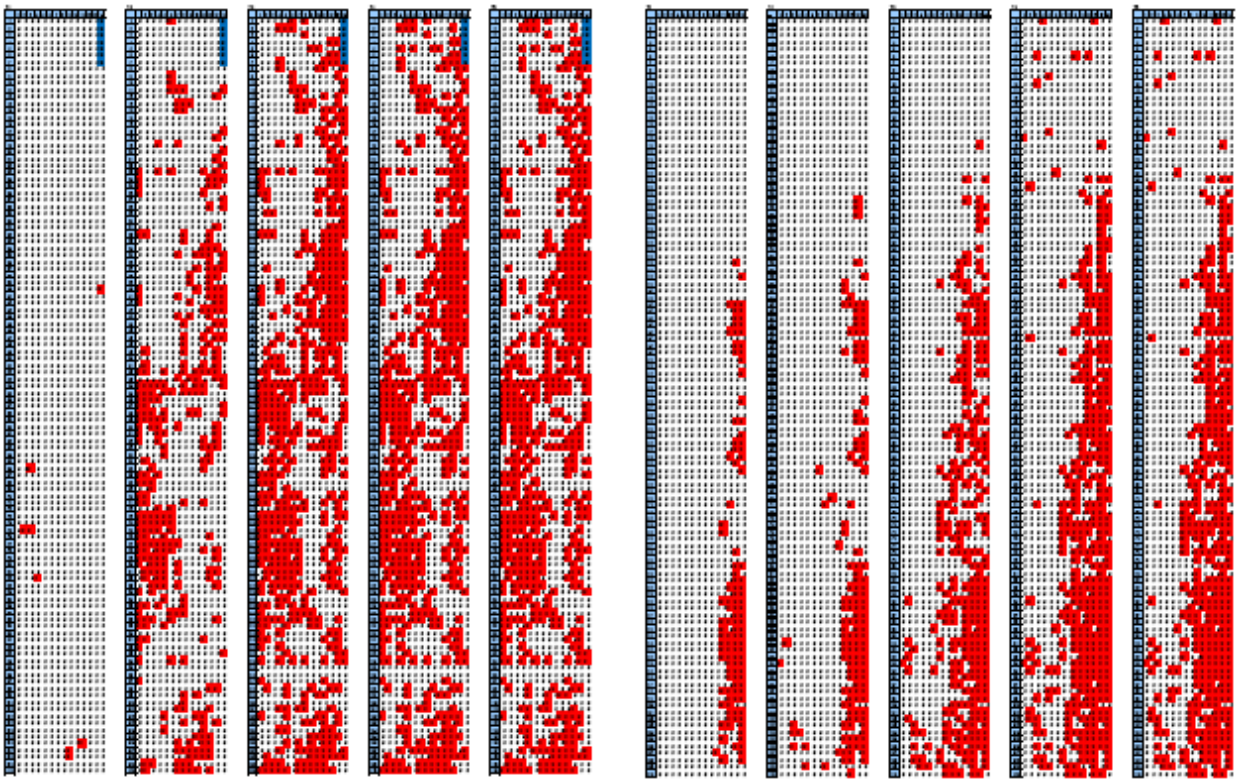


* Symptomatic trees are shaded. Newly symptomatic trees are also checked (✓). In this example, symptomatic trees were not immediately removed from the block.

Source: After Su, Hong-Ji. 2008. Research and Health Management of Citrus Huanglongbing in Taiwan, Proceedings of the 2008 International Research Conference on Huanglongbing, pp. 58-93.

The increase in the number of symptomatic trees is not always as dramatic as that seen in Figure 6, nor are the responses uniform, even in a single grove (Figure 7). Location of innocula sources, edge effects, tree age, tree health, variety, and season each affects the spread of HLB. As these patterns become more evident and data on the spread of HLB in Florida are collected, a clearer picture of the impact of the disease on the industry will emerge.

Figure 7. Time Course of the Spread of HLB Symptoms in Two Florida Citrus Blocks in Five Scounting Cyles over Two Years*



* Symptomatic trees are red. In this example, symptomatic trees were removed from the block as soon as possible.
Source: After Gottwald, T., Irey, M. and Taylor, E. 2008. HLB Survival Analysis – A Spatiotemporal Assessment of the Threat of an HLB positive Tree to its Neighbors, Proceedings of the 2008 International Research Conference on Huanglongbing, pp. 253-257

Polymerase Chain Reaction (PCR) analysis has been used both to verify HLB infection in symptomatic trees and to identify infected asymptomatic Florida trees. Uniform procedures for these analyses are incorporated into the USDA APHIS New Pest Response Guidelines: Citrus Greening Disease.[99] The University of Florida and U.S. Sugar laboratories have evaluated samples from more than 100,000 Florida trees.[100] However, this molecular biological testing is costly and the search is underway to identify faster and less costly alternatives. Scouting has already increased producer costs substantially. If testing becomes a required management practice for the FFT insurance, the impact of these costs on producers must be considered.

A range of HLB management alternatives are currently employed in Florida. Some producers, especially those whose groves are heavily affected, are implementing very limited responses to the disease. Experience in Brazil has shown that once a substantial population of trees in a grove is infected with *Ca. L. asiaticus*, the grove will be economically viable for only one to three

[99] United States Department of Agriculture, Animal and Plant Health Inspection Service, 2008, New Pest Response Guidelines: Citrus Greening Disease, http://www.aphis.usda.gov/plant_health/plant_pest_info/citrus_greening/downloads/pdf_files/cg-nprg.pdf, accessed March 3, 2009.

[100] Michael Irey and Paul Julian, personal communications, February, 2009.

years. Based on observations in Brazilian groves where no control was undertaken, even productive trees have losses of production approaching 50 percent (50%) during this period of decline. When the grove fails, it is abandoned, removed, or replaced. Abandonment and removal will reduce citrus acreage under production, total citrus production in the state, and demand for auxiliary services such as processing, scouting, equipment sales, and services. They also eliminate a source of producer income. Replacement introduces substantial additional costs, with biological and economic risks that are not fully understood. Replacement does maintain the grove population density, and consequently income from citrus fruit production, especially beyond the third or fourth year after replacement.

Aggressive management practices limit the effects of HLB, but increase production costs. Scouting and spraying to control psyllids are estimated to increase costs of caring for a mature Florida Valencia orange grove from $911 per acre to $1,289 per acre, an increase of 41 percent.[101] With open market prices currently depressed (currently ≈ $0.80 to $0.90 per pound solids) by large citrus processor inventories, income from production is likely not to meet the costs of production and HLB management. At $1.25 per pound solid delivered to the processing plant, the net present value of the groves is estimated at $2,605 without control efforts for Citrus Greening and at $5,129, with full Citrus Greening management practices (4 additional pesticide treatments, 4 scouting cyles per year, and replacement of trees that are lost or removed). Futher challenging the producer, a precise determination of the net present value of a grove is not possible, except perhaps on a grove by grove basis where prices are established under a long term contract. Consequently, management decisions are poorly informed by the available quantitative cost and income information.

Many producers, academics, and grove managers believe that HLB will effect major changes throughout the industry. It is likely that additional economic abandonment of citrus groves will occur, especially for groves where production is not under contract. Groves with substantial infection levels can not be managed using traditional tree replacement practices. These groves will be abandoned, pushed, or possibly reestablished, depending on the economics and the disease pressure. Groves with minimal infections (i.e., <2%) will require aggressive management practices that can not be supported by open market sales at current prices. Consequently, many changes are anticipated, including further industry consolidation, and eventually higher farm-level, wholesale, and retail prices for Florida citrus products. These changes will inevitably affect the position of the Florida citrus industry, and consequently of the U.S. in the global market for citrus products. The ripple down effect of these changes to the entire economy of the state will be enormous.

HLB has already had a substantial impact on the citrus industry in Florida. Most citrus producers in Florida have operated on thin margins over the last 20 years. Freezes, hurricane, disease, and the public policies related to disease management have each lead to years with substantial yield reductions. In years when citrus yields are higher, market prices are depressed. One effect of these patterns has been a consolidation of the industry, with the departure of both smaller producers and smaller processors. While some of the groves from the smaller producers have been incorporated into groves of major producers, many others were abandoned or are

[101] Morris, A. and Muraro, R. 2008. Economic Evaluation of Citrus Greening Management and Control Strategies. University of Florida IFAS Extension, http://edis.ifas.ufl.edu/document_fe712, accessed February 11, 2009.

maintained at a minimal level to "harvest" special property tax rates for agricultural land. These patterns of producer response are likely to continue, changing the demographics of the Florida citrus producer.

The Impact of HLB on the FFT Program

The historic production model for citrus in Florida, and consequently the model upon which the FFT program was structured, anticipated a productive tree life span of approximately 50 years. This model is no longer viable, either as the basis for a business plan or for an FFT incorporating Citrus Greening as an insurable cause of loss. Barring development of an effective control mechanism for Citrus Greening, growers are likely to shift to a production model in which the expected lifespan of a block may be as little as 15 years. This shift will necessarily affect the FFT insurance program, in part because of changes in tree age-structure within the typical grove, and in part because "normal" mortality will be substantially greater than that modeled in the current rating structure. There are not sufficient data to evaluate either of these effects at this time. However, the substantial data currently being collected should be considered as they become available.

SECTION VI. INSURANCE RISK AND MITIGATION STRATEGY

This section considers the impacts and potential design issues which including Citrus Greening as a cause of loss for the FFT plan would induce to the provisions, underwriting guide, loss adjustment standards, and county special provisions. A summary of potential mitigation approaches to minimize the effects of identified risks on program integrity is included.

FFT Crop Provisions

Section 1 – Definitions

Add a definition of Citrus Greening that addresses the issue of symptomatic and asymptomatic infected trees.

Modify the definition of destroyed tree so it includes a tree that exhibits the symptoms of HLB. One definition to minimize the implications of identified risks on program integrity can be formed by adding the following language to the existing definition: "With respect to HLB, a destroyed tree is any tree that an agricultural expert determines to be infected and that will be removed not later than NN days following the end of the insurance period. Trees identified as infected using PCR testing or similar biochemical tests will also be considered destroyed." A provision such as this requires a positive assessment of the existence of the infection by a person trained to identify HLB. This could be a loss adjuster with appropriate training. A scout, paid by the producer, could be considered to have a conflict of interest with regard to the identification of affected trees. Biochemical testing would need to be conducted by an approved laboratory. Some mechanism to tie the results of the testing to particular trees would be required. The provision should also require "immediate" removal of the symptomatic tree to establish the "destruction" of the tree, although a short delay after the end of the insurance period is needed to accommodate discovery of symptomatic trees late in the insurance period.

Once a tree is identified as symptomatic, insurance will not attach to it for the following crop year under the terms of section 8(b) of the Crop Provisions. However, if the tree is not removed, it is not considered as destroyed; hence, no indemnity is payable.

Immediate removal would be an appropriate strategy to eliminate a source of infection for other trees in the unit. This strategy also eliminates uncertainties about when a tree should be considered so unproductive that it is considered destroyed in some year after the initial discovery of the infection (during which intervening period it is a source of infection).

Section 8 – Insured Crop

Section 8(b) states that the insured crop does not include trees that: "(3) Are unsound, diseased, or unhealthy; or (4) no longer have the potential to produce a yield typical of healthy trees of the same age as the subject trees, unless such trees were topworked or buckhorned and qualify as stage I or II." While none of the terms in section 8(b)(3) are defined, common usage would consider trees that

display symptoms of HLB as diseased. Depending on how rapidly HLB spreads within a tree, it may not be capable of producing a yield typical of healthy trees shortly after it displays initial symptoms. These provisions considered singly or jointly appear to deny coverage on a tree infected with *Ca.* L. *asiaticus* for crop years after it is discovered, as described earlier. Revised language would be needed if a tree is not considered destroyed immediately.

Add a provision that insurable trees on the unit must be certified free of HLB by an agricultural expert on or before the sales closing date for the initial year of coverage if HLB is added as an insurable cause of loss. Any trees with existing symptoms of HLB would be determined uninsurable under the terms of section 8(b). If coverage is continuous, newly infected trees would be covered. This raises the question of whether asymptomatic trees showing the presence of *Ca.* L. *asiaticus* through a biochemical test are free of HLB or not free of HLB under the terms of the provisions.

Section 12 – Settlement of Claim

As discussed earlier, the current provisions in section 12(b) do not appear to include HLB within the definitions of damaged or destroyed trees. For the reasons discussed in that section, the terms of this section must be modified as well to accommodate inclusion of HLB as a covered cause of loss.

Special Provisions

Section 10(a)(5) of the Crop Provisions requires a statement on the Special Provisions to describe the coverage provided for "insects, diseases, and other pathogens." Coverage for HLB would fall within these terms and require a precisely worded statement to describe the extent of the coverage. Pursuant to the definition of destroyed tree proposed earlier, an appropriate statement could be worded as follows: "In accordance with section 10(a)(5) of the Crop Provisions, HLB is a covered cause of loss provided the determination of the infection is made by an agricultural expert."

Underwriting Guide

Section 3 – Definitions

Add the definition of Citrus Greening included in the Crop Provisions.

Modify the definition of destroyed tree to reflect the modified definition included in the Crop Provisions.

Section 4 – Background Information

The discussion within this section does not recognize two causes of loss specifically authorized by the Crop Provisions, as follows: (1) flooding due to high groundwater levels, if allowed by the Special Provisions; and (2) insects, diseases, and other pathogens, as specifically provided by the Special Provisions. At a minimum, these causes of loss should be added. Specific discussion about Citrus Greening in this section may or may not be needed; however, since it

discusses the addition and deletion of citrus canker, limited discussion of Citrus Greening may be appropriate.

Section 10 – Insured Crop

Changes would be needed to accommodate any changes to section 8 of the Crop Provisions.

Florida Fruit Tree Pilot Loss Adjustment Standards Handbook (LASH)

Section 2 B – Terms, Abbreviations, and Definitions

Add the definition of Citrus Greening included in the Crop Provisions.

Modify the definition of destroyed tree to reflect the modified definition included in the Crop Provisions.

Section 4 – Florida Fruit Tree Appraisals

Modify sub-section A to re-define a stand of damaged trees (SDT). The LASH is written with the premise that a cause of loss has caused damage to an entire unit but with "pockets" in which the damage may be worse than in other "pockets." Hence, the appraisal methods rely upon sampling one or more areas within the unit and measuring the amount of damage within each area. Infections by *Ca.* L. *asiaticus* may or may not be concentrated into specific areas within the unit since the cause of loss is not widespread as is the case with freezes and windstorms. The entire unit is the most likely SDT for Citrus Greening, and individual trees that exhibit symptoms within the unit should be appraised.

Modify sub-section B to state that infections by *Ca.* L. *asiaticus* is determined on a tree by tree basis. Selection of a sample is not appropriate.

Modify sub-section C to state that all trees that exhibit symptoms of Citrus Greening are included in the sample.

Section 5 – Appraisal Methods

Sub-section 5A – General Information

Add a new appraisal method as follows: Citrus Greening.

Add a new use as follows: To measure and appraise the number of trees that exhibit symptoms of Citrus Greening.

Sub-sections 5B and 5C – Damage Occurring During the Year of Set-out and Damage Occurring in Any Year Following the Year of Set-out

Modify both sections to describe the method used to declare a tree as destroyed when HLB is found to be present.

Appendix III (Manual 13) Data Acceptance System

Add a new cause of loss code for Citrus Greening so this particular cause of loss may be specifically tracked in the database.

The foregoing does not constitute a recommendation that HLB be added as a covered cause of loss, but instead provides guidance as to a method to minimize adverse selection and to assure that only losses due to the disease are covered. The conceptual basis of the coverage can be described as follows:

1. Trees on the unit must be certified free of *Ca.* L. *asiaticus* or HLB on or before the sales closing date for the first year of coverage by an agricultural expert or infected trees must be identified and excluded from insurability. A break in continuity requires a new certification of the condition of the trees since it would once again become the first year of coverage.

2. Infected trees discovered during the insurance period must be removed promptly. Identification must be made by an agricultural expert as this term is defined in the Basic Provisions. If not removed, the trees are not insured in any subsequent crop year and no indemnity is paid for the current crop year.

SECTION VII. FEASIBILITY RECOMMENDATIONS

As outlined earlier, an amendment to a policy is feasible when:

- There is enough interest in the insurance for the risks insured to be spread over an acceptable number of insureds and appropriate geographic areas;
- Peril(s) addressed by the amendment are identifiable;
- Effective loss control mechanisms for the peril are available;
- An actuarially-sound premium rate addressing all perils can be determined and charged to customers who are willing to pay the price;
- Customers cannot adversely select against the program;
- Moral hazards are avoidable or controllable; and
- The insurance cannot unduly disrupt local, regional, or national markets.

The Contractor identified specific tests of the feasibility of an amendment to the FFT insurance policy incorporating HLB as an insurable cause of loss. The outcomes of incorporation of HLB as a cause of loss under the FFT policy using these tests are detailed below:

- *There must be enough interest for the risk to be spread over an acceptable pool of insureds.* Current experience with the FFT program suggests that the critical population size criterion will easily be met if HLB can be incorporated as an insurable cause of loss for FFT policies offered at a price that is acceptable to producers. While the pool of insureds for FFT insurance has declined somewhat, it is safe to say a subsidized insurance plan indemnifying tree losses caused by this disease would gain almost universal acceptance. Assuming rates for FFT insurance covering losses caused by HLB reflect the actual risk, the subsidy provides an attractive incentive to participate in the program. The citrus community is broadly engaged in responding to a variety of issues related to HLB infections. This engagement is another element supporting the contention that "an acceptable pool of insureds" would participate in the program.
- *There must be an appropriate geographic distribution of production to assure a sound financial basis for the insurance.* In Florida, the citrus production community extends across the state in the southern counties. Citrus trees are currently insured under the FFT program in all 27 counties where the insurance is offered. The only limitation on meeting the geographic distribution criterion would be the relatively uniform geographic, geological, agricultural, and weather characteristics in the Florida citrus production area. Since Florida has declared the entire state to be at risk of infection within one year (see section III), there is little chance that losses in one part of the state can be counted on to be offset by gains in another part. Whereas hurricanes and freezes typically impact portions of the state and vary in severity within the areas where the damage occurs, *Ca.* L. *asiaticus* appears to be capable of causing losses in every part of the citrus area of the state in any year. The key to understanding this requirement is knowledge of how rapidly the disease will spread within infected groves and among areas of the state.
- *Producers or their agents must be willing to pay the appropriate price for the insurance.* Since the study was initiated because of concerns about the impact of HLB on all elements of the Florida citrus industry, there is *a priori* evidence of customer interest. All producers who addressed the issue with the Contractor indicated an interest in the insurance. The willingness of producers or their agents to pay the cost of FFT expanded to incorporate HLB as a cause of loss will be influenced primarily by the added costs

associated with an expansion of the list of insurable perils. However, decisions to purchase the insurance will also be impacted by any required underwriting constraints.

- *Perils affecting production must be identified and appropriately categorized as insurable or not insurable*. HLB is easily identified in symptomatic trees. Experienced scouts can accurately identify affected symptomatic trees with accuracy greater than 90 percent (90%). In addition, HLB can be identified in asymptomatic trees using Polymerase Chain Reaction (PCR) genetic testing. While both scouting for visible symptoms and PCR testing are expensive, the criterion that the cause of loss is identifiable is met. Citrus Greening would be classified as insurable under the product design the Contractor was to evaluate under this contract.
- *Appropriate loss controls must be available so that best practices can be defined and required of producers*. It is not currently possible to identify appropriate, comprehensive loss control procedures for HLB infections in Florida. Experiences in other countries suggest eradication of HLB is not feasible. There do not appear to be groves in Florida that are completely free of HLB infections.[102] The only mechanism to demonstrate freedom from infection is testing using biochemical techniques such as PCR. While testing every tree in a grove would be both expensive and logistically difficult, negative results from such testing would not be unequivocal, since sectoral infections within asymptomatic trees increase the probability of false negative results. While recommended practices for very mild infections (<1 percent (1%) of trees) of HLB and extensive infections (>30 percent (30%) of trees) of HLB are available, many groves have infections in the range (1 percent (1%) $\geq X \leq$ 30 percent (30%)) where best practices have not been clearly defined. Furthermore the existence of infected asymptomatic trees makes enforcement of any defined best practice difficult. However, so long as the insured cannot select against the insurer by knowingly insuring infected trees with visible symptoms, an insurance offer fair to both parties could be possible. Since experience shows that infected trees will die within a relatively short period of time, the most appropriate insurance design most likely is to pay an indemnity (for losses exceeding the deductible) immediately upon detection of the disease and removal of the tree. Known infected trees must be subject to the Crop Provisions that deny coverage to diseased trees.
- *It must be possible for an actuarially-sound premium rate to be determined*. Current data are not adequate to determine an appropriate premium rate. Data currently being collected by Florida through a survey of producers for the crop year that ended in 2008 may provide information that would be useful. However, since it is only one year, the information will be limited.
- *Customers must not be able to select insurance only when conditions are adverse.* Currently HLB infections are endemic in Florida. At this time, a transition from the historic longer-lived, more productive grove structure to a less productive grove with a shorter financially-viable life appears inevitable, barring any immediate breakthroughs via the extensive research effort now being mounted by the citrus industry and the state. There is a risk that some growers might engage in actions to maximize infected trees so that the transition is paid in part by the insurance.

[102] Dr. Steven Futch, Crop Expert, personal communication, February, 2009.

- *Moral hazards must be avoidable or controllable. There must be a clearly defined outcome or phenomenon to be insured and the outcome must be subject to random variation; the variation in outcome must be separable into that part which can or might be manipulated, and that part which cannot be controlled.* Mitigation strategies for HLB infections of citrus in Florida are not yet well defined. Appropriate management practices for very mild infections (<1 percent (1%) of trees) and extensive infections (>30 percent (30%) of trees) are generally accepted within the industry, but for moderate levels of infection, the practices to minimize tree losses and behaviors to minimize financial losses may not be completely congruent. The existence of infected asymptomatic trees makes enforcement of any defined best practice difficult unless these practices are uniform for any level of infection.
- *There can be no chance of beneficial gain.* The citrus industry in Florida has been in flux for decades. Freezes in the 1980's, competition from Brazil, ACC, hurricanes (especially those in 2004 and 2005), rising and declining land values, and the recent limitations on credit availability have all contributed to this instability. An insurance structure for FFT incorporating HLB as a cause of loss that would not provide some individuals substantial beneficial gain is inconceivable. Under these circumstances, informational asymmetries benefiting the insured and penalizing the insurance provider are inevitable. While the insurance might be only a vehicle to manage HLB risk for many producers, for others it would provide a buffer for losses associated with land speculation, decreased production associated with changes in management practices, and international completion. Furthermore, even for insureds focused on production, indemnity payments could become a fundamental element of the typical income stream as regular tree replacement increases from two to four percent (2%-4%) to six to eight percent (6% - 8%) per annum, thereby increasing indemnities from zero to one to three percent (1% - 3%) of the liability under the Occurrence Loss Option. This suggests that the deductible under the Option perhaps might be increased to ten percent (10%) so that normal tree replacement costs continue to be absorbed by the insured.
- *There must be no unacceptable change in market behavior or unacceptable market distortions in terms of either a change in quantity supplied or shift in the supply curve.* In the U.S., there has been an historical division of the citrus production between Florida (which has provided primarily citrus for juice) and the rest of the citrus producing states (which have produced primarily for the fresh fruit market). It is not possible to anticipate the specific market changes that will result from HLB or from an offer of tree insurance for losses caused by HLB. However, it is reasonable to propose that if the disease is insurable in one region, it should be insurable in all regions. In fact, the limited infections outside Florida would support the incorporation of HLB as a cause of loss for tree policies in those regions rather than in Florida, where the disease is endemic, incurable, and where disputes about appropriate practices abound. It is much less problematic to develop underwriting procedures for areas with little or no disease, than to establish a system of underwriting for areas with a wide range of infection levels.

  Furthermore, questions about the impacts on markets extend far beyond the U.S. Tropicana, a major juice processor in Florida, turned to Brazil for juice supplies in 2000-2001 and 2004-2005, periods when supply in Florida was limited. As a result of these imports, prices in Florida were depressed from levels that would have been predicted

based only on domestic supplies.[103] Furthermore, those purchases were tied to longer term pricing agreements, which have kept open market prices low even as supplies from domestic production in Florida decline. New export markets for orange juice are opening,[104] just as Brazil and the U.S. begin to deal with the impact of HLB. While it can not be said that market changes resulting from the introduction of insurance for tree losses caused by HLB are necessarily unacceptable, it is almost certain that the changes in the market are unpredictable and that some of the potential scenarios would include unacceptable market distortions or behaviors.

This feasibility study examined three broad classes of feasibility criteria:

- Acceptability to producers;
- Responsibility to taxpayers; and
- Market neutrality.

While the introduction of HLB as a cause of loss would almost certainly be acceptable to producers, especially if it were available in all citrus producing regions, these minimal criteria for feasibility cannot be satisfied. The status of HLB in Florida creates situations where offering the insurance would not be responsible to the taxpayer and where the potential for unacceptable market effects is great. Consequently, under the existing conditions, the proposed policy change is infeasible. The Contractor cannot envision an appropriate mechanism to rate the risks associated with HLB during this transitional phase in Florida.

Nonetheless, the citrus industry in Florida, and most likely throughout the U.S., is facing an inevitable crisis of far-reaching proportions. HLB will cause substantial additional changes in almost every aspect of citrus farm-level practices and finances. Many of these changes will be costly. The timing of the crisis, on the heels of weather and disease incidents during the early years of this decade, catches the Florida citrus industry in a particularly vulnerable situation. The added impact of precipitously declining land values and tight credit markets limits the responses producers can implement to maintain their markets, market shares, and productivity.

The Government should anticipate requests for identification of the HLB as a "natural disaster." A structure that cannot be manipulated by the recipient of the disaster aid, but not an insurance product, may need to be identified and implemented to address this catastrophe. While few would agree with the statement made by Peter McClure, Chairman of the Florida Citrus Producers Research Advisory Council, that "The citrus industry in Florida is facing collapse,"[105] there are fewer still who would argue that the industry will not be changed dramatically by HLB. Many of the changes are already evident.

The Florida citrus industry as a whole has been remarkably resilient. An element of this resilience is evident in the ongoing research supported by the state and the industry. The Florida Citrus Commission has recently approved 115 research projects, funded primarily from grower assessments and taxes on citrus produced in Florida, to address these challenges. Researchers

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[103] Sara Kennedy, 2008, Growers, Tropicana at odds over citrus 'dumping', Bradenton Herald, http://www.flcitrusmutual.com/news/bradentonherald_dumping_030908.aspx, accessed March 8, 2009.

[104] United States Department of Agriculture, Foreign Agricultural service, 2008, World Markets and Trade, http://www.fas.usda.gov/htp/2008_OrangeJuice_WorldMarketTrade.pdf, accessed March 8, 2009.

[105] At the December 2008 international conference on Citrus Greening organized by Citrus Mutual.

addressing HLB are also funded by Federal grants and private sources. Yet these diverse efforts will require years, or perhaps even decades, before they define the next steps of an industry that has been in Florida for centuries. A bridge to this future is required, but tree insurance is not appropriate at this moment as either the foundation or the principal structure of that bridge.

Nonetheless, with the financial challenges facing producers and the rapid changes in both the industry and market, it is important to introduce government or insurance support to address the risks associated with Citrus Greening as soon as it is both feasible and possible. Consequently, the Contractor recommends ongoing monitoring of the citrus industry, HLB, and data availability. At the minimum, the areas monitored should include:

- CHRP Progress Reports;
- Florida data on the progression of the disease;
- Changes in phytosanitary regulations;
- Abandoned Grove Initiative data;
- Research into HLB resistance; and
- NASS and state annual tree and acreage inventories.

As soon as the annual effects of HLB on changes in Florida citrus tree demographics have stabilized, the question of the feasibility of incorporating Citrus Greening into the FFT program should be revisited.

SECTION VIII. BIBLIOGRAPHY

Articles identified with an * in the bibliography represent historical elements of the literature on Huanglongbing that address the spread, detection, surveillance, and management of the disease, but are not available except as print publications that include substantial additional unrelated material.

Achor, D. S., K-R. Chung, E. Exteberria, N. Wang and L.G. Albrigo. 2008. Anatomical evolution of symptoms from infection with the HLB bacterium, Proceedings of the 2008 International Research Conference on Huanglongbing, p. 163.

AgriLogic, Inc. 2006. Rating Methodology: Pilot Florida Fruit Tree Insurance Program. Task Order # RMA-RED-02-08, Contract # 53-3151-1-00009.*

Arriaga, J. T. 2008. Dirección de Protección Fitosanitaria: Manual Técnico para la Detección del Huanglongbing de los Cítricos.

Astúa-Monge, G., Francischini, F.J.B., Kemper, E., Capella, A., Kitajima, J.P., Ferro, J.A., da Silva, A.C.R., Alellyx Applied Genomics, R. James C. Maxwell. 2008. Transgenic approaches to control bacterial diseases of citrus, Proceedings of the 2008 International Research Conference on Huanglongbing, p. 329.

Atwood, R., Spann, T., and Yates, J. 2007. 2007 Citrus Canker and Greening Handling Protocols for Master Gardner Plant Clinics. University of Florida Institute of Food and Agricultural Science brochure.

Aubert, B., and J.M. Bové. 1980. Effect of penicillin or tetracycline injections of citrus trees affected by greening disease under field conditions in Reunion Island in: Proceedings of the 8th Conference International Organization of Citrus Virologists, E. C. Calavan, S. M. Garnsey, and L. W. Timmer, eds., IOCV, Riverside, CA, 103-108, http://www.ivia.es/iocv/, accessed 3/1/2009.

Aubert, B., and S. Quilici. 1984. Biological control of psyllid vectors of greening disease in Reunion Island. in: Proceedings. of the 9th Conference. of the International Organization. of Citrus Virologists. S. M. Garnsey, L. W. Timmer, and J. A. Dodds, eds., IOCV, Riverside, CA, 118-123, http://www.ivia.es/iocv/proceedings/IX/Aubert,B and S.Quilici, accessed 3/1/2009.

Aubert, B., A. Sabine, P. Geslin, and L. Picardi. 1984. Epidemiology of the greening disease in Reunion Island before and after the biological control of the African and Asian citrus psyllas, Proceedings of the International Society of Citriculture 1:440-442.*

Aubert, B., M. Garnier, D. Guillaumin, B. Herbagyandodo, L. Setiobudi, and F. Nurhadi. 1985. Greening, a serious disease threat for the citrus production of the Indonesian archipelago. Future prospects of integrated control, Fruits 40:549-563. *

Aubert, B. 1987. *Trioza erytreae* Del Guercio and *Diaphorina citri* Kuwayama (Homoptera: Psylloidea), the two vectors of citrus greening disease: Biological aspects and possible control strategies, Fruits 42:149-162. *

Aubert B. 1990. Integrated activities for the control of huanglungbing-greening and its vector Diaphorina citri Kuwayama in Asia in Proceedings of the 4th International Asia Pacific Conference on Citrus Rehabilitation, B. Aubert, S. Tontyapornand, D. Buangsuwoon, eds., Chiang Mai, Thailand, 133-144.*

Aubert, B. 1992. Citrus greening disease, a serious limiting factor for citriculture in Asia and Africa, Proceedings of the . International. Society of Citriculture, 817-820.*

Aubert, B., M. Grisoni, M. Villemin, and G. Rossolin. 1996. A case study of huanglongbing (greening) control in Reunion in Proceedings of the 13th Conference International Organization of Citrus Virologists, J. V. da Graça, P. Moreno, and R. K. Yokomi, eds., IOCV, Riverside CA, 276-278. http://www.ivia.es/iocv/ accessed 3/1/2009.

Aubert, B. 2008. Historical perspectives of HLB in Asia, Proceedings of the 2008 International Research Conference on Huanglongbing, pp 16-24.

Avery, P.B.L, Hunter, W.B.2, Hall, D.G.2, Jackson, M.A.3, Powell, C.A.1, Rogers. 2008. Investigations of the feasibility for managing the Asian citrus psyllid using Isariafumosorosea, Proceedings of the 2008 International Research Conference on Huanglongbing, p. 290.

Baldwin, E., J. Manthey, A. Plotto, G. McCollum, M. Ireyfumosorosea. 2008. An Update on the Effect of HLB on Orange Juice Flavor – 1) Chemical Components, Proceedings of the 2008 International Research Conference on Huanglongbing, pp. 234-235.

Bassanezi, R.B., L. H. Montesino, L. Amorim, M.C.G. Gasparoto, A. Bergamin Filho. 2008. Yield reduction caused by Huanglongbing in different sweet orange cultivars in São Paulo, Brazil, Proceedings of the 2008 International Research Conference on Huanglongbing, pp. 237-238.

Bastianel, C., M.Garnier-Semancik, J. Renaudin, J.M. Bové, and S. Eveillard. 2005. Diversity of "*Candidatus* Liberibacter *asiaticus*," Based on the omp Gene Sequence, Applied and Environmental Microbiology 71:6473-6478. accessed 3/1/2009 http://www.pubmedcentral.nih.gov/picrender.fcgi?artid=1287744&blobtype=pdf.

Beattie, G.A.C., P. Holford, D.J. Mabberley, A.M. Haigh, R. Bayer, and P. Broadbent. 2006. Aspects and insights of Australia-Asia collaborative research on Huanglongbing. in: Proceedings of the International Workshop for the Prevention of Citrus Greening Disease in Severely Infected Areas. Intentional Research Division, Agriculture Forestry and Fisheries Research Council Secretariat, Ministry of Agriculture, Forestry and Fisheries, Tokyo, Japan, 47-64. *

Beattie, G.A.C., Holford P., Mabberley D.J., Haigh A.M. and Broadbent P. 2008. On the Origins of Citrus, Huanglongbing, Diaphorina citri and Trioza erytreae , Proceedings of the 2008 International Research Conference on Huanglongbing, pp. 25-57.

Beattie, G.A.C., and Holford P. 2008. Current HLB Situation and Industry Perspective in Asia, Proceedings of the 2008 International Research Conference on Huanglongbing, p. 95.

Belasque Jr. J.; R. B. Bassanezi; P. T. Yamamoto; S. A. Lopes; A. J. Ayres; J. C. Barbosa; A. Tachibana; A. R. Violante; A. Tank Jr.; C. L. Giorgetti; F. Di Giorgi; F.E.A. Tersi; G. M. Menezes; J. Dragone; L. F. Catapani; R. H. Jank Jr.; J. M. Bové. 2008. Factors associated with control of huanglongbing in Sao Paulo, Brazil: a Case Study, Proceedings of the 2008 International Research Conference on Huanglongbing, pp. 296-300.

Bergamin Filho, A.; Gasparoto, M. C. G.; Bassanezi, R. B.; Amorim, L. 2008. Relationship between insecticide sprays and huanglongbing progress in a citrus orchard in São Paulo, Brazil , Proceedings of the 2008 International Research Conference on Huanglongbing, pp. 244-246.

Bextine,B.R., S. Gunawan, W.B. Hunter, and R.G. Shatters. 2008. Molecular approach for early detection of *Candidatus* Liberibacter species in Texas Citrus, Proceedings of the 2008 International Research Conference on Huanglongbing, pp. 128-129.

Bonani, J.P., Appezzato-da-Gloria, B., Fereres, A., Engels, F.E., Lopes, J.R.S. 2008. Leaf age influencing acquisition of Candidatus Liberibacter asiaticus by the psyllid vector, Diaphorina citri Kuwayama, Proceedings of the 2008 International Research Conference on Huanglongbing, p. 219.

Bové, J. M. 1986. Greening in Arab Peninsula: Towards new techniques for its detection and control. FAO Plant Protection Bulletin. 34:7-14. *

Bové, J.M. 2006. Huanglongbing: A destructive, newly-emerging, century-old disease of citrus. Journal of Plant Pathology, 88:7-37. *

Bové, J.M., Teixeira, D.C., Wulff, N.A., Eveillard, S., Saillard, C., Bassanezi,R.B.,Lopes, S., Yamamoto, P.T., Ayres, A.J. 2008. Several Liberibacter and Phytoplasma Species are Individually Associated with HLB, Proceedings of the 2008 International Research Conference on Huanglongbing, pp. 138-139.

Brlansky, R.H., and M.E. Rogers. 2007. Citrus Huanglongbing: Understanding the Vector-Pathogen Interaction for Disease Management, American Phytopathological Society, APS Feature story, http://www.apsnet.org/online/feature/HLB/, accessed January 15, 2009.

Brown, M.G. 2008. The Florida Department of Citrus, Economic and Market Research Department, 2007, Florida Citrus Outlook 2007-08 Season, http://www.floridajuice.com/pdfs/Outlook2007-08-103107.pdf, accessed January 31, 2009.

Brown, M.G. 2008. Florida and Brazil Orange-Juice Trends, http://www.floridajuice.com/user_upload/files/trend795_422f60b3e7fa7.pdf, accessed February 28, 2009.*

Buitendag, C.H. and L.A. von Broembsen. 1993. Living with citrus greening in South Africa. in P. Moreno, J.V. daGraça and L.W. Timmer, eds., Proceedings of the Twelfth Conference of the International Organization of Citrus Virologists, pp. 269-273.accesssed 3/1/2009 http://www.via.es/iocv? Proceedings/XII/Buitendag,C.H. and L.A. von Broembsen

Burckhardt, D. 1994. Generic key to Chilean jumping plant-lice (Homoptera: Psylloidea) with inclusion of potential exotic pests. Rev. Chilean Ent. 21:57-67. *

CABI International. 2005. Crop Protection Compendium, 2005 Edition. Citrus huanglongbing (greening) disease. CAB International, Wallingford, UK.*

Capoor, S. P. 1963. Decline of citrus trees in India, Bulletin of the National Institutes of Science, India 24:48-64. *

Cevallos-Cevallos J.M., Reyes-De-Corcuera J.I. 2008. Metabolite Changes in HLB Orange Leaves by GC-MS and Other Techniques, Proceedings of the 2008 International Research Conference on Huanglongbing, pp. 176-177.

Chamberlain, H. L. and M. S. Irey. 2008. Comparison of a starch-based field test for Huanglongbing to results from realtime PCR testing of field samples from symptomatic trees in Florida, Proceedings of the 2008 International Research Conference on Huanglongbing, p. 130.

Chao, H.Y., Y. H. Chiang, S.L. Lee, C.S. Chiu, and W.F. Su. 1979. A preliminary study on the relation between the prevalence of the Citrus Yellow Shoot (Huanglungbin) and the citrus psyllid Diaphorina citri Kuwayama. Acta Phytopathologica Sinica. 2:121-126. *

Chen, C., Qibin Yu, Fred Gmitter Jr. 2008. Efficient Enrichment of the Pathogen DNA from HLB Infected Host, Proceedings of the 2008 International Research Conference on Huanglongbing, p. 153.

Chen, C, Jiwu Zeng, Ganjun Yi, Yuanhui Xiao, Shanhan Ou, Fred G. Gmitter Jr. 2008. A Preliminary Survey of HLB Survivors Found in Abandoned Citrus Groves, Proceedings of the 2008 International Research Conference on Huanglongbing, p. 335.

Chung, K.-R. and Brlansky, R. H. 2006. Citrus Diseases Exotic to Florida: Huanglongbing (Citrus Greening). University of Florida IFAS Extension.

Coletta-Filho H.D., Alves, K.C.S., Carlos, E.F. 2008. Improvement of Candidatus Liberibacter asiaticus diagnosis by nested-PCR, Proceedings of the 2008 International Research Conference on Huanglongbing, p. 120.

Cortez-Mondaca, E, Noraya Ely Lugo-Angulo ,y Jesús Pérez-Márquez. 2008. Natural Enemies of Diaphorina citri Kuwayama inNorthwest Mexico, Proceedings of the 2008 International Research Conference on Huanglongbing, p. 291.

Costa, M.G., Felippe, M.R., Garbim, L.F., Carmo-Uehara, A., Yamamoto, P.T., Barbosa, J.C.O. 2008. Spatial Distribution of Adults of Diaphorina citri Kuwayama (Hemiptera: Psyllidae) in Valencia Sweet Orange Trees, Proceedings of the 2008 International Research Conference on Huanglongbing, p. 221.

da Graça, J.V. 1991. Citrus greening disease. Annual Revue of Phytopathology 29:109-136.

da Graça, J.V., and L. Korsten. 2004. Citrus huanglongbing: Review, present status and future strategies in: Diseases of Fruits and Vegetables, Vol. I, S.A.M.H. Naqvi, ed., Kluwer Academic Press, Dordrecht, The Netherlandsm 229-245.

da Graça, J.V., Skaria, M., Sétamou, M., Kunta, M., Arredondo, M., Salas, B.,Parker, P.E. 2008. Texas Steps Up Surveys for Huanglongbing and the Asian Citrus Psyllid, Proceedings of the 2008 International Research Conference on Huanglongbing, pp. 102-103.

Das, A.K. 2004. Rapid Detection of Candidatus Liberibacter asiaticus, the bacterium, associated with citrus Huanglongbing (Greening) disease using PCR, Current Science 87:1183-1185. accessed 3/1/2009 http://www.ias.ac.in/currsci/nov102004/1183.pdf.

Das, A. K. 2008. Citrus greening (Huanglongbing) disease in India : Present status and Diagnostic efforts, Proceedings of the 2008 International Research Conference on Huanglongbing, p. 119.

Davis R.I., T.G. Gunua, M.F. Kame, D. Tenakanai, and T.K. Ruabete. 2005. Spread of citrus huanglongbing (greening disease) following incursion into Papua New Guinea. Australasian Plant Pathology 34: 517-524.*

Davis, R.I. 2008. Plant and Disease Image Library, Citrus huanglongbing ‘Candidatus Liberibacter spp.’ a-Proteobacteria, http://www.padil.gov.au/viewPest.aspx?id=494, accessed February 11, 2009.

Deng, X., Chen, J., Xu, J., Guo, H., Pu, X., Cai, L., and Li, H. 2008. Current situation of citrus Huanglongbing associated with “Candidatus Liberibacter asiaticus” in Guangdong, China, Proceedings of the 2008 International Research Conference on Huanglongbing, p. 127.

Duan, Y. P. L. J. Zhou, D. Hall, W.B. Li, H. Lin, H. Doddapaneni, L. Liu, C. M. Vahling and T. Gottwald. 2008. Genome Analysis of Candidatus Liberibacter asiaticus Reveals Unique Features for Designing HLB Control Strategies, Proceedings of the 2008 International Research Conference on Huanglongbing, p. 144.

Ebert, T.A., Rogers, M.E. and R.H. Brlansky. 2008. Seasonal Occurrence of Candidatus Liberibacter asiaticus in Asian Citrus Psyllids in Florida, Proceedings of the 2008 International Research Conference on Huanglongbing, pp. 229-230.

Etxeberria, E., Gonzalez, P., Dawson, W., and Spann, T. 2007. An Iodine-Based Starch Test to Assist in Selecting Leaves for HLB Testing. University of Florida IFAS Extension.

Fang, D.,Wang Guoping, Yi Ganjun Hong Ni, Zhong Yun. 2008. Comparison of Detection Sensitivity of Different Primer Pairs for Citrus Huanglongbing Bacterium , Proceedings of the 2008 International Research Conference on Huanglongbing, pp. 122-123.

Florida Department of Agriculture and Consumer Services. 2007. Pest Alert: Asian citrus psyllid - A serious exotic pest of FL citrus, http://www.doacs.state.fl.us/pi/enpp/ento/dcitri.htm, accessed February 1, 2009, no longer available.

Florida Department of Agriculture and Consumer Services. 2007. Florida Agriculture Statistical Highlights, http://www.florida-agriculture.com/pubs/pubform/pdf/Florida_Agriculture_Statistics_Brochure.pdf, accessed February 7, 2009.

Florida Department of Citrus. 2007. Florida Citrus Production Trends 2008-09 Through 2017-18 Update, http://www.floridajuice.com/user_upload/files/trends20_4769381f2ac7e.pdf, accessed February 1, 2009.

Florida Department of Citrus. 2007. 2006 – 2007 Annual Report, http://www.floridajuice.com/user_upload/files/annual%20r_486b85a52ed08.pdf, accessed February 1, 2009.

Florida Department of Citrus. 2008. Citrus Reference Book, http://www.floridajuice.com/pdfs/RB2008.pdf, accessed February 1, 2009.

Folimonova, S.Y., Stephen M. Garnsey, and William O. Dawson. 2008. Examination of host responses of different citrus varieties to HLB infection, Proceedings of the 2008 International Research Conference on Huanglongbing, p. 331.

French, J.V., C.J. Kahlke, and J.V. da Graça. 2001. First record of the Asian citrus psylla, Diaphorina citri Kuwayama (Homoptera: Psyllidae), in Texas, Subtropical Plant Science 53:14-15. accesss 3/1/2009 http://www.rgvhortsociety.org/SPSJ/v53%202001/SPSJ%2053%2014-15%20French%20Kahlke%20&%20da%20Graca.pdf.

Garnier, M., and J.M. Bové. 1983. Transmission of the organism associated with citrus greening disease from sweet orange to periwinkle by dodder. Phytopathology 73:1358-1363.*

Garnier, M., N. Danel, and J.M. Bové. 1984. Etiology of citrus greening disease. Annals of Microbiology (Institute Pasteur) 135A:169-179. *

Garnier, M., and J.M. Bové. 1993. Citrus greening disease and the greening bacterium, in Proceedings of the 12th Conference of the International Organization for Citrus Virology

P. Moreno, J. V. da Graça, and L. W. Timmer, eds.,. International Organization of Citrus Virologists, Riverside, California, 212-219.accessed 3/1/2009 http://www.ivia.es/iocv/ proceedings/XII/Garnier, M and J.M. Bove, 1993.

Garnier, M., and J.M. Bové. 1996. Distribution of the Huanglongbing (greening) Liberobacter species in fifteen African and Asian countries, p.. In J. V. da Graça, P. Moreno, and R. K. Yokomi (eds.), Proceedings of the 13th Conference of the International Organization for Citrus Virologists. International Organization of Citrus Virologists, Riverside, California, 388-391 accessed 3/1/2009 http://www.ivia.es/iocv/ proceedings/XIII/Garnier, M and J.M. Bove, 1996.

Gasparoto, M. C. G. ; Bassanezi, R. B. ; Lopes, S. A. ; Frare, G. ; Martins, E. C. ; Della Coletta Filho, H. ; Amorim, L. 2008. Influence of temperature on Huanglongbing infection under controlled environment, Proceedings of the 2008 International Research Conference on Huanglongbing, pp. 164-165

Gatineau, F., H.T. Loc, N.D Tuyen, T.M. Tuan, N.T. D. Hien, and N.T.N. Truc. 2006. Effects of two insecticide practices on population dynamics of Diaphorina citri and huanglongbing incidence in South Vietnam. in: Proceedings. of the Huanglongbing–Greening International Workshop, Ribeirão Preto, Brazil, 110. *

Giles, F. 2007. An Alternative Approach, Florida Grower, p. 6-8.

Goodrich-Schneider, R, C.A. Sims, T. Spann, M.D. Danyluk and R.L. Rouseff. 2008. Effect of Greening Plant Disease (Huanglongbing) on Orange Juice Flavor and Consumer Acceptability, Proceedings of the 2008 International Research Conference on Huanglongbing, p. 236.

Gottwald, T.R., J.V. da Graça, and R.B. Bassanezi. 2007. Citrus Huanglongbing: The pathogen and its impact. Online. Plant Health Progress doi:10.1094/PHP-2007-0906-01-RV.

Gottwald, T., Irey, M., Bergamin-Filho, A., Bassanezi, R, and Gilligan. 2008. A Stochastic Spatiotemporal Analysis of the Contribution of Primary versus Secondary Spread of HLB, Proceedings of the 2008 International Research Conference on Huanglongbing, pp. 247-252.

Gottwald, T., Irey, M. and Taylor, E. 2008. HLB Survival Analysis – A Spatiotemporal Assessment of the Threat of an HLB positive Tree to its Neighbors, Proceedings of the 2008 International Research Conference on Huanglongbing, pp. 253-257

Gottwald, T. and Irey, M. 2008. The Plantation Edge Effect of HLB – A Geostatistical Analysis. Proceedings of the 2008 International Research Conference on Huanglongbing, pp. 265-268.

Gottwald, T., Parnell, S., Taylor, E., Poole, K., Hodge, J., Ford, A., Therrien, L., Mayo, S. and Irey, M. 2008. Within-tree distribution of Candidatus Liberibacter asiaticus, Proceedings of the 2008 International Research Conference on Huanglongbing, pp. 270-273.

Graham, J. H., M.S. Irey, W. O. Dawson, D. Hall, Y. Duan. 2008. Assessment of transmission of Liberibacter asiaticus from seed to seedlings of 'Pineapple' sweet orange and Carrizo citrange, Proceedings of the 2008 International Research Conference on Huanglongbing, pp. 174-175.

Grosser, J.W., Dutt, M., Omar, A., Orbovic, V. and Barthe, G.A. 2008. Towards the Ultimate Solution: Genetic Resistance to HLB in Commercial Citrus, Proceedings of the 2008 International Research Conference on Huanglongbing, p. 330.

Gullino, M., Fletcher, J., Gamliel, A., and Stack J. 2005. Crop Biosecurity Assuring our Global Food Supply. Nato Science for Peace and Security Series – C: Environmental Security.

Halbert, S. 1999. Asian citrus psyllid - A serious exotic pest of FL citrus, http://entnemdept.ifas.ufl.edu/dcitri.htm, accessed January 31, 2009.

Halbert, S.E., and K.L. Manjunath. 2004. Asian citrus psyllids (Sternorrhyncha: Psyllidae) and greening disease of citrus: A literature review and assessment of risk in Florida. Florida. Entomology. 87:330-353.

Halbert, S. 2005. The discovery of huanglongbing in Florida in: Proceedings of the 2nd International Citrus Canker and Huanglongbing Workshop, Orlando, Florida 50. http://www.doacs.state.fl.us/pi/chrp/images/2nd_International_Canker_Huanglongbing_Research_Workshop_2005.pdf accessed 3/1/2009.

Halbert,S. E., Keremane L. Manjunath, and Matthew W. Brodie. 2008. Large-scale distribution of Diaphorina citri Kuwayama and citrus Huanglongbing in Florida , Proceedings of the 2008 International Research Conference on Huanglongbing, p. 107.

Hall, D. G. 2008. Effects of Freezes on Survival of Diaphorina citri, Proceedings of the 2008 International Research Conference on Huanglongbing, pp. 192-193.

Hall, D. G. 2009. An Assessment of Yellow Sticky Card Traps as Indicators of the Abundance of Adult Diaphorina citri (Hempitera: Psyllidae) in Citrus. Journal of Economic Entomology, 102(1) 446-452.

Harmon, C.L., M.L. Keremane, and T.S. Schubert. 2007. National Plant Diagnostic Network Citrus Greening Diagnostic and Detection Efforts. National Plant Diagnosic Network, 2007 National Meeting, http://www.plantmanagementnetwork.org/proceedings/npdn/2007/posters/03CitrusGreeningDiagDetection.pdf, accessed January 26, 2009.

Hocquellet A., P. Toorawa, J. M. Bové, and M.Garnier. 1999. Detection and identification of two candidatus Liberobacter species associated with citrus huanglongbing by PCR amplification of ribosomal proteins genes of B operon. Molecular and Cellular Probes 13: 373-379.*

Hodges, A., E. Philippakos, D. Mulkey, T. Spreen, and R. Muraro. 2001. Economic Impact of Florida's Citrus Industry, 1999-2000. Economic Information Report EIR-01-2. Food and

Resource Economics Department, University of Florida, Gainesville, FL (July). http://economicimpact.ifas.ufl.edu/publications/er01-2-citrus.pdf, accessed February 7, 2009.

Hodges, A., W. Mulkey, R. Muraro, and T. Spreen. 2003. County Property Values and Tax Impacts of Florida's Citrus Industry. University of Florida IFAS Extension.

Hodges, A., M. Rahmani, and D. Mulkey. 2006. The Economic Impacts of the Florida Citrus Industry in 2003-04. Economic Information Report EIR-01-2. Food and Resource Economics Department, University of Florida, Gainesville, FL. http://edis.ifas.ufl.edu/FE633, accessed February 7, 2009.

Hung, T.H., M.L. Wu and H.J. Su. 2000. Identification of alternative hosts of the fastidious bacterium causing citrus greening disease. Journal of Phytopathology 148: 321-326.*

Hung, T.H., S.C. Hung, C. N. Chen, M.H. Hsu and H.J. Su. 2004. Detection by PCR of Candidatus Liberibacter asiaticus, the bacterium causing citrus huanglongbing in vector psyllids: application to the study of vector-pathogen relationships. Plant Pathology 53: 96-102.

Ichinose, K., Bang, D. V., Dien, L. Q. 2008. Better management for citrus greening: chemical-uses or guava-interplanting? Proceedings of the 2008 International Research Conference on Huanglongbing, pp. 308-309.

Irey, M., Mai, P.; Graham, J. and Johnson, J. 2008. Data trends and results from an HLB testing laboratory that has processed over 64,000 commercial and research samples over a two year period in Florida, Proceedings of the 2008 International Research Conference on Huanglongbing, p. 101.

Irey, M.; Gottwald, T.; Stewart, M., and Chamberlain, H. 2008. Is it possible to replant young groves in an area with endemic HLB – a hierarchical sampling approach to determine infection? Proceedings of the 2008 International Research Conference on Huanglongbing, pp. 108-109.

Irey, M., Sieburth, P., Brlansky, R. , DaGraça, J. , Graham, J., Gottwald, T. , Hartung, J., Hilf, M., Kunta, M. , Manjunath, K., Ling, H., Ramdugu, C., Roberts, P., Rogers, M., Shatters, R., Sun, X., and Wang, N. 2008. Lessons learned from a comparison and evaluation of multiple HLB testing laboratories employing common and different testing methodologies applied to a common set of samples, Proceedings of the 2008 International Research Conference on Huanglongbing, p. 111.

Irey, M., Gast, T., Terra, R. and Snively, J. 2008. Observations gleaned from the geospatially referenced and documented spread of HLB in three commercial groves in Florida and the implications of these observations on scouting and management decisions, Proceedings of the 2008 International Research Conference on Huanglongbing, pp. 303-304.

Jagoueix, S., J.M. Bové, and M. Garnier. 1994. The phloem-limited bacterium of greening disease of citrus is a member of the subdivision of the Proteobacteria. International Journal of Systematic Bacteriology 44: 379-386. accessed 3/1/2009 http://ijs.sgmjournals.org/cgi/reprint/44/3/379.

Jagoueix, S., J.M. Bové, and M. Garnier. 1996. PCR detection of the two 'Candidatus' liberobacter species associated with greening disease of citrus. Molecular and Cellular Probes 10: 43-50.*

Kim, J, Uma Shankar Sagaram, Jacqueline K. Burns, Jian-Liang Li, and NianWang. 2008. Response of sweet orange (Citrus sinensis) to Candidatus Liberibacter asiaticus infection: microscopy and microarray analyses , Proceedings of the 2008 International Research Conference on Huanglongbing, p. 171.

Knapp, J.L., S. Halbert, R. Lee, M. Hoy, R. Clark, and M. Kesinger. 2004. The Asian Citrus Psyllid and Citrus Greening Disease. Integrated Pest Management (IPM), University of Florida, http://ipm.ifas.ufl.edu/agriculture/citrus/asian.shtml, accessed February 7, 2009

Kobori, Y., T. Nakata, Y. Ohto and F. Takasu. 2008. Ecological studies on initial invasion of Diaphorina citri into the newly plantingcitrus fields, Proceedings of the 2008 International Research Conference on Huanglongbing, p. 220.

Koizumi, M., M. Prommintara, G. Linwattana, and T.Kaisuwan. 1993. Field evaluation of citrus cultivars for greening resistance in Thailand, in Proc. 12th Conference of the International Organization of Citrus Virologists, P. Moreno, J.V. da Graça, and L.W. Timmer [eds.], University of California, Riverside, pp. 274-279.

Leavitt, M., Young, L., Guerrero, A., and Weingart, C. 2008. Abandoned Agricultural Property. Dean, Mead, Egerton, Bloodworth, Capouano & Bozarth, P.A.

Leite, R.P. 2008. Occurrence and management strategies for HLB in the State of Paraná, Brazil, Proceedings of the 2008 International Research Conference on Huanglongbing, p. 302.

Le Roux, H. F., S.P. van Vuuren, M.C. Pretorius, and C.H. Buitendag. 2006. Management of Huanglongbing in South Africa. in Proceedings of the Huanglongbing–Greening Intational. Workshop, Ribeirão Preto, Brazil, 43-47. *

Li, W., Yongping Duan, Ronald H. Brlansky, Elizabeth Twieg and Laurene Levy. 2008. Incidence and Population of ‘Candidatus Liberibacter asiaticus’ in Asian Citrus Psyllids (Diaphorina citri) on Citrus Plants Affected by Huanglongbing in Florida, Proceedings of the 2008 International Research Conference on Huanglongbing, p. 231.

Lin, H., Doddapaneni, H., and Civerolo, E. L. 2008. A novel molecular diagnostic tool for improved sensitivity and reliability detection of “Candidatus Liberibacter asiaticus”, bacterium associated with huanglongbing(HLB), Proceedings of the 2008 International Research Conference on Huanglongbing, pp. 117-118.

Lin K-h, C.N. Roistacher, and J.V. da Graça. 1996. Dedicated to Lin Kongxiang, Proceedings of the 13th Conference of the International Organization for Citrus Virology, J. V. da Graqa P. Moreno R. K. Yokomi, eds., International Organization of Citrus Virologists, Riverside, California, iii-iv, accessed March, 1, 2009.

Llauger, R., Luis, M., Collazo, C., Peña I., González, C., Batista, L., Teixeira, D.,Martins, E., Perdomo, A., Casín, J.C., Peréz, J.L., Cueto, J.R. and Bové, J.M. 2008. Current situation of citrus Huanglongbing in Cuba , Proceedings of the 2008 International Research Conference on Huanglongbing, pp. 97-100.

Lopes, S. A., Frare, G. F., Bertolini, E., Wulff, N. A. 2008. Liberibacter populations in citrus and orange jasmine trees in the State of São Paulo, Brazil, Proceedings of the 2008 International Research Conference on Huanglongbing, pp. 159-160.

López-Arroyo, J .I., Juan Jasso, Marco A. Reyes, Jesús Loera-Gallardo,Edgardo Cortez-Mondaca3, Mario A. Miranda. 2008. Perspectives for biological control of Diaphorina citri (Hemiptera: Psyllidae) in Mexico, Proceedings of the 2008 International Research Conference on Huanglongbing, p. 289.

Manthey, J. A. 2008. Differences in Secondary Metabolites in Leaves from Trees Affected with the Greening (HLB) Disease. Proceedings of the 2008 International Research Conference on Huanglongbing, p. 182.

Mead, F. W. 1977. The Asiatic citrus psyllid, Diaphorina citri Kuwayama (Homoptera: Psyllidae). Entomology. Circular No. 180. Florida. Department of Agriculture. and Consumer Services., Division. of Plant Industry, Gainesville, FL. accessed 3/1/2009, http://www.doacs.state.fl.us/pi/enpp/ento/entcirc/ent180.pdf.

Mead, F. W. 1998. Asiatic citrus psyllid, Diaphorina citri Kuwayama (Insecta: Hemiptera:: Psyllidae). University of Florida IFAS Extension.

Miyakawa, T., and K.Tsuno. 1989. Occurrence of citrus greening disease in the southern islands of Japan, Annals of the Phytopathological Society of Japan 55: 667-670. *

Moll, J.N., and M.M. Martin. 1973. Electron microscope evidence that citrus psylla (Trioza erytreae) is a vector of greening disease in South Africa. Phytophylactica 5:41-44. *

Moore, Gloria A., Khalaf, Abeer A., Febres, Vicente J., Li Liu, and Gmitter, Jr., Frederick G. 2008. A Newly Developed Agilent Microarray Designed for the Characterization of Citrus Responses to Pathogens, Proceedings of the 2008 International Research Conference on Huanglongbing, p. 328.

Morris, A. and Muraro, R. 2008. Economic Evaluation of Citrus Greening Management and Control Strategies. University of Florida IFAS Extension.

Mossler, M. A. and Aerts, M. J. 1999 2006. Florida Crop/Pest Management Profiles: Citrus (Oranges/Grapefruit). University of Florida IFAS Extension.

Muraro, R. and Roka, F. 2003. Citrus Reset Analysis. University of Florida IFAS Extension.

Muraro, R. and Spreen, T. 2003. Comparative Marketing Costs for FCOJ from Florida and Sao Paulo. University of Florida IFAS Extension.

Pietersen, G., Kotzé, A., Phahladira, M.N.B., Schwerdtfeger, M. 2008. Survey for "Candidatus" Liberibacter species in South Africa, Proceedings of the 2008 International Research Conference on Huanglongbing, pp. 105-106.

Plotto, A., G. McCollum, E. Baldwin, J. Manthey, M. Irey. 2008. An Update on the Effect of HLB on Orange Juice Flavor – 2) Sensory Evaluation, Proceedings of the 2008 International Research Conference on Huanglongbing, p. 241.

Polek, M., Vidalakis, G., and Godfrey, K. 2007. Citrus Bacterial Canker Disease and Huanglongbing (Citrus Greening). University of California Division of Agriculture and Natural Resources Publication 8218.*

Polek, M. and Luque-Williams, M.J. 2008. The State of California implements its action plan for Asian Citrus Psyllid, Proceedings of the 2008 International Research Conference on Huanglongbing, p. 322.

Poole, G., Windham, W., Heitschmidt, G., Park, B., and Gottwald, T. 2008. Visible/near-infrared spectroscopy for discrimination of HLB-infected citrus leaves from healthy leaves, Proceedings of the 2008 International Research Conference on Huanglongbing, pp. 155-157.

Qureshi, J. A., and Philip A. Stansly. 2008. Managing Asian Citrus Psyllid Diaphorina citri with Soil and Foliar Applications of Insecticides, Proceedings of the 2008 International Research Conference on Huanglongbing, pp. 292-294.

Ramallo, J., Acosta, E., Rojas, A., Stein, B. 2008. PCR for detection of Asian and American strains of Candidatus Liberibacter in Citrus, Murraya and Diaphorina from Northwest Argentina, Proceedings of the 2008 International Research Conference on Huanglongbing, pp. 125-126.

Reddy, J.D., and Gabriel, D.W. 2008. A transgenic approach to the control of citrus greening, Proceedings of the 2008 International Research Conference on Huanglongbing, pp. 343-348.

Robles, G.P.1, Sánchez, A.H. 1, Méndez, L.O. 2008. National Plan for detection of HLB in Mexico, Proceedings of the 2008 International Research Conference on Huanglongbing, p. 104.

Rogers, M. E. and Stansly, P. 2006. Biology and Management of the Asian Citrus Psyllid, Diaphorina citri Kuwayama, in Florida Citrus. University of Florida IFAS Extension.

Rogers, M. E., Stansly, P. A., and Stelinski, L. L. 2006 2008. 2009 Florida Citrus Pest Management Guide: Asian Citrus Psyllid and Citrus Leafminer. University of Florida IFAS Extension.

Rogers, M. E., Brlansky, R. H., Ebert, T. A., Serikawa, R. H., Schumann, R. A., and K. P.Stelinski. 2008. Acquisition of Candidatus Liberibacter asiaticus by the Asian citrus psyllid,Diaphorina citri, and the potential use of insecticides to prevent pathogen transmission., Proceedings of the 2008 International Research Conference on Huanglongbing, pp. 217-218.

Roistacher, C.N. 1991. Techniques for biological detection of specific citrus graft transmissible diseases, (Greening). FAO, Rome, 35-45.accessed 3/1/2009 http://www.fao.org/docrep/t0601e/T0601E09.htm#Greening

Sadoyama, Y and Tetsuya Takushi. 2008. The seasonal incidence of Candidatus Liberibacter asiaticus infection in the Asian citrus psyllid, Diaphorina citri Kuwayama (Homoptera: Psyllidae) in Okinawa, Japan., Proceedings of the 2008 International Research Conference on Huanglongbing, pp. 223-224.

Sagaram, U. S., Pankaj Trivedi, Jeong-soon Kim, Ron H Brlansky, Micheal E. Rogers, Lukasz L Stelinski, Chris Oswalt, and Nian Wang. 2008. Quantification of viable Candidatus Liberibacter asiaticus in hosts usingQuantitative PCR with the aid of ethidium monoazide (EMA), Proceedings of the 2008 International Research Conference on Huanglongbing, pp. 223-224.

Schuster, D.J., P.A. Stansly, J.E. Polston, P.R. Gilreath, and E. McAvoy. 2007. Management of whiteflies, whitefly vectored plant virus, and insecticide resistance for vegetable production in southern Florida. ENY-735, University of Fla., Gainesville, FL. accessed 3/1/2009 http://edis.ifas.ufl.edu/pdffiles/IN/IN69500.pdf

Sétamou, M. and Patt, J. M. 2008. Response of Asian citrus psyllid to aromas emitted by the flushing shoots of their rutaceous host plants in a Y-tube olfactometer, Proceedings of the 2008 International Research Conference on Huanglongbing, p. 232.

Shatters, Jr., R. G. 2008. Detection of Candidatus Liberibacter asiaticus in Citrus Seedlings Germinated from Florida Seed., Proceedings of the 2008 International Research Conference on Huanglongbing, p. 173.

Shatters, Jr., R. G., Hunter, W., Hall, D., Niedz, R., Evens, T. J. 2008. Optimizing qPCR for Detection of Candidatus Liberibacter Species in Plants and Psyllid Samples ,Proceedings of the 2008 International Research Conference on Huanglongbing, p. 121.

Spann, T., Atwood, R., Yates, J., Rogers, M., and Brlansky, R. 2008. Dooryard Citrus Production: Citrus Greening Disease. University of Florida IFAS Extension.

Spann, T., Atwood, R., and Yates, J. 2008. Dooryard Citrus Production: the Value of the Florida Citrus Industry to Florida Residents. University of Florida IFAS Extension.

Spreen, T.H., Brown, M.G., Jauregui, C. 2008. The Production and Price Effects of Citrus Greening in Sao Paulo and Florida on the World Orange Juice Market, Proceedings of the 2008 International Research Conference on Huanglongbing, p. 239.

Stansly, P.A., Qureshi, J. A. and Arevalo, H. A. 2008. Integrated Pest Management of the Asian Citrus Psyllid (ACP) in Florida, Proceedings of the 2008 International Research Conference on Huanglongbing, pp. 286-288.

Stelinski, L.L., Onagbola O.E., and Rouseff, R.L. 2008. Chemical Ecology of Asian Citrus Psyllid (Diaphorina citri) and Potential Applications of Behavior-Modifying Chemicals for its Management, Proceedings of the 2008 International Research Conference on Huanglongbing, p. 279.

Stover, E., Bowman, K., McCollum, G., Niedz, R. 2008. Developing Transgenic Solutions for HLB Resistant Citrus at the US Horticulture Research Laboratory, Proceedings of the 2008 International Research Conference on Huanglongbing, p. 327.

Su, Hong-Ji. 2008. Research and Health Management of Citrus Huanglongbing in Taiwan,Proceedings of the 2008 International Research Conference on Huanglongbing, pp. 58-93.

Subandiyah, S., T. Iwanami, S. Tsuyumu and H. Ieki. 2000. Comparison of 16S rDNA and 16S/23S intergenic region sequences among citrus greening organisms in Asia, Plant Disease 84: 15-18. accessed 3/1/2009.

Teixeira, D.C., A.J. Ayres, E.W. Kitajima, F.A.O. Tanaka, J.L. Danet, S. Jagoueix-Eveillard, C. Saillard, and J.M. Bové. 2005. First report of a Huanglongbing-like disease of citrus in São Paulo State, Brazil, and association of a new liberibacter species, "Candidatus Liberibacter americanus", with the disease. Plant Disease. 89:107.accessed 3/1/2009

Teixeira, D.C., C. Saillard, S. Jagoueix-Eveillard, J.L. Danet, A.J. Ayres, and J.M. Bové. 2005. "Candidatus Liberibacter americanus" associated with citrus huanglongbing (greening disease) International Journal of Systematic and Evolutionay Microbiology 55:1857-1862. http://ijs.sgmjournals.org/, accessed 3/1/2009.

Teixeira, D.C., J.L. Danet, S. Eveillard, E. C Martins, W.C. Jesus Junior, P.T. Yamamoto, S.A. Lopes, R.B. Bassanezi, A.J. Ayres, C. Saillard, and J.M. Bové. 2005. Citrus huanglongbing in São Paulo State, Brazil: PCR detection of the 'Candidatus' Liberibacter species associated with the disease. Molecular and Cellular Probes 19:173-179.

Torres, M.G., Parra, J.R.P. 2008. Bioecology of Diaphorina citri and Tamarixia radiata: zoning for citrus groves of the State of São Paulo, Proceedings of the 2008 International Research Conference on Huanglongbing, p. 275.

Tsagkarakis, A.E. and M. E. Rogers. 2008. Effects of host plant on fitness of the Asian citrus psyllid, Diaphorina citri, Proceedings of the 2008 International Research Conference on Huanglongbing, pp. 161-162.

Tsai, J.H., and Y.H. Liu. 2000. Biology of Diaphorina citri (Homoptera: Psyllidae) on four host plants. Journal of Economic Entymology 93:1721-1725.

United States Department of Agriculture, Animal and Plant Health Inspection Service. 2005. Plant Health: Citrus Greening, http://www.aphis.usda.gov/plant_health/plant_pest_info/citrus_greening/background.shtml, accessed February 2, 2009.

United States Department of Agriculture, Animal and Plant Health Inspection Service. 2006. Pest Alert: Get the Facts on Citrus Greening, or Huanglongbing, http://www.aphis.usda.gov/publications/plant_health/content/printable_version/cg_pest_alert_2-06.pdf, accessed March 3, 2009.

United States Department of Agriculture, Animal and Plant Health Inspection Service. 2007. Huang Long Bing, or Citrus Greening, http://www.aphis.usda.gov/publications/plant_health/content/ printable_version/id_card_cg_10-20-5.pdf, accessed February 25, 2009.

United States Department of Agriculture, Animal and Plant Health Inspection Service. 2008. New Pest Response Guidelines: Citrus Greening Disease, http://www.aphis.usda.gov/plant_health/plant_pest_info/citrus_greening/downloads/pdf_files/cg-nprg.pdf, accessed March 3, 2009.

United States Department of Agriculture, Animal and Plant Health Inspection Service. 2008. Questions and Answers: USDA's Federal Order to Prevent the Spread of Citrus Greening and the Asian Citrus Psyllid, http://www.aphis.usda.gov/publications/plant_health/content/printable_version/faq_rev_cg08.pdf, accessed March 3, 2009.

United States Department of Agriculture, Animal and Plant Health Inspection Service. 2008. New Pest Response Guidelines: Citrus Greening Disease, http://www.aphis.usda.gov/plant_health/plant_pest_info/citrus_greening/downloads/pdf_files/cg-nprg.pdf, accessed March 3, 2009.

United States Department of Agriculture, National Agricultural Statistics Service. 1990-2006. Commercial Citrus Inventories, 1996–2008 (preliminary). accessed through http://www.nass.usda.gov/Statistics_by_State/Florida/ Publications/Citrus/index, accessed February 7, 2009.

United States Department of Agriculture, National Agricultural Statistics Service. 2008. Commercial Citrus Inventory Citrus Preliminary Report, http://www.nass.usda.gov/Statistics_by_State/Florida/Publications/Citrus/ccipre/ccipr08.pdf.

United States Department of Agriculture, National Agricultural Statistics Service. 2008. 2007-08 Florida Citrus Summary, http://www.nass.usda.gov/Statistics_by_State/Florida/Publications/Citrus/index, accessed February 7, 2009.

United States Department of Agriculture, National Agricultural Statistics Service. 2008. 2006-07 Citrus Summary, accessed through http://www.nass.usda.gov/Statistics_by_State/Florida/Publications/Citrus/index, accessed February 7, 2009.

University of Florida IFAS Extension. 2008. Citrus Greening: A serious threat to the Florida Citrus Industry. Brochure.

Urasaki, N., Kawano, S., Mukai, H., Uemori. T., Takeda, O. and Sano, T. 2008. Detection of "Candidatus Liberibacter asiaticus" by cycleave isothermal andchimeric primer-initiated amplification of nucleic acids (Cycleave ICAN), Proceedings of the 2008 International Research Conference on Huanglongbing, pp. 114-115.

Van den Berg, M.A., S.P. van Vuuren, and V.E. Deacon. 1992. Studies on greening disease transmission by the citrus psylla, Trioza erytreae (Hemiptera: Triozidae). Israel Journal of Entomology. 25-26:51-56. *

Weinert, M.P., S.C. Jacobson, J.F. Grimshaw, G.A. Bellis, P.M. Stephens, T.G. Gunua, M.F. Kame and R.I. Davis. 2004. Detection of Huanglongbing (citrus greening disease) in Timor-Leste (East Timor) and in Papua New Guinea. Australasian Plant Pathology 33: 135-136.*

Xu, C.F., Y.H. Xia, K.B. Li, and C. Ke. 1988. Further study of the transmission of citrus huanglongbing by a psyllid, Diaphorina citri Kuwayama. in: Proceedings. of the 10th Conference of International Organization of. Citrus Virologists. L. W. Timmer, S. M. Garnsey, and L. Navarro, eds. IOCV, Riverside, CA. 243-248 accessed 3/1/2009 http://www.ivia.es/iocv/.

Xue-yuan, Z. 2006. Huanglongbing in China in: Proc. of the Huanglongbing–Greening International. Workshop, Ribeirão Preto, Brazil, 3. *

Yamamoto, P.T., M.R. Felippe, L.F. Garbim, J.H.C. Coelho, N.L. Ximenes, E.C. Martins, A.P.R. Leite, M.C. Sousa, D.P. Abrahão, and J.D. Braz. 2006. Diaphorina citri (Kuwayama) (Hemiptera: Psyllidae): Vector of the bacterium Candidatus Liberibacter americanus in: Proceedings of the Huanglongbing-Greening International Workshop, Ribeirão Preto, Brazil, 96.*

Yamamoto, P.T., Felippe, M.R., Rugno. G.R., Beloti, V.H., Coelho, J.H.C., Ximenes,N.L., Garbim, L.F., Carmo-Uehara, A.. 2008. Population Dynamics of Diaphorina citri in Citrus Orchard in São Paulo State, Brazil , Proceedings of the 2008 International Research Conference on Huanglongbing, p. 222.

Yamamoto, P.T., Felippe. M.R., Beloti, V.H., Rugno, G.R. 2008. Efficiency of Insecticides to Control Diaphorina citri, Vector of Huanglongbing Bacteria, Proceedings of the 2008 International Research Conference on Huanglongbing, pp. 284-285

Yates, J., Futch, S., and Spann, T. 2008. Scouting for Citrus Greening. University of Florida IFAS Extension.

Zaka, SM, and Zeng, XN. 2008. Repellent effect of guava odor against adults of citrus psyllid, Diaphorina citri, Proceedings of the 2008 International Research Conference on Huanglongbing, pp. 276-277.

Zhang, S., Reddy, S., and Gabriel, D.W. 2008. Evaluation of potential pathogenicity genes identified by genomic sequencing of *Ca.* Liberibacter asiaticus, Proceedings of the 2008 International Research Conference on Huanglongbing, pp. 132-134.

Zhao, X.-Y. 1996. Citrus Production and the Occurrence of Virus Diseases in the Mainland of China, Proceedings of the 13th Conference of the International Organization for Citrus Virology, J. V. da Graqa P. Moreno R. K. Yokomi, eds., International Organization of Citrus Virologists, Riverside, California, 8-11.accessed March, 1, 2009.

Zhou, L.-J L., S. Benyon, , C. A. Powell, T. Gottwald and Y.-P. Duan. 2008. Improved Detection of Low-titer, Non-lethal, Seed Transmitted Candidatus Liberibacter asiaticus in Citrus, Periwinkle and Dodder Using Nested PCR, Proceedings of the 2008 International Research Conference on Huanglongbing, pp. 112-113.

Zhou, L.-J., C. A. Powell, T. Gottwald and Y. P. Duan. 2008. Genetic Diversity of Candidatus Liberibacter asiaticus and *Ca.* L. americanus Based on Sequence Variations of Their rRNA Operon, Proceedings of the 2008 International Research Conference on Huanglongbing, pp. 149-152.

Appendix A

Florida Fruit Tree Dollar Plan Insurance Experience for Citrus

Exhibit 1. Historical Experience for Citrus in the Florida Fruit Tree Program
Exhibit 2. 2008 County-Level Participation for Citrus in the Florida Fruit Tree Program

Exhibit 1. Historical Experience for Citrus in the Florida Fruit Tree Program

Table A1. Cumulative Florida Fruit Tree Insurance Experience by Species 2001-2007

Crop Name	Liability (dollars)	Premium (dollars)	Indemnity (dollars)	Loss Ratio	Loss Cost Ratio
All Other Citrus	364,904,446	8,561,508	5,083,461	0.59	0.01
Avocado	47,136,984	1,329,781	439,414	0.33	0.01
Carambola	1,517,351	34,108	4,013	0.12	0.00
Grapefruit	856,466,478	23,112,434	26,429,983	1.14	0.03
Lemon	10,753,774	214,714	12,425	0.06	0.00
Lime	9,463,895	323,404	2,179,294	6.74	0.23
Mango	2,148,122	53,806	3,403	0.06	0.00
Orange	6,339,574,747	142,591,025	92,194,542	0.65	0.01
Citrus Total	7,581,163,340	174,803,085	125,899,705	0.72	0.02
Non-Citrus Total	50,802,457	1,417,695	446,830	0.32	0.01
Total	7,631,965,797	176,220,780	126,346,535	0.72	0.02

Source: CropData, www.cropdata.com, accessed November 3, 2008

Table A2. 2001-2007 Total Annual Florida Fruit Tree Insurance Experience by Coverage

Year	Coverage Flag	Liability (dollars)	Total Premium (dollars)	Indemnity (dollars)	Loss Ratio	Loss Cost Ratio
2001	Additional	423,595,495	10,911,106	2,573,238	0.24	0.01
2002	Additional	682,119,728	17,804,683	1,563,015	0.09	0.00
2003	Additional	699,112,594	17,459,608	1,745,764	0.10	0.00
2004	Additional	558,010,134	14,222,203	7,158,512	0.50	0.01
2005	Additional	723,448,066	18,144,149	66,699,039	3.68	0.09
2006	Additional	1,062,504,156	13,708,077	3,549,392	0.26	0.00
2007	Additional	750,323,421	23,898,669	2,647,428	0.11	0.00
Totals		4,899,113,594	116,148,495	85,936,388	0.74	0.02
2001	Catastrophic	413,117,835	9,014,097	1,102,981	0.12	0.00
2002	Catastrophic	416,121,517	9,249,551	1,192,778	0.13	0.00
2003	Catastrophic	358,028,345	8,015,923	1,372,300	0.17	0.00
2004	Catastrophic	463,906,529	10,283,849	1,680,136	0.16	0.00
2005	Catastrophic	404,549,964	8,781,739	33,781,315	3.85	0.08
2006	Catastrophic	220,078,828	2,709,974	100,384	0.04	0.00
2007	Catastrophic	440,119,327	11,645,273	375,848	0.03	0.00
Totals		2,715,922,345	59,700,406	39,605,742	0.66	0.01

Flag

Source: CropData, www.cropdata.com, accessed November 3, 2008

Table A3. 1996-2008 Annual Florida Fruit Tree Insurance Premiums by Citrus Species

	FFT Plan Premiums (dollars)					
Year	**Orange**	**Grapefruit**	**Lemon**	**Lime**	**All Other Citrus**	**Total**
1996	1,441,327	230,701		57,729	261,896	**1,991,653**
1997	1,797,665	229,705		64,211	283,969	**2,375,550**
1998	2,265,869	238,250	0	65,332	267,603	**2,837,054**
1999	2,501,428	237,061	0	82,450	279,661	**3,100,600**
2000	10,388,673	2,346,153	15,943	263,427	852,494	**13,866,690**
2001	15,201,740	3,235,672	28,971	156,592	1,112,506	**19,735,481**
2002	21,538,823	3,823,387	38,877	97,762	1,377,477	**26,876,326**
2003	20,583,230	3,377,062	39,924	40,584	1,254,665	**25,295,465**
2004	19,669,819	3,386,528	38,877	25,194	1,193,973	**24,314,391**
2005	22,224,369	3,574,400	40,172	2,754	1,295,005	**27,136,700**
2006	13,574,509	2,055,322	0	287	746,533	**16,376,651**
2007	29,798,873	3,660,063	27,893	231	1,581,349	**35,068,409**
2008	16,028,340	1,756,143	13,945	1,248	986,136	**18,785,812**

Source: CropData, www.cropdata.com, accessed March 18, 2009.

Table A4. 1996-2008 Annual Florida Fruit Tree Insurance Loss Ratios by Citrus Species

	FFT Plan Loss Ratio					
Year	**Orange**	**Grapefruit**	**Lemon**	**Lime**	**All Other Citrus**	**Total**
1996	0.00	0.00		0.00	0.00	**0.00**
1997	0.00	0.00		0.00	0.00	**0.00**
1998	0.00	0.00		0.05	0.00	**0.00**
1999	0.00	0.00		0.00	0.00	**0.00**
2000	0.13	0.56	0.00	14.12	0.01	**0.46**
2001	0.17	0.09	0.00	4.34	0.05	**0.19**
2002	0.07	0.02	0.00	12.66	0.00	**0.10**
2003	0.10	0.20	0.00	6.32	0.07	**0.12**
2004	0.36	0.38	0.00	0.00	0.34	**0.36**
2005	3.45	5.49	0.31	2.25	3.46	**3.72**
2006	0.11	1.02		0.00	0.07	**0.22**
2007	0.02	0.65	0.00	0.00	0.00	**0.09**
2008	0.00	0.00	0.00	0.00	0.00	**0.00**

Source: CropData, www.cropdata.com, accessed March 18, 2009.

Table A5. 1996-2008 Annual Florida Fruit Tree Insurance Experience for Orange by Coverage Flag

Year	Coverage Flag	Policies Sold	Policies Earning Premium	Units Indemnified	Liability (dollars)	Indemnity (dollars)
1996	CAT	461	408	1	74,560,901	1,070
	Buy-up	20	20	0	4,014,624	0
1997	CAT	609	537	0	87,031,217	0
	Buy-up	45	44	0	8,951,963	0
1998	CAT	735	698	0	111,734,430	0
	Buy-up	34	26	0	6,525,047	0
1999	Limit	17	15	0	732,316	0
	CAT	770	717	0	121,946,556	0
	Buy-up	18	16	0	7,229,997	0
2000	CAT	2,397	2,342	5	399,847,231	1,090,783
	Buy-up	148	147	0	35,781,909	0
	Limit	421	420	1	107,625,038	290,160
2001	CAT	2,118	2,075	6	349,139,103	1,004,070
	Buy-up	990	981	8	319,596,759	1,619,790
2002	CAT	2,102	2,008	5	349,986,384	1,117,484
	Buy-up	1,183	1,169	2	550,896,566	325,170
2003	CAT	1,953	1,861	13	299,200,543	1,269,581
	Buy-up	1,226	1,191	7	579,320,895	817,535
2004	CAT	1,852	1,736	17	399,413,843	1,631,345
	Buy-up	1,197	1,147	21	445,341,132	5,528,887
2005	CAT	1,924	1,777	154	367,197,848	29,154,971
	Buy-up	1,672	1,587	199	588,960,442	47,599,705
2006	CAT	1,302	1,078	6	192,503,258	76,100
	Buy-up	2,257	2,080	39	903,775,536	1,422,122
2007	CAT	1,281	1,278	10	395,395,400	127,278
	Buy-up	1,462	1,459	16	598,859,378	500,504
2008	CAT	1,594	1,546	0	480,924,948	0
	Buy-up	1,354	1,312	0	489,445,779	0
2009	CAT	1,693	1,623	0	633,336,265	
	Buy-up	1,286	1,225	0	536,286,926	

Source: CropData, www.cropdata.com, accessed March 18, 2009.

Table A6. 1996-2008 Annual Florida Fruit Tree Insurance Experience for Grapefruit by Coverage Flag

Year	Coverage Flag	Policies Sold	Policies Earning Premium	Units Indemnified	Liability (dollars)	Indemnity (dollars)
1996	CAT	244	216	0	7,354,209	0
	Buy-up	9	9	0	2,565,316	0
1997	CAT	304	270	0	6,537,406	0
	Buy-up	15	14	0	2,951,039	0
1998	CAT	309	282	0	8,179,792	0
	Buy-up	14	7	0	2,727,410	0
1999	CAT	267	236	0	7,557,637	0
	Buy-up	7	6	0	2,727,130	0
	Limit	6	5	0	78,468	0
2000	CAT	687	649	4	45,846,180	787,408
	Buy-up	64	63	2	13,178,606	471,831
	Limit	206	204	1	43,069,649	46,774
2001	CAT	538	514	2	39,795,419	48,256
	Buy-up	429	419	6	70,736,716	252,841
2002	CAT	489	462	2	41,334,491	75,294
	Buy-up	444	436	0	88,630,388	0
2003	CAT	426	398	3	35,757,250	64,071
	Buy-up	421	406	4	81,233,591	618,570
2004	CAT	376	358	2	40,678,332	7,226
	Buy-up	373	348	8	77,437,580	1,266,623
2005	CAT	414	381	38	33,542,610	4,541,841
	Buy-up	479	444	113	92,403,360	15,064,739
2006	CAT	260	223	2	16,091,337	7,076
	Buy-up	586	527	20	110,428,445	2,093,711
2007	CAT	268	266	12	29,250,974	248,570
	Buy-up	387	380	21	99,145,985	2,141,165
2008	CAT	342	330	0	38,205,447	0
	Buy-up	321	311	0	73,349,500	0
2009	CAT	331	312	0	49,372,492	
	Buy-up	285	268	1	81,902,920	

Source: CropData, www.cropdata.com, accessed March 18, 2009.

Table A7. 1996-2008 Annual Florida Fruit Tree Insurance Experience for Lemon by Coverage Flag

Year	Coverage Flag	Policies Sold	Policies Earning Premium	Units Indemnified	Liability (dollars)	Indemnity (dollars)
1998	CAT	1	0	0	0	0
1999	CAT	1	0	0	0	0
2000	CAT	1	1	0	921,521	0
	Limit	1	1	0	7,905	0
2001	Buy-up	2	2	0	1,689,194	0
2002	Buy-up	2	2	0	1,956,975	0
2003	Buy-up	3	3	0	2,061,634	0
2004	Buy-up	2	2	0	1,956,975	0
2005	Buy-up	2	2	1	2,022,209	12,425
2006	Buy-up	1	0	0	0	0
2007	CAT	1	1	0	1,039,488	0
	Buy-up	1	1	0	27,299	0
2008	CAT	1	1	0	1,123,771	0
	Buy-up	1	1	0	29,512	0
2009	CAT	2	2	0	1,447,590	

Source: CropData, www.cropdata.com, accessed March 18, 2009.

Table A8. 1996-2008 Annual Florida Fruit Tree Insurance Experience for Limes by Coverage Flag

Year	Coverage Flag	Policies Sold	Policies Earning Premium	Units Indemnified	Liability (dollars)	Indemnity (dollars)
1996	CAT	47	35	0	1,737,078	0
	Buy-up	6	6	0	368,515	0
1997	CAT	50	44	0	2,044,361	0
	Buy-up	4	4	0	322,075	0
1998	CAT	53	47	0	2,460,495	0
	Buy-up	7	7	1	118,509	3,569
1999	CAT	54	51	0	2,577,002	0
	Buy-up	10	9	0	448,703	0
	Limit	1	1	0	9,753	0
2000	CAT	22	21	6	440,557	129,890
	Buy-up	36	36	31	5,421,939	2,775,307
	Limit	8	8	7	989,596	815,440
2001	CAT	8	6	0	63,959	0
	Buy-up	32	32	9	4,072,664	678,853
2002	CAT	4	3	0	55,863	0
	Buy-up	25	21	4	2,955,168	1,237,845
2003	CAT	4	4	1	223,463	24,819
	Buy-up	19	17	3	1,117,735	231,591
2004	CAT	3	3	0	165,539	0
	Buy-up	15	13	0	694,339	0
2005	CAT	1	0	0	0	0
	Buy-up	6	4	1	83,012	6,186
2006	Buy-up	4	2	0	26,179	0
2007	Buy-up	3	3	0	5,974	0
2008	Buy-up	4	3	0	51,388	0
2009	Buy-up	4	3	0	62,247	

Source: CropData, www.cropdata.com, accessed March 18, 2009.

Table A9. 1996-2008 Annual Florida Fruit Tree Insurance Experience for All Other Citrus by Coverage Flag

Year	Coverage Flag	Policies Sold	Policies Earning Premium	Units Indemnified	Liability (dollars)	Indemnity (dollars)
1996	CAT	220	194	0	7,294,714	0
	Buy-up	11	11	0	3,409,889	0
1997	CAT	268	233	0	7,943,443	0
	Buy-up	25	24	0	3,952,321	0
1998	CAT	315	289	0	10,393,664	0
	Buy-up	23	14	0	2,559,923	0
1999	CAT	323	293	0	10,310,390	0
	Buy-up	11	9	0	2,680,945	0
	Limit	6	6	0	131,040	0
2000	CAT	720	685	1	28,301,459	7,150
	Buy-up	65	63	0	6,586,876	0
	Limit	154	151	0	8,856,276	0
2001	CAT	571	549	1	19,830,179	40,995
	Buy-up	380	375	2	25,226,259	14,578
2002	CAT	539	510	0	20,725,293	0
	Buy-up	415	403	0	35,503,321	0
2003	CAT	496	471	1	19,106,230	13,829
	Buy-up	422	407	1	32,951,812	78,068
2004	CAT	479	449	6	19,560,701	41,565
	Buy-up	376	354	11	30,075,335	363,002
2005	CAT	465	418	24	17,665,982	804,405
	Buy-up	456	416	47	37,776,972	3,670,493
2006	CAT	296	241	1	8,609,801	17,208
	Buy-up	566	506	3	46,182,495	33,559
2007	CAT	263	254	0	13,490,339	0
	Buy-up	373	366	2	38,199,727	5,759
2008	CAT	319	302	0	16,375,509	0
	Buy-up	341	329	0	36,608,703	0
2009	CAT	340	316	0	20,901,683	
	Buy-up	321	304	0	38,913,583	

Source: CropData, www.cropdata.com, accessed March 18, 2009.

Exhibit 2. 2008 County-Level Participation for Citrus in the Florida Fruit Tree Program

Table A10. 2008 County Level Participation for Oranges in the Florida Fruit Tree Program

County	Coverage Flag	Policies Sold	Policies Earning Premium	Liability (dollars)
Brevard	CAT	16	15	3,377,809
	Buy-up	12	12	563,057
Charlotte	CAT	18	17	7,185,367
	Buy-up	17	16	15,320,185
Citrus	CAT	1	1	25,861
Collier	CAT	23	22	37,357,162
	Buy-up	28	27	28,388,252
De Soto	CAT	154	147	51,762,585
	Buy-up	126	123	108,021,195
Glades	CAT	8	8	9,725,433
	Buy-up	13	13	5,899,731
Hardee	CAT	311	304	42,456,560
	Buy-up	171	159	26,399,163
Hendry	CAT	47	43	80,936,128
	Buy-up	65	58	65,187,878
Hernando	CAT	5	5	310,109
	Buy-up	6	5	170,876
Highlands	CAT	175	171	60,532,736
	Buy-up	123	121	32,711,404
Hillsborough	CAT	67	65	7,267,936
	Buy-up	36	34	4,980,491
Indian River	CAT	59	57	18,126,934
	Buy-up	31	30	12,530,020
Lake	CAT	64	63	5,826,829
	Buy-up	41	41	5,723,779
Lee	CAT	5	5	4,576,585
	Buy-up	23	23	22,470,805

Source: CropData, www.cropdata.com, accessed November 3, 2008

Table A10. 2008 County Level Participation for Oranges in the Florida Fruit Tree Program (Continued)

County	Coverage Flag	Policies Sold	Policies Earning Premium	Liability (dollars)
Manatee	CAT	36	36	13,832,367
	Buy-up	21	21	18,435,214
Marion	CAT	6	6	379,073
	Buy-up	5	5	881,036
Martin	CAT	24	23	29,382,771
	Buy-up	12	12	18,086,267
Okeechobee	CAT	16	16	10,267,796
	Buy-up	12	12	4,931,508
Orange	CAT	17	15	973,993
	Buy-up	20	18	3,531,388
Osceola	CAT	27	25	6,246,532
	Buy-up	16	16	8,019,545
Palm Beach	CAT	1	1	442,464
	Buy-up	1	1	740,420
Pasco	CAT	37	34	5,203,743
	Buy-up	59	59	7,045,557
Polk	CAT	400	394	54,619,587
	Buy-up	453	444	77,803,749
Sarasota	CAT	4	4	208,357
	Buy-up	3	3	1,466,060
Seminole	CAT	4	4	57,354
	Buy-up	10	10	1,131,417
St. Lucie	CAT	61	57	29,462,621
	Buy-up	46	46	18,841,640
Volusia	CAT	8	8	380,256
	Buy-up	4	3	165,142

Source: CropData, www.cropdata.com, accessed November 3, 2008

Table A11. 2008 County Level Participation for Grapefruit in the Florida Fruit Tree Program

County	Coverage Flag	Policies Sold	Policies Earning Premium	Liability (dollars)
Brevard	CAT	8	7	119,075
	Buy-up	9	9	138,854
Charlotte	CAT	3	3	853,327
	Buy-up	4	4	855,116
Citrus	CAT	1	1	12,936
Collier	CAT	7	7	605,527
	Buy-up	2	2	5,959,048
De Soto	CAT	6	5	303,696
	Buy-up	11	10	1,618,964
Glades	CAT	5	5	209,352
Hardee	CAT	20	19	398,311
	Buy-up	4	3	244,286
Hendry	CAT	14	13	2,991,946
	Buy-up	13	12	3,783,354
Highlands	CAT	21	20	1,138,876
	Buy-up	13	12	640,539
Hillsborough	Buy-up	4	3	209,065
Indian River	CAT	70	68	13,773,874
	Buy-up	52	50	21,154,215
Lake	CAT	10	10	358,059
	Buy-up	11	11	998,554
Lee	CAT	1	1	57,750
	Buy-up	9	9	3,268,591

Source: CropData, www.cropdata.com, accessed November 3, 2008

Table A11. 2008 County Level Participation for Grapefruit in the Florida Fruit Tree Program (Continued)

County	Coverage Flag	Policies Sold	Policies Earning Premium	Liability (dollars)
Manatee	CAT	7	7	241,032
	Buy-up	1	1	17,200
Marion	CAT	1	1	3,509
	Buy-up	1	1	6,000
Martin	CAT	5	5	1,011,238
	Buy-up	4	4	1,272,563
Okeechobee	CAT	5	5	688,249
	Buy-up	7	7	1,077,595
Orange	CAT	2	2	6,885
	Buy-up	1	1	12,660
Osceola	CAT	3	3	586,135
	Buy-up	3	3	712,960
Palm Beach	Buy-up	1	1	456,010
Pasco	CAT	2	2	30,646
	Buy-up	3	3	22,039
Polk	CAT	78	75	2,030,255
	Buy-up	113	112	4,423,471
Sarasota	Buy-up	1	1	276,440
Seminole	CAT	1	1	1,672
	Buy-up	2	2	198,785
St. Lucie	CAT	69	67	12,759,272
	Buy-up	52	50	26,003,191
Volusia	CAT	3	3	23,825

Source: CropData, www.cropdata.com, accessed November 3, 2008

Table A12. 2008 County Level Participation for Lemon in the Florida Fruit Tree Program

County	Coverage Flag	Policies Sold	Policies Earning Premium	Liability (dollars)
Hendry	CAT	1	1	1,123,771
Martin	Buy-up	1	1	29,512

Source: CropData, www.cropdata.com, accessed November 3, 2008

Table A13. 2008 County Level Participation for Limes in the Florida Fruit Tree Program

County	Coverage Flag	Policies Sold	Policies Earning Premium	Liability (dollars)
Miami-Dade	Buy-up	4	3	51,388

Source: CropData, www.cropdata.com, accessed November 3, 2008

Table A14. 2008 County Level Participation for All Other Citrus in the Florida Fruit Tree Program

County	Coverage Flag	Policies Sold	Policies Earning Premium	Liability (dollars)
Brevard	CAT	10	9	259,432
	Buy-up	3	2	18,010
Charlotte	CAT	5	5	408,913
	Buy-up	3	3	999,214
Collier	CAT	7	7	1,124,257
	Buy-up	8	8	3,016,563
De Soto	CAT	9	9	824,892
	Buy-up	12	11	2,245,440
Glades	CAT	2	2	221,606
	Buy-up	3	3	590,033
Hardee	CAT	21	21	839,114
	Buy-up	15	15	1,323,789
Hendry	CAT	11	10	2,343,336
	Buy-up	7	7	3,148,890
Hernando	CAT	1	1	11,033
Highlands	CAT	30	29	1,308,839
	Buy-up	19	17	1,720,961
Hillsborough	CAT	6	6	325,860
	Buy-up	7	7	519,642
Indian River	CAT	25	24	754,874
	Buy-up	15	15	1,971,902
Lake	CAT	33	29	1,599,925
	Buy-up	27	26	2,814,574
Lee	Buy-up	5	5	1,357,502

Source: CropData, www.cropdata.com, accessed November 3, 2008

Table A14. 2008 County Level Participation for All Other Citrus in the Florida Fruit Tree Program (Continued)

County	Coverage Flag	Policies Sold	Policies Earning Premium	Liability (dollars)
Manatee	CAT	3	3	78,584
	Buy-up	4	4	325,620
Marion	CAT	2	2	162,976
	Buy-up	2	2	26,240
Martin	CAT	9	8	619,817
	Buy-up	4	4	997,374
Okeechobee	CAT	1	1	35,200
	Buy-up	10	10	899,687
Orange	CAT	4	3	24,217
	Buy-up	7	5	171,572
Osceola	CAT	5	5	337,876
	Buy-up	5	4	343,292
Palm Beach	CAT	1	1	149,215
	Buy-up	1	1	2,504,580
Pasco	CAT	8	8	79,937
	Buy-up	18	18	590,335
Polk	CAT	95	92	3,474,341
	Buy-up	132	131	8,319,908
Sarasota	Buy-up	1	1	184,400
Seminole	Buy-up	8	8	464,859
St. Lucie	CAT	31	27	1,391,265
	Buy-up	24	21	2,050,296
Volusia	Buy-up	1	1	4,020

Source: CropData, www.cropdata.com, accessed November 3, 2008

Appendix B

USDA New Pest Response Guidelines: Citrus Greening Disease

At the time this report was prepared, this document was also available at http://www.aphis.usda.gov/plant_health/plant_pest_info/citrus_greening/downloads/pdf_files/cg-nprg.pdf

Appendix C

Florida Department of Agriculture and Consumer Services Division of Plant Industry Asiatic Citrus Canker Eradication Regulations

Source: Florida Department of Agriculture and Consumer Services, Division of Plant Industry, 2008, Asiatic Citrus Canker Eradication Regulations, https://www.flrules.org/gateway/readFile.asp?sid=0&tid=5117834&type=1&file=5B-58.001.doc.

5B-58.001 Citrus Canker Eradication.

(1) Definitions. For the purpose of this rule, the definitions in Section 581.011, Florida Statutes, and the following definitions shall apply:

(a) Approved landfill. A landfill that is fenced, that prohibits the removal of dumped material, and that requires that dumped material be covered at the end of every day on which dumping occurs.

(b) Citrus Canker Certificate. A document issued by an authorized representative of the department verifying compliance with the requirements of these rules.

(c) Citrus. All members and any hybrids of the subfamily Aurantioideae, of the family Rutaceae including any plants, plant parts, fruits, seeds and any other parts thereof. For the purpose of this rule the remaining subfamilies, Rutoideae and Toddalioiodeae, of the family Rutaceae are excluded from this definition.

(d) Citrus canker. A bacterial disease of citrus incited by the organism *Xanthomonas axonopodis pv. citri*, (formerly known as *Xanthomonas campestris pv. citri*), Asian strain.

(e) Citrus Canker Risk Assessment Group. A group of scientists and regulatory officials with knowledge of citrus canker disease and its eradication appointed by the director to make biologically sound recommendations for the control and eradication of citrus canker from the state. Risk assessments are science-based evaluations. The risk assessment group provides scientific opinion and recommendations on control and eradication strategies and other issues upon request for assistance from the Citrus Canker Eradication Program.

(f) Commercial citrus grove. A solid set planting of 40 or more citrus trees.

(g) Commercial citrus-producing area. American Samoa, Arizona, California, Florida, Guam, Hawaii, Louisiana, Northern Mariana Islands, Puerto Rico, Texas, and the Virgin Islands of the United States.

(h) Exposed. Determined by the department to likely harbor citrus canker bacteria because of proximity to infected plants, or probable contact with personnel, or regulated articles, or other articles that may have been contaminated with bacteria that cause citrus canker, but not expressing visible symptoms.

(i) Infected. Harboring citrus canker bacteria and expressing visible symptoms.

(j) Landscape maintenance operators. Any person or company engaged in the business of landscape maintenance where equipment or other regulated articles are moved between non-contiguous properties.

(k) Regulated articles. Any article capable of transporting or harboring citrus canker; including:

1. Trucks, tractors and all other equipment used in the production, cultivation, harvesting, processing and packing, and transportation of citrus or regulated articles, or entering citrus groves for other non-production purposes.

2. All tools and nursery equipment used in the quarantine areas.

3. Plant clippings and lawn and yard debris from the quarantine area.

(2) Purpose. This rule is enacted to prevent the spread of citrus canker and to eradicate citrus canker within the State of Florida. To accomplish that purpose, this rule declares citrus canker to be a plant pest and a nuisance, establishes a quarantine areas, establishes eradication and control procedures, prohibits the removal of citrus nursery stock or citrus nursery plants or plant products from the quarantine areas, regulates the sale of citrus fruit originating in the quarantine areas, identifies regulated articles, and provides for entry of authorized representatives upon

properties where citrus canker is known to exist or upon properties which have been exposed to citrus canker.

(3) Declaration of citrus canker as a plant pest. Pursuant to Section 581.031(6), Florida Statutes, citrus canker, is declared to be a plant pest and a nuisance capable of causing serious damage to citrus. Any citrus, or any other regulated article capable of transporting or harboring citrus canker and therefore capable of spreading the disease is also declared to be a nuisance.

(4) Quarantine area. An area around a site where an infestation of citrus canker is known to occur will be quarantined. The geographical boundaries of the quarantine area shall be established by risk assessment procedures and will be published in a major newspaper of general distribution in each area affected and through other appropriate media. Risk assessment procedures will consider the agressiveness of the pathogen in the field, the level of disease inoculum, the location and spatial distribution of infected and exposed plants, the variety and type of plants, the risk of spread to areas growing citrus commercially, maintenance practices, and other relevant information. An area shall be released from quarantine provided no detections of citrus canker have occurred during a minimum two-year period of intensive survey and a declaration that citrus canker has been eradicated from the area.

(5) Control procedures.

(a) Risk Assessment. The department shall perform risk assessment procedures to determine the steps necessary to eradicate, control, and prevent the dissemination of citrus canker. The Director shall evaluate the risk assessment requests in consultation with the Citrus Canker Risk Assessment Group Leader to determine the need to engage the services of the Citrus Canker Risk Assessment Group to conduct a full risk assessment. All citrus trees which are infected or infested shall be removed. The decision to remove exposed trees will take into consideration the recommendations of the Citrus Canker Risk Assessment Group. In developing the recommendations, the Citrus Canker Risk Assessment Group will take the following variables into consideration: property type, cultivar, cultivar susceptibility, tree size and age, size of block, tree spacing, horticultural condition, tree distribution, tree density, weather events, wind breaks, movement factors, disease strain, exposure, infection age, infection distribution, disease incidence, Asian citrus leafminer damage, survey access, security of property, sanitation, management practices, closeness of other host properties, and closeness of other infected properties.

(b) Immediate Final Orders. The Department shall issue an Immediate Final Order stating the quarantine and control methods to be implemented on the infected or exposed citrus located on the property. It may be delivered in person, by mail or similar common carrier, or posted on the property. Immediate final orders are not required for control action in commercial citrus groves provided the owner agrees voluntarily to the control action and enters into an agreement not to sue with the department.

(6) Movement of citrus nursery stock or citrus plants.

(a) The movement or planting of citrus nursery stock, citrus plants or plant parts in the quarantine area is prohibited with the exception of citrus nursery stock planted in a commercial citrus grove as recommended by risk assessment procedures or destined to an area other than a commercial citrus-producing area.

(b) Citrus nursery stock may move through the quarantine area for planting outside the quarantine area provided it is completely covered or enclosed in containers or in a compartment of a vehicle during movement. The shipment must be accompanied by an invoice denoting a purchaser outside of the quarantine area.

(7) Movement of citrus fruit originating within the quarantine area. Notwithstanding subsection (6) of this rule, citrus fruit produced within the quarantine area may be moved from or within the quarantine area upon obtaining a citrus canker Citrus Fruit Harvesting Permit, Revised 6/99, DACS-08123 (formerly PI-123), from the Citrus Canker Program, 3027 Lake Alfred Road, Winter Haven, Florida 33881, and incorporated herein by reference, and be in compliance with the following requirements:

(a) The grove producing the fruit has been inspected by the department and found to be free of citrus canker. Groves must be mowed and otherwise maintained to facilitate inspection.

(b) The fruit has been treated in accordance with subsection (12) of this rule.

(c) The fruit is not destined for a commercial citrus – producing area which is prohibited by the USDA in 7 CFR 301.75.

(d) All citrus harvesters, haulers, packers, and processors operating in the quarantine areas or handling regulated articles from the quarantine areas must sign a compliance agreement, DACS-08031, effective 5/99, and incorporated into this rule by reference. A copy of DACS-08031 may be obtained from the Citrus Canker Program, 3027 Lake Alfred Road, Winter Haven, Florida 33881.

(e) All movement of bulk fruit must be with a limited permit, DACS-08156, effective 6/99. A copy of DACS-08156 may be obtained from the Citrus Canker Program, 3027 Lake Alfred Road, Winter Haven, Florida 33881.

(8) Retail sale of citrus fruit. All citrus fruit sold by retail establishments must originate from outside the quarantine area or be in compliance with section (7). All retail establishments shall maintain records demonstrating compliance with this provision. Any retail establishment failing to maintain the required records shall be subject to stop sale of its citrus fruit.

(9) Movement of plant clippings and lawn and yard debris.

(a) Requirements. Plant clippings and lawn and yard debris may be moved from or within the quarantine area for disposal in an approved landfill or for composting in a recycling facility only under the following conditions:

1. The plant clippings or yard debris must be completely covered during transportation.

2. If mechanical failure prevents unloading of debris, the department shall be notified immediately. This material may not be stored or held overnight outside the quarantine area.

(b) Landscape maintenance operators within the quarantine area shall demonstrate that they have:

1. Treated regulated articles in accordance with the requirements of subsection (13) of this rule upon departure from any property.

2. Treated personnel in accordance with the requirements of subsection (14) of this rule when departing from any property.

(c) Compliance Agreements. All landscape maintenance operators within the quarantine areas must enter into a compliance agreement DACS-08031, effective 5/99, providing for compliance with this rule. All landscape maintenance companies will be provided with a serialized decal upon signing a compliance agreement. Decals shall be prominently displayed on the driver's side of the windshield of the vehicle. All landscape maintenance operators shall on demand provide the department with a list that includes the names and physical address of all clients.

(10) Movement of citrus fruit through Quarantine Area. Notwithstanding subsection (6) of this rule, citrus fruit originating outside the quarantine areas may be moved through the quarantine area without a citrus canker certificate provided the following conditions are met:

(a) Citrus fruit must be accompanied by a receipt or bill of lading verifying that the citrus fruit originated outside of the quarantine area;

(b) The citrus fruit must be completely covered or enclosed in containers or in a compartment of a vehicle during movement through the quarantine area, except that covering or enclosure is not required if the citrus fruit is moved through the quarantine areas without stopping except for refueling or for traffic conditions such as traffic lights or stop signs.

(11) Decontamination requirements. All harvesters, intermediate handlers, grove caretakers, packers, and processors both within and outside of the quarantine area must decontaminate equipment, personnel and regulated articles and sign the applicable compliance agreement, DACS-08031, effective 5/99, and incorporated into this rule by reference. A copy of DACS-08031 may be obtained from the Citrus Canker Program, 3027 Lake Alfred Road, Winter Haven, Florida 33881. All non-production people entering commercial citrus groves must decontaminate equipment, personnel and regulated articles in accordance with (13) and (14) if contact with citrus does occur.

(12) Treatment of citrus fruit. Citrus fruit for which treatment is required by this rule must be treated in accordance with label directions in one of the following ways in the presence of an authorized representative of the department, or at a facility operating under a compliance agreement, DACS-08031, effective 5/99, with the department:

(a) Thoroughly wetted for at least 2 minutes with a solution containing 200 parts per million sodium hypochlorite, with a solution maintained at a pH of 6.0 to 7.5, or

(b) Thoroughly wetted with a solution containing sodium o-phenyl phenate (SOPP) at a concentration of 1.86 to 2.0 percent total solution for 45 seconds if the solution has sufficient soap or detergent to cause a visible foaming action, or for 1 minute if the solution does not contain sufficient soap to cause a visible foaming action.

(13) Treatment of Regulated Articles. Regulated Articles for which treatment is required by this rule must be treated in one of the following ways in the presence of an authorized representative of the department, or at a facility operating under a compliance agreement with the department:

(a) All surfaces must be treated to the point of runoff with 200 parts per million sodium hypochlorite solution. A pH of 6.0 to 7.5 must be maintained in the solution.

(b) All surfaces must be treated to the point of runoff with 2000 parts per million solution of quaternary ammonium chloride (0.2% OAC).

(c) All surfaces must be washed thoroughly to the point of runoff with a hot water and detergent solution under high pressure maintained at a minimum temperature of 160 degrees F. (71 degrees C).

(d) All surfaces must be thoroughly cleaned with steam with a minimum temperature of 160 degrees F (71 degrees C) maintained at the point of contact.

(14) Treatment of Personnel. Personnel departing from property in the quarantine area shall wash or treat all exposed areas of the body and clothing with an antibacterial soap, wash, spray or other approved solution.

(15) Citrus plants in containers. Maintaining citrus plants in containers within the quarantine areas is prohibited unless they are located in a nursery or nursery stock dealer establishment which is registered with the department or are awaiting planting in a commercial grove. Citrus plants in containers found in quarantine areas will be confiscated immediately and destroyed without compensation. It shall be unlawful for nursery stockdealers in the quarantine areas to add citrus plants to their inventory. It shall be unlawful for nurseries to add citrus plants to their

inventory unless they have a demonstrated market for the plants in states or countries outside of a commercial citrus-producing area as defined in (1)(g). Nurseries and nursery stockdealers operating in the retail trade must keep all citrus plants in a secure locked area or the plants will be confiscated by the department without compensation.

(16) Entry of authorized representatives. All owners and occupants of properties on which citrus canker is known or suspected to exist shall permit entry of authorized representatives of the Department of Agriculture and Consumer Services for purposes of inspecting, taking of specimens, or collecting suspect infected fruit, photographing or documenting tree information, applying or supervising treatments, or conducting control activities.

Specific Authority 570.07(21), (23), 581.031(1), (4), (5), 581.091(1), 581.101(1), 581.184 FS. Law Implemented 570.07(2), (13), (21), 581.031(6), (7), (9), (15), (17), 581.083, 581.101, 581.131, 581.141, 581.184, 581.211 FS. History–New 1-17-96, Amended 4-9-96, 5-14-97, 8-19-97, 11-19-97, 11-16-99, 7-17-00, 2-22-01.

Appendix D

USDA APHIS and FDACS DPI
Citrus Health Response Plan (CHRP)
State of Florida
2006-2007

At the time this report was prepared, this document was also available at http://www.aphis.usda.gov/plant_health/plant_pest_info/citrus/index.shtml through the program document link.