

Strategic Planning for the Florida Citrus Industry

Addressing Citrus Greening Disease

Citrus greening, a disease that reduces yield, compromises the flavor, color, and size of citrus fruit and eventually kills the citrus tree, is now present in all 34 Floridian citrus-producing counties. Caused by an insect-spread bacterial infection, the disease reduced citrus production in 2008 by several percent and continues to spread, threatening the existence of Florida's \$9.3 billion citrus industry. A successful citrus greening response will focus on earlier detection of diseased trees, so that these sources of new infections can be removed more quickly, and on new methods to control the insects that carry the bacteria. In the longer-term, technologies such as genomics could be used to develop new citrus strains that are resistant to both the bacteria and the insect.

Among the many citrus diseases that have invaded Florida, citrus greening, known in the international scientific community as huanglongbing or HLB, presents the greatest threat to Florida's citrus industry. Citrus greening infects every type of citrus, and can quickly spread from one tree to a whole orchard. Infected trees yield fewer fruit, and the fruit that is produced is small, lopsided, green in color, and has a bitter flavor, rendering it unusable. There is no cure for citrus greening disease.



In Florida, citrus greening is universally associated with the bacterium *Candidatus Liberibacter asiaticus*, which is spread by an insect called the Asian citrus psyllid (pronounced "sill-id"). First detected in the United States in Florida in 2005, the disease has spread throughout Florida's citrus-producing counties and has also been reported in Texas, Georgia, Louisiana, and South Carolina. By 2008, the removal of infected

trees and the adverse effects of the infection had reduced Florida citrus production by several percent. The rapid spread of the disease threatens continued reductions in the future.

The incursion of citrus greening disease has been more effective than any prior event in bringing industry, government, and universities together in the defense of citrus production in Florida. Local, state and international meetings have been organized to educate citrus growers about the disease, and increased industry

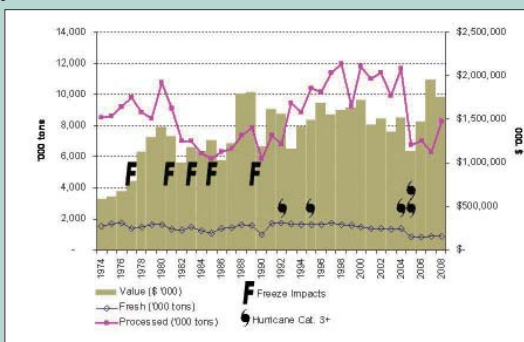
and government research efforts have yielded insight into citrus greening that could result in the development of new disease and insect control strategies. However, there is an urgent need to identify immediate actions to keep the citrus industry viable while new approaches for long-term disease mitigation are developed.

At the request of the Florida Department of Citrus, the National Research Council convened a committee to develop a strategic

The Citrus Industry

Citrus fruit ranks as first internationally in trade value among all fruits and is produced commercially in about 140 countries, but the primary citrus producers are Brazil, the Mediterranean Basin, the United States, and China. In the United States, Florida (68.7 percent), California (27.5 percent) and Texas (2.7 percent) and Arizona (1.1 percent) produce almost the entire commercial citrus crop. Brazil and Florida dominate the production of oranges for juice, and Florida's hot, humid climate is perfect for producing oranges with high juice content.

The Florida citrus industry is estimated to have a \$9.3 billion economic impact, employing approximately 80,000 people full-time as citrus grove workers, seasonal pickers, haulers, processors, packers and managers. The combined annual wage of citrus workers in Florida is \$2.7 billion, or about 1.5 percent of the state's wage income.



Florida citrus production in tons (lines) and dollar value (bars). Source: USDA-NASS (2008)

plan for addressing citrus greening disease. The committee was charged to examine the current citrus disease situation in Florida and the status of public and private efforts to address citrus greening, the capacity of the industry to mobilize a scientifically based response to disease threats and to translate scientific advances into products and services for the protection of Florida Citrus Industry in the short and long term.

Responses to Citrus Greening

The report's authoring committee found that at the present time, there are no effective means of curing a tree once it becomes infected with citrus greening. Treatments with heat or antibiotics are effective for shoot cuttings used in nursery stock but cannot eradicate the disease from whole trees. Vigorous pruning of symptomatic parts of the tree provides only short-term relief, and nutritional sprays have not demonstrated any real benefits in preventing the spread of citrus greening. The committee concluded that currently, the best approach for managing the disease is to:

- Remove infected trees to reduce the pool of bacteria
- Keep Asian citrus psyllid populations as low as possible
- Ensure that replacement trees are grown in insect-proof greenhouses, as has been required in Florida since January 2008

High-priority Recommendations

Although the committee is optimistic that advances in modern biology will enable the development of new methods to prevent or control citrus

greening disease in the future, there are several high-priority actions that could help sustain the Florida citrus industry until these new approaches have been developed. Those actions should be implemented simultaneously, and are focused on ways to improve the efficiency and effectiveness of current best management practices to limit the spread of the disease.

Create Citrus Health Management Areas

Establishing Citrus Health Management Areas would facilitate the coordinated control of psyllid populations, and the removal of trees infected with citrus greening. Citrus Health Management Areas will be regions of about 10,000 to 50,000 acres with similar levels of infection, which will mandate best management practices for the clean-up of abandoned orchards, the design and implementation of compensation plans, coordination of area-wide psyllid sprays, and removing infected urban citrus. The management areas should also include test plots to facilitate high-priority studies aimed at developing new strategies for managing the disease.

Integrate efforts to improve practices for insecticidal control of the psyllid

To date, the application of insecticides has been the most effective method of psyllid population control, but there are concerns that the widespread use of insecticides could result in several negative consequences. Repeated use of the same insecticides could lead to the emergence of a strain of insecticide-resistant psyllids, expose farm workers to potentially dangerous levels of chemicals, reduce populations of beneficial insects, and contaminate groundwater. The committee

recommends integrating new research approaches with management efforts to maximize insecticide effectiveness while minimizing risks. Such new research includes monitoring fluctuations in levels of psyllid populations over the course of a year, studying psyllid behavior to understand how they acquire and transmit the bacteria, testing new insecticide ingredients, and experimenting with the timing of insecticide applications relative to the appearance of “flush”, the new growth on citrus trees favored by psyllids.

Support the search for biomarkers for early detection of disease

To limit the spread of disease, infected trees are removed to reduce the pool of infected trees for psyllids to feed on. Infected trees are visually identified by the mottled leaves and yellow shoots which are symptomatic of citrus greening, and laboratory tests are used to confirm the diagnosis. However, visual identification can sometimes miss infected trees—visible symptoms can take months or even years to emerge, and trees that were mature when infected often display only mild symptoms. If infected trees could be identified and removed sooner than visual scouting allows, the spread of citrus greening would be significantly reduced. Biomarkers are chemical signals such as tree volatiles or protein levels that change in response to a specific biological event, such as infection with citrus greening. Research to identify the biomarkers for citrus greening could

result in the development of a test to identify trees infected with the disease before visual symptoms emerge, speeding the time to their removal from the orchard.

Emphasize to growers the importance of removal of infected trees in groves, and encourage homeowners to remove backyard citrus trees, especially infected trees

Citrus growers need a better understanding of the critical importance of rapid detection and removal of affected trees for mitigation of citrus greening. Training programs should be used to teach scouting and detection methods. The news media and internet should be used to inform homeowners in Florida about the role of backyard citrus and ornamental relatives of citrus (such as Orange Jasmine or *Murraya*) in spreading the disease. Regulations enforcing the removal of citrus trees from residential property would be very difficult to enforce; homeowners must be encouraged to plant citrus substitutes voluntarily.

Near-, Intermediate- and Long-term Strategies

In addition to its highest priorities, the committee recommends starting work on numerous research directions with near-, intermediate-, and long-term outcomes. First, in order to develop citrus cultivars resistant to the disease—a potentially lengthy process—the search should begin now for molecules that can make citrus plants resistant to the bacteria and the insect.



Asian Citrus Psyllids

A pest of citrus and close relatives of citrus, Asian citrus psyllids damage citrus plants through their feeding activities—the insects extract a large amount of sap as they feed, and produce honeydew, a clear, sticky secretion that coats the leaves of the citrus plant and encourages a sooty mold to grow. Psyllids also inject a salivary toxin into the leaves as they feed, which prevents leaves from expanding properly. New shoot growth that is infested with psyllids cannot develop properly, and is susceptible to breaking off. Even more serious than this direct damage, psyllids spread the bacterium that causes the citrus greening infection, picking it up by feeding on

infected citrus plants, and passing it on when they move on for their next meal.

Asian citrus psyllids are native to Asia but are now found in many countries. In the United States, psyllids first appeared in Florida in 1998. The insects were accidentally spread to Texas in 2001 on citrus nursery stock imported from Florida. Asian citrus psyllids are fed upon by many types of predators, including spiders, lacewings, and their primary predator, the cocconellid beetle, or ladybug; however, these predators are not effective in reducing the spread of citrus greening.

Photos by David Hall, USDA-ARS (top)
Michael Rogers, UF-CREC (bottom)

Similarly, insecticide-based strategies are unlikely to be sustainable in the long term, and therefore work should begin soon on developing alternatives to insecticides.

In the intermediate term, citrus farmers may need to try alternative horticultural strategies in order to maximize fruit production. For example, denser planting of smaller, fast-producing trees would allow profitable production and the recovery of costs before greening eventually took over the grove.

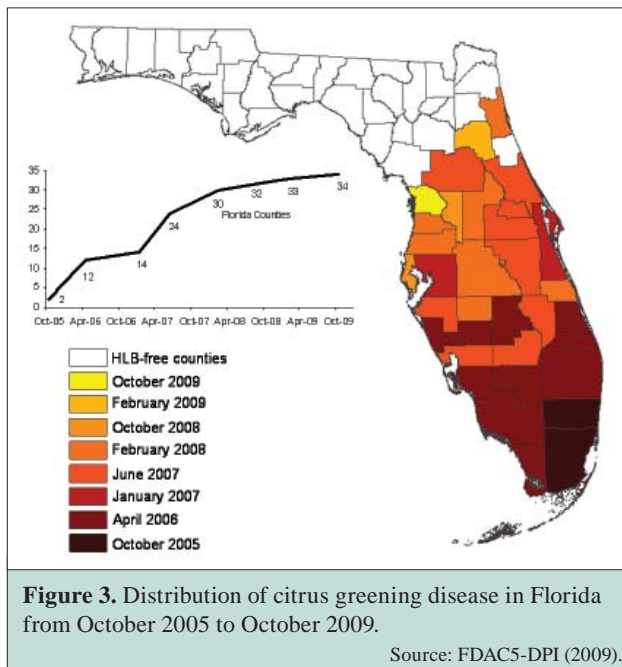


Figure 3. Distribution of citrus greening disease in Florida from October 2005 to October 2009.

Source: FDAC5-DPI (2009).

A better understanding of the biology of psyllids and their interactions with the plant host, the bacteria, and the environment may yield information on strategies to control the insect population more effectively

As an example, data suggest that female psyllids release pheromones that attract males, and psyllids may be attracted to citrus tree volatiles. These chemical compounds could be used to direct psyllids to congregate at certain sites where their destruction would be more easily accomplished. Other strategies under consideration are the discovery and use of plants that attract psyllids away from citrus, the use of plants that form barriers to psyllid movement, or the use of psyllid repellents on citrus.

Modern biological tools could be used to generate citrus varieties that are resistant to citrus greening

There are no naturally occurring varieties of citrus that are resistant to citrus greening; however, modern biology techniques such as genetic transformation of mature citrus tissue could be used to generate greening-resistant citrus trees. Other areas of research that could help include systemically acquired resistance, which is the activation of a systemic defense reaction in the tree. Another approach is to target psyllids by generating citrus plants that produce their own insecticides.

Committee on Strategic Planning for the Florida Citrus Industry: Addressing Citrus Greening Disease

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The National Academies appointed the above committee of experts to address the specific task requested by the Florida Department of Citrus. The members volunteered their time for this activity; their report is peer-reviewed and the final product signed off by both the committee members and the National Academies. This report brief was prepared by the National Research Council based on the committee’s report.



For more information, contact the Board on Agriculture and Natural Resources at (202) 334-3062 or visit <http://nationalacademies.org/banr>. Copies of *Strategic Planning for the Florida Citrus Industry: Addressing Citrus Greening Disease* are available from the National Academies Press, 500 Fifth Street, NW, Washington, D.C. 20001; (800) 624-6242; www.nap.edu.

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