Citrus Research and Development Foundation, Inc.

FY 2014-15 Annual Report

Covering the Period
July 1, 2014 – June 30, 2015

"Advance disease and production research and product development activities to ensure the survival and competitiveness of Florida citrus"

Retain Health of Existing Trees
– Critical for Near-Term Industry Survival

Provide Tools for Success of New Plantings
– Necessary for Stabilizing Loss of Acreage

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The Quest for Solutions to HLB: Reflections on FY 2014-15

The Florida industry continues to struggle to cope with immediate impacts of the chronic infection of its trees with *(CLas),* the pathogen which is responsible for citrus greening disease, or HLB. The Citrus Research and Development Foundation, Inc. (CRDF) has aggressive programs to develop basic understanding of the disease and to deliver remedies to the groves to dampen the impact of this disease. With a majority of the citrus tree population in Florida infected, the challenge is two-fold: 1) to stabilize or improve the declining productivity of trees in chronic decline from the disease; and 2) to enable citrus growers to successfully replant trees and groves to stop the steady decline of overall citrus production in the state. During 2014-2015, CRDF is managing approximately 100 research projects involving teams from across the country to develop short, intermediate and long-term solutions to this devastating disease. Of greatest priority are the projects that promise to deliver management tools in the near-term. In addition to this competitively awarded research support, CRDF has evolved a Commercial Product Delivery Program, overseen by an aggressive Committee of Board members and engaged industry participants. This committee has the responsibility of translating research results into tools available to citrus growers. This latter focus has been the target for investment of state legislative funding over the past two years.

2014 was a significant period in the evolution of research and the advancement of efforts by CRDF to deliver solutions to HLB in Florida. It also was a significant year from a national perspective, as federal funds were committed and programs established to respond to the concerns over this disease in all citrus states.

CRDF made significant strides in developing and delivering the results of research into field trials and grower demonstrations, focusing more effort on the near-term need to provide tools to growers. The strength of the CRDF research portfolio and significant progress from many projects allowed CRDF to transform many topics into delivery projects, greatly increasing the work flow and momentum of the Commercial Product Delivery Committee. CRDF added new capacity to design and manage field trials, and reinforced the need to evaluate chemical therapy of *Candidatus Liberibacter asiaticus (CLas)* in infected plants. Many candidate bactericidal chemicals were evaluated in assays and have been advanced for participation in field trials. Significant resources have been committed to field evaluations of several materials. CRDF project managers have reached out to commercial partners to access their knowledge and experience, and have established working relationships that have moved testing along.

During 2014-15, a number of field trials were initiated, placing potential tools in grower/cooperator situations. Among the tools being evaluated are: plant growth regulators to retain fruit on HLB-infected trees; commercial microbial products and programs which are reported to enhance citrus tree ability to withstand infection; combinations of nutrients, soil amendments and other cultural practices targeted to maintain health and productivity in infected trees; integration of tools to protect and promote new plantings; and bactericidal treatments for both HLB and citrus canker. During 2014, plans and plant propagation advanced to enable spring 2015 commercial scale plantings of candidate tolerant rootstocks from the UF, IFAS and USDA, ARS citrus breeding programs. In addition, field days were sponsored to demonstrate the emergence of thermal therapy as an immediate tool for reducing bacterial infection in small trees infected with *CLas*. Scale-up efforts were begun to expand on the proven use of solar heat enclosures placed over trees, and supplemental heat (steam) was tested for the first time in spring 2014, leading to significant follow-up activities during FY 2014-15.

The CRDF annual operating budget for FY 2014-15 was just over $18 million, and the $3.5 million investment from the state legislature provided important support for short term research and delivery projects. Announcement of significant federal funding made available in late 2014 through the Federal Farm Bill provided much-needed support for long-term objectives met through multi-year competitive grants managed through the USDA, National Institute of Food and Agriculture (NIFA). Complementary Congressional commitment of “shovel-ready” project support for responding to citrus HLB nation-wide also is providing support to the broader efforts. However, Florida citrus growers are at increased risk of further losses following three consecutive years of declining production, in part due to pre-harvest fruit drop losses in groves most impacted by HLB.

We are often asked how CRDF determines change of course: when a line of inquiry is no longer useful and also when new ideas are put to the test. The simple answer is that, like the Citrus Production Research Advisory Council (Box Tax Council) before it, CRDF funds projects with annual reviews and evaluation. Contracting of institutions like University of Florida or the US Department of Agriculture allows project funding for up to 3 years, but continued funding renewal is based on adequate progress and availability of funds. In this manner, continuous evaluation allows CRDF to end projects whose prospects have dimmed, while adding new ideas, investigators, and new methods into the process.

A natural endpoint of projects within the system described above occurs at least once every 3 years, or more frequently as needed. At the same time, CRDF considers new projects each year. At close of FY 2014-15, more than half of CRDF’s projects ended (about 80 of the former 130 projects). This is a significant change in the portfolios of research and product delivery efforts and at the same time, an important opportunity to determine how to move more rapidly and in a focused way towards our goals of managing HLB. This turnover allowed CRDF to review projects and selectively invite new pre-proposals and proposals to address the needs going forward. From 81 ending projects, 29 research proposals were invited and 19 delivery project proposals were invited for consideration. This process focused on the best ideas from scientists who have been addressing priority areas. With these proposals in hand, CRDF Research Management Committee and the Commercial Product Delivery

Committee reviewed the plans with help from outside experts and final recommendations were provided to the Board for approval at the June 18 Board Meeting at Bonita Springs.

CRDF refocused efforts on projects which promise to address how short-term tools can be used to combat the increasing intensity of disease in Florida groves. To determine the effectiveness and adaptability of new tools, field trials are being established across a broad front: to target the pathogen (bactericides and thermal therapy); to target the vector psyllid (CHMA support, resistance monitoring and how insecticides are impacting ACP populations); and to target the plant (nutrition, modifying soil and irrigation qualities to benefit root health and nutrient uptake, tolerant rootstocks). Field trails are an important way to evaluate how growers can sustain tree health in the presence of HLB.

Recognition that efforts to discover and deliver solutions could be accelerated with additional funding and other support led to the approval of state legislative funding and two significant federal programs that have begun to support the HLB effort nation-wide. The USDA, Animal and Plant Inspection Service, Multi-Agency Cooperation (MAC) Group was formed to implement $21 million dedicated to advance delivery of "shovel-ready" projects across the citrus states. A majority of these resources have been committed to projects as the year ends, with additional plans in place for 2015. Similarly, the USDA, National Institute of Food and Agriculture (NIFA), Specialty Crop Research Initiative (SCRI) established a competitive grant program to support citrus disease research and extension efforts. The outcome of this first year of a five year, $25 million per year program was announced early in 2015 with 7 projects approved. Industry input into the NIFA, SCRI Citrus Disease Research and Extension Program is provided through the National Agricultural Research, Extension, Education and Economics (NAREEE) Citrus Disease Subcommittee. This subcommittee includes representatives from Florida, Texas and California, and, through them, the CRDF, TCPB and CRB, which assist with prioritization of research topics to be included in the request for proposals.

While the goals to overcome this disease remain in front of us, FY 2014-15 has been a pivotal year in the organization, funding and coordination of a monumental effort to deliver solutions to HLB. CRDF is poised to sustain this aggressive effort in 2015-16.

Early in 2015, CRDF staff, committees and the Board planned for next phases of funding to develop and deliver solutions to HLB and citrus canker, taking into consideration a number of factors:

- Maturity of significant numbers of current CRDF-funded projects by June 30, 2015
- Announcement of USDA, NIFA, SCRI Citrus Disease Research and Extension Program awards
- Implementation of USDA, APHIS MAC "shovel-ready projects" to deliver HLB research
- Advances emerging from the research and delivery portfolios of CRDF and others
- The greatest needs of the Florida industry in its fight against HLB

A critical responsibility for CRDF going forward is the coordination of efforts across the expanding funding programs to ensure that the most critical research is supported. Communication with the other

programs is essential to prevent gaps in funding, as well as to avoid overlapping funds committed to similar project ideas. The related challenge will be tracking progress in these programs as their projects move forward, as each program has its own progress reporting requirements and timelines.

General Organization

Board of Directors: CRDF is governed by a Board of Directors composed of ten industry representatives appointed by the Florida Department of Citrus and Florida Citrus Mutual, as well as one representative of the Florida Department of Agriculture and two representatives of the University of Florida. The Board members in place during 2014-15 are listed below.

Board of Directors

Walter T. (Tom) Jerkins, Jr., President
Ricke A. Kress, Vice President
Hugh W. Thompson, III, Treasurer
Jerome M. (Jerry) Newlin, Secretary
Robert H. (Bobby) Barben
N. Larry Black, Jr.
Jacqueline K. Burns, Ph.D.
Lisa Conti, Ph.D.
Joe L. Davis, Jr.
Mary L. Duryea, Ph.D.
William B. McLean, III
Wayne H. Simmons
Robert J. (Bob) Stambaugh

Committees: The 6 committees of CRDF are constituted of Board and non-Board members and are appointed according to the By-Laws by various sectors of the industry that they represent. The 2014-15 committee membership follows and the organizational structure of CRDF's Board and Committees is illustrated below in Figure 1.

Commercial Product Development

William B. (Ben) McLean III*
N. Larry Black, Jr.
Joe L. Davis, Jr.
Mary L. Duryea, Ph.D.
Ricke A. Kress
Jerome M. (Jerry) Newlin
Hugh W. Thompson III

NON-BOARD MEMBERS:
Timothy A. Anglea, Ph.D.
David Howard**
Peter McClure
Anderson H. (Andy) Rackley
Shannon Shepp
Tom Stopyra

Finance and Audit

Hugh W. Thompson III*
N. Larry Black, Jr.**
Jackie Burns, Ph.D.
Joe L. Davis, Jr.
Robert J. (Bob) Stambaugh

Governance

Robert J. (Bob) Stambaugh*
Jackie Burns, Ph.D.
Ricke A. Kress**
Jerome M. (Jerry) Newlin

Industry Research Coordinating

Wayne H. Simmons*
NON-BOARD MEMBERS
Dave Crumbly
Carson A. Futch**
Kevin Gaffney
Paul M. Genke
V. C. Hollingsworth III
Frank Hunt III
Thomas F. (Tom) Kirschner
Nick Kretchman
Peter McClure
Phillip Rucks
Joseph B. (Joby) Sherrod
John F. Veldhuis
Mitchell T. (Mitch) Willis

Research Management

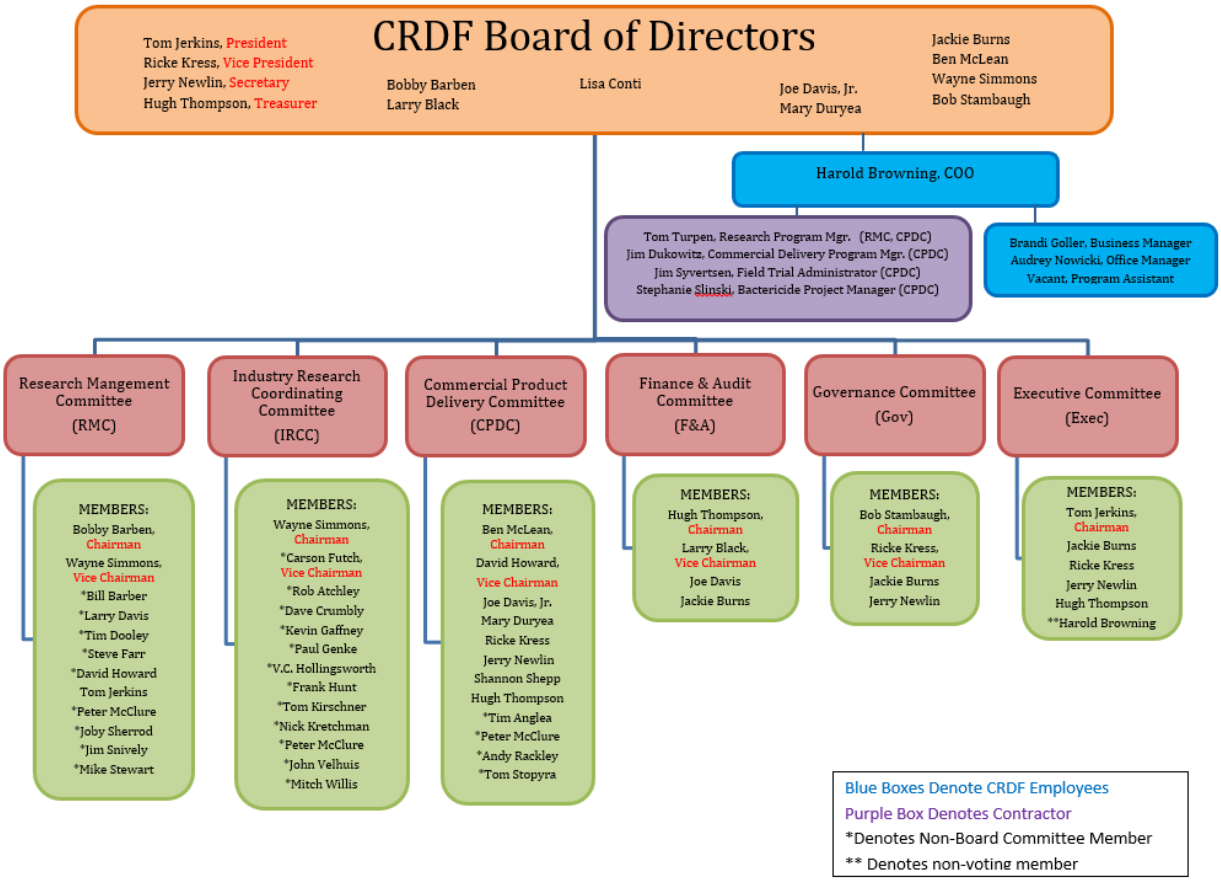
Robert H. (Bobby) Barben*
Walter T. (Tom) Jerkins, Jr.
Wayne H. Simmons**
NON-BOARD MEMBERS:
William H. (Bill) Barber
Larry Davis
Tim Dooley
Steve Farr
David Howard
Peter McClure
Joseph B. (Joby) Sherrod
James A. (Jim) Snively
Mike Stewart

Executive Committee

Walter T. (Tom) Jerkins
Jackie Burns, Ph.D.
Ricke A. Kress
Jerome M. (Jerry) Newlin
Hugh W. Thompson III
Harold W. Browning, Ph.D. (non-voting)

*Chairman
**Vice Chairman

Figure 1. CRDF Board and Committee Structure, 2014-15



Meetings of the Board and Committees: Generally the Board of Directors meets monthly, with a combined November/December meeting sandwiched between the holidays. These meetings are publically noticed and attendance is open to the public. Committees meet as necessary and follow similar public notice policies. The schedule of CRDF Board and Committee meetings for the period July 1, 2014 through June 30, 2015 is depicted in Table 1.

Table 1. Schedule of Board and Committee Meetings Held in FY 2014-15

Board	Finance & Audit	Governance	Research Management	Commercial Product Delivery	Industry Research Coordinating	Executive
7/22/14				7/1/14	7/16/14	
8/26/14		8/20/14				
9/23/14	9/18/14		9/22/14	9/11/14 9/18/14		
10/28/14	10/27/14		10/16/14 10/24/14 10/27/14	10/23/14		10/28/14
12/9/14				12/2/14		
1/27/15	1/26/15	1/13/15	1/21/15	1/20/15		1/27/15
2/24/15		2/18/15	2/17/15			
3/24/15	3/17/15	3/9/15	3/19/15	3/19/15		3/24/15
4/28/15						
5/26/15	5/18/15			5/19/15		5/7/15
6/18/15	6/10/15 6/15/15	6/11/15	6/9/15	6/12/15		

Governance

During FY 2014-15, changes to Board and committee membership were addressed by the Governance Committee, including the replacement of founding Director Dr. Joe Joyce by Dr. Jackie Burns, new Dean of Research for UF, IFAS. Dr. Joyce stepped down as a result of shift in his UF responsibilities. His experience with DSOs and leadership in CRDF was vital from inception of the Foundation and will be missed. Governance also addressed annual review of the COO and reviewed other staff evaluations, discussing and approving the documentation and appropriate compensation associated with current and new employees.

Recruitment of a new Business Manager position was completed with the hiring of Ms. Brandi Goller in July, 2014. This staff addition was stimulated by the increasing complexity of contracting, revenue management from additional sources, and the general growth in all business operations. Separation of duties and appropriate controls on accounting and financial operations is facilitated with the addition of a third staff member, and the planning distributed duties and responsibilities to balance both control and workload. Unfortunately, Program Assistant Diane Johnson left CRDF in spring, 2015 to relocate to southwest Florida. The position remained vacant through the balance of the fiscal year and is scheduled to be refilled in first quarter, 2015-16.

The Governance Committee addressed several other issues during FY 2014-15, including the need for additional infrastructural and project and program management for CRDF. These activities are reported elsewhere in the report.

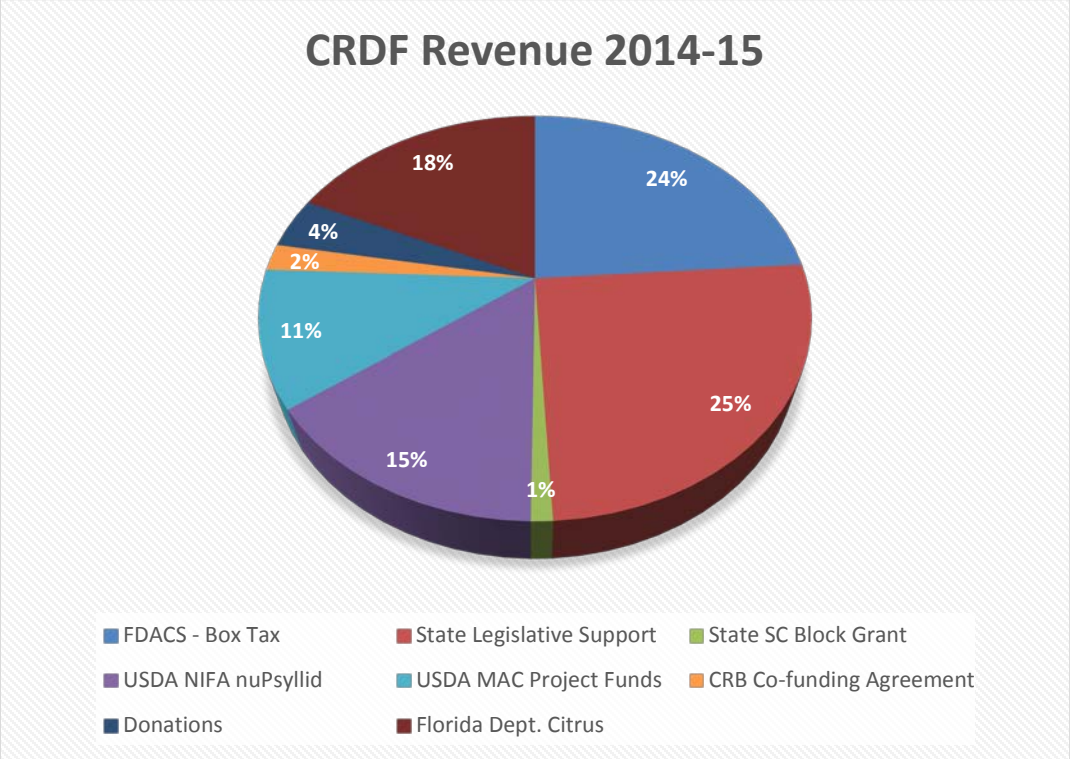
Finance and Audit

The annual CRDF Budget process led to presentation of the draft FY 2014-15 annual operating budget at the May, 2014 Board meeting and subsequent approval at the June Board meeting on June 12, 2014. Revenue sources to support HLB and other disease research, and to move forward solutions are significantly less than in previous years, with reduced revenue expected from the Research Box Tax Program and similar reduction in support from the Florida Department of Citrus. Funding support from the Florida Legislature was successful, reduced from eight million dollars in FY 201-3-14 to three and one-half million dollars for FY 2014-15. The result will be a reduction in the overall budget available to CRDF to support HLB research efforts, particularly new projects. Budget planning has targeted reduction of reserves as a method to maintain momentum in research and delivery priorities. Similar budget processes were underway as FY 2014-15 ended. The June 18 Board of Directors approved the FY 2015-16 CRDF Operating Budget, balancing revenues from traditional sources with newly approved research and delivery project plans for the year. Approved Operating Budgets for FY 2014-15 and FY 2015-16 are presented in appendices C and D at the end of this report.

Sources of Revenue

CRDF works closely with citrus industry organizations, government agencies and other potential sponsors to meet its financial needs. The Foundation seeks to secure both current year and long-term resources to fund the citrus research and commercialization program. Obtaining stable, long-term sources of funding will assure the research community of the ongoing commitment by the citrus industry as well as provide credibility to the licensing and business development aspects of the Foundation. However, this proves to be a challenging effort as most revenue sources allocate funding one year at a time. Figure 2 illustrates CRDF Revenues for the FY 2014-15 by source and proportion of total revenues. Grower investment in HLB solutions remains a major source of support for CRDF, as both research box tax and FDOC revenues are generated from grower taxes on fruit harvested.

Figure 2. Overview of CRDF revenue sources for fiscal year 2014-15.



Outside Contributions

CRDF continues to attract outside funding to support the efforts of Florida growers. During FY 2014-15, two donors provided funds to support programs. Coca-Cola International and Bayer CropScience provided funds to support CRDF programs, making multi-year commitments to advance solutions.

In January 2014, Coca-Cola North America recommitted financial support to HLB research by pledging 3 years of support to total $1,500,000. Working with the University of Florida Foundation and CRDF, Coca-Cola renewed their commitment of similar terms which provided support over the period 2011-13. This contribution is in consideration of Coca-Cola's abiding interest in maintaining a sustainable citrus industry and finding solutions for huanglongbing (HLB) disease.

In a similar show of support, Bayer CropScience graciously committed support to HLB research. Working through the Florida Specialty Crop Foundation, Bayer provided support of HLB research in an agreement which recognizes the need both by CRDF and FSCF for significant follow-on investment before discovery research findings can be optimally and expeditiously translated into commercial applications for the public benefit. Bayer provided support in the amount of $200,000 over 3 years and CRDF integrated this commitment into its project funding decisions and budgeting. Contributions from both Coca-Cola and Bayer CropScience will provide bridging support as HLB solutions are advancing.

Annual Third Party Audit Summary

The audited Financial Statement for CRDF for the period July 1, 2013 through June 30, 2014 is provided in appendix E. Complete final audit reports may be found on the CRDF website at citrusrdf.org.

Significant Audit Findings: The following highlights are taken from the Management Letter accompanying the FY 2013-14 third-party Audit, conducted by Bunting, Tripp and Ingley, LLP.

Qualitative Aspects of Accounting Practices

- Management is responsible for the selection and use of appropriate accounting policies. The significant accounting policies used by the Foundation are described in Note A to the financial statements. We noted no transactions entered into by the Foundation during the year for which there is a lack of authoritative guidance or consensus. All significant transactions have been recognized in the financial statements in the proper period.
- Accounting estimates are an integral part of the financial statements prepared by management and are based on management's knowledge and experience about past and current events and assumptions about future events. Certain accounting estimates are particularly sensitive because of their significance to the financial statements and because of the possibility that future events affecting them may differ significantly from those expected. The most sensitive estimates affecting the Foundation's financial statements are the accounts payable for contract research payments and the balance of unexpended grant funds. We evaluated the key factors and assumptions used to develop the balances of these liabilities and determined that they are reasonable in relation to the financial statements taken as a whole.
- Certain financial statement disclosures are particularly sensitive because of their significance to financial statement users. The most sensitive disclosure affecting the Foundation's financial statements is the balance of the liability for unexpended contract funds. The balance of the liability for unexpended contract funds at June 30, 2014 was $2,671,375. Our audit procedures found adequate documentation to support this balance and that the Foundation's internal procedures for tracking contract expenditures and balances was also satisfactory.

Internal Operational Audit

An internal operational audit of the Citrus Research Development Foundation, Inc. was conducted during the 2014-2015 fiscal year. The audit was completed in June, 2015, and the final report has just been received.

The University of Florida, Office of Internal Audit (OIA) conducts its audits in accordance with the International Standards for the Professional Practice of Internal Auditing as promulgated by the Institute of Internal Auditors (IIA). We plan to utilize the Committee of Sponsoring Organizations of the Treadway Commission (COSO) framework for the evaluation of internal controls in the unit being audited. COSO

defines internal control as a process, effected by an entity's board of directors, management, and other personnel, designed to provide reasonable assurance regarding the achievement of objectives in the following three categories: effectiveness and efficiency of operations, reliability of financial reporting and compliance with applicable laws and regulations. Based on COSO there are five key elements in an internal control system of an entity:

- ***Control Environment***- establishes the foundation for the internal control system by providing fundamental discipline and structure.
- ***Risk Assessment***- involves the identification and analysis by management of relevant risks to achieve predetermined objectives.
- ***Control Activities***- the policies, procedures, and practices that ensure management objectives are achieved and risk mitigation strategies are carried out.
- ***Information and Communication***- supports all other control components by communicating control responsibilities to employees and by providing information in a form and time frame that allows people to carry out their duties.
- ***Monitoring-*** covers the external oversight of internal controls by management or other parties outside the process; or the application of independent methodologies, like customized procedures or standard checklists, by employees within a process.

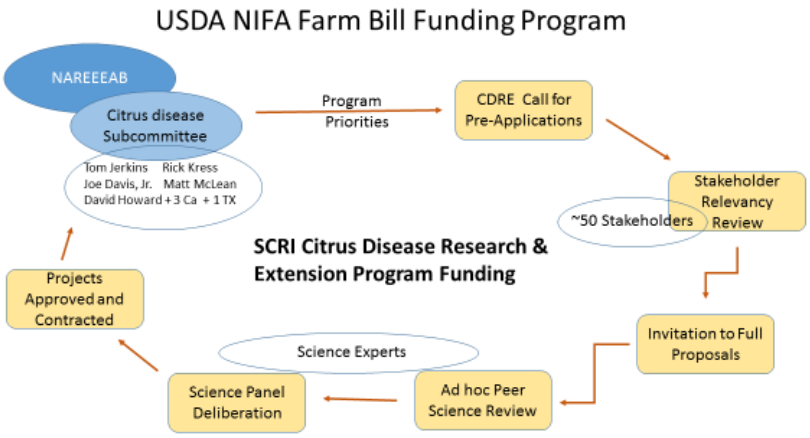
The final report of this audit of procedures and controls is pending and implementation of recommendations will occur through the CRDF Finance and Audit Committee, Governance Committee and Board of Directors. Preparing for the audit and providing information to the audit group allowed CRDF staff to revisit policies and procedures, and the volume of information requested required CRDF to document procedures that had not previously been specifically committed to an office manual. Feedback from the process has assisted CRDF in updating controls and separation of duties in the accounting operations. This will be valuable as CRDF refills the vacant Program Assistant Position.

New Roles for CRDF

The roles and responsibilities of CRDF are changing, with greater need to coordinate the multiple opportunities for development and testing of HLB research ideas, as well as the greater need to move research results forward to field trial, regulatory consideration where appropriate, and ultimately, commercial adoption. In this changing environment, CRDF continues to provide the leadership necessary to bring all of these efforts together for Florida growers. The Citrus Research and Development Foundation is working in concert with new federal sources of funding for HLB research to maintain the momentum of research and to transition roles in the presence of recent allocation of significant USDA programs addressing HLB. Each of these programs have elements in common with CRDF programs as illustrated below:

USDA, National Institute of Food and Agriculture (NIFA), Specialty Crop Research Initiative (SCRI), Citrus Disease Research and Extension Program (CDRE). This is a national competitive grant program designed specifically to support developmental and problem-solving research to address citrus HLB. The first cycle of the competitive process has been completed and resulted in seven multi-year projects being approved. A second cycle of solicitation for pre-proposals will be announced within the next few months, and all HLB researchers are encouraged to respond to this funding opportunity. This program is authorized for $25 million per year for five years.

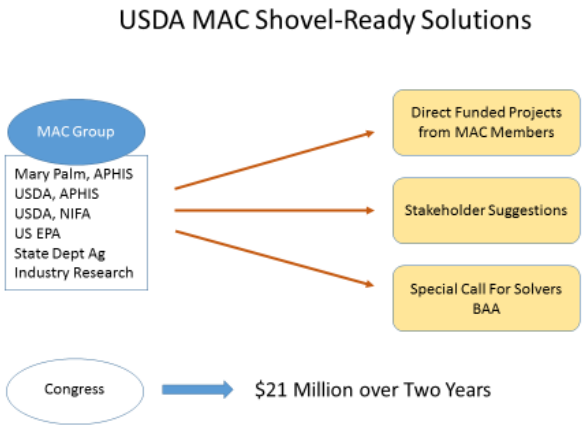
Figure 3 illustrates the NIFA SCRI Citrus Disease Research and Education Program processes and decisions.



The USDA, Animal and Plant Health Inspection Service (APHIS) was awarded funding to support delivery of near-term solutions to HLB across US citrus states, with $21 million to be expended over 2 years. This program is overseen by a Multi-Agency Coordination Group (MAC) and has approved a number of projects since the program began. These funds will complement citrus industry and state legislative

investments in research. Researchers should follow news and announcements relating to this funding program as well. Figure 4 illustrates the USDA, HLB MAC funding and decision processes.

Figure 4. USDA, APHIS HLB-MAC Funding Program processes and decisions.



In the context of these new funding sources, CRDF recognizes that there is considerable additional funding available to address all aspects of HLB and to address citrus across all producing states. We strive to remain engaged in all aspects of the search for and delivery of solutions to HLB and will be communicating closely with the USDA programs and funded projects, as we have done in the past with the California and Texas industry's HLB research efforts.

Integration of New Federal Funding Initiatives into CRDF Programs and Goals

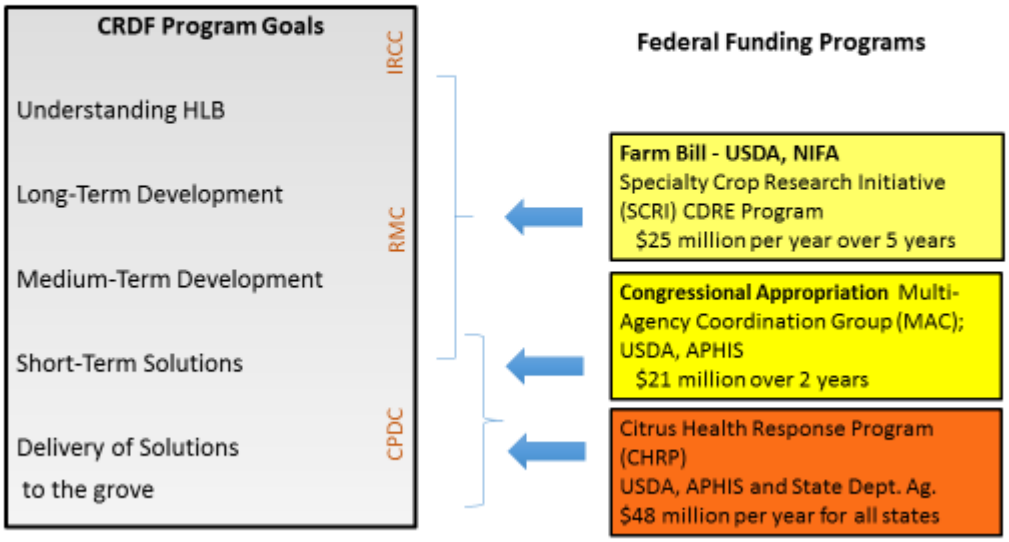
With implementation of new federal funding to support research and delivery of solutions for Huanglongbing (HLB) in U.S. citrus, there are many questions about how the funding interacts with established programs already underway to meet these needs.

The diagram below (Figure 4)shows how federal funding through the USDA, NIFA Specialty Crop Research Initiative (SCRI), through USDA, Animal and Plant Health Inspection Service (APHIS) Multi-Agency Coordination Group (MAC group), and through USDA, APHIS Citrus Health Response Program (CHRP) is being coordinated to complement and accelerate existing programs managed by the Citrus Research and Development Foundation in Florida (green box below) and similarly by the Citrus Research Board in California.

Emergence of substantial additional funding comes at a critical time when the Florida crop size has been reduced and thus is providing less research support, and when the need for field evaluation and delivery of solutions has never been greater. The federal programs are well underway, with elected officials, agency representatives and researchers all understanding the need for speed in providing tools to reverse the HLB-induced decline of Florida citrus trees, and to prevent introduction and rapid spread of the disease in other U.S. citrus producing states.

A similar overview of the funding details shows how the programs will complement one another in providing expanded funds to meet the needs of the US citrus industry in their efforts to find solutions to HLB. The following table summarizes the new federal programs in concert with CRDF programs.

Figure 5. Relationship of Federal Funding Programs Directed at Citrus HLB to CRDF Programs and Organization.

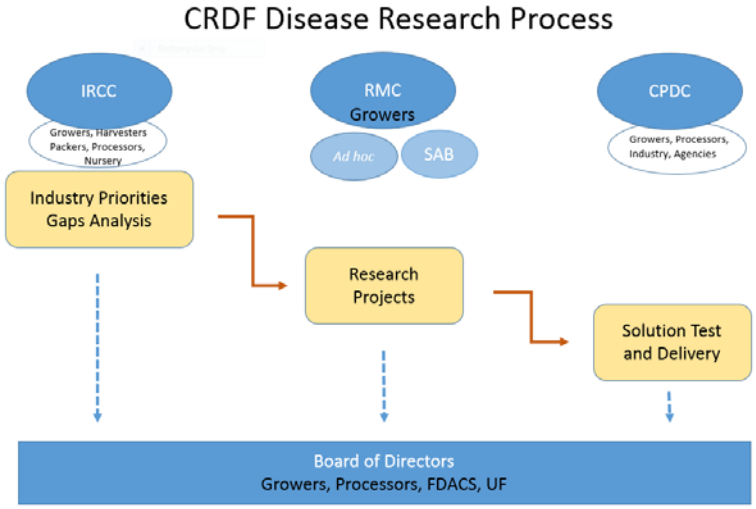


CRDF Procedures for Selecting and Funding Research and Delivery Projects

The management of the CRDF research programs and the commercial product delivery program has become increasingly complex as more research results are approaching utilization in the field. With five years of concentrated research behind us, it is time to look closely at how we can integrate the knowledge of HLB and how it affects citrus tree health with the discovery and evaluation of a wide array of tools targeted at the vector insect (ACP), the pathogen (*CLas*) and the citrus plant. With this increasing complexity, CRDF has committed additional resources to ensure that all possible avenues for short-term solutions are receiving full attention. This expansion of effort complements the project and program management that supported CRDF's research since the HLB campaign began in 2008. CRDF committees and the board have directed an expanded plan for project management of research as well as delivery projects, and as a result, work plans and budgets have been developed to address the expanding needs. Additional expertise is recruited to provide leadership for CRDF programs so that all solutions can move quickly to the field.

The next section briefly describes the processes used to solicit, review and select from among research ideas that are communicated to CRDF via the Citrus Advanced Technology Program (CATP) and subsequently, procedures for Commercial Product Delivery project selection and approval. These procedures are patterned after national competitive programs with goals to select the best science and to prioritize projects that will lead to solutions usable by growers.

Figure 6. CRDF prioritization and project approval Process flow for CRDF research and delivery projects.



CRDF Committee Activities and Programs to Develop Solutions to HLB

Research and delivery projects that have been underway with funding from CRDF have duration of funding for up to 3 years. During 2014-15, 80 projects matured and projects ended by the beginning of the next fiscal year, July 1, 2015. These projects represent competitive research projects as well as commercial product delivery projects, and cover the broad range of efforts to address the vector, pathogen and plant elements of the HLB disease system. Some of the projects have been underway through two cycles of funding, up to 6 years, while others have only been in place for a couple of years. Among these are critical projects that have momentum towards adding to our understanding and providing management tools and tactics. These projects must be identified and encouraged to continue. Other projects are reaching a logical conclusion and may not require further support.

Also in this portfolio are projects that qualify for and may have received commitment for continuation of funding from the federal HLB Farm Bill NIFA and USDA, PAHIS, MAC programs that emerged in 2014-15. CRDF has assumed responsibility for coordinating the current programs with those emerging from the new funding programs, and for continuing to provide the bridge from research to field delivery of solutions. CRDF committees discussed the range of projects that were ending and recommended to the Board that those projects that have potential to support development of solutions be invited to develop and submit continuing proposals. This process followed established procedures that have been used by CRDF since the 2008 cycle of HLB research funding to review and approve the most valuable proposals.

The CPDC receives quarterly progress reports on all project topics overseen by this committee that are developed by project managers. These reports, when approved by the Committee and Board, are posted to the CRDF website. Interested parties are encouraged to access this report and other information on the website citrusrdf.org.

Research Management

Funding to Support Citrus Disease Research

CRDF policy is to accept proposals for projects with a time frame of up to 3 years. Following the initial contract year, continued funding is contingent upon successful demonstration of progress on first year objectives as evidenced by progress reports, and the continued availability of funding.

Request for Research Pre-Proposals, Proposals and Application Process

CRDF develops a general request for pre-proposals to solicit investigators who are interested in conducting research and delivering projects related to the focus on citrus diseases important to Florida citrus. The core priorities from the CRDF business plan referenced by IRCC gaps analysis (Figure 5) serve as the basis for this request, and applicants are directed to these priorities as they consider an application. Applicants also are encouraged to review the web-posting of the current approved research project list and public-posted progress reports for each project. With input from the *Scientific Advisory Board* (SAB), *Industry Research Coordinating Committee* of CRDF, and the CRDF Board of Directors, the CRDF *Research Management Committee* (RMC) drafts the request to include specific areas for which additional research is needed in each year's Request for Applications (RFA).

Research Pre-Proposal Review

Following the due date, all submitted pre-proposals are evaluated by the CRDF Scientific Advisory Board. Each one-page summary of the proposed idea is considered in the context of current program priorities, ongoing research supported by CRDF and other sources, scientific merit, and the potential benefit of the proposed project to the citrus industry. Pre-proposals are ranked and recommendations forwarded to the RMC.

In turn, the RMC integrates SAB recommendations with their independent appraisal of pre-proposals and determines pre-proposals from which full proposals are invited. The resulting list of those invited by the Board for full proposals is then posted on the website. Investigators of selected projects are requested to submit a full proposal by the specified due date following instructions posted on the website.

Research Proposal Review

Independent peer review of research proposals is accomplished through the use of technical review panels to evaluate and score the full proposals for project funding. The Program Manager recruits multiple (minimum 3) unbiased, non-conflicted, third party *ad hoc* peer reviewers to review each full proposal, who submit evaluation scores and comments for each reviewed proposal for consideration as SAB and RMC deliberate.

Proposals are specifically assigned to SAB members for review and scoring based on the objectives of the proposal and the expertise of SAB members. In this way, SAB members are assigned to lead discussion of each proposal as the SAB conducts a multi-day review to evaluate, discuss peer reviewer scores, and rank all proposals for recommendation to RMC of projects to fund. At this meeting, SAB also reviews annual progress reports of all projects that are currently supported by CRDF, evaluating progress for continued funding and in preparation for analysis of the new proposals.

Approval of Research Projects

The Program Manager and SAB Chairman present results to the CRDF RMC, with recommendations for funding. Proposal rankings are discussed at the RMC meeting and individual proposals are discussed, in particular with regard to the potential to contribute to solutions if the project objectives are met. RMC concludes their analysis by providing a ranked list of proposals recommended for funding, and any conditions associated with the recommendations to the CRDF Board of Directors. Ultimately, The Board of Directors meets to receive recommendations of the RMC, discuss and make final decisions on approval of proposals to be funded based on recommendations and available funding.

Research Management Committee

The Research Management Committee is comprised of citrus growers or production managers who have hands-on experience with all aspects of growing the crop, and familiarity with the disease challenges and current tools available to manage them. This expertise is a strong complement to the scientific expertise which evaluates the design, rigor, and qualifications presented in the proposals. The RMC is able to balance the ranking based on scientific value with the practical use of results in managing the disease challenges or to advance citrus production in the presence of diseases.

Scientific Advisory Board (SAB)

The initial SAB was selected from those with experience in the National Research Council strategic planning process and call for proposals in 2008. The Foundation seeks SAB members who value and possess: 1) a diversity of opinion, 2) the capability for independent thought and decision-making, 3) deep individual expertise relative to the Foundation research challenges, 4) the absence of personal or professional conflicts, and 5) transparency, integrity and respect for the impact of science both on citrus growers and society in general.

There are no fixed terms for SAB members and members are added as needed to cover the need and complement the range of expertise of the group. Dr. George E. Bruening, Professor Emeritus of UC Davis, played an integral role in establishment of the CATP research program process, and has chaired the SAB from 2008 through 2015.

<u>CRDF Citrus Advanced Technology Program (CATP) Research Portfolio</u>

The Research portfolio of CRDF is transitioning as projects mature and results are implemented in the field. The portfolio of 107 projects highlighted below are spread across the breadth of topical priorities that have been established for attacking HLB, as well as 11 projects focused on non-HLB topics such as citrus canker, citrus black spot, and other pests and diseases that are important. As projects complete

their 1-3 year life cycle, CRDF is analyzing the progress being made and determining the need to continue the various lines of research. With availability of Federal funds through the USDA, APHIS Multi-Agency Coordinating (MAC) Group and the USDA, NIFA Specialty Crop Research Initiative Citrus Disease Research and Extension Program, CRDF is attempting to focus more attention on the immediate delivery to field of technologies and tools that will help the industry in the short term.

As FY2014-15 draws to a close, CRDF will evaluate the expiring projects and developed plans to address the next steps. This involved working with the researchers involved as well as securing the appropriate resources to ensure that gaps in progress on important topics do not occur. Many activities, such as knowledge mapping of research topics to determine the most important next steps, and coordination with the federal programs, accompanied the analysis of current CRDF-funded projects that are coming to an end.

CRDF is in a unique position to provide the catalyst for moving solutions to the field, and to integrate the actions of state and federal programs that are playing a greater role in funding the necessary long-term to short-term research on HLB. As our partner citrus-producing states increase their efforts in addressing Asian citrus psyllid and HLB, close coordination will be important to encourage the best programs moving forward and to aid in communication between researchers and the industries.

Table 2. CRDF Research Project Portfolio, depicting projects ending June 30, 2015 and those continuing into FY 2015-16.

CRDF Research Category	Projects Ending < 7/01/15		Projects Continuing > 7/01/15	
	# Projects	Total Budget	# Projects	Total Budget
1. Consequences of HLB infection	0		1	$ 237,500
2. CLas culture, genomics, molecular	7	$ 1,952,070	4	$ 1,680,137
3. Citrus response to infection	4	$ 304,090	2	$ 496,182
4. HLB pathogen/disease detection	3	$ 583,581	0	
5. HLB epidemiology and mitigation	11	$ 2,459,788	8	$ 2,504,017
6. ACP monitoring and behavior	4	$ 628,470	1	$ 577,703
7. ACP chemical, biological mgmt	7	$ 1,719,149	4	$ 1,127,681
8. ACP trapping and repelling plants	0		0	
9. Citrus genomics and transcriptomics	1	$ 458,000	1	$ 240,000
10. Conventional citrus resistance breeding	7	$ 2,317,621	4	$ 2,052,136
11. Transgenic/ vector mediated resistance	11	$ 2,832,556	6	$ 3,026,921
12. Model systems, inc. screening	2	$ 296,384	3	$ 1,318,803
Non HLB Pest and Disease Research	7	$ 1,356,198	9	$ 3,162,545
Total Research Projects	**64**	**$ 14,907,907**	**43**	**$ 16,423,625**

CRDF considered the next round of research and delivery projects in March, 2015 and moved forward with the process to identify and review projects of value that pursue solutions to HLB. March 2015 Research Management Committee and Board meetings approved invitations for full proposals from

both research and delivery areas of the Foundation's portfolio. Among the projects invited were 28 projects under the Research Management area. These projects range from one to three years and were subjected to peer review and industry review for the value that they might contribute to getting solutions into the hands of growers. Highlights of the successful research pre-proposals include:

- Eleven projects directed towards development and testing of rootstocks and scions that show tolerance or resistance to HLB. These projects represent the core breeding programs at UF, IFAS and USDA, ARS, but also includes projects working to include non-traditional approaches to developing HLB-resistant plants. This topical area is viewed by many as long-term, but due to prior investment and a continuous effort for over 2 decades, many candidates exist and those submitting new proposals will focus most clearly getting available materials to the field.

- Four projects focus on continued efforts to culture the bacteria causing HLB. This goal has not yet been met, despite considerable effort. Since it is vital to understanding HLB, tracing movement and disease development, and screening for potential solutions, continued culturing effort is warranted. Those writing proposals to this area have been encouraged to join forces and to share approaches to reach the goal.

- Two projects continue focus on Asian Citrus Psyllid (ACP) movement and transmission of *Candidatus Liberibacter asiaticus (CLas)*.

- Citrus nutrition in the face of HLB is the topic of one proposal, building on previous attention to this area.

- While the majority of projects focus on HLB, one project each is being invited to respond to citrus black spot and citrus canker.

The progressive scientific and grower reviews of the preproposals led to approval of 18 projects, some with modified scope and budget. These were approved at the June 18 Board Meeting. Looking forward, CRDF will manage its research interests through the following steps:

- Continue the stewardship of the 145 projects that are in the CRDF portfolio and which will continue for up to 3 years.

- Consider revisions/adjustments to approved projects to optimize progress on a case-by-case basis.

- Retain and increase CRDF efforts to move results to field trials and commercialization, monitoring ongoing research funded by CRDF and others.

- Coordinate with California and Texas as they increase investment in HLB research.

- Coordinate with the federal HLB funding programs to keep communication open and synergize the resources to best use.

- As funding decisions are made in the federal programs, we will evaluate the need to fill gaps and extend ongoing progress through a modified CRDF research proposal program.

The last element, responding to the outcomes of other funding, began late in 2014 and will continue as more information emerges and CRDF funding decisions arise. Whereas, our normal schedule has been disrupted (in a good way) by other funding programs, CRDF to continue moving forward and to focus on near-term delivery of solutions. CRDF has redoubled its efforts to make sure that solutions emerging from research are getting to field trials and being handed off to citrus growers for their use in combating HLB in the shortest time possible. This will be increasingly important as new research projects take hold with support from the federal funding programs. This Federal and State funding is a welcome complement to ongoing investments from the industry, and the hard work of moving from lab to field will remain a role for CRDF and its Commercial Product Delivery Committee. Having the direct connection to growers and field trials is an important function of CRDF, and increased commitment of effort and resources will ensure that the quickest pathway from testing to utilization can be found. Among the main thrust areas are the development and evaluation of therapies for trees infected with HLB, and tools that can be applied to new plantings and resets to increase their likelihood of reaching productive age in the presence of disease.

Knowledge Mapping I: How Can Progress To Date Be Evaluated and Focused in Continuing Efforts?

CRDF supports a periodic effort to determine how the research that is being funded fits into established research priorities, and how those priorities need to change over time. The focus at present is necessarily pointed at delivering solutions to Huanglongbing (HLB), but at the same time, there also is ongoing work on other important disease issues like citrus canker and citrus black spot. Citrus breeding as an area of research has been going on in Florida for over 100 years, and it is the continuation of this work that has led to the possibilities that are emerging with candidate tolerant rootstocks from both USDA-ARS and UF-IFAS citrus breeding programs. CRDF is supporting HLB-related breeding efforts as well.

A partnership was established in 2014 to conduct in-depth analysis of progress to date and needs for specific topics of greatest importance to delivering solutions to HLB. The first of these multi-day facilitated review, and analysis sessions focused on the development of bacterial therapies to reduce CLas titer in infected plants. This is one of few strategies for management of existing citrus trees that can affect the disease by reducing bacterial titer.

Results of the first Knowledge Mapping session included development of a composite situation and need statements from meeting summaries. A brief overview of this is provided here, and those interested are directed to the CRDF webpage for more information.

Bactericides: This category includes traditional antibiotics used in agriculture, as well as other chemicals that are being evaluated for their ability to reduce bacterial populations

a. Situation: Organization and coordination of research is essential to move forward with complex solutions. Timelines require new models for problem solving using public research capabilities.
   Needs: A systematic structure that can organize and roadmap all HLB research efforts and address research and career goals within a team environment.
b. Situation: Antibiotics offer an opportunity to address current infection in a majority of Florida citrus trees, offering the potential to stabilize tree health and productivity until other strategies for managing HLB emerge.
   Needs: While a number of traditional antibiotics are being evaluated, alternatives should be pursued, particularly those that do not overlap in use with human medicine. A pipeline approach can overcome anticipated resistance development.
c. Situation: Discovery of antibiotic candidates is underway in research labs, but the connection to companies with capacity to deliver the products is lacking.
   Needs: Focus efforts on identifying and establishing corporate partnerships
d. Situation: While candidate materials are emerging from screening efforts, methods to deliver antibiotics to the site of activity in citrus phloem are necessary.
   Needs: Delivery of metered doses to phloem of infected trees in a manner that is safe and effective, with consideration of varying chemistries and their movement in citrus phloem.
e. Situation: A significant element of approval for use of antibiotics is characterization of the residue presence and behavior.
   Needs: Quantitative data on efficacy and residues from field trials is vital to meeting timelines.
f. Situation: Screening of large numbers of candidate antibiotics requires a repeatable, progressive assay system.
   Needs: Urgency of need requires that a system of standardized assays are developed and used across the board to rapidly compare and select from candidates, and to advance ranking candidates to field trials.
g. Situation: The regulatory process for approval of antibiotics is intensive and there are barriers to acceptance of additional uses of antibiotics in agriculture.
   Needs: Regulatory pursuit is important and relationships with appropriate agencies, registrants and regulatory experts should be pursued.
h. Situation: Previous commercialization and research efforts have been conducted against HLB in South Africa.
   Needs: A thorough evaluation of previous efforts will inform current efforts and should be completed immediately.
i. Situation: Field trials resulting from candidate assays are the ultimate determining factor in advancing antibiotics.
   Needs: Focus on development of field trials of advancing candidates.
j. Situation: Antibiotic screening and evaluation requires coordination and good communication to sectors of the industry.
   Needs: A consistent framework would be valuable for decision-making and for outreach on use of these tools.

Thermal Therapy: Complementing efforts at chemical bactericides is the development of applied heat to thermally reduce bacterial populations. In this case achieving temperature differentials that will affect CLas and not harm citrus plant tissue is among the challenges.

a. Situation: Thermal therapy is rapidly advancing though technology development and field evaluations.
   Needs: With increasing experimentation and trials, it is important to capture data and experience that can inform next steps.
b. Situation: Progress in field use of thermal therapy is impeded by logistics of covering large acreage and managing time/temperature combinations.
   Needs: Clarification of the role of phage in affecting thermal treatment results.
c. Situation: The specifics of thermal treatment are being characterized using both solar and supplemental heat sources.
   Needs: The biological implications of thermal treatment potentially include side effects. These implications need to be examined, including the ability of *CLas* to adapt to heat conditions and the impacts of heat treatment to the microbial community being treated.
d. Situation: As thermal therapy is adopted, the variations due to plant phenology, genotype and seasonality will come into play.
   Needs: Complementary research on the interactions of thermal treatment across horticultural and environmental variables will help clarify best practices for its use.
e. Cost of thermal therapy applications will need to be reviewed and addressed.

CRDF Knowledge Mapping II: Disease Resistant Citrus Plants

A parallel effort has recently been initiated to dive deeper into the HLB research programs funded by CRDF and by other organizations, looking at what we have learned and how it is leading towards solutions. This effort is focused on HLB and will identify critical missing pieces of research across the many topics that are being investigated to provide strategies to prevent or respond to infection by HLB and to enhance management of Asian citrus psyllid (ACP) populations. A joint effort of CRDF with Florida citrus processors will evaluate each of the core areas that are leading to HLB management tools, with the ultimate goal to identify and focus resources on shortening the time to delivery.
This process, expected to be completed over the next 6 months, will be used by CRDF to refocus resources and programs. In addition, the results of this effort will also provide necessary guidance to the federal funding programs that have emerged to assist in addressing HLB needs.

The concerted effort in Florida against HLB has been ongoing since 2008, with some areas of research predating the first major HLB grant program. Accumulation of results, information and interpretation allow for analysis of progress, identification of barriers, and a general pathway for each strategy to follow to reach success. This is easy to describe, but more difficult to accomplish across the complex HLB/citrus system and across the many scientists around the country and world now working on HLB. CRDF has recognized the need for this analysis and also that it would have to be separated into specific

topics. Last fall, CRDF and allied partners conducted a two-day exercise to determine what has been learned and what are the next steps for accelerating solutions targeted at reducing *CLas* bacteria in infected plants. Scientists who were invited to this event shared results, perspectives and hypotheses, and were facilitated in this exercise to identify what barriers exist to working together more closely to find solutions. Specific sessions discussed what can be done to advance the short-term therapies like thermal treatment and chemical bactericides. The 25 participants discussed broad organizational issues as well as detailed technical challenges, and identified several areas where improvement could help move the entire group towards the end point of delivery of tools. The emphasis was on combined, rather than individual efforts. The results of this effort have been shared with committees and the board, and several recommendations have been implemented.

The next phase of this analysis will focus on how best to bring tolerant or resistant plant materials into use in the shortest time. This topic has seen more investment than any other area, and although long-term in nature, has yielded promising results, including the release of UF and USDA rootstocks that appear more tolerant to HLB than standard rootstocks. It is time to bring this group of scientists and interested parties together to assess where we are with conventional and engineered citrus improvement, and to plan for the most important next steps. This analysis is scheduled to occur this fall and should allow new opportunities for cooperation and collaboration to emerge. A desired end point is a clear pathway for field evaluation, data analysis and communication about the most promising rootstocks and scions. Propagation and release of the front-runners is vital as new plantings are being considered across the state. CRDF recognizes that tolerance or resistance to HLB is an important element of grove management today, and will lead to future sustainability of new plantings.
Growers request regular updates on promising solutions, and are really asking “how soon will be have answers”. While the analyses described above may not provide definitive answers, these exercises will identify where further support by CRDF and other sources is needed. As this information is gathered, it is anticipated that specific next steps can be characterized and the appropriate teams assembled to take action. Resources are available to push forward with the most critical programs. As was mentioned in the earlier discussion regarding federal and CRDF funding programs, CRDF can play a significant role in making sure these emerging needs are addressed with both CRDF and federal funding.

Summary of Accomplishments in Research FY 2014-15

Following are short statements of progress across the HLB spectrum of research. These notes are taken from progress reports and reports to sponsors which summarize research findings.

Asian citrus psyllid

Significant effort has been directed towards the discovery of new methods of controlling psyllid populations. Certain citrus cultivars, such as Cleopatra mandarin, seem to be incapable of supporting the

full developmental life cycles of psyllids. Gmitter-538 has evaluated this phenotype in Cleopatra-derived families and other complex citrus hybrids using caged psyllid nymphs on pesticide-free, field grown trees, as well as in controlled greenhouse and laboratory conditions. These observations have now been replicated in a number of experiments demonstrating the consistency of the response of ACP to specific individual hybrids. In addition, new candidate plants have been identified from other studies of HLB impact on diverse citrus germplasm, which have shown either no impact or dramatically delayed infection, and new hybrid families have been produced from some of these for possible future studies. These include certain mandarins as well as other complex citrus hybrids. It appears that suppression of ACP by Cleopatra mandarin and hybrids derived from it is a heritable characteristic, thereby opening new possibilities to understand the genetic control and underlying mechanisms of the characteristic. It remains to be determined whether these new candidates likewise possess genetics that may be transmitted to offspring and whether the mechanisms underlying the phenomenon are the same or different. Such information might lead to new strategies to minimize the HLB-vectoring capacity of ACP or to discoveries of new ACP natural product pesticides.

RNA interfering (RNAi) methodology is emerging as a promising new tool for control of agricultural pests including ACP and other sap-sucking Hemipterans. Research projects in several independent laboratories have corroborating results indicating that dsRNA targeting specific psyllid sequences can be synthesized and delivered to insects by hemolymph injection or orally, and even topically. Dozens of sequences with various levels of efficacy have been described from individual researchers and from the open discovery award promotion with InnoCentive™ (Dawson-618 and Falk-531). Several receptors have been identified in psyllids that are required for the CLas to circulate in the vector and additional targets are being identified through advanced proteomic methods (Killiny-559). These are additional targets for RNAi intervention. Using the potato psyllid as a model system, Falk-531 was able to compare multiple viral and non-viral delivery systems to understand how to optimize the specificity and efficiency of mRNA degradation. dsRNA may be delivered to the tree potentially by injection or as a spray or drench or through synthesis in plant tissue via transgenic citrus or citrus transfected with viral vectors such as Citrus Tristeza Virus (CTV). The advantage of the CTV delivery system is the low cost of a biological control method if the constructs are stable and effective. Synthetic RNA will require the demonstration of low-cost of goods, a practical delivery technology and longevity of protection for commercial use.

Continuing research from several laboratories has identified an entirely novel class of psyllid control products targeting specific psyllid genes. There are several examples of specific active sequences and delivery systems based on plant viral vectors (Citrus Tristeza Virus) as a vehicle to carry the protective sequences into trees (Dawson-516, 618) (Falk-531) (Folimonova-533). These protective sequences (RNAi) might also be delivered through transgenic technology or applied exogenously. Several sequences have been identified that are kill adult psyllids and especially reduce the numbers of progeny nymphs that successfully develop to adults while feeding on plants containing RNAi. Furthermore, in many cases, any survivors are found to be clean of CLas. Naturally occurring variation in environmental conditions also influence the vector competency of ACP (Pelz-Stelinski-582).

We know that psyllids aggregate and transmit disease primarily at the borders of groves initially as the disease spreads and then across whole blocks and larger groves (known as the so-called “edge effect”). We also know that the progeny of infected psyllids can acquire CLas from young flush locally before the bacteria move systemically in the plant. Thus control of the borders is critical for area wide management. Some of the RNAi sequences can be delivered to plants via CTV and are toxic to psyllids feeding on those

plants and even more toxic to nymphs. In several cases the nymphs that do survive to adulthood are free of CLas. Therefore, it is possible that inoculating young plantings with CTV expressing these RNAi sequences would both reduce psyllid numbers and reduce CLas inoculum in the remaining psyllid population. This concept ("Psyllid Shield") has now been modeled mathematically in detail and shows great promise to protect solid-block new plantings. CRDF continues to try and promote commercialization efforts towards field trials of this concept and registration of a new control product if successful.

The most dramatic reduction in psyllid populations has been achieved through coordinating grower practices through Citrus Health Management Areas (CHMAs). Several projects support this infrastructure including diagnostics system support (Roberts-589, Irey-827), ongoing studies in basic psyllid biology including attractants, repellants, and pheromones as well as trapping and monitoring ACP (Rogers-446, Stansly-600). It is essential to maintain stewardship of existing products for ACP control through responsible coordinated use and rotation (Rogers-590). While resistance monitoring has shown a broader response to insecticidal treatment, no significant case of insecticide resistance has been confirmed in field populations (Stelinski-765). Subtle effects of psyllid behavior may have dramatic epidemiological consequences. For example, ACP is actually attracted to CLas infected citrus and to uninfected plants exposed to volatiles from infected trees. This finding has been generalized to include uninfected but damaged trees (Stelinski-766). Lapointe (-561) has advanced the methodology to detect psyllid responses to volatile organic compounds and demonstrated a new response to degradation products, formic and acetic acids. Dawson (-517) reports the important finding that psyllid nymphs may efficiently acquire CLas in locally infected flush before the bacteria moves more systemically in the tree. This has important implications for detection and control of disease spread and has been modeled by collaborators and used to facilitate screening for resistance. Santra (-858) has developed novel anti-feeding materials to protect citrus from ACP and these are currently in evaluation. By screening a collection of 42 Bt endotoxin-producing strains, one strain has been identified that produces a toxin with good activity on ACP (Chougule-711). Another novel method of ACP biological control is based on entomopathogenic fungi and an auto-dissemination system. These dispensers combined with citrus-blend lures significantly reduce ACP populations in field trials (Setamou-760) and have attracted the interest of a commercial partner.

<u>CLas pathogen therapy</u>

Natural product antibacterial compounds may be more rapidly registered for use on food crops. Wang-916 tested 27 bacterial isolates show to produce antibacterial compounds. The bacteria have been recovered, purified and confirmed by 16S rDNA sequencing including several isolated from Florida groves. The antagonistic activity against *Agrobacterium, Sinorhizobium meliloti* and *Xanthomonas citri pv. citri* was determined and 5 strains, belonging to *Paenibacillus, Burkholderia* and Streptomyces showed good antagonistic activity. Three bacteria showing high antimicrobial activities have been sequenced to help understand the mechanism. The bioinformatics analysis is in process. Four bacterial strains: two *Burkholderia*, one *Pseudomonas geniculata*, and one *Rhodococcus* strain have been tested for their activity and all showed induced plant defenses against infection by *Xanthomonas citri*. In addition several genes involved in antimicrobial biosynthesis have been identified and several strains have been genetically tagged to further monitor the colonization of beneficial bacteria.

These strains were inoculated to citrus roots and the colonization was determined by inoculation and recover method in lab condition using small citrus seedlings. Around 10E8 cfu were inoculated to each

seedling. Approximately 10E4 cfu were recovered from roots 20 days after inoculation (dpi). In a separate experiment, two *Burkholderia* strains were tested and up to 10E5 cfu/g soil was recovered at five days post inoculation. Field trials are in the planning stages, groves have been selected and surveyed for HLB disease severity.

Wang (-608) has an extensive collection of bacteria (>400) isolated from Florida citrus roots and rhizosphere that can be cultured. This collection is being screened for beneficial properties including plant growth promoting and antibacterial properties. Numerous field trials and greenhouse assays have yielded several at least 3 isolates may delay symptom development on inoculated trees.

While the bacterial causative agent of HLB still cannot be cultured with a useful protocol, a close relative can be manipulated now in the laboratory and this system has been adapted for rapid screening of antibiotic activities. While conducting a search for bacteriophage, Gonzalez (-726) discovered an iron-chelating natural product compound with good antibacterial activity (Siderophore ALS84). Over 769 compounds, sourced from both corporate and academic collaborators, have been tested and several selected for further development (Triplett-767) both individually and in combinations and with heat treatment of trees in the field and greenhouse (Powell-617) (Ehsani-586). This surrogate assay system also may be useful to accelerate development of a type of “phage” therapeutic treatment based on bacterial viruses that lyse CLas (Gabriel-723). In another laboratory, this related species of CLas has been developed into a system to discover and develop new phage treatments for HLB (Gonzalez-726).

Water suspensions of oil nano-emulsions are being investigated as penetrants for antibacterial compound delivery to the phloem (Powell-584). Some of the most potent compounds discovered to date are in the tetracycline family and are available in commercial quantities. Novel tetracyclines that are not used in human or animal health show great commercial potential for the treatment of this disease (Nelson-775).

Possible new strains of CLas have been detected in Florida. These test negative for standard procedures to detect CLas (and citrus pathogen relatives) but can be detected with more sensitive methods. It is important to understand this relationship and whether any of these bacteria might “cross-protect” citrus from more virulent strains (Lee-563). Nine of these isolates have been propagated in plants at the USHRL in Ft. Pierce.

Citrus Host Plant Interventions

HLB impairs the vascular system of the tree and results in dramatic early loss of fibrous roots. Subterranean monitoring systems have been implemented to screen cultivars and growth conditions directly for root health (Graham-732). Graham (-731) has also shown that bicarbonate stress is a major factor that compounds root loss and impairs root function induced by HLB. This root stress is potentially exacerbated by the root pathogen *Phytophthora nicotianae*. Conventional fungicide treatments are not sufficient to restore root health to HLB positive trees (Graham-545). Two plant genes involved in the host response to CLas that are thought to be responsible for phloem plugging have been cloned and the targeted host genes have been silenced (turned off) with viral vectors (Citrus Tristeza Virus) containing RNAi in an attempt to ameliorate symptoms (Gowda-728). These plants are currently being challenged with CLas. Plant growth hormones may partially mitigate this symptom.

In an effort to reduce fruit drop and the exacerbation of this symptom with drought, Albrigo (-776, 777, 778, 809, 850) and Schumann (-707) have initiated a number of field trials including grower and CRDF-supported (Rogers-927, England-503) collaborations to test commercially available products and culture conditions for beneficial effects. Basic research continues to understand the movement of the bacterial pathogen in infected trees and to test the effects of novel carotenoid based hormones on disease (Strigolactone) (Etxeberia-710, 899).

HLB also causes off-season bloom and Albrigo (-850) is seeking to update a flowering prediction algorithm for these disease conditions. Baldwin (-702) has extensively analyzed peel oil volatiles from HLB affected fruit. While there are significant and potentially negative impacts, the profiles remain generally just below the detection of the human sensory panels for the samples tested.

A field trial of over 70 rootstocks has identified several that are relatively tolerant to HLB and performing well with nutritional treatments (Gruber-903) in both the greenhouse and the field. Many trees are appropriate for high-density plantings and have been released commercially on an accelerated timetable (Grosser-548) (Gmitter-539, 615). Both growers and plant breeders have observed relatively rare surviving individual citrus trees in a background of dying blocks. A comprehensive program is in place to understand this phenomenon, whether the phenotype is heritable or may be correlated with the soil microbiome (Wang-780), or simply represents a statistical distribution of variability (Gmitter-537).

Several *Citrus* and *Poncirus* genotypes and more diverse accessions demonstrate relative tolerance to HLB. It is important to research whether this genetic variation is useful for commercial scion or rootstock development (Stover-605) (Ramadugu-758) (Bowman-508). Efforts continue to narrow the thousands of candidate genes associated with this trait to a number that can be analyzed experimentally (Gmitter-724) (Duan-523) and new targets have been identified through comparative genomics analysis of the pathogen-host interactions as well (Grishin-733).

The goal of several projects is to understand how CLas interacts with the natural innate defense systems of the host citrus, such as the “SAR” response. This system appears important to disease progression because of differences in the SA response in relatively tolerant and resistant citrus cultivars and because of the effects of compounds that either improve the host response and/or mitigate the ability of CLas to block the host response (effectors such as SecA and SA hydroxylase). It is unclear whether combinations of these treatments will have sufficient economic benefit but candidate materials have been advanced to greenhouse (Mou-754) and field trials (Wang-609) and inform the design of possible transgenic solutions (Mou-754) (Bowman-508) including specific pathogen-triggered immunity (Moore-572).

A factorial (AxB) replicated field trial with six treatments aims to demonstrate effects of foliar or ground applied nutritional programs on intensively managed young citrus plantings (Schumann-598).

Antibodies are valuable research reagents for development of diagnostics and other applications. Hartung (-551) has isolated and optimized production of several candidates and demonstrated their utility in identifying the presence and location of CLas in infected plant tissues. These may also have utility in transgenic plants as resistance genes (Hartung-552) and these lines are currently being screened for their utility.

Many candidate genes for resistance to HLB have been introduced into transgenic citrus and the early flowering gene (FT) is a likely technology to facilitate introduction of new traits in transgenic citrus by accelerating fruit production (Moore-573) (Grosser-547) (Horvath-556) (Orbovic-579) (Stover-606, 607) (Duan-717). Significant effort has increased the screening capacity to evaluate superior citrus cultivars (Hall-502). Work continues to improve transgenic production methods (Li-749) (Moore-752).

NIFA Grant and Status

The purpose of this NIFA-CAPS is to create attractive options for management of HLB by replacing the wild type insect vector (ACP) with a population that is unable to transmit the bacterial causative agent (CLas). Achieving this outcome will require progress in the following three areas of emphasis – An Effector Mechanism, A Driver System, and Diffusion. The current conditions threatening citrus production nationally require our key personnel to work concurrently on parallel technical plans and to accelerate the leading alternatives based on assessments by our team leaders, advisors and management. The 5-year project, near its third year end, supports a three-fold approach:

I. Develop a psyllid management strategy based on the development of psyllid populations (nuPsyllid) incapable of transmitting CLas and strategically release the nuPsyllid population to displace current ACP populations (wtPsyllid) that have invaded the US.
II. Provide optimized orchard management strategies for integration of the proposed population displacement technique into current orchard management practices: a). Southeast and Southern U.S. (FL and TX) where both the ACP and CLas are endemic or detected. b). Western U.S. (CA and AZ) where ACP is present and spreading while there is currently no detection of HLB.
III. Integrate orchard and nuPsyllid management strategies with monitoring strategies to continually assess effectiveness, and provide outreach education to the grower stakeholders and citizens about the control strategy.

The assessment of progress by the project teams has suggested a near-term application of this research for the protection of new solid block plantings from HLB. This concept “Psyllid Shield” is being evaluated for field trials to demonstrate efficacy. While it is not full insect replacement, it is based in part on research progress in the search for Effectors. CRDF has supplemented funding to model field results under various scenarios and has selected 5 RNAi sequences as field trial candidates based on the results of indoor experiments with caged insects. CRDF is seeking additional stakeholders to plan for larger scale field trials of this disease management concept.

This team, representing 23 institutions and about 70 individuals, met in February 2015 prior to the HLB Conference and discussed project goals progress and plans going forward. The consensus of the team leaders and stakeholder advisors developed at the Annual meeting was to continuing with the

concurrent work plan originally proposed with respect to the Driver and Effector teams into years 4/5. A draft update to the project objectives and budget is in progress.

Other Citrus Disease Research

Black Spot, Blight, Canker, Diaprepes

While the CRDF recognizes that HLB is the primary focus of effort, there is continuing interest in developing solutions for other diseases and pests affecting. In addition to their importance in citrus production, the injury by these other diseases and pests accelerates tree decline when combined with effects of HLB infection. The IRCC gaps analysis (covered later) helps guide the prioritization of these additional disease threats. The following table reports the investment by CRDF in both research and delivery of solutions with these other pests and diseases.

Table 3. CRDF investment in citrus diseases and pests beyond HLB.

REDUCE IMPACT OF OTHER DISEASES	Research		Delivery		
	CRDF	NIFA	CRDF	MAC	Total
Citrus Canker	$ 3,043,544		$ 834,133		$ 3,877,677
Citrus Black Spot			$ 909,302		$ 909,302
Phytophthora	$ 336,714				$ 336,714
Diaprepes Root Weevil	$ 80,000		$ 134,500		$ 214,500
Citrus Blight	$ 400,000				$ 400,000

Non HLB Disease and Pest Research Accomplishments

CRDF identifies and supports research on several other diseases that cause significant economic loss for citrus production in addition to HLB.

Copper is proven to control canker but may be undermined by overuse. Novel biocide formulations that enable slow release of EPA-approved Quaternary Ammonium compounds have shown excellent protection of citrus from citrus canker (Santra-759). Given the decline in root health in the HLB environment, it is important to investigate nematode biodiversity, including beneficials and parasites (Duncan-525).

Multiple phages (see above) have been isolated and characterized with the potential to control citrus canker disease (Gonzalez-726). The phage component “tailocins” are also effective at protecting citrus from canker as a mixture. This is a novel form of biocontrol with commercial potential. Biofilms are protection that bacteria use to defend themselves from environmental hazards and these plant pathogens use a communication system known as quorum sensing to trigger biofilm formation (see above and Wang-610). Basic research in biofilm formation has been advanced by (Graham-546). This is an important target for development of new canker disease control interventions and several new inhibitors have been identified and advanced to field trials by (Wang-610). Strong resistance to the canker pathogen has been engineered in a transgenic model system and is being transferred to citrus (Horvath-555).

The citrus leafminer insect significantly exacerbates canker disease. New control research to establish baseline susceptibility to currently used insecticides and measure the efficacy of new actives continues (Stansly-601).

International Citrus HLB Conference, February 2015

The third international conference focusing on HLB research progress was held in February in Orlando, following the tradition of previous meetings to focus attention on the discovery and delivery of solutions to HLB. First started in 1999 and focused on citrus canker, this series of conferences has occurred every two years, and in 2005, HLB became a topic of focus along with canker. In ensuing conferences, the topic has been specifically focused on HLB. CRDF is proud to be the major sponsor and planning participant in these conferences, and particularly the grower outreach meetings that follow the conference. A summary of this meeting may be found later in this report. This is appropriate, as CRDF has managed funding on behalf of the citrus industry for a significant number of the projects and scientists that were represented at the HLB Conference.

The February 2015 conference spanned a five-day period, with about 450 participants from 22 countries. Oral papers and keynote overviews were organized around the following topics that address the components of the HLB disease system: the vector psyllid, the pathogen *(CLAS)*, and the host plant citrus.

- *Cultural Control and Epidemiology*
- *Host-Pathogen Interactions*
- *Pathogen - Infection Consequences*
- *Pathogen-Vector Interactions*
- *Vector*
- *Vector-Host Interactions*

Organized according to these topics, there were over 100 formal presentations distributed across the 3 biological elements (vector, host and pathogen), and more importantly, the interactions among each of the intersections as described above. During breaks in the formal program, more than 100 posters were on exhibit throughout the meeting period. The posters were organized according to the above topics as well, allowing one to wander through sections of the poster arena and view similar topics together. While the formal presentations dominated the meeting time, the more informal poster periods allowed one-on-one and small group discussions around the visual presentation of the poster.

As with any scientific meeting, the HLB Conference is a great opportunity for scientists and engineers with common interests to share ideas, results and plans. The specific focus of this meeting on citrus HLB makes those interactions even more valuable. Thus, one of the great benefits of such a meeting is the exchange of ideas and information, and the follow-up collaborations that are formed. Of particular interest in this regard is that important teams are forming around the new federal HLB funds, and the HLB conference offered a great opportunity for these teams to meet and advance their plans and

proposals. Several side meetings were conducted with cooperative teams working out details and budgets.

Another feature of the 2015 HLB conference was the breadth of research being reported by individuals and groups that are located in areas that are newly infected with HLB or are working in advance of the spread of the disease. In addition to strong participation from Florida and other citrus states (Texas, Arizona, and California), there were representatives from 22 countries, many that are building programs in response to recent infection by HLB. Notably, Brazil had many delegates who provided important updates on their work to understand and manage HLB in their country. Other South and Central American countries were represented and the audience heard updates on the level of spread of disease and responses in these areas.

To the observer, the information presented and discussed at the HLB Conference ranged from deep technical science that is novel and exploratory to field trials and experiments to better understand and manipulate various components of the disease and the citrus production system. Since the meeting has avoided running concurrent sessions, all participants have a chance to attend all of the presentations, allowing everyone to broaden their perspectives beyond their own specialty, and to see the bigger picture of the effort against HLB.

To a grower participating in the conference, the presentations might appear overly technical and short on practical information of interest to growers. By design, the agenda contained the full spectrum of topics that ranged from foundational science to testing of solutions. Since the meeting is primarily held to allow interaction and communication among scientists, this is one of the side-effects. However, the organizers recognized the need for a non-technical component to emerge that can provide the relevant updates to growers. Additional details of the International HLB Conference can be found at http://www.irchlb.org/hlb.aspx, and the American Phytopathology Society website will host the published papers of this conference.

Commercial Product Delivery

The Commercial Product Delivery Committee is focused on an array of near-term topics, including suppression of the psyllid, interventions to reduce bacterial titer in infected plants and cultural practices that may provide enhanced ability of citrus trees to withstand infection. Recent meetings have committed additional support for field trials of plant growth regulators to determine the ability of these chemicals to affect pre-harvest HLB-related fruit drop. The first season of field experiments to evaluate commercial microbe products ended, and the three sites will be continued in 2015. This side-by-side comparison of several season-long programs was encouraged by citrus growers who aren't certain of the impacts of these treatments on tree health. The study included complementary nutritional and compost treatments as prescribed by those marketing the products.

Among the most active topics is the effort to identify, screen and place into field trials a wide range of chemicals that are targeting the reduction or elimination of C*Las* from infected trees. Activities supported by CRDF range from discovery of new potential chemicals, comparing assay results to move candidate chemicals forward, and finally, to conduct appropriate field trials. The proof of utility comes when materials are applied under field conditions, and this is where the appropriate rates, application methods, timing of use, and expectations of efficacy are derived. Field trials also lead to development of residue information and other data essential to separate the best performers and to seek regulatory approval. Considerable activity is ongoing in these areas, with reports of progress provided each time the committee meets.

Each year, the Commercial Project Delivery project managers organize the ongoing projects into appropriate topics so that reporting and discussion at CPDC meetings can follow the hierarchy. During 2014-15, projects were organized according to the following topics. A more complete list of individual funded projects pursued in 2014-15 is presented in Appendix B.

Table 4. Commercial Product Delivery Project Organization by Topic, FY 2014-2015.

Tier 1: Active Projects		
		<u>Therapy for Existing Trees</u>
	1	Antimicrobial Strategies
	2	Naturally Occurring Microbial Products
	3	Thermal Therapy
	4	Plant growth regulator interactions with HLB
	5	Strategic Inoculum Removal to Manage HLB in Florida
	6	Case Analysis of Success in Responding to HLB
		<u>New Plantings</u>
	7	Asian Citrus Psyllid Management
	8	Tolerant rootstock plantings

	9	Psyllid Shield – Delivering RNAi with CTV Vector
	10	Integrating HLB Management tools into Model New Groves
Tier 2: Facilitate and Monitor Projects	11	Candidate HLB Tolerant Scion Evaluation in Field Trials
	12	(MCTF): Deploying Canker-Resistance Genes
	13	Diaprepes pheromone
Tier 3: Information Projects	14	Citrus Leafminer area-wide mating disruption
	15	CTV vector
	16	HLB Escapes

Funding of Commercial Product Delivery Projects

Peer-reviewed research often ends when research has been carried to the point where delivery of the solutions to the intended audience is the next step. As described above, the peer review process for research projects encourages practical outcomes, but falls short of prescribing how these results are delivered. Thus, CRDF has established the Commercial Product Delivery Committee (CPDC) to manage these next steps. The process for consideration and approval of a CPDC project is described here.

Identification of Research Results Ready for Delivery to the Citrus Industry

During annual CPD project review, new projects are intensively reviewed for their scientific merit and practical value in contributing towards providing solutions to the citrus industry. All existing research projects are reviewed as well, with an eye to identify progress, milestones, as well as limitations experienced on each project. Through the process described above, the *ad-hoc* reviewers as well as the SAB identify research results which are ready for delivery, and this feedback informs the Research Management Committee as they evaluate projects and recommend those most worthy of approval to the Board. In this way, the Research Management Committee and the Program Manager communicate research results that have delivery potential to the Commercial Product Delivery Committee. Similarly, progress in research or product delivery beyond CRDF is reviewed routinely and ideas for delivery emerge from this review as well. A unique aspect of CRDF is the “Solutions” page on the CRDF website which serves as a collection point for unsolicited HLB solution ideas and candidate tools and materials. Project managers respond to formal submissions and, when appropriate, determine next steps to evaluate ideas coming forward.

Development of the Project Overview, Roadmap and Timetable, and Consideration of Funding Needs

With discussion and approval of updated research results, the Commercial Product Delivery Committee acts to establish a Commercial Product Delivery Project, and assign the Program Managers and CRDF

Staff to develop the necessary framework moving forward, including pathways, timelines, and resource needs. This project plan is developed with input from expertise within and outside of CRDF, and the plan is presented for consideration by the CPDC at a committee meeting. When appropriate, necessary follow-on research or development steps are defined, and appropriate experts are requested to submit specific plans and budgets to be included in the project.

Review and Evaluation of CPDC Projects

Products of CPD planning and project development are presented to CPD for discussion and ultimately for funding consideration. In many cases, the CPD project overview and specific project plans and budgets are reviewed by the Chair of the SAB and other experts to provide continuity with the foundational research leading to this step. In addition, CPD projects under development may be shared with the Research Management Committee for their consideration and input. When fully developed, a CPD project is formally presented to the Committee for discussion, clarification and, ultimately, for recommendation for approval of both the plan and specific funding requests for each project. Quarterly written updates of all active CPD projects allow the Committees and CRDF to maintain awareness of project progress and to discuss the need for additional action and prioritization of effort and funding.

Approval of CPDC Projects

When recommended by the Commercial Product Delivery Committee, the proposed project activities and specific funding requests are placed on the Board of Directors agenda, and projects and associated funding requests are acted upon by the Board. Approved project plans and budgets are then contracted in concert with standard agreement terms used in CRDF research agreements.

Commercial Product Delivery Committee Composition

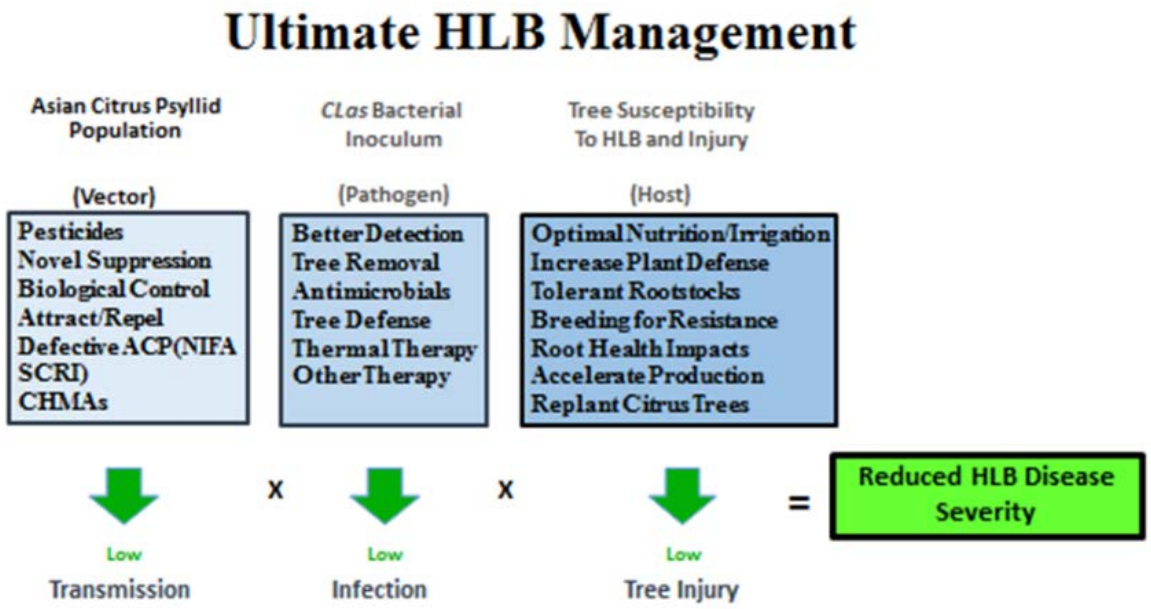
The Commercial Product Delivery Committee is comprised of a broad range of citrus industry representatives, as well as experts from related fields who can provide insight into delivery of research results via usable tools and products for the industry. Appointments to this and other committees are considered within committee and approved by the President of the Board. The expertise represented on the committee is supplemented by outside expertise and by a program management team on a project-by-project basis. There is active participation in discussions and development of partnership arrangements, whereby appropriate expertise is applied to develop the pathway, timetables and other issues of research product delivery for each project. As with the Research Management Committee, the Commercial Product Delivery Committee relies heavily on the research expertise resident in the review process steps to identify the best science, and also to note when research is ready to move to delivery phase. In most cases, these results emerge from CRDF-funded projects that have been subject to the peer review process described above.

Table 5. Profile of CPD funded projects during FY 2014-15, separating projects ending from those that will continue into FY 2015-16.

CRDF Commercial Product Delivery	Projects Ending < 7/01/15		Projects Continuing > 7/01/15	
Program Topic	# Projects	Total Budget	# Projects	Total Budget
Antimicrobial therapy	9	$ 2,567,858	4	$ 506,587
Naturally Occurring Microbes	0		4	$ 468,386
Thermal Therapy	2	$ 467,177	1	$ 105,782
Plant Growth Regulators	5	$ 175,717	1	$ 132,660
ACP Management	3	$ 269,720	0	
Tolerant Rootstock Plantings	3	$ 548,088	1	$ 333,774
Psyllid Shield (RNAi)	1	$ 487,383	1	$ 113,523
HLB Escapes	1	$ 176,000	0	
Non-HLB Pests and Diseases	1	$ 803,126	3	$ 213,333
Total CPD Projects	**25**	**$ 5,495,069**	**15**	**$ 1,874,045**

The CRDF Commercial Product Delivery Committee continues to seek projects that will put tools into the hands of growers who are battling HLB in existing plantings, as well as trying to prevent buildup of the disease in new plantings. We are working across the range of opportunities depicted in the graphic below in the belief that integrated use of all available tools will contribute to success in managing citrus in the presence of HLB. Figure 7 summarizes the tools being sought to address: Asian citrus psyllid populations and their transmission of *CLas* (left side of graph); therapy against the bacterium (middle portion); and opportunities to target the citrus tree (right) through cultural and genetic approaches to make the tree less susceptible to infection, or to increase the ability of the tree to defend against disease once infected. This graphic also communicates the value of adopting all of the available tools, with progress in each of the areas (vector, pathogen and host tree) contributing to overall reduction in severity of the disease.

Figure 7. Targets of HLB intervention based on insect vector, pathogen bacteria, and the host citrus plant.



Many ongoing field trails moved through harvest and fruit quality evaluation as the 2014-15 season ended, including experiments evaluating plant growth regulators, HLB treatments, and combinations of cultural practices designed to enhance young tree growth and success. Harvest data complements other measurements taken during the growing season. Field trials of various chemical and thermal therapy strategies are being evaluated. Within season measures have been taken for 2014 in these trials as well, and fruit evaluation was completed. Many of these trials will continue into subsequent years, and data derived from the current year will guide directions for next year. CRDF project managers and the field trial administrator work with researchers and grower cooperators to keep these trials on target and to evaluate results. Trials were planned for 2015 to extend the goals of developing and demonstrating HLB solutions. New field trials of bactericidal candidates have been initiated. In addition, the thermal therapy scale-up efforts being considered for support by the USDA, APHIS Multi-Agency Coordination (MAC) Group were evaluated by CRDF support staff to compare treatments and to help in evaluating the impact of heat therapy on HLB-infected trees.

CRDF continues to work with registrants of Asian citrus psyllid (ACP) control chemicals to extend current labels for these materials, and meets frequently with state and regulatory agencies to discuss plans for additional tools for ACP and HLB.

This summary lists some of the ongoing field trials supported by CRDF that were in place during the 2014 production season:

- Evaluation of season-long ACP population management with pesticide materials, rates, and application methods
- Evaluation efficacy of antimicrobial treatments for reduction of CLas population and measure phyto-toxicity
- Measurement of commercial microbe product applications on tree health and productivity
- Determine the effects of thermal treatment of HLB-affected trees on growth response and CLas titer reduction
- Evaluation of candidate HLB-tolerant rootstocks in replicated field trials
- Testing the ability of single full-dose or multiple low-dose applications of plant growth regulators to affect pre-harvest fruit drop
- Integrating ACP management, high planting densities, and irrigation/nutrition strategies into new citrus plantings
- Treatments to adjust bicarbonates and/or pH imbalances in soil and irrigation water
- Large-scale demonstration of citrus leafminer disruption through pheromone technology

Many of these field trials continue into the 2015 season to evaluate cumulative effects of treatments. Harvest information this season will allow evaluation of the season-long value of treatments and connect tree response to productivity and fruit quality.

Citrus growers participate as cooperators in these various field trials and are acknowledged here for the contributions that they are making in hosting field experiments. The placement of these field trials across the citrus regions of Florida assists in determining regional differences in response to the treatments being tested.

Twenty project ideas were invited for full proposals in the Commercial Product Delivery area, resulting from review of the large number of projects ending by June 30, 2015. These projects test solutions that can be implemented in the short term and include:

- Eight projects support development and testing of bactericides to provide therapy to infected trees. These range from assays to field trials to development of required regulatory information.
- Three projects address ACP efforts through continuing support for Citrus Health Management Areas (CHMAs) and for pesticide effectiveness and resistance monitoring in areas under

increased pesticide use. These projects emphasize the importance of continued diligence in managing ACP populations across the state.

- Five project ideas provide support for continued field trials, including the PCR testing necessary to evaluate treatments, and other general support functions related to getting solutions to the field.
- Support for one field site for testing citrus breeding candidates also in included in this set of ideas approved for full proposals.

Full proposals resulting from these invitations followed CRDF review and consideration processes, ultimately being presented for discussion and final approval at the June 2015 Board Meeting. This allowed CRDF to put the 15 successful projects in place by July 1 as the new fiscal year began. A new feature of the CRDF process is to evaluate these projects against the new federal funding programs overseen by USDA, NIFA (SCRI Citrus Disease Research and Extension Program) and the USDA, APHIS Multi-Agency Coordinating Group (MAC) program. Close communication is vital to ensuring that high priorities are met and that solutions come forward more quickly.

Topical Highlights

CRDF's Approach to Development of Bactericides

A major goal for CRDF research and product development activities is the treatment of HLB-infected trees with therapy which will reduce the titers of *Clas* populations within the plant, allowing the plant to stabilize and perhaps to recover from the symptoms of HLB disease. The two approaches to treatment are use of thermal therapy (heat treatment) and application of antimicrobial chemicals that can reach *CLas* populations within the plant. The benefit that can be derived from these approaches is unproven at present, but for tress which have not yet become severely impacted by the disease, it offers the potential to sustain productivity of existing trees and extend the life of current tree populations as a bridge until alternative management methods are available.

CRDF has been supporting the discovery of compounds designed to kill CLas, and has directed increasing attention and resources to advancing research results, integrating current information on antimicrobial use in other crops, and has focused on meeting the requirements to field test and deliver antimicrobial solutions to growers. This has become the major thrust of the Commercial Product Delivery Committee and support teams.

To accomplish the goals, investments are being made in the following areas:

- Encourage sharing of research results from CRDF projects focused on antimicrobials against HLB
- Partner with companies so that they can drive anti-microbial product development and overall commercialization processes

- Move results to field trials that incorporate formulation and application methods
- Engage with state and federal regulatory agencies who oversee this area of agricultural practices
- Facilitate and support the above efforts to accelerate the commercialization processes that will lead to tools ready for grower use
- Bring project managers on board to track RMC and CPDC research projects relevant to the identification, screening, formulation and delivery of antimicrobial materials against HLB and integrate into other CRDF activities

What are the approaches that are being used?

Biological treatments are being evaluated in field research, with many potential objectives being considered. Among these are beneficial microbe products, many of which are commercially available for use in citrus, and for which little performance evidence exists. Like nutritional treatments, there are questions of what can be expected from their use, as well as how they can be optimized and integrated into overall citrus management in the era of HLB. CRDF is sponsoring side-by-side comparisons of programs that use these materials in commercial grove settings to determine if there are relationships between season-long programs containing beneficial microbe products and tree response. These are multi-year field trials that were initiated in early in 2014.

Among the antimicrobial strategies which are being advanced are several different groups of materials, each having chemical, biological and regulatory features. The goal is to provide solutions as soon as possible, while continuing to pursue all avenues that will provide safe, economical and sustainable tools in the intermediate term. We utilize the following structure to describe potential antimicrobial tools that are the focus of CRDF and others interested in these solutions.

1) Conventional Antibiotics: Streptomycin and Oxytetracycline are considered most likely to be approved among conventional antibiotics, since there is precedence for their use in agriculture. Since there are relatively few of these materials available for use in agriculture, CRDF is investigating those with the shortest time to regulatory approval and which demonstrate potential for use. Corporate research is committed to move antibiotics in this group forward, and CRDF is working closely with companies who have experience in this area.

2) Agricultural Antibiotics used on food crops in other countries have been considered, and some of these materials have been evaluated in preliminary assays. These candidates offer another opportunity for therapy against *CLas*, while posing unique challenges, including unraveling international intellectual property issues.

3) New Molecular Entities: Compounds with specificity and potency customized to treat HLB and not used for human or animal health. This group includes materials emerging from discovery research funded by CRDF.

4) Biopesticides: This group provides advantage for regulatory consideration based on their natural occurrence or derivation. Commercially available materials in this group that are used for other targets and/or crops are being evaluated for use in HLB suppression.

5) Simple plant essential oils comprise another group of materials which may have the potential for more rapid deployment through a reduced commercialization and regulatory paths. Laboratory evidence for efficacy of these materials against *CLas* must translate into field performance for these materials to move forward. Since they are naturally derived and have been used in agriculture, regulatory processes may favor early availability. In addition, CRDF will screen all reasonably available essential oils and other natural products on the EPA 25(b) "Minimum Risks Pesticides" list for activity against HLB.

In summarizing the status of these antimicrobial strategies, it is important to balance multiple dimensions of risk inherent in developing a product that is safe, effective and can be registered for agricultural use through federal and state agencies. In addition to regulatory concerns, we have to optimize dosages that are non-phytotoxic but still effective against *Clas*.

What are the activities that will move these groups forward?

Assays to screen candidate materials: Research teams funded by CRDF have developed several different assays which test candidate materials for their ability to kill *CLas* or closely related bacteria. These are complementary tests that can be used in parallel to evaluate large numbers of compounds for activity, and then refine the details of their activity and phytotoxicity in subsequent steps to identify leading candidates.

Candidate antimicrobials coming from all sources available are being tested in these assays, including materials emerging from research projects, existing libraries of antimicrobial candidates, and commercial products used in agriculture that have known antimicrobial activity. This suite of assays allows a large number of candidates to be reduced to manageable numbers to enter field trials.

Formulation of candidates: Candidate materials that are being considered for field evaluation must be formulated for delivery into the plant where *CLas* resides, and must have properties that will promote distribution within the plant, enough persistence to reduce *CLas,* and to address other concerns, like application safety and non-target effects.

Fortunately, many materials being evaluated already are formulated for field use. However, CRDF also is engaging experts in formulation to assist in developing candidate products for field testing.

Field tests: The proof of utility can only emerge from carefully designed field tests, comparing the candidates against one another and against untreated controls. Initially, this is accomplished in small plots with young trees to provide more rapid response in controlled environments. Subsequently, large scale field trials are necessary to determine commercial-scale response and effectiveness on larger trees. Field trials currently are in place across this horizon, with small preliminary trials being conducted on some candidates while larger-scale trials are being performed for some materials.

Regulatory support will be crucial as field trials are designed and installed to address the evaluation of performance, while also collecting data required for commercial registration. The range of

requirements varies among groups, and also varies according to whether there is current use of the material in agriculture. Concurrent development of biological and regulatory information will shorten the timetable for new or existing products. CRDF relies on external expertise in regulatory processes to provide guidance and interface with regulatory agencies.

Two recent meetings between CRDF and state and federal regulatory agencies provided guidance to the evaluation and commercialization of antimicrobial strategies that are moving forward. Frequent consultation is an important element of maintaining direction that will lead to success.

Expectations for Bactericides

While few believe that antimicrobials will provide a complete solution, these tools, like many others will integrate into HLB management programs and can provide a unique opportunity to potentially stabilize current HLB infections that are in early stages, and perhaps to help retain tree health once bacterial titers are reduced. This is vital in the short term to maintain citrus production in Florida, and to protect new plantings as they become infected. The evaluation of a wide range of materials should provide options in the intermediate term to assist with resistance management, a concern with antimicrobial materials. In the longer view, antimicrobial materials that have been designed for *CLas* have potential to contribute to sustainable tools for HLB management.

Like all of the challenges presented by HLB in Florida citrus, the development and delivery of antimicrobial materials is complex, uncertain and will require time and resources to provide solutions. CRDF has prioritized development of antimicrobial solutions, and is aggressively pursuing all avenues available. Management of the numerous pathways, participants and materials involved has created the need for additional parties to join together, and we are confident that results are forthcoming that will lead to tools for use by growers. The ultimate use of antimicrobial materials will be dependent upon concurrence by processors and consumers.

We are fortunate that Dr. Stephanie Slinski has joined the effort to coordinate the antimicrobial pursuit, serving as a full-time Florida-based project manager for this area. Her background and experience will serve her well in coordination and communication in this complicated environment. Her resume is posted on the CRDF website at citrusrdf.org.

Regulatory Activities to Accompany Delivery of Solutions

During the past year, the Commercial Product Delivery Committee of CRDF has focused heavily on understanding and communicating the situation with HLB in Florida to State and Federal Regulatory Agencies to assist them in understanding the need for the therapies described above. In addition, we have asked for guidance from the regulatory agencies so that regulatory processes can be anticipated, planned into field research, and expedited as results emerge. An important meeting was held in

conjunction with the September 2014 IR-4 Southern Regional Workshop which focused on the challenges of registration of antimicrobial materials in specialty crops, particularly citrus. Presentation by the U.S. Environmental Protection Agency (EPA), Food and Drug Administration (FDA) and Centers for Disease Control (CDC) in the meeting provided strong indication of the regulatory requirements, data needs, and also conveyed the willingness of these agencies to work through the difficult issues surrounding use of antimicrobial chemicals in agriculture. A presentation by CRDF highlighted the industry's need for bacterial treatment, and detailed the many activities underway to identify and test different classes of materials in the field. A more complete report of this meeting can be found on the CRDF website citrusrdf.org.

During FY 2014-15, CRDF led or participated in numerous meetings with the US Environmental Protection Agency (EPA), USDA, APHIS, Federal Food and Drug Administration (FDA) and the Centers for Disease Control (CDC) on a range of topics, including regulatory pathways, processes, and considerations for expansion of existing pesticide registrations for ACP controls, as well as preliminary determinations on process for registration of therapeutic bactericides for use against CLas. Continuing conversations also were held regarding the status of other technologies advancing towards field deployment for HLB and Citrus canker management, including engineered resistance in citrus rootstocks and scions, deployment of RNA interference, and the potential regulatory considerations associated with development and release of ACP populations which are unable to transmit *Liberibacter* to citrus trees. These ongoing interactions allow CRDF to incorporate appropriate information into decisions on advancing solutions, as well as to anticipate the research elements necessary in addition to demonstration of efficacy.

At least once annually, CRDF participates in Florida tours of EPA and other regulatory agency tours where agency representatives receive direct access to the situation in citrus groves, and participate in conversations about the progress towards solutions.

Closer to home, CRDF has evolved strong relationships with the Florida Department of Agriculture and Consumer Services, and in particular their Pesticide Registration Division, as this agency is the first stop on advancing solutions through state and federal regulatory processes. CRDF is fortunate to have a formal arrangement with Florida Fruit and Vegetable Association in developing regulatory strategies and moving solutions forward.

<u>Commercial-Scale Field Trials of HLB-Tolerant Rootstocks</u>

Among the more likely long-term solutions to HLB that will lead towards stability and economic viability is implementation of citrus scions and rootstocks in new plantings that provide partial to full tolerance or resistance to HLB infection and disease development. This has been a primary long-term objective of CRDF since its inception, as well as being a key focus of the University of Florida and USDA, Agricultural Research Service (ARS) citrus breeding programs in Florida. Greenhouse and field trials of many sizes

have been put in place, and natural infection by bacteria-laden Asian citrus psyllids is providing disease infection pressure to these field plantings. Much attention has been paid to field sites such as the UF, IFAS St. Helena field trial, as well as trials on the Picos Road Farm of USDA, ARS. These trials have a number of different rootstocks or scions in small replicates, allowing direct comparisons of a large number of genotypes under similar location and management practices.

In the environment of HLB, citrus susceptibility to disease is an important component of developing solutions. As rootstocks from the breeding programs are being evaluated, CRDF has encouraged early release and other strategies to make these rootstocks available to growers. Past success in 2013-14 in rootstock release activities from USDA, ARS and UF, IFAS is encouraging, and CRDF will continue to work with both variety improvement programs and their plant release mechanisms to ensure that rootstock materials showing promise are made available for further grower evaluation either through open release or through Materials Transfer Agreement (MTA) strategies.

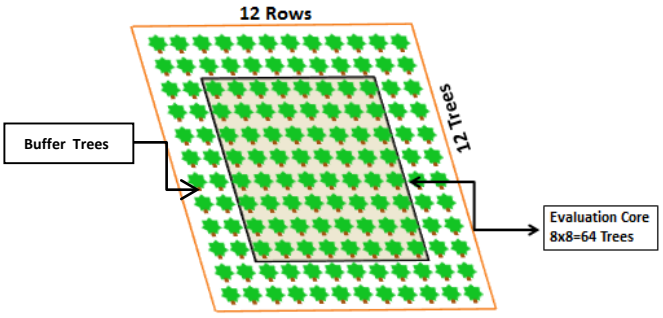
CRDF arranged for sufficient numbers of 5 HLB-tolerant candidate rootstock trees to plant commercial-scale replicated field trials with cooperative growers, compared to 2 standard rootstock at each site. These trials are located in two citrus regions of the state and are hosted by commercial citrus growers to facilitate real-world evaluation under commercial production, harvesting and marketing conditions. Only grower-cooperators who fit these criteria were considered for hosting the field trials. While CRDF is interested in overlaying appropriate design in these plantings, the plantings necessarily need to conform to general grower practices, including being treated as a solid planting as far as cultural practices, harvesting and marketing are concerned. For this reason, one consistent scion will be used in all field trial sites.

CRDF implemented Phase I grower field trials of most promising candidate HLB tolerant rootstocks emerging from early field trials in FY 2014-15. Trees for Phase I grower plantings at three sites will be available beginning in spring, 2015, and two of the three trials were planted before June 30. The third trial was planted in July. CRDF-funded trial administration and data support will provide liaison with the grower cooperators beginning at pre-plant and continuing after the trials are planted.

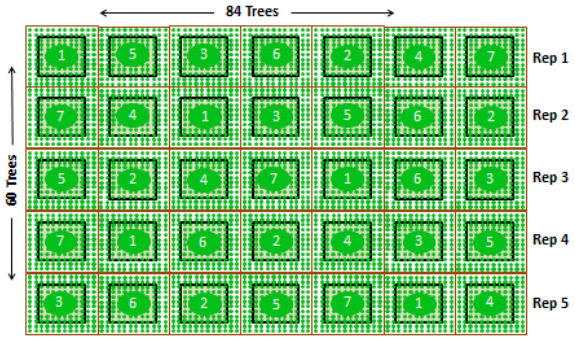
Details of the field trial Plantings considered by potential trial hosts were:

- The recommended block design is a 12 x 12 planting (144 trees in each block) for each rootstock per replicate. This “square” orientation is preferred over long rectangular blocks (e.g., 9 x 16 or 8 x 18) to optimize the buffering effects.
- Two buffer rows and two row-end buffer trees in each plot (shown in figure below, left) that allows a non-edge block of 8 x 8 trees, or 64 trees per replicate per rootstock to evaluate for HLB and other performance parameters across the trial
- With this block size, there will be 144 trees per replicate per rootstock

- With 5 replicates of each rootstock, 720 trees of each rootstock will be planted per site and a total tree population of 5,040 for the 7 rootstocks in each location in the state.
- The number of acres planted will vary with the tree and row spacing chosen. Under conventional spacing, this is approximately 1 acre per plot and thus 35 total acres per location in the state.



Individual Rootstock Candidate Plot
All Trees Same Genotype (144 Trees)



Whole Planting View: HLB Tolerant Rootstock Trial Design
7 rootstocks x 5 Replicates = 35 Plots
Numbers within each plot represent rootstock number in the trial

Candidate HLB-tolerant rootstocks: The rootstock trial were planted at the sites as follows:

Indian River Site:	Ridge Site:	Southwest Flatwoods Site:
Orange 4 (UFR-2)	Orange 4 (UFR-2)	Orange 4 (UFR-2)
Orange 15 (UFR-3)	Orange 15 (UFR-3)	Orange 15 (UFR-3)
Orange 19 (UFR-4)	Orange 19 (UFR-4)	Orange 19 (UFR-4)
46 x 31-02-13 (UFR-16)	46 x 31-02-13 (UFR-16)	46 x 31-02-13 (UFR-16)
US 942 (USDA, ARS)	US 942 (USDA, ARS)	US 942 (USDA, ARS)
US – 812 Standard at all sites	US – 812 Standard at all sites	US – 812 Standard at all sites
Sour orange: Indian River	Carrizo citrange: Ridge only	Swingle – Southwest flatwoods

Since no field cooperators came forward from the Indian River area interested in planting oranges, the third trial was selected for planting on a ridge site. All rootstocks for planting in these three trials were budded with '1-14-19 Valencia' for scion uniformity. This facilitates a straight comparison of performance, including yield and fruit quality, as well as facilitating production, harvest and fruit marketing across all rootstocks.

Expectations for planting and cultural practices in the field trials:

Planting plans were designed to maximize the ability to compare buffered blocks of solid planted rootstocks. Within-row spacing of trees on the different rootstocks considered the growth habits of scions on each of the rootstocks. The rootstock breeders provided recommendations on specific rootstocks that may benefit from tighter or more open spacing, but have indicated that all rootstocks that are included in these field plantings should perform well at 10 foot within-row spacing. This assessment is focused on 10-12 years of economic life of the planting. Complete records on the planting

plan, dates of planting, and other relevant details such as soil type, organic matter, irrigation water salinity, pH and bicarbonates, were collected at planting.

Cultural practices: Once planted, the following general practices are encouraged to support the planting and provide for a reasonable evaluation of the rootstocks:

- Aggressive psyllid management according to current CHMA recommendations or equivalent for young trees and early mature trees. Active participation in a CHMA or cooperative treatment area is encouraged as relevant
- Irrigation, nutrition and grove floor management consistent with current practices to promote root health and growth in the presence of HLB
- Freeze protection should be a component of the planting plan

Considerations for grower cooperators:
The grower cooperators are the primary investors in this trail, well beyond the investment by CRDF and the industry in providing the trees and encouraging the planting. CRDF will encourage discretion in seeking access to field trials for observation, data collection, and field days associated with the trials. There is a need to balance the purpose of demonstrating the performance of the HLB-tolerant rootstocks under commercial production with property and business considerations.

In March, the first of three phase I commercial field trials was planted, involving 5 replicates of new rootstocks as well as two standard rootstocks commonly used in each area. All rootstocks were propagated with a common Valencia close to allow side-by-side comparison of growth, disease progression, and when appropriate, yield and fruit quality determination The field trial grower cooperators were chosen from solicitations to the industry for those interested parties, and the CRDF Board selected the finalists using a lottery draw.

The planting in Southwest Florida was installed mid-March by A. Duda and Sons, following the protocols and plot designs provided by CRDF. Adequate numbers of each rootstock were planted in each replicate to allow buffer areas between plots and to observe how each rootstock performs when placed in a solid planting. Similar plantings occurred in June and July on the ridge by Peace River Packers and Ben Hill Griffin, Inc., respectively. Data will be gathered from these cooperator sites by the CRDF field trial team, and the UF and USDA citrus breeding teams. Field days at appropriate intervals will be planned and communicated to the industry.

Figure 8. Installation of commercial-scale field trials of HLB tolerant rootstocks. The planting illustrated is from Duda and Sons, Southwest Florida.

What has been delivered to growers?

A brief summary of the topical areas that received priority attention in 2014-15 follows. The FY 2014-15 State Legislative funding, which complemented grower investment, has enabled considerable progress in these areas.

1 Asian Citrus Psyllid (ACP) Management and Citrus Health Management Areas (CHMAs)
Continuing progress in research on methods for suppression of the vector insect which spreads HLB has allowed the CRDF, working with product registrants, growers and with regulatory agencies, to increase the availability of tools to combat ACP populations. Several expansions of use for currently labelled insecticidal products (neonicotinoids and others) have been achieved through these efforts, and several new products also have been registered for use on Florida citrus. While work continues on alternative strategies to manage the psyllids and prevent HLB spread, strategic chemical management remains a critical tool, especially for young trees within the first several years of their field life.
Complementing the effort to develop ACP tools, research has provided information on how insecticidal tools can be used during critical times of the season, such as bloom. Alliances between Florida Department of Agriculture and Consumer Services (FDACS), Florida Fruit and Vegetable Association, federal regulatory agencies, citrus growers and commercial beekeepers have allowed plans to proceed for use of ACP tools while protecting the health of honeybees foraging in citrus groves during bloom. Florida's efforts here are serving as a model for this issue in other crops and in other agricultural states.

2. Non-chemical strategies for reducing ACP populations, including biological control with Tamarixia radiata and pathogens which can reduce ACP populations.

3 Disease progression and the role of nutrition in mitigating disease:
One of the earliest efforts in responding to HLB was determining how HLB disease progressed in infected trees of different ages, and how irrigation and nutrition might impact that progression. Grower trials and experiences informed that differences observed could be associated with macro and micro nutrient programs and supplements, and field research was conducted to better understand the extent to which therapy using irrigation and nutrition could affect disease symptoms, including decline and pre-harvest fruit drop.

4. Root System Impacts from HLB
CRDF-funded research has identified the significant impacts of early invasion of citrus root systems following *CLas* infection. This new knowledge is being expanded to determine how this varies among citrus varieties and how this can be off-set with cultural practices. The knowledge of this phenomenon has allowed researchers to begin field trials of treatments that will at the same time favor vigorous root growth and also will assist in reducing other citrus root stresses, due to soil fungi, insects and other stress conditions. Managing roots in a holistic manner will support the retention of tree health and productivity of HLB-infected trees, perhaps prolonging their productive lives.

5. Thermal Therapy to Slow/Reverse the Decline of HLB-Infected Trees

Research in recent years has identified that heat applied to citrus trees can impact bacterial levels. Researchers have characterized how solar energy can be captured in temporary tree enclosures to reduce *CLas* levels while not injuring the tree, and results are promising. Similarly, the addition of supplemental heat via steam or other sources offers the potential to more rapidly treat larger numbers of trees of greater size. Current efforts in the field are addressing scale-up of these methods to make them commercially available and economically viable. The Federal MAC funding has recently approved support for this scale-up effort, complementing current investments through CRDF.

6. Treatments to correct soil and irrigation water conditions unfavorable to citrus health

Research also has focused on the citrus tree's change in response to irrigation water and soil chemistry that is brought on with HLB infection. The acidity (pH) and dissolved solids in soil and irrigation water impacts citrus roots, and when these roots are compromised, tree health is impacted. Field trials testing various methods to adjust imbalanced chemistry in soil and irrigation water already are showing results, and this promises to provide another immediate tool for managing HLB.

7. Chemical Therapy to Slow/Reverse the Decline of HLB-Infected Trees

A wide range of antimicrobial candidates have been under investigation in recent years, in a search to develop methods to lower the bacterial populations in HLB-infected trees. This project area bridges from fundamental research projects to commercial delivery, and is increasingly moving to field trials of top performing candidates in different groups of chemistries. The details of material, dose, plant toxicity, application methods and timing, and regulatory considerations are proceeding simultaneously. Due to the importance of having tools to reverse the health of infected trees, therapy for infected trees has become a high priority for CRDF attention and investment.

8. Evaluation of Plant Growth Regulators for their Role in Preventing Pre-Harvest Fruit Drop

Since fall of 2013, a series of field trials have been conducted across Florida citrus groves to determine if timely treatments of one or more plant growth regulators can reduce the pre-harvest fruit drop impacting the industry. Cooperative trials with growers have evaluated the timing and rates of these PGRs, followed by evaluation of how much fruit drop was reduced. Several of these trials are continuing through the 2014 Valencia fruit harvest season. Limited benefit has been observed, and additional strategies are being evaluated. Results of ongoing trials will strengthen our understanding of this opportunity.

9. Deployment of Tolerant Rootstocks to Defend Against HLB

The citrus breeding programs of University of Florida and USDA, Agricultural Research Service (ARS) have yielded information on new rootstocks which appear to perform better than conventional rootstocks when infected with HLB. These rootstocks are not fully evaluated for all horticultural characteristics, but Florida citrus growers are willing to assume some risk in untested tools due to the

critical situation. With this in mind, UF and USDA have made early releases of some of the leading rootstocks, and CRDF has facilitated the translation of the best of class of these rootstocks into grower trials. Arrangements for propagation of sufficient numbers of orange trees on these rootstocks have been made, and the commercial-scale replicated trials of these rootstocks were planted in spring-summer 2015. The combination of encouraging early release of these rootstocks so that growers can purchase them, with the support of three commercial scale field trials in the three citrus growing regions of Florida will allow rapid adoption of those rootstocks that hold up under full field pressure.

10. Removal of HLB-Infected Citrus Groves

Elimination of ACP populations and pockets of *CLas* bacteria residing in citrus groves which are no longer being managed for production has emerged as a growing challenge. In plant diseases moved by vector insects, the persistence of such inoculum sources generally prevents economical production in adjacent managed plots. Such appears to be the case with citrus and HLB, and CRDF has amassed information supportive of efforts to reduce this risk. Based on this information, FDACS has begun a program to strategically remove economically abandoned citrus groves, demonstrating the biological impacts of removing these insect and disease reservoirs on adjacent groves. The CHMAs provide an ideal tool for planning, communication, and follow-up. It is the goal of this program to demonstrate the benefit of inoculum removal to citrus growers so that progressively, economically abandoned infected trees can be removed and replanted throughout the citrus industry. Removal of reservoirs of ACP and CLas will improve the performance of all other HLB management tools, reducing both disease and vector pressure from areas adjacent to commercial production.

11. Support for New Plantings and Model New Groves

Numerous projects are underway to integrate emerging information and tools into new citrus plantings so that growers regain the confidence the replant. Horticultural inputs, psyllid management and other aspects of establishing new groves are being integrated. In addition, information emerging from field research on HLB enabled the CRDF, in concert with industry groups, to work with USDA to receive approval of the Tree Assistance Program to cost-share the planting new trees in groves made uneconomical by HLB infection. Testing of advanced citrus production systems, including high density plantings, intensive irrigation/fertilization and growing citrus under containment have provided insights into how new groves should be planned and managed.

All of the near-term field activities were made possible with partial or total support from 2013-14 and 201-15 state legislative support. As the summary above indicates, there are continuing trials that require support in FY 2015-16. In addition, CRDF is analyzing results of 81 of our 130-project portfolio that will end by June 30, 2015, to determine the next steps in moving these results to field use. The delivery of results of these projects will be paramount in our priorities for funding in 2015-16. Those projects which can compete in the peer reviewed developmental grant programs funded by the Farm Bill are being encouraged in that direction, while CRDF is focused on transitioning real-time results to grower tools.

Integrating Investments in HLB and other Disease Research Important to Florida Citrus Growers

Almost one year has passed since the two federal funding sources were announced. Projects are now underway in both the USDA, National Institute of Food and Agriculture (NIFA), Specialty Crop Research Initiative (SCRI) and the USDA, APHIS Multi-Agency Coordinating Group (MAC) programs for citrus disease. At the same time, the Citrus Research and Development Foundation (CRDF) is adjusting its programs to focus grower resources on near-term solutions and to continue to deliver results as soon as they are available.

Table 6. Summary of relative funding available to address HLB and other citrus diseases.

HLB Research and Solutions Funding Programs 2014-15			
Source	**CRDF**	**USDA, NIFA Farm Bill**	**USDA, APHIS MAC**
Amount	$16-20 million per year	$25 million per year	$21 million over 2 years
Period of Funding	since 2008 (6 years	5 years	2 years
Programs	Peer-Reviewed Research Projects	Peer-Reviewed Competitive Grants	Direct Funding Projects
	Commercial Product Delivery		Stakeholder Suggestions
No. Projects	130 +/-	7	25

Table 7 below summarizes investments (total project costs in June, 2015) of CRDF's research and product delivery portfolios, organized by some of the major topics of intervention in managing HLB and other challenges. Along with the CRDF investment, latest commitments from the two federal programs have been inserted to show the complementarity of the efforts and the focus on these important management elements. While these numbers are not inclusive of all investments from the CRDF or the federal programs, they depict a significant portion of the investment at this time. CRDF and the federal programs are engaging in evaluation of new projects, and additional updates will highlight how this funding picture continues to change.

Table 7. Overview of funding committed to specific HLB strategies by CRDF and federal funding programs.

REDUCING DISEASE IN TREES	Research		Delivery		
	CRDF	NIFA	CRDF	MAC	Total
Bactericides	$ 1,155,142	$ 6,700,000	$ 1,753,245	$ 1,326,000	$ 10,934,387
Thermal Therapy		$ 3,500,000	$ 927,455	$ 1,266,000	$ 5,693,455
Inoculum Removal				$ 1,000,000	$ 1,000,000

8

PREVENTING SPREAD	Research		Delivery		
	CRDF	NIFA	CRDF	MAC	Total
ACP Movement	$ 814,674		$ 211,681		$ 1,026,355
ACP Management & CHMAs	$ 4,100,103	$ 4,500,000	$ 1,426,265	$ 2,998,000	$ 13,024,368
New Plantings Systems			$ 936,705	$ 615,000	$ 1,551,705
Tolerance in Rootstocks and Scions	$ 1,424,649		$ 4,916,042	$ 1,000,003	$ 7,340,694
Engineering Resistance	$ 3,550,894				$ 3,550,894

SUSTAINING TREE HEALTH	Research		Delivery		
	CRDF	NIFA	CRDF	MAC	Total
Nutrition			$ 407,500		$ 407,500
Soil/Water Conditions & Treatment	$ 477,576		$ 385,193	$ 173,000	$ 1,035,769
Compost, Microbe Products	$ 187,296		$ 782,078	$ 216,000	$ 1,185,374
Integrating Approaches to Health				$ 1,543,000	$ 1,543,000

FRUIT DROP AND FRUIT QUALITY	Research		Delivery		
	CRDF	NIFA	CRDF	MAC	Total
Influence of PGRs on Infected Trees	$ 470,849		$ 814,144		$ 1,284,993
Impact of HLB on Fruit Quality			$ 110,000		$ 110,000

Industry Research Coordination Committee

The By-Laws of CRDF define the purpose of the Industry Research Coordinating Committee and assign the Committee responsibility for recommending the research priorities for the Florida citrus industry to the Board that are outside the scope of work of the Research Management Committee. This committee will focus efforts on threats or opportunities for all elements of the industry that fall within its scope. This committee will perform a GAP analysis and, working with all elements of the Florida citrus industry, establish research priorities that fall within its scope.

Previous efforts to conduct analysis of ongoing research projects and compare those to industry needs were carried out by the Florida Citrus Industry Research Coordinating Council (FCIRCC). This committee annually conducted a gaps analysis and shared the results with the industry. In 2011, CRDF assumed the responsibilities previously associated with the FCIRCC, and a report representing the transitional efforts of IRCC to complete the analysis for 2011-12 was presented in August 2012. This report represents the 2013-14 efforts to update the priorities, research inventory and gaps analysis.
While plans for research and CPD activities are moving forward, the Industry Research Coordinating Council revisits the needs of the industry and compares those needs to direction of research and funding resources. Periodically the IRCC evaluates citrus-wide priorities and accumulates the inventory of research being conducted on citrus nation-wide. A gaps analysis then is conducted to identify gaps between what appear to be priorities and the depth of ongoing investment in each of the priorities. The committee completed this activity in summer, 2014 and a synopsis is provided here. This is the only effort that looks beyond the current need focus on HLB research to identify other needs that are affecting segments of the Florida industry. The full details of this exercise can be found at citrusrdf.org.

The Industry Research Coordinating Committee is responsible for recommending the research priorities for the Florida citrus industry to the Board that are outside the scope of work of the Research Management Committee. This committee will focus efforts on threats or opportunities for all elements of the industry that fall within its scope. This committee will perform an annual GAP analysis and, working with all elements of the Florida citrus industry, establish research priorities that fall within its scope.

The Industry Research Coordinating Committee (IRCC) of CRDF completed the process to look at broad research priorities for citrus which include nursery, production, harvesting, processing and fresh fruit needs. Assembly of the portfolio of projects that are being conducted across the U.S. has been completed, with each project being assigned to the list of revised priorities. These projects are inclusive of CRDF funded work but also represent funds from other sources, like the California Research Board, USDA-Agricultural Research Services, UF-Institute of Food and Agricultural Sciences and the Florida Department of Citrus. The IRCC then evaluated the ongoing work and identified gaps where the level of effort appears to be less than is needed to meet the priority. The outcome of this evaluation is a report

which identifies the important gaps in research for which attention needs to be directed. In some cases, the gap at present will remain unmet until HLB solutions have stabilized citrus production and resources can be re-directed to other needs.

This process, was conducted over a 4 month period, and culminated with presentation of the gaps report to the CRDF Board of Directors at the July 22, 2014 meeting. Not surprisingly, the highest ranking gaps are related to HLB, followed by plant improvement (also directed towards solutions to disease problems), citrus canker management, and priority to improve nursery adoption of new rootstocks and scions emerging from the breeding programs. This report is posted on the CRDF website citrusrdf.org, for use by interested parties.

Florida Citrus Research Priorities – Top Gaps and Proposed Actions, Completed July 2014

This section of the report reflects the final results and recommendations of the Industry Research Coordinating Committee and their efforts to accomplish the following for 2014:

- Organize citrus research priority input from all sectors of the industry
- Assemble an inventory of current research projects related to citrus (focus on Florida, but with information from Texas and California citrus efforts)
- Review priorities versus level of effort (inventory) and identify gaps
- Discuss each gap and characterize needed actions
- Assist in implementing the actions approved by the CRDF Board of Directors.

The following 12 gaps were identified. The list of major priorities and their sub-priorities (Appendix I) provides the context for the gaps identified, compared to other priorities identified that currently appear to be addressed adequately, according to the IRCC efforts. For each gap, there is reference to its placement in the overall priorities, summary of the discussion, and recommended action. Please refer to the CRDF webpage for full details and the report.

Gap #1: Priority A. Citrus HLB (Greening): Sub-element 1. HLB Research, with a strong emphasis on the need for an approved therapy for use on mature producing trees. The Committee was united in the belief that a mature tree therapy is the most important immediate industry need.

Gap #2: Priority A. Citrus HLB (Greening): Sub-element 2. Identify treatments to keep trees productive with high quality fruit.

Gap #3: Priority A. Citrus HLB (Greening): Sub-element 9. Develop HLB management strategies and evolve BMPs for greening.

Gap #4: Priority B. Plant Improvement / Citrus Genetics - Recurring funding to support plant improvement breeding programs is essential in preparing for a post- HLB world. Many of the varieties that we currently produce and pack are obsolete. Additionally, breeding programs are greatly enhancing the genetic diversity within available plant populations, allowing for valuable screening through natural

selection. Some of the most promising tolerant rootstocks and scion selections were created through support of conventional breeding programs.

Gap #5: Priority B. Plant Improvement / Citrus Genetics: Sub-element 4. How can growers get new rootstocks into the field quicker?

Gap #6: Priority D. Nursery
This is a new element of research prioritization, and has not yet received adequate consideration. The abilities and flexibility of Florida nurseries to supply the demand for new plantings and inter-sets is a challenge, and built-in lag times interfere with smooth supply/demand relationships.

Gap #7: Priority F. Citrus Production Systems: Sub-element 1. Fertilization/Irrigation - Incorporate nutritional/water requirements into management recommendations for "advanced production systems". Refine nutritional recommendations for rates, sources of materials, application (include variable rate technology); this should consider effects of soil pH, carbonates and nutrient uptakes. Develop cost reduction measures for irrigation and fertilization.

Gap #8: Priority G. Fruit Harvesting: Sub-element 2. Organize and coordinate harvesting research to link mechanization, economics, and horticultural aspects of harvesting. Evaluate efficiency of mechanical harvesting.

Gap #9: Priority K. Processing Technologies
Lack of personnel at research facilities has stalled any advances here, while the need for improved processing and identification of value-added streams continues to exist. Without research support and evaluation, the processing industry cannot evaluate and adopt new processing technologies, methods and opportunities.

Gap #10: Priority M. Fruit Quality/Decay Control
As with many research priority areas, post-harvest quality research has been sidelined in pursuit of solutions to HLB. At present, available materials are addressing the treatment of post-harvest fruit decay and disease issues. However, the list of approved materials is shrinking, leaving the fresh industry vulnerable to new diseases or loss of effective current materials.

Gap #11: Priority M. Fruit Quality/Decay Control: Sub-element 3. Anti-microbial Coatings: The goal is to obtain a natural additive for an existing commercial coating that will penetrate into wounds in the fruit peel and eliminate bacteria or other organisms that may cause decay.

Gap #12: Priority N. Lab Testing Methods: Many Florida citrus processing support and testing technologies have been used for decades, and many are antiquated compared to evolving technologies in other arenas. While assays and machinery have advanced in other industries, the ability to take advantage of these advances has declined as public institutional investment in post-harvest aspects of citrus has declined. The Gap identified in 2012 in this area recommended that processors individually or collectively attempt to bridge the adaptation and adoption gap and work directly with other processing industries and suppliers to find and validate replacement technologies, primarily relating to testing. However, scientists and engineers at Universities, federal labs and at FDOC formerly played a significant

role in developing, validating, and delivering new processing test procedures, methods, and equipment. The Expertise is being lost.

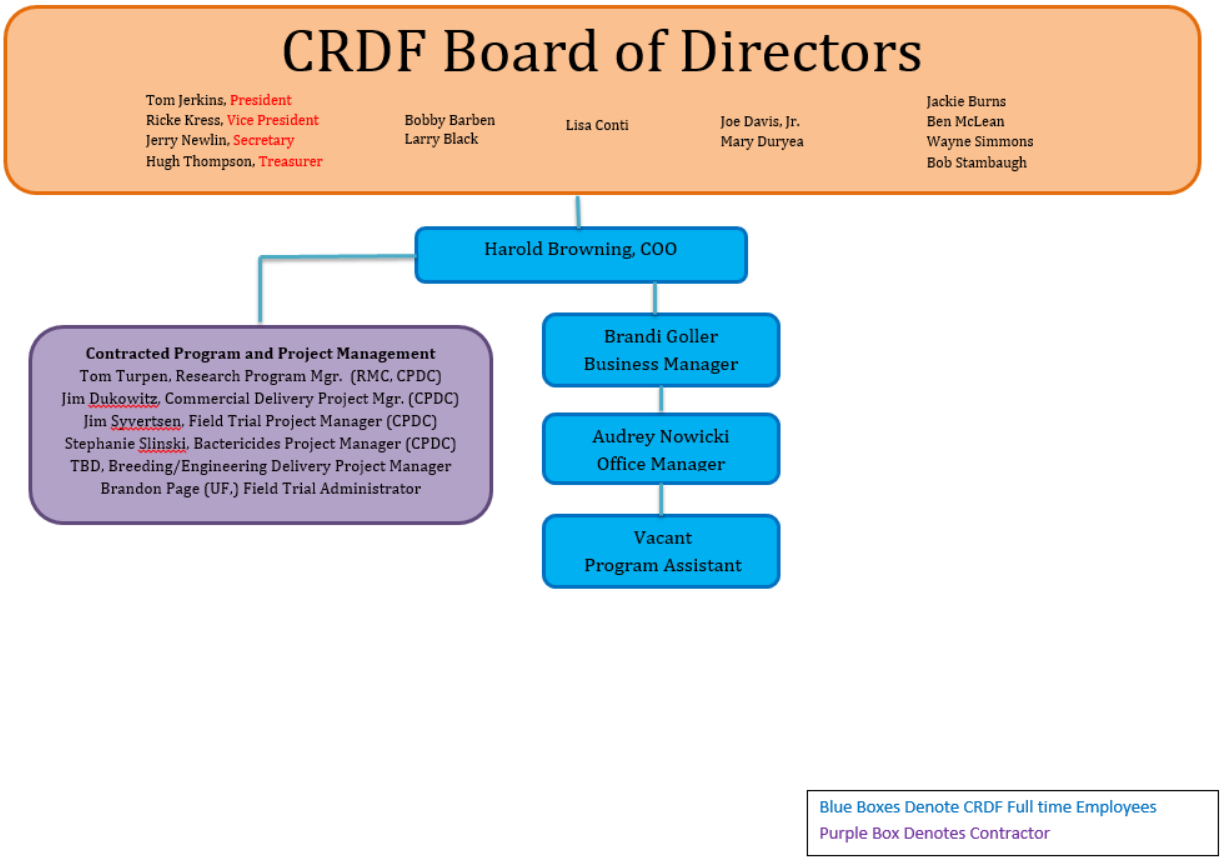
CRDF Operations

This section identifies the structure of CRDF staff and contracted program and project management. The positions and individuals identified in Figure 9 (page 61) provide support to committees and the Board, as well as conducting daily operations of the Foundation. Contracting, accounting and financial reporting area among the operational functions performed by this group, as well as reporting to sponsors and managing reporting from projects that are funded to committees, Board and to the citrus industry at large. As the scope of CRDF activities and the complexities of funding has expanded in recent years, the staff and contractor needs has likewise increased. CRDF is attempting to balance this additional work load with the desire to invest as much of available funding directly in the projects dedicated to developing and delivering solutions.

The establishment of this Foundation within the State of Florida, University of Florida as a Direct Service Organization (DSO) has led to significant resources of UF being committed to the effort, including provision of space, utilities and communication, and access to Human Resources, UF General Counsel, Accounting Software and other critical functions at little or no cost to CRDF. In addition, liaison with the University of Florida Foundation facilitates the management of donor contributions to the programs and goals of CRDF.

Significant cost-savings to the industry have been realized through this partnership, and UF is to be acknowledged for their strong support of the industry's efforts.

Figure 9. CRDF Staff Organizational Chart and Project Support



Research Project Management

Specific plans and needs for research program management were identified in the original business plans, and this has expanded to support a broader portfolio, to assess research conducted by other organizations and other funding sources, and as the CRDF has expanded to the delivery of solutions. Since CRDF was formed, CRDF has contracted with Technology Innovations Group (TIG) for research program management, and with awarding of the USDA, NIFA, SCRI nuPsyllid grant program in 2012, TIG was contracted to provide project direction to this five-year, $9.5 million dollar contracted project with USDA.

CPDC Project Management

As CPD projects have grown and the topics have expanded, CRDF has recruited project management expertise from a diversity of sources, assigning topical areas to each and developing topic work plans

and estimates for management annually. In this way, appropriate expertise can be applied as needed and the process can expand and contract as needs arise.

Table 8 below describes the plans and budget for project management for CPD topics for FY 2014-15. Note that time estimates allow for flexibility of planning and accountability for time. During early 2014-15, CRDF realized the need for more project management effort in the pursuit of bactericidal therapy for HLB-infected trees. CRDF implemented plans for a full-time Florida-based project manager to provide daily operational oversight and management of the antimicrobial strategies and projects in support of HLB treatments. Dr. Stephanie Slinski joined CRDF as a contract Project Manager in September 2014 and provides the primary lead for bactericidal research, formulation, field trials, and coordination of communication in this important topical area. Dr. Slinski has a strong background in plant pathology and is well-suited for this technical area.

Table 8. CRDF Program Management for Commercial Product Delivery Topics, FY 2014-15

		Commercial Product Delivery Management				
		Description		**FY 2014-15 Est. Hours/Month**	**FY 2014-15 Budget Est. Expense**	**FY2014-15 Budget Travel**
Tier 1: Active Projects						
		Therapy for Existing Trees				
	1	Antimicrobial Strategies	TIG	73	144,540	7,200
	2	Naturally Occurring Microbial Products	J. Syvertsen	10	19,200	3,000
	3	Thermal Therapy	H. Browning	10		1,200
	4	Plant growth regulator interactions with HLB	J. Syvertsen	20	38,400	400
	5	Strategic Inoculum Removal to Manage HLB in Florida	H Browning	2		400
	6	Case Analysis of Success in Responding to HLB	H. Browning	9		1,200
		New Plantings				
	7	Asian Citrus Psyllid Management	H. Browning	25		6,000
	8	Tolerant rootstock plantings	J. Syvertsen	20	38,400	2,400
	9	Psyllid Shield – Delivering RNAi with CTV Vector	TIG - T. Turpen	8	15,840	3000
	10	Integrating HLB Management tools into Model New Groves	H. Browning	10		2500
	11	Candidate HLB Tolerant Scion Evaluation in Field Trials	H. Browning	6		250
Tier 2: Facilitate and Monitor Projects						
	12	(MCTF): Deploying Canker-Resistance Genes	TIG	3	5,940	
	13	Diaprepes pheromone	TIG - J. Dukowitz	7	13,860	
	14	Citrus Leafminer area-wide mating disruption	H. Browning	2		
Tier 3: Information Projects						
	15	CTV vector	TIG	2	3,960	
	16	HLB Escapes	H. Browning	2		
Subtotals		Product Delivery Mgmt - TIG		93	$ 184,140	10,200
		Product Delivery Mgmt - Jim Syvertsen		50	96,000	5,800
		Product Delivery Mgmt - Harold Browning		66		11,550
		Totals		209	**$ 280,140**	**$ 27,550**

Contracting for Management, Communication and Website Support

The list of contracts below provide an overview of the contracted support for CRDF, including program and project management as described above, provision of regulatory expertise to projects advancing to levels where regulatory consideration occurs, and contracts to support communication and other functions of CRDF.

1. Research and Product Delivery Program Management –
   Contractor: Technology Innovations Group

2. Commercial Product Delivery Project Management – Renewal of option agreement
   Contractor: Dr. James Syvertsen

3. IT and Website Support
   Contractor: Ecostat – Contact: Dr. Steve Rogers

4. WEB Support and Progress Report System Development
   Contractor: University of Florida, Information Technology

5. Regulatory Interactions – FFVA:
   Contractor: Florida Fruit and Vegetable Association – Contact Mike Stuart

6. Regulatory Interactions TPR: MOA under FFVA contract:
   Contractor: Third Party Registrations – Contact: Dan Botts

7. Communications: *Citrus Industry* Magazine:
   Contractor: *Citrus Industry* Magazine and Southeast Agnet

8. Communication: CRDF newsletter:
   Contractor: Florida Citrus Mutual

9. Education: Florida Citrus Mutual Annual Grower Meeting and Educational Seminar:
   Contractor: Florida Citrus Mutual

10. Education: Southeast Ag-Net Citrus Expo Educational Seminar Sponsorship
    Contractor: Southeast Agnet

11. Education: Publication of Citrus Research Papers Presented at Annual FSHS Meeting
    Contractor: Florida State Horticultural Society

CRDF Communication with Clients

The Mission of CRDF is to advance disease and production research and product development activities to ensure the survival and competitiveness of Florida citrus growers through innovation.

Role of communication: An integral part of this mission is to communicate activities and results of research and prospective solutions to growers, grower organizations and other interested parties. Regular communication of CRDF activities also is vital to inform and encourage those who provide funding support for CRDF programs as well as statutory requirements for financial and other business reporting.

The first presentation of a CRDF communication plan occurred in February 2010, when an overview was provided to the Florida Department of Citrus and the CRDF organizers. That presentation highlighted the importance of communication regarding HLB research progress in a challenging environment where information is plentiful and one can become inundated with duplicated communication. Thus, the efforts by CRDF to communicate directly and to encourage those conducting research and development projects related to HLB and other citrus diseases seek to optimize the flow of progress through existing channels, and where necessary, to create new opportunities. Since CRDF officially began, the collective board, committee members, staff, and contractors have held as important the need to keep citrus stakeholders informed.

The 2009 CRDF Business Plan broadens the charge, stating that "the Foundation will endeavor to report on the research projects funded by grants outside those funded by the Foundation so that the industry has a complete overview of the research efforts directed at solving the greening problem". This has been incorporated into our communication plan, and has been further enabled through the integration of the Florida Citrus Industry Research Coordination Committee functions into CRDF in 2011. Thus, our communication plan has broad reach, and among our activities, sponsoring the International HLB Conference brings information from worldwide research into focus.

Goal of CRDF communication: The most important purpose for communication external to CRDF is to inform citrus growers and other sectors of the citrus industry of progress in providing solutions to HLB, citrus canker and other citrus diseases. Therefore, events and activities which offer opportunities for reporting to the industry are of greatest interest and will be targeted by CRDF internal communication activities. A critical complement to this effort is to encourage all board members, committee members and the scientists conducting the sponsored research to regularly communicate regarding the programs and accomplishments, and to acknowledge the role of CRDF in linking industry with the research community who will be delivering the solutions.

The communication goals of CRDF are met through planned and opportunistic activities and events, conducted specifically for communication or as a component of broader activities. A significant commitment of operating budget is committed to communication to meet the goals

CRDF Involvement in Grower Education and Outreach Activities

Communication is vital in this era of HLB impact. CRDF is attempting to use all avenues to reach growers with updates on the programs and progress related to HLB and other priorities, like citrus canker. Monthly magazine columns provide updates, and grower meetings are major opportunities for work funded by CRDF to be reported. These meeting occur across the annual calendar and several are coming up in the next few weeks/months that offer updates on a number of topics

Bonita Springs Citrus Grower Annual Meeting, hosted by Florida Citrus Mutual. The Grower Education Session on Thursday morning, June 18 will provide updates focused on both maintenance of mature trees infected with HLB and several presentations focused on new plantings and available tools to get young trees into production. As usual, this will be a mix of researcher and grower updates.

Ag EXPO, hosted by Southeast AgNet. This two-day event in August at the Lee Civic Center in Fort Myers offers a broad program with updates on many topics related to HLB. Interspersed with time slots to visit the Trade Show, the Ag Expo is another important venue for communication of HLB news. The UF, IFAS Extension Team does an outstanding job at their demonstration booth at the Ag EXPO, providing materials, information and tools for diagnosis and treatment of citrus pests and diseases.

Regional Grower Meetings, which occur regularly through the year, are yet another mechanism for information dissemination. Whether organized around a regional citrus grower association, or planned by the IFAS Extension Team, these meeting provide the forum for results presentation and discussion, and with a mix of field days and seminars, provide current information on topics of importance across the state.

Grower meetings around the state provide timely update on a range of tools that are being implemented in Florida groves, including the following:

- Many growers are including newly released rootstocks from the USDA and UF, IFAS breeding programs in their new plantings. These rootstocks have shown advantage over conventional rootstocks in the presence of HLB and need broader evaluation in grower hands.
- Irrigation and fertilization programs make a difference, and there are a wide range of programs that growers are implementing specific to their site, soils, and tree health situations. While we don't fully understand the cause/effect with various nutritional and irrigation programs, field evidence indicates that aggressive cultural practices are slowing decline of infected trees.
- Advances in understanding the interaction of HLB with citrus root systems have enabled growers to apply specific management to improve or sustain root health, including altering pH,

adjusting for high bicarbonates, treatment for complicating root issues like *Phytophthora* and *Diaprepes*, and considering application of mulches, soil microbes and other treatments.

- With help from federal funding, thermal therapy is being scaled up and a number of companies have built and are testing steam application methods to reduce HLB disease and restore tree health.
- Asian citrus psyllid (ACP) management continues to be important, and there is a great opportunity to make it better through more cooperative, large-scale ACP management programs as well as increased understanding of specific tactics and how they affect ACP populations. The Florida Department of Agriculture and Consumer Services is rearing and releasing ACP parasitoids in areas where pesticide treatments are not being applied in an effort to dampen the populations of ACP in these refuges.
- Growers who are resetting trees or replanting groves have a range of strategies that can be applied to increase the odds of growing trees to maturity with limited HLB infection. In combination with planting incentive programs, many growers are removing least productive groves and replanting while incorporating aggressive management strategies.
- CRDF continues to fund research targeting these practices as well as other tools which are not yet available. Field trials of bactericides continue to make progress, while additional efforts to identify and field test a wide range of other HLB management tools continue.

International Research Conference on HLB – Grower Day

A meeting for growers was held on Thursday March 12, 2015 from 9:00am to 12:00pm at the UF-IFAS Citrus Research and Education Center, Lake Alfred, FL to present salient points conveyed at the IRCHLB III conference. The grower day was separated from the date of the conference to allow summaries of various topics to be extracted from the wealth of information presented. It was organized to address issues most important to growers and other industry representatives. The complexity of HLB and the elements that interact to create the disease scenario experienced by Florida growers makes it difficult to extract the practical elements from the larger body of work that is ongoing. The Grower Day presentations were built around the following questions.

- What tools are available or emerging to support planting of new trees or groves in Florida?
- What are the tools available for transition of young citrus trees to mature, producing trees (4-7 years)?
- What programs and solutions are emerging and available for minimizing the impacts of HLB on mature, producing trees?
- Are there additional areas of research that will lead to new tools in the short-medium timeframe?
- What are we learning from research outside of Florida that will help in developing and delivering solutions to HLB in Florida?

The presentations at grower day were assisted with additional request of those submitting presentations and posters to the HLB Conference. Each applicant was required to provide a non-technical summary to be included as a slide in their presentation or a summary panel on their poster. This facilitated the organization of the grower day topics.

Those presenting at Grower Day offered an overview of the questions listed above, having focused on a pre-sorted set of HLB Conference presentations that addressed their topic. Thus, the speakers and their teams gathered perspective throughout the conference on a subset of the overall presentations, and had several weeks to distill their thinking.

CRDF acknowledges the outstanding work of all involved in the planning and execution of this event, and for taking the additional step to improve upon the grower summarization process from previous conferences. We particularly thank the Organizing Committee and Florida Citrus Mutual for their significant efforts to make these meetings a success.

CRDF Web Resources

From the beginning, CRDF has relied heavily on our website (citrusrdf.org) to communicate information to the citrus industry and public, as well as to distribute information of importance to committees and the Board. It has also served as an important interface with the research community who responds to requests for proposals and the posting of proposal forms and instructions. A sampling of information that can be found by browsing the CRDF website includes:

- *Approved minutes of Committee and Board Meetings*
- *List of currently active funded projects supported by CRDF*
- *Quarterly Progress Reports for all research projects, including the USDA, SCRI nuPsyllid Research Project*
- *An overview of each CRDF committee and board with current members*
- *A "Solutions" interface for submission of ideas on how to manage HLB*
- *Announcements for upcoming meetings*

APPENDIX A

CRDF Research Projects Funded as of July 1, 2015

Project No#	Principal Investigator	Project Title	Contract Total	Start Date	End Date
502	Hall, David	High-Throughput Screening of Transgenic Citrus for HLB Resistance.	$ 190,200	6/1/2012	7/31/2015
547	Grosser, Jude	Applying Advances of Juvenile Citrus Transformation Technology	$ 478,852	4/1/2012	7/31/2015
548	Grosser, Jude	Understanding and Manipulating the Interaction of Complex Rootstock Genetics and Constant Nutrition to Enhance the Establishment, Longevity and Profitability of New Citrus Plantings in HLB-Endemic Areas.	$ 327,319	4/1/2012	7/31/2015
723	Gabriel, Dean	Exploiting the Las phage for potential control of HLB: year 2.	$ 308,701	5/1/2013	7/31/2015
773	Wang, Nian	Control HLB by developing antimicrobial compounds against Candidatus Liberibacter asiaticus	$ 276,965	8/1/2013	7/31/2015
606	Stover, Ed	Production of Transgenic Commercial Scion Cultivars Resistant to HLB and Canker: Continued AMP Approaches and Novel Transgenic Strategies	$ 480,753	8/15/2012	8/14/2015
533	Foliomonova, Svetlana	Deployment of a superinfecting Citrus tristeza virus-based vector in the field: a measure to effectively protect field citrus trees against HLB	$ 399,252	6/1/2012	8/31/2015
582	Pelz-Stelinski, Kirsten	Factors influencing transmission of the huanglongbing (greening) pathogen by the Asian citrus psyllid and methods for interrupting the transmission process	$ 577,703	5/1/2012	8/31/2015
503	England, Gary	The support of Citrus Research and Extension efforts by maintaining and improving the Mid Florida Citrus Foundation grove	$ 237,500	10/1/2012	9/30/2015
544	Graham, Jim	Improved management of citrus canker through use of systemic acquired resistance and more bioavailable copper bactericides	$ 285,750	10/1/2012	9/30/2015
766	Stelinski, Lukasz	Biotic and abiotic factors that cause Asian citrus psyllids to accept hosts: potential implications for young plantings and pathogen transmission.	$ 145,039	4/1/2013	9/30/2015
816	Etxeberria, Ed	Identification of potential pathways for the spread of HLB through citrus vascular systems: Supplement	$ 20,252	4/1/2014	9/30/2015
769	Triplett, Eric	A team approach to culturing Ca. Liberibacter asiaticus.	$ 448,257	4/16/2013	10/15/2015

CRDF Research Projects Funded as of July 1, 2015

Project No#	Principal Investigator	Project Title	Contract Total	Start Date	End Date
531	Falk, Bryce	Transgenic RNAi-based psyllid control	$ 418,092	11/1/2012	10/31/2015
539	Gmitter, Fred	Creation, Development, and Screening of Citrus Germplasm for Resistance to HLB and Citrus Canker (Core Breeding)	$ 1,584,585	11/1/2012	10/31/2015
615	Gmitter, Fred	Evaluation of Rootstocks Appropriate for Higher Density Groves and Advanced Citrus Production Systems Leading to a Sustainable, Profitable Florida Citrus Industry	$ 160,247	11/1/2012	10/31/2015
818	Etxeberria, Ed	Determining the contents of citrus phloem sap and its directional movement throughout the year	$ 39,460	5/1/2014	10/31/2015
919	Dewdney, Megan	A method to monitor for Guignardia citricarpa (Gc) ascospores in Florida groves.	$ 42,650	5/1/2014	10/31/2015
907	Johnson, Evan	Zinkicide: A novel therapeutic zinc particulate based formulation for preventing citrus canker and HLB.	$ 203,744	6/1/2014	11/30/2015
607	Stover, Ed	A secure site for testing transgenic and conventional citrus for HLB and psyllid resistance	$ 249,219	1/1/2013	12/31/2015
516	Dawson, Bill	Develop citrus resistant or tolerant to HLB using the CTV vector and transgenic approaches	$ 1,239,174	8/1/2012	1/31/2016
447	Stansly, Phil	Role of Nutritional and Insecticidal Treatments in Mitigation of HLB in New Citrus Plantings	$ 324,430	2/15/2012	2/14/2016
732	Graham, Jim	Understanding and reducing early root loss in HLB affected trees	$ 359,931	4/1/2013	3/30/2016
716	Dewdney, Megan	Improved fungicide control measures for pre- and post-harvest management of citrus black spot	$ 289,300	4/1/2013	3/31/2016
731	Graham, Jim	Calcium carbonate may reduce root health and exacerbate HLB expression	$ 198,214	4/1/2013	3/31/2016
736	Gruber, Barrett	Expedited Indian River Evaluation of Tetrazyg Rootstocks Surviving the HLB-Gauntlet	$ 96,538	4/1/2013	3/31/2016
750	Ma, Wenbo	Identification of key components in HLB using effectors as probes	$ 299,781	4/1/2013	3/31/2016
759	Santra, Swadeshmukul	Fixed-Quat: A novel alternative to Cu fungicide/bactericide for preventing citrus canker	$ 260,050	4/1/2013	3/31/2016

CRDF Research Projects Funded as of July 1, 2015

Project No#	Principal Investigator	Project Title	Contract Total	Start Date	End Date
767	Triplett, Eric	Rapid identification of antibiotics useful in the control of citrus greening disease	$ 406,637	4/1/2013	3/31/2016
805	Long, Sharon	Functional genomics of Liberibacter in a model system	$ 540,197	4/1/2014	3/31/2016
834	Duan, Yongping	Optimizing Heat Treatment in the Fields and Understanding the Molecular Mechanism Behind the Success of Thermotherapy for the Control of Citrus HLB	$ 385,900	4/1/2014	3/31/2016
711	Bonning, Bryony	Identification of Bacillus thuringiensis endo-toxins active against Adult Asian Citrus Psyllid	$ 500,000	5/1/2013	4/30/2016
715	Dewdney, Megan	The leaf litter cycle of citrus black spot and improvements to current management practices	$ 577,352	5/1/2013	4/30/2016
717	Duan, Yongping	Control Citrus HLB by Blocking the Function of two Critical Effectors Encoded by Candidatus Liberibacter asiaticus	$ 410,000	5/1/2013	4/30/2016
724	Gmitter, Fred	Accelerating Citrus Gene Discovery for HLB Tolerance/Resistance	$ 399,500	5/1/2013	4/30/2016
726	Gonzalez, Carlos	A Bacterial Virus Based Method for Biocontrol of Citrus Canker	$ 468,016	5/1/2013	4/30/2016
726L	Gonzalez, Carlos	A Bacterial Virus Based Method for Biocontrol of Liberibacter	$ 386,902	5/1/2013	4/30/2016
730	Graham, Jim	Monitoring streptomycin resistance in Xanthomonas citri in support of FireWall registration for canker	$ 141,129	5/1/2013	4/30/2016
749	Li, Yi	Development of Technologies Important for Creation and Commercialization of Transgenic HLB Resistant Citrus	$ 229,683	5/1/2013	4/30/2016
752	Moore, Gloria	Cell Penetrating Peptides for Citrus Genetic Improvement and Disease Resistance	$ 136,251	5/1/2013	4/30/2016
754	Mou, Zhonglin	Application of a natural inducer of systemic acquired resistance and engineering non-host resistance in citrus for controlling citrus canker	$ 366,032	5/1/2013	4/30/2016
853	LaPointe, Stephen	Why is Poncirus trifoliata resistant to colonization by Asian citrus psyllid?	$ 187,681	5/1/2014	4/30/2016
15-008	Etxeberria, Ed	Determination of CLas signal in HLB-affected citrus trees	$ 53,572	7/1/2015	6/30/2016

CRDF Research Projects Funded as of July 1, 2015

Project No#	Principal Investigator	Project Title	Contract Total	Start Date	End Date
925	Dutt, Manjul	Diaprepes control using a plant based insecticidal transgene approach	$ 80,000	7/1/2014	6/30/2016
873	Lee, Richard	Application of new technologies to expedite cleaning of new accessions for use in Florida	$ 180,000	9/1/2014	8/31/2016
921	Schneider, William L.	Determining the role of a novel virus in Citrus blight.	$ 400,000	10/1/2014	9/30/2016
809	Albrigo, Gene	Citrus preharvest drop related to HLB disease-Nature and control	$ 240,000	4/1/2014	3/31/2017
850	Albrigo, Gene	Scheduling ACP spring spray selection based on the Citrus Flowering Model	$ 90,000	4/1/2014	3/31/2017
858	Santra, Swadeshmukul	New non-phytotoxic composite polymer film barrier as ACP repellent for controlling HLB infection	$ 350,000	4/1/2014	3/31/2017
910	Powell, Chuck	An integrated approach for establishment of new citrus plantings faced with the HLB threat	$ 369,714	4/1/2014	3/31/2017
922	Wang, Nian	Control citrus canker by manipulating the EBE (effector binding element) of CsLOB1 which is the citrus susceptibility gene for citrus canker disease	$ 436,045	4/1/2014	3/31/2017
803	Duan, Yongping	Characterization and manipulation of the prophages/phages of 'Candidatus Liberibacter asiaticus' for the control of citrus huanglongbing	$ 574,219	5/1/2014	4/30/2017
838	Morgan, Kelly	Effect of selected concentrations of calcium bicarbonate on expression of HLB in the greenhouse and grove	$ 349,491	5/1/2014	4/30/2017
899	Etxeberria, Ed	Strigolactones type growth regulators to combat HLB in Florida	$ 347,426	5/1/2014	4/30/2017
15-017	Killiny, Nabil	Disrupt LuxR solo quorum sensing that mediates plant virulence and insect transmission of Candidatus Liberibacter asiaticus to control the disease	$ 157,144	7/1/2015	6/30/2017
903	Gruber, Barrett	Establishing citrus nutrition trials for young & mature trees in the Indian River Region to promote plant growth, mitigate HLB, decrease fruit drop, and improve postharvest fruit storage properties	$ 360,000	7/1/2014	6/30/2017
916	Wang, Nian	Screening and application of antibacterial producing microbes to control citrus Huanglongbing	$ 431,180	7/1/2014	6/30/2017

CRDF Research Projects Funded as of July 1, 2015

Project No#	Principal Investigator	Project Title	Contract Total	Start Date	End Date
15-009	Gabriel, Dean	Exploiting the Las phage for potential control of HLB	$ 419,500	8/1/2015	7/31/2017
15-024	Stelinski, Lukasz	Predicting When, Why, and Where Asian citrus psyllids move to increase effectiveness of insecticide sprays.	$ 161,116	8/1/2015	7/31/2017
15-021	Pelz-Stelinski, Kirsten	Regulation of Las transmission and microbial colonization by the Asian citrus psyllid immune system	$ 185,732	9/1/2015	8/31/2017
780nu	Shatters, Bob	Rear and Release Psyllids as Biological Control Agents - An Economical and Feasible Mid-Term Solution for Huanglongbing (HLB) disease.	$ 1,264,097	9/1/2012	8/31/2017
781nu	Falk, Bryce	Rear and Release Psyllids as Biological Control Agents - An Economical and Feasible Mid-Term Solution for Huanglongbing (HLB) disease.	$ 1,504,880	9/1/2012	8/31/2017
782nu	Hartung, John	Rear and Release Psyllids as Biological Control Agents - An Economical and Feasible Mid-Term Solution for Huanglongbing (HLB) disease.	$ 174,900	9/1/2012	8/31/2017
783nu	Bartels, David	Rear and Release Psyllids as Biological Control Agents - An Economical and Feasible Mid-Term Solution for Huanglongbing (HLB) disease.	$ 347,534	9/1/2012	8/31/2017
784nu	Brown, Judy	Rear and Release Psyllids as Biological Control Agents - An Economical and Feasible Mid-Term Solution for Huanglongbing (HLB) disease.	$ 720,767	9/1/2012	8/31/2017
785nu	Grafton-Cardwell, Elizabeth	Rear and Release Psyllids as Biological Control Agents - An Economical and Feasible Mid-Term Solution for Huanglongbing (HLB) disease.	$ 487,481	9/1/2012	8/31/2017
786nu	Polek, MaryLou	Rear and Release Psyllids as Biological Control Agents - An Economical and Feasible Mid-Term Solution for Huanglongbing (HLB) disease.	$ 40,000	9/1/2012	8/31/2017
787nu	Galindo, Celestina	Rear and Release Psyllids as Biological Control Agents - An Economical and Feasible Mid-Term Solution for Huanglongbing (HLB) disease.	$ 450,494	9/1/2012	8/31/2017
788nu	Hay, Bruce	Rear and Release Psyllids as Biological Control Agents - An Economical and Feasible Mid-Term Solution for Huanglongbing (HLB) disease.	$ 1,221,682	9/1/2012	8/31/2017

CRDF Research Projects Funded as of July 1, 2015

Project No#	Principal Investigator	Project Title	Contract Total	Start Date	End Date
789nu	Rohrig, Eric	Rear and Release Psyllids as Biological Control Agents - An Economical and Feasible Mid-Term Solution for Huanglongbing (HLB) disease.	$ 230,274	9/1/2012	8/31/2017
790nu	Coop, Leonard	Rear and Release Psyllids as Biological Control Agents - An Economical and Feasible Mid-Term Solution for Huanglongbing (HLB) disease.	$ 85,829	9/1/2012	8/31/2017
791nu	Setamou, Mamoudou	Rear and Release Psyllids as Biological Control Agents - An Economical and Feasible Mid-Term Solution for Huanglongbing (HLB) disease.	$ 225,477	9/1/2012	8/31/2017
792nu	Giulianotti, Marcelo	Rear and Release Psyllids as Biological Control Agents - An Economical and Feasible Mid-Term Solution for Huanglongbing (HLB) disease.	$ 294,873	9/1/2012	8/31/2017
793nu	Gang, David	Rear and Release Psyllids as Biological Control Agents - An Economical and Feasible Mid-Term Solution for Huanglongbing (HLB) disease.	$ 322,491	9/1/2012	8/31/2017
794nu	Pelz-Stelinski, Kirsten	Rear and Release Psyllids as Biological Control Agents - An Economical and Feasible Mid-Term Solution for Huanglongbing (HLB) disease.	$ 957,223	9/1/2012	8/31/2017
795nu	Turpen, Tom	Rear and Release Psyllids as Biological Control Agents - An Economical and Feasible Mid-Term Solution for Huanglongbing (HLB) disease.	$ 360,000	9/1/2012	8/31/2017
796nu	White, James	Rear and Release Psyllids as Biological Control Agents - An Economical and Feasible Mid-Term Solution for Huanglongbing (HLB) disease.	$ 50,000	9/1/2012	8/31/2017
797nu	Browning, Harold	Rear and Release Psyllids as Biological Control Agents - An Economical and Feasible Mid-Term Solution for Huanglongbing (HLB) disease.	$ 75,000	9/1/2012	8/31/2017
798nu	Browning, Harold	Rear and Release Psyllids as Biological Control Agents - An Economical and Feasible Mid-Term Solution for Huanglongbing (HLB) disease.	$ 2,000	9/1/2012	8/31/2017
799nu	Browning, Harold	Rear and Release Psyllids as Biological Control Agents - An Economical and Feasible Mid-Term Solution for Huanglongbing (HLB) disease.	$ 20,000	9/1/2012	8/31/2017

CRDF Research Projects Funded as of July 1, 2015

Project No#	Principal Investigator	Project Title	Contract Total	Start Date	End Date
800nu	Browning, Harold	Rear and Release Psyllids as Biological Control Agents - An Economical and Feasible Mid-Term Solution for Huanglongbing (HLB) disease.	$ 30,000	9/1/2012	8/31/2017
801nu	Browning, Harold	Rear and Release Psyllids as Biological Control Agents - An Economical and Feasible Mid-Term Solution for Huanglongbing (HLB) disease.	$ 135,000	9/1/2012	8/31/2017
15-027	Triplett, Eric	Developing a culture medium for Liberibacter asiaticus through comparative multi 'omics analysis with its closest cultured relative, L. crescens	$ 325,912	10/16/2015	10/15/2017
15-002	Bowman, Kimberly	Development of Supersour and Other Promising Rootstocks for Florida	$ 959,860	7/1/2015	6/30/2018
15-003	Bowman, Kimberly	Metabolomic profiling to accelerate development of HLB tolerant rootstocks	$ 539,104	7/1/2015	6/30/2018
15-005	Dewdney, Megan	Asexual inoculum production of Guignardia citricarpa, the causal agent of citrus black spot	$ 255,227	7/1/2015	6/30/2018
15-010	Gmitter, Fred	Development and Commercialization of Improved New Disease Resistant Scions and Rootstocks - the Key For a Sustainable and Profitable Florida Citrus Industry	$ 1,797,148	7/1/2015	6/30/2018
15-020	Mou, Zhonglin	Create citrus varieties resistant to Huanglongbing (HLB) through transgenic and nontransgenic approaches	$ 112,688	7/1/2015	6/30/2018
15-022	Reuber, T. Lynne	Engineering citrus for canker resistance	$ 367,598	7/1/2015	6/30/2018
15-023	Schumann, Arnold	Citrus nutrition studies for improved survival of HLB-affected trees	$ 281,804	7/1/2015	6/30/2018
15-028	Wang, Nian	Control citrus Huanglongbing (HLB) by counteracting the SA hydroxylase of Candidatus Liberibacter asiaticus	$ 430,697	7/1/2015	6/30/2018
15-042	Wang, Nian	Control citrus Huanglongbing using endophytic microbes from survivor trees	$ 467,000	7/1/2015	6/30/2018
15-013	Grosser, Jude	Understanding and Manipulating the Interaction of Rootstocks and Constant Nutrition to Enhance the Establishment, Longevity and Profitability of Citrus Plantings in HLB-Endemic Areas.	$ 126,019	8/1/2015	7/31/2018

CRDF Research Projects Funded as of July 1, 2015

Project No#	Principal Investigator	Project Title	Contract Total	Start Date	End Date
15-026	Stover, Ed	Implementing Transgenic Tools to Produce Commercial Scion Cultivars Resistant to HLB and Canker	$ 540,758	8/15/2015	8/14/2018
15-025	Stover, Ed	HLB Resistance and Tolerance in Citrus Scion Breeding	$ 441,935	10/1/2015	9/30/2018

APPENDIX B

CRDF Commercial Product Delivery Projects Funded as of July 1, 2015

Project No#	Principal Investigator	Project Title	Contract Total	Start Date	End Date
931C	Gonzalez, Claudio	In Vitro testing of chemicals on tree leaves collected from HLB-infected trees to determine their efficacy against HLB	$ 203,918	2/1/2014	7/31/2015
618C	Dawson, Bill	RNAi InnoCentive Project Extension (Phase II): In planta Characterization of dsRNA Effect on all Psyllid Life Stages and Selection of Target(s) to Advance to Commercialization.	$ 487,383	4/1/2013	9/30/2015
780C	Wang, Nian	Evaluation of Soil-Based Antimicrobials as Control Agents against HLB.	$ 176,000	5/1/2013	10/31/2015
929.2C	Rucks, Phil	Field Trial of HLB Tolerant RootstockPRCN Contract #2659 deposit on orange trees paid March 2014; delivery in Spring 2015. Trees are tagged, inspection by appointment only.	$ 124,740	3/25/2014	10/31/2015
776C	Albrigo, Gene	Frequent Low Rate Application of 2-4,D and Cytokinin to study plant symptom reduction in HLB affected trees	$ 132,660	1/1/2014	12/31/2015
945C	Gonzalez, Claudio	RSA - Rapid Evaluation method to evaluate drug's effectiveness directly from tree samples	$ 101,959	4/1/2015	12/31/2015
926.1C	LaPointe, Stephen	Sub on Large-scale mating disruption of citrus leafminer validation and product launch	$ 80,000	2/1/2014	1/31/2016
926.2C	Stelinski, Lukasz	Sub on Large-scale mating disruption of citrus leafminer validation and product launch	$ 20,000	2/1/2014	1/31/2016
926.3C	Urrutia, William	Large-scale mating disruption of citrus leafminer validation and product launch	$ 113,333	2/1/2014	1/31/2016
941C	Pelz-Stelinski, Kirsten	Influence of Thermal Therapy on Transmission of Candidatus Liberibacter asiaticus	$ 105,782	2/1/2015	1/31/2016
944C	Pelz-Stelinski, Kirsten	RSA - Small plant assay for testing the efficacy of antimicrobial materials against HLB	$ 125,797	3/1/2015	1/31/2016
943C	Rogers, Michael	Support for scale-up of Thermal Therapy Treatment: Evaluation before and after thermotherapy heat treatments to combat HLB	$ 82,456	3/1/2015	2/28/2016
946C	Nufarm	Mycoshield Magnitude of Residue Study for Citrus Crop Group.	$ 291,370	3/12/2015	3/11/2016

CRDF Commercial Product Delivery Projects Funded as of July 1, 2015

Project No#	Principal Investigator	Project Title	Contract Total	Start Date	End Date
15-046C	Curtis, John	Evaluation of GRAS/biopesticide products as a protectant and therapy for HLB on Valencia oranges.	$ 24,304	4/1/2015	3/31/2016
932.1C	Keesling, James	Mathematical Modeling to evaluate Psyllid Shield Concept	$ 113,523	6/1/2014	5/31/2016
934.1C	Wang, Nian	Soil Drenches of products to combat initial HLB infection in young citrus trees	$ 11,028	6/1/2014	5/31/2016
934C	Curtis, John	Soil Drenches of products to combat initial HLB infection in young citrus trees	$ 15,000	6/1/2014	5/31/2016
15-031C	Etxeberria, Ed	Development of a laser-based system to deliver antimicrobials to citrus trees: Greenhouse testing	$ 197,585	7/1/2015	6/30/2016
15-040C	Triplett, Eric	Rapid turn-around evaluation of up to 1200 promising antimicrobial compounds (or combinations), using the L.crescens assay	$ 26,040	7/1/2015	6/30/2016
15-043C	Wang, Nian	Rapid turn-around evaluation of up to 25 antimicrobial compounds for efficacy in reducing titers of the bacterium Candidatus Liberibacter on diseased 6-year old trees Hamlin on Swingle.	$ 55,000	7/1/2015	6/30/2016
15-045C	Zale, Janice	Continued Funding for the Mature Citrus Facility to Produce Disease Tolerant, Transgenic Citrus	$ 317,963	7/1/2015	6/30/2016
928.1C	Sutherland, Dudley	Field Trial of Naturally Occuring Microbes	$ 100,788	4/11/2014	3/31/2017
928.2C	Booker, Brad	Field Trials of Soil Microbials to combat HLB - Ridge Site crop Consultant	$ 81,146	4/1/2014	3/31/2017
928.3C	Yonce, Henry	Field Trials of Soil Microbials to combat HLB - Southwest FL Site crop Consultant	$ 187,296	4/1/2014	3/31/2017
928.4C	Wang, Nian	Field Trials of Naturally occuring microbes to combat HLB	$ 99,156	4/1/2014	3/31/2017
15-030C	Rogers, Michael	Continuing Field Trial Support for CRDF CPDC	$ 322,129	7/1/2015	6/30/2017
15-032C	Irey, Mike	Continued Support for the Southern Gardens Diagnostic Laboratory	$ 291,799	7/1/2015	6/30/2017
15-034C	Roberts, Pam	Continuation of diagnostic service for growers for detection of Huanglongbing in citrus and psyllids to aid in management decisions	$ 287,688	7/1/2015	6/30/2017
15-035C	Rogers, Michael	Continuing support of Citrus Health Management Areas	$ 115,017	7/1/2015	6/30/2017

CRDF Commercial Product Delivery Projects Funded as of July 1, 2015

Project No#	Principal Investigator	Project Title	Contract Total	Start Date	End Date
15-037C	Santra, Swadeshmukul	T-SOL™ antimicrobial for the management of citrus canker and HLB	$ 240,224	7/1/2015	6/30/2017
15-038C	Stelinski, Lukasz	Insecticide resistance monitoring and management in Florida citrus to maintain sustainable control of Asian citrus psyllid within Citrus Health Management Areas	$ 129,491	7/1/2015	6/30/2017
940C	Beeson, Richard C.	Propagation of Rootstock Tree Production in Greenhouses by Seed, Stem Cuttings and Tissue Culture to Accelerate Budded Tree Production for Outplanting	$ 333,774	10/1/2014	9/30/2017
15-033C	Orbovic, Vladimir	Support role of the Citrus Core Transformation Facility remains crucial for research leading to production of Citrus plants that may be tolerant or resistant to diseases.	$ 270,000	7/1/2015	6/30/2018
15-036C	Rogers, Michael	Correlating pesticide residue analysis with psyllid feeding to improve protection of young trees	$ 451,603	7/1/2015	6/30/2018
15-016C	Hall, David	High-Throughput Inoculation of Transgenic Citrus for HLB Resistance	$ 375,000	8/1/2015	7/31/2018
15-039C	Stover, Ed	Secure site for testing transgenic and conventional citrus for HLB and psyllid resistance	$ 260,980	1/1/2016	12/31/2018

APPENDIX C

CRDF FY 2014-15 BUDGET PROJECTIONS - APPROVED BY CRDF BoD 6/12/14

Category	Budget Item	FY 2013-2014 REVISED BUDGET	FY 2014-2015 APPROVED BUDGET	FY 2014-2015 BUDGET CHANGES	Comments
	Cash Carry Forward	$ 6,035,668	$ 5,528,708	$ 5,848,948	
	Revenue				
	FDACS - Box Tax - Research, CPD, Operations	$ 4,777,000	**$ 3,301,000**	**$ 3,301,000**	
	State Legis. Support 2013-14			$ 756,470	final billing
	State Legis. Support (FDACS)	8,000,000	3,500,000	3,500,000	
	State SCBlock Grant	270,017	145,107	145,107	
	USDA SCRI NIFA Grant	1,966,000	2,031,760	1,566,238	
	USDA MAC Project Funds	-	-	1,132,794	
	CRB-Co-funded Agrmt.	300,703	293,662	293,662	
	Donations	66,667	566,667	566,667	
	External Funds Subtotal	**$ 10,603,387**	**$ 6,537,196**	**$ 7,960,938**	
	FDOC - Previous FY Carry-in A/R	$ 500,000	$ 200,000	$ 200,000	
	FDOC Research Support Curent Year	2,500,000	2,500,000	2,500,000	
	FDOC Research Support Carry-out A/R	(500,000)	(200,000)	(200,000)	
	FDOC Subtotal	**$ 2,500,000**	**$ 2,500,000**	**$ 2,500,000**	
	Interest Income	$ 40,000	**$ 35,000**	**$ 35,000**	
	Total Revenue	**$ 17,920,387**	**$ 12,373,196**	**$ 13,796,938**	
	Expenses - Current Allocated Projections				
	Administrative Costs				
	Staff Salaries/Benefits	$ 323,000	$ 415,605	$ 415,605	
	NIFA Staff Salaries/Benefits	15,000	15,000	15,000	
	Audit/Legal/Banking	20,000	45,000	45,000	Additional $20,000-legal counsel
	Staff Travel	15,000	15,000	15,000	
	Financial Fees	3,000	15,500	15,500	
	Office Equipment & Supplies	15,000	18,000	18,000	
	NIFA Supplies	4,000	4,000	4,000	
	Web, Email & Data Support	73,000	82,300	82,300	Ecostat estimate updated
	Subtotal Administrative Operations	**$ 468,000**	**$ 610,405**	**$ 610,405**	
	Research Projects				
	Project CATP A/P Carry-in	$ 850,000	$ 400,000	$ 400,000	
	Project Current Year Projections	11,550,644	10,492,366	10,492,366	
	CATP New Project Estimates	500,000			
	Project Enhancements Committed	1,990,946			
	Project CATP A/P carry-out	(850,000)	(400,000)	(400,000)	
	USDA, NIFA Project Subcontracts	1,836,000	1,904,760	1,904,760	
	Subtotal	**$ 15,877,590**	**$ 12,397,126**	**$ 12,397,126**	
	Research Delivery Projects (CPD)				
	Research Delivery Projects	$ 883,973	$ 1,254,160	$ 1,254,160	
	Research Delivery Project Enhancements 2013-1	1,689,201	-	-	
	New Research Delivery Projects 2014-15	-	2,900,000	2,900,000	Additional $1 M new projects in FY 2014-15
	Subtotal	**$ 2,573,174**	**$ 4,154,160**	**$ 4,154,160**	
	Subtotal Research & Delivery	**$ 18,450,764**	**$ 16,551,286**	**$ 16,551,286**	
	Research Operations				
	Research Management	$ 115,500	$ 75,000	$ 75,000	
	NIFA Project Management	72,000	72,000	72,000	
	Research Review Travel	42,000	45,000	45,000	
	NIFA Travel	9,000	6,000	6,000	
	NIFA Advisory Committee	30,000	30,000	30,000	
	Reviewer Reimbursement	30,000	30,000	30,000	
	Research Workshops	15,000	25,000	25,000	
	Subtotal	**$ 313,500**	**$ 283,000**	**$ 283,000**	
	Research Delivery Operations (CPD)				
	Research Delivery Management	$ 115,000	$ 387,880	$ 387,880	Adjusted for Project Management
	Research Delivery Travel	20,000	32,550	32,550	
	Research Delivery Workshops	25,000	25,000	25,000	
	CRDF Newsletters, Columns	34,000	34,000	34,000	
	Education Sponsorship	20,000	20,000	20,000	
	Research Open House	20,000	-	-	
	Subtotal	**$ 234,000**	**$ 499,430**	**$ 499,430**	
	Subtotal Research & Delivery Operations	**$ 547,500**	**$ 782,430**	**$ 782,430**	
	International HLB Conference	-	$ 100,000	$ 100,000	
	Subtotal Research/Delivery Expense	**$ 18,998,264**	**$ 17,433,716**	**$ 17,433,716**	
	Total Budget Expense	**$ 19,466,264**	**$ 18,044,121**	**$ 18,044,121**	
	Estimated Ending Cash Balance	**$ 4,489,791**	**$ (142,217)**	**$ 1,601,765**	*10/2/14 12:00 AM*

REVENUE

OPERATING EXPENSES

RESEARCH & DELIVERY EXPENSES

APPENDIX D

CRDF FY 2015-16 Budget Projections - Approved by BoD 6-18-2015

Category	Budget Item	FY 2014-2015 Approved Budget	FY 2015-2016 Budget (Draft)	Comments
	Cash Carry Forward	$ 5,528,708	$ 1,357,833	Ending Cash Balance @ 6/30/2015
	Revenue			(estimated amounts in brown)
REVENUE	FDACS - Box Tax - Research, CPD, Operations	$ 3,301,000	**$ 2,970,000**	110 million boxes x $.03 x 90%
REVENUE	State Legis. Support (FDACS)	3,500,000	**8,000,000**	
REVENUE	State SCBlock Grant	145,107	-	
REVENUE	USDA SCRI NIFA Grant	2,031,760	2,914,662	
REVENUE	USDA MAC Project Funds	1,500,000	1,284,421	
REVENUE	CRB-Co-funded Agrmt.	293,662	71,663	
REVENUE	Donations	566,667	566,667	
REVENUE	**External Funds Subtotal**	**$ 11,338,196**	**$ 15,807,413**	
REVENUE				
REVENUE	FDOC - Previous FY Carry-in A/R	$ 200,000	$ -	
REVENUE	FDOC Research Support Curent Year	2,500,000	-	
REVENUE	FDOC Research Support Carry-out A/R	(200,000)	-	
REVENUE	**FDOC Subtotal**	**$ 2,500,000**	**$ -**	
REVENUE	Interest Income	$ 35,000	**$ 10,000**	
REVENUE	**Total Revenue**	**$ 13,873,196**	**$ 15,817,413**	
OPERATING EXPENSES	**Expenses - Current Allocated Projections**			
OPERATING EXPENSES	**Administrative Costs**			
OPERATING EXPENSES	Staff Salaries/Benefits	$ 415,605	$ 690,153	
OPERATING EXPENSES	NIFA Staff Salaries/Benefits	15,000	17,500	
OPERATING EXPENSES	Audit/Legal/Banking	45,000	30,000	
OPERATING EXPENSES	Staff Travel	15,000	7,000	
OPERATING EXPENSES	Financial Fees	15,500	15,500	
OPERATING EXPENSES	Office Equipment & Supplies	18,000	15,800	
OPERATING EXPENSES	NIFA Supplies	4,000	7,616	
OPERATING EXPENSES	Web, Email & Data Support	82,300	60,300	
OPERATING EXPENSES	**Subtotal Administrative Operations**	**$ 610,405**	**$ 843,870**	
RESEARCH & DELIVERY EXPENSES	**Research Projects**			
RESEARCH & DELIVERY EXPENSES	Project CATP A/P Carry-in	$ 400,000	$ 400,000	
RESEARCH & DELIVERY EXPENSES	Project Current Year Projections	10,492,366	4,989,188	
RESEARCH & DELIVERY EXPENSES	CATP New Project Estimates	-	3,240,640	
RESEARCH & DELIVERY EXPENSES	Project CATP A/P carry-out	(400,000)	(400,000)	
RESEARCH & DELIVERY EXPENSES	USDA, NIFA Project Subcontracts	1,904,760	2,722,733	
RESEARCH & DELIVERY EXPENSES	**Subtotal**	**$ 12,397,126**	**$ 10,952,561**	
RESEARCH & DELIVERY EXPENSES				
RESEARCH & DELIVERY EXPENSES	**Research Delivery Projects (CPD)**			
RESEARCH & DELIVERY EXPENSES	Research Delivery Projects	$ 1,254,160	$ 561,102	
RESEARCH & DELIVERY EXPENSES	New Research Delivery Projects 2014-15	2,900,000	3,019,112	
RESEARCH & DELIVERY EXPENSES	**Subtotal**	**$ 4,154,160**	**$ 3,580,214**	
RESEARCH & DELIVERY EXPENSES				
RESEARCH & DELIVERY EXPENSES	**Subtotal Research & Delivery**	**$ 16,551,286**	**$ 14,532,775**	
RESEARCH & DELIVERY EXPENSES	**Research Operations**			
RESEARCH & DELIVERY EXPENSES	Research Management	$ 75,000	$ 75,000	
RESEARCH & DELIVERY EXPENSES	NIFA Project Management	72,000	84,000	
RESEARCH & DELIVERY EXPENSES	Research Review Travel	45,000	20,000	
RESEARCH & DELIVERY EXPENSES	NIFA Travel	6,000	12,964	
RESEARCH & DELIVERY EXPENSES	NIFA Advisory Committee	30,000	68,849	
RESEARCH & DELIVERY EXPENSES	NIFA Training	-	1,000	
RESEARCH & DELIVERY EXPENSES	Reviewer Reimbursement	30,000	30,000	
RESEARCH & DELIVERY EXPENSES	Research Workshops	25,000	25,000	
RESEARCH & DELIVERY EXPENSES	**Subtotal**	**$ 283,000**	**$ 316,813**	
RESEARCH & DELIVERY EXPENSES				
RESEARCH & DELIVERY EXPENSES	**Research Delivery Operations (CPD)**			
RESEARCH & DELIVERY EXPENSES	Research Delivery Management	$ 387,880	$ 321,740	
RESEARCH & DELIVERY EXPENSES	Research Delivery Travel	32,500	40,650	
RESEARCH & DELIVERY EXPENSES	Research Delivery Workshops	25,000	20,000	
RESEARCH & DELIVERY EXPENSES	CRDF Newsletters, Columns	34,000	41,000	
RESEARCH & DELIVERY EXPENSES	Education Sponsorship	20,000	20,000	
RESEARCH & DELIVERY EXPENSES	Research Open House	-	-	
RESEARCH & DELIVERY EXPENSES	**Subtotal**	**$ 499,380**	**$ 443,390**	
RESEARCH & DELIVERY EXPENSES				
RESEARCH & DELIVERY EXPENSES	**Subtotal Research & Delivery Operations**	**$ 782,380**	**$ 760,203**	
RESEARCH & DELIVERY EXPENSES	**International HLB Conference**	**100,000**	$ -	
RESEARCH & DELIVERY EXPENSES	**Subtotal Research/Delivery Expense**	**$ 17,433,666**	**$ 15,292,977**	
	Total Budget Expense	**$ 18,044,071**	**$ 16,136,847**	
	Estimated Ending Cash Balance	**$ 1,357,833**	**$ 1,038,399**	*2015-06-15 BRG*

APPENDIX E

CITRUS RESEARCH AND DEVELOPMENT FOUNDATION, INC.

STATEMENTS OF FINANCIAL POSITION

JUNE 30, 2014 AND 2013

ASSETS	2014	2013
Cash	$ 1,193,096	$ 1,903,546
Funds deposited in state spending account	35,861	3,258
Accounts receivable	487,500	-
Investments	4,140,343	4,126,032
Contract payments receivable	1,840,650	295,695
Total assets	$ 7,697,450	$ 6,328,531
LIABILITIES AND NET ASSETS		
Liabilities		
Accounts payable	$ 4,440,682	$ 3,318,074
Unexpended contract funds	1,242,228	2,671,375
Total liabilities	5,682,910	5,989,449
Net Assets		
Unrestricted net assets	2,014,540	339,082
Total liabilities and net assets	$ 7,697,450	$ 6,328,531

The accompanying notes to financial statements should be read in conjunction with this statement.

CITRUS RESEARCH AND DEVELOPMENT FOUNDATION, INC.

STATEMENTS OF ACTIVITIES

YEARS ENDED JUNE 30, 2014 AND 2013

	2014	2013
Revenue and Support		
Research contract funding:		
Special State Legislature Appropriation	$ 7,668,302	$ 2,000,000
Florida Department of Agriculture and Consumer Services	5,183,672	4,164,498
Florida Department of Citrus	2,525,475	4,626,907
U.S. Department of Agriculture	1,492,071	377,066
California Research Board	284,015	52,447
Donations	500,000	-
Investment earnings	52,921	9,860
Total revenue and support	17,706,456	11,230,778
Expenses and Supporting Services		
Research project contracts	11,984,185	11,421,024
Research delivery contracts	3,121,931	1,092,198
Administrative support	924,882	993,551
Total expenses and supporting services	16,030,998	13,506,773
Increase (decrease) in net assets	1,675,458	(2,275,995)
Net assets - beginning of year	339,082	2,615,077
Net assets - end of year	$ 2,014,540	$ 339,082

The accompanying notes to financial statements should be read in conjunction with this statement.

CITRUS RESEARCH AND DEVELOPMENT FOUNDATION, INC.

STATEMENTS OF CASH FLOWS

YEARS ENDED JUNE 30, 2014 AND 2013

	2014	2013
Operating Activities		
Increase (decrease) in net assets	$ 1,675,458	$ (2,275,995)
Adjustments to reconcile increase (decrease) in net assets to net cash provided (used) by operating activities:		
Reinvested earnings in bank account	(37,055)	(26,058)
Unrealized (gain) loss on investments	(15,866)	38,197
(Increase) decrease in:		
State spending account	(32,603)	2,781
Accounts receivable	(487,500)	2,681,393
Contract payments receivable	(1,544,955)	681,587
Accrued investment earnings	-	252
Increase (decrease) in:		
Unexpended contract funds	(1,429,147)	(1,121,604)
Accounts payable	1,122,608	217,086
Total adjustments	(2,424,518)	2,473,634
Net cash provided (used) by operating activities	(749,060)	197,639
Investing Activities		
Proceeds from sale of investments	400,000	-
Purchase of investments plus reinvested earnings	(361,390)	(3,015,705)
Net cash provided (used) by investing activities	38,610	(3,015,705)
Net decrease in cash	(710,450)	(2,818,066)
Cash, beginning of year	1,903,546	4,721,612
Cash, end of year	$ 1,193,096	$ 1,903,546

The accompanying notes to financial statements should be read in conjunction with this statement.