7. FIELD STUDY INVESTIGATION SUMMARY

> The plural of anecdote is not data

Roger Brinner

> Also on hand was Mark Fagan, the public information officer. He tried to explain, "This tree may not look sick to you, but in a few months, it will start losing its canopy and fruit won't mature any more," Fagan said sternly. "And the disease will spread another 1900 feet to other trees."
>
> "That's bullshit," fumes Maria.

Anatomy of a Quarantine, Miami New Times, Kirk Nielsen, July 6, 2000.

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1. The Detailed Investigation

The online appendices of this book present a thorough investigation of the 1998 citrus canker field study. This chapter summarizes the conclusions reached in these appendices. There were six separate analyses of the collected data. For each analysis, a brief summary of the analysis performed and the validity of results are provided in this chapter. A list of the appendices is provided at the end of this chapter.

The summaries on the analyses perform may be too brief for many readers. Hopefully the summaries will entice readers to examine the full review presented in the appendices. Often, authors relegate material of lesser importance to the appendices, so the flow of the narrative can continue without an overload of technical details. However, in this case, although the investigation is technical in nature, it is not of lesser importance. In fact, it is essential to this chapter.

Every effort was made to evaluate the study on a "bottoms up" approach. This involved examining the data collection and study sites, prior to a review of the methods and results used in the study. Ideally, a bottoms up approach would begin with examining the study plan, any changes to these plans, survey forms, GPS meters training, instructions to inspectors, their training prior to inspections, their background and all computer software used in the study. However, none of this information has been made public.

The primary article on the field study was published in Phytopathology by Gottwald et al in April 2002.[8] For convenience, this document is referred to as the "2002 article." An initial summary of results was published in 2001 as a Letter to the Editor in Phytopathology by Gottwald et al.[7] Other documents released by the Florida Department of Agriculture and Consumer Services as a result of legal action in November 2000 were also useful. These documents include reports from the Citrus Canker Risk Assessment Meeting in May 1999[3], the interim report of the field study, as received by the Department in October 1999, and copies of the viewgraphs of a presentation made by Dr. Gottwald in Broward Court[6] in November 2000. These documents are provided on the website.

The study's objectives were identified in Commissioner Crawford's press release in February 1998.[1] The Commissioner asked scientists to track the movement of the citrus canker disease in three specified sites for one year, and meet every month to discuss the results. The study was to coincide with the moratorium on healthy tree cutting in Miami-Dade County.

2. What the Researchers/Department Would Like Residents to Believe

The Department wanted residents to believe good science lead to the 1900-ft policy. A second message was that the Department was guided only by the best researchers. Finally, the 1900-ft radius was portrayed as distance less than the maximum distance citrus canker could spread during a storm, but was still sufficient to eradicate the disease. For both public relations and legal purposes, the Department wanted to make it clear that it was exercising restraint when it implemented the 1900-ft rule.

This is a short summary of findings as shown below was taken principally from the published 2002 article on the study.[8] However, other statements of findings, including Dr. Gottwald's testimony in November 2000 in Broward Court[6], and abstracts of presentations made at American Phytopathological Society meetings were also considered.

- **Distance Necessary to Capture (DNC) Method:** The "distances of spread" helped regulators in an adjustment of the eradication radii. An average "distance of spread" is not provided in the 2002 article, but there is a general statement that 1900-ft is within the range of values of distances necessary to circumscribe in the first four periods of the 2002 published article.

- **Weather Analysis:** Citrus canker lesions are at the maximum visibility, on the average, 107 days following a rain storm with wind.

- **Inter-point distance analysis (IPD):** When all possible distances are considered, the maximum inter-tree distances ranges from 914 m (2,999 ft) to 4754 m (15,597 ft), for all study sites.

- **Quadrat Analysis and Mapping:** Using an index from random quadrat sampling, the development of citrus canker as it develops was shown in a "real" time sequence. Contour maps show development of new foci, followed by infilling.

- S**patial point pattern analyses**: These analysis provided further evidence of long distances of spread are possible.
- **Semivariance analyses:** Changes in the range attribute (RSTD) indicate rapid increases in disease development in both the spatial and temporal scales.

The Department's short summary of the epidemiology research changed as the eradication program progressed as documented in Short Note 6.3.

Peer Review Science

On numerous occasions, the Department has suggested, that residents should consider the 1900-ft rule as proper because it was based on peer reviewed science. The two articles on the field study, one published in January 2001 as a Letter to the Editor[7], and the second article published in April 2002[8], were peer review by the American Phytopathological Society (APS), which is a well respected international society focused on new research in all aspects of plant diseases. Their website is www.apsnet.org. It is noted that the April 2002 article provided details on the field study including methodology, data collection, results and conclusions as required by the APS.

Neither of the two articles on the field study were published prior to the implementation of the 1900-ft rule. The only document available for review was the October 13, 1999 interim report, which the Department has not publically distributed, except as evidence in the Broward Court in November 2000.

The issue of peer review only seems relevant because the Fourth District Court of Appeals accepted the idea of the Department that the 1900-ft policy was, in some manner, a scientific result based on the publication of the April 2002 article. The process used by the APS to select articles suitable for publication through the peer review, is discussed in Short Note 5.3. Peer review does not mean the reviewers or Editor-in-Chief accept the results, but that the article satisfies certain criteria for submission. In fact, at times publication allows others to publish a rebuttal to the articles, identifying the problems with studies.

3. Real and Synthetic Chronology

The real chronology is the record of when a tree was discovered with citrus canker. Each discovered infected tree has a second date associated with it, called the initial infection dates or IID according to the 2002 published article.[8] These are calculated dates, obtained from the discovery date minus the age of the oldest lesion on the infected tree. These dates are used to calculate the "synthetic chronology" of events. The raw data, which would include the discovered date, age of the oldest lesion and initial infection date for each infected tree has never been released by the USDA/ARS.

In a presentation in Broward Court in year 2000, Dr. Gottwald presented a selection of lesion ages ranging from 4 to 10 months.[6] Since the lesion age is shows considerable variations, the synthetic chronology may have little in common with the "as discovered" or the real chronology.

All results are presented in the published paper according to synthetic chronology. This makes it impossible to know the state of the site was prior to the study or what was discovered as infected trees during the study. For example, it is unknown the number of discovered infected trees in February 1998, when Commission Crawford first announced the study, nor in December 1998, when Dr. Gottwald presumably made a presentation of results at the USDA office in Orlando. The number of infected trees at the end of the study is known, but the date on which surveys ended is unknown.

The use of the synthetic chronology appears to be unique to the Florida field study, at least in the published technical literature. After a considerable literature search, no other article could be located, which used this approach.

4. Inspections and Study Sites, Appendix A

What was done

The details of the surveys of residential properties as described in the primary article on the study[8] in conjunction with other public documents are presented in this appendix. There were three sites in Miami-Dade County and two sites in Broward County in the 2002 published article.

The study required multiple entry onto properties to identify healthy and infected citrus trees. The inspections identified the citrus trees and whether they were infected with citrus canker or healthy. In addition, the age of the oldest lesion on the tree in terms of days, had to be identified, as this is necessary information for the "Distance Necessary to Circumscribe (DNC) Procedure." Parcels would be inspected approximately 60 days.[8] Earlier presentations of the study indicate that monthly inspections of all properties were made.[3] It is presumed that on subsequent visits to a lot, the same information would be recorded.

The published article[8] provides no information on inspections of residential lots outside the boundaries of the study sites. FDACS website summary of the epidemiology study indicates the area outside of the sites were free of infected trees at the onset of the study.

It is noted the Department held a series of public hearings in 2001, as required as part of passage of new eradication rules. None of the scientists involved in the Florida field study (Drs. Gottwald, Graham, Sun, Riley, Ferrandino, and Hughes) were in attendance at any of these hearings.

Did the surveys provide reliable data?

The same problems which plagued the eradication program, likely existed during the field study. These problems include difficulties in accessing backyards, identification of citrus canker particularly in the early stages of development and full inspection of back yard areas, particularly in the summer which in well known for afternoon downpours. Visits to all sites indicated Site D1 (Carol City) was most likely to have inspection problems, as it is an economically depressed area. The most common deterrents against break-ins were chain link fences and guard dogs.

The Commissioner's press release in February 1998 was very short and lacking critical details, such as the relationship between the field study and protocol changes. The press release stated nothing about the effectiveness of the current 125-ft policy nor a need to enlarge the eradication circles. According to the press release, the choice of the study sites would be subject to the approval of the USDA. Beyond this, the press release did not specifically state which organizations would be involved in the study.

As previously stated, the principal investigator of the study, Dr. Gottwald, testified in Broward Court in November 2000, that the 1900-ft policy was not agreed upon based on the results of any report.[6] In year 2000, public relations officials with the Department, were explaining the 1900-ft rule was based on a large field study with 19,000 citrus trees, led by Dr. Gottwald.

Basic information on the field study, including time of inspections, study site locations, survey sheet entries and how conflicting data were reconciled, was either missing, inconsistent or contradictory. For example, it is unknown when inspections began and ended in each of the sites. The Broward sites were added some time after the start of the inspections in Miami-Dade County, but it is unknown when this occurred. The only date known is, February 26, 1998, when Commissioner Crawford announced the field study.

Without this information on the start and end dates, it is unknown how many visits to yards were made in each site. Likely, there would be times when a visit would be incomplete, either due to access problems or weather events. Return visits to yards were never discussed. How could inspectors know they had been inspecting the same trees? The inaccuracy of the GPS meters (+/- 25 ft) was well documented, and likely inadequate for determining tree locations with a back yard. It is assumed that the determination of the oldest lesion age was done at the time of inspection or shortly afterwards.

If the inspectors did not have the prior inspection sheets, they may have inspected the lesion ages on the same tree twice. But, if there were blemishes on the foliage, it may have simply dropped off. Or the oldest lesions may have been on the very top leaves, as new leaves are the most susceptible to canker, but the most difficult to see. Owners may also simply trim off infected leaves. Obviously, if they thought the Department was going to destroy their tree if they found evidence of canker, so owners would be motivated to "clean up" the tree.

The conflicting information regarding the study site locations is reviewed in detail in Appendix A. It was necessary to examine documents from presentations and published articles, in this reviewed. Many discrepancies in the site boundaries are noted.

5. Distance Necessary to Circumscribe (DNC) Method, Appendices B and B1

What was done

This is a short summary of the DNC method. It is thoroughly described with examples in Appendix B. It was first described in the 2002 article.[8] No prior application is cited in the references. There appears no similar application of this method in Phytopathology, at least to year 2016. Selected results have been provided in several documents including a Letter to the Editor of Phytopathology[7] in 2001 as discussed in Appendix B. without a formal description.

The DNC method is a theoretical means of determining a set of distances, which the authors refer to as "distances of spread" or "distances necessary to circumscribe or capture." Each infected tree is associated with another infected tree, deemed the tree responsible for the infection. The DNC method is consistent with a "parent-offspring" model, where every offspring is matched with a parent. At some point, the offspring becomes a parent, capable of infecting more trees. For this review, parent and offspring trees are referred to as prior infected (PI) and newly infected (NI) trees, respectively.

The field study article[8] refers to PI and NI trees as focal or alpha trees, and secondary infected trees, as given in the article in tables 1 to 5, columns 4 and 5. The steps, as given below, relate only to trees infected to citrus canker.

1. IID Calculation Step: The IID of each tree is calculated as IID = discovery date - age of the oldest lesion.

2. Time Period Parsing Step: Each infected tree is assigned time period based on its IID as a new infected (NI) tree. This creates twenty-four 30-day time periods, each with a discrete number of infected trees.

3. Near Neighbor Association Step: For a particular time period, all trees in the prior time periods are PI trees. Any infected tree with an IID less than the start date of the first period is a PI tree or potential parent for infected trees in first time period. The method chooses the nearest PI tree to each of the NI trees as the responsible PI for the infection and calculates the inter-tree distance for each NI trees. The number of distances must equal the number of NI trees within the time period.

According to this step, two infected trees may be next to each other, but if they are in the same 30 day holding period, one tree can not be responsible for passing the disease to the other tree. There are other cases shown with longer holding periods (60, 90, 120 days), with different rules, as explained in more detail in Appendix B.

4**. Statistical analyses:** The prior step results in a set of distances for each site, equal to the number of discovered infected trees. The method of calculation of the 95th longest distance is not discussed in the 2002 published article[8], but is assumed to be based on percentile estimation.

From examination of five other presentations of results prior to 2002, it was concluded in Appendix B1 that the DNC method was not applied in a consistent manner, as some of the distances would exceed the maximum distances within the study sites. It was concluded that these distances were calculated by associating infected trees from within the study site with infected trees far beyond the study site boundaries. In the next time period, trees outside the site would not be used further in distance calculation. Thus, this alternative means of associating trees is termed "Use them and lose them" method in Appendix B1.

Are the DNC method and results valid?

The most cited results of the DNC method, are the "distances necessary to circumscribe" with a 95% probability with the 30-day temporal windows, as presented in the primary published article. These distances ranges from 0 to 11,608 ft, when based on the results from all study sites and all time periods.

The central problem with the DNC method is that it requires accurate identification the age of all lesions on a citrus tree, to determine the age of the oldest lesion. An error as small as one day in the oldest lesion age can result in the incorrect assignment of a tree to a temporal period. It is shown that an error of 10 days in estimation of oldest lesion age will result in an 18% probability that a tree will be assigned to the incorrect temporal period. The size of the lesion in these 10 days would increase by 0.30 mm, assuming an approximate 0.10 mm/month as given by Schubert, et al, in the 2001 article. All lesions can not be identified in a citrus tree, and the oldest ones are likely to be high in the canopy. Uniform expansion does not occur, as over time, the yellow and brown halos can diminish or even disappear, and citrus canker can resemble citrus scab, a fungal disease.[12] In Argentina, most misidentification occurs when only older lesions are present.[13]

Further problems with the distance calculations are discussed in Appendix B1. In this appendix, unusual long distances from 1999 to 2001 presentations were investigated. These distance results would not fit within the sites. It was further discovered that the April 2002 published article also used infected trees located outside of the study sites. This was evident in a 2014 published article by Neri et al[10], which provided maps of infected trees used in the study. In study sites D1 and D2, it is clear that the field study did not limit the observations to the square mile sections, defined by sector-township-range (STR) as stated in the published article.

These are serious violations of the study's controls. Since the distance from any infected tree could be related to another tree, whether it was inside the site, or beyond the site, then any infected tree within South Florida could be related to the source trees within the site. Without controls, the larger distances shown in the tables are arbitrary, and are dependent only on the discretion of researchers on how far beyond the site boundaries are acceptable.

Under these conditions, none of the results in the April 2002[8] and January 2001[7] articles should be reliable estimates of inter-tree disease travel distances.

6. Weather Analyses, Appendix C

What was done

Correlation analysis as presented in the 2002 article showed a correlation relationship with two daily time series, a weather index and canker incidences. For Sites D1, D2 and D3, a maximum correlation coefficient (r^2) of 0.988 results at an offset of approximately 107 days, which is termed as the "maximum visibility" of canker lesions. Additional time offsets of each study site were provided in the October 13, 1999 interim report as follow:

Table 7.1 Cross-Correlation Analysis (from October 13, 1999 Interim Report)

	Disease x Precipitation X 100		Disease vs. Precip. X 100 X Wind Gust	
Study Site	Offset (days)	Corr. r^2	Offset (days)	Corr. r^2
1	59	0.988	101	0.987
2	55	0.983	111	0.982
3	198	0.959	198	0.962
Broward	-8	0.995	13	0.986
Total (All Sites)	39	0.991	79	0.986

All correlation coefficients in this range (0.959 to 0.991) would generally be considered excellent, and indicate a high level of certainty that a linear relationship exists between the two variables.

For each site, the coefficient is computed from two cumulatively summed time series. The first series is the weather index, based on the product of rain and wind velocity. The second series is the citrus canker incidences occurring in the sites over the study period of 540 days. The incidence curves used the same as in Tables 1 to 5, which are a direct result of the parsing of infected trees into finite time periods based on their IID's (Step 2 of the DNC method).

Are the weather analyses valid?

When variables which are obviously unrelated show high correlations, this can be by design or by accident. The most common textbook example is of the "by accident" type. For instance, there may be a positive correlation between the number of Americans living past 65 years old, verses the sale of Coca-Cola when compared as time series. Both variables are likely increasing with time, likely influenced by an increasing population (a lurking variable) and no causality should be associated between these variables.

However, in this case, it is clearly a case of spurious correlation by design. A statistical trick was used to show excellent correlation between incidences of citrus canker and weather events. The two time series (disease incidences and weather index) are the result of cumulative summation of their underlying series. After the cumulative summation, the series will inevitably show high correlation value even if the

underlying series are composed two random independent values. An example of this statistical trick is shown in the Appendix C.

In order to confirm this conclusion, the correlation analyses was duplicated for Site D1. The results were nearly the same for the cumulatively summed series, however when the series was not cumulatively summed, the maximum positive correlation coefficients is 0.1219 at a time offset of 441 days. This supports the conclusion that the correlation between weather events and disease incidences based on IID time scale is very weak or non-existent.

Also, the concept of a single "maximum visibility time" appears contrary to the biological process. It would imply that the canker becomes less visible after this point in time. The lesion becomes more apparent and distinguishable from other foliar diseases with time.

Finally, the disease incidences are not on a "as discovered" basis, but on the initial incident date basis. These dates takes into consideration the time of latency. As such, if these dates were correct, then the offset time of 107 days has nothing to do with the time to discovery of citrus canker or the time to reach maximum visibility.

This is not to suggest that a time lag does not occur between when there is a rainstorm, and the subsequent incidences of citrus canker can be observed. For many reasons, there may be an "observation lag" ranging from a few months to a number of years, depending on many factors. Obviously, developing relationships are more difficult in residential areas, particularly if inspections are infrequent.

The weather correlation analysis was used in the 2002 article to suggest more frequent inspections could be used with the 125-ft policy would be ineffective in eradicating citrus canker. This was discussed in the Technical Task Force Meetings in 1999. The weather analysis was presented by Dr. Gottwald at least three times: (1) October 13, 1999 interim report, (2) Broward Court presentation in November 2000, and (3) the 2002 published article. It was cited in the Fourth Court of Appeals opinion as evidence of scientific study.

7. Inter-Point Distance Analysis (IPD), Appendix D/D1

What was done

The IPD method calculates a large set of inter-tree distances considering any tree could be the source tree for the other newly infected trees as shown in Figure 7.1. The IPD method was applied to all study sites. The published article[8] presents a frequency distribution graph along with the peak and maximum distance values. The article indicates these values represent "overestimates" of the distance of spread.

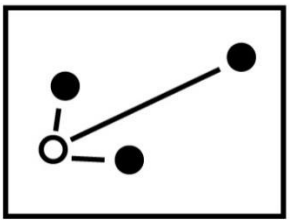

Figure 7.1 Inter-Point Distance Procedure

Is the IPD analysis valid?

The method calculates thousands of hypothetical distances. The calculated maximum distances for each site range from 0.6 miles to approximately 3 miles. The frequency distribution is often referred to as a histogram, which is useful in estimating probabilities of events. The frequency approach to estimating probabilities under the presumption each distance value is possible and equally probable. For example, a calculated distance of 50-ft would have the same probability of occurrence as one 5000-ft away. This leads to absurd conclusions on the possible range of dissemination.

However. the authors never refer to the frequency diagram as a histogram, and typical descriptive statistics of a distribution such as the mean and median, were not presented. As presented, the frequency diagrams are seemingly correct results, but the interpretation that these distances relate to dissemination distances or "distances of spread" by storm events is improper.

The article states that the values presented in the frequency diagram provides an overestimation of distances. For a widely dispersed disease, the peak and maximum distances are functions of the area of the site and geometry, and are unrelated to any inter-tree travel. If a similar study consider all infected trees in Florida, the maximum frequency values would have been on the order of hundreds of miles.

Further confusion in the results is identified in Appendix D1, where the number of distances in the article is nearly twice the number of distances which should result, if the procedure as stated had been followed. It is likely that the authors are not calculating distances between source and newly infected trees, but calculating distances between all infected trees as discovered in the sites.

Physically, these maximum frequency values of up to 3 miles distance as travel distances are impossible. Assuming the lots are approximately ¼ acre squares (104 x 104 ft), for rain water to go 3 miles, with citrus canker bacteria, it would have to travel across 150 lots to reach an infected tree. The rain drop would have to first pass through the canopy of an infected tree, and then go over fences, canal, lakes, roads and perhaps 150 houses, to infect another tree.

8. Quadrat Sampling and Related Analysis, Appendix E

What was done

A quadrat is an areal sample. In the field study, it was a square, 0.5 km on a side for a total area of 0.25 km^2 (61 acres). As described in the 2002 published article, the field study used random quadrat sampling, where the Cartesian coordinates of the quadrat centers were chosen using a random number generator, limited to the bounds of the study site.[8]

Random sampling is used to provide an unbiased sample of a larger area.[9] Through random sampling, a property or attribute of the disease can be assessed, such as the number of infected plants per unit area, and trends or other patterns may be inferred.

In the published article, the random quadrat sampling generates statistics for each site which are used in two analyses: (1) A linear regression analysis of variables with an indexes of disease severity and normalized disease incidences, and (2) Contour maps showing citrus canker development in a time sequence. Regression results are shown in Figures 6A to 6J and contour mapping in Figure 7 in the 2002 article.

Linear regression forms a relation between an independent variable, *x*, and a dependent variable, *y*. The authors describe a fairly complex procedure of creating various index variables in the primary article, which is reviewed in Appendix E.

The citrus canker development in time as shown in Figure 7 of the published article relies on the results of the DNC parsing step 2. Thus, the synthetic chronology is used. The authors do not present any results of canker development in actual time as discovered.

Are the quadrat sampling and related analyses valid?

The published article did not suggest that the quadrat sampling or related analysis were used to support distance of spread estimates. Further, the regression analysis shows only very weak relationships. Thus, the question of validity of the analysis would have little impact on the overall conclusions of the article. However, as documented in Appendix E, and summarized in this section, the statistical analyses based on quadrat sampling is severely flawed and unreliable.

The application of random sampling appears to be highly unusual, because the study sites do not need to be sampled. All properties within the sites were repeatedly surveyed on a regular basis.

The method to calculate representative statistics from the quadrat samples in several cases seemed very odd. One example is statistics related to tree heights. These tree height values were normalized within each sample. For example, if one sample contained heights in the range of 5 to 25 ft, then after normalization, the 5 ft value would equal 0 and the 25 ft value would equal 1. Homeowners' citrus tree heights can vary from about 2 ft to more than 25 ft, so it would be impossible to combine quadrat samples for any meaningful statistics. Additional details are provided in Appendix E. Indexes with normalized sample data are used in 5 of the 10 regression plots in the 2002 article.[8] Thus, there is an unusual allegation in Appendix E that the authors of the published article, purposely "dirtied" their data.

Quadrat sampling extends over "non-citrus" areas and beyond the borders of the site. The contour map shows concentrations of citrus canker in canals, lakes, parking lots, etc. The figure below shows citrus canker located in a lake between NW 192 St and Honey Hill Dr in Carol City.

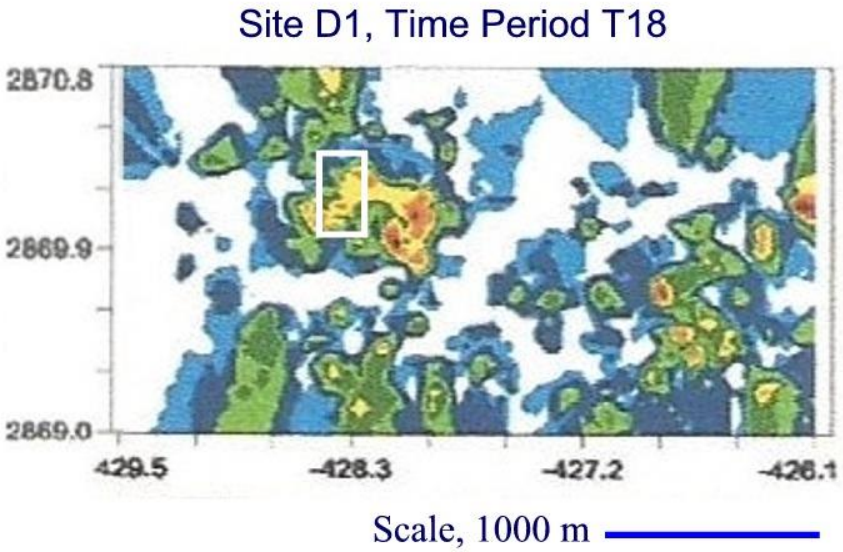

Figure 7.2: Site D1, Time Period T18, with location of lake between NW 192 Street and Honey Hill Dr. , Carol City, Florida

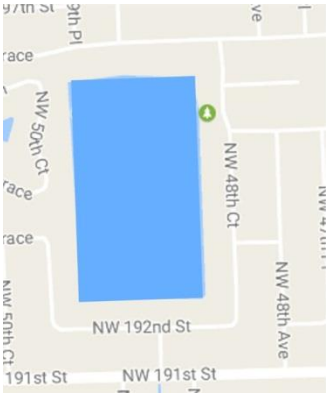

Figure 7.3 Lake at NW 192 St and Honey Hill Dr., Carol City, FL

The image of citrus canker spreading out from a series of foci is simply a creative illusion, as quadrats indiscriminately sample areas which can contain both residential yards and non-citrus areas such as lakes, canals, roads, schools, commercial centers and parking lots. The contouring method, along with the analyses in the next two sections, are based on the assumption of a continuum, where it is assumed citrus canker can be present in any location. While this may be nearly true for a nursery, and a grove with close spacing, it is not true for residential areas. In fact, all the study sites contain large non-citrus areas and there is no real evidence that the bacterium could transverse these areas.

9. Spatial Point Pattern Analyses (Appendices F/F1)

What was done

Spatial point pattern (SPP) analysis provides statistics on a set of points, distributed within a sample space. In the field study, the data consists of the locations of infected trees. It is claimed in the 2002 article that the described SPP method is a modification to Ripley K evaluation and would eliminate the need to consider boundary effects. However, this claim is not supported by any discussion within the article. The statistics are actually calculated by inter-point distance (IPD) analysis. In this case, IPD analysis was performed for each time period. These time periods are a result of the synthetic chronology as discussed in Appendix B.

For each time period, two empirical distributions were developed, an infected tree IPD distribution and a comparison distribution, denoted as Kexp, These distributions are shown in Figure 4 of the published 2002 article.[8] The Kexp distribution is bounded by lower and upper set of confidence limits. While the IPD distribution of infected trees is clearly defined, the Kexp distribution is not.

Are the spatial point pattern analyses valid?

The spatial point pattern analyses do not provide meaningful inferences of the inter-tree distances of transmission of citrus canker bacteria. As explained below, it is also concluded all citrus trees in the backyards of residents are likely to show departures from a complete spatial randomness pattern (CSR) undistinguishable from CSR departures of infected trees alone.

All distance related statistics are based on a comparison of two cumulative distribution as described in Figure 4 of the 2002 published article.[8] The article did not provide clear definition of the Kexp curve, but the text of the article suggested it was based on a complete spatial randomness (CSR) pattern. This conjecture was supported by Monte-Carlo simulation. As described in the Appendices F and F1, a Monte-Carlo model was created to simulate inter-point distances of a CSR pattern, based on a rectangular area. By varying aspect ratios in a trial and error manner, a close match of the Kexp distribution was obtained. Thus, it appears the Kexp curve was based on a computer generated result, rather than field collected data.

The match only added confidence of the basis of the Kexp curve, not the confidence interval. The confidence intervals presented in Figure 4 are different from those obtained from the Monte-Carlo

simulation for Site D1. The derivation of confidence intervals based on the hyper-geometric distribution, appears to be in error.

The authors consider the distances related to maximum departure of infected trees from a CSR pattern to be significant. It is not, because all citrus trees, healthy and infected, are likely to show some departures from a CSR pattern. This is based on the simple observation that homeowners are more likely to plant citrus trees in the backyards of their lots. There are no citrus within the numerous areas, such as lakes, canals, roads and houses. Residents do not chose locations at random. Finally, in order to make a valid analysis, the authors would first have to present evidence that the pattern of residential citrus trees can be represented by a CSR pattern.

Since these disparity between curves can easily be attributed to the typical pattern of residential fruit trees found in residential areas, no meaningful inferences can be made to the inter-tree transmission distances of citrus canker bacteria.

10. Semivariance Analysis (Appendix G)

What was done

Semivariance methods are used to identify specific patterns or trends in spatial data. The methods provide statistics on the spatial variation of a specific attribute denoted as a *T* variable, which is a continuous and real variable. Semivariance analysis is used extensively in mining applications, where the attribute is commonly is the mineral content of a unit sample of rock.

In the case of the field study, the *T* variable is the duration that the infected tree was infected according to the synthetic chronology. The synthetic chronology is based on back dating trees to the exact date of their first infection with values *t* range from 1 to 25 corresponding to their time window. If a tree has an initial infection date (IID) less than the start date of the first period, then $t = 25$. Similarly, if the citrus tree is deemed initially infected in the second period, then $t = 24$.

The semivariance analysis is dependent on the parsing of infected trees in the DNC method. resulting in a synthetic chronology. The transitional spherical model was fitted to the data. From this fit, the properties of the variogram (range, nugget and sill) were obtained.

Is the Semivariance Analysis valid?

The RSTD values were obtained from the theoretical variogram models, not the field data. However, no graphs are presented showing the fit of data to the models, so range values can not be evaluated. Due to the large non-citrus areas, the assumption of a continuum for the transitional model is violated. So, the attribute. *T*, or any other property from the infected trees can not be evaluated using the semivariance analysis.

However, if one considers the RSTD results are valid, it is noted that these RSTD values do not support a conclusion that the citrus canker can be disseminated long distances.. The five RSTD values given in the

article range from 9 to 119 m, which is closer to the existing 38.1 m (125-ft) eradication policy, than 579 m (1900-ft) , the post Jan 2000 policy.

However, Dr. Dixon, Bureau Chief of the Plant Pathology section of FDACS/DPI made a presentation in 2001 in public hearings in support of an amendment to Department rules, in which he stated these results collaborate the distances of spread.[2]

11. Field Study Provided No Meaningful Results

Six analyses from the field study were reviewed in detailed as presented in the appendices and briefly summarized in the prior sections. These were not six independent analyses. Each analyses depended on the DNC procedure which created the synthetic chronology based on the discovery dates and lesion ages. In fact, it is impossible to determine from the 2002 article [8] when the discoveries of citrus canker were made, as all analyses are conducted using the synthetic time chronology.

After the determination that the DNC method was invalid, the review could have ended at this point. Instead, each analysis was reviewed on its own, and in each case, the analysis was invalid. So, even if one believes that the DNC method could produce a correct synthetic chronology, the rest of the statistics lack credibility.

Thus, it is concluded that the Florida field study provided no useful information for the determination of the 1900-ft rule. This is actually consistent with the principal investigator, Dr. Gottwald's claim in Broward Court in November 2000 that the general agreement of the 1900-ft radius was not based on any report. It is contrary to the claim of FDACS that the 1900-ft rule originated with the field study results.

The investigation showed each of the six analyses was invalid. This includes the 107 day maximum visibility (Appendix C), the inter-point distance analysis with a maximum distance of 3 miles (Appendix D), and the quadrat analysis demonstrating the spread of citrus canker over lakes, canals, parks and other non-citrus area (Appendix E). This was a surprising result, as from the onset of the review, it was thought there were would be some valid statistical results.

The study lacked basic controls. Obviously, a residential area is not a grove. There are no controls what each owner can do to frustrate the discovery of the disease. The most obvious is removal of infected foliage and fruit. But, citrus canker promotes early leaf drop. A poorly maintained citrus tree would likely have multiple problems — improper planting, lack of irrigation, nutrient deficiencies, and myriad pest and diseases. So, how is it possible, that the single most essential information, the age of the oldest lesion on the tree, could be determined? And yet to avoid errors of incorrect pairing of trees, which directly affect the calculation of distance, this lesion age would have to be determined in terms of day from the initial infection date.

This study is characterized as a hoax or fraud, if one considers this research to be either forming the basis of the 1900-ft rule or supporting its validity. There is no other word which really fits. Viewed strictly from the outside, the 2002 published article[8] on the field study has all the normal trappings of a scientific article. Tables of results, graphs, maps, equations, and even a derivation, which did not make much sense.

However, when viewed in detailed, every analyses had major problems. The 107 day maximum visibility as investigated in Appendix C is the result of a statistical trick to produce the appearance of excellent correlation, when in fact, the correlation was poor or non-existent.

It is not suggested that all six authors of the study, as identified in the 2002 published article[8] , understood that the statistical analyses were invalid. The only researcher with expertise in epidemiology, besides Dr. Gottwald, was Dr. Frank Ferrandino. It is believed that Dr. Ferrandino's participation in the study was very limited. He is credited to developing a computer program to provide statistical analysis of the spatial point pattern, but it is likely from the published article, this program was never actually used.

It is believed that the other four authors (Drs. Sun, Graham, Taylor and Riley) of the 2002 article had only general knowledge of the study. While the expertise in the pathology of citrus canker of all four authors is beyond question, none of these scientists appear to have extensive background in spatial analysis and epidemiology.

Nothing within the 2002 article suggested the 1900-ft rule was a direct result of the field study. The article was not determinative of the rule, but supportive of a rule in excess of 125-ft. It is stated that many of the distances of spread as calculated in the study exceeded 1900-ft. The article would be useful in a superficial sense, to demonstrate to the public, the media and judges involved legal challenges to the program, that considerable study had been conducted, and this study was supportive of the current policy.

The question arises, that if this study is so extremely flawed as to offer no meaningful result to regulators, then how could it have been published in the prestigious journal of Phytopathology, published by the American Phytopathological Society. As noted in Chapter 6, the general definition of epidemiology is the change in disease in groups over time and space, not the study of how to control or eliminate diseases. A novel method of analyzing survey data may be considered valuable and publishable research. Also, it is likely the reviewers likely did not give close scrutiny to each analysis, because the article drew only very general conclusions from these analyses. However, the reviewers should have insisted more detailed information on data collection, the location of sites, the data collection period and how certain data such as oldest lesion age, were determined.

12. Back to Property Inspections — Another Piece of the Puzzle

This review is not yet complete. It was concluded that property inspections were at times, incomplete as not all citrus trees or citrus canker were discovered. Subsequent visits may have documented information which was inconsistent with prior inspections. It was presumed that the same FDACS employees conducting routine CCEP inspections would bring GPS meters with them to the study sites, when they did the special surveys within the study site. They would fill out both the normal inspection forms and special forms to be used in the field study. The special forms would be turned into the USDA as Dr. Gottwald would tabulate the results.

The locations of infected trees in study site D2 in North Miami are shown below in Figure 7.4 as provided in the article by Neri et al.[10]. Dr. Gottwald is a co-author of this article and provided the field data. This

location is documented in Appendix A as provided on the website. According to the 2002 published article[8], the boundaries conform to a square mile section, as defined by the TRS system (township-range-section). The eastern boundary is North State Rd 9, which is less than 100-ft from I-95, and acts essentially as a feeder road. Yet, infected trees are shown approximately 500 to 700 ft to the east of US I-95. This distances can not be explained by errors in GPS meters.

This is a surprising result, since it is impossible for surveyors to be unaware of which side of US I-95 highway they are collecting data. This is a high speed, interstate highway, with 5 lanes of traffic in each direction (Figure 7.5). The highway would likely act as natural barrier to the transport of citrus by windblown rain. Why would any researcher extend the inspections to the eastern side of US I-95? On the eastern side, these trees are all within residential sections. The nearest infected tree could easily be just over the neighbor's fence and outside the site. In this case, the infected tree would not be part of the study.

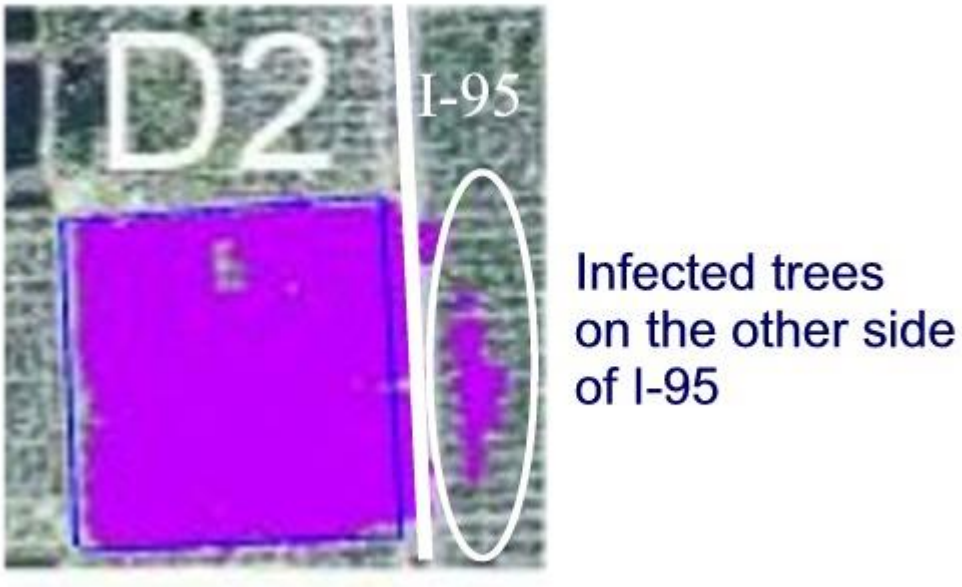

Figure 7.4: Incidences of citrus canker outside of site boundaries (Site D2)[10]

The article in which Figure 7.4 appeared, was published in 2014.[10] It was verified the data are the same because the disease incidence progress curve, as presented in the 2002 article[8], matches exactly with the 2014 article's curve. A similar analysis was done for Site D1 which had an identical progress curve as well.

Figure 7.5: Northbound traffic on Interstate Highway I-95 at Rush Hour in Miami-Dade County

(Source: By B137 - Own work, CC BY-SA 4.0, https://commons.wikimedia.org/w/index.php?curid=48998674)

Also, in study site D1, infected trees were located outside of the site's boundaries in every direction. As described in Appendix A, the infected trees in site D1 are located from 200 to 700 ft beyond the major roads which presumably were the site borders.

More Discrepancies and Uncertainties Identified

Discrepancies in boundary locations from various presentations are noted in five study sites as described in Appendix A. For example, the size of study site B1 is stated as 6.0 square miles based on two sources, while three others sources show it to be 2.75 square mile, approximately half the size.

As part of this investigation, each site was visited. Each bounding street was a major road. It was unreasonable to assume surveyors would not know which were the confining streets and stay on the proper side. Also, the parcel lot number for each property was easily available from the CCEP database, providing the Section-Township-Range identifier. Surveyors making repeat visits would know when they were inside or outside of the site.

There is uncertainty of when data were collected. The published article[8] provides no dates for the end of data collection. Correspondence from the Department varies anywhere from June to November 1999 as provided in Appendix A. Based on the published article[8], the end date of the last temporal window was November 14, 1999. But Dr. Gottwald sent to the Department an interim report a month earlier, on October 13, 1999 — a month before the end. What sense does this make? Further, what is the sense of obtaining general agreement on the 1900-ft rule in a meeting in the December 1998, if the field study was slated to last one year (through at least March 1999, 12 months since Commissioner Crawford announced the field study).

13. Department/USDA field study narrative starts to fall apart

The conflicting information comes from the very best sources, publications by Dr. Gottwald of the USDA/ARS and a letter from the Director of FDACS/DPI, Mr. Gaskalla. The inspections of backyards during the field study were at the direction of the Department. How could they not know where the study had taken place?

It seemed unrealistic to believe FDACS sent Dr. Sun to "visually inspect" all citrus trees infected with citrus canker. He would have to practically live in South Florida. If there were 3323 infected trees within the sites, there were likely many be more in the surrounding area. If a single one mile square section is inspected in the surrounding area, just ½ mile from the boundary, approximately three square miles would have to be inspected.

The 2002 published article on the field study and the 1999 interim report discuss the conversions of the longitude and latitude data to UTM coordinates. The published article identifies two models of GPS meters. But, the GPS Garmin model 12XL had an option to read out in UTM coordinates. Why bother with conversions? This just did not make sense.

Then at the end of the study, not a single document on the study was retained by FDACS. The entire dataset would have likely fit on a single CD, even in year 1999. This was very odd considering it was their inspectors checking regularly on the health of approximately 19,000 citrus trees. Why would the Department not be interested in retaining the information gathered in the study on the age of the citrus tree and the size of the canopy, for all 19,000 citrus trees?

It has already been mentioned how odd it was, that inspectors did not check for citrus leafminer. The Department emphasized at every opportunity, how injuries by the leafminer would make citrus trees many times more vulnerable to canker. Symptoms of citrus leafminer would be very obvious to inspectors.

Assuming the decision was made in December 1998 to use 1900-ft, then why would the Department want to continue to send inspectors into the same study sites from January to November 1999 to repeatedly inspect the same properties every 60 days? Why would the Department want Dr. Sun to inspect visually the infected trees from January to November 1999? Funding was scarce, and one would think inspectors during 1999 would be needed in the northern areas of Broward and Palm Beach Counties, instead of the three sites within Miami-Dade County and two sites in Broward, close to the Miami-Dade/Broward County borderline.

It is further not explained how inspectors on their 60 day return visit to the properties would be able to correctly locate the same citrus on the properties. Due to the inaccuracy of GPS meters, they would have to rely on some notes to be sure they had the right trees in cases of more than one tree. Would they again record the lesion ages, the variation of canker lesions, top to bottom, or directionally, north, south, east and west? Would they again record all information? What would they do if the data were inconsistent with the previous visit?

Further, read carefully, the 2002 article does not say that GPS meters were used every day in each site. It does gives some specifications of two models of GPS meters, with the implications these were used during

the study. Also, FDACS webpage discussion of the "Epidemiology Study" states that only GPS technology was used.

A Desktop-based Field Study?

It is believed the entire field study was done simply for political and legal reasons. Prior to the creation of the Task Force in February 1999, the 1900-ft policy decision had already been made between the two key participants— USDA/APHIS and FDACS/DPI. This is consistent with Dr. Gottwald's court testimony that there was already a consensus by December 1998, to extend cutting to 1900-ft. He also states this in the 2001 article.

A possible explanation for the conflicting information on the study sites, and the lack of information on the start and end dates is the field study was not conducted by a special group of inspectors with GPS meters. There may have been a few special inspections in the beginning, but not for the entire study period.

It is alleged that most or all of the field study was done in Dr. Gottwald's office at the USDA. More specifically, Dr. Gottwald simply downloaded prior inspection records. Much of the information would be of no use to him, such as the names and addresses of the residents. But, the CCEP database included longitude and latitude of every property. The longitude and latitude data was used by CCEP to calculate eradication radii.

Possible use of CCEP database data to locate citrus trees

It is suggested the center locations of residential lots came from the CCEP database instead of actual tree locations in the Florida field study. The center locations were part of the CCEP database since it was necessary data to determine the removal distances.

The USDA/ARS refused to disclose all data involved in the Florida field study, including the locations of citrus trees. If the CCEP database were used, this could be seen in the data, as every citrus tree within a particular lot would have exactly the same coordinates corresponding the lot's centroid location.

But would accuracy really have been lost if the CCEP database was used? It is likely at times the database locations could be less prone to error particularly with smaller backyards. In examining lot sizes, many lots have backyard spaces approximately 1,500 to 3,000 ft^2. Assuming a square geometry with an area of 3,000 ft^2, this space would be 55 x 55 ft. Also, citrus trees are likely planted from 10 to 15 ft from the back of the yard, the trees would be 30 to 45 ft away from the house. In the published article in 2002, and others presentation prior to this article, the GPS meters are accurate to approximately +/- 25 ft. Given the small area likely to contain a citrus trees, it is fairly easy for GPS meter-based coordinates to place the citrus tree in the wrong lot. This is particularly true if the citrus tree is located in the corner of a lot. At least, if the CCEP database was used, these errors would not occur.

Oldest lesion age — all fun and games

It is alleged that the "oldest lesion age" identification, through backyard visits were either totally or partially fabricated. Perhaps, Dr. Sun made a few trips to Miami, so there would be some record in case

he was required to testify. Many of the lesion age determinations were not done by any of the other inspectors, but were created by Dr. Gottwald as he sat at his computer, putting data into Excel spreadsheets. It would not have taken him a long time. As the lesion ages were created by Dr. Gottwald, the locations of PI and NI trees in each hypothetical scenario would be displayed. At this point, it was all fun and games.

However, it is suggested that data fabrication had some limitations. The Excel spreadsheet contained only infected trees were identified by Department inspectors. No infected trees or addresses were ever invented. It is also possible that Dr. Sun visually identify some of the infected trees in Miami at the beginning of the study.

The "Desktop" field study would explain plenty

If this desktop field study narrative is true, it would explain many of the more puzzling aspects of the study. First, is the secrecy and confusion surrounding the inspection dates and site locations. The missing details on the study were very obvious. It would explain why FDACS would claim it retained none of the field data. Imagine a state agency which spends 18 months collecting field data, and has no desire to retain any data. It would explain the extraordinary efforts of the Department to avoid a trial on the validity of the 1900-ft rule, which would require depositions from everyone, all the way down to those conducting the surveys.

The desktop field study would also explain how, if data collection ended by July 17, 1999, as Dr. Dixon stated in the Public Hearing, it was possible for Dr. Gottwald to present data extending to November 15, 1999. The answer was he did not need to collect the data, he just downloaded records from the CCEP database.

It is possible explanation of why the only date, ever mentioned in published articles is August 1998, the date of a cooperative agreement, because this is the date that Dr. Gottwald is given full access to the CCEP database. It is possible that on the date of this agreement, it was understood by Dr. Graham of UF/IFAS and Drs. Dixon, Sun and Schubert that the field study would be a desktop exercise.

The desktop field study would explain the selection of Carol City, in Miami-Dade County as Site D1 where access to property was the most difficult due to chain link fences. It always seemed very difficult for Dr. Sun, fairly short in physical stature, could access back yards surrounded by chain link fences.

The age of each tree and the size of the canopy were part of the collected data, but never used in any of the analysis. The authors never state how the tree age was determined. Data were either created on the desktop, or absent altogether.

The presence of citrus leafminer presence was not collected because this information was not within the CCEP database. Did officials ever wonder why the field study did not include the presence of citrus leafminer?

It would also explain the strange procedure used in the creation of indexes for correlation analysis. Researchers frequently take pains to "clean up" data to make it more meaningful. However, in this case, the strange normalizing procedure seemed to actually "dirty" the data, making indexes and the related

correlation analyses less meaningful. The discussion is provided in Appendix E. It is conjectured that Dr. Gottwald did not want any meaningful results to come from improperly collected data on approximately 19,000 trees.

Does it matter?

While the allegation that some of the Florida field study data were fabricated may seem very serious, perhaps this is not as serious as it seems. It has already been established that none of the six analyses are valid. Might they be valid, if data collection occurred on the ground, rather than data downloaded from the CCEP database? The answer is an emphatic no — there is not a single statistics within the field study which would be improved if the data unique to the field study were collected by surveyors.

It makes little difference if an inspector goes to a tree, and guesses at the oldest lesion age, or Dr. Gottwald makes up the numbers in his office. In fact, it would have been a waste of time, making repeated visits to back yards, if the end results were going to be the same.

14. Concluding Remarks

The conclusion reached in this chapter is every single analyses in the Florida field study as published were so severely flawed that neither the statistics nor the conclusions are meaningful to the establishment of an eradication radius. To the layman, the articles have the look of science, full of equations, tables, and figures. Under close examination, there was not a single analysis which stood up against scrutiny. Perhaps, the most telling of all statistical analyses was the weather analyses. The use of cumulative sum variables was simply an old statistical trick. This led to the conclusion that the entire field study was done for show.

However, this conclusion then turns to a question of how could a group of scientists from the USDA, the FDACS and University of Florida/IFAS collaborate on such a hoax. How is it possible that Dr. Gareth Hughes, a well known epidemiologist, and co-author of a recent textbook on plant disease epidemiology[9] would be part of a study that was seriously flawed? It is suspected that this "team effort" never existed and the 2002 article was written entirely by Dr. Gottwald. From the end of the study in late 1999 to the submittal of a manuscript in November 2001, there was nearly two years to prepare the article.

The Department has contended that the 2001 and 2002 articles were validated through the peer review process. This is the normal process of selecting submitted manuscripts to be published. It is not a thorough review of methodology and results. Further, it was stated the 1900-ft policy was recommended at the May 11, 1999 meeting of the Risk Assessment Group. The only reporter at the meeting, Mr. Paul Power from the Lakeland Ledger did not report any change in policy in his May 12, 1999 article.[11]

It is alleged in this chapter that much of the data were not collected, but simply downloaded from the CCEP database. Further, it is alleged that some of the data were simply fabricated, but the significance of this minimal, because the entire study was meaningless to the policy decision. It however, resulted in the USDA/ARS refusal to release their data, even after a Freedom of Information Act request had been submitted.

It is believed Dr. Gottwald was being honest, when he stated that the 1900-ft rule was not based on any report. However, Dr. Gottwald's assertion that the 1900-ft distance was the result of an unofficial meeting in December 1998 at USDA/ARS office with officials of various state and federal agencies and citrus industry leaders and where no minutes were recorded nor was there a list of invited guests seems highly implausible.

Another piece will be set in place in Chapter 8. Please keep reading.

Short Notes on the Website:

SN 1.3 Long Distance Transport of Citrus Canker by Hurricanes and Tornadoes
SN 6.2 The 1900-ft Policy and the Published Articles by Dr. Gottwald et al.
SN 6.3 Comparison of Department Website Justification Statements
SN 6.4 1990 Highlands Observational Study

Key References:

7. Gottwald, T.R., Hughes, G., Graham, J.H, Sun, X., Riley, T., 2001. The Scientific Basis of Regulatory Eradication Policy for an Invasive Species, Phytopathology, 91:30-34.

8. Gottwald, T.R., X. Sun, Riley, T. Graham, J.H., Ferrandino, F. and Taylor, E., 2002. Geo-Referenced Spatiotemporal Analysis of the Urban Citrus Canker Epidemic in Florida, Phytopathology, Vol 92, No. 4.

Appendices:

These appendices provide the critical review of the Florida field study. Readers' comments may be included in Appendix H, or posted separately on the website. Comments will only be posted with permission of the sender.

Appendix A: Basic Information of the Florida Field Model
Appendix B: Distance Necessary to Circumscribe (DNC) Method
Appendix B1: Unusual Field Study Results
Appendix C: Weather analyses
Appendix C1: The Gottwald Canker Forecast Model
Appendix D: Inter-Point Distance Analyses
Appendix D1: IPD Supplemental Information
Appendix E: Random Quadrat Procedure and Related Analyses
Appendix F: Spatial Point Pattern Analyses
Appendix F1: Supplemental Information
Appendix G: Semi-Variance Analyses
Appendix H: Additional Epidemiology Review/Comments/Errata*

* Appendix H will be added after publication and updated as needed.