8. UNDISCLOSED STUDIES

> The implementation of the 1,900-ft rule will result in an effective clear-cutting of the majority of dooryard citrus within approximately 793 square miles (2,054 km^2) of the Miami metropolitan area in Dade and Broward Counties. An estimated 750 thousand dooryard trees will be removed from urban areas in Dade and Broward Counties within the next year.

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

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1. Filling In the Gaps

Chapter 7 made a critical discovery — the Florida field study was not the origins of the 1900-ft rule. When carefully reviewed, the study as presented in the 2002 published article[11] did not provide any meaningful analyses to establish an eradication radius. Further, the article was published more than two years after adoption of the 1900-ft policy. Thus, one piece of the puzzle is solved. Yet, if 1900-ft did not come from the field study, then what was the true origin of the rule?

As previously mentioned in Chapter 1, Section 8, Dr. Gottwald in sworn testimony on November 9, 2000, in Broward District Court when asked where the 1900-ft distance came from, stated:

> No, the report does not discuss the meeting that occurred in December 1998 in which there was a group of scientists, regulatory agents and growers present in a room and decided upon 1900 feet. 1900 foot *[rule]* is not decided upon this, the manuscript or anything else, it was decided upon by a group, a body of regulators, university scientists as well as ARS scientists, etc. It was not decided upon by these reports.

Dr. Gottwald was referring to an interim report, sent to the Department on October 13, 1999.

Dr. Gottwald is being partially truthful, the 1900-ft rule did not come from any report. However, given the enormous impact of the change to a 1900-ft rule, the choice was not done in an arbitrary manner, by an unnamed group assembled at the USDA/ARS office in December 1998. At the Broward Court trial in November 2000, the Department could not provide a single document to show who attended the meeting and what was discussed. In fact, the December 1998 meeting may have never taken place or it was simply a meeting of the inner circle of plant pathologists and two officials, Deputy Commission Craig Meyer and Director of DPI Richard Gaskalla.

Evidence suggests that a computer simulation study was developed by Dr. Gottwald and likely completed prior to December 1998. It is believed that this was the true origins of the 1900-ft rule. The model provided assessments on the areal coverage and tree eradication estimates for various radii. A healthy to infected tree (H/I) ratio for each radii could be calculated.

Incredibly, the field study was entirely a smoke screen. Remember, in all communications and publications, neither Dr. Gottwald nor the Department ever used the words, "field study", but always opted for a more vague wording, "epidemiology research", or the "Gottwald study", which could include other research studies. The epidemiology research identified "distances of spread", which again was vague. Epidemiology is a broad discipline, and includes both conceptual simulation models and weather analysis as discussed in Chapter 6.

It was unlikely that a team effort was involved in the field study. All presentations were made by Dr. Gottwald, usually accompanied by Dr. Graham, UF/IFAS professor and soil microbiologist. Dr. Gottwald was the principal investigator for the citrus canker epidemiology research, and no other scientist in the USDA/ARS or USDA/APHIS was part of any study. He was the first author on the two publications related to the field study. Others were included at participants, but their participation was more as co-authors to presentations made by Dr. Gottwald. The Department stated that all data related to the epidemiology research was retained by Dr. Gottwald.

Dr. Gottwald did not chose the 1900-ft radii. Rather, he provided the technical information by which officials could use in selecting a radius in less than a totally arbitrary manner. It was founded on one truism — if 100% of all citrus were eliminated from an area, then there would be 100% elimination of citrus canker. It would follow that any radius that destroyed a high percentage of citrus trees, would effectively eliminate the chance for subsequent outbreaks of canker.

In addition to simulation studies, it is suggested that there was a second series of undisclosed internal studies were conducted from 1996 to 1998. These studies involved a field experiment in Miami-Dade County to demonstrate the potential distance of citrus canker transmission. The supporting evidence of the field experiment is speculative, and only briefly reviewed as it had no impact on the eradication program. The researchers in this field experiment were Drs. Gottwald and Graham.

2. Evidence leading to a Simulation Model Approach

The following are three key facts which lead to the conclusion that the assessment of the 1900-ft and other radii was the result of a simulation model approach developed by Dr. Gottwald.

#1: The number of trees to be eradicated needed to be estimated

Any recommended eradication radius would need some estimate of cost, which in turn would require an estimate of the number of trees to be eradicated. As the larger radius are evaluated, the chance the eradication circles will overlap must be considered. This is not a trivial problem. The number and locations of future infected trees would be impossible to identify on a map. The most effective way to estimate the "clear-cut" area (areal coverage) including an overlap factor would be using a computer simulation model based on random number generation. The model is explained in detail in the next section. The same computer model used to calculate the percentage of areal coverage for any specific radii could estimate the number of trees eradicated for a specific radius. Thus, both areal coverage and tree eradication estimates (healthy and infected) would be determined by the same computer program. The program would also determine the healthy to infected tree ratio.

Dr. Gottwald presented the eradication estimate of 750,000 to 1,500,000 trees in Miami-Dade County in November 2000 (Figure 8.1) It is likely this is the same presentation presented in June 2000 at the International Citrus Canker Research Workshop.

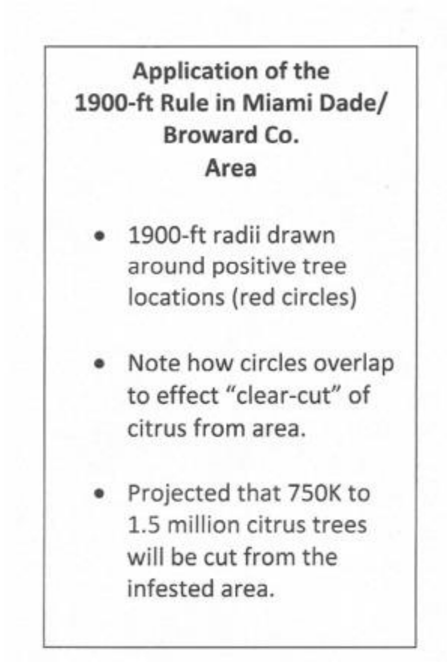

Figure 8.1: Presentation by Dr. Gottwald, Broward Court, November 2000

It would make little sense for officials, including as Mr. Craig Meyer, FDACS Deputy Commissioner of Agriculture and Dr. Stephen Poe, Program Director for Citrus Canker, USDA/APHIS to discuss various eradication radii without budget and general logistics estimates, in particular the number of cutting crews and program duration. This would require the tree eradication estimates.

#2: The necessary simulation program had already been developed

Dr. Gottwald created essentially the same computer routine that would provide the eradication estimates. This was revealed in the April 2002 article which provided details on the field study.[11] The simulation model as used for areal coverage estimates would randomly locate circles of a specified radius within an area of interest (square mile section). This is essentially the same as the random quadrat sampling used in the Florida field study, as discussed in the published article[11] and reviewed in Appendix D.

In the April 2002 article[11], randomly located squares were employed in quadrat sampling while the clear-cut model, used circles. It is likely that Dr. Gottwald first created the program with randomly located circles to calculate the areal coverage and other statistics using Excel Visual Basic Applications (VBA). Then he changed the geometry of the sampling objects from circles to squares. It would require only a minor changes to the code.

As discussed in Appendix D, the quadrat sampling as presented the April 2002 article[11] appeared to be a very unusual application, since all lots within each study site had been repeatedly surveyed. However, it makes perfect sense that the original intent of the program was to calculate areal coverage and the number of trees (healthy and infected) to be eradicated for various radii.

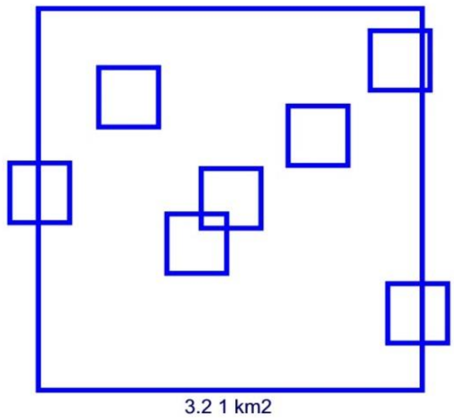

Figure 8.2: Random Quadrat (0.5 km on a side) in a square mile

#3: Determination of a clear cutting radii was the intention of the Voronoi Tessellations - Broward 2000 Presentation

It is suggested that the presentation of Voronoi tessellations indicate Dr. Gottwald was looking for a method to estimate a radii with a high level of areal coverage, consistent with the objective an eradication program which would leave few pockets of citrus in residential areas.

The Voronoi tessellations presentation was presented in Broward court in year 2000, and likely this is the same presentation in June 2000 at the International Citrus Canker Research Workshop.[8] Tessellations refers to the tiling of a flat surface. With this method, the boundaries of the polygon are drawn to be equidistant from the points on either side of the boundaries. An more complete explanation of this technique is provided in the online supporting documents website. Also, many examples can be found on the internet.[14]

The presentation of Voronoi tessellations at the Workshop in June 2000 was very brief. Dr. Gottwald does not indicate why the analysis was done, nor offer any numerical results from the work. It is suggested the method was used to identify the expected areal coverage of various radii. This would be consistent with the goal of clear-cutting a high percentage of citrus within residential areas. This work may have been used to complement the simulation work. The distance from the infected tree to the most distant vertex of the polygons (Voronoi cell) could be calculated for all cells. These distances could then be sorted from low to high and percentile levels could be calculated. The percentile levels would give a probability value for each distance. Additional discussion of Voronoi tessellations can be found in Short Note 8.2.

The results would complement the simulation modeling because this work does not assume a fixed number of trees in each section, and the trees are not assumed to be randomly distributed. The method could be used to calculate the high probability distances for all trees within Miami-Dade and Broward Counties, if tree locations were approximated using Department's database.

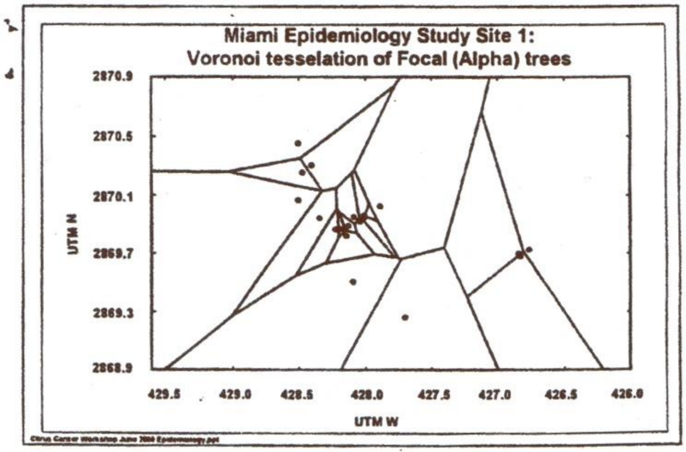

Figure 8.3: Miami Epidemiology Study Site 1, Voronoi Tessellations

In sum, the 1900-ft rule was a mathematical result, solved numerically by simulation. It was not a biological one. The objective was not to capture the next generation of infected trees but to provide a high level of areal coverage with large eradication circles. It would also provide the tree eradication estimate, needed for planning purposes.

3. Monte-Carlo Simulation Model Concepts

A stochastic or Monte-Carlo model uses repeated generation of random numbers (replications) to represent uncertainty in the system. It is a specific numerical solution to a mathematical problem. In the model, infected trees within a specified area can be located with randomly selected coordinates as shown in Figure 8.4. To illustrate the concept of overlap, the circles with a 300-ft radii were drawn around these locations. Each circle would encompass 6.5 acres, so with no overlap, 10 infected trees would cover 65 acres or about 10% of the area would be cut down. But, the areal coverage is less than this, because some circles overlap. Also, areal coverage is reduced because some circles lie partially outside the square,

To calculate the effect of overlap, it is necessary to run the model many times, with different random locations of infected trees and calculate each time the percent of area which would be enclosed by the circles. The multiple runs or realizations provide estimates of expected areal coverage and eradication estimates. Programs such as Excel with Visual Basic Applications can simulate the affect of various radii on the areal coverage.

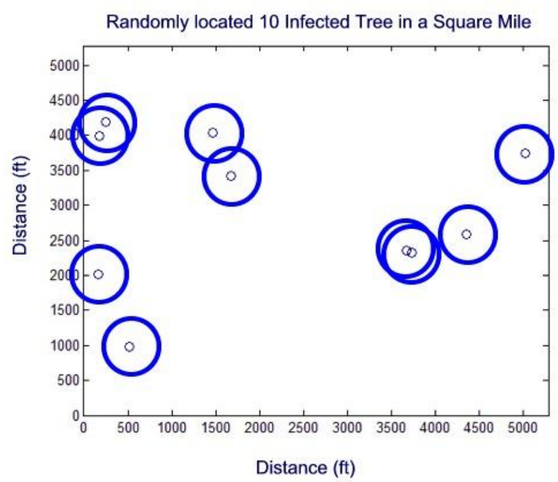

Figure 8.4: 10 Randomly Located Trees in a Square Mile with 300-ft Circles

4. Model Procedures and Results

To test the proposition that the 1900-ft rule was chosen based on a simulation model, two models were constructed using the MATLAB© program. Each model requires two input values: (1) The number of infected trees in the specified area and (2) The cutting radius. The result is the percentage of clear-cut area or areal coverage. This is the equivalent to the probability that any healthy tree randomly located within the section would be cut down. Each model considered 10 infected trees randomly located within a square mile

The first model, identified as the "Closed Model' determined the areal coverage based only on infected trees within the square mile block. It is closed to the effects from other adjacent sections.

The second model, identified as the "Open Model" included the effects of infected trees in the surrounding sections, as shown in Figure 8.5. The center block and surrounding blocks (a total of 9 blocks) are populated with 10 infected trees each, and randomly located. Calculated percentage of clear cut area was calculated only within the center square. As shown below, infected trees located within the eradication radius of the center block will increase the percentage of the area clear cut.

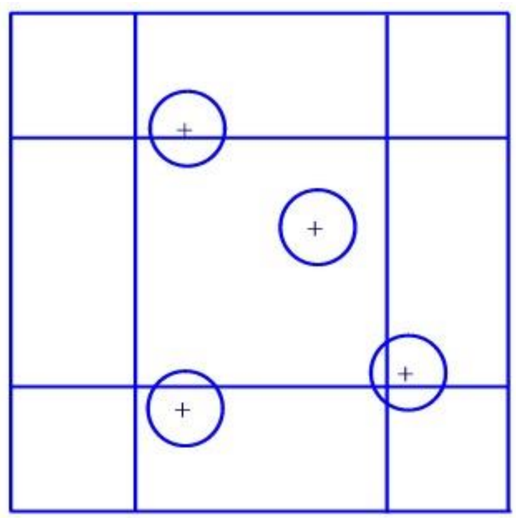

Figure 8.5: Open Model Showing 4 Infected Trees Outside of the Center Section

Areal coverage results

Results are shown in Tables 8.2 and 8.3 for closed and open sections, respectively. All results are the average of at least 3 runs with 300 replications each. The results are accurate to about +/- 0.2%. The accuracy of estimates depends only on the number of replications and the spacing of the mesh points used to calculate areal coverage.

Table 8.2: Closed Section Model Results

Radius (ft)	% area with trees removed
2700	99.5
1900	94.7
1600	89.8
1200	74.6

Table 8.3: Open Section Model Results

Radius (ft)	% area with trees removed
1900	98.7
1600	95.3
1400	89.3
1200	80.8

The "% area with trees removed" can also be considered an estimate of a theoretical probability. It is the probability that any citrus tree within a section, would be located within at least one eradication circle, given 10 trees are infected in the section and both healthy and infected trees are randomly located. It is a theoretical result, as tree locations are unlikely to be correctly represented by a complete spatial randomness pattern.

For 1900-ft, the simulation model results in either 95 or 99% areal coverage, depending whether a section is open or closed. A property which borders on a canal, lake or any large non-citrus area would be partially closed, so the areal coverage would be between these two estimates. If a section has fewer than 10 infected trees, or the infected trees are clustered together, then the areal coverage percentages are lower. Complete MATLAB code and discussion of computer programs are provided in the online supporting documents website (Short Note 8.1).