APPENDIX C1

THE GOTTWALD CANKER FORECAST MODEL

INTRODUCTION

This appendix discusses unpublished research by Dr. Gottwald on predictive models for new incidences of citrus canker. This model was reviewed only because of the focus in my book on the origins of the 1900-ft rule. As stated in Chapter 9, the forecast model presented at a critical Task Force meeting, on November 16, 1999 by Dr. Gottwald prior to the promulgation of the 1900-ft policy by Commissioner Crawford. The minutes of this meeting are posted on the internet. The model results were likely presented on at least 3 separate occasions by Dr. Gottwald, which are the Task Force meeting, the International Citrus Canker Research Workshop, and in Broward County court.

The are few details on this model. It is recognized that in the preliminary research efforts, researchers are not obligated to provide details on methodology. In fact, when this model was first presented in November 1999, Dr. Gottwald stated that the model might go be further refined.

All basic information for this review was from viewgraphs as provided in the 2000 Broward Court case and is provided at the end of this review. It is likely this model was presented at the Citrus Canker International Research Workshop ICCRW), because at the bottom of the viewgraph presented in Broward Court, it is written, "Canker Workshop June 2000 Epidemiology.ppt,"

According to the transcript of the workshop, Dr. Gottwald presented a model capable of making forecasts of three tropical storms or hurricanes, Floyd, Harvey and Irene. The minutes of the November 16, 1999 Task Force Meeting are posted on the website, and Dr. Gottwald provides forecasts of the new incidences of canker from the same three storms.

The modeling work seems exclusively done by Dr. Gottwald, so a name that bears his name seemed appropriate in this case.

REVIEW OF MODEL EQUATION AND PREDICTIONS

The following equation was presented in November 2000 Broward Court hearing:

$$DI = a + b\sqrt{100y} + c\sqrt{100p} + d\sqrt{100p \cdot g}$$

where *y, p*, and *g* are the number of infected trees, precipitation in inches and wind gusts in mph, evaluated at an initial time, t_o, and DI, is the cumulative number of infected trees after 107 days. The constants in the equation for *a, b, c,* and *d* are -48.8, 62.1, -34.3 and 5.6, respectively. Values of constants to six figure accuracy are provided in the copy of the viewgraphs are provided at the end of this appendix.

When presented at the June 20, 2000 ICCRW meeting, Dr. Gottwald stated he decided to "flatten" the model, which likely means the use of square root of the variables. As the number of infected trees increases in an area, there are less available host trees, thus diminishing infection rates. This is discussed in Chapter 6, as part of the disease progress curves.

The measures used in this review were the delta increase in disease and the percentage increase using the Gottwald model as follows:

$$\Delta\, Increase = DI - y$$

$$Percent\ increase = \frac{DI - y}{y} x\ 100$$

Initially, two cases were examined in this review: (1) Zero rainfall and precipitation and (2) 5" of rain and 40 mph wind. The results are shown in Table 1 below in terms of percentage increase:

Table 1: Percentage Increase and delta increases from Gottwald's Model

	Percentage increase		Increased Incidences	
y	Zero Case	40 x 5 Case	Zero Case	40 x 5 Case
500	168%	172%	839	860
1000	91%	94%	915	940
1500	57%	59%	857	885
2000	36%	38%	729	760

The zero case had conditions of zero wind and rain. The 40 x 5 case had conditions of 40 mph wind gusts and 5" of rain. The model predicts that 168% increase in disease incidences,

occurring after a day with no storm event if there are 500 uncut infected trees, while there would be a 172% increase if there were a 40 mph wind and 5" of rain. The model appears to be relatively insensitive to changes in wind speed and rainfall.

The model was run with a series of cases, with the y variable ranging from 500 to 2000, the rain variable from 0 to 5" and the wind gust variable in the range of 0 to 40 mph. The results are shown in Tables 2, 3 and 4. Table 4 shows the increases vary from 557 to 938 newly infected trees if the cases with zero rain and zero wind gusts are excluded.

The model further extends an improper correlation analysis. A statistical trick was used (cumulatively summed variables) to obtain a high correlation. Most likely, 107 days after a tropical storm, the cumulative number of infected trees is higher, because every day surveyors were going into new areas and discovering more infected trees. Every month has a higher cumulative number of trees because it is impossible to make an exhaustive search of the approximately 1,000 square miles in Miami-Dade County.

Finally, the forecast equation is based on the "synthetic chronology" as explained in Appendix B. The synthetic chronology substracts the date of the oldest lesion from the discovery date to obtain the onset of infection, or initial infection date. Latency is taken into account in this calculation. Logically, infection should occur soon after a storm, not months later. It is the appearance of identifiable lesions which may take months or years to develop.

PRESENTATION BY DR. GOTTWALD ON RECENT STORM EVENTS

The table below shows the input and results as presented in Broward Court in November 2000. A copy of the slide is provided in Figure 2 at the end of this appendix. It is likely a similar table of inputs results was presented at the November 16, 1999 task force meeting and at the International Citrus Canker Research Workshop on June 20, 2000.

Table 2: Disease Increase Model for Citrus Canker. :

Disease Increase Model for Citrus Canker					
	Num Trees Infected i-alpha (yo)	Precipitation (in)	Wind Gust (mph)	Est. Num New Infected Trees in 107 days	Est. Num New Infected Trees in 107 days
Floyd	1000	1	35	1902.3	902.3
Harvey	1000	2	50	1968.4	983.4
Irene	1000	18	90	2707.8	1707.8
					3593.5
Floyd	600	1	35	1326.9	826.9
Harvey	1228	2	50	2286.1	960.1
Irene	2285	18	90	3713.6	1427.6
					3214.6

Based on 3 storms which passed through Miami in late 1999, the model estimates 3594 trees would become infected, assuming 1,000 infected trees were present prior to the storms. The second set of calculations estimates 3215 new infected trees using different values for the number of infected trees. As shown in the prior section, this model would have predicted 3 storms with zero rain and wind would have resulted in 2,715 new infected trees.

The details on the three storms are as follows:

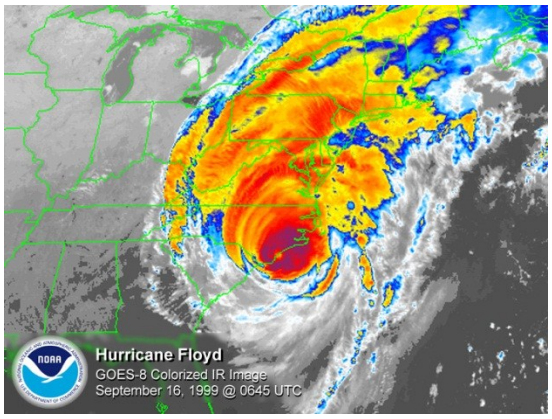
- Hurricane Floyd (September 7 to 18, 1999) passed over the Bahamas and it hard in North Carolina. With only 1" of rain and maximum wind gusts up to 35 mph, it clearly missed Miami.
- Tropical storm Harvey (September 19 to 22, 1999) passed over Naples and continued in a north easterly across Florida. Initially rainfall was as much as 10" as it passed over Naples, it rained only 2" when it cross over Miami.

- Hurricane Irene (October 13 to 18, 1999) passed over the Florida Keys and Miami-Dade, Broward and Palm Beach counties. The highest recorded wind speed was in the Big Pine Key with 102 mph winds. It is noted that in 2001, citrus canker was discovered on Big Pine Key.

IMPACT ON THE 1900-FT RULE

Figure 1 below is a satellite photograph of Hurricane Floyd. Although it clearly missed Florida, with only 1" of rain and 35 mph, it is certainly an eye catching photograph.

Figure 1: Hurricane Floyd as it passed over North Carolina



In Dr. Gottwald's 2001 article, he states the reasons for the delay in the implementation of the 1900-ft rule.

> The timely implementation of the 1,900-ft rule and the sentinel tree grid system would not have been feasible in 1999, given existing funding and manpower constraints. However, once the results of the epidemiology study became widely known and understood, citrus industry groups pressured the CCEP for a more effective eradication effort. These groups immediately lobbied state and federal sources for stepped up financial support of the 1,900-ft rule. Within a matter of days, the Governor and Commissioner of Agriculture of Florida announced that 175 million of combined state and federal assistance.

Dr. Gottwald is possibly referring to the November 16, 1999 Task Force meeting, where both Dr. Gottwald and Mr. Richard Gaskalla urged support of the 1900-ft rule. It may have been, as Dr. Gottwald states, that following the November 16, 1999 Task Force meeting, the citrus industry groups lobbied for the 1900-ft rule, with compensation and an industry-friendly risk assessment program. Approximately 76 million dollars was allocated for compensation to growers. Although the Task Force had voted to recommend the 1900-ft policy, it is likely the Commissioner of FDACS and Governor Bush would not approve the eradication program until it included compensation for growers.

The "results of the epidemiology study" is likely the potential of tropical storms, hurricanes and tornados being able to disseminate citrus canker from the south of Florida to the central

growing regions. The general theme of the presentation is is to alert growers that citrus canker is headed your way and you don't have much time left.

The minutes of the meeting state,

> Tim *[Dr. Gottwald]* talked about the different hurricanes that have occurred this season (i.e., Floyd, Harvey and Irene.) Hurricane Floyd skirted up the coast and Tim reported that he wanted to use that as an example of what was going on with a hurricane... .

Further in the meeting, the minutes state:

> Tim *[Dr. Gottwald]* said he is going to make a plea and it is that going to 125 feet isn't going to do it, nor will 800 feet. If you want to have an effect, you will have to take much more out. Normal rain storm events can spread the disease 1900-ft.

SUMMARY

1. The model further extends an improper correlation analysis between storm events and citrus canker incidences.

2. The validity of the model can not be reviewed in a "bottom's up" manner as it has never been formally published.

3. The cases of zero rain and zero wind gusts produced a range of increases of between 729 to 839 new infected trees. Considering all other cases of less than 5" of rain and wind gusts up to 40 mph, the model results in increase of between 557 to 938 newly infected trees.

4. The Gottwald canker forecast model has never been published. This review was undertaken because of historical reasons. The model predictions on three storms was part of the "epidemiology research" aimed at advancing the 1900-ft policy as identified in a January 2001 article by Dr. Gottwald.

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