

Estimating Spread of Citrus Canker in Urban Miami via GPS

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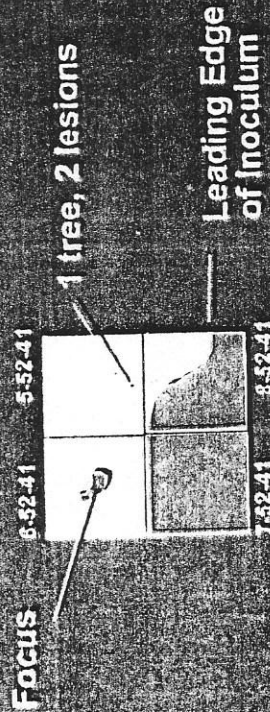


Agricultural
Research
Service

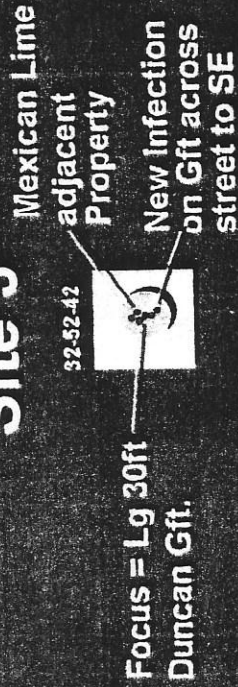


Miami Citrus Canker Epidemiology Research Sites

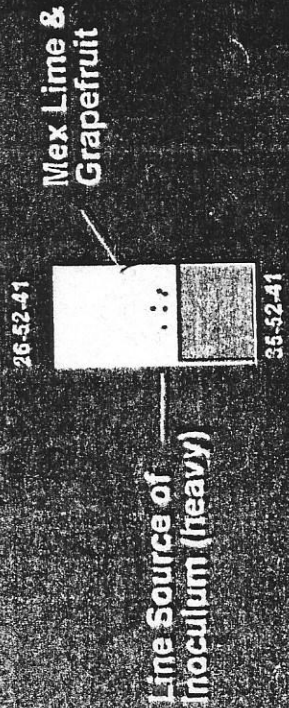
Site 1



Site 3



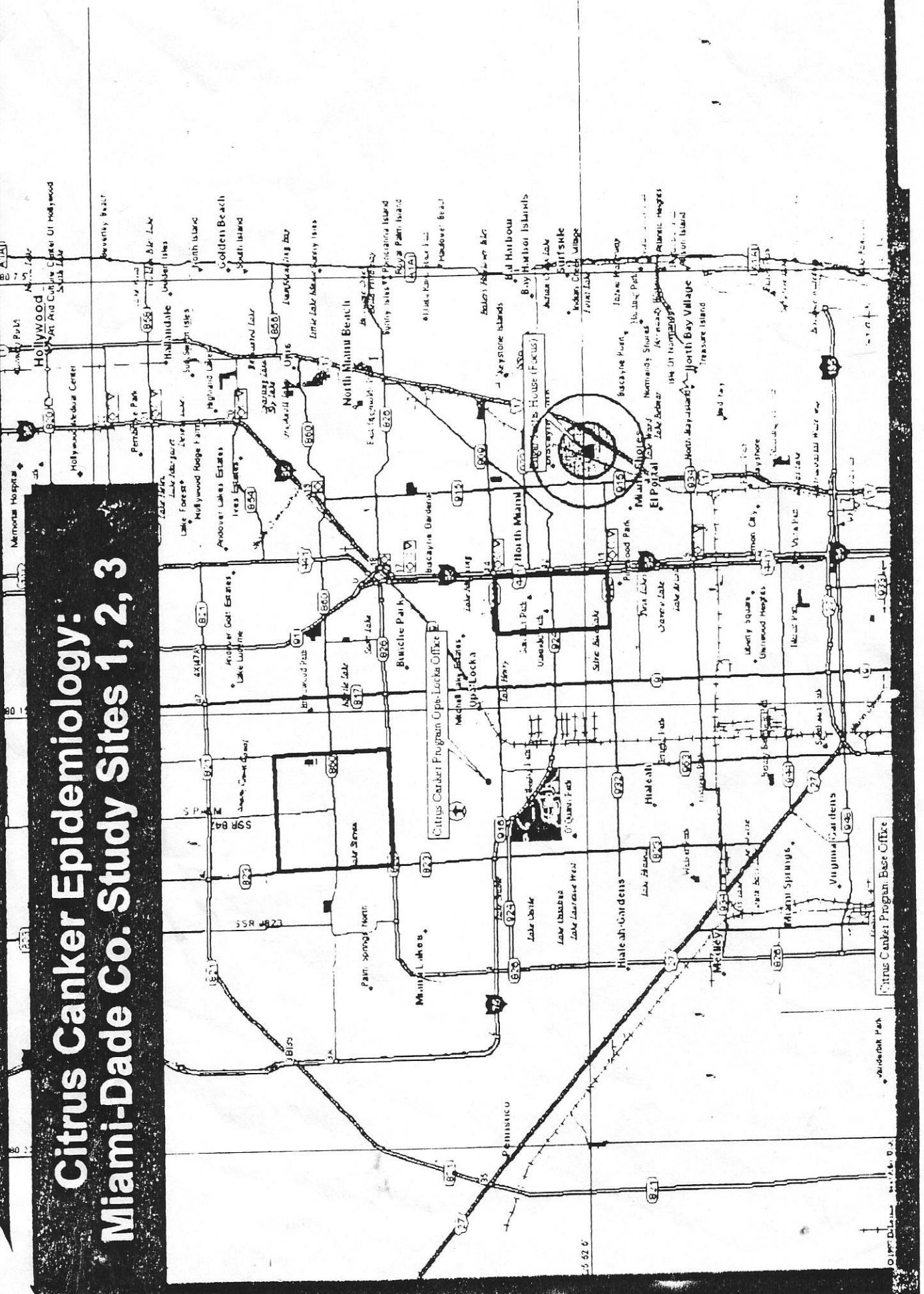
Site 2



Also established a subsequent 4th site in Broward Co.

Total > 19,000 trees tracked via DGPS

Citrus Canker Epidemiology: Miami-Dade Co. Study Sites 1, 2, 3



Miami Epidemiology Study Site 1: Voronoi tessellation of all trees

2870.9

2870.5

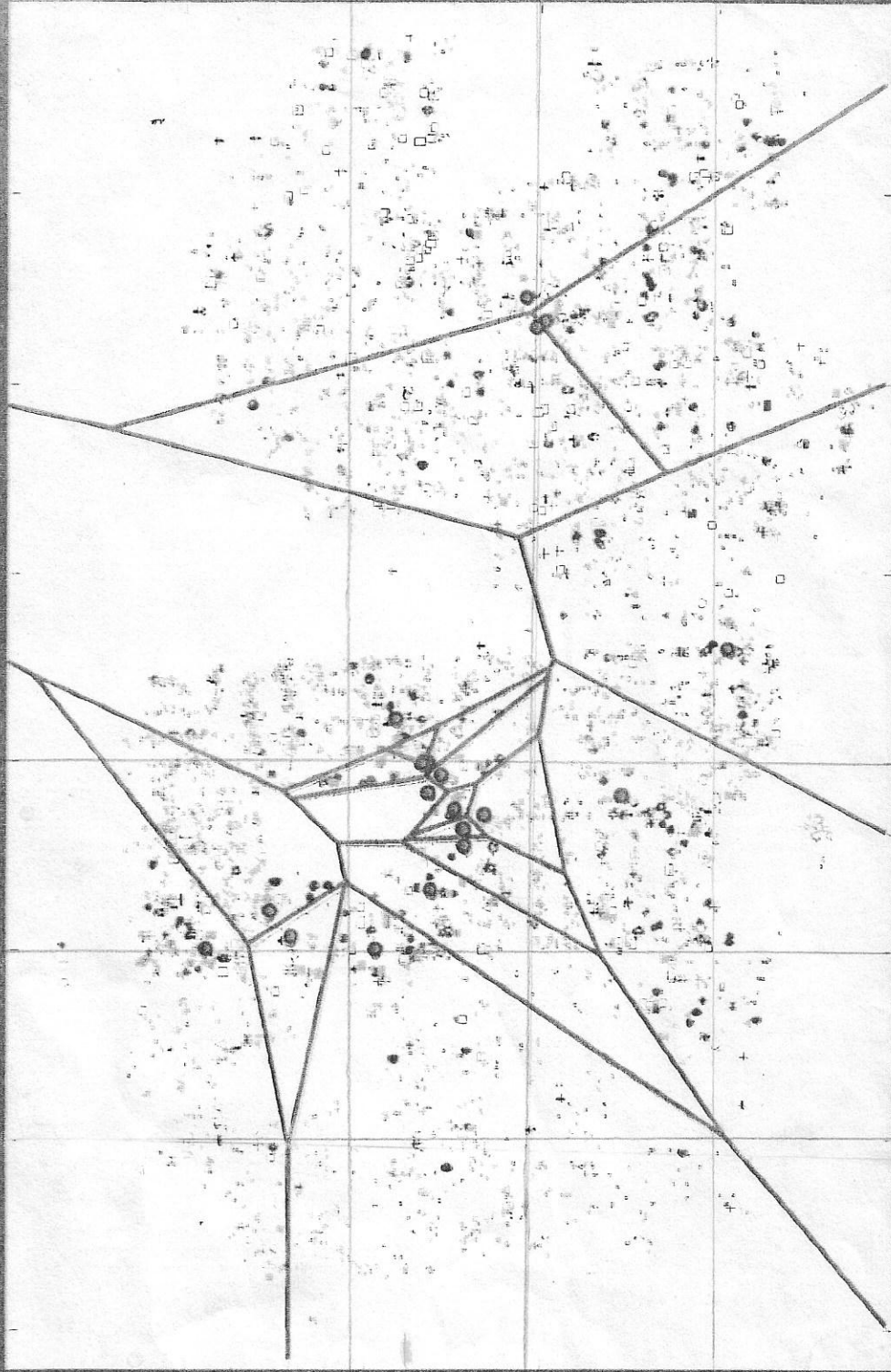
2870.1

2869.7

2869.3

2868.9

UTM N



429.5

429.0

428.5

428.0

427.5

427.0

426.5

426.0

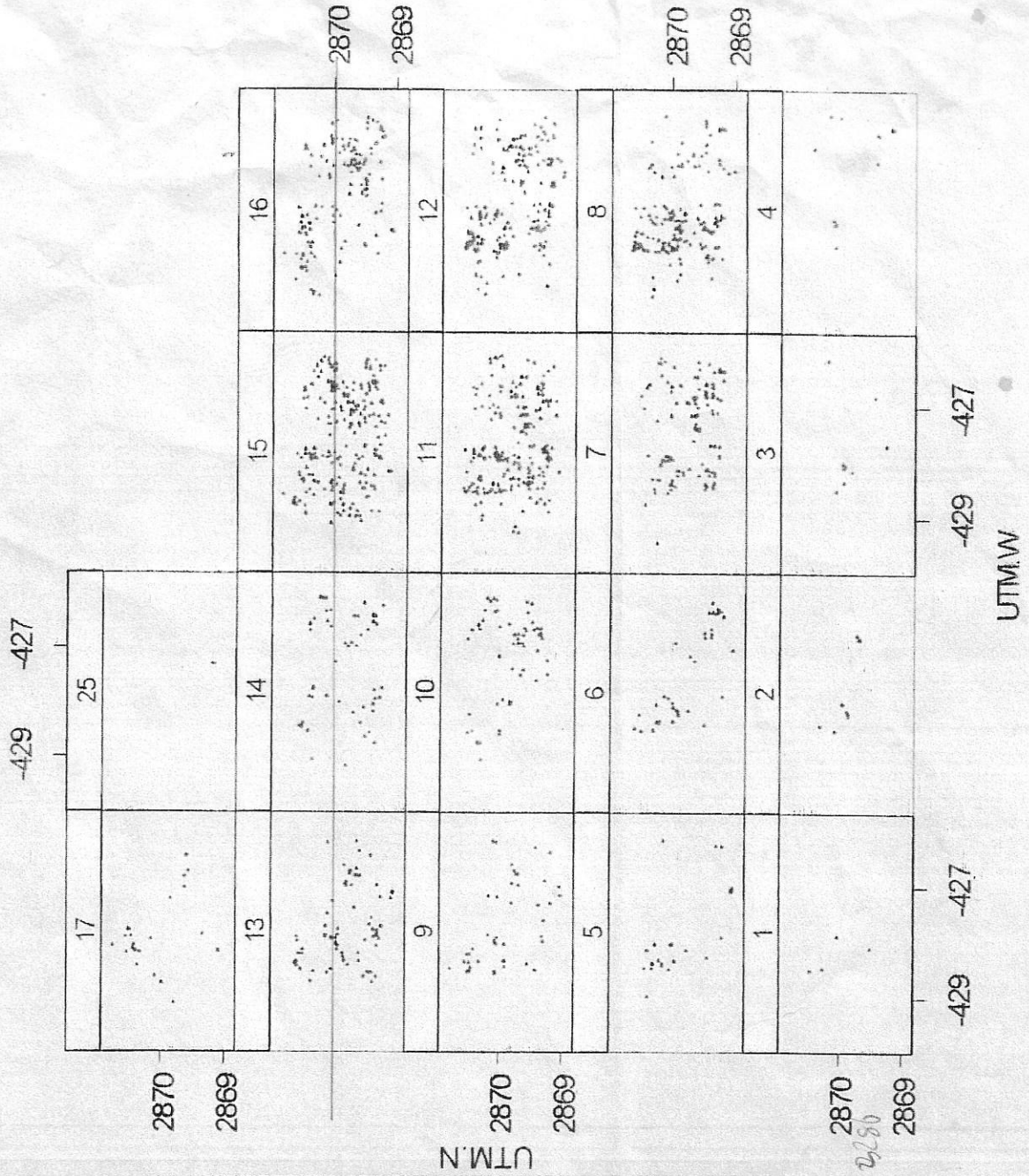
UTM W

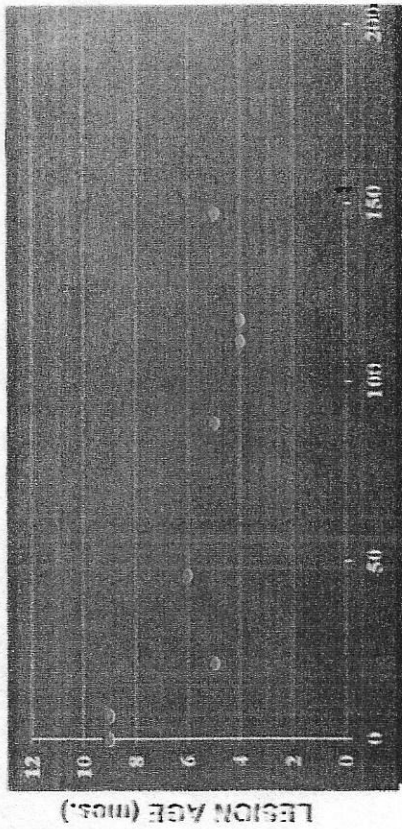
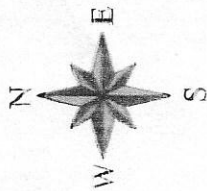
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Miami Site 1 Data

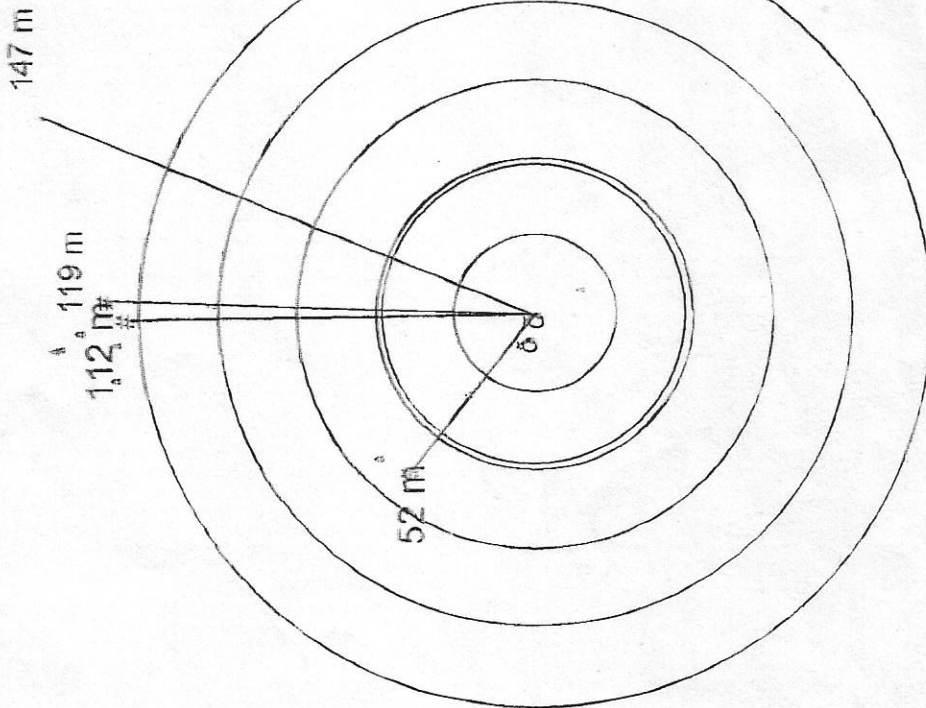
Trellis graph of
cancer incidence
data parsed into
30-day intervals

Miami Site 1





DISTANCE (m)



Broward 3

- 0 Lesion Age 9 months
- # Lesion Age 6 months
- # Lesion Age 5 months
- # Lesion Age 4 months
- A Healthy Trees

0 100 Meters



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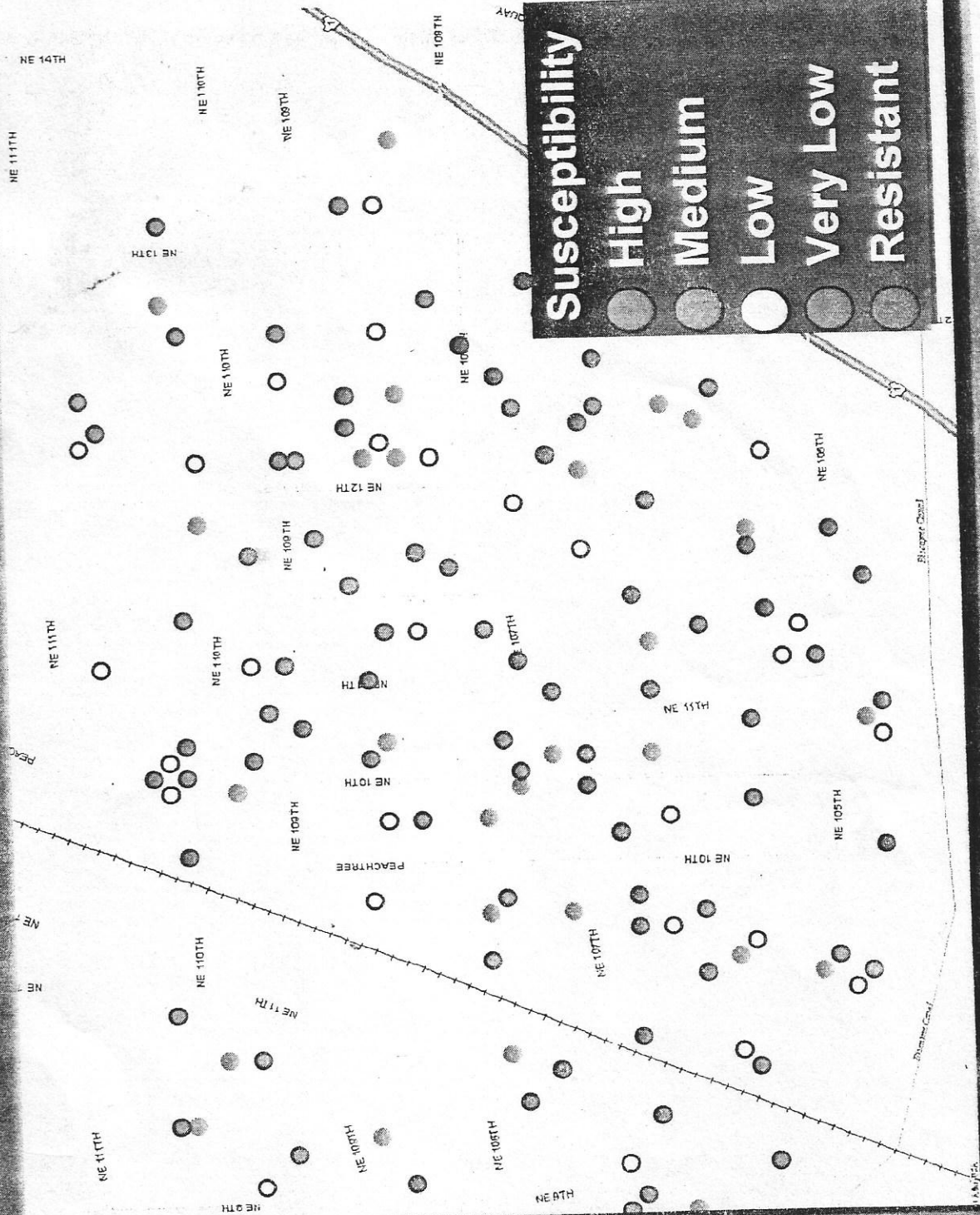
Disease Spread Restrictions Due to Host Susceptibility

usceptibility: can vary greatly depending upon :

- Cultivar resistance
- Host health
- Horticultural care
- Growth stage, etc.

as a result,

- 1) Plant material in an area varies widely in susceptibility
- 2) There is not a uniform distribution of susceptible plants.
- 3) Traditional disease gradients cannot be calculated



Site 1: Second 2-Month Window

Canker Circumscribed

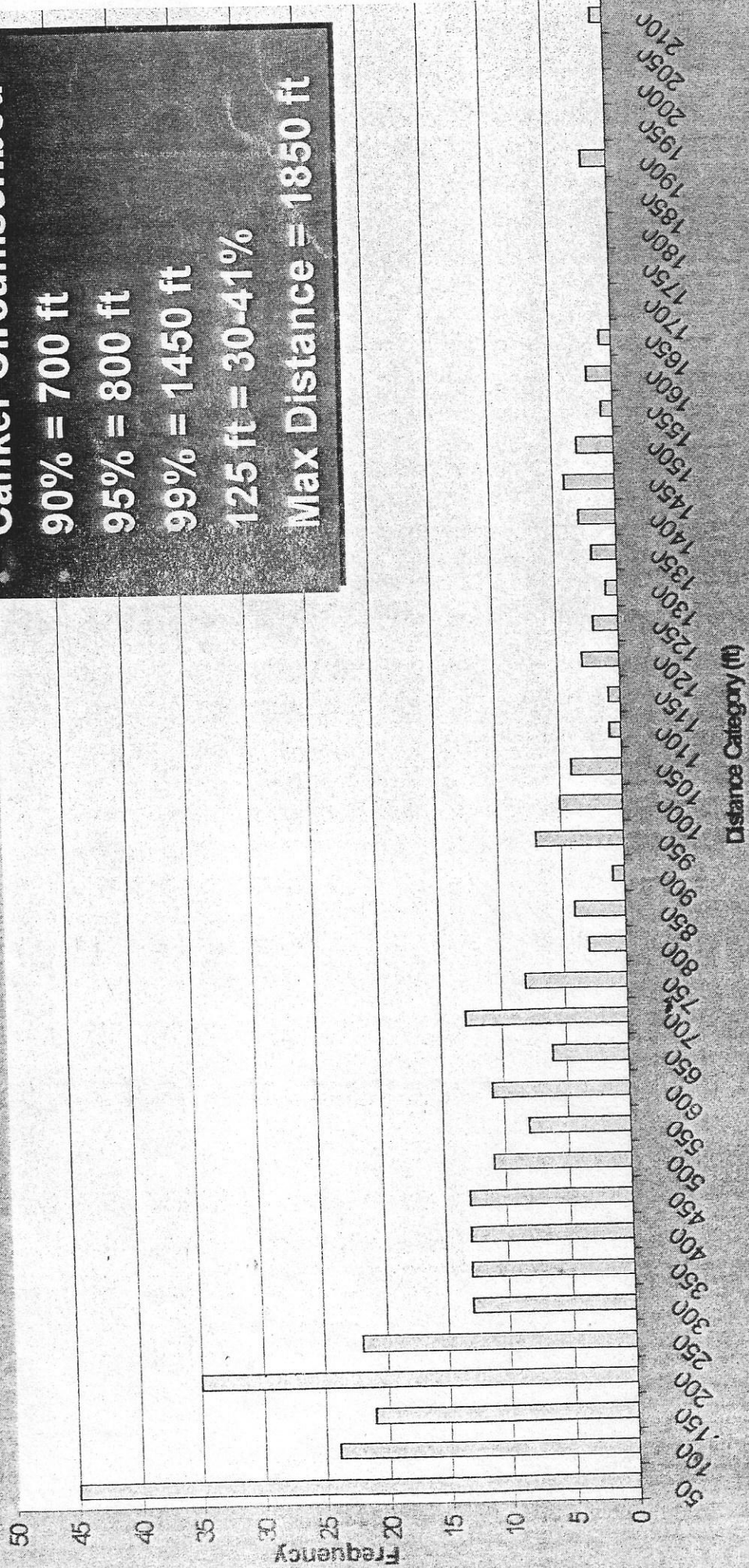
90% = 700 ft

95% = 800 ft

99% = 1450 ft

125 ft = 30-41%

Max Distance = 1850 ft



Citrus Canker Urban Epidemiology - Site 1

Total trees: 6051 Diseased: 1752 (29%)

Focal to secondary tree infected tree distances were calculated via a VB routine.

Distances are presented to the nearest 50 ft.

Possible distance of spread diminishes with each successive temporal window examined.

CCEP regulatory agency decided to us the 99% level.

Temporal Window	No. Focal (Alpha) Trees	No. 2ndary-Infected Trees	% Captured at 125 ft	90%	95%	99%	Max. Distance
1st 1-Mo Window	38	15	13	800	4150	4150	4150
2nd 1-Mo Window	52	39	33	1450	1450	1650	1650
3rd 1-Mo Window	90	73	41	1200	1600	1900	1900
4th 1-Mo Window	162	235	30	700	800	1450	1850
5th 1-Mo Window	396	124	36	350	500	700	750
6th 1-Mo Window	519	32	69	250	950	950	950
1st 2-Mo Window	38	53	24	1450	1450	4150	4150
2nd 2-Mo Window	90	307	22	1050	1400	1650	2100
3rd 2-Mo Window	396	155	39	350	600	950	950
4th 2-Mo Window	550	490	56	300	350	700	850
1st 3-Mo Window	38	125	24	1400	1450	3200	4150
2nd 3-Mo Window	90	430	22	950	1250	1600	2100
3rd 3-Mo Window	396	420	45	350	450	700	950
1st 4-Mo Window	38	359	14	1400	1650	2150	4150
2nd 4-Mo Window	90	461	21	950	1300	1800	2250
3rd 4-Mo Window	396	644	46	350	650	850	950

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Citrus Canker Urban Epidemiology - Site 2

Total trees: 6019 Diseased: 971 (16.1%)

- Focal to secondary infected tree distances were calculated via a VB routine.
- Distances are presented to the nearest 50 ft.
- Possible distance of spread diminishes with each successive temporal window examined.
- CCEP regulatory agency decided to us the 99% level.

Temporal Window	No. Focal (Alpha) Trees	No. 2ndary-Infected Trees	% Captured at 125 ft	90%	95%	99%	Max. Distance
1st 1-Mo Window	21	17	17.6	2050	3400	3400	3400
2nd 1-Mo Window	28	7	14.3	950	950	950	950
3rd 1-Mo Window	30	1	0	450	450	450	450
4th 1-Mo Window	53	23	39.1	450	500	700	700
5th 1-Mo Window	130	31	48.4	450	1050	2050	2050
6th 1-Mo Window	253	48	68.8	400	450	550	550
1st 2-Mo Window	21	24	12.5	2700	3050	3400	3400
2nd 2-Mo Window	30	23	39.1	450	500	700	700
3rd 2-Mo Window	82	80	52.5	400	500	2050	2050
4th 2-Mo Window	253	205	38.5	800	800	1900	1950
1st 3-Mo Window	21	24	12.5	2750	3050	3400	3400
2nd 3-Mo Window	30	54	39.1	450	700	2050	2050
3rd 3-Mo Window	82	179	52.5	550	1050	3050	3050
4th 3-Mo Window	253	210	38.5	800	1000	1900	1950
1st 4-Mo Window	21	47	12.7	2150	2750	3400	3400
2nd 4-Mo Window	30	102	35.3	450	600	1600	2050
3rd 4-Mo Window	82	283	30	1500	2250	3050	3100
4th 4-Mo Window	253	278	36.7	750	1000	1950	2200

Citrus Canker Urban Epidemiology - Site 3

Total trees: 1094. Diseased: 32 (2.9%)

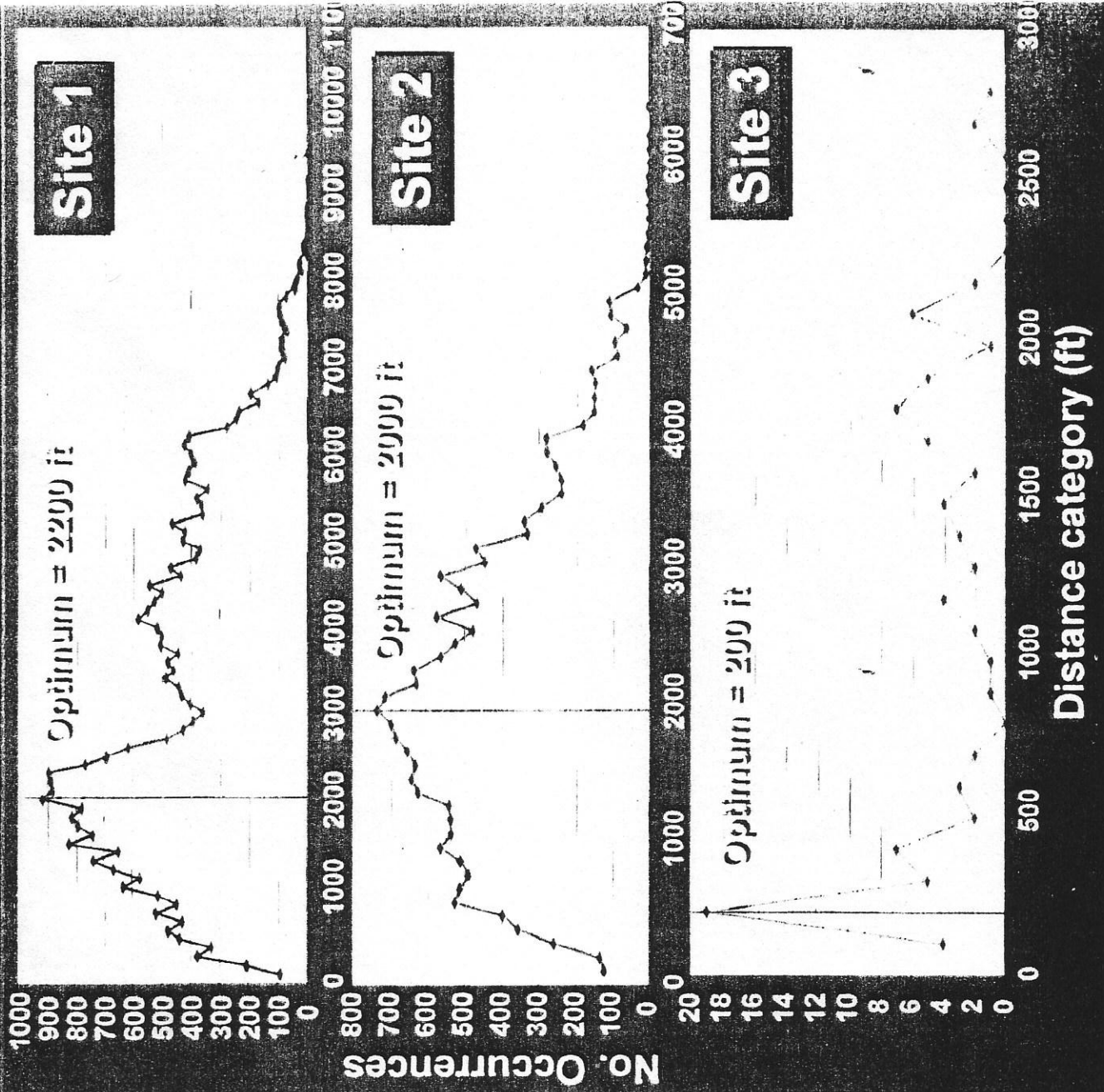
- Focal to secondary infected tree distances were calculated via a VB routine.
- Distances are presented to the nearest 50 ft.
- Possible distance of spread diminishes with each successive temporal window examined.
- CCEP regulatory agency decided to us the 99% level.

Temporal Window	No. Focal (Alpha) Trees	No. 2ndary: Infected Trees	% Captured at 125 ft	90%	95%	99%	Max. Distance
1st 1-Mo Window	2	2	0	200	200	200	200
2nd 1-Mo Window	8	6	33.3	1950	1950	1950	1950
3rd 1-Mo Window	15	10	20	900	900	900	900
4th 1-Mo Window	18	5	0	850	850	850	850
1st 2-Mo Window	2	4	0	650	650	650	650
2nd 2-Mo Window	4	3	0	200	200	200	200
3rd 2-Mo Window	7	7	28.6	1950	1950	1950	1950
4th 2-Mo Window	15	15	6.7	900	900	900	900
1st 3-Mo Window	2	2	0	650	650	650	650
2nd 3-Mo Window	3	3	0	200	200	200	200
3rd 3-Mo Window	7	7	0	1950	1950	1950	1950
4th 3-Mo Window	15	16	6.3	2000	2200	2200	2200
1st 4-Mo Window	3	4	0	650	650	650	650
2nd 4-Mo Window	7	3	0	200	200	200	200
3rd 4-Mo Window	7	7	0	1950	1950	1950	1950
4th 4-Mo Window	9	16	6.3	2200	2200	2200	2200

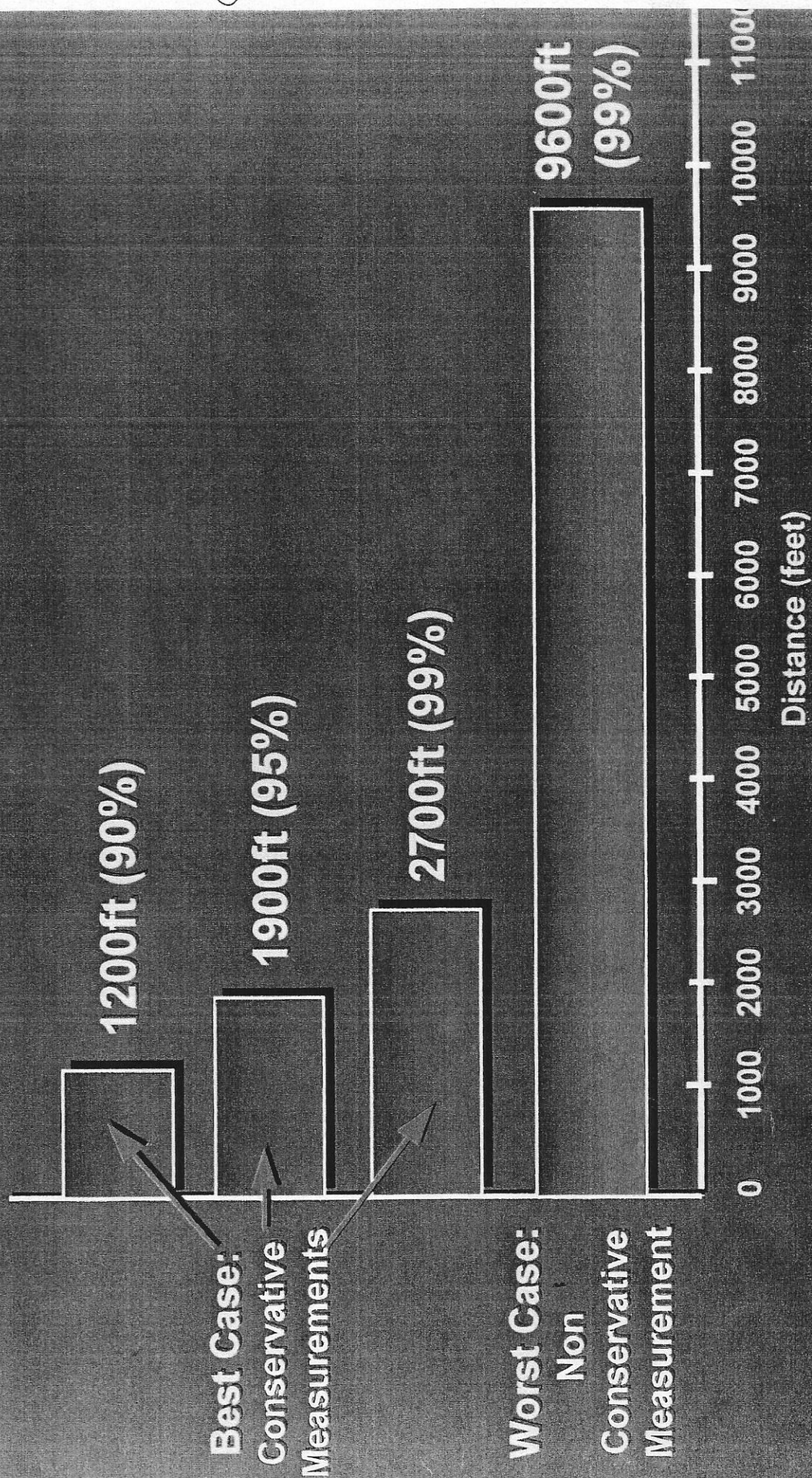
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Focal to Secondary- Infected Trees Distance Calculations

- Maximum distances were calculated via a VB routine.
- Number of occurrences are presented in 100 foot distance categories (increments).

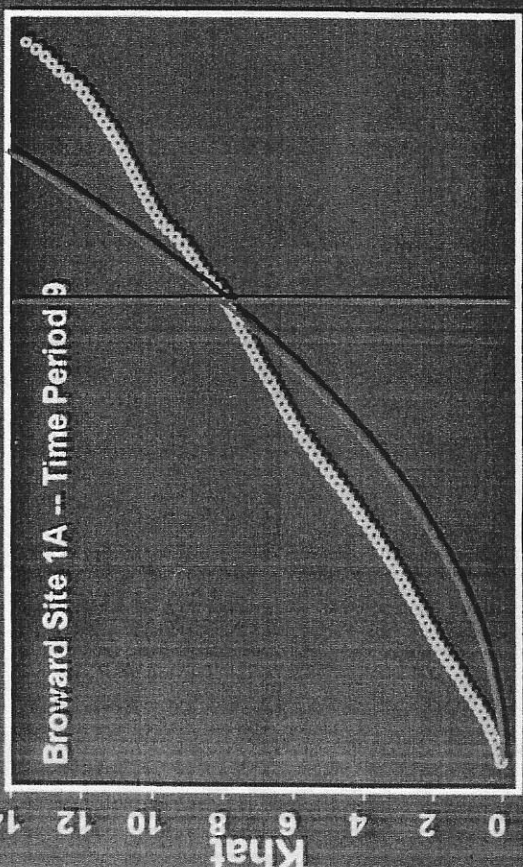
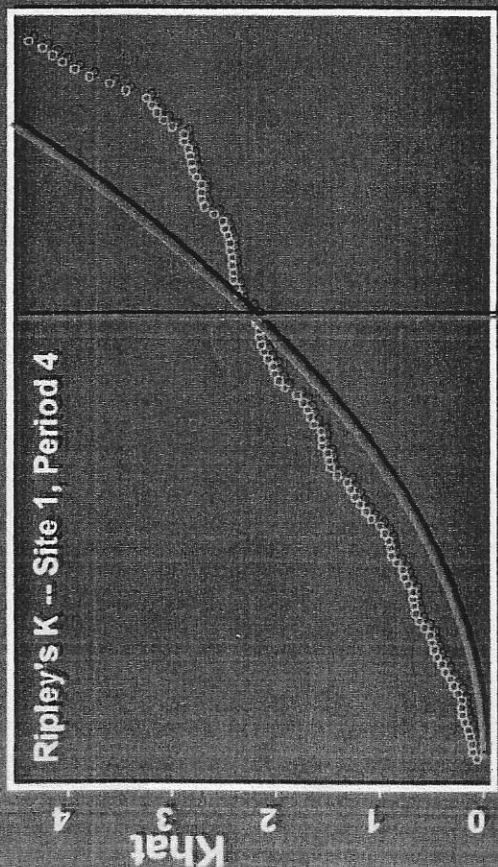
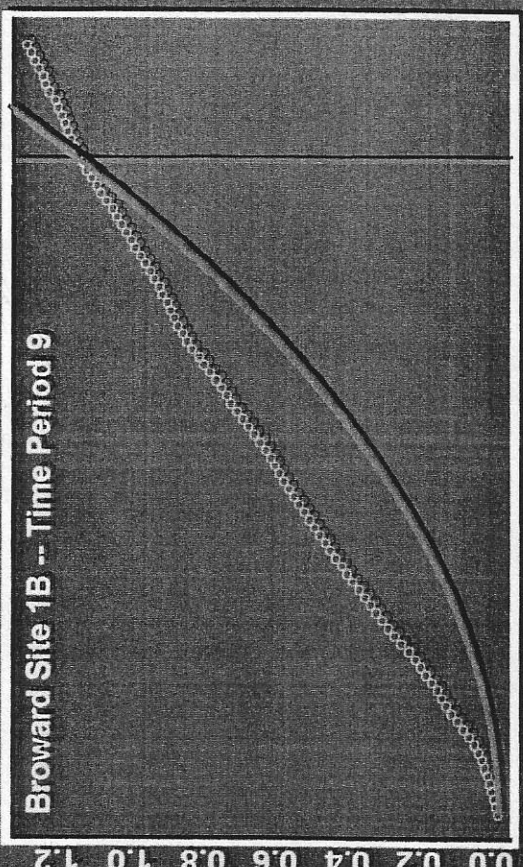
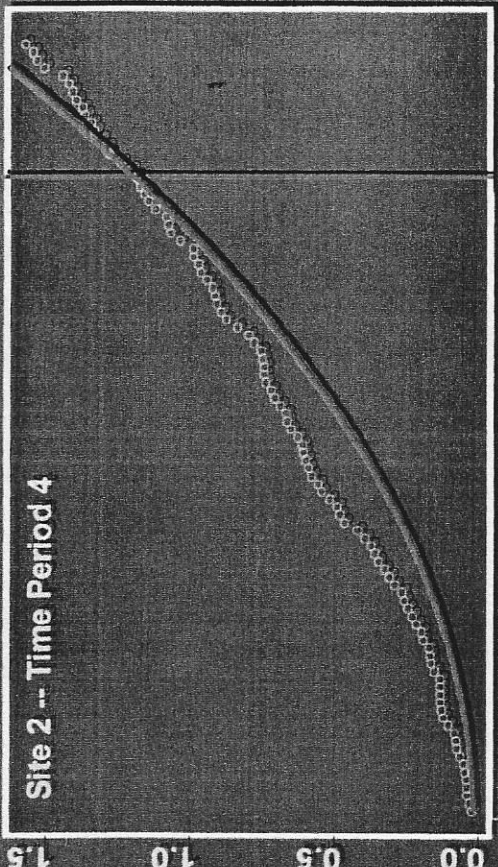


Extremes of the Canker Disease Spread Envelope Best Case and Worst Case Scenarios



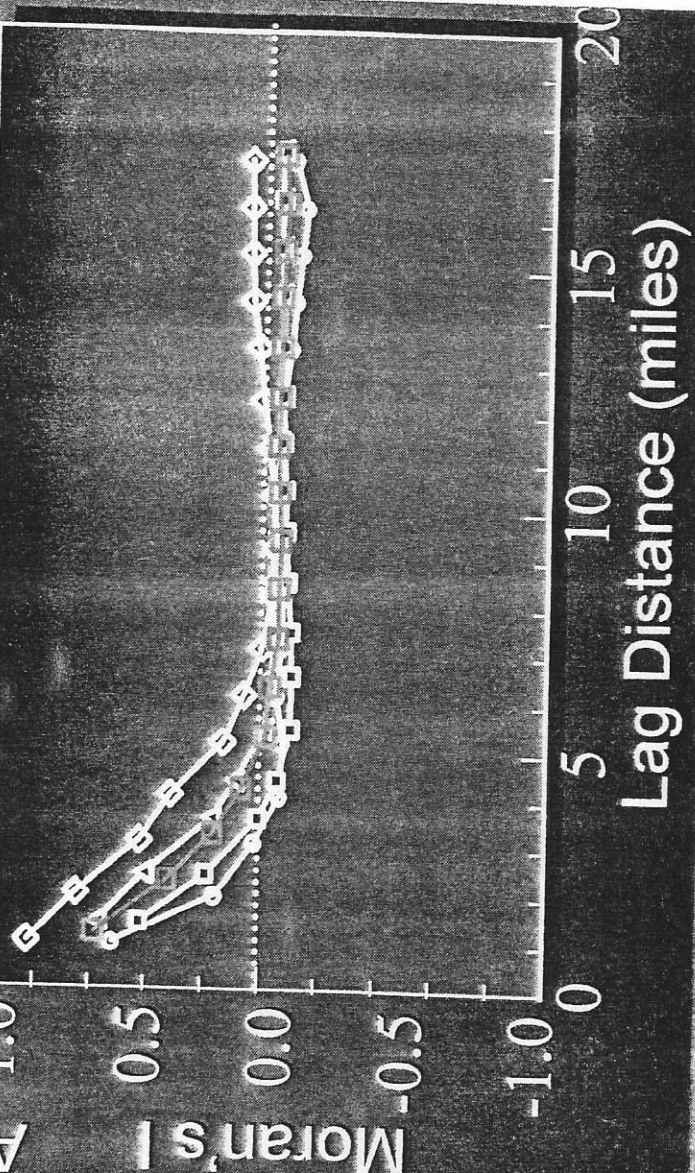
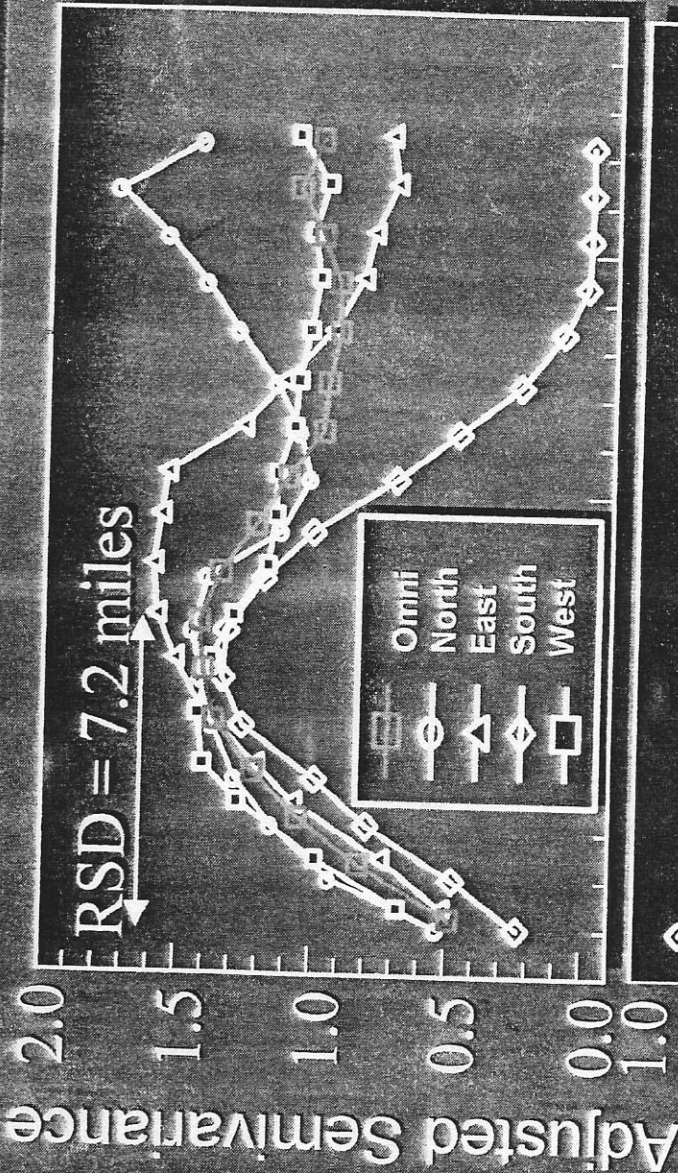
Ripley's K Calculation of Spatial Dependency

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Miami Citrus Canker Distribution: Spatial Analyses

RSD = Range of
Spatial
Dependency



Consistency of Findings

These findings are not inconsistent with those previously described under South Florida Grove conditions (Smoak Grove) discovered in October 1990. Plant Dis. 76:389-396. 1992.

Dissemination from lemon trees in adjacent property to new foci in grove were:

- 230 m (754 ft.)
- 410 m (1345 ft.)
- 810 m (2657 ft.)

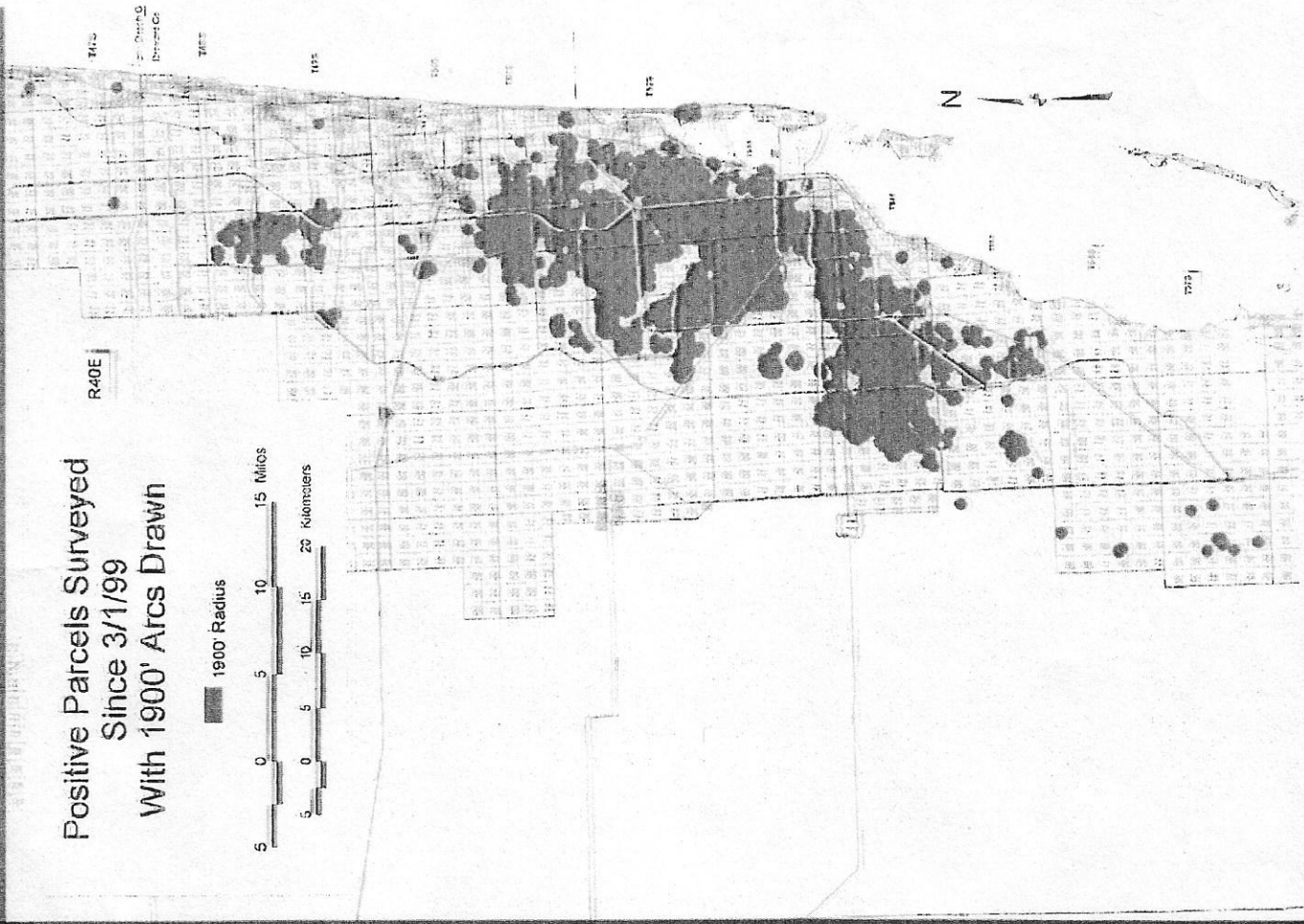
Spread was believed to be due to a mid August 1989 storm that passed over the area.

Application of the 1900-ft Rule In Miami Dade/Broward Co. Area

1900-ft radii drawn
around positive tree
locations (red circles).

Note how circles overlap
to effect "clear-cut" of
citrus from area.

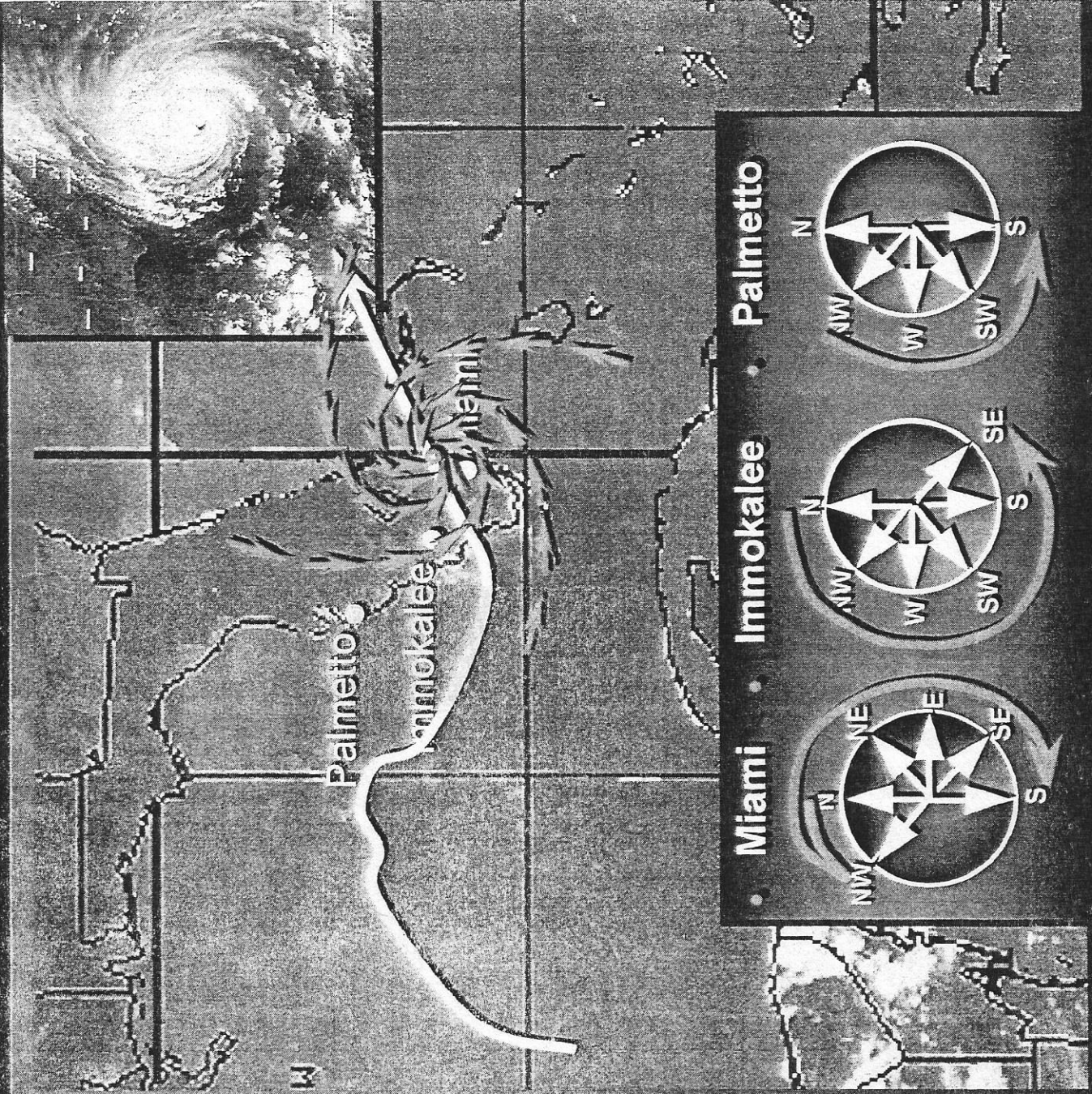
Projected that 750K to
1.5 million citrus trees
will be cut from the
infested area.



Tropical Storm Harvey Winds Sept 21, 1999

Rain 2+ inches
Max Sustained winds
50 mph
Wind gust Miami
> 41 mph

Winds in Miami
N,NW,N,E,SE,S
Immokalee
N,NW,W,SW,S
Palmetto
NW,W,SW,S



Citrus Canker Disease Increase Model

$$DI = a + b\sqrt{y_{lag107}} + c\sqrt{p_{lag107}} \times 100 + d\sqrt{g_{lag107}} \times 100$$

Where:

DI = Predicted number of canker-infected trees at t_{+107da}

y_{lag107} = Number of canker-infected trees at t_0

p_{lag107} = Precipitation in inches at t_0

g_{lag107} = Wind gust in mph at t_0

$a = -49.789542$

$b = 62.130538$

$c = -34.316483$

$d = 5.587152$

- The model is constrained:
- The model is valid for a range of 500 to 2500 existing diseased trees.
- Saturation effect: The model assumes a diminishing number of trees available for infection as the number of existing diseased trees increases.

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Conclusions

Citrus Canker increase in Urban Miami can be predicted by estimating:

- The number of existing infected trees.
- The amount of rain a storm event produces.
- The maximum wind gust association with a storm.

For Sept. - Oct. 1999, Floyd-Harvey-Irene events.
The model predicted (3598) 3000-4000 new canker-infected trees.

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Future Epidemiology Research Areas

- Correlation of spread data with meteorological data at 1km resolution and development of canker spread model.
- Evaluate canine detection/sensitivity to citrus canker volatile/aromatic compounds.
- Test for possible dissemination of Xcc from landfills used to dispose of infected/exposed trees.
- Evaluate the feasibility of remote sensing to detect canker at various lesion growth stages/cultivars/incidence levels (Borengasser).
- Continue survival/decontamination studies employing PLWCG.
- Evaluate most promising new canker control compounds against known benchmarks (Graham)
- Collaborate with Brazilians on canker spread and control projects in Brazil (Bergamin-Filho & Amorim, Liete)