Demonstration of a Sustainable Approach to Citriculture within a National Wildlife Refuge in the Indian River Area

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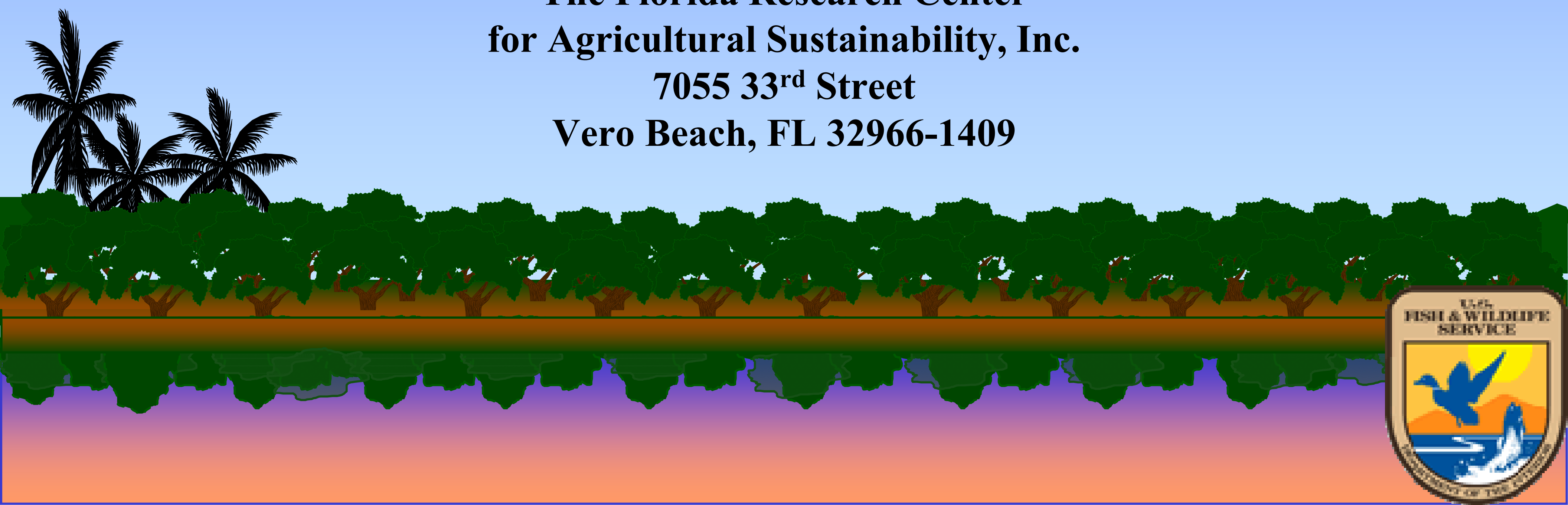


Dedication
And
In Memory of:

Cecil Edwin Bryan

Roy F. Roberts, Jr.

Who were principally responsible for the success of the project

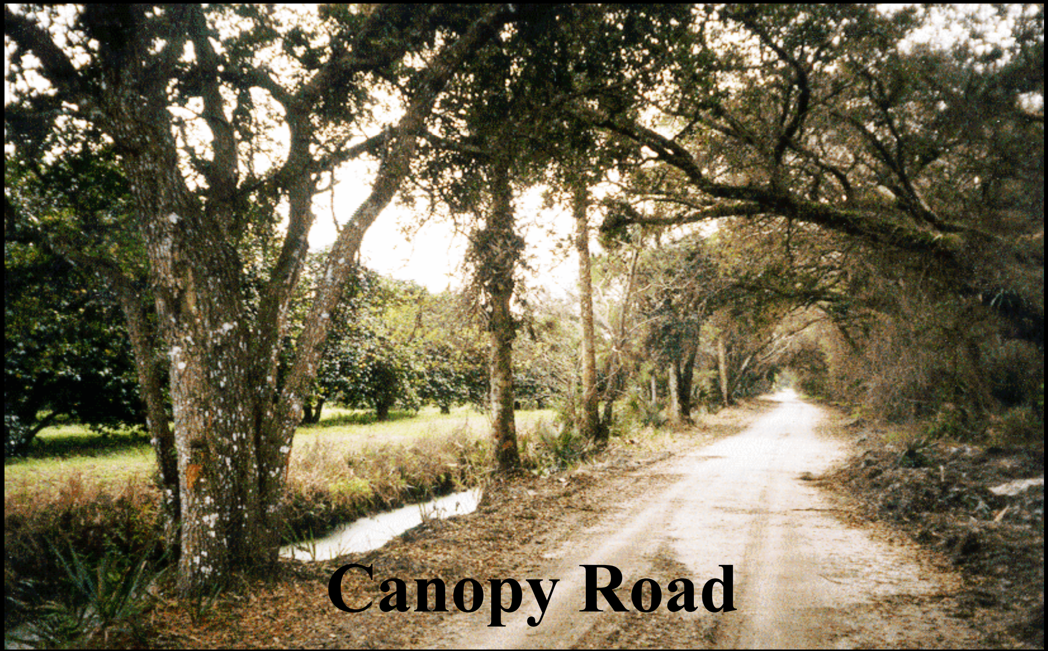
What is SUSTAINABLE AGRICULTURE* ?

"The integrated system of plant and animal production practices having a site-specific application that will, over the long-term:

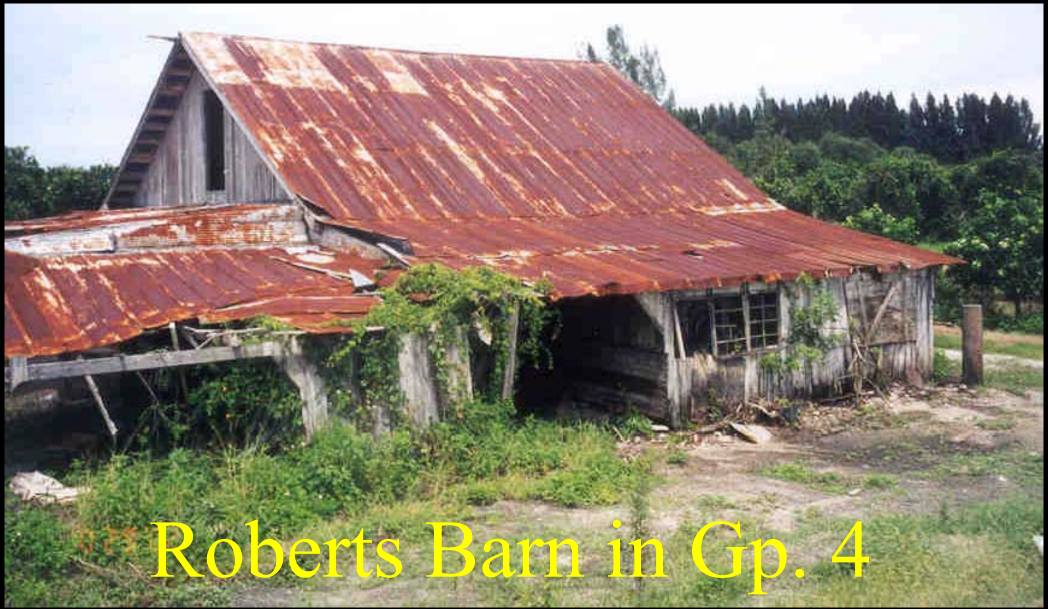
1. Satisfy human food and fiber needs
2. Enhance environmental quality and the natural resource base upon which the agriculture economy depends
3. Make the most efficient use of nonrenewable resources and on-farm resources and integrate, where appropriate, natural biological cycles and controls
4. Sustain the economic viability of farm operations
5. Enhance the quality of life for farmers and society as a whole"

* as defined by the National Research Council,1989

The groves at the MINWR the oldest active groves in the US and have a history of producing very high quality fresh fruit.



Canopy Road



Roberts Barn in Gp. 4

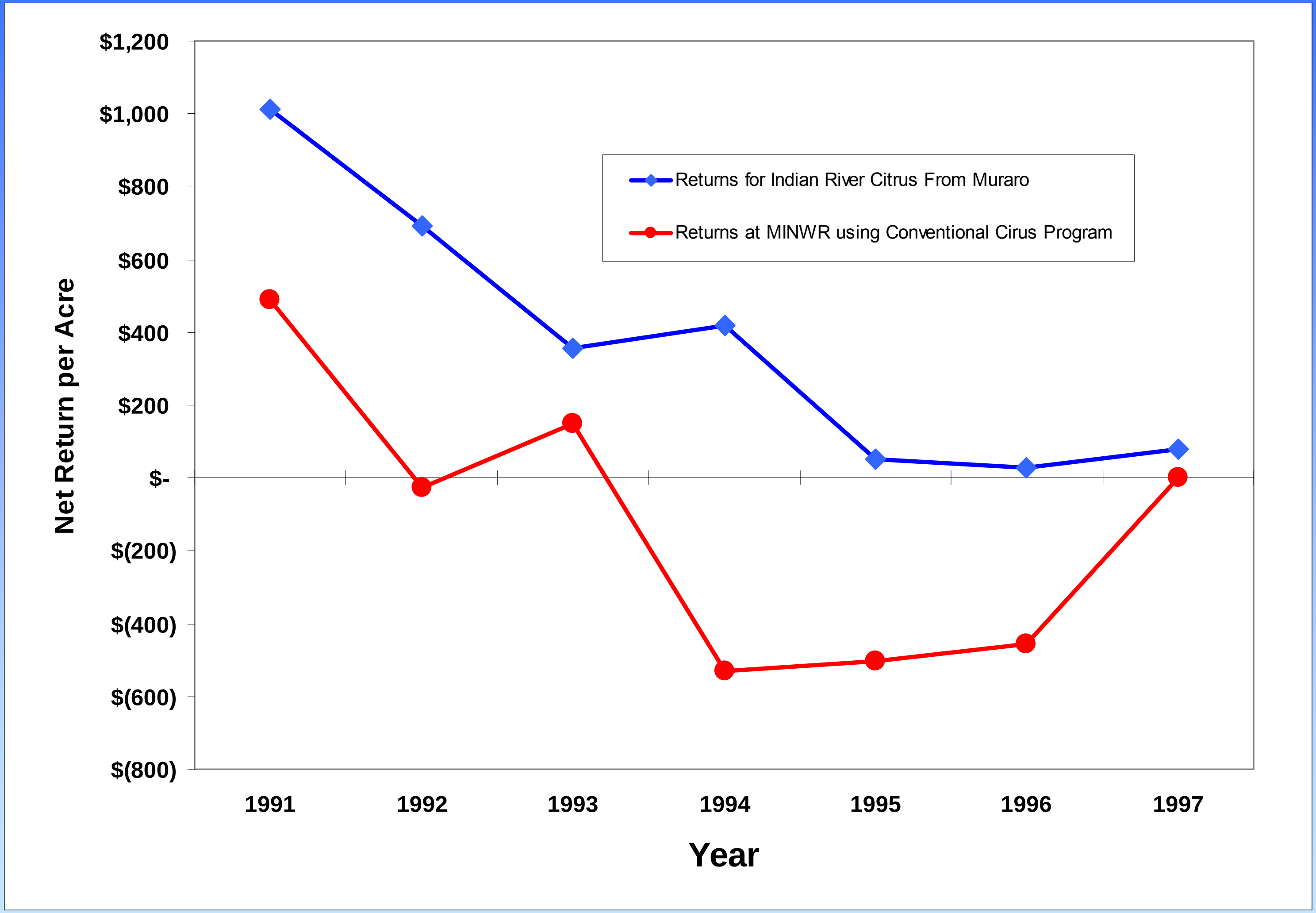
Dummett Homestead

A canopied grove road gives a sense of times past while the highway to the Kennedy Space Center adjacent to the groves, leads to the future.

Animals and native habitat intersect within the groves

The Citrus Groves at the Merritt Island National Wildlife Refuge (MINWR) represent an unique opportunity to demonstrate a Sustainable Citrus Program (SCP) with citrus groves intermingled and surrounded by pristine native habitat while at the same time in close proximity to the Kennedy Space Center.

Growers who bid on the citrus groves in the 90's, broke their leases in 1997 with the USFWS due to poor returns.

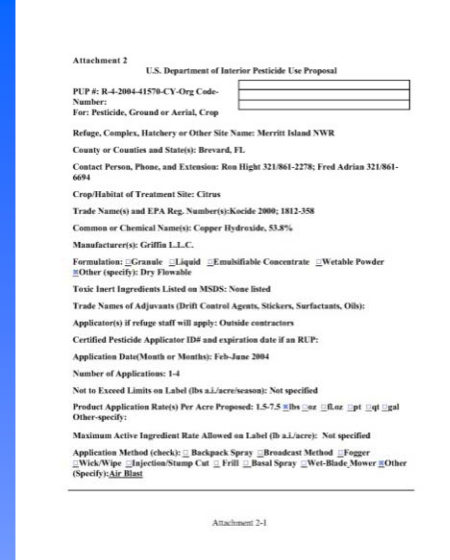


Graph of the 1991-1997 net returns for the government managed groves compared with the UF* net returns for the Indian River Citrus Region.

*R. Muraro, "Budgeting Costs and Returns for IR Citrus", IFAS, Univ. of Fla.

Purpose of
Sustainable Citrus Program

- To reduce chemical and other inputs to the citrus operations in the refuge
- To restore economic profitability to the groves
- To determine the horticultural and economic feasibility and environment aspects of a sustainable agricultural approach to citriculture at an operational scale
- To document and communicate the findings and developments produced by this project


Attachment 2

U.S. Department of Interior Pesticide Use Proposal

PUP #: R-4-2004-41570-CY-Org Code-Number:
For: Pesticide, Ground or Aerial, Crop

Refuge, Complex, Hatchery or Other Site Name: Merritt Island NWR

County or Counties and State(s): Brevard, FL

Contact Person, Phone, and Extension: Ron Hight 321/861-2278; Fred Adrian 321/861-6694

Crop/Habitat of Treatment Site: Citrus

Trade Name(s) and EPA Reg. Number(s):Kocide 2000; 1812-358

Common or Chemical Name(s): Copper Hydroxide, 53.8%

Manufacturer(s): Griffin L.L.C.

Formulation: ☐Granule ☐Liquid ☐Emulsifiable Concentrate ☐Wetable Powder ☒Other (specify): Dry Flowable

Toxic Inert Ingredients Listed on MSDS: None listed

Trade Names of Adjuvants (Drift Control Agents, Stickers, Surfactants, Oils):

Applicator(s) if refuge staff will apply: Outside contractors

Certified Pesticide Applicator ID# and expiration date if an RUP:

Application Date(Month or Months): Feb-June 2004

Number of Applications: 1-4

Not to Exceed Limits on Label (lbs a.i./acre/season): Not specified

Product Application Rate(s) Per Acre Proposed: 1.5-7.5 ☒lbs ☐oz ☐fl.oz ☐pt ☐qt ☐gal Other-specify:

Maximum Active Ingredient Rate Allowed on Label (lb a.i./acre): Not specified

Application Method (check): ☐ Backpack Spray ☐Broadcast Method ☐Fogger ☐Wick/Wipe ☐Injection/Stump Cut ☐ Frill ☐Basal Spray ☐Wet-Blade Mower ☒Other (Specify):Air Blast

Attachment 2-1

Primary Areas of Activity+

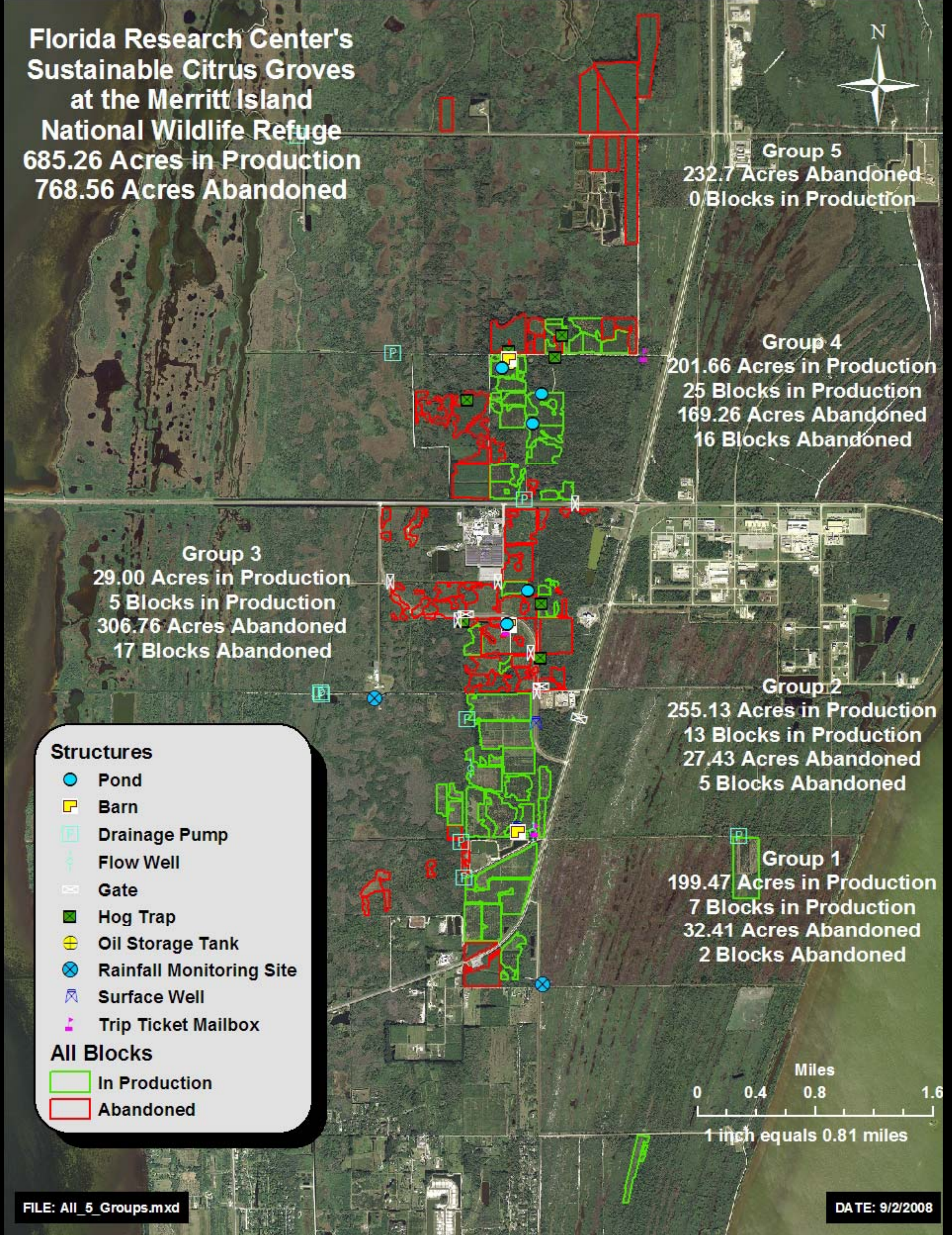
- Consolidate and Organize Existing Data
- Evaluate and Appraise Blocks in Terms of Productivity (Abandon or Keep in Production)
- Agronomic Aspects
  - Implement SCP
  - Detailed Recordkeeping, Inputs, Yields, Soil/Leaf Sampling & GIS
  - Grove Management and Data Collection
- Economic Study of Costs and Returns
  - Use IFAS Model Developed by R. P. Muraro
- Environment Impact of SCP on Citrus Groves
  - Third Party Quarterly Analysis of Storm Water for Nutrients and Pesticides (Monitoring & Compliance Issues)

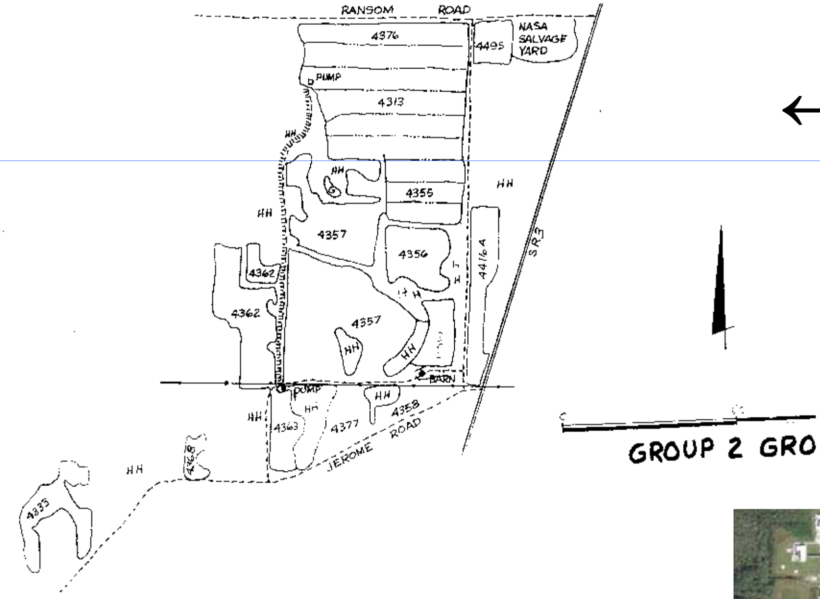
In 1998 the MINWR Groves comprised 1454 acres.

Over the 10 yr. duration of the project, 769 acres were abandoned due to:

- NASA expansion, roads, borrow pits
- Poor tree condition
- Abandonment of unprofitable blocks.

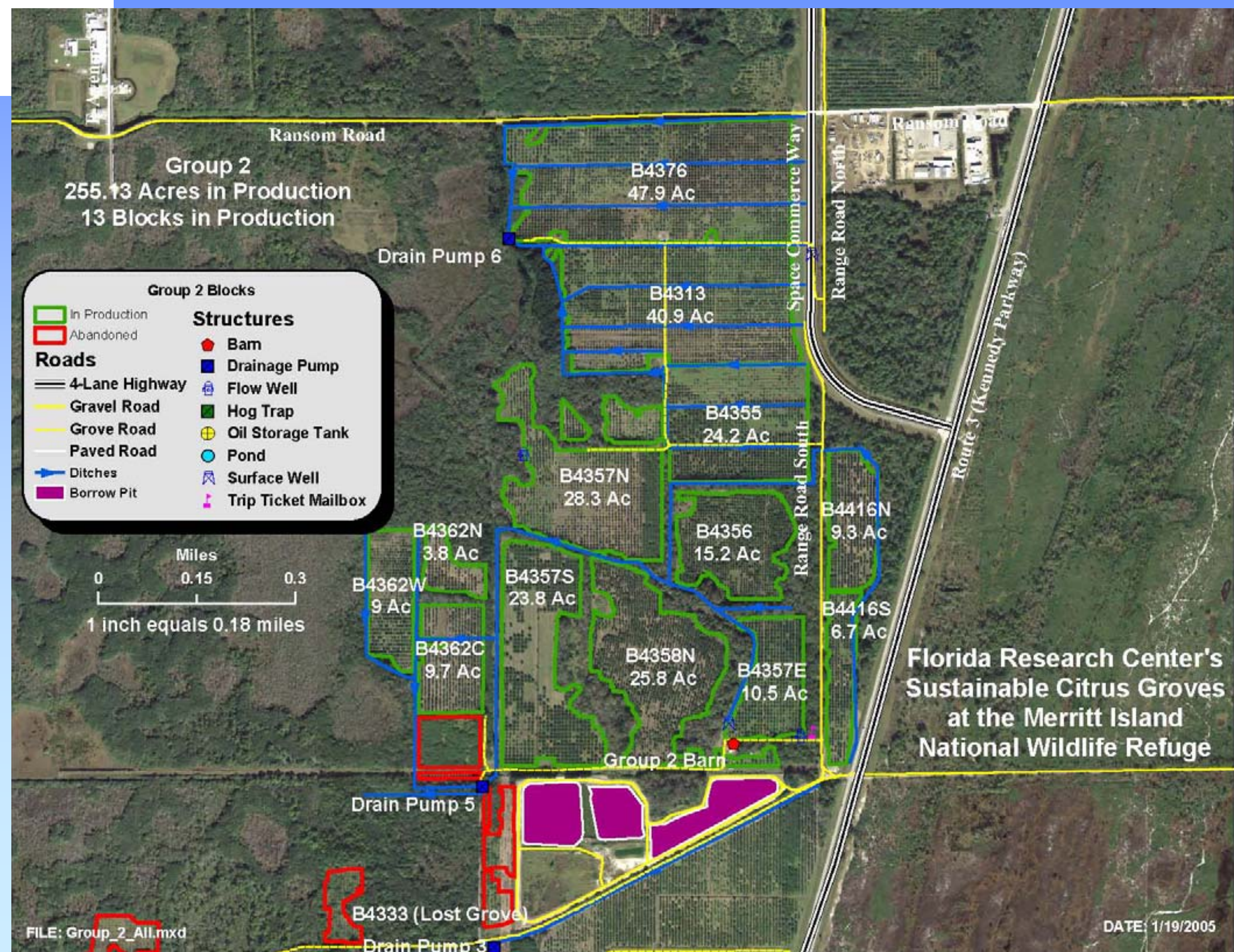
The GIS allowed us to document these changes and add new features and structures accurately and effectively.



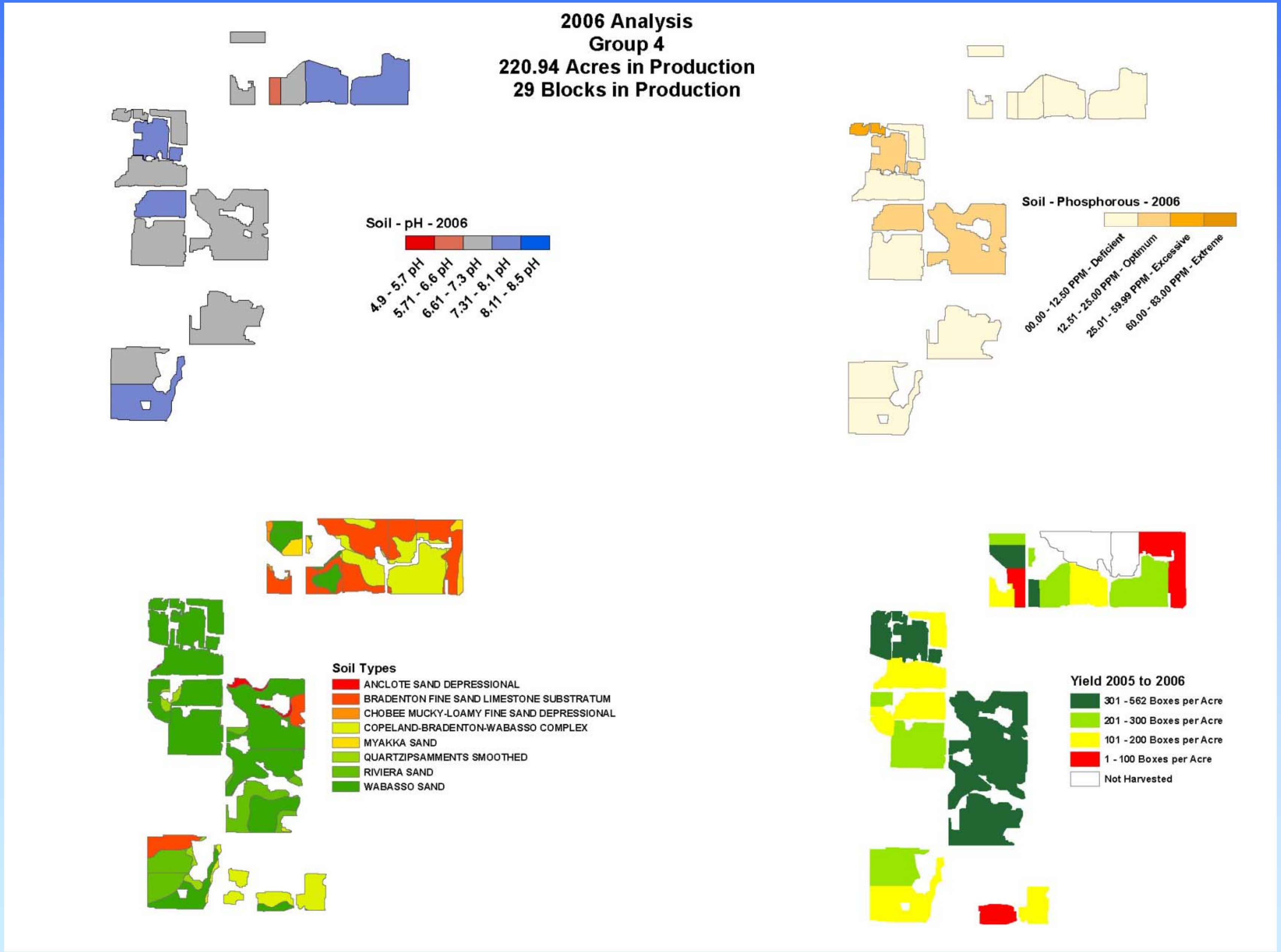


←Initial Use of Maps -1998

Current GIS Map Overlaid On Digital Ortho Quad HR Images ↓



Our GIS Proved To Be Very Useful And Versatile As A Management Tool



Ten Criteria for Agriculture Sustainability

1. Fertility management and soil health
2. Water management
3. Insect and disease management
4. Waste management and nutrient recycling
5. Weed management
6. Bio-Diversity
7. Plant and animal adaptation
8. Energy use
9. People
10. Economics

Fertility Management and Soil Health

1. In year 1, we made layered applications of Urban Plant Debris Compost applied on top of Broiler Litter to build organic matter (Applied to Drip Edge)
2. Two to three broadcast applications of low salt index fertilizers derived from Calcium Nitrate, Sulfate of Potash, and Sulfate of Potash Magnesia were made annually [No Ground Applied Phosphorus]
3. Use of granular potash (SOP & SPM) source materials
   - Deemed more efficient, slow release and better spread (No Cl or NH_3)
4. Calcium Nitrate excelled as a nitrogen source (Problems with ammoniacal nitrogen)
5. Foliar applications of Slow Release Nitrogen (Triazone), Potassium Phosphate (Lexx-A-Phos™), and Chelated Micronutrients (KeyPlex™) [All P was foliar applied]

Compost Placement is Essential

Apply the compost as a band along the drip line of the tree rows.

Nutrient Source and Grade Were Essential Components of the Fertility Program

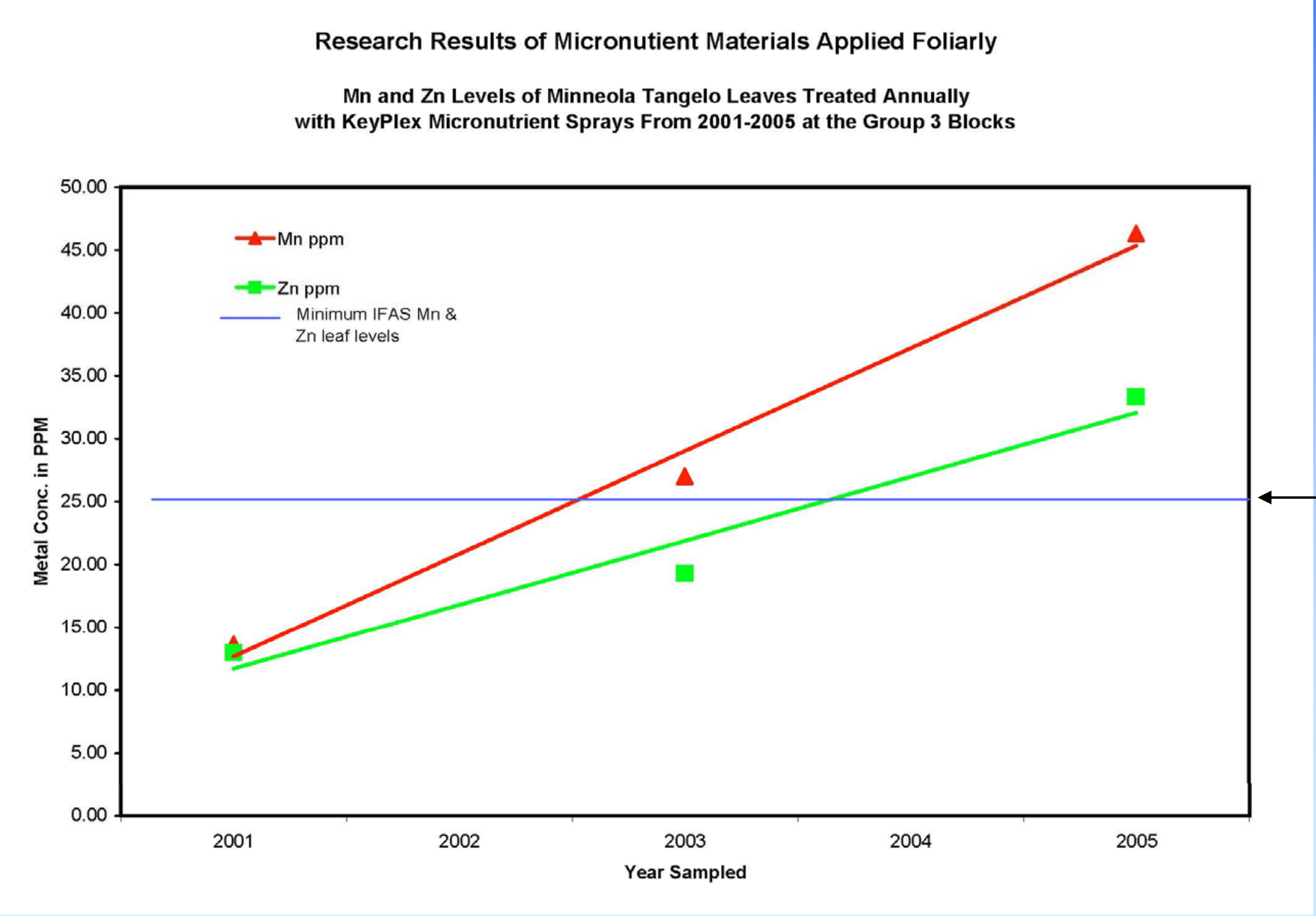
Foliar Fertilization

10-15 % Nitrogen and All Phosphorus was foliar applied

Application Timing is Based on Plant's Growth Stage

Bud Swell in Citrus is an ideal time to apply foliar nutrients

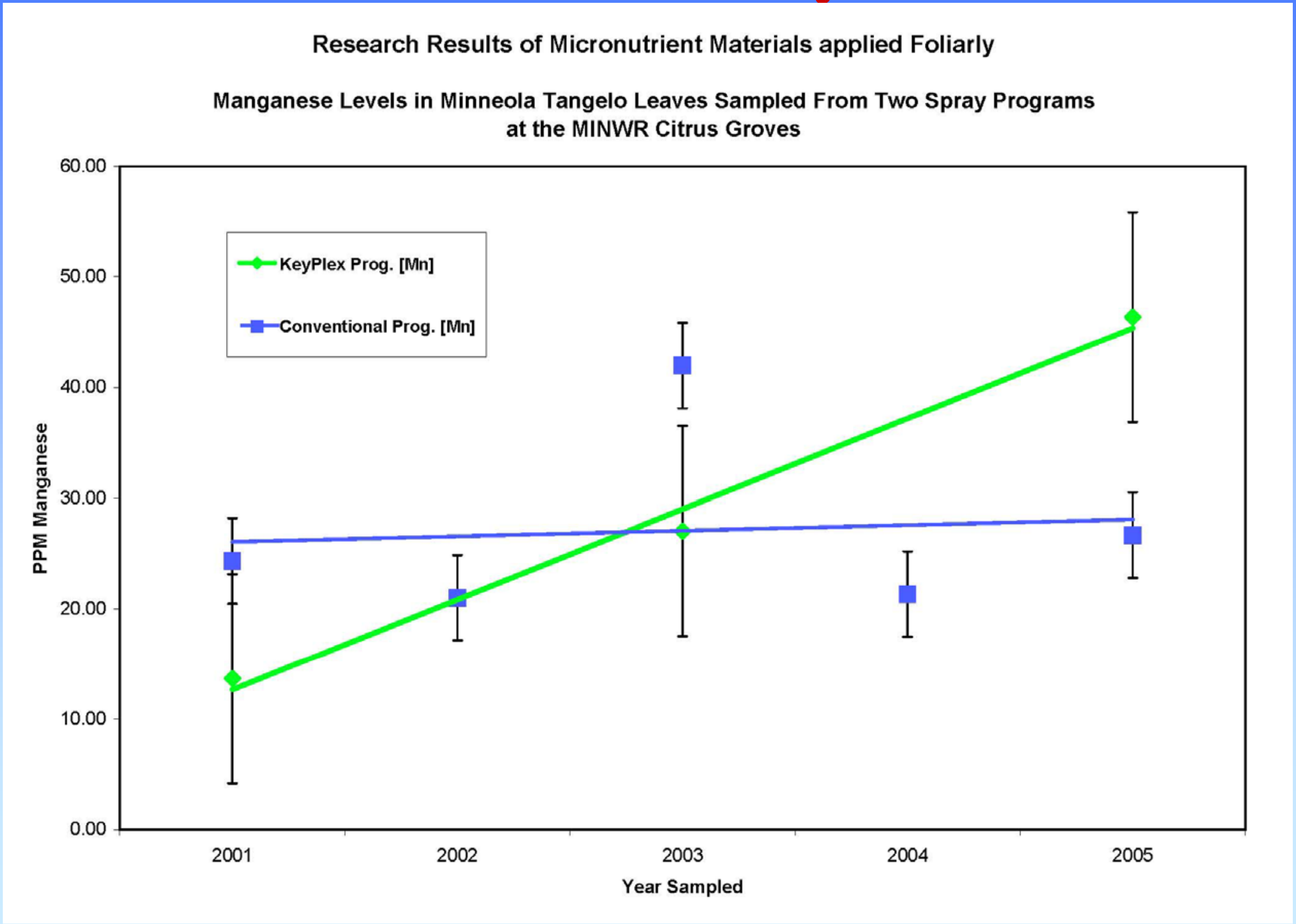
Nutritional Response of Mn & Zn Levels In Leaves Observed From Multiple Foliar Applications of KeyPlex™ Based on Leaf Analysis



Optimum

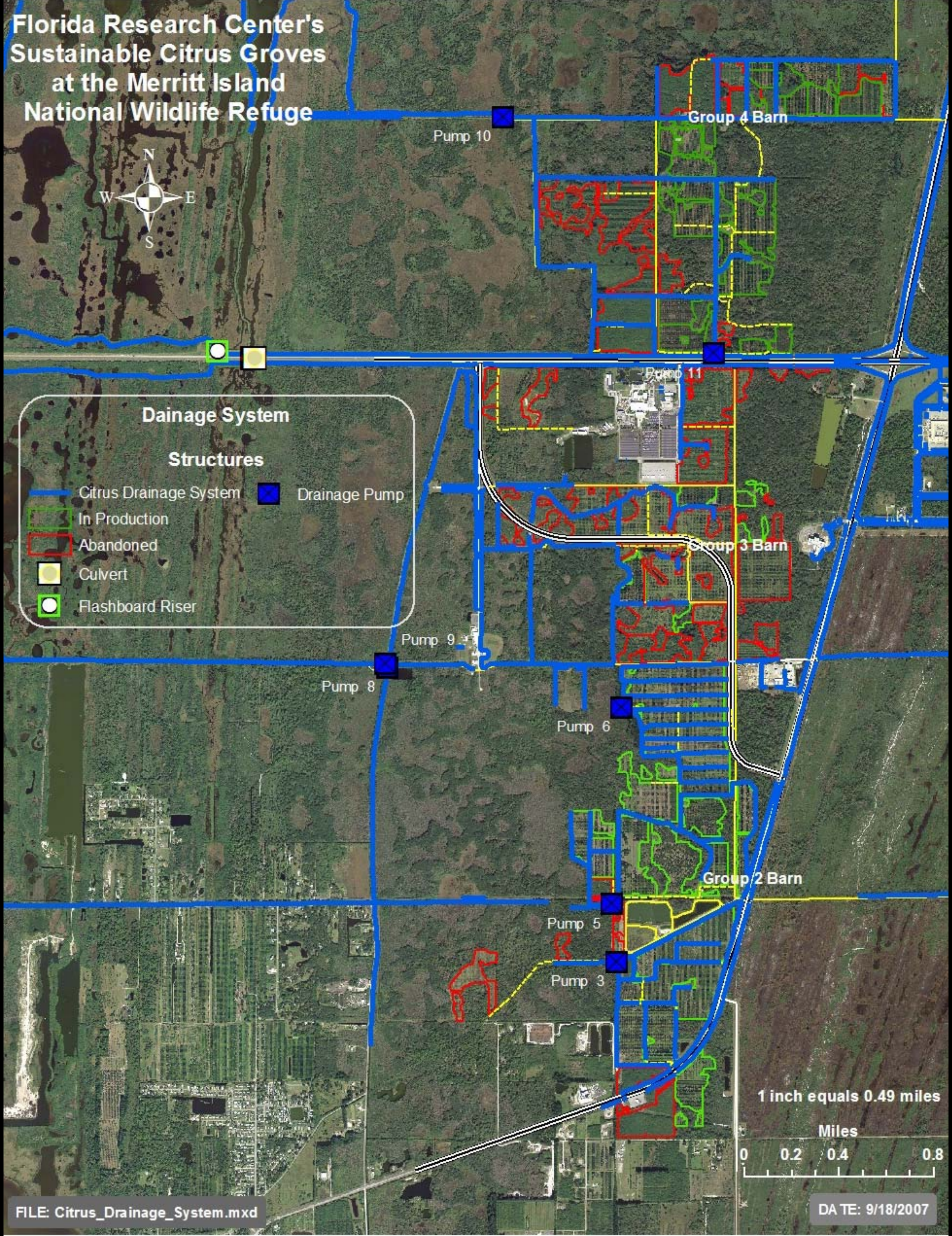
IFAS Level

A Comparison of 2 Micronutrient Formulations Applied As Foliar Sprays Based On Leaf Analysis



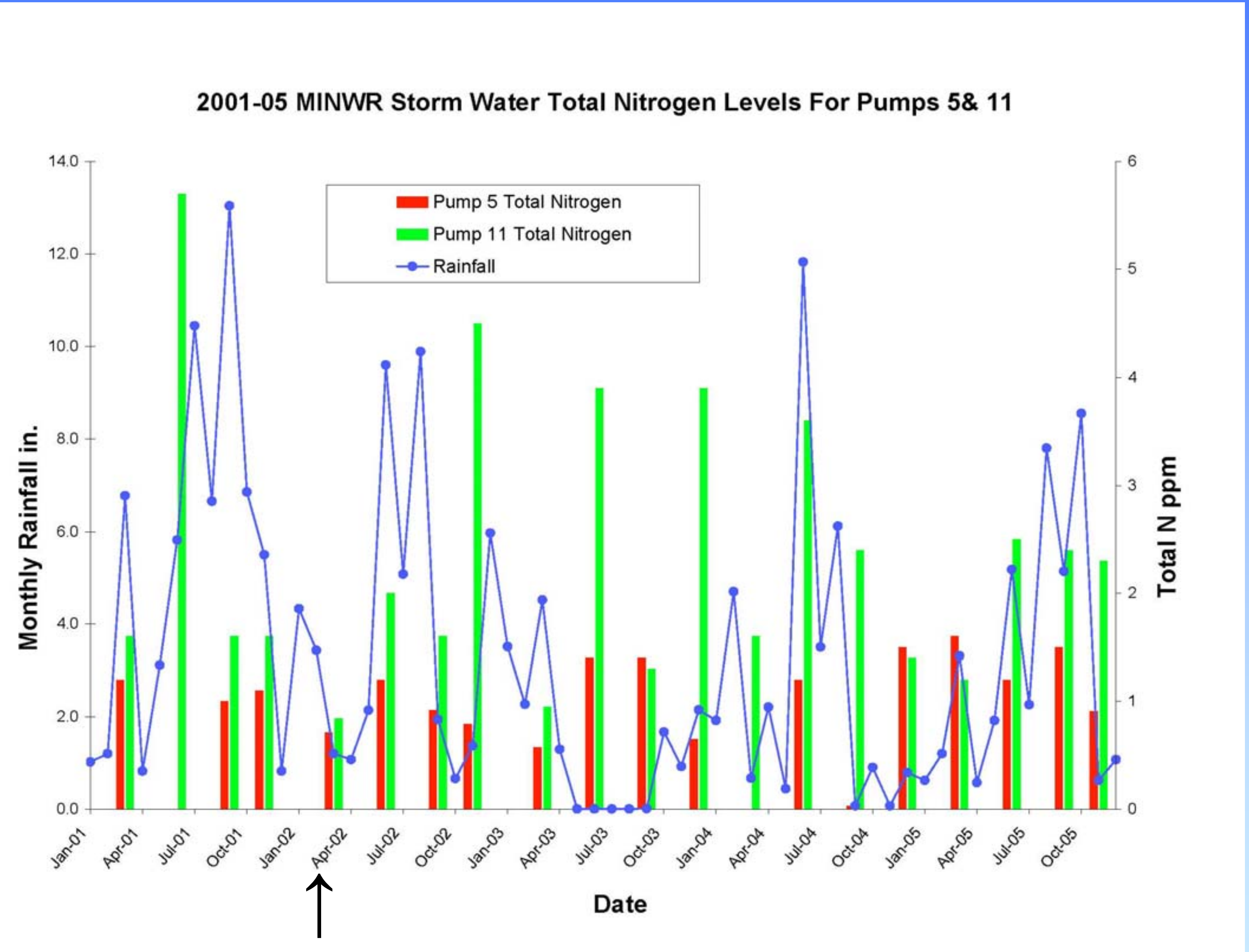
Water management

- No Irrigation
- Drainage is Key
- Pumps are critical
- Tides have a major impact



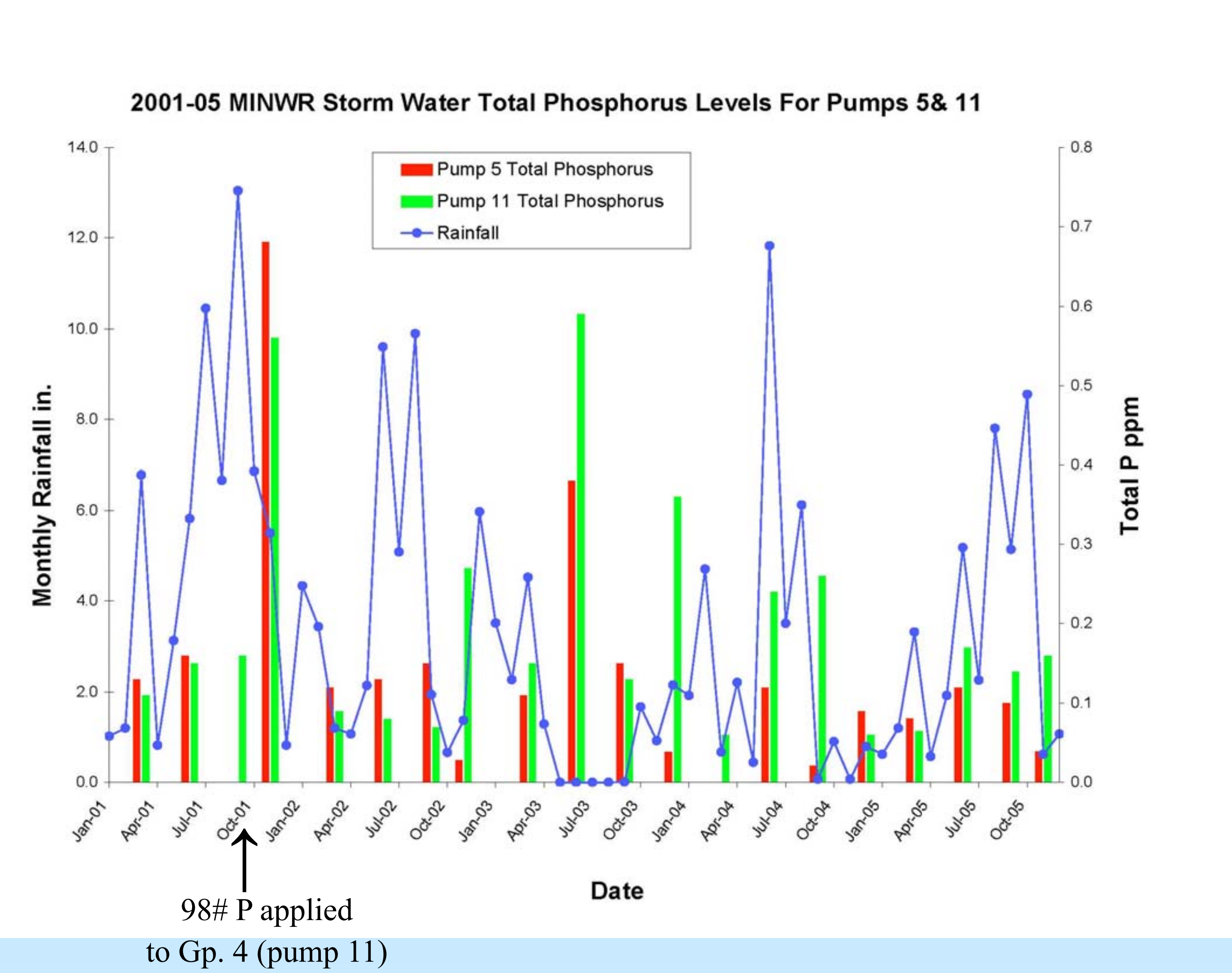
GIS Maps show their value with elaborate and complicated drainage systems

Water Quality Analysis of Stormwater Discharged From Groves As a Means To Evaluate Environmental Impact of The Sustainable Citrus Program



72# N Applied
To Group 2 Pump 5

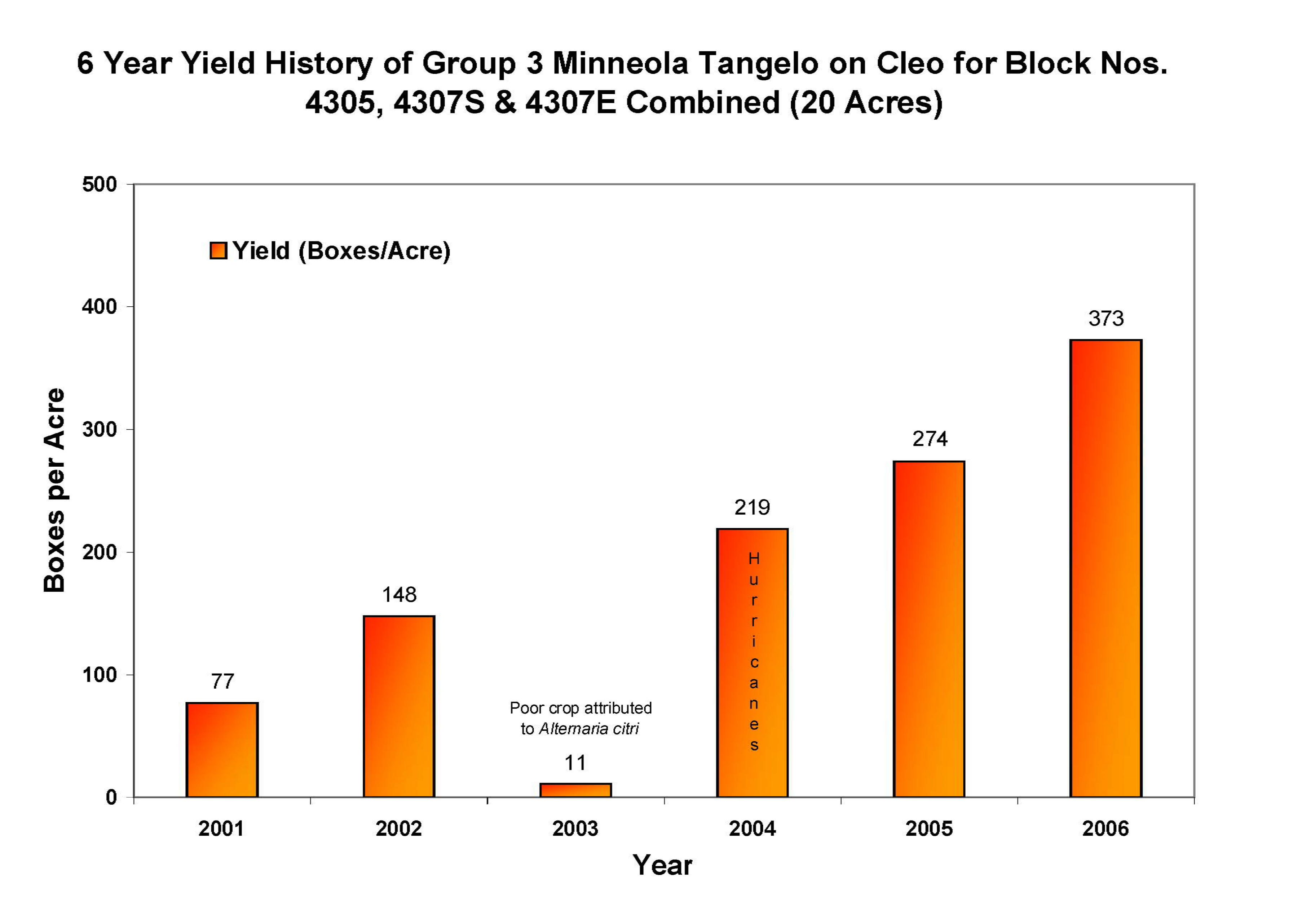
Phosphorus Levels in Stormwater for Pumps 5 & 11 (Gp. 2 & 4)



Insect and Disease Management

- Petroleum Spray Oil (As Insecticide & Fungicide)
- Utilization of Two Bio-Pesticides:
  - KeyPlex-DP™ (Micronutrient with SAR Package)
    - Provided Greasy Spot & PFD Control
  - Lexx-A-Phos™ (Phosphorus Fertilizer with SAR Inducer)
    - Provided Alternaria (4 out of 5 yrs.) & Phytophthora Control
- Biocontrol was enhanced by refugia & reduced use of pesticides
  - Introduced parasitoids *Lipolexis scutellaris* for BCA control was not allowed (Considered Exotic by USFWS)
  - No Copper Fungicides were applied up to March 2007
- Biocontrol of CRM was In place until copper applications were initiated due to Canker concerns

Alternaria control was obtained with the use of Lexx-A-Phos five out of six years

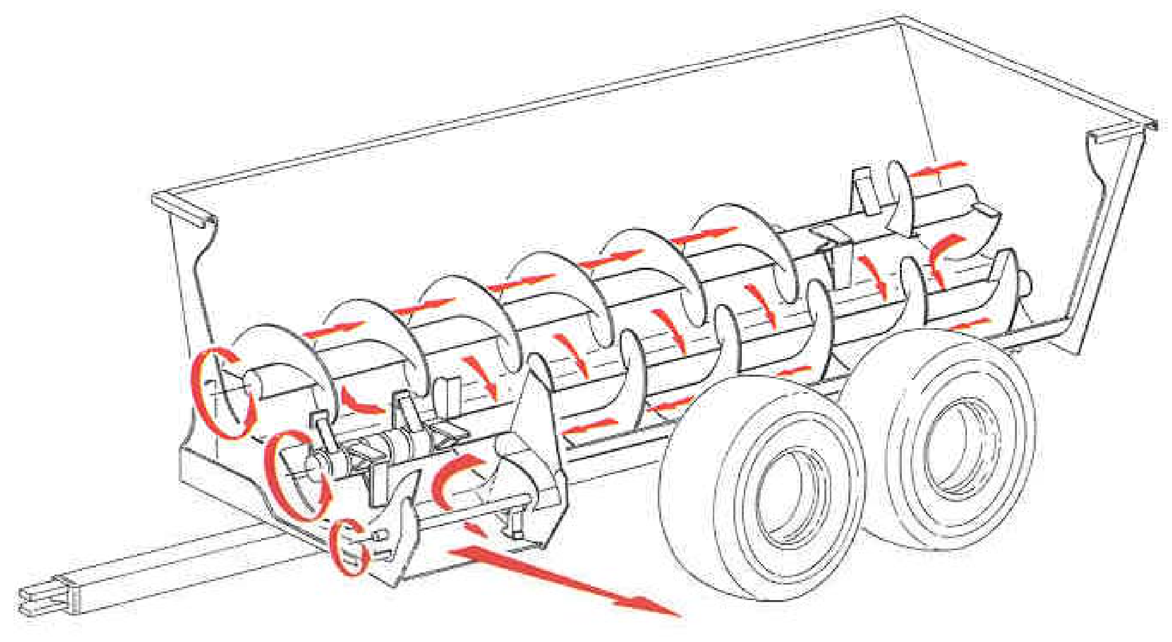


2005 Minneola Crop
Insect & Fungus Free

Waste Management and Nutrient Recycling

- Layered bands of broiler litter (1.9 tons/Acre) and Urban Plant Debris (2.4 tons/Acre) were applied in Fall. (Use of broiler litter was suspended due to food safety issues)
- Made use of NASA scrubber waste arising from nitrate residue (rocket fuel) washed with KOH from shuttle launch site. This was applied as a liquid fertilizer containing KNO_3 with herbicide boom

Design features of the Side Delivery Compost Spreader



Cut-away view showing Patented Material Flow

Forged-steel, free-swinging hammers feature a nylon bushing and replaceable manganese steel wear plate for long life and low-cost replacement. Optional hard facing is available for industrial applications spreading highly abrasive materials.

Hammer Discharge

Patented Free-Swinging Hammer Expeller

A Modified Side Delivery Compost Spreader

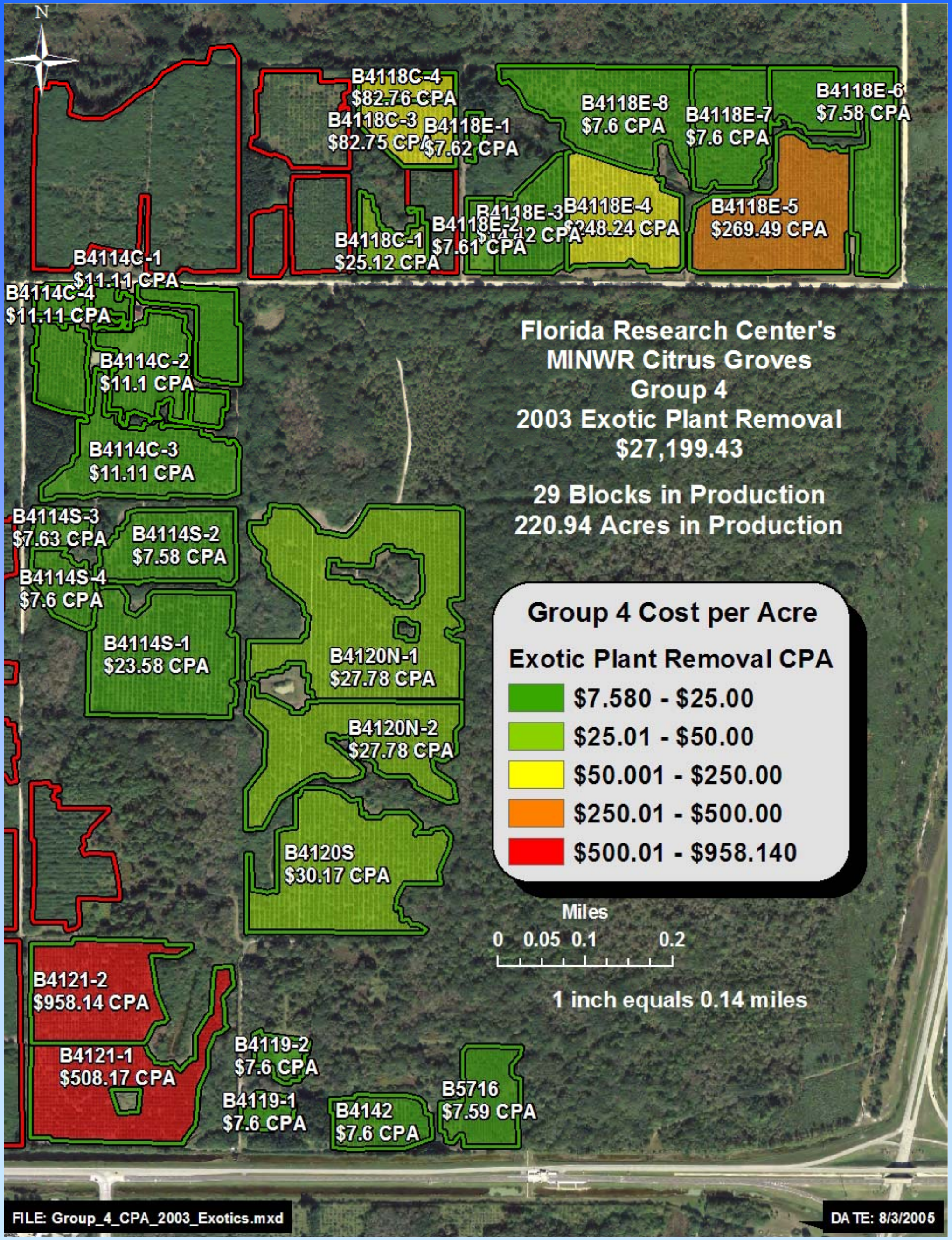
The final version of modified compost spreader designed for application of organic matter to citrus. Lateral support to the sides was accomplished by means of attaching side rails constructed out of the same 11 gauge carten steel used to fabricate the hopper sides.

Benefits of Compost Applications

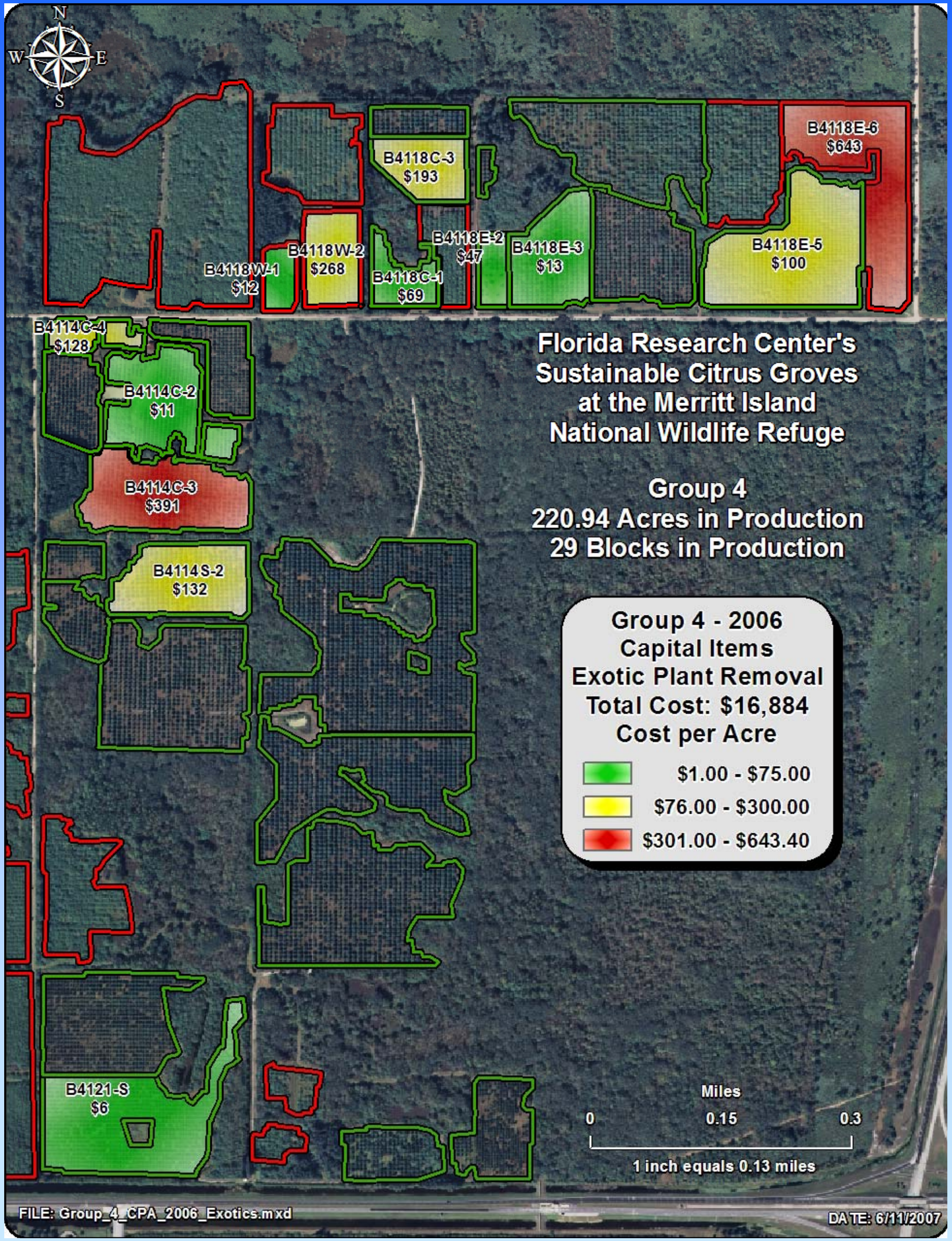
1. Stimulates plant root growth
2. Increases nutrient uptake
3. Decreases evaporation
4. Increases water holding capacity
5. Reduces surface water runoff
6. Facilitates drainage
7. Regulates soil temperature
8. Provides a rich substrate for soil microbes
9. Increases soil's Cation Exchange Capacity (CEC) which increases the soil's nutrient holding capacity

Weed Management

- Under tree weed control was accomplished with Glyphosate and LandMaster herbicides. (3 x/yr.)
- No pre-emergent herbicide were allowed due to Refuge and Program restraints. (restoration)
- Biggest problems were Guinea Grass, B. Pepper and Vines.
- Use of low TDS (municipal water) improved herbicide performance.
- Chemical mowing paid huge dividends by reducing mowing to once per year.



N
B4118C-4
$82.76 CPA
B4118C-3
$82.75 CPA
B4118E-1
$7.62 CPA
B4118E-8
$7.6 CPA
B4118E-7
$7.6 CPA
B4118E-6
$7.58 CPA
B4118E-3
B4118E-4
$248.24 CPA
B4118E-5
$269.49 CPA
B4118C-1
$25.12 CPA
B4118E-2
$7.61 CPA
B4114C-1
$11.11 CPA
B4114C-4
$11.11 CPA
B4114C-2
$11.1 CPA
B4114C-3
$11.11 CPA
B4114S-3
$7.63 CPA
B4114S-2
$7.58 CPA
B4114S-4
$7.6 CPA
B4114S-1
$23.58 CPA
B4120N-1
$27.78 CPA
B4120N-2
$27.78 CPA
B4120S
$30.17 CPA
B4121-2
$958.14 CPA
B4121-1
$508.17 CPA
B4119-2
$7.6 CPA
B4119-1
$7.6 CPA
B4142
$7.6 CPA
B5716
$7.59 CPA
Florida Research Center's
MINWR Citrus Groves
Group 4
2003 Exotic Plant Removal
$27,199.43
29 Blocks in Production
220.94 Acres in Production
Group 4 Cost per Acre
Exotic Plant Removal CPA
$7.580 - $25.00
$25.01 - $50.00
$50.001 - $250.00
$250.01 - $500.00
$500.01 - $958.140
Miles
0 0.05 0.1 0.2
1 inch equals 0.14 miles
FILE: Group_4_CPA_2003_Exotics.mxd
DATE: 8/3/2005



N
W
E
S
B4118E-6
$643
B4118C-3
$193
B4118W-2
$268
B4118W-1
$12
B4118C-1
$69
B4118E-2
$47
B4118E-3
$13
B4118E-5
$100
B4114C-4
$128
B4114C-2
$11
B4114C-3
$391
B4114S-2
$132
B4121-S
$6
Florida Research Center's
Sustainable Citrus Groves
at the Merritt Island
National Wildlife Refuge
Group 4
220.94 Acres in Production
29 Blocks in Production
Group 4 - 2006
Capital Items
Exotic Plant Removal
Total Cost: $16,884
Cost per Acre
$1.00 - $75.00
$76.00 - $300.00
$301.00 - $643.40
Miles
0 0.15 0.3
1 inch equals 0.13 miles
FILE: Group_4_CPA_2006_Exotics.mxd
DATE: 6/11/2007

Bio-Diversity

Establish and Maintain Refugia for Beneficial Insects


Painted Bunting
Photo by Deanna Dawson

Plant Adaptation

Economics

- “The bottom-line will get you every time”

  – Wes Jackson

Economic evaluations were based on R. P. Muraro's "Budgeting Costs & Returns"

Table 3.--Estimated annual per acre costs and returns for a mature, white seedless grapefruit grove producing for the fresh market, Indian River area, 2004-05[a]

	Item	Description	Amount		Your cost
			---------- Dollars ----------		
I.	Revenue	92 boxes @ $11.95[b]		1,099.40 ←	______
II.	Expenses[c]				
	Weed control				
	Mow middles	3 times per year	29.91		______
	Chemical mow (Table 2-A, Option #9)	2 times per year	10.16		______
	General grove work/sprouting, etc.	(2 labor hours per acre)	27.12		______
	Herbicide (Table 2-A, Options #1, #6 & #7)		132.88	200.07	______
	Spray program (Table 1-A, Options #1, #3, #4 @ 2, #8 & #12)			405.43	______
	Fertilizer (Table 3-A, Option #2)			140.18	______
	Dolomite (Table 7-A, Option #1)			14.65	______
	Pruning (maintenance)				
	Topping	($275.00/hr. ÷ 10 A/hr.) ÷ 2 yrs.	13.75		______
	Hedging	($257.50/hr. ÷ 10 A/hr.) ÷ 1.5 yrs.	17.17		______
	Removing/chop brush	($8.99/A ÷ 1.5 yrs.)	6.00		______
	Raise skirts of trees	($14.00/A ÷ 2 yrs.)	7.00	43.92	______
	Tree replacement and care	(1 through 3 years)			
	Remove trees (Table 12-A)	5 trees per acre	25.40		______
	Prepare sites, repair mound, and plant resets	Including 5 trees per acre	59.85		______
	Supplemental fertilizer, sprout, etc. (Trees 1-3 years)	Including application	49.65	134.90	______
	Microsprinkler irrigation (Table 7-A, Option #4)			166.17	______
	Drainage ditch annual cost (Table 7-A, Option #5)			42.46	______
	Total grove care expenses			1,147.78	______
III.	Management	$4.00 per acre per month[d]		48.00	______
IV.	Total specified costs[e]			1,195.78 ←	______
V.	Return (loss) to land, trees, and ownership			(96.38) ←	Bottom-Line
VI.	Break-even price for total grove care expenses				

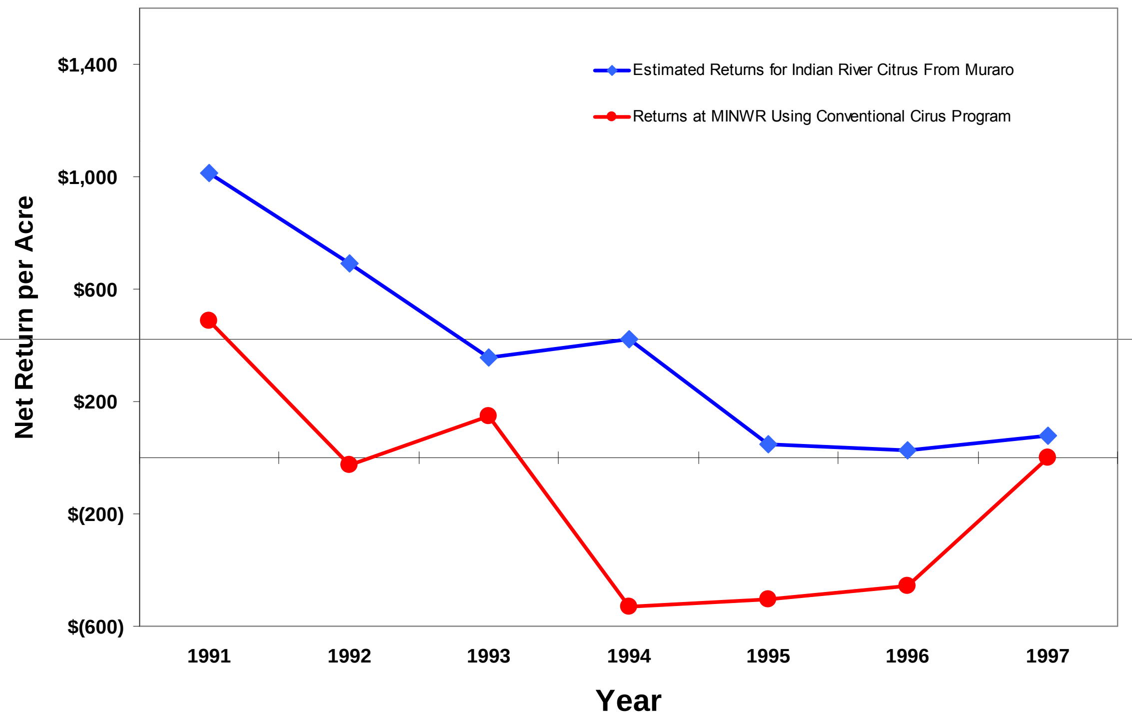
6

Boxes per acre					Boxes per acre				
325	375	425	475	525	325	375	425	475	525
$ On-tree price per box					$ Delivered-in price per pound solids for eliminations[f]				
3.54	3.06	2.70	2.42	2.19	1.54	1.44	1.36	1.30	1.25

[a]Although the estimated annual per acre grove costs shown in Table 3 are representative for a mature Indian River white seedless grapefruit grove, the grove care costs for a specific grove site may differ depending upon the grove practices performed; e.g., a Temik application would add $127.50 per acre; extensive tree loss due to blight or tristeza may double the tree replacement and care costs; travel and set-up costs may vary due to size of citrus grove and distance from grove equipment barn; etc.; truck watering of resets could add another $7.95 per acre (average 5 waterings).

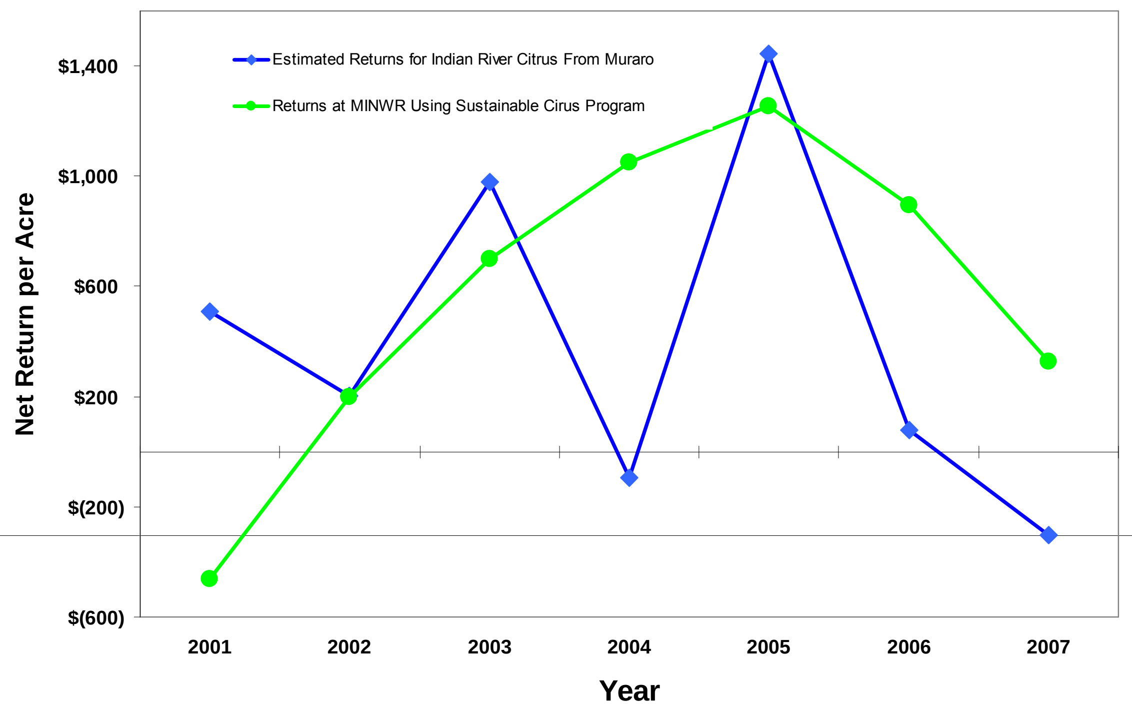
[b]On-tree price per box is preliminary; assumes average of all methods of sale (fresh and processed).

Economics

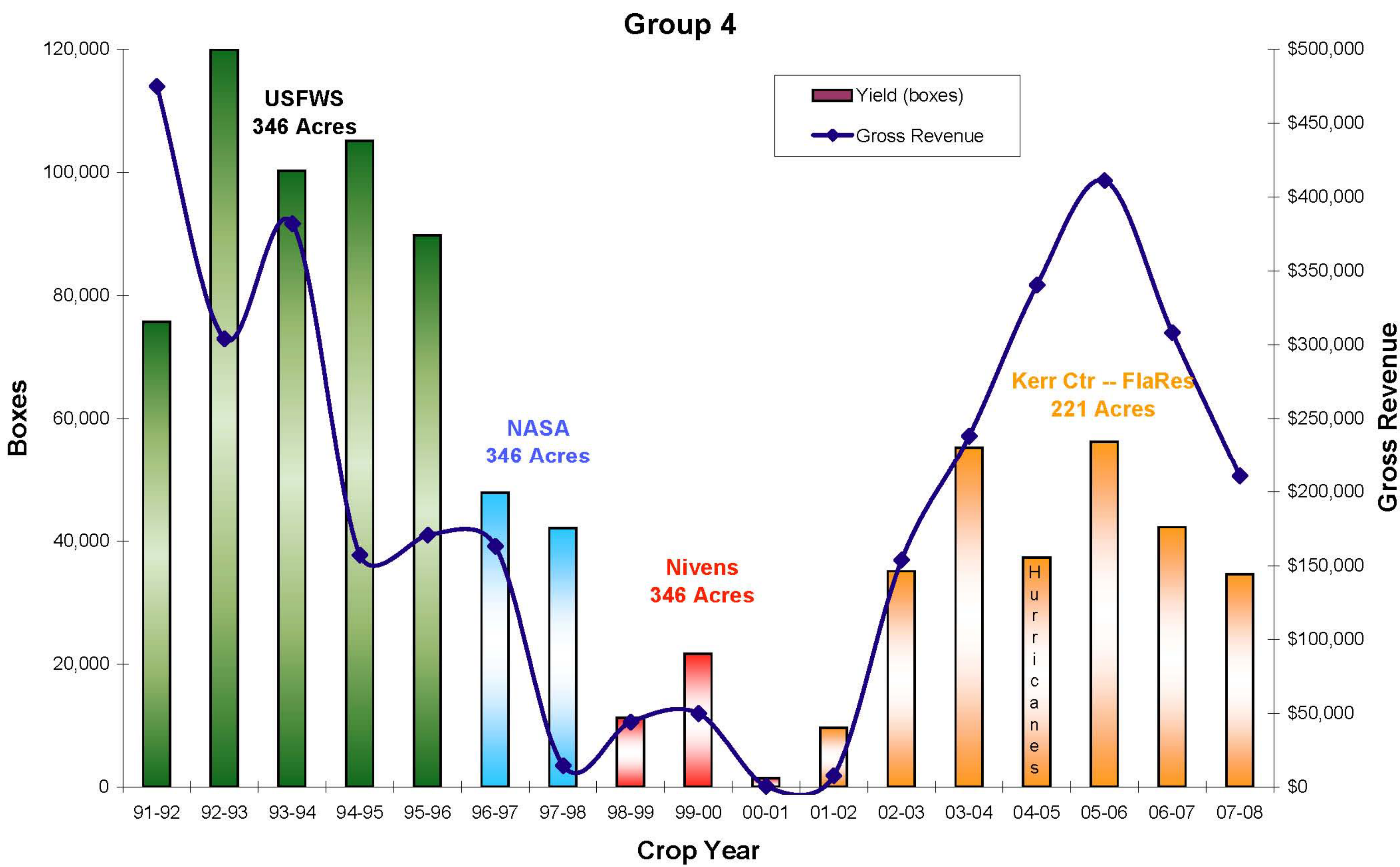


Net Returns of the MINWR Groves Using a Conventional Citrus Program versus UF Estimated Returns for White Grapefruit in the Indian River Region from 1991 - 1997

Net Returns of the MINWR Groves Using a Sustainable Citrus Program versus UF Estimated Returns for White Grapefruit in the Indian River Region from 2001 - 2007

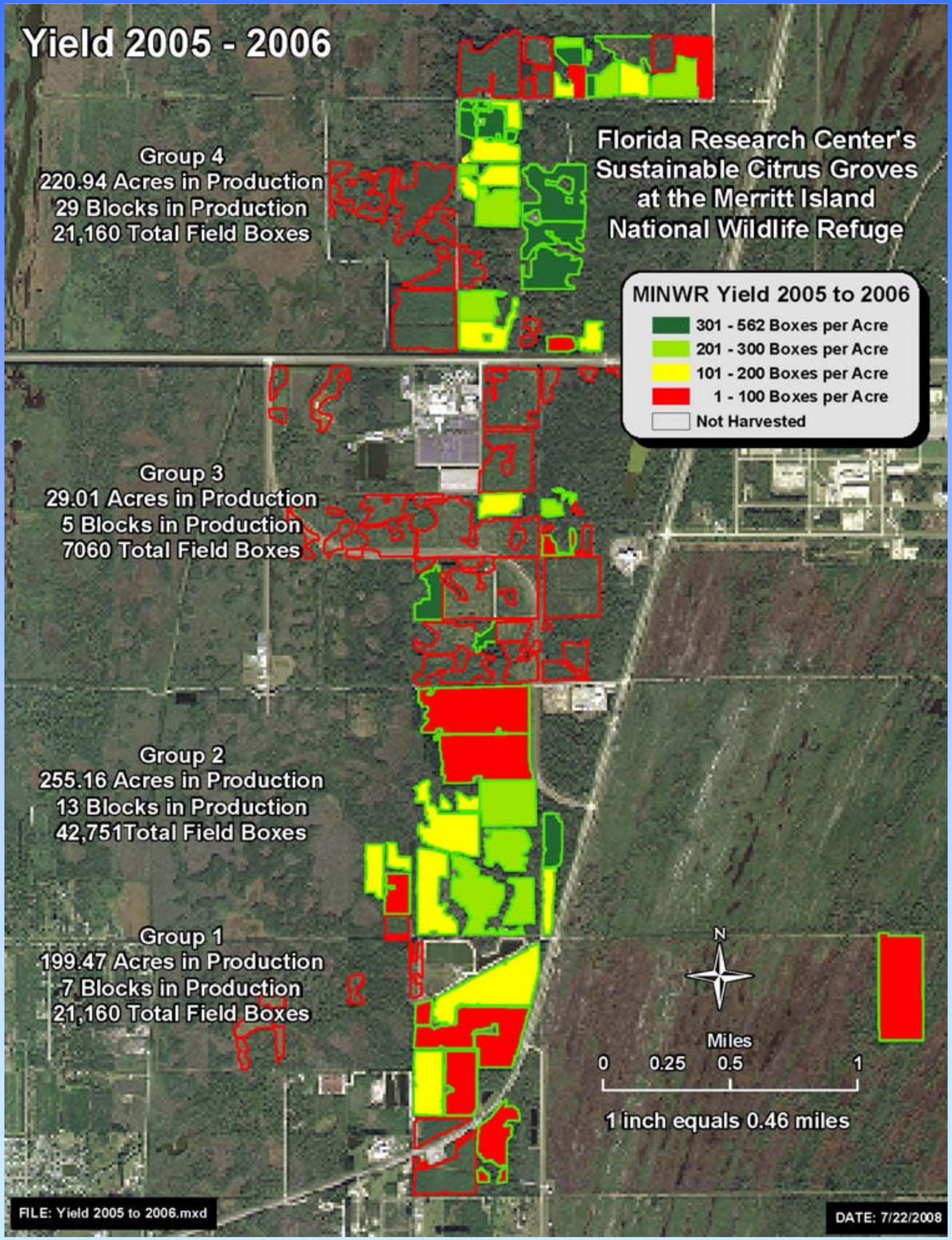


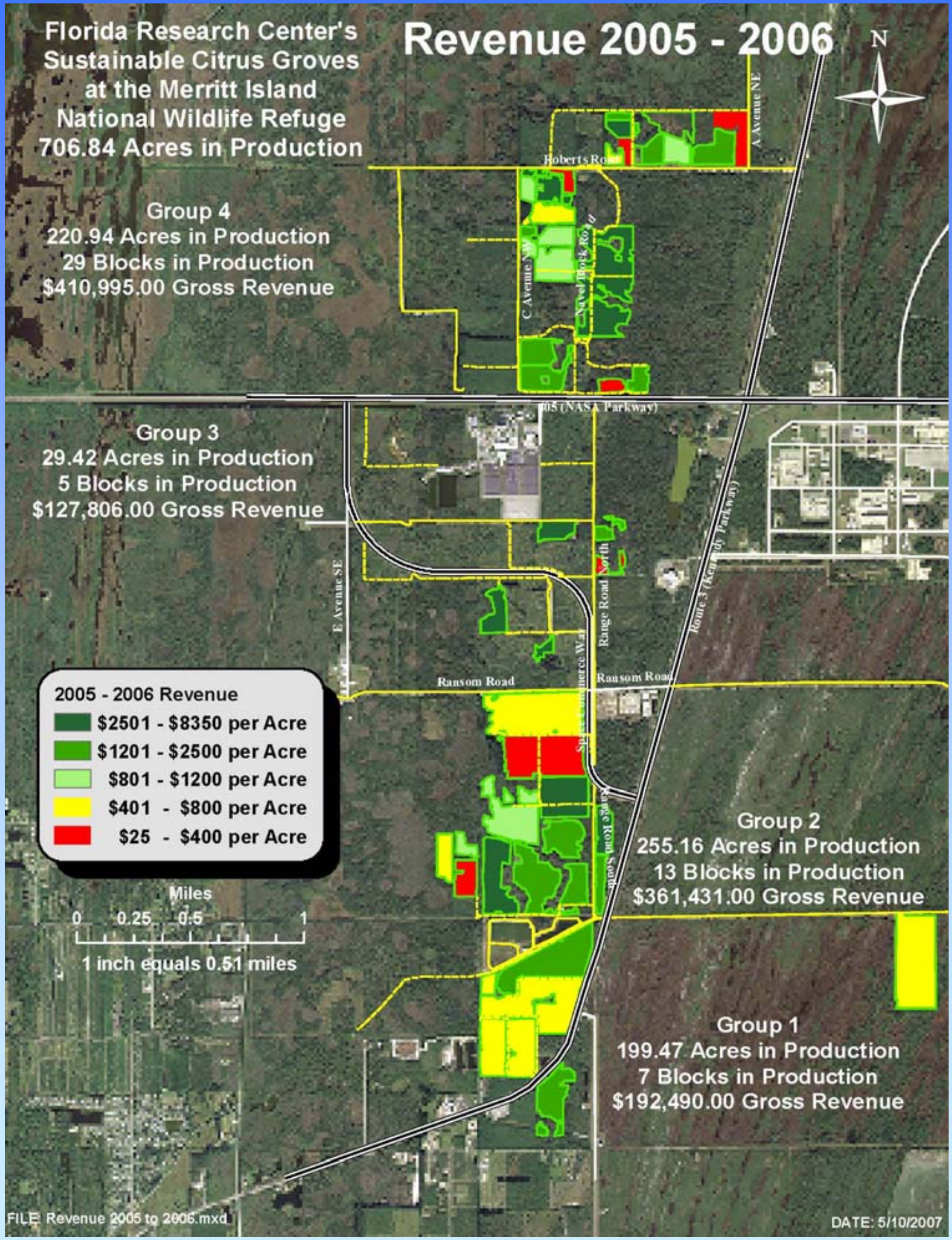
Economics



Group 4
Yield (boxes)
Gross Revenue
USFWS
346 Acres
NASA
346 Acres
Nivens
346 Acres
Kerr Ctr -- FlaRes
221 Acres
Hurricanes
Boxes
120,000
100,000
80,000
60,000
40,000
20,000
0
Gross Revenue
$500,000
$450,000
$400,000
$350,000
$300,000
$250,000
$200,000
$150,000
$100,000
$50,000
$0
Crop Year
91-92
92-93
93-94
94-95
95-96
96-97
97-98
98-99
99-00
00-01
01-02
02-03
03-04
04-05
05-06
06-07
07-08

GIS View of Economics





Economics

Average Change In Yield and Revenue Per Acre For The Group 4 MINWR Citrus Groves Using The Sustainable Citrus Program (2001-07) vs. The Conventional Citrus Program (1991-97)		
Variety	Change in Yield	Change in Gross Revenue
Navel Orange	-7.5%	80.8%
Minneola Tangelo	1.2%	129.3%
Red Grapefruit	-59.9%	177.4%
TOTAL All Varieties	-26.0%	59.3%

The SCP Met Our Goals
Agriculturally , Environmentally, and Economically

Suggestions for Future Work

- Find and develop additional incentives for the grower to implement sustainable practices
- Need a replacement rootstock that is equivalent to or better than Sour Orange
- Develop harvesting system that leaves eliminations on site for nutrient recycling