Land-Use and Land-Cover Change:

Decadal-Scale Dynamics of Land Ownership, Land Management and Carbon Storage Patterns in the Southeastern Coastal Plain Region of the U.S.

Players and Partners

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Overall Coordination, Remote Sensing/Land-cover Classification, Carbon Estimates

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School of Forest Resources and Conservation
Ecosystem Process Measurements, Carbon Estimates (Currently NSF LTER Program Director)

Grenville Barnes
Geomatics Program
Land Ownership/Land Tenure

Ameriflux Network Forest Canopy Tower

Scot E.Smith
Geomatics Program
Remote Sensing, Algorithm Development

Christine Leslie
Geomatics Program
Graduate Student

Not shown: Rob Britts, Geography Department, Graduate Student

Objectives of the Study

(1) to determine the links between changes in land ownership, land management, land cover change, and carbon storage patterns within the southeastern lower coastal plain region of the United States;

(2) to determine the effects of specific land ownership patterns on the carbon storage and sequestration rates of representative regional ecosystems at already established long-term intensive research sites; and

(3) to establish the study area as a site for long-term monitoring of carbon storage patterns.

Science Implications

- Regionalizing point measurements – scaling from towers to landscapes (bottom-up not top-down).
- Measuring human activity as a factor driving land-cover/land-use change (“disturbance”).
- Developing empirical models of biomass/carbon in land cover classes in a large physiographic region (~ecoregion).
- Developing estimates of C storage change based on extensive and intensive measurements of biomass and carbon exchange in several major land-cover classes.

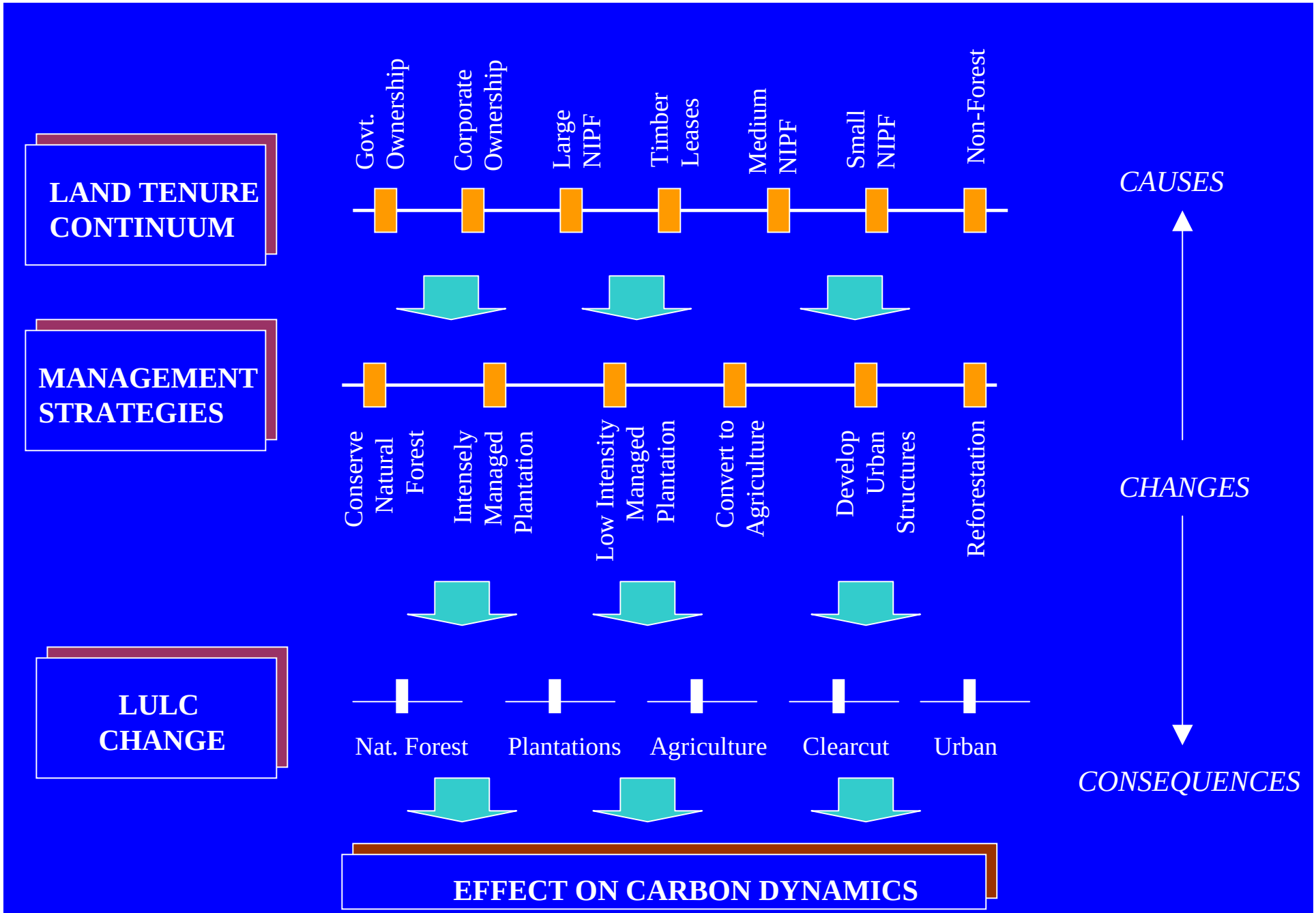


Figure 1. Conceptual Model Of Land-Cover and Land-Use Change in the Southeastern U.S.

Study Area

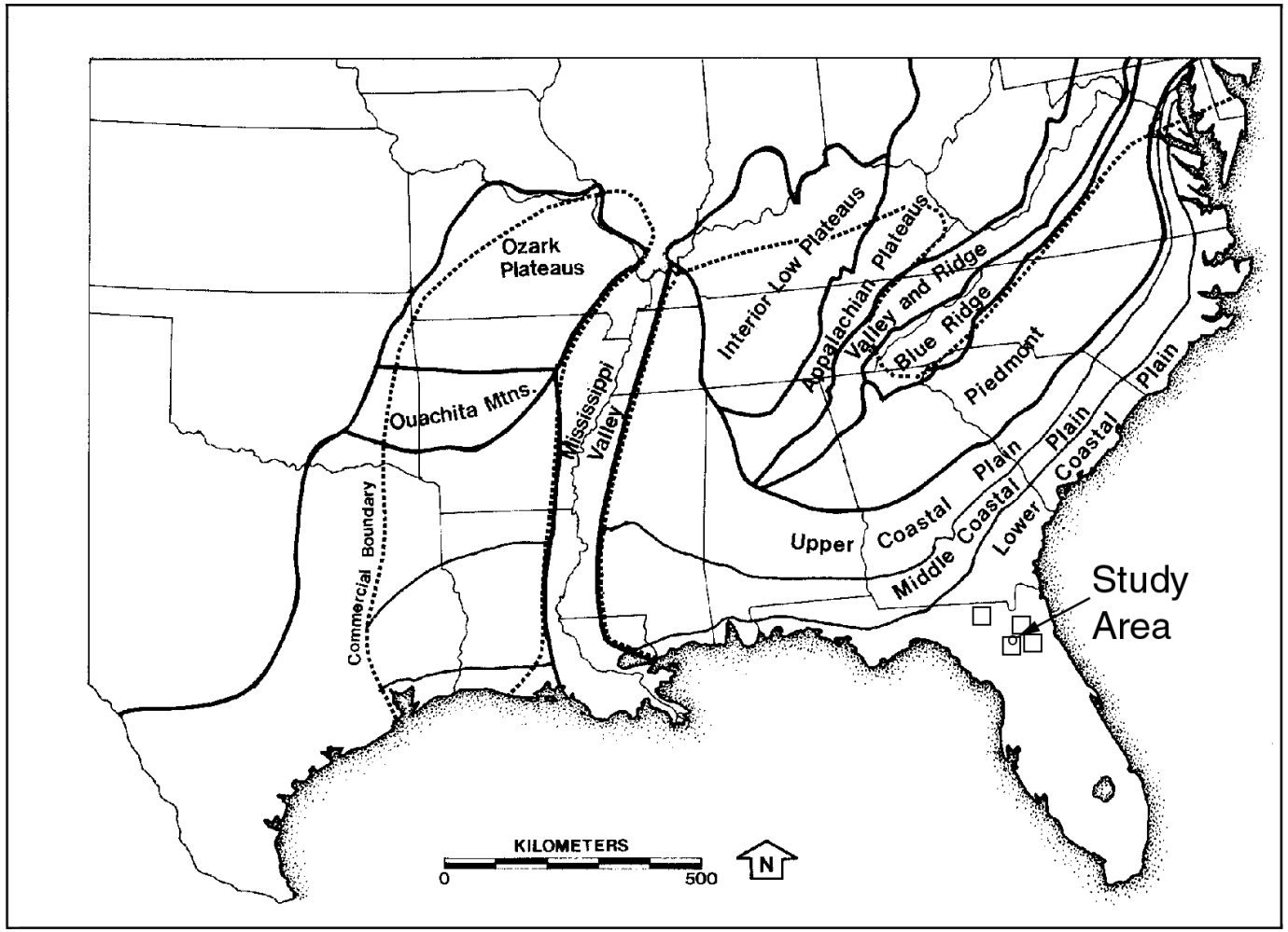
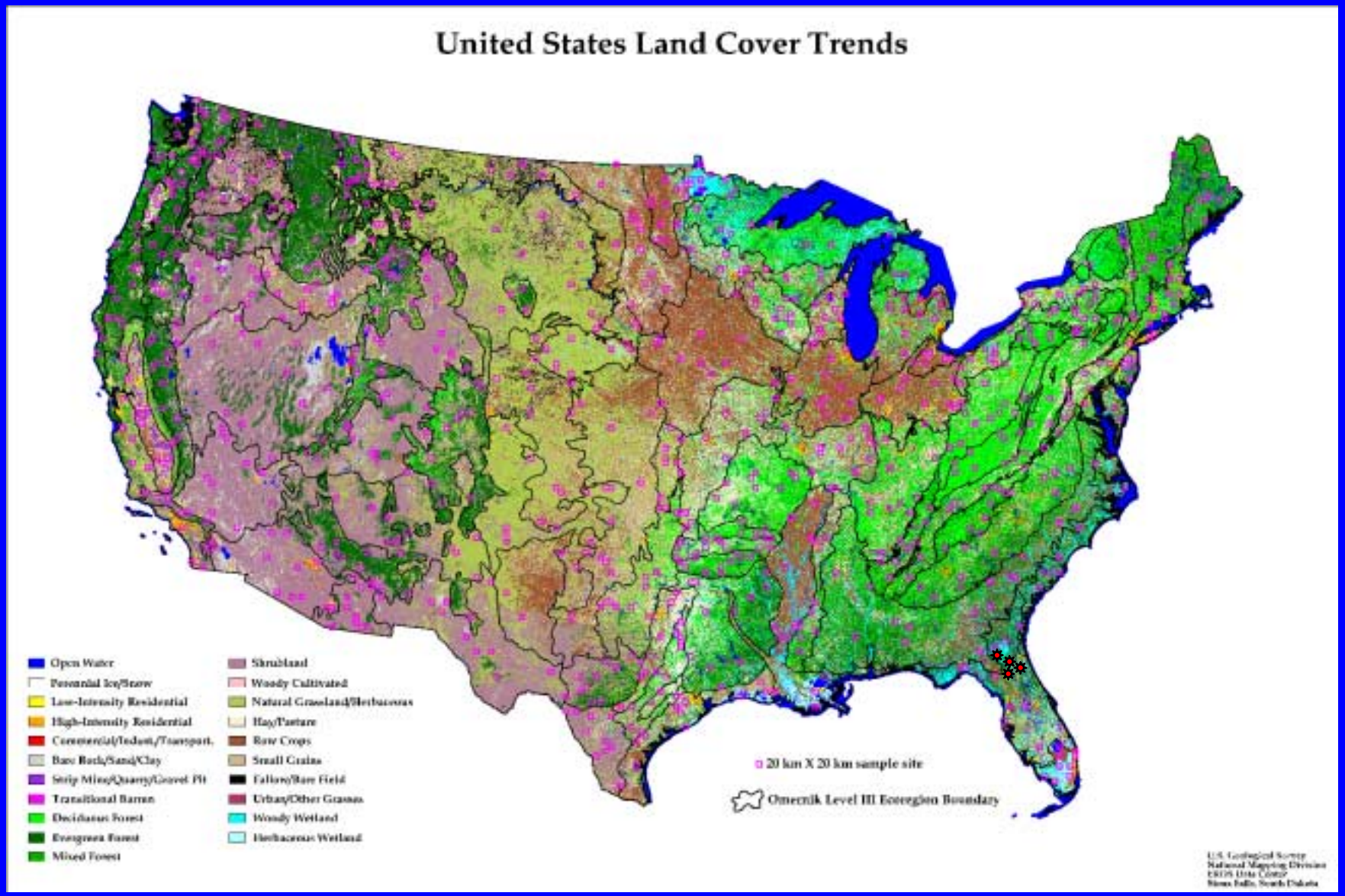


Figure 2. Physiographic provinces of the southeastern U.S.



Thank You, Tom Loveland

Study Area

- **Lower coastal plain, historically longleaf pine flatwoods with frequent fire.**
- **Soils primarily sands – low nutrients.**
- **Major landowners are forest industries and non-industrial private landowners, many of whom lease forests to industries.**
- **Major land use is plantation loblolly or slash pine forests (~agriculture).**
- **Fire suppression – fire frequency has decreased, intensity increased.**
- **C accumulates in litter – fires rapid, intense, and destructive.**
- **Highly dynamic landscape in space and time.**
- **High spatial variability; flat, but minor elevation changes = desert to wetland.**
- **Highly dynamic temporally**
  - **Harvest cycles; 25-yr recently changed to 20-yr in some cases.**
  - **Climate, moist but inter-annual variability quite high – multi-year droughts.**
  - **Fires**

Study Area - Forests

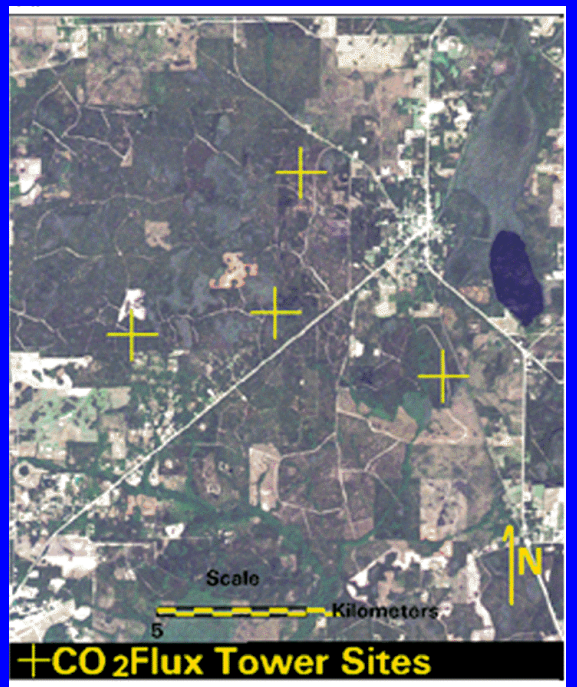


Figure 2. Landsat TM imagery from 27 March 1997. A. "True-color" image using bands 3, 2, and 1 for red, green, and blue. B. Interprete results of an unsupervised land-cover classification.

Study Area - Fire

Prescribed burning in slash pine plantation – rare management practice.

Accidental fire in cypress wetland

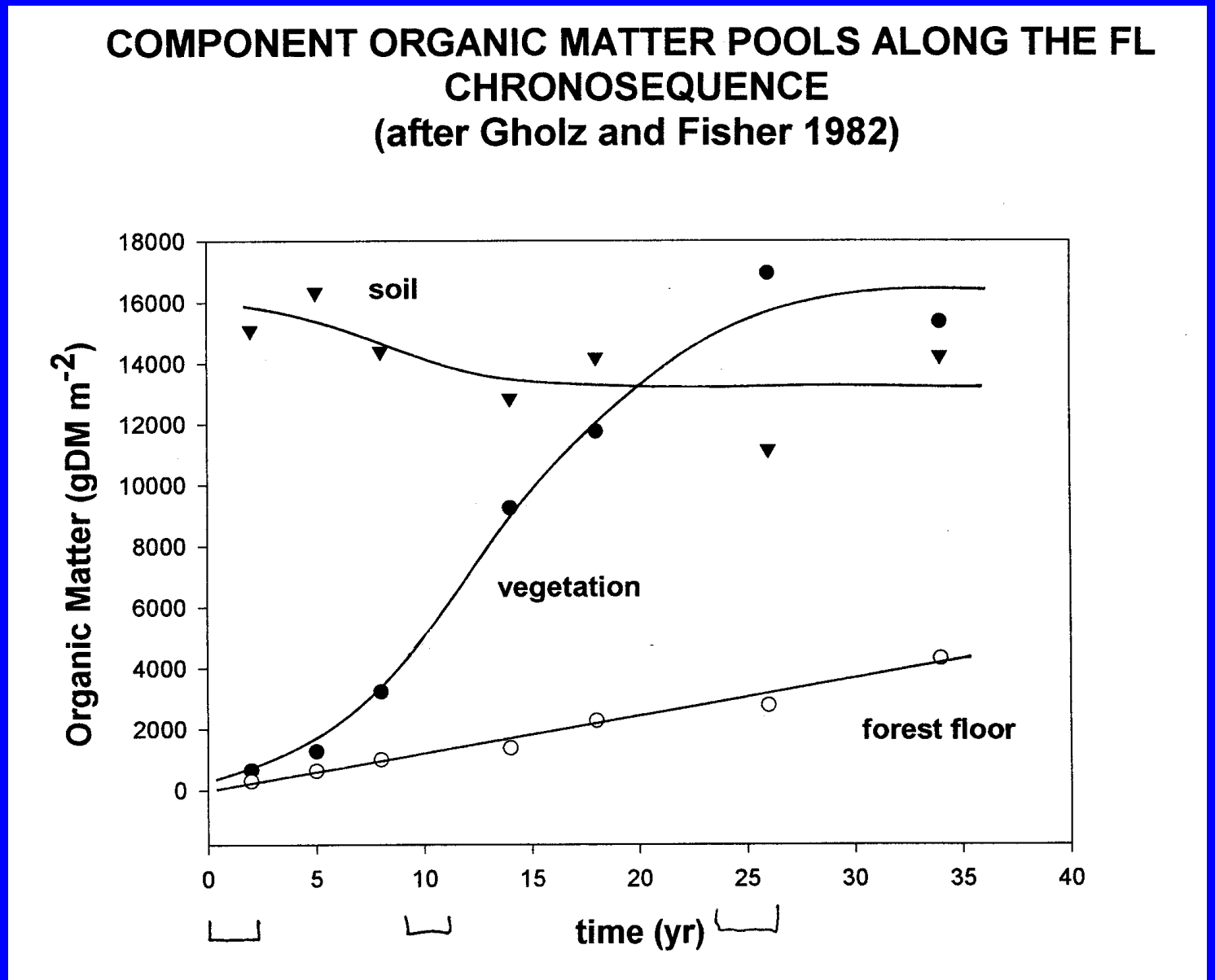
Study Area – Other

Phosphate mining in Hamilton County

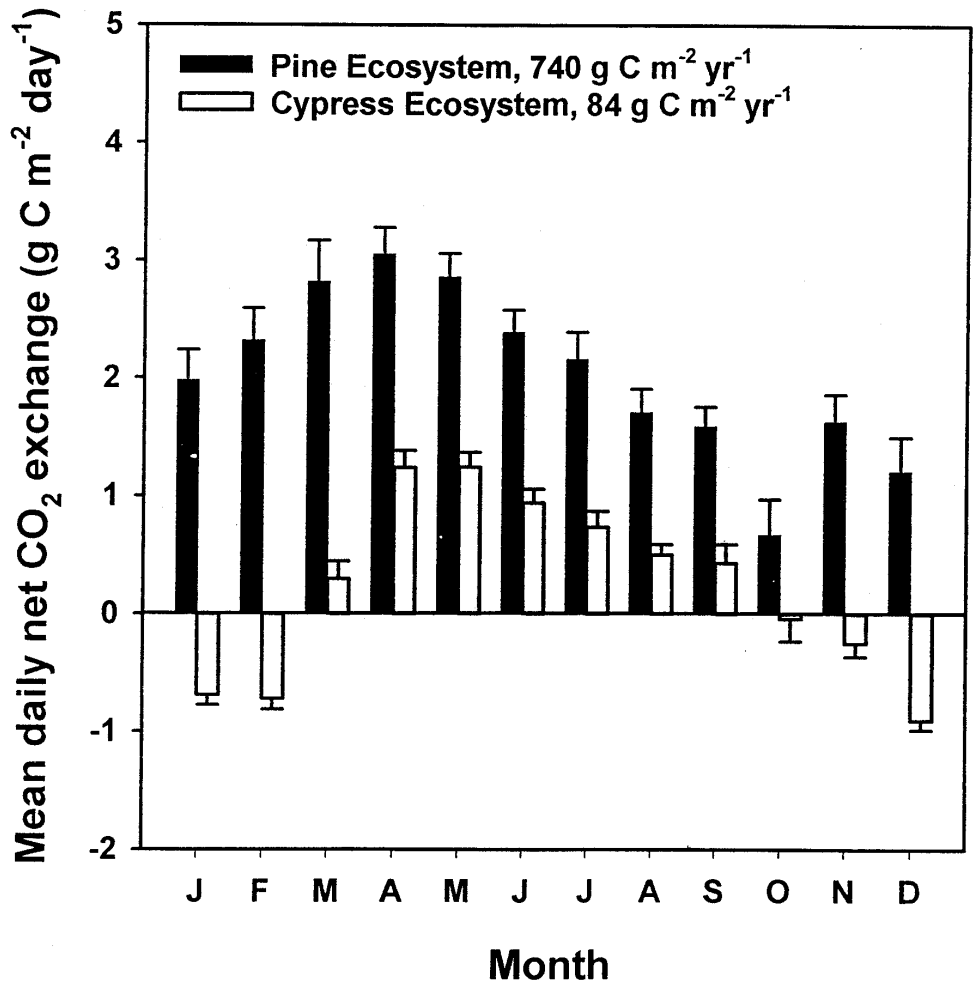
Heritage for the research

- Ecosystem studies in SE U.S. since ’50’s
  - H.T. Odum
  - Brown, Lugo, et al.
- Forest ecological productivity with remote sensing approaches in study area since 1979
  - Gholz
  - Curran
  - et al.

Plantation Pine Biomass Accumulation



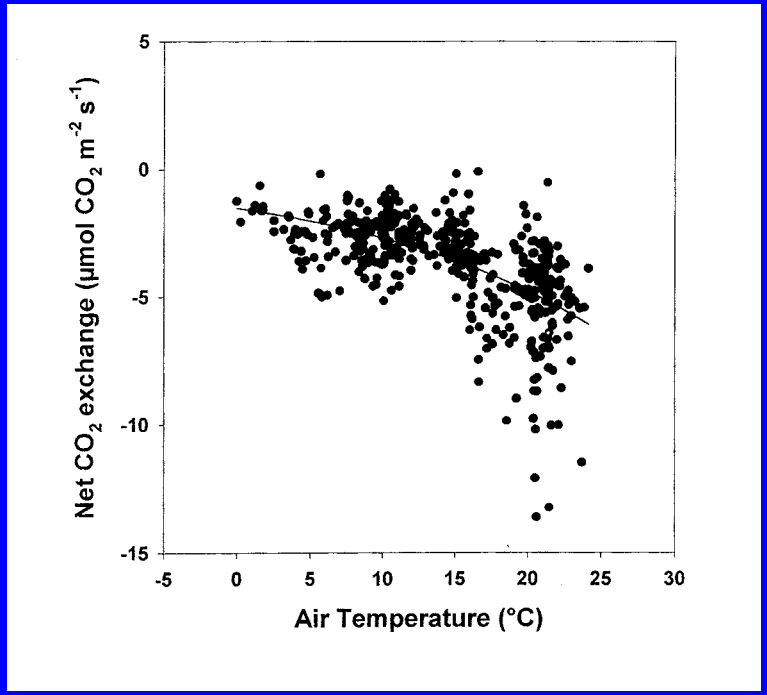
Plantation Pine and Cypress Productivity



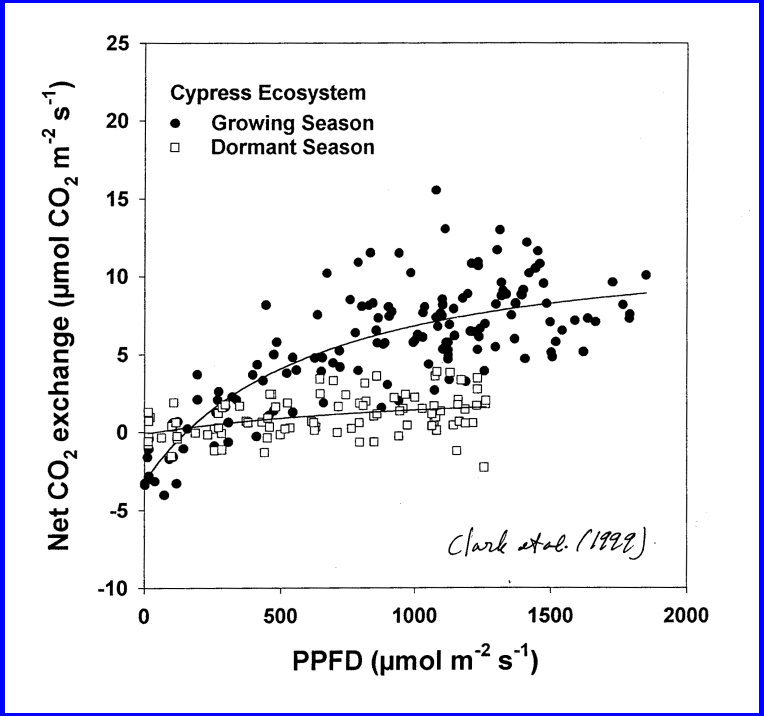
Clark et al. 1999

Environmental Factors

Pine



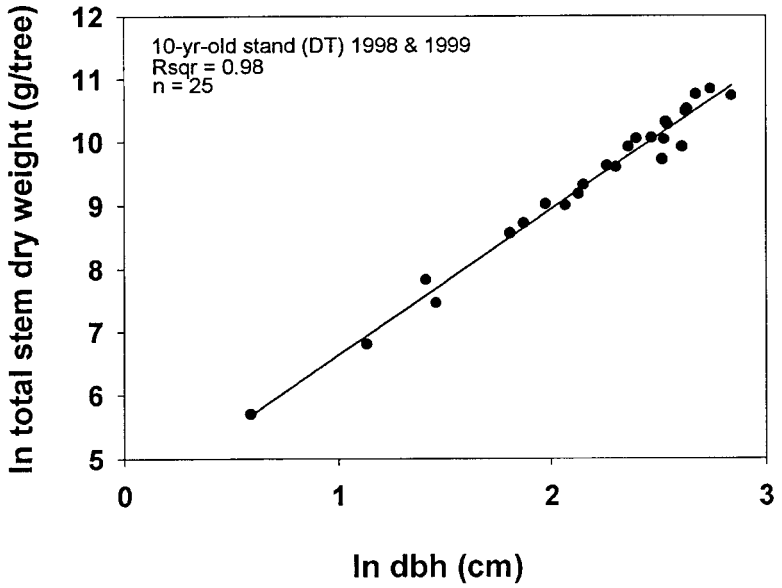
Cypress



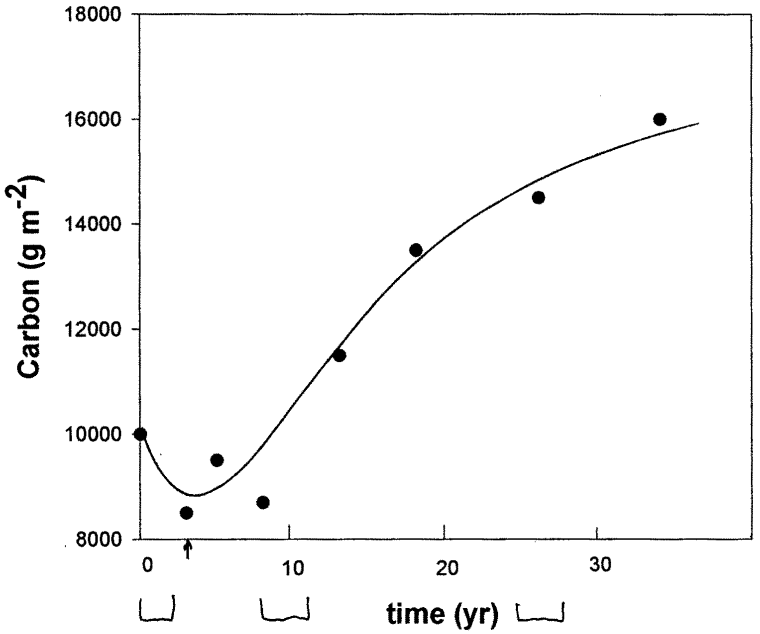
Clark et al. 1999

Biomass and Carbon

Allometry



ECOSYSTEM CARBON CONTENT
(vegetation + soil + litter) in the Florida slash pine chronosequence
(Gholz and Fisher 1982)



Cypress Wetland Ecosystems

TABLE 4. Mean bulk density, organic matter, and phosphorus content (P) of top 20 cm of soil.*

Study site	Bulk density (g/cm^3)	Organic matter (%)	Organic matter (kg/m^2)†	Total P (mg/kg dry soil)	Total P ($g\ P \cdot m^{-2}$)†
Domes					
Natural					
Small Dome 1	0.51	8	6.40	135	10.5
Small Dome 2	0.42	13	10.7	218	17.1
Bermed Dome	0.18	49	11.4	395	8.6
Large Dome‡	0.29	§	§	302	17.5
Nutrient enriched					
Pasture Dome	0.58	18	13.6	1095	113.8
Sewage Dome	0.20	§	§	549	22.0
Floodplain forest	0.68	8	10.0	379	46.6
Scrub cypress	1.28	<1	0.0	0.9	0.23

* Mean of three samples per site.
† Organic matter and phosphorus content were calculated as the means of the three individual samples per site.
‡ From Deghi 1977.
§ Not sampled.

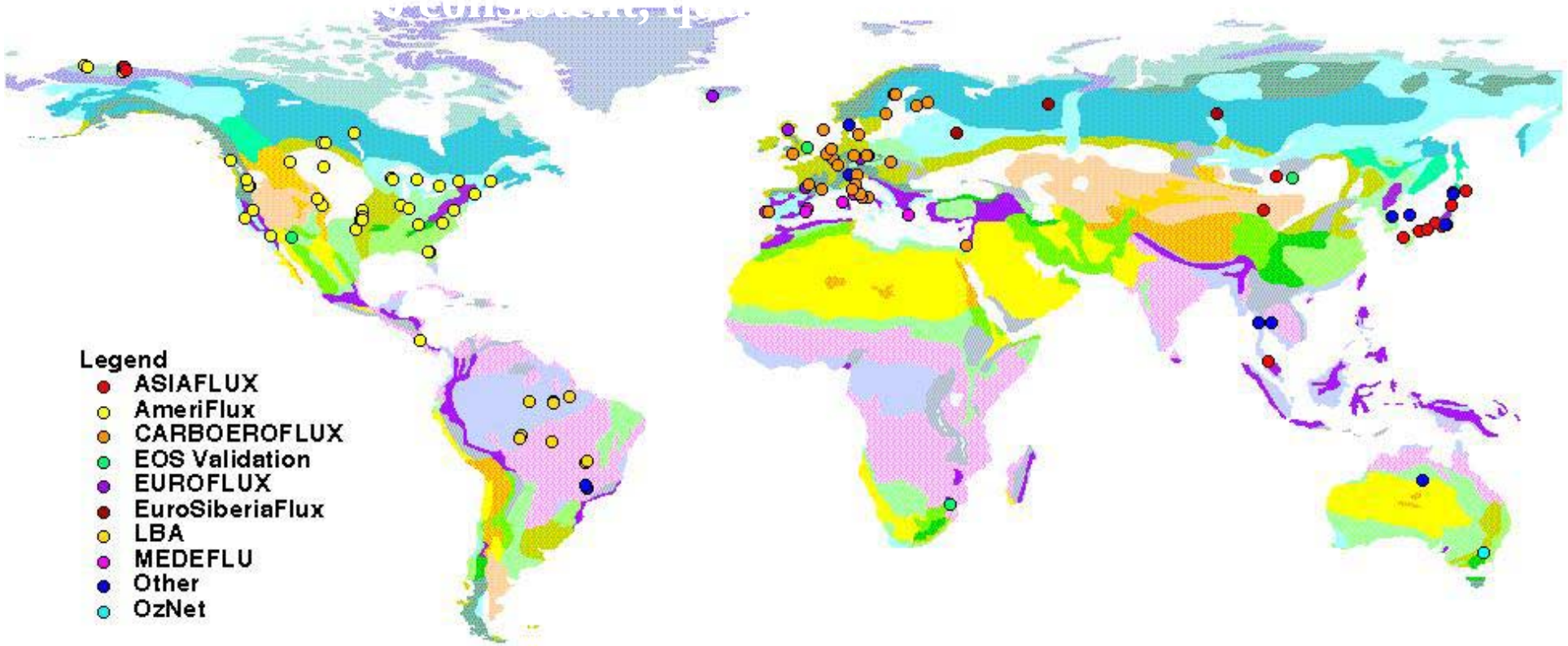
TABLE 8. Aboveground biomass of the tree stratum (≥2.5 cm dbh) in Florida cypress forests.

Study site	Leaves (g/m^2) Cypress (% of total)	Leaves (g/m^2) Other species	Leaves (g/m^2) Total	Total biomass (kg/m^2) Cypress (% of total)	Total biomass (kg/m^2) Other species	Total biomass (kg/m^2) Total
Small Dome 1	245 (71)	100	345	16.4 (80)	4.2	20.6
Small Dome 2	267 (63)	159	426	17.2 (74)	5.9	23.1
Bermed Dome	319 (64)	184	502	18.0 (77)	5.4	23.5
Large Dome	265 (57)	200	465	21.4 (80)	5.2	26.6
Pasture Dome	118 (44)	151	269*	5.4 (44)	6.8	12.2
Sewage Dome	472 (85)	81	553*	17.3 (80)	4.4	21.7
Floodplain forest	338 (51)	325	663*	22.8 (80)	5.6	28.4
Scrub cypress	132 (88)	18	150	3.4 (94)	0.2	3.6

* Estimated from the regression equation of optical density and estimated leaf biomass (see text).

Brown, S. et al. 1981. Ecol. Monogr.

AmeriFlux and FluxNet



Methods

- The three objectives will be addressed by:
- 1. Determining changes in land-cover and land-use patterns in the lower Coastal Plain region from 1975 - 2000.
  - Analyses of archived and contemporary satellite remote sensing data in 4 sample areas (~15 by 15 km each) within a single Landsat Thematic Mapper or Multi-Spectral Scanner (TM/MSS) scene from north-central Florida and southeastern Georgia (WRS 2 Path 17, Row 39), using 2-6 scenes per year (or every other year if data budget is insufficient) for the past 25 years.
- 2. Determining changes in land ownership/tenure and management practices across the same sample areas over the past 25 years, and linking the human activities with observed land-cover changes via empirical quantitative models.
  - Analysis of parcel records from archives maintained by county tax assessors offices.
  - Interviews with land-owner representatives, inspection of some corporate records.

Methods

- 3. Determining changes in the regional C storage over the past 25 years
  - Estimating changes in C stored in tree, understory, leaf litter, and soil biomass over time resulting from land use changes in the sample areas, based on a synthesis of previous studies, existing data, and ongoing studies on carbon storage in regionally representative ecosystems.
  - Look-up tables, vegetation index calibration, LAI estimation, ANN approaches.
- 4. Determining the effects of environmental conditions (e.g. climate), wildfire and prescribed fire, and logging on ecosystem carbon storage, and C sequestration rates within regionally representative ecosystems
  - Measurements at existing long-term carbon dynamics research sites and archival weather and fire (state Department of Forestry) data, and land-cover change analysis of Landsat MSS and TM data.

Land-Cover Classification
Hybrid – Unsupervised/Supervised

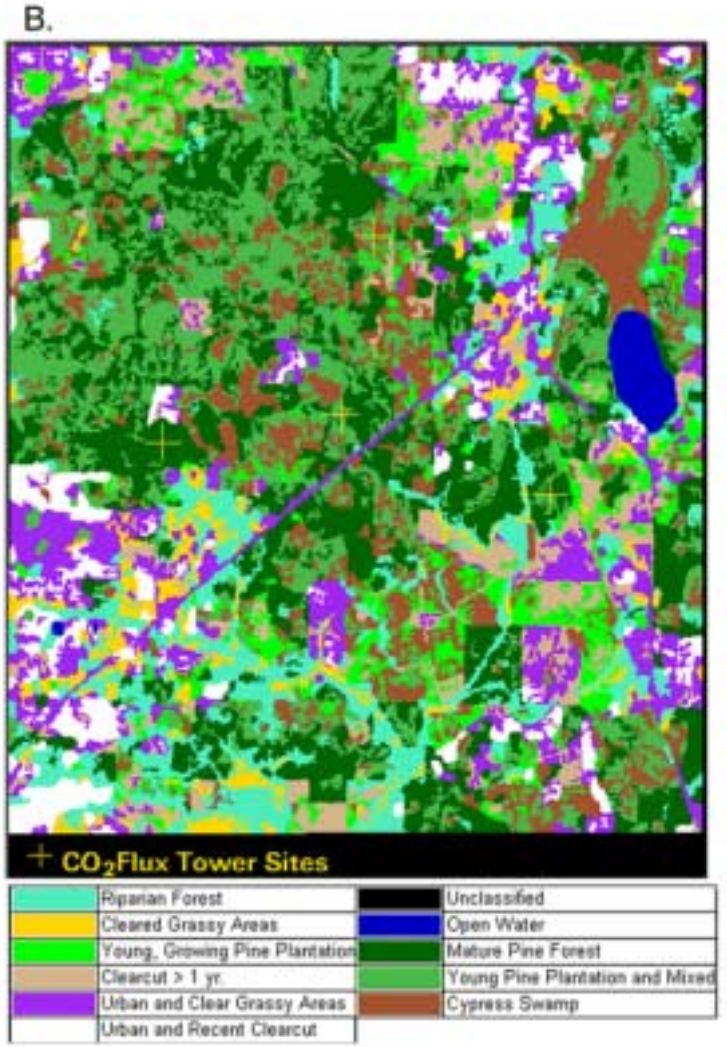
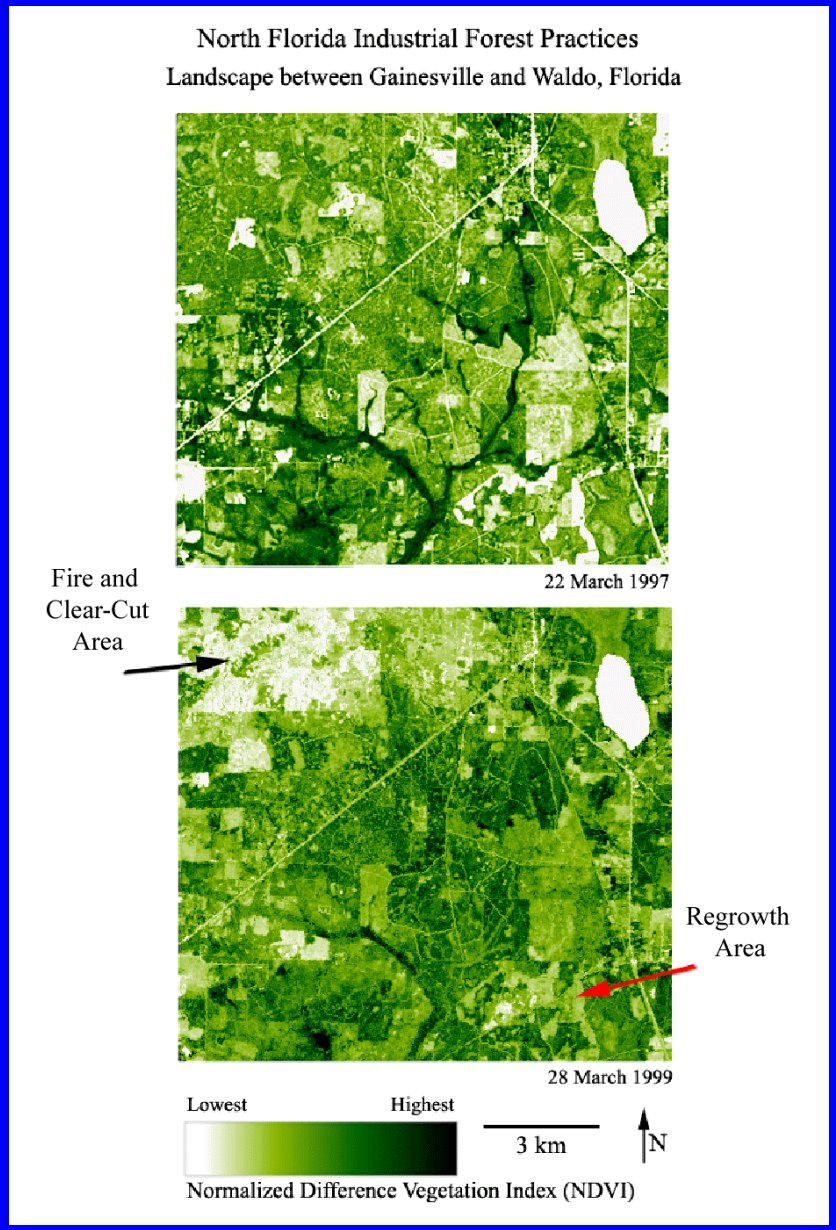
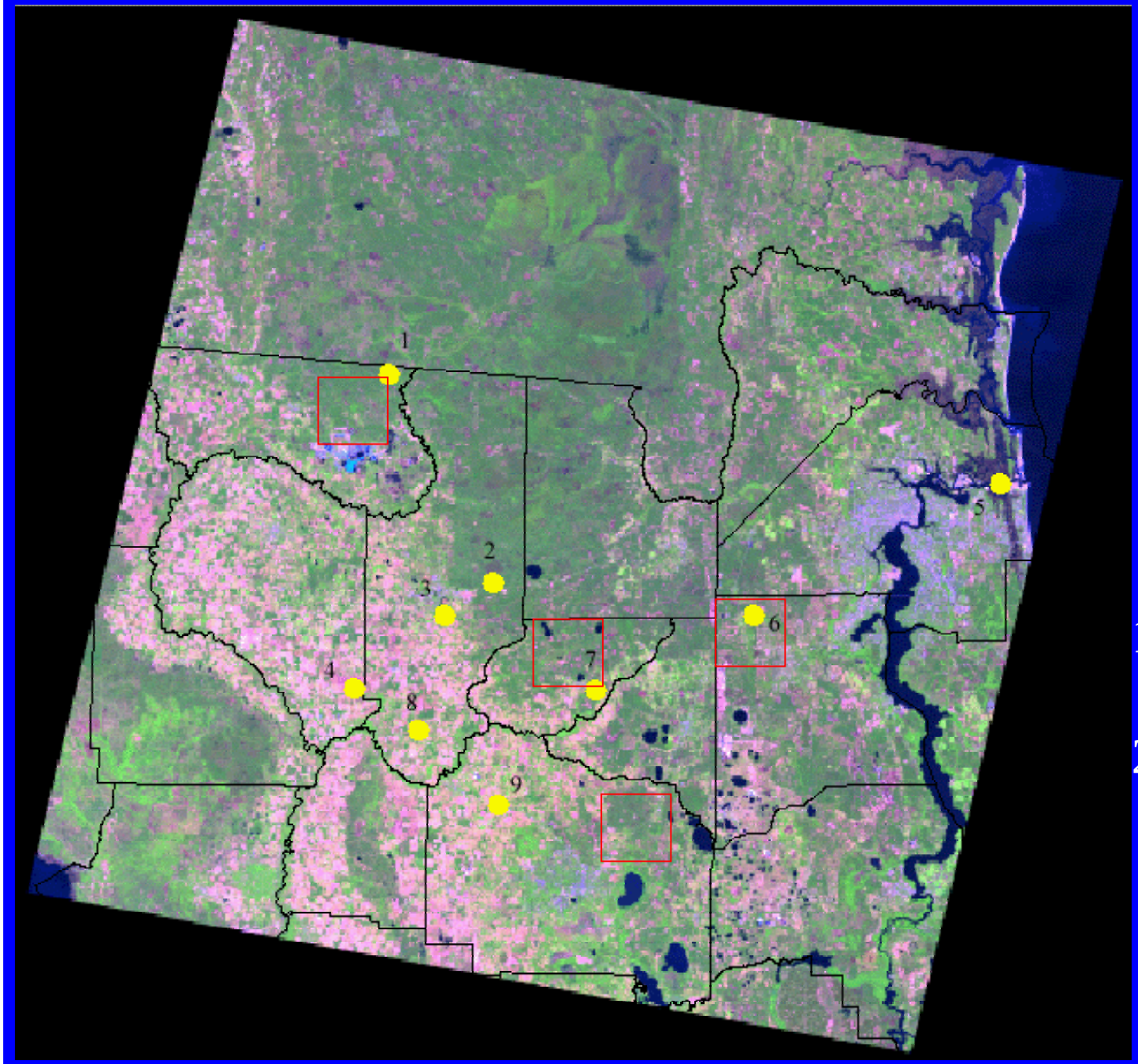


Figure 2. Landsat TM imagery from 27 March 1997. A. "True-color" image using bands 3, 2, and 1 for red, green, and blue. B. Interpreted results of an unsupervised land-cover classification.



Vegetation Indices and Other Parametric (Continuous Field) Approaches

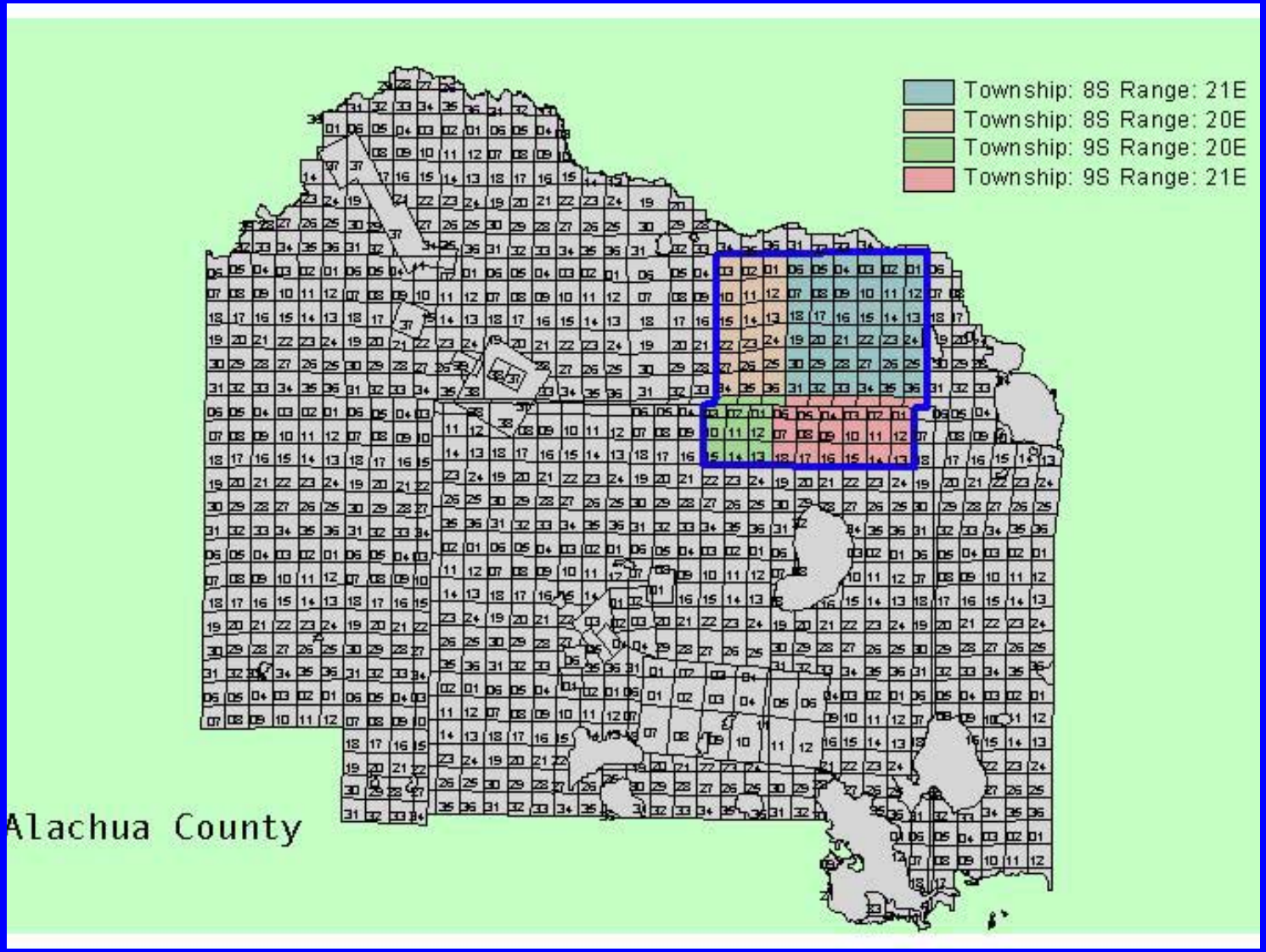
Also: LAI by Jensen 2000 method



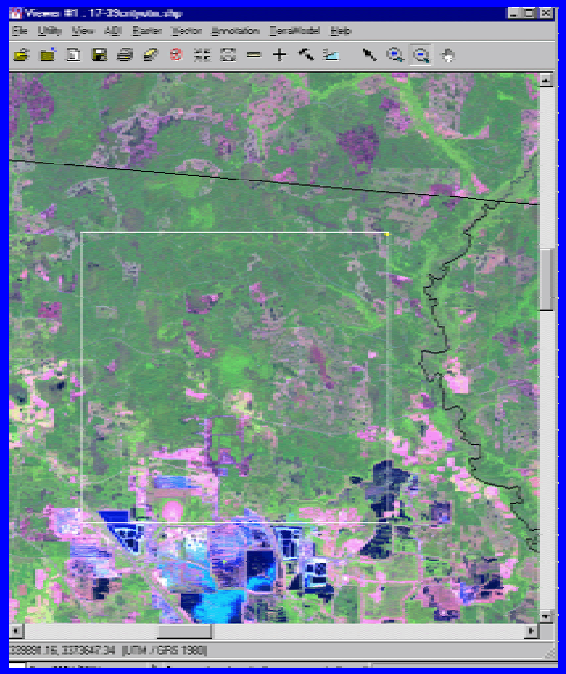
Random Points and Final Study Areas

1. Within one county.
2. Boundaries modified to conform to land boundary system.

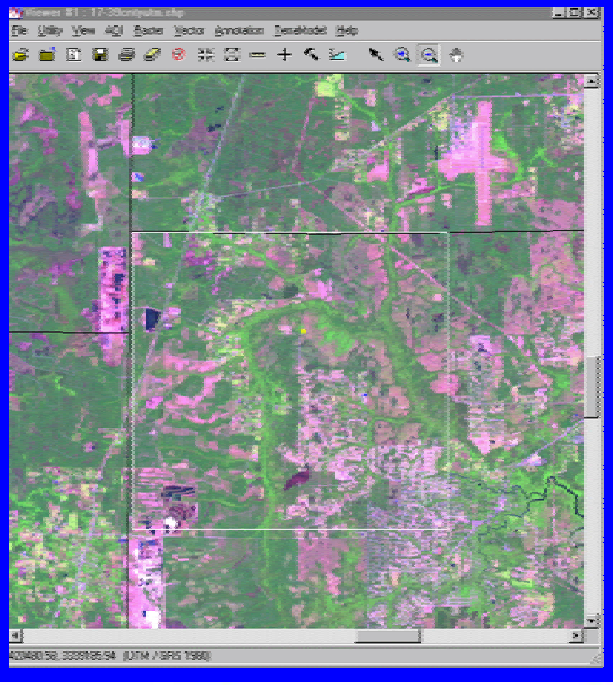
Study Areas and the Land Boundary System.



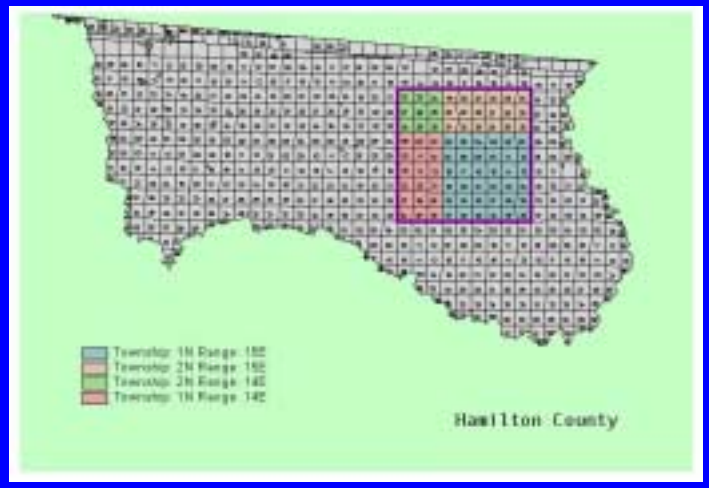
Study Areas and the Land Boundary System

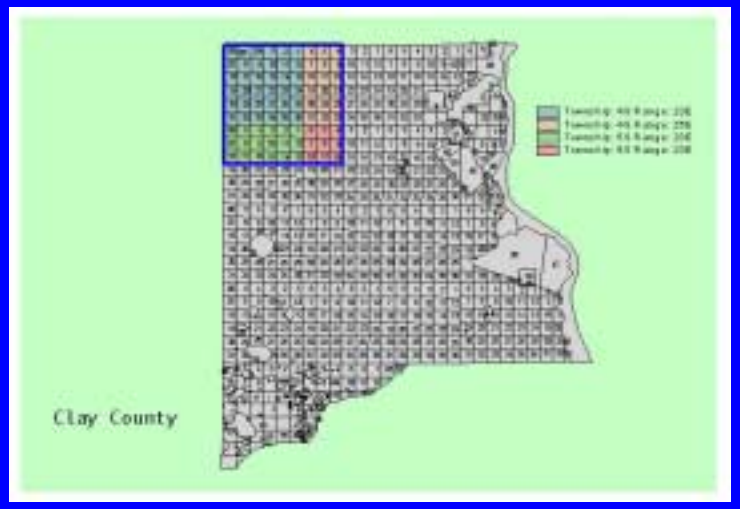


Hamilton County

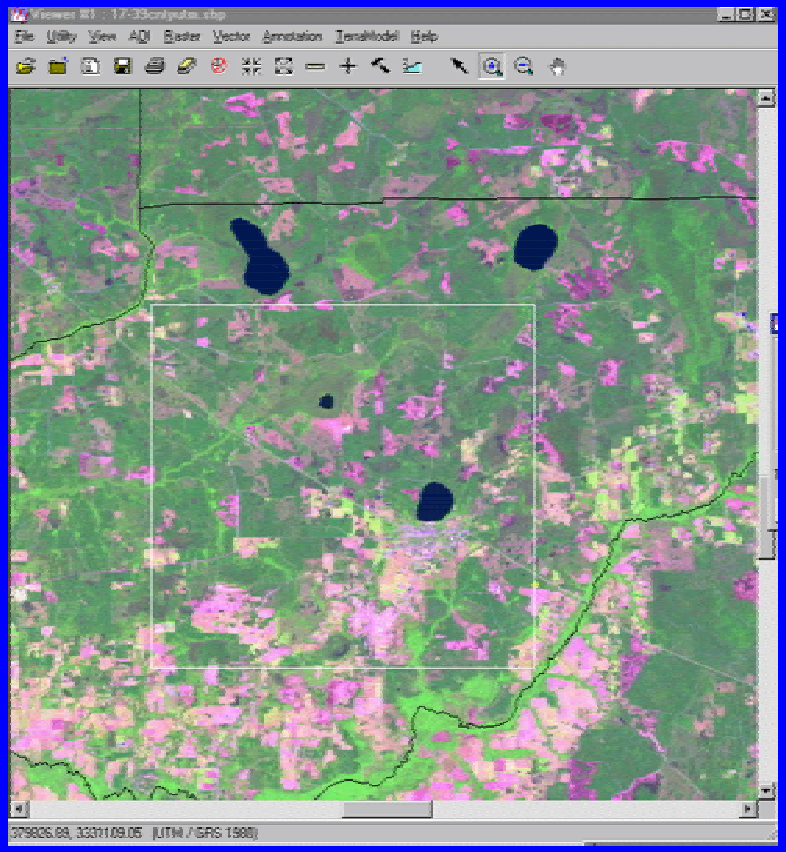


Clay County

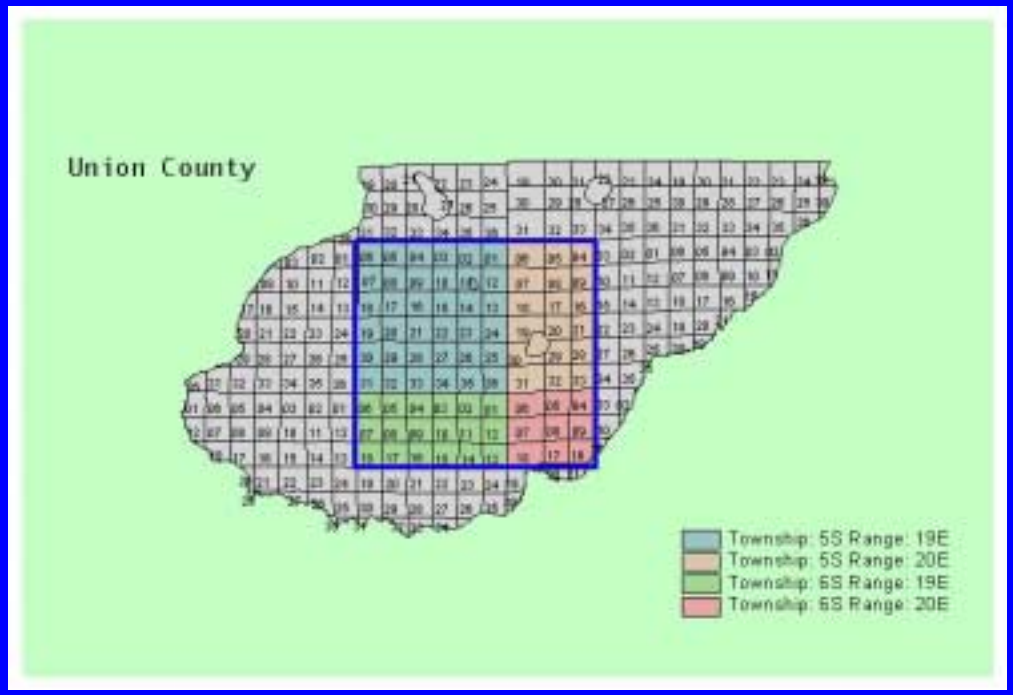




Study Areas and the Land Boundary System



Union County



Methods and Data Plan

- Landsat data coincident with phenologically critical times.
- Land-ownership methods
- Satellite data processing

Phenology and Available Landsat Data

CRITICAL DATES FOR IMAGERY	
1 - End of Litterfall	1/1-1/15
2 - Min LAI	3/1-3/15
3 - LAI Expansion	6/10-6/30
4 - Max LAI	8/25-9/10

Phenology and Available Landsat Data

- 74 sufficiently cloud-free scenes available over the 25 years of the study period.
  - 2 ETM+ as of August 2000, still looking.
  - 49 TM
  - 23 MSS, some overlap with TM
- Only 2 or so years have complete phenological coverage
  - 1984 and 1986, maybe 1991. Drought years.
- Fall/Winter/Spring scenes are common, summer scenes are rare.
  - Inter-annual comparisons possible; major LCLUC objectives met.
  - Intra-annual variation will be difficult.

Land Tenure/Ownership Patterns

Objectives:

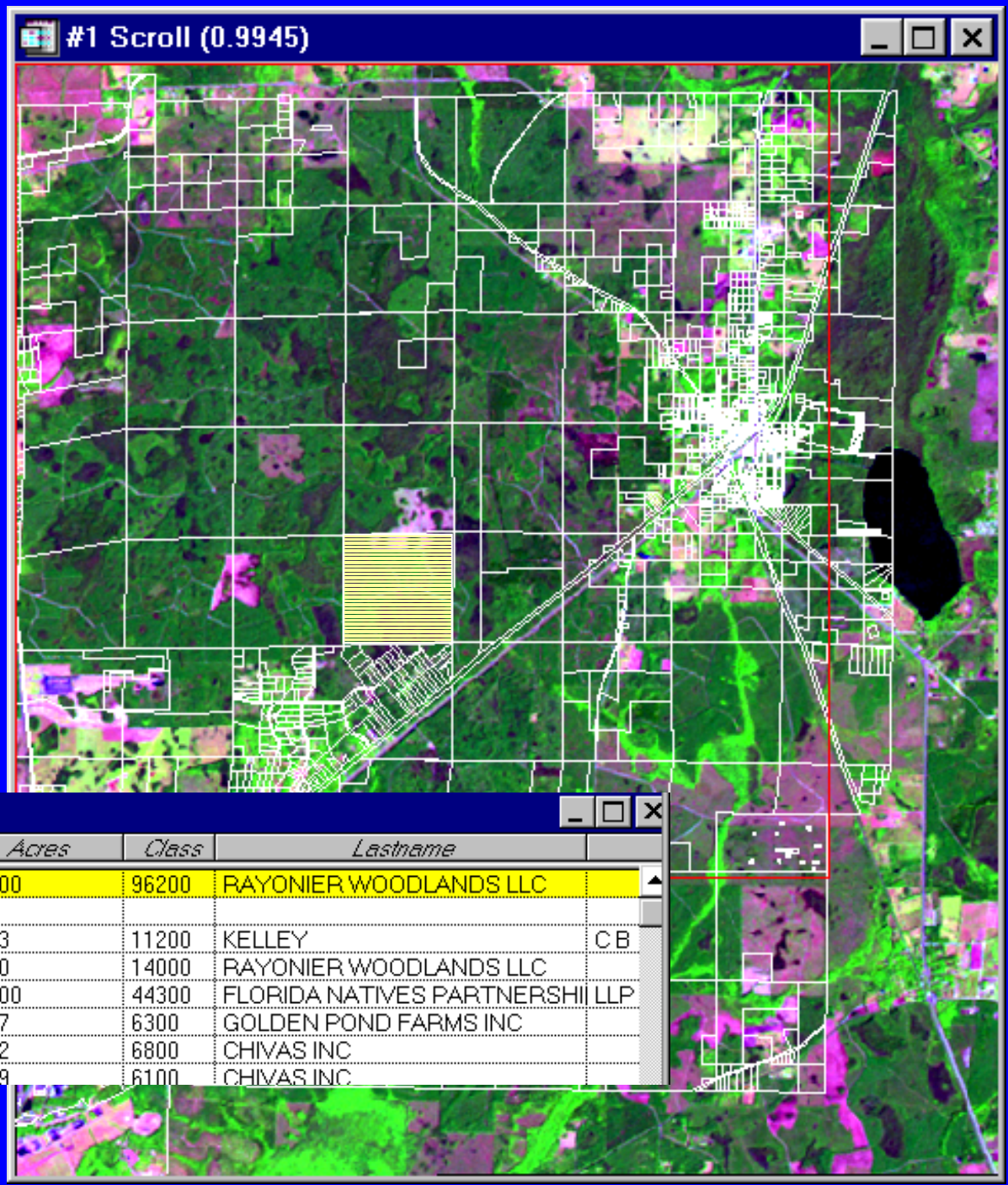
- Document changes in parcel size & ownership type between 1975-2000
- Analyze how this has affected LULC and carbon sequestration

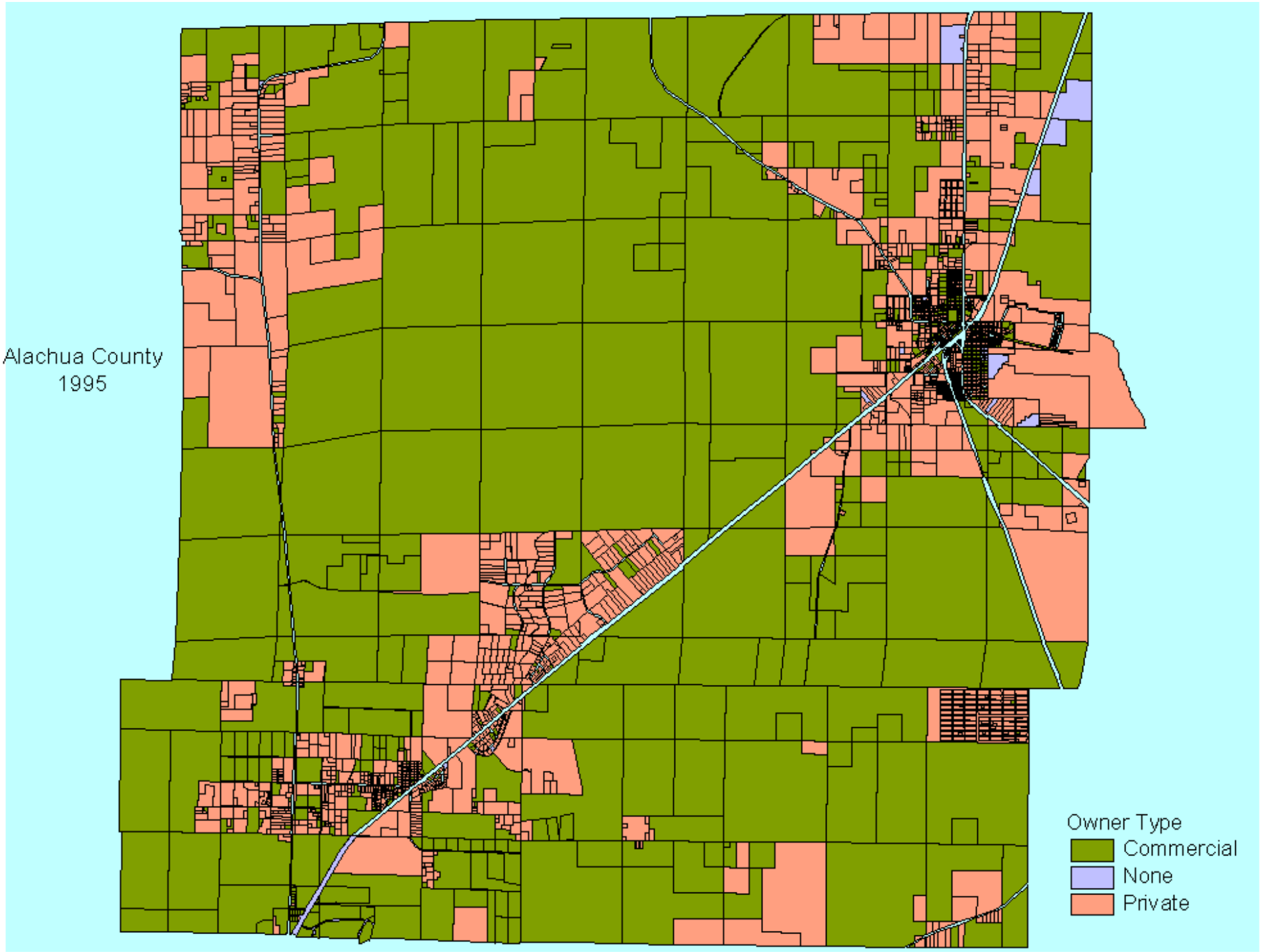
Issues/Questions:

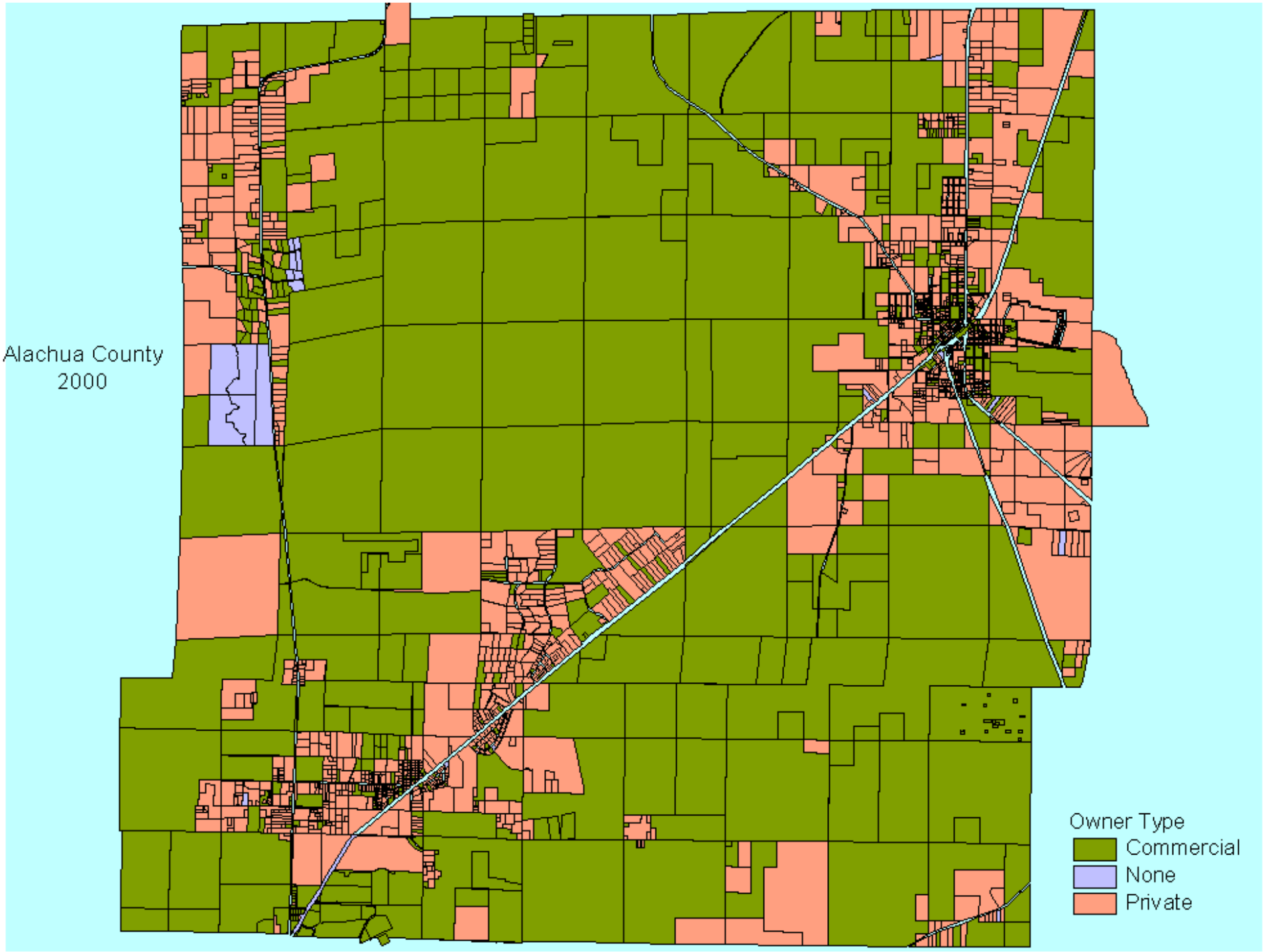
- Space scale (parcel, section or township)
- Time scale (per change, annual, 5 year, 25 years)
- Link between land tenure and management practices
- Trends and impacts on carbon
- Urban parcels

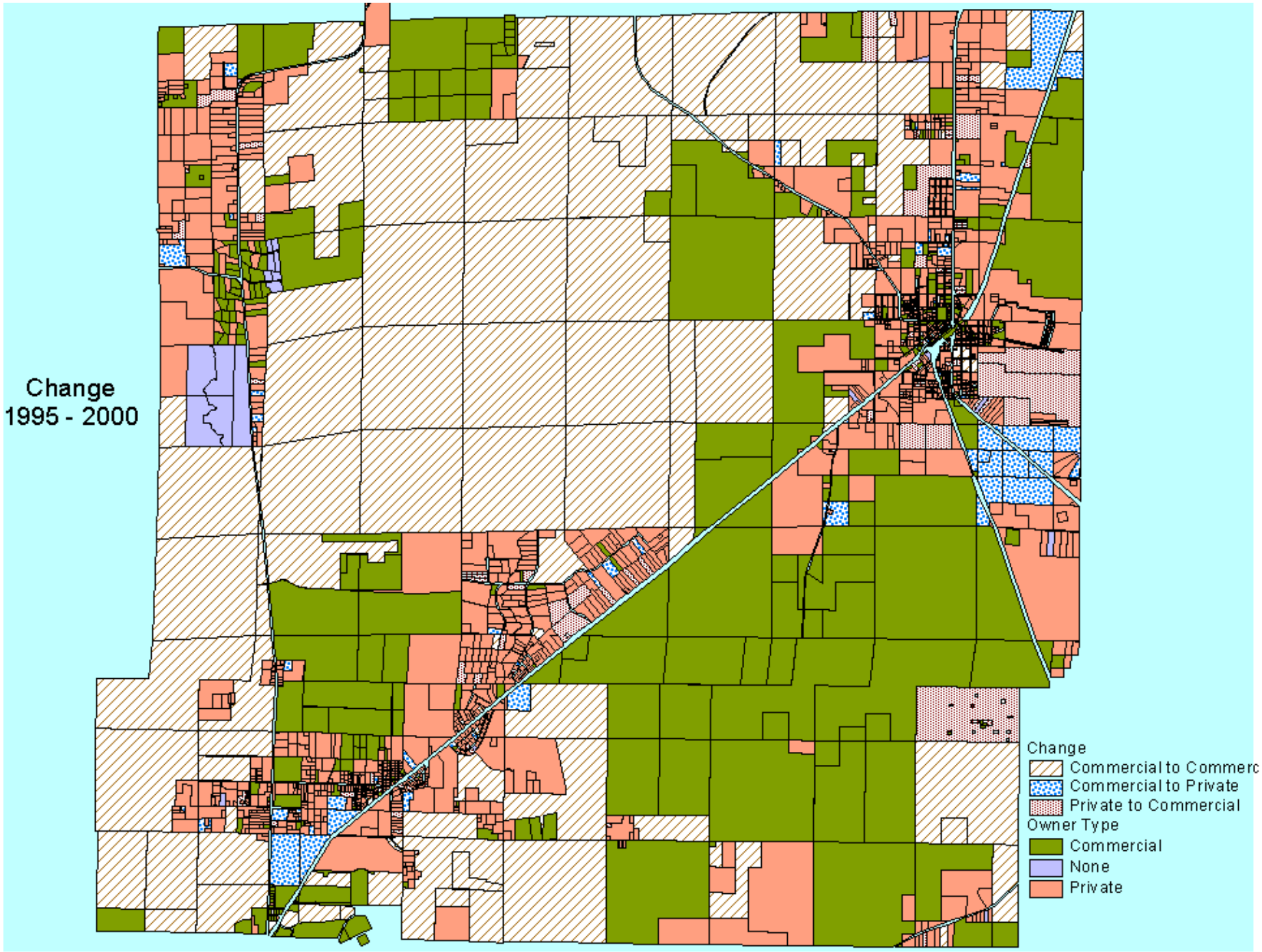
American forests have come to represent…the material and symbols society wields in its debates over nature, the environment, natural resources, and property (Heasley & Guries 1998)

Property Boundaries and Information




Alachua County
1995
Owner Type
Commercial
None
Private


Alachua County
2000
Owner Type
Commercial
None
Private


Change
1995 - 2000
Change
Commercial to Commercial
Commercial to Private
Private to Commercial
Owner Type
Commercial
None
Private

Schedule

Schedule of Activities May 2000 - April 2003

	Yr 2000								*Yr 2001*												*Yr 2002*												*Yr 2003*			
Activity	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**
I. Land-Use Change																																				
acquire imagery																																				
pre-processing																																				
Data Analysis																																				
Fieldwork																																				
II. Land Ownership																																				
site selection																																				
research digital records																																				
research public records																																				
Data Organization																																				
Longitudinal Analysis																																				
Integrate with LULC																																				
Integrate with Carbon data																																				
Follow-up Fieldwork																																				
	Yr 2000								*Yr 2001*												*Yr 2002*												*Yr 2003*			
	May	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**
III. Carbon Dynamics																																				
tower flux measurements																																				
litterfall collections																																				
tree growth measurements																																				
prescribed fire experiment																																				
biomass data synthesis																																				
IV. Integrative Activities																																				
report writing																																				
papers																																				
web site																																				

The End, or is more C actually sequestered in these systems?

New Land-Use/Environmental Change Institute (LUECI) at UF

- Multiple departments/colleges.
- LCLUC/LUCC agenda is part of basic perspective.
- Adds climate-change time scale (decades to millennia).
- Support from highest administration ($$).
- As many as 6 new appointments over next few years – watch for advertisements.