Land-Use and Land-Cover Change:

Land Management, Carbon Storage, and Policy Implications for the Southeast US Coastal Plain

Authors and Team: A Very Complex System

- Michael W. Binford (Geographer/Landscape and Aquatic Ecologist)
- Grenville Barnes (Land-Tenure/Cadastral Specialist)
- Henry Gholz (Terrestrial Ecosystem Ecologist)
- Scot Smith (Remote Sensing/GIS Specialist)

Objectives

(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 land ownership patterns on the carbon storage and sequestration rates of a representative regional ecosystem at already established long-term intensive research sites.

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.
- 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.

Study Area

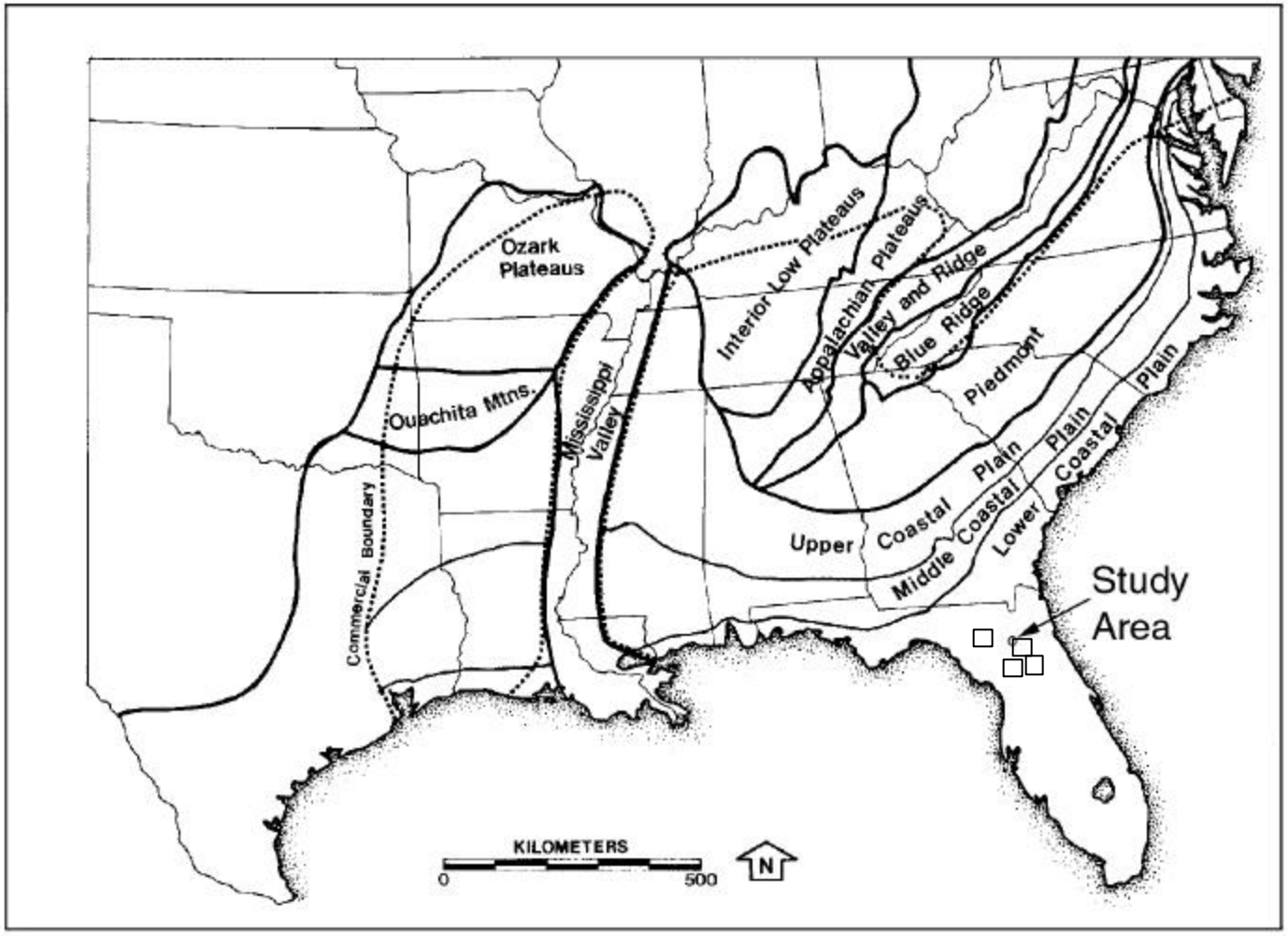
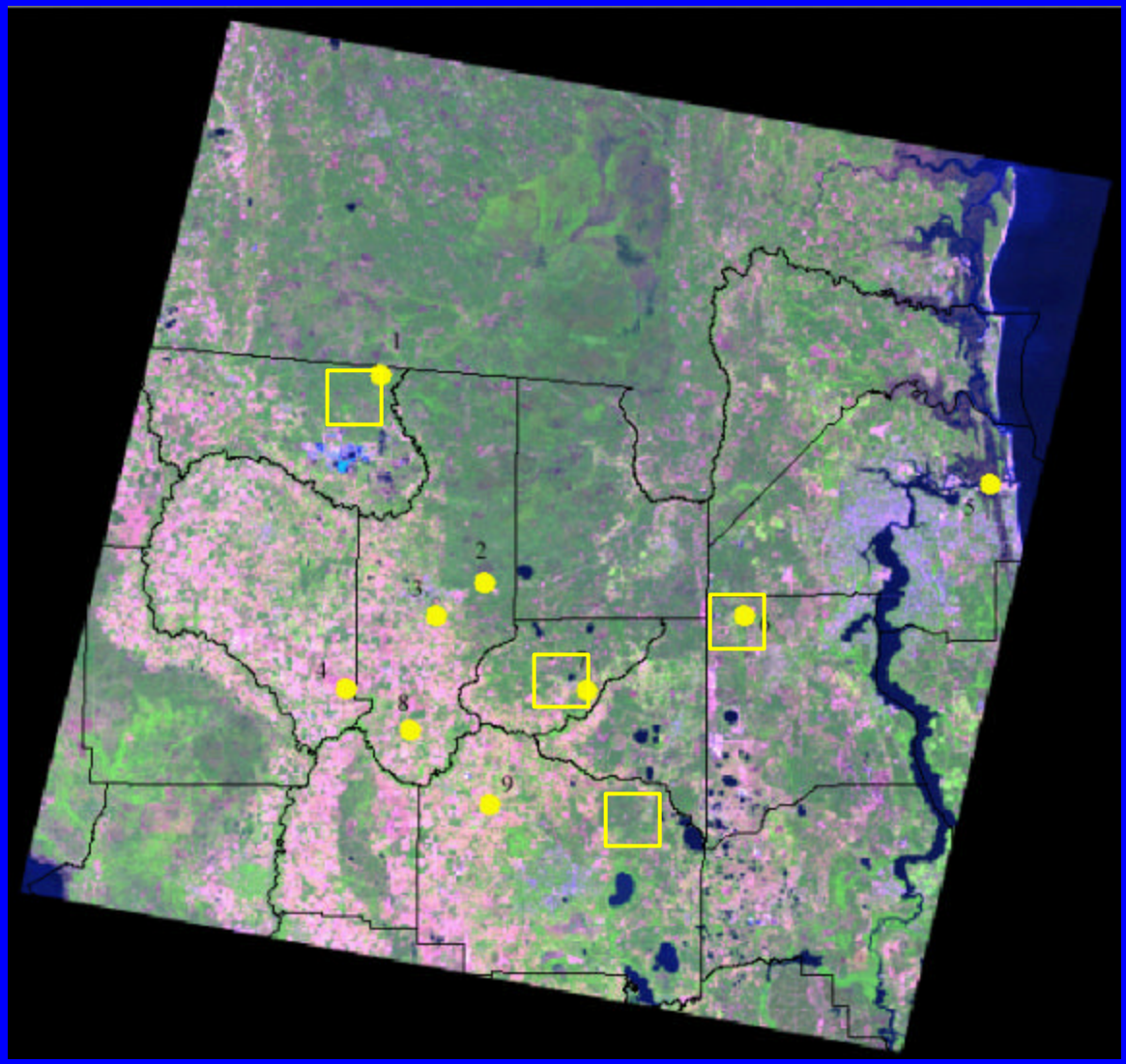


Figure 2. Physiographic provinces of the southeastern U.S.

Study Area

□

~15-km square



Landsat
WRS 2
P17 R39

Using eddy covariance for estimating NEE

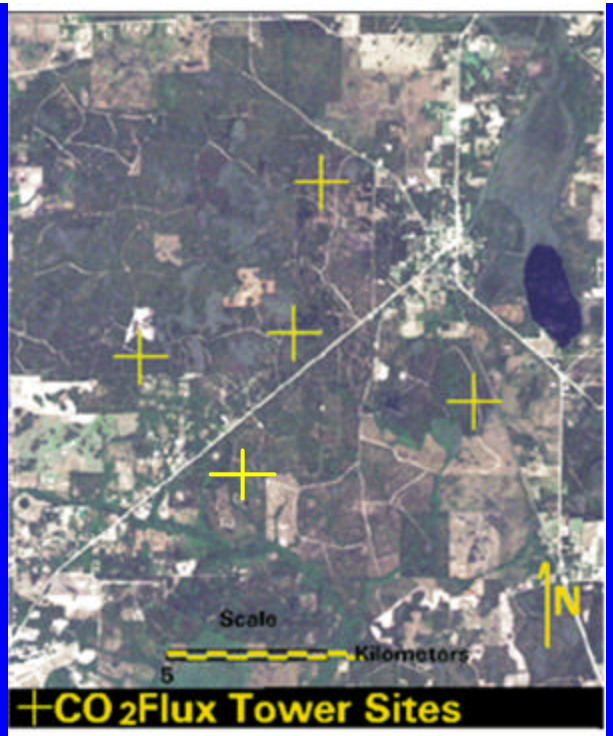


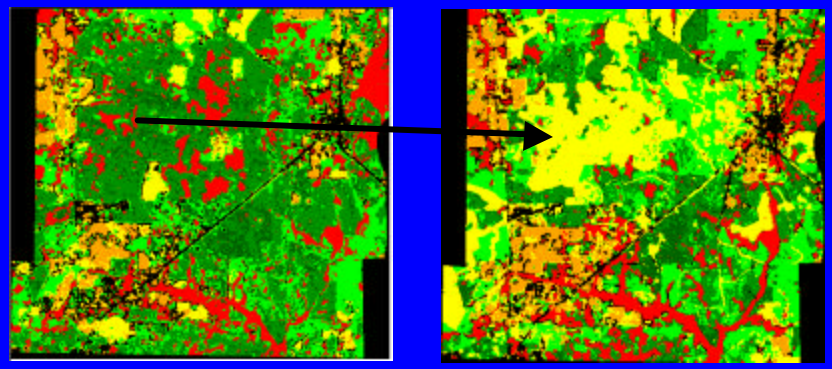
Figure 2. Landsat TM imagery from 27 March 1997. A. "True-color" image using bands 3, 2, and 1 for red, green, and blue. B. Interprete results of an unsupervised land-cover classification.

Industrial Forestry – Slash Pine

Vegetation Dynamics and Carbon Sequestration in North Florida

Landsat TM/ETM
5,4,3 = R,G,B
Composite
Alachua County
Study Site

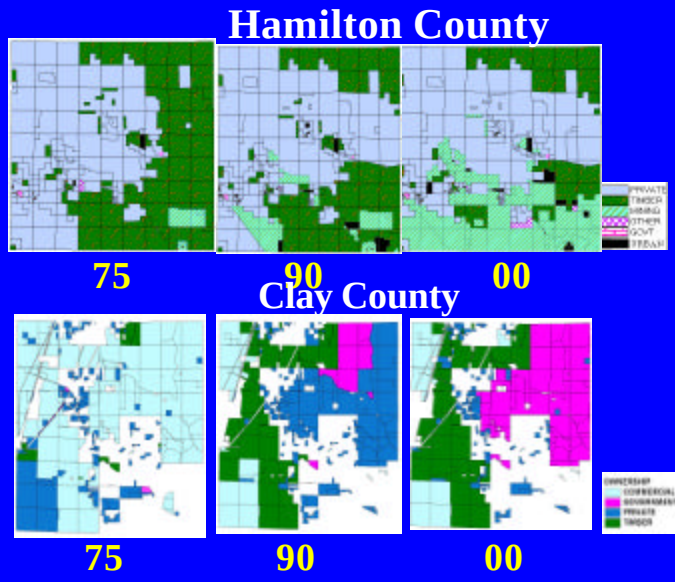
Landscape Dynamics



Jan 1998 Jan 1999

- Vegetation is Dynamic

- Ownership is Dynamic



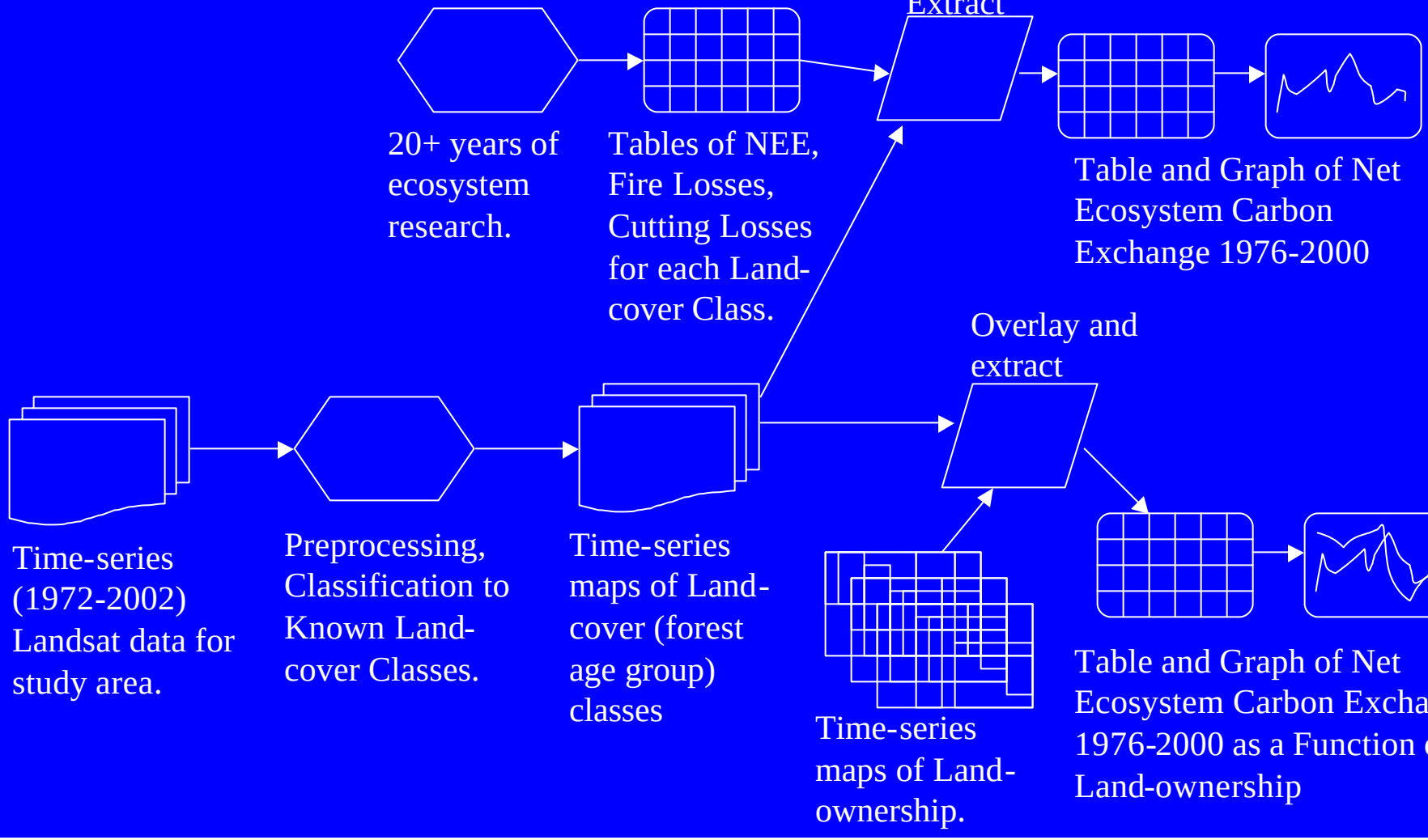
- Management is Dynamic

?

Approaches to Linking Ecosystem Research with Satellite Data

- Land-cover classification, including age classes for plantation pine, linked to
  - Look-Up-Tables of Net Ecosystem Exchange measured by eddy-flux towers, and Total Ecosystem Biomass/C measured in many sites over many years.
  - LUT of C removal by Fire and Harvest
- Continuous field
  - Statistical relationships between RS data and C storage
  - Artificial Neural Network approaches to estimating C storage from RS data
- Ecosystem modeling (Biome-BGC) expressed spatially by forest age
  - Accounting for climate variation

Method


Combine and Extract
20+ years of ecosystem research.
Tables of NEE, Fire Losses, Cutting Losses for each Land-cover Class.
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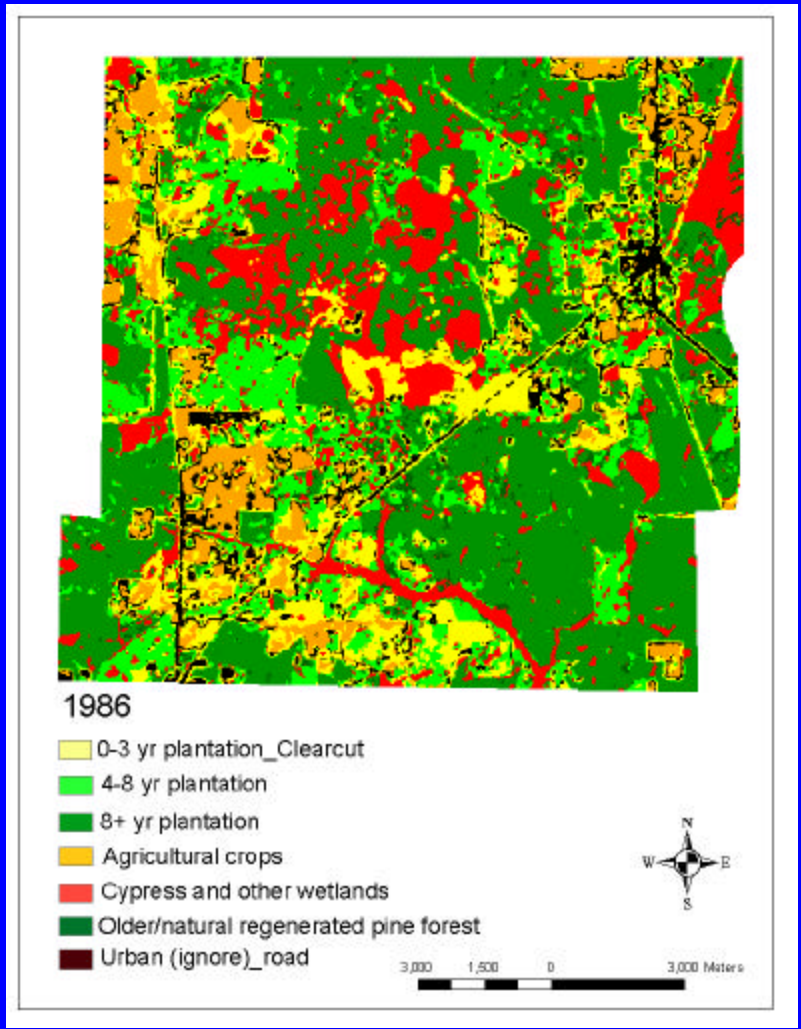
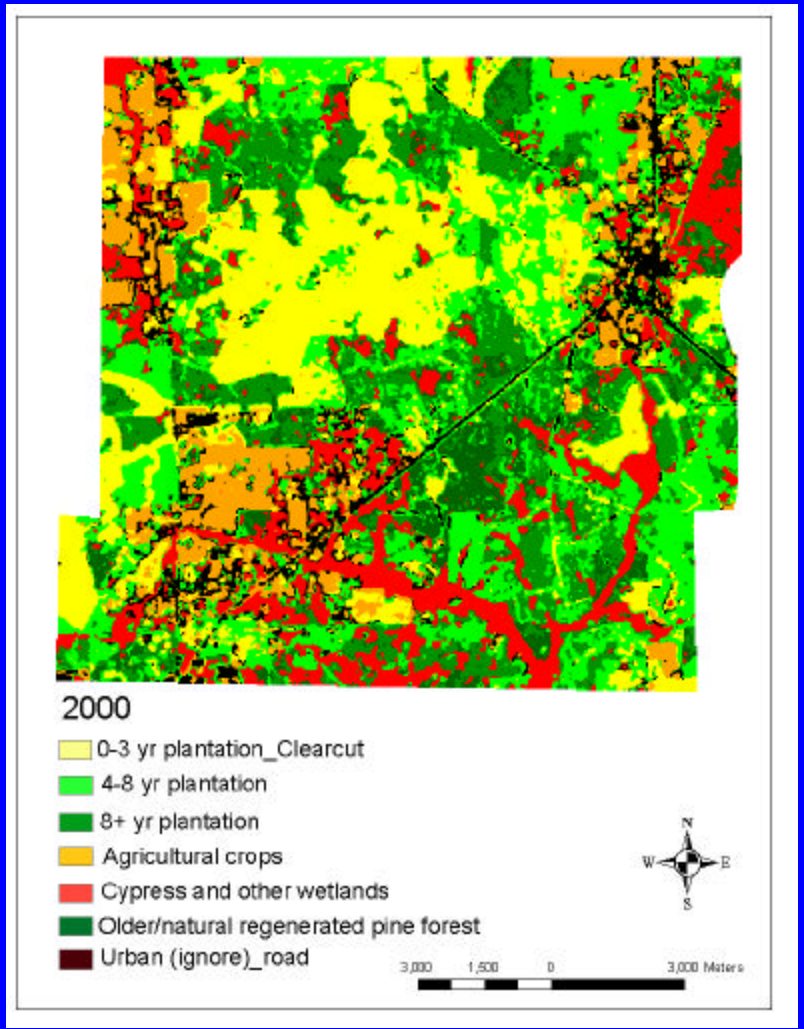
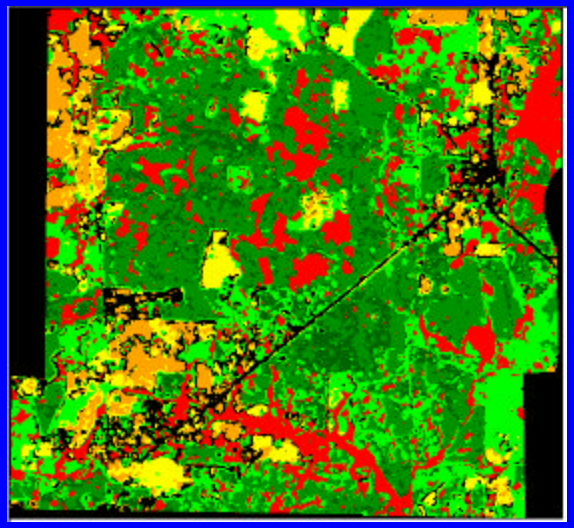
Land-Cover Change is Continuous

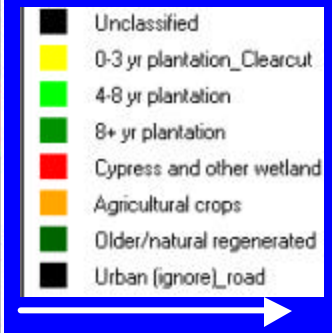




Land-cover From-To Analysis

Jan 1998





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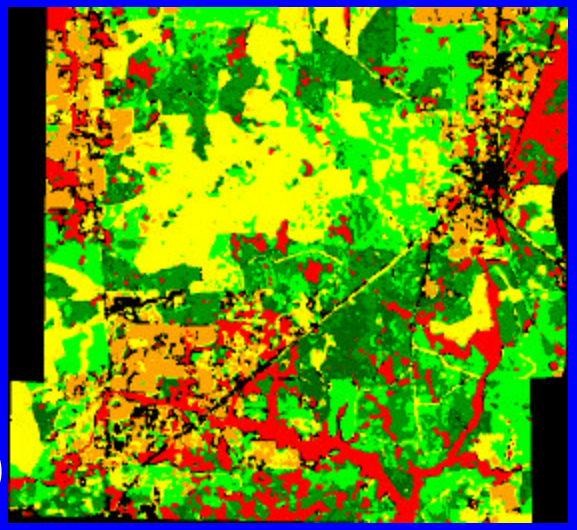
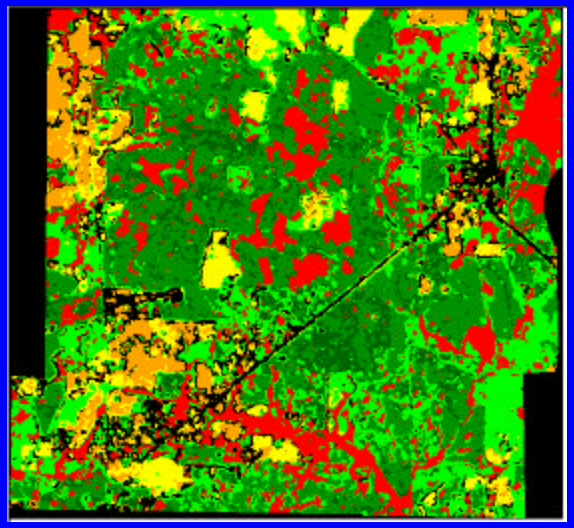
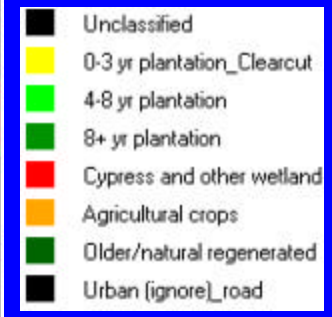


Change Matrix 1998 - 1999 (after the great Waldo fire of 1998)										
		1999								Burned
	1998	1	2	3	4	5	6	7	Total	hectares
0-3 yr plantation_Clearcut	1	681	1042	1413	592	146	535	546	4955	147
4-8 yr plantation	2	291	2013	843	838	49	447	183	4666	363
8+ yr plantation	3	0	270	1756	122	0	269	1	2417	1296
Cypress and other wetlands	4	19	685	315	1533	5	201	52	2810	482
Agricultural crops	5	395	90	28	46	886	6	374	1825	11
Older/natural regenerated pine forest	6	4	406	743	198	0	538	10	1901	449
Urban (ignore)_road	7	170	348	14	187	98	31	649	1497	87
	Total	1560	4855	5112	3516	1185	2026	1815	20071	2835
							Total Unchanged =		8057	
							Percent Unchanged=		40	

Land-Cover – Carbon Dynamics: Linking Ecosystem Research with Satellite Data

Jan 1998





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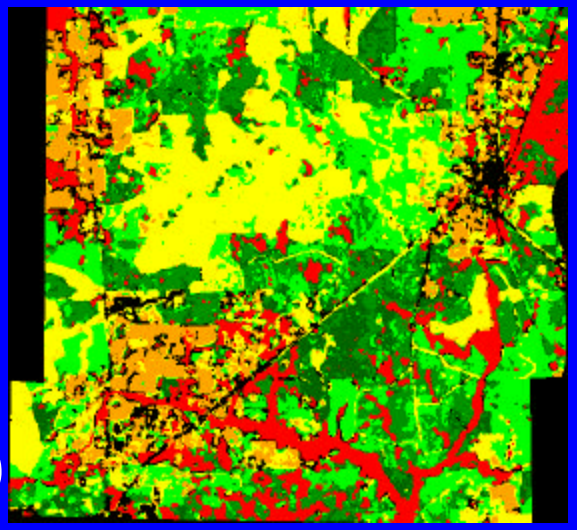


Fire Effects

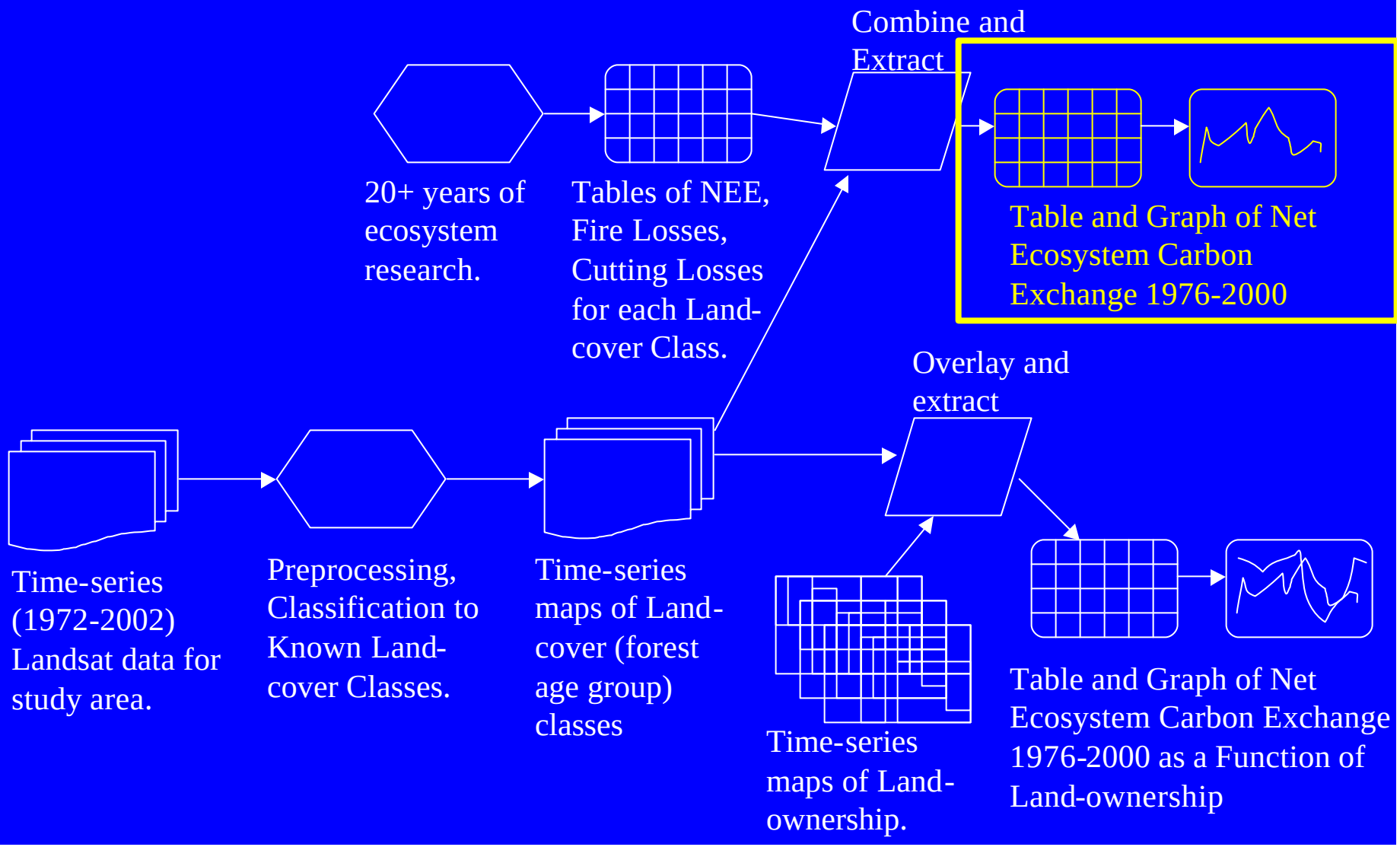
Age Classes	Biomass Removal (T ha-1)	std. Dev.
0-3	1.0	0.8
4-8	4.3	3.3
> 8	38.2	15.7

Total Landscape C_{exc} = Σ (Class area * C_{exc} $area^{-1}$)

Positive values indicate net C uptake by the ecosystem, negative values indicate net C output from the system.

NEE estimates for age classes:	NEE (g C m-2 y-1)	NEE (T C ha-2 y-1)
Age Class		
0-3 yr plantation Clearcut	-850	-8.50
4-8 yr plantation	145	1.45
8+ yr plantation	575	5.75
Cypress and other wetlands	60.5	0.61
Agricultural crops	0	0.00
Older/natural regenerated pine forest	180	1.80
Urban (ignore)		
water (ignore)		

One Part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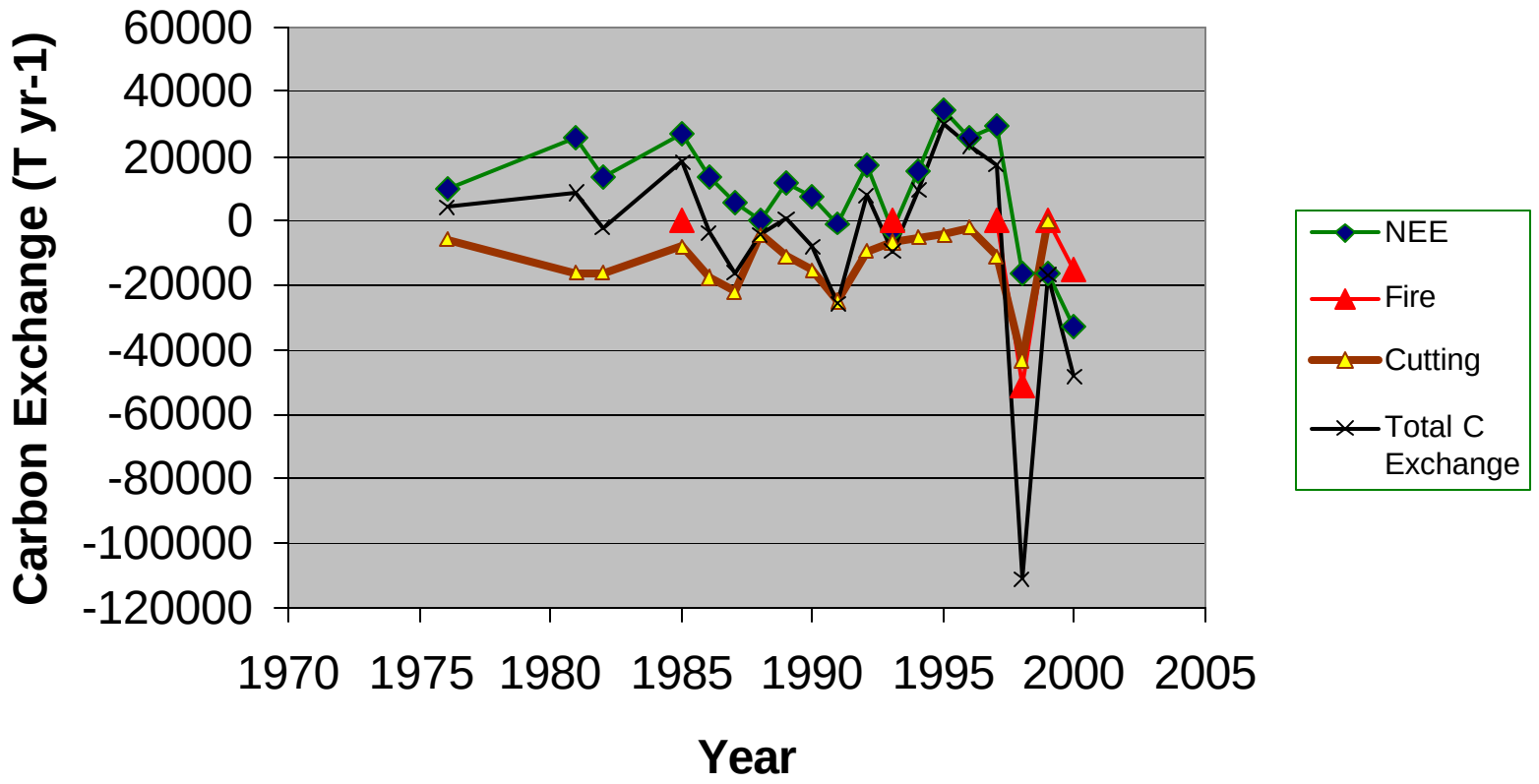
Regional Annual Carbon Budgets 1976-2000 (T landscape^{-1})

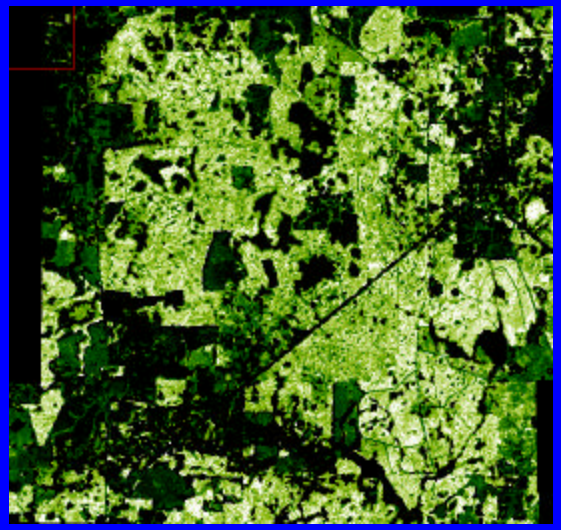
Year	NEE	Fire	Harvest	Total C Exchange	Total C Exchange without harvest		
1976	10289		-5719	4570	10289		
1981	25306		-16164	9143	25306		
1982	14155		-16235	-2080	14155		
1985	26710	-295	-8043	18372	26415		
1986	13651		-17288	-3637	13651		
1987	6196		-22187	-15991	6196		
1988	256		-4299	-4043	256		
1989	11795		-11218	577	11795		
1990	7287		-15539	-8252	7287		
1991	-980		-24723	-25703	-980		
1992	17588		-9698	7890	17588		
1993	-2859	-148	-6300	-9307	-3007		
1994	15005		-5319	9686	15005		
1995	34243		-4440	29802	34243		
1996	25272		-2221	23050	25272		
1997	28950		-11066	17884	28950		
1998	-16332	-51187	-43379	-110898	-67519		
1999	-16332	-219	-343	-16894	-16552		
2000	-33028	-15568		-48596	-48596		
Average	**8799**		**-12455**	**-6549**	**5250**		
Total	**167172**	**-67417**	**-224182**	**-124427**	**99755**		

Vegetation Dynamics and Carbon Sequestration in North Florida



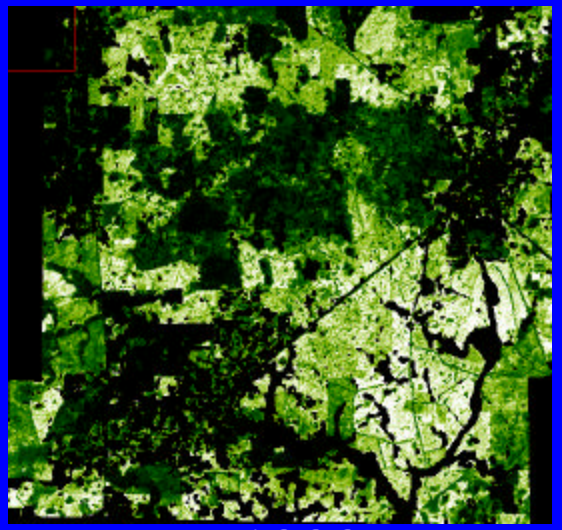
Continuous-Field C Estimates

Total C = 3,655,000 T



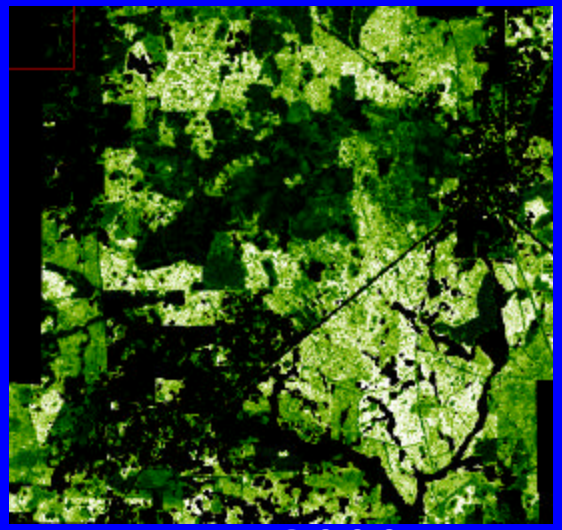
Jan 1998

Total C = 3,799,200 T

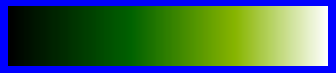


Jan 1999

Total C = 3,721,540 T



Jan 2000



0 T ha^{-1} 75

Total Ecosystem Biomass (g m^{-2}) = -1298.90 + 1287.41 * (SR)

Total Ecosystem C = Total Ecosystem Biomass / 2

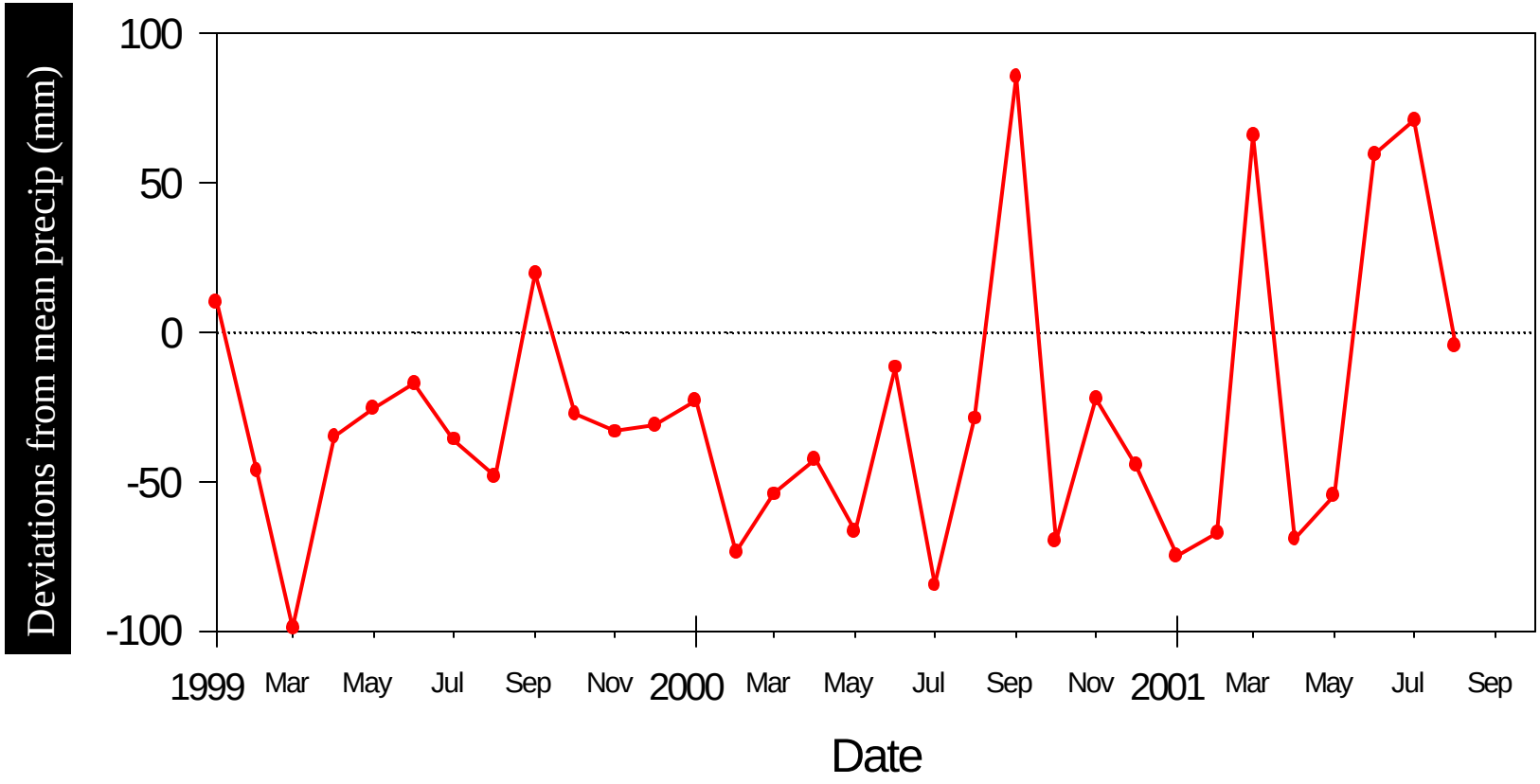
R^2 = 0.88

Climate Variation: Previous research showed that…

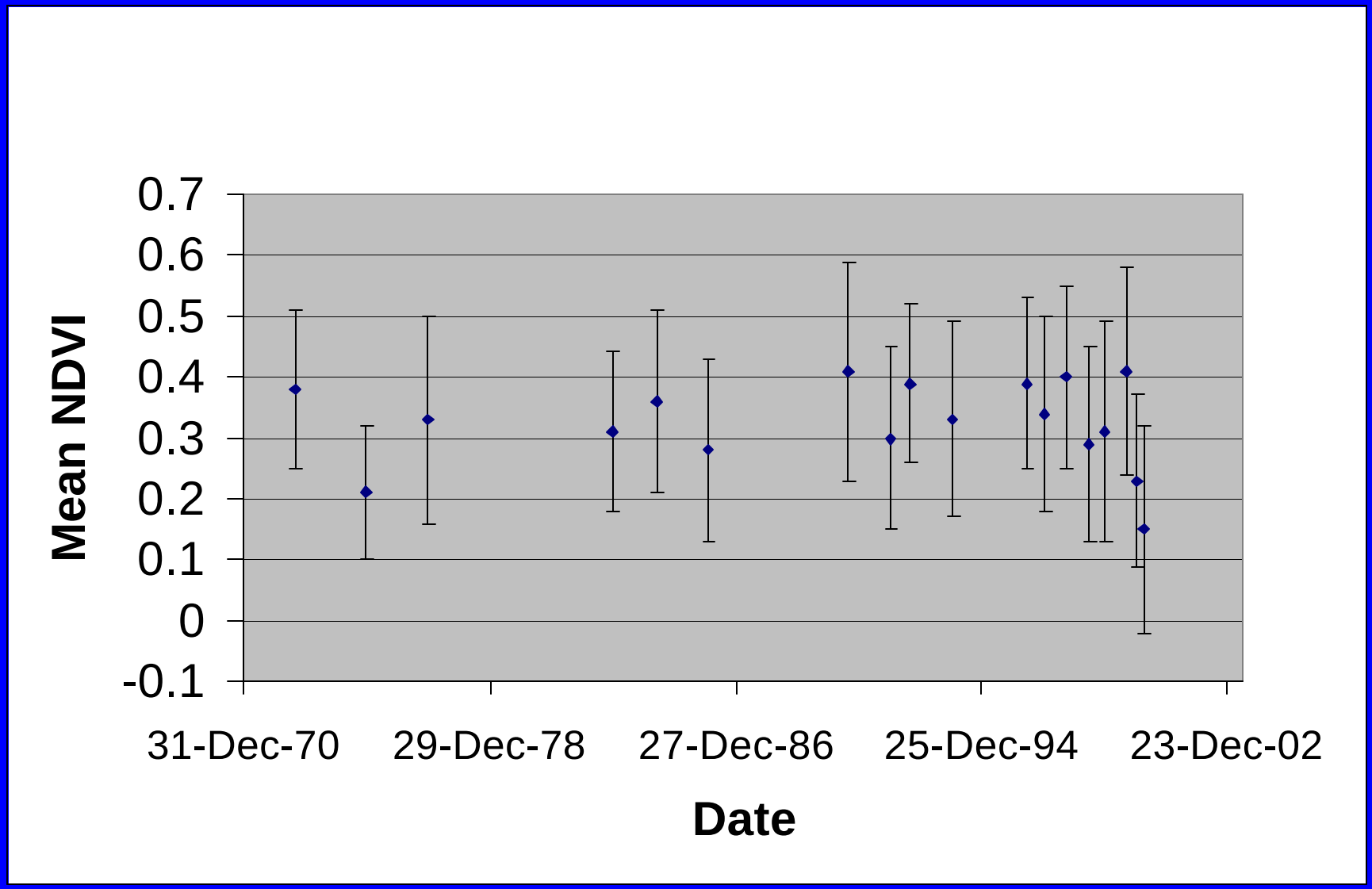
- **Plantation pine growth is not affected by irrigation or impacted by water table depth under "average conditions"**
- **And that growth is primarily nutrient limited**

So no further attention was placed on modeling interactions between C and H_2O

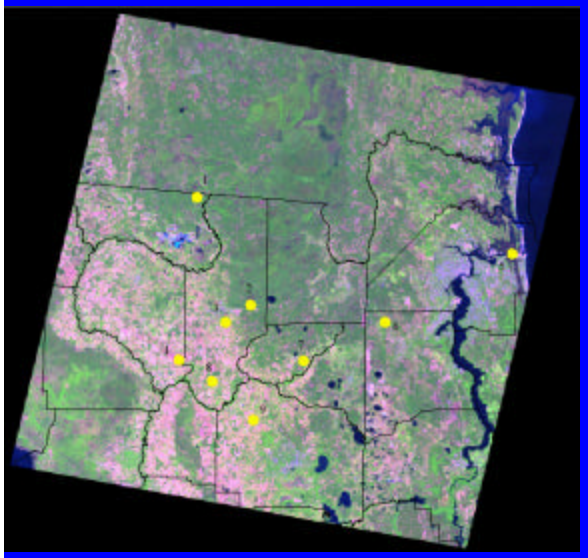
But A “100 year drought” occurred in 1999-2002, altering our modeling strategy

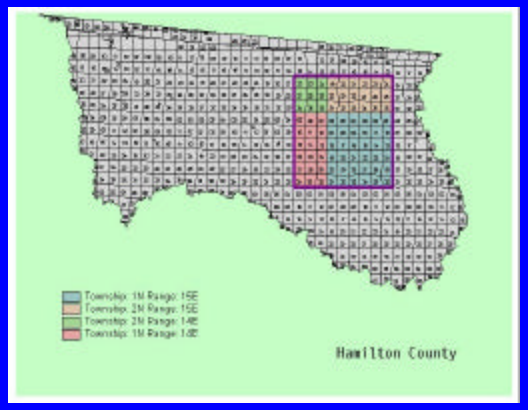


Mean NDVI time series (1972-2000), north Florida 15 x 15 km landscape

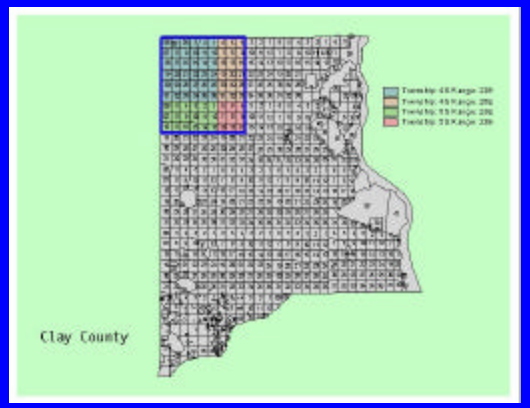


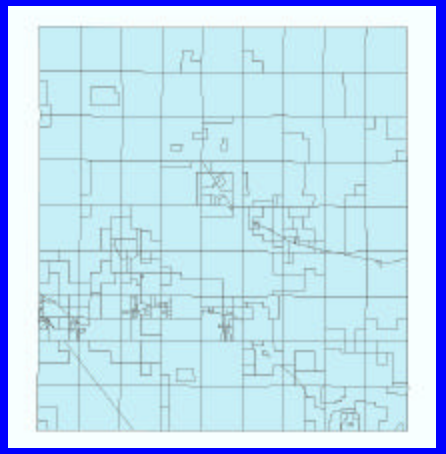
Developing a Spatio-Temporal Cadastral Database



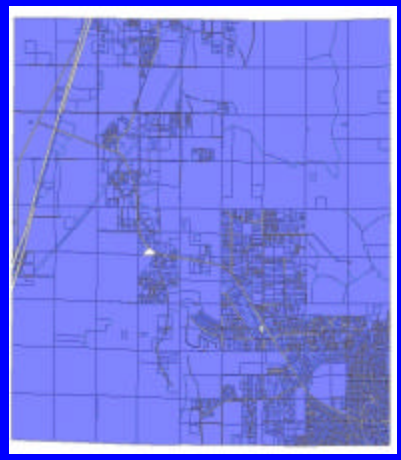


Original Rectangular PLSS Subdivisions





Current Cadastral Parcels (2000)



Definition

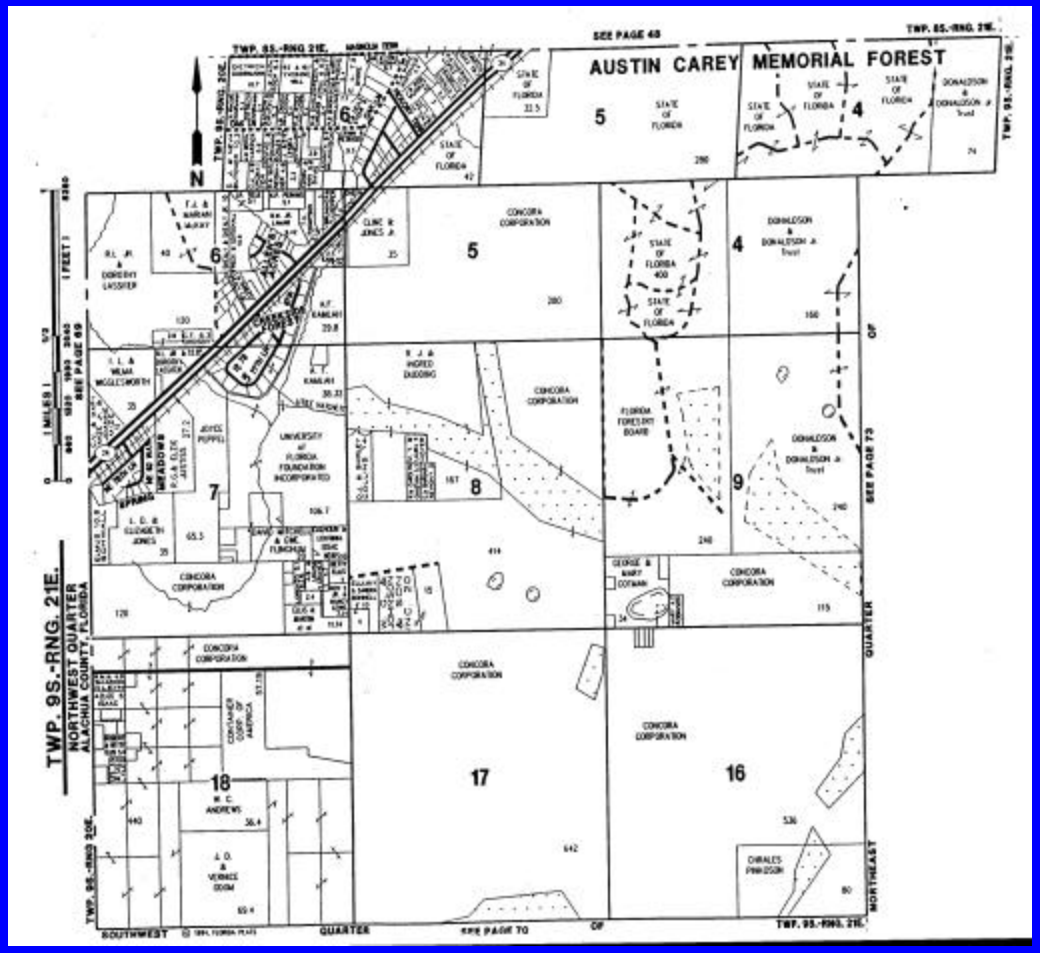
- Land Tenure

The social institution (rules, rights, restrictions) that controls the use and allocation of land and its associated resources

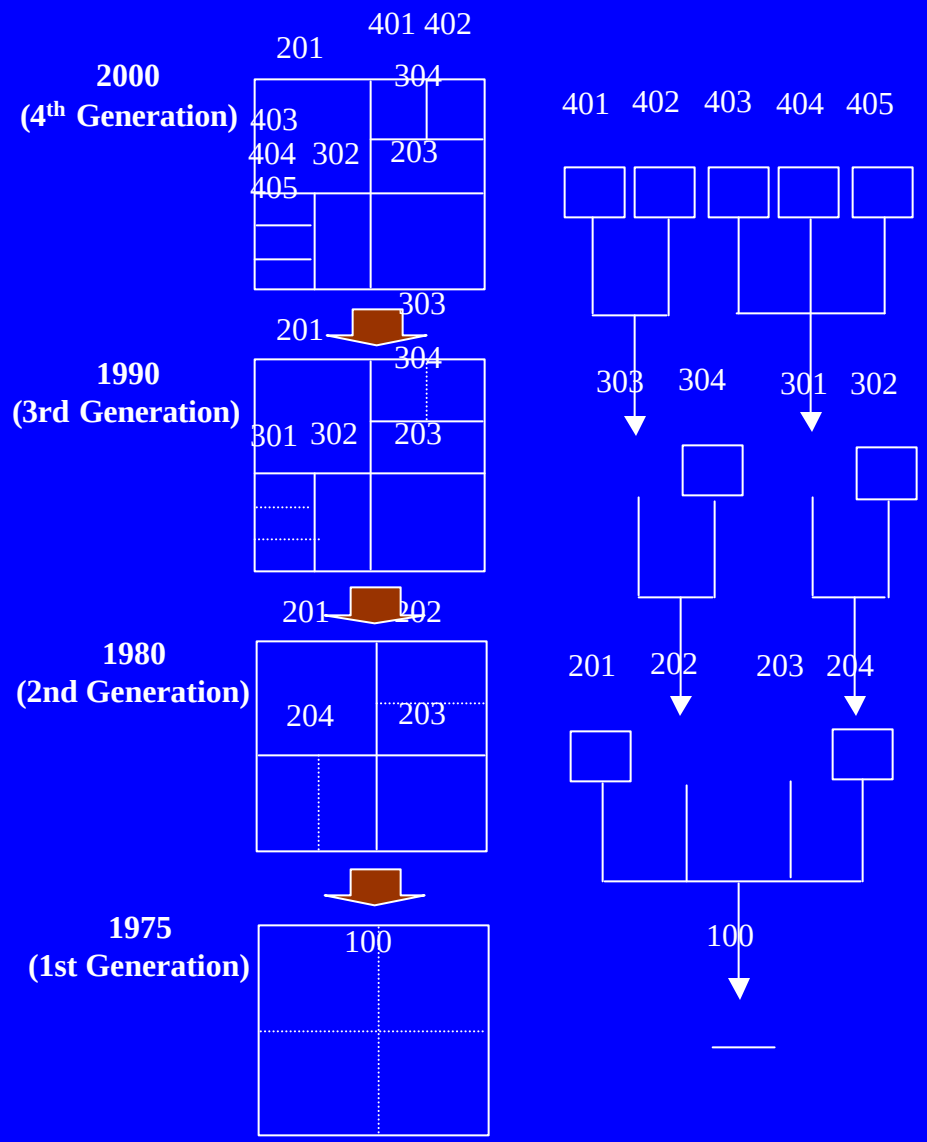
Cadastral Methods – Field Work

Extracting Cadastral Data from the Alachua County Property Appraiser's Office

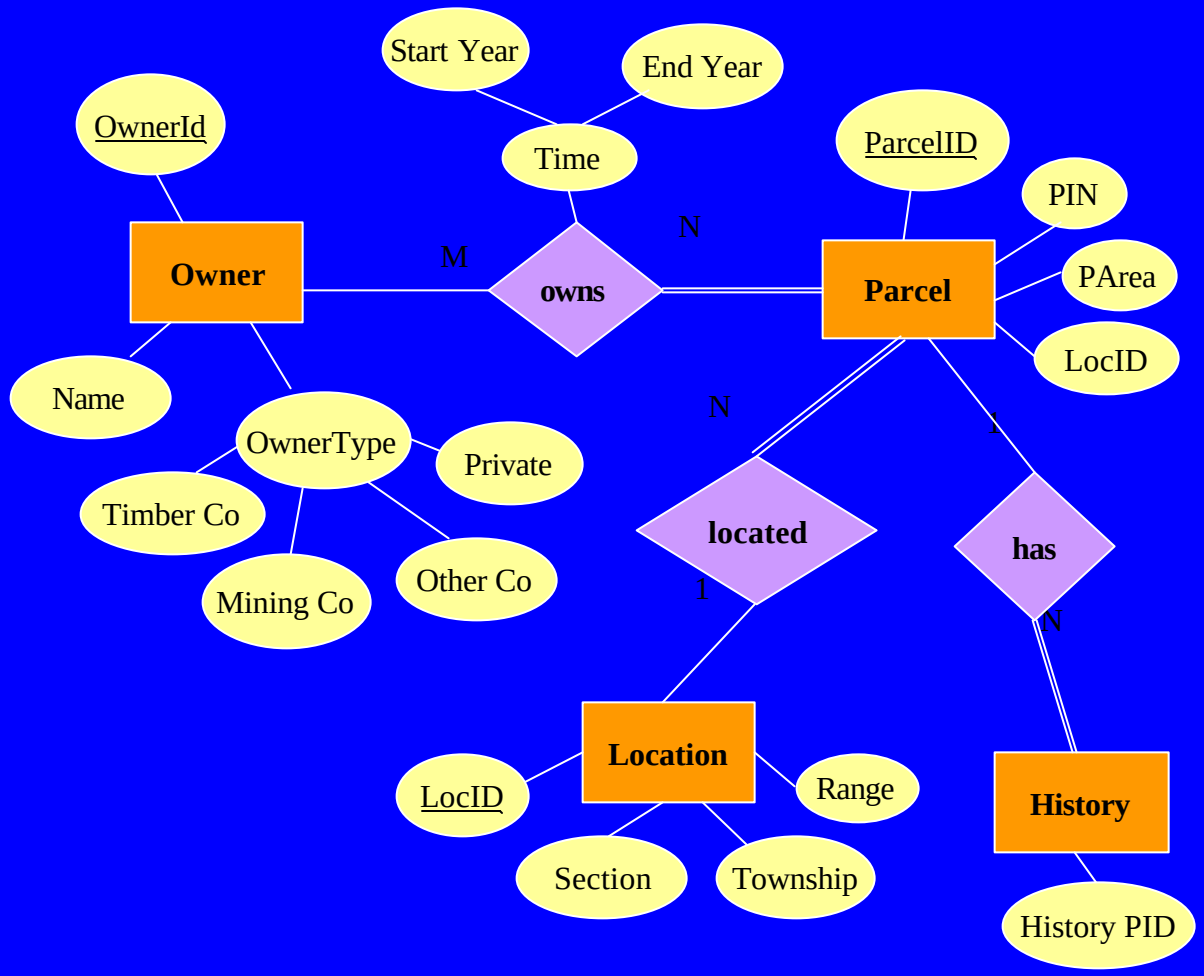
Typical Appraiser's Tax Map



Reconstruction of Parcel Histories

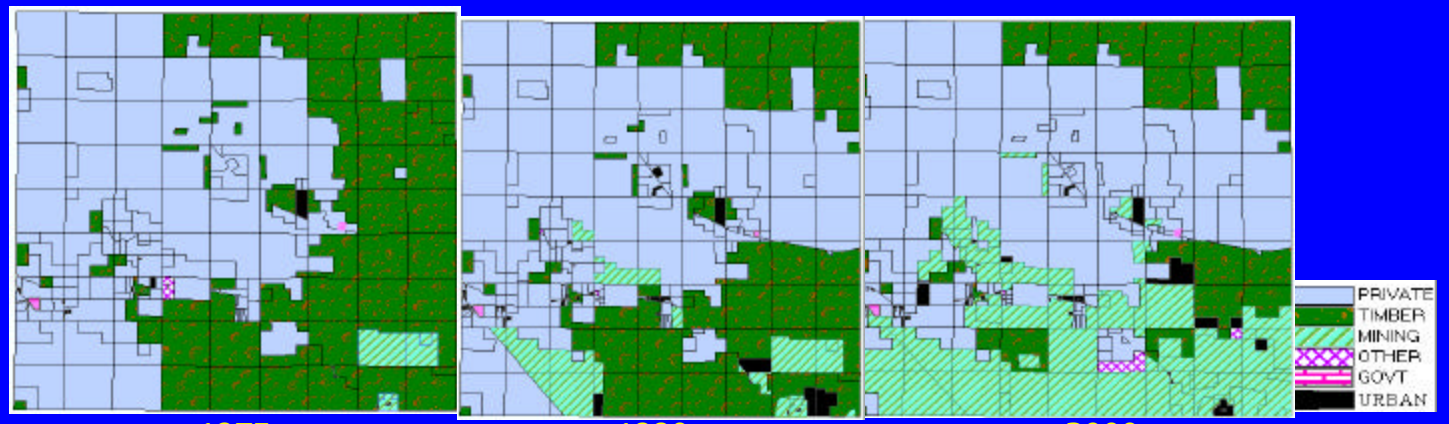


Object-oriented Parcel Data Tracking: Linking Location, Time, and Description



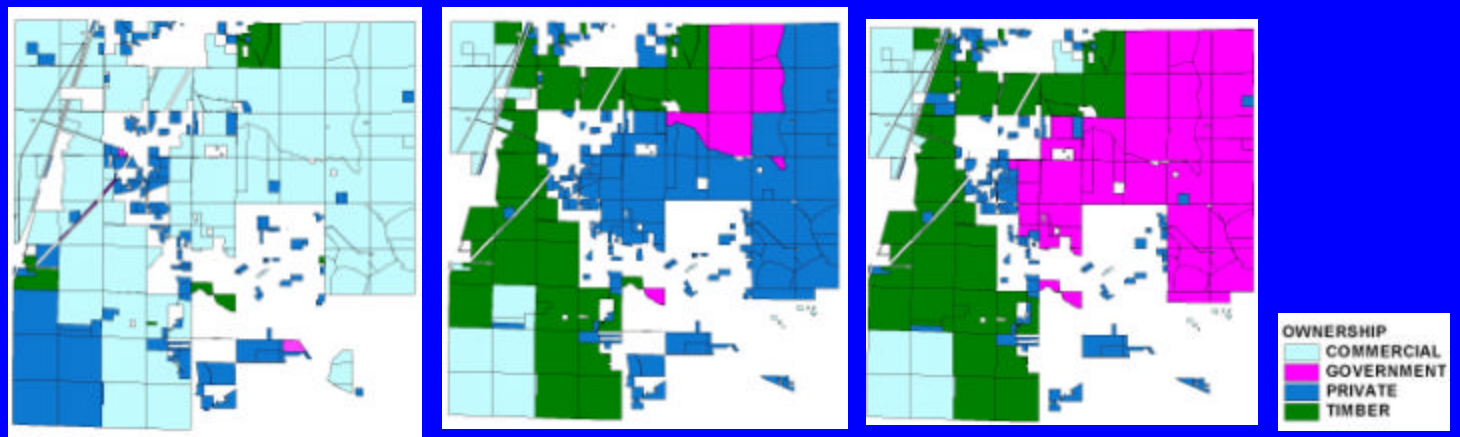
Ownership Evolution 1975-2000

Hamilton County



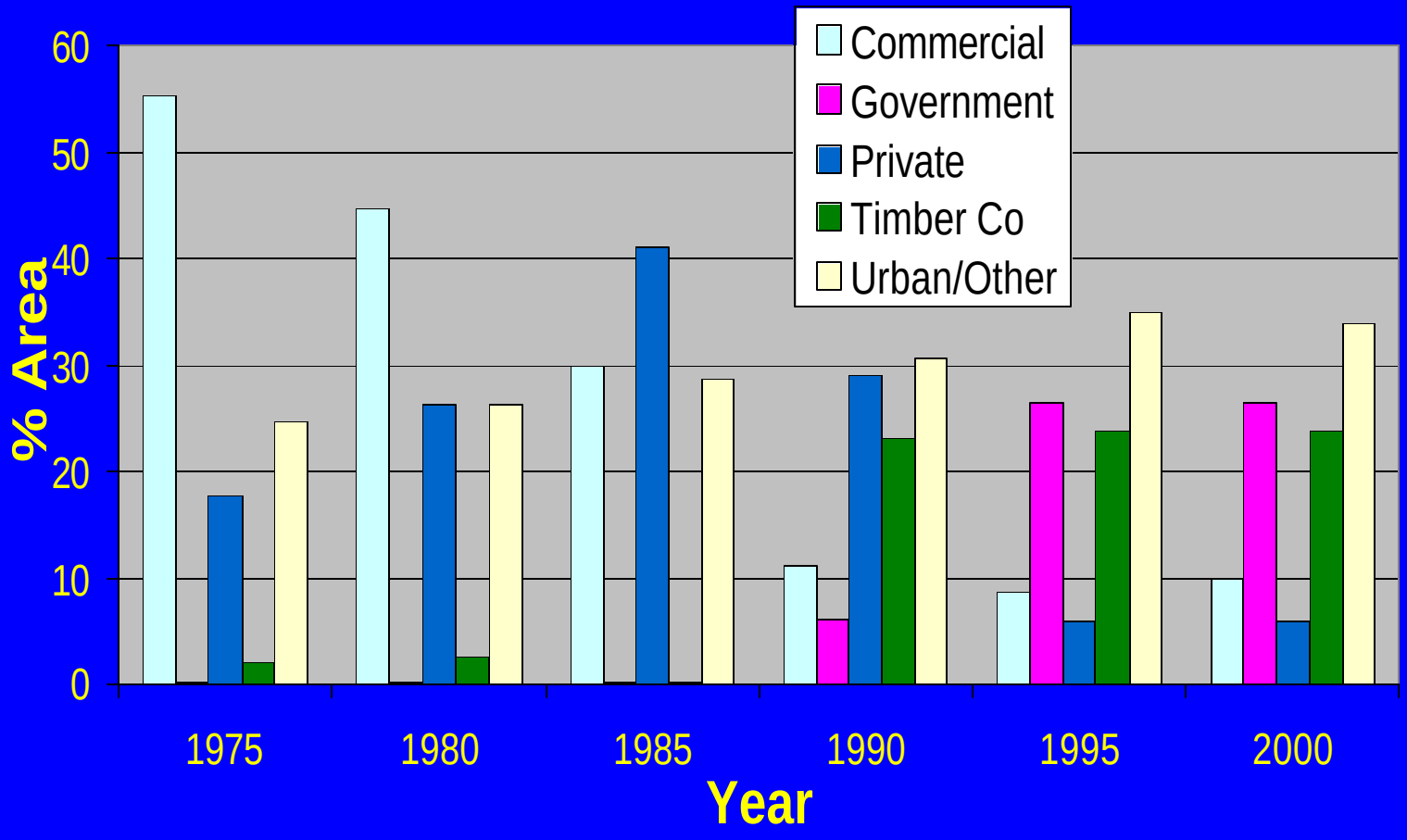
1975 **1990** **2000**

Clay County

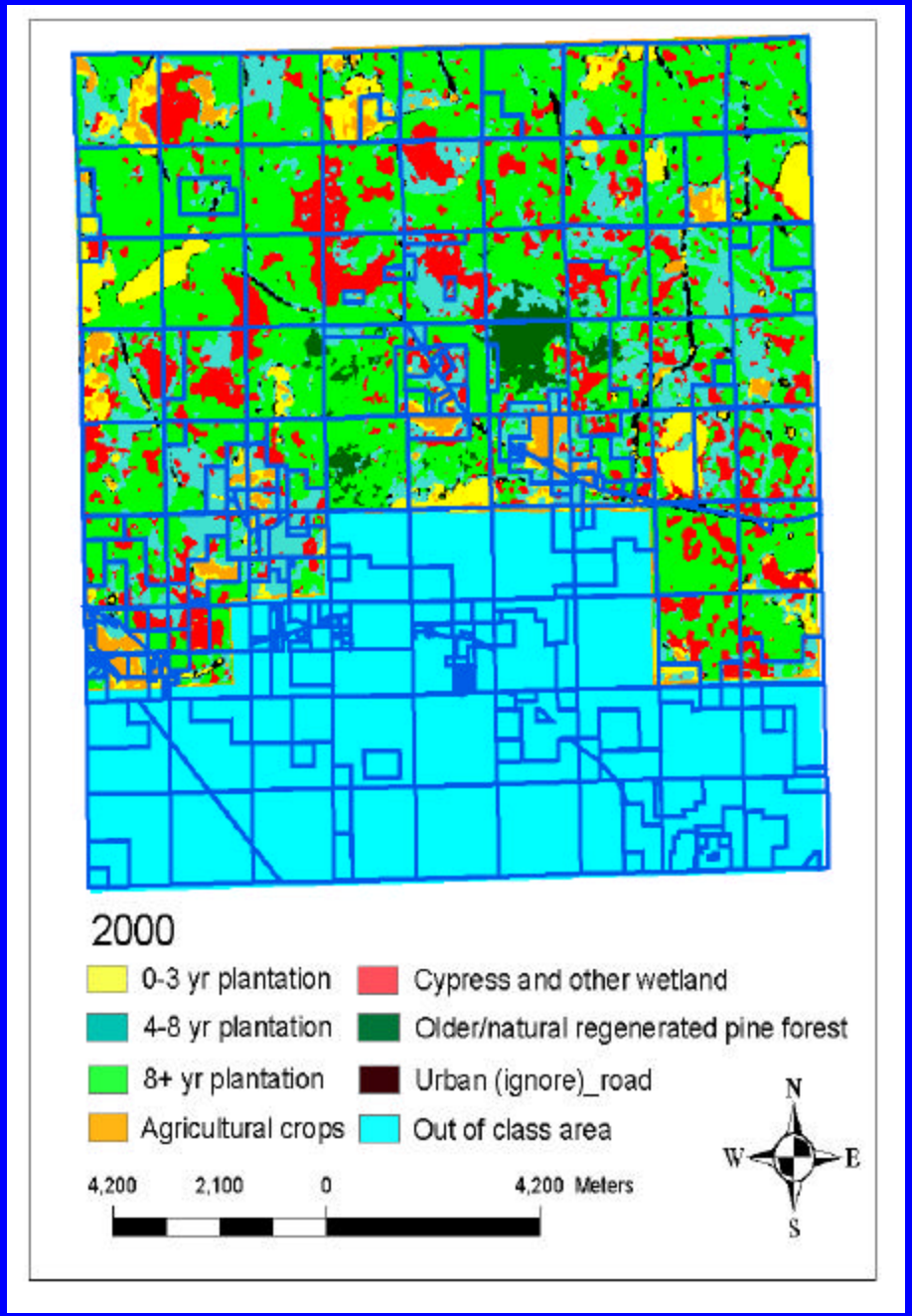


1975 **1990** **2000**

Ownership Classes of Clay County – 1975 to 2000



Integration of Ownership and Land Cover – Hamilton County



Main Points

- The world in a grain of sand – 15 km square to represent the entire SE US Coastal Plain
- Exercise in inductive reasoning
- Link to regional scale (Turner)
  - Cause -> Outcome
- Linkage of *in situ* observations to satellite data (Skole)
- Management usually ignored (Houghton)

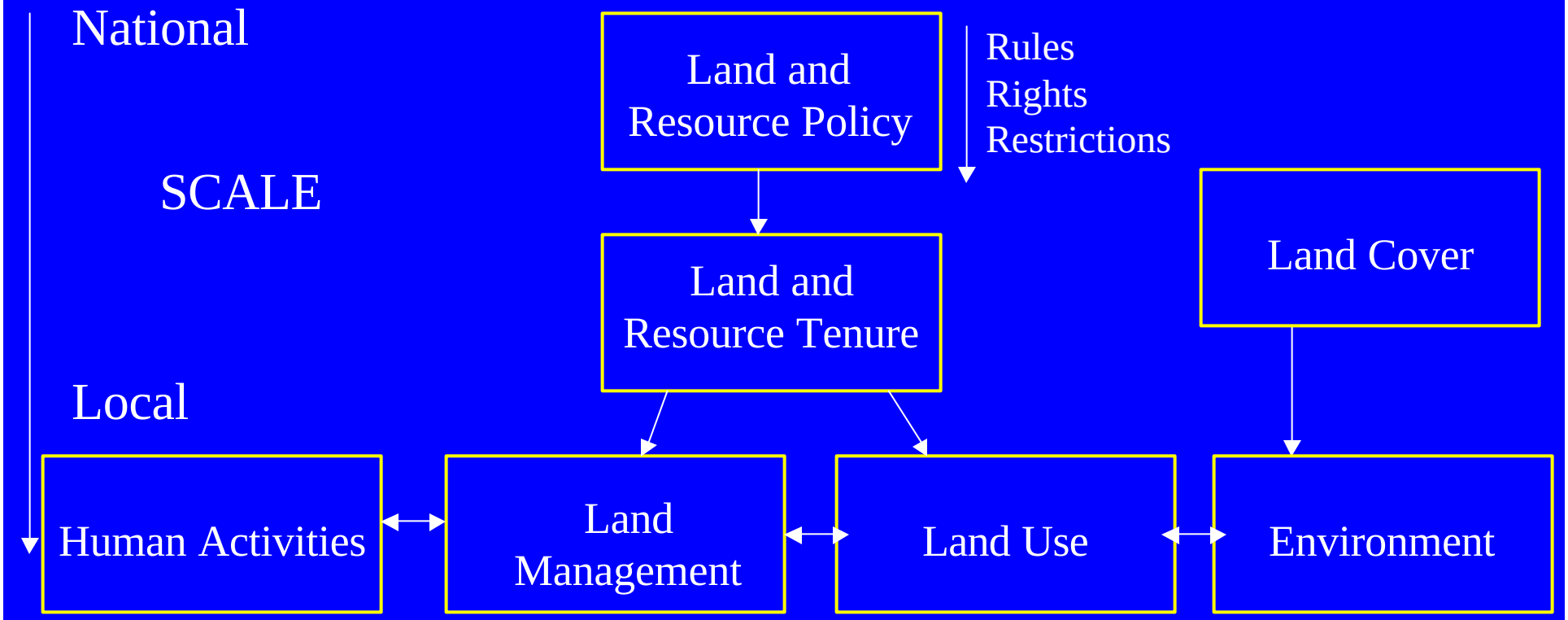
Main Points 2

- Carbon dynamics
  - NEE fairly stable ~10,000 T C yr^{-1} $landscape^{-1}$
  - Variation mostly a consequence of harvesting
    - Cutting resets NEE, initially highly negative
    - Cutting removes C from landscape (but not necessarily adds to atmosphere)
  - Fire has immense effect
    - Huge loss of C to atmosphere
    - Periodic
    - Resets NEE level over large and small areas

Main Points 3

- Only now (after 2 years of study) linking to land ownership, but is very difficult.
- Will not explain land-cover or C dynamics, but is necessary first step.
  - Owners can conduct activities, make decisions
  - Owners can lease rights of land-cover activities to others who make decisions
- Land Tenure and Management Practices are proximate causes
  - Harvest rotation period, Fertilization, Thinning
  - Fire management
  - change in land use

Linking Land Management and Policy



Land Policy/Tenure provides the rules, rights, restrictions that control management and use of the land/resources (Rules of the Game).
Land Use/Management operates at local scale (Playing of the Game).
Tenure/Policy operates at national/state level.

Main Points 4

- Future:
  - Paper-products companies who do own land are increasingly quitting the lumber business to become land-development companies
    - St. Joe Paper Co. -> St. Joe Development Co.
    - Georgia-Pacific
    - Others?
  - Land owners are changing
    - Heirs selling off
    - Insurance companies (Holding companies)
  - Are these and other factors incorporated into landscape-change models?

Policy Implications

- Public policies
  - Land purchases
  - Conservation Easements
- Private interests
  - Land-use restrictions
- Research policies
  - Inherent complexity
    - Captured by modeling?

The End