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The Spatial and Temporal Dimensions of Contemporary U.S. Land Cover and Land Use Change and Implications for Carbon Dynamics

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Research Objectives

Objectives: In each of 84 conterminous U.S. ecoregions:

- Determine the spatial, temporal, and sectoral variability of land cover change for 5 periods (1973, 1980, 1986, 1992, and 2000).
- Document the regional driving forces of change.
- Assess the extent that land cover change affects local, regional, and national carbon fluxes.

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Temporal Framework

- Analysis of change from 1970's through 2000.
- Temporal center points and data source:
  - 1973 Landsat MSS - from NALC
  - 1980 Landsat MSS - new archival data
  - 1986 Landsat MSS - from NALC
  - 1992 Landsat MSS and TM - from NALC, MRLC
  - 2000 Landsat ETM+ - from MRLC 2000

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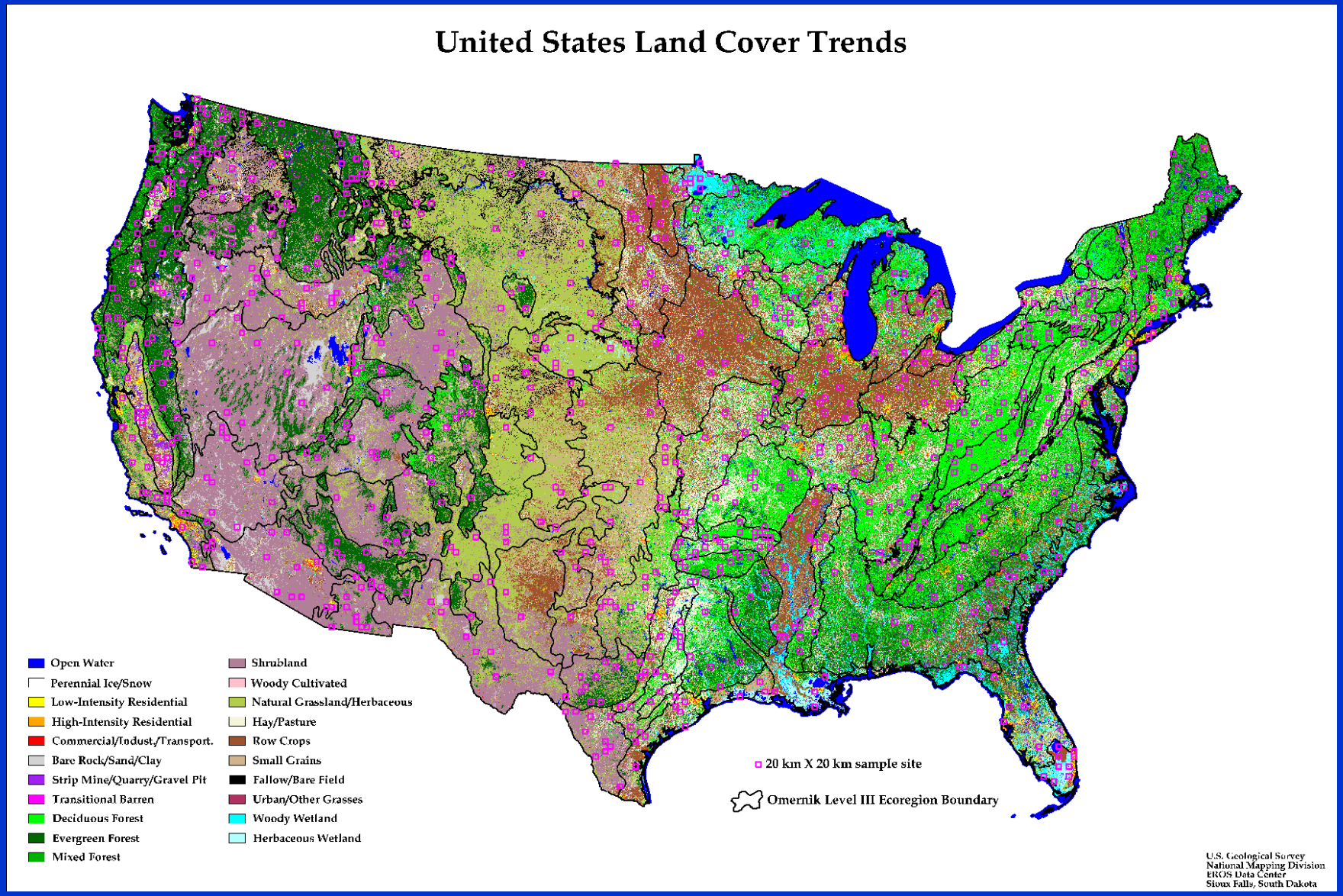

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Through the interpretation of sample blocks in each ecoregion, identify 1 % of actual land cover change at an 85% confidence level.

Ecoregions and Land Use

- Land use provides a strong integrative tool for revealing ecosystem patterns because it reflects the spatial patterns of potentials and capacities of land.
- Ecoregion characteristics determine the range of land cover changes that can potentially occur.
- Localizes estimates and driving forces of change.
- Ecoregions framework can be extended to the continent and globe.

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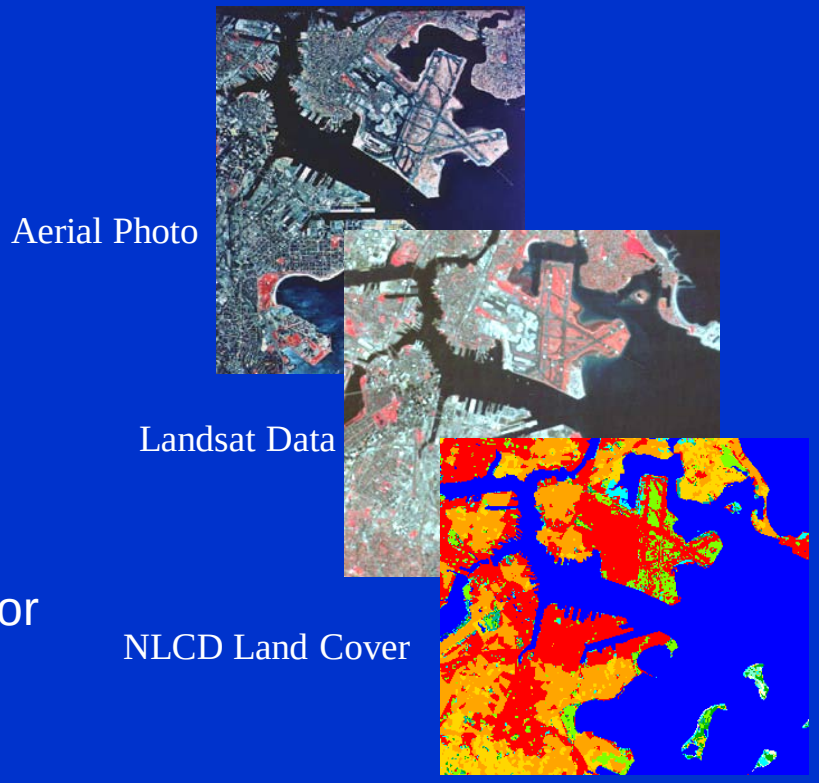
Mapping Land Cover/Land Cover Change

- 1992 NLCD Land Cover
  - Serves as 1992 baseline
  - “Clean-up” of NLCD
- Change-vector analysis
  - Brightness/greenness difference between successive Landsat dates
  - Change/no-change mask
- Manual interpretation of change
  - Use of aerial photography, Landsat for interpreting change



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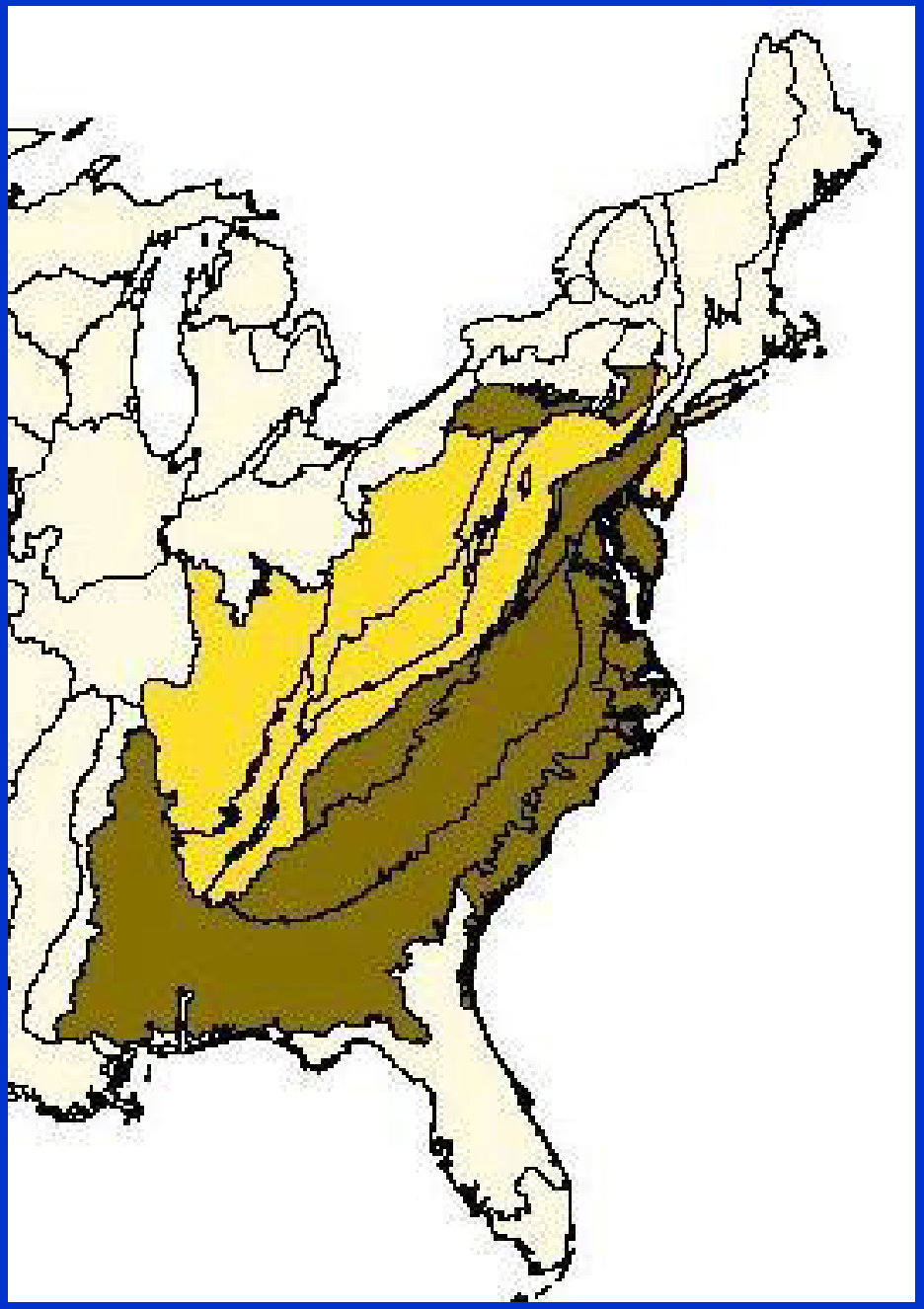
Status of Land Cover Change Analysis

Brown: Completed

Tan: Analysis Underway



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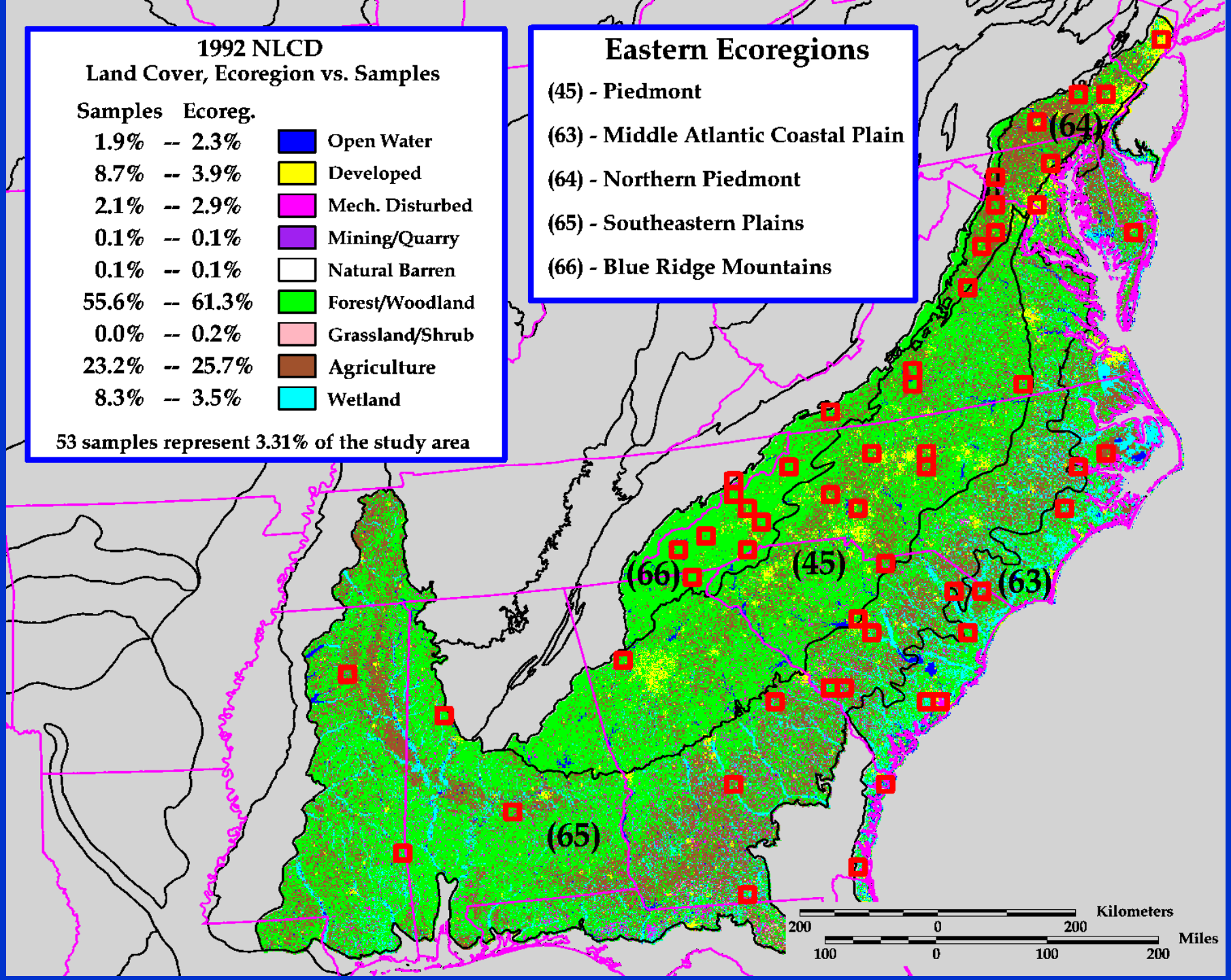
Eastern US Ecoregions Land Cover Change Summary

Ecoregion	1973-1980		1960-1986		1986-1992		1992-2000	
	% Change	85% CI	% Change	85% CI	% Change	85% CI	% Change	85% CI
Mid-Atlantic Coastal Plains	5.7	1.6	6.6	2.3	7.4	2.4	8.9	2.6
Southeastern Plains	5.1	1.3	6.4	1.7	9.1	2.3	10.7	2.4
Northern Piedmont	1.4	0.5	1.5	0.4	1.3	0.3	2.6	0.6
Piedmont	3.2	1.3	3.9	1.9	6.5	2.5	7.0	2.4
Blue Ridge	0.5	0.2	0.4	0.2	0.6	0.2	0.9	0.2
North Central Appalachia	1.6	0.8	2.4	1.5	2.3	0.8	3.1	0.8
Overall	4.2	0.7	4.5	0.7	5.3	0.9	5.6	0.9

Eastern Ecoregions: Most Frequent Land Cover Conversions

Ecoregion	1973 to 1980		1980 to 1986		1986 to 1992		1992 to 2000	
	Area (km^2)	Change	Area (km^2)	Change	Area (km^2)	Change	Area (km^2)	Change
Mid-Atlantic Coastal Plains	2120	Forest to Disturbed	1950	Forest to Disturbed	2157	Forest to Disturbed	2506	Disturbed to Forest
Southeastern Plains	6600	Forest to Disturbed	8091	Forest to Disturbed	11226	Forest to Disturbed	13542	Forest to Disturbed
Piedmont	1666	Forest to Disturbed	3069	Forest to Disturbed	4817	Forest to Disturbed	4603	Forest to Disturbed
Northern Piedmont	182	Ag to Urban	184	Ag to Urban	127	Ag to Urban	347	Ag to Urban
Blue Ridge	112	Forest to Urban	95	Forest to Urban	85	Forest to Disturbed	192	Forest to Urban
North Central Appalachia	208	Forest to Disturbed	266	Disturbed to Forest	296	Forest to Disturbed	274	Forest to Disturbed


1992 NLCD
Land Cover, Ecoregion vs. Samples
Samples Ecoreg.
1.9% -- 2.3% Open Water
8.7% -- 3.9% Developed
2.1% -- 2.9% Mech. Disturbed
0.1% -- 0.1% Mining/Quarry
0.1% -- 0.1% Natural Barren
55.6% -- 61.3% Forest/Woodland
0.0% -- 0.2% Grassland/Shrub
23.2% -- 25.7% Agriculture
8.3% -- 3.5% Wetland
53 samples represent 3.31% of the study area
Eastern Ecoregions
(45) - Piedmont
(63) - Middle Atlantic Coastal Plain
(64) - Northern Piedmont
(65) - Southeastern Plains
(66) - Blue Ridge Mountains
(64)
(66)
(45)
(63)
(65)
Kilometers
200 0 200
Miles
100 0 100 200

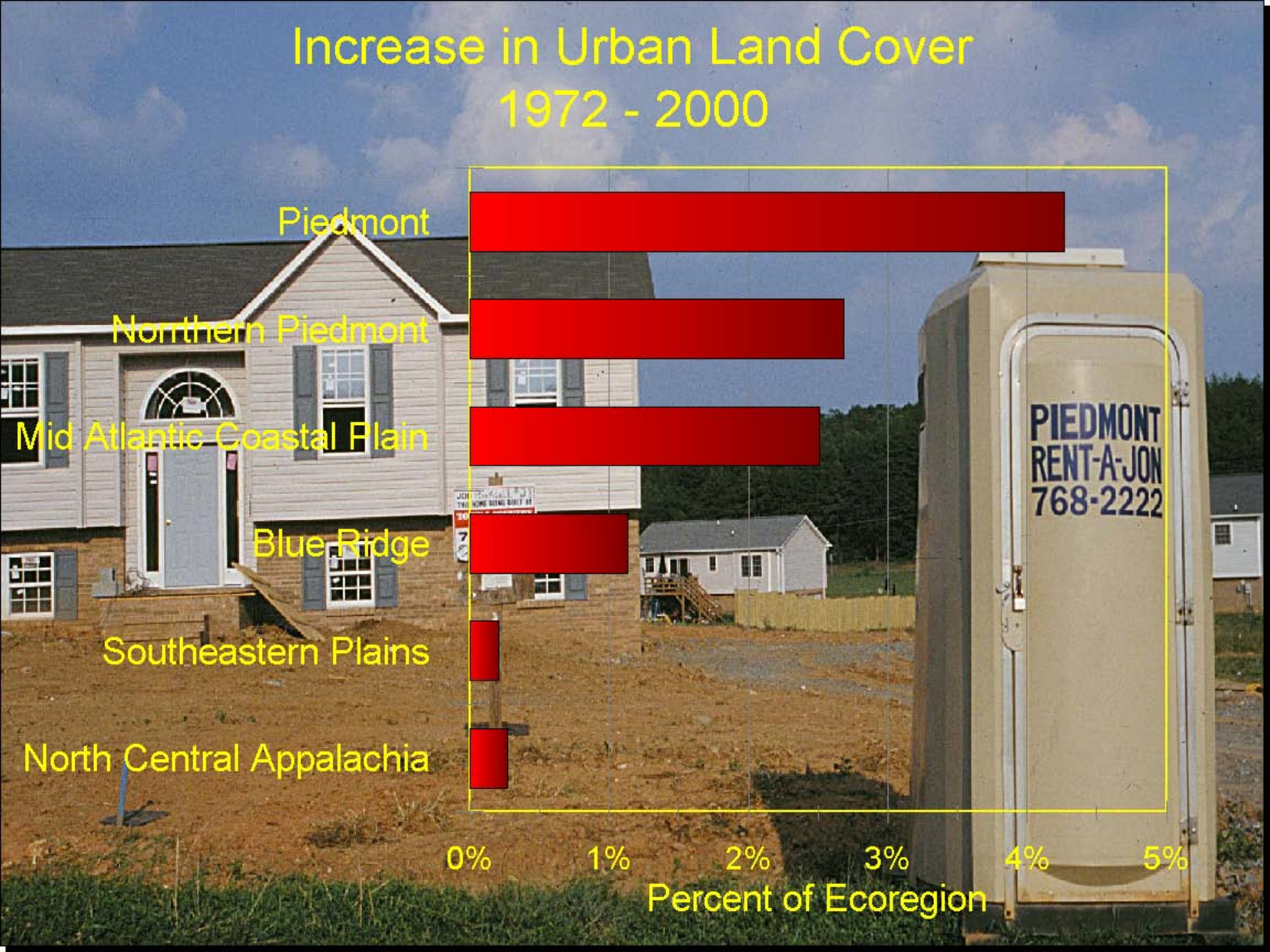
Eastern U.S.: Most Frequent Overall Land Cover Conversions

1973 to 1980		1980 to 1986		1986 to 1992		1992 to 2000	
Area (km^2)	Change	Area (km^2)	Change	Area (km^2)	Change	Area (km^2)	Change
10,710	Forest to Disturbed	13,231	Forest to Disturbed	18,217	Forest to Disturbed	20,004	Forest to Disturbed
8,653	Disturbed to Forest	10,416	Disturbed to Forest	13,521	Disturbed to Forest	17,584	Disturbed to Forest
3,057	Forest to Agriculture	3,015	Agriculture to Forest	7,416	Agriculture to Forest	5,324	Agriculture to Forest
2,165	Forest to Urban	2,277	Forest to Agriculture	2,904	Forest to Urban	4,524	Forest to Urban
1.342	Agriculture to Forest	1,875	Forest to Urban	1,390	Forest to Agriculture	2,116	Wetlands to Disturbed
641	Agriculture to Urban	810	Agriculture to Urban	1,198	Agriculture to Urban	1,827	Forest to Agriculture

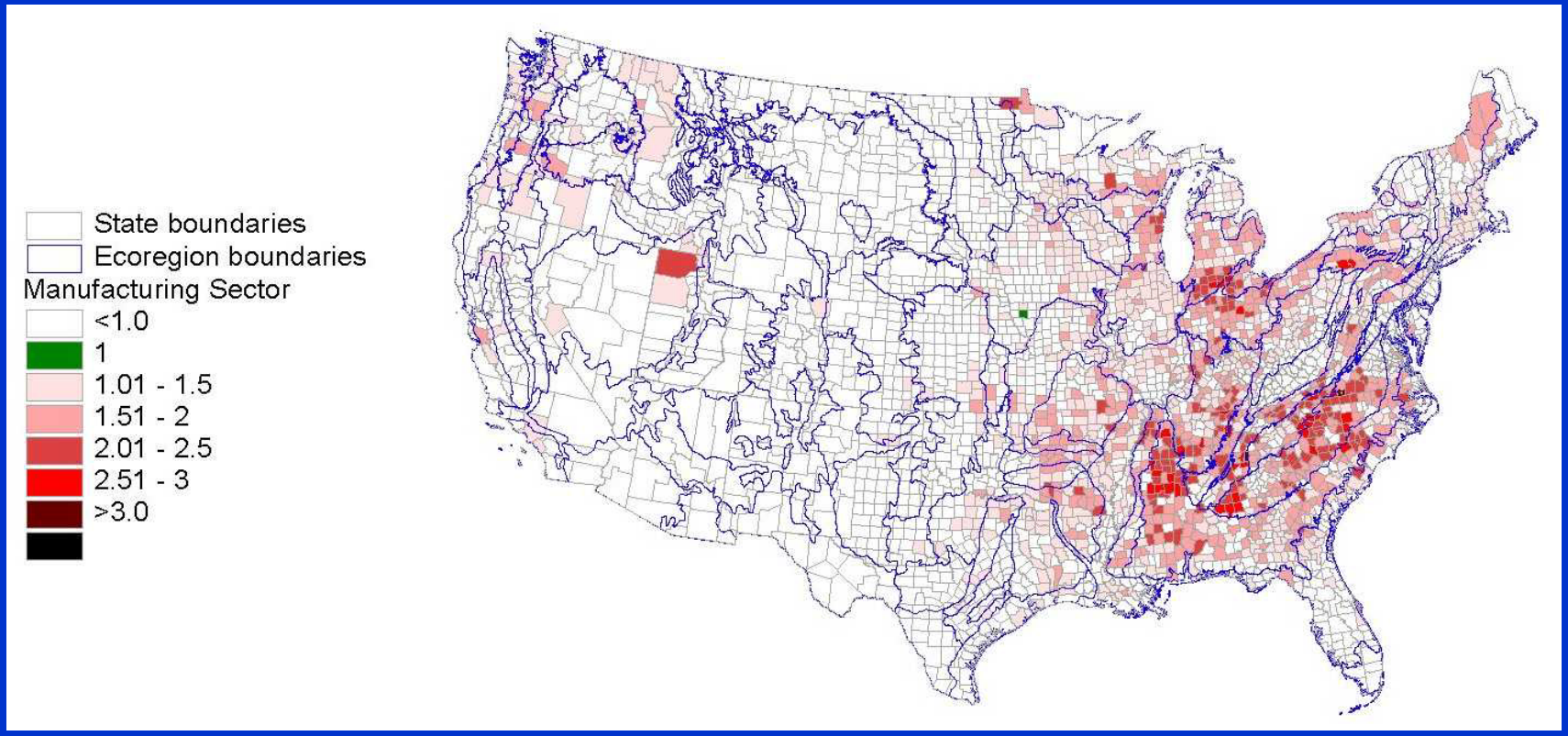
Percent Urban/Developed Cover for Eastern U.S. Ecoregions: 1972-2000

Ecoregion	1972	1980	1986	1992	2000	Increase (% of ecoregion)
North Central Appalachia	1.4	1.4	1.6	1.7	1.8	0.3
Southeastern Plains	8.4	8.6	8.6	8.6	9.8	0.2
Blue Ridge	6.0	6.3	6.5	6.7	7.2	1.1
Mid Atlantic Coastal Plain	6.3	6.8	7.5	8.2	8.8	2.5
Northern Piedmont	22.5	23.4	24.4	25.2	27.3	2.7
Piedmont	10.2	10.8	11.3	12.7	14.5	4.3

Increase in Urban Land Cover
1972 - 2000



Index of Local Importance – Manufacturing, 1990



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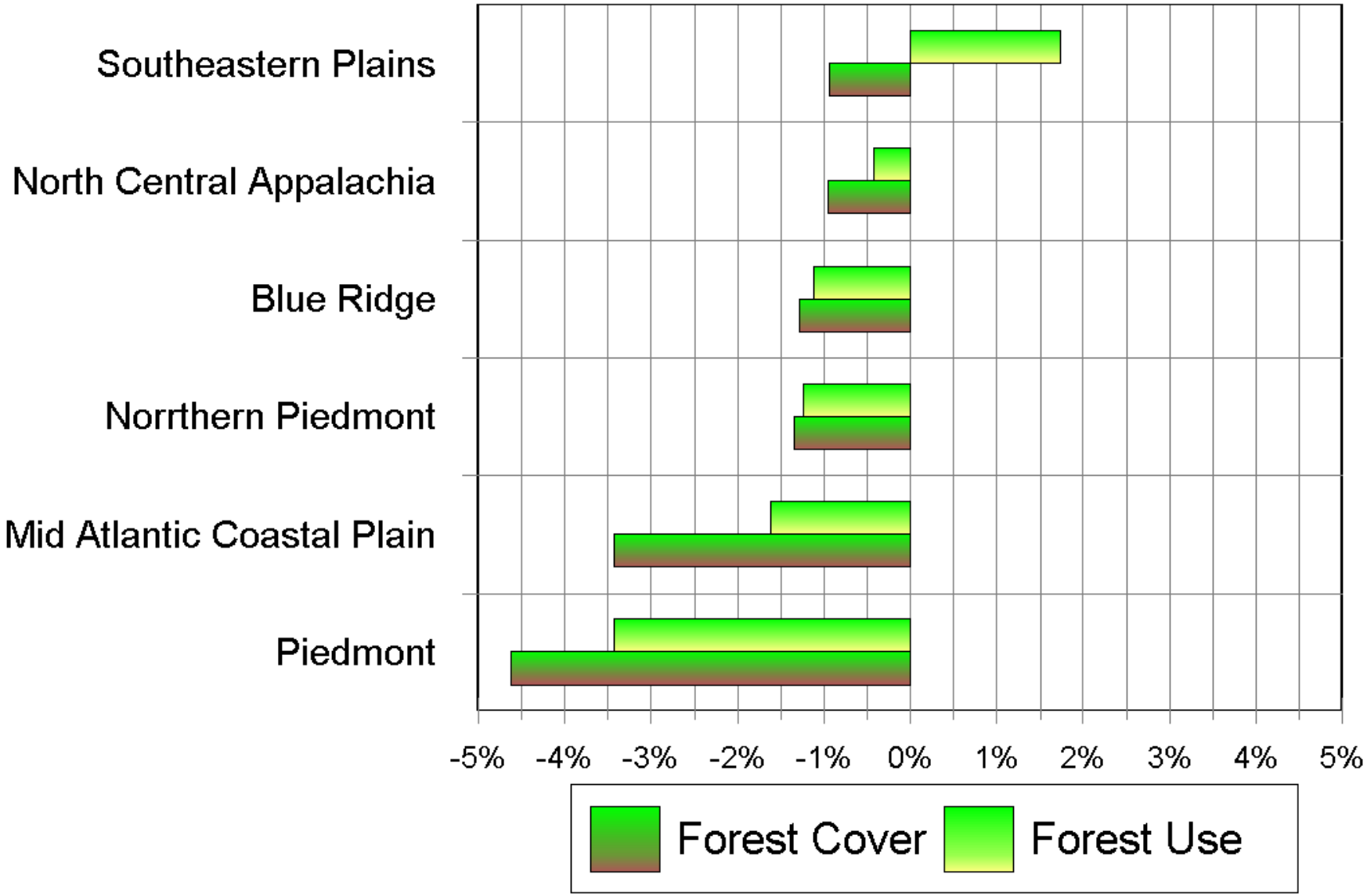
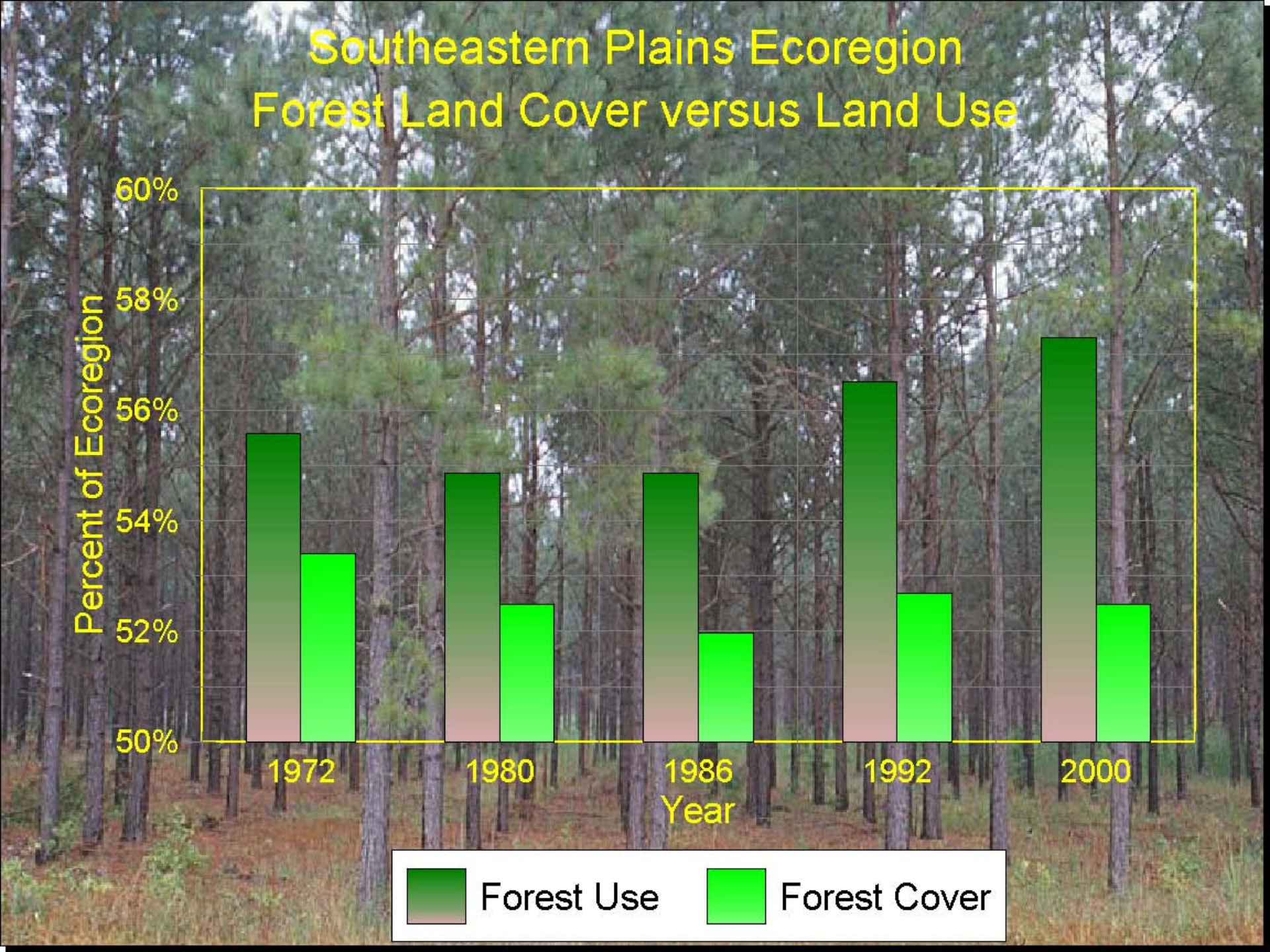
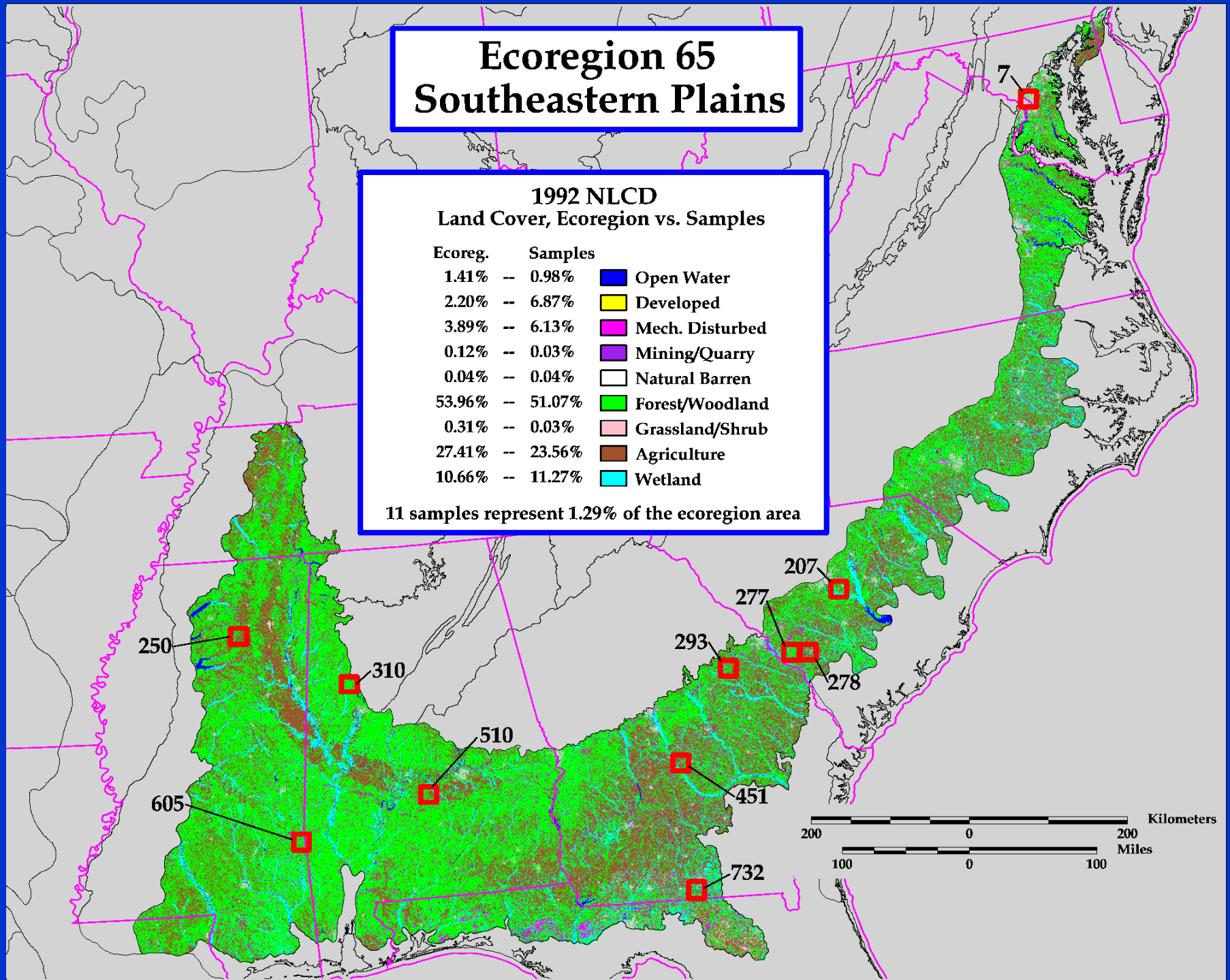
Percent Forest Land Cover for Eastern U.S. Ecoregions: 1972-2000

Ecoregion	1972	1980	1986	1992	2000	Increase (% of ecoregion)
Piedmont	60.9	60.1	59.1	57.6	56.3	-4.6
Mid Atlantic Coastal Plain	34.2	32.6	31.8	30.9	30.8	-3.4
Northern Piedmont	35.5	35.4	35.2	35.0	34.2	-1.3
Blue Ridge	83.1	82.6	82.5	82.2	81.8	-1.3
North Central Appalachia	90.2	90.0	90.0	89.5	89.2	-0.9
Southeastern Plains	53.4	52.5	52.0	52.7	52.5	-0.9

Forest Cover vs. Forest Use
Selected Eastern U.S. Ecoregions




Southeastern Plains Ecoregion
Forest Land Cover versus Land Use
Percent of Ecoregion
60%
58%
56%
54%
52%
50%
1972
1980
1986
1992
2000
Year
Forest Use
Forest Cover


Ecoregion 65
Southeastern Plains
1992 NLCD
Land Cover, Ecoregion vs. Samples
Ecoreg. Samples
1.41% -- 0.98% Open Water
2.20% -- 6.87% Developed
3.89% -- 6.13% Mech. Disturbed
0.12% -- 0.03% Mining/Quarry
0.04% -- 0.04% Natural Barren
53.96% -- 51.07% Forest/Woodland
0.31% -- 0.03% Grassland/Shrub
27.41% -- 23.56% Agriculture
10.66% -- 11.27% Wetland
11 samples represent 1.29% of the ecoregion area
7
207
277
278
293
250
310
510
451
605
732
Kilometers
200 0 200
Miles
100 0 100

Sample 65-8, Southeastern Plains (Percent Cover)

Category	1973	1980	1986	1992	2000
Water	0.8	0.8	0.8	0.9	0.9
Developed	0.7	0.7	0.7	0.9	0.9
Disturbed	1.1	2.2	3.7	1.5	4.4
Mining	0.0	0.0	0.0	0.0	0.0
Forest	46.1	42.8	40.0	47.0	47.4
Grass/Shrub	0.0	0.0	0.0	0.1	0.0
Agriculture	37.6	39.3	40.2	34.3	32.5
Wetland	13.7	14.2	14.6	15.5	14.0

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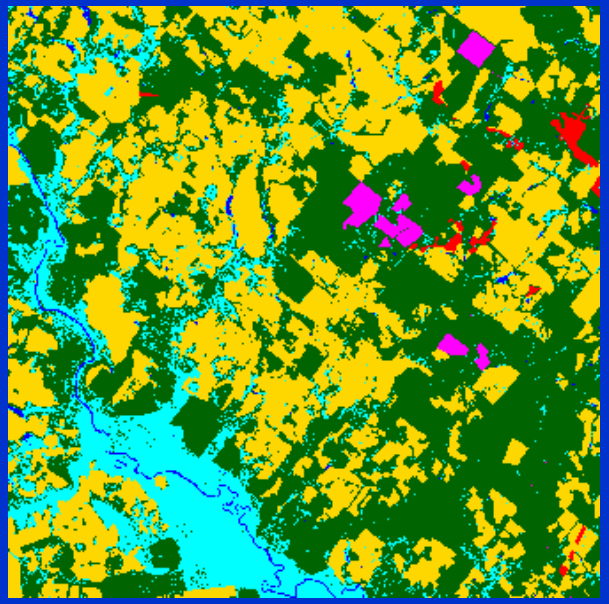
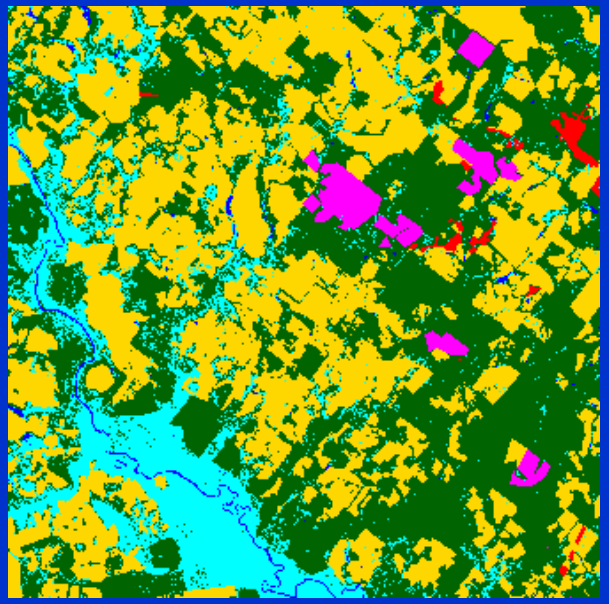
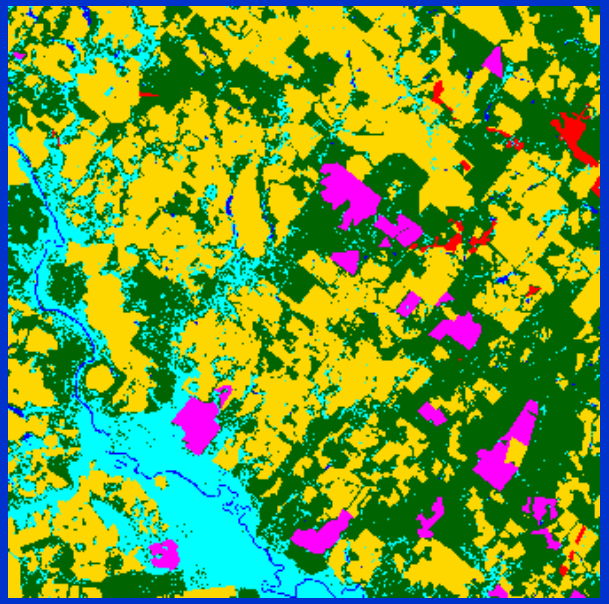
Sample 65-451, Southeastern Plains



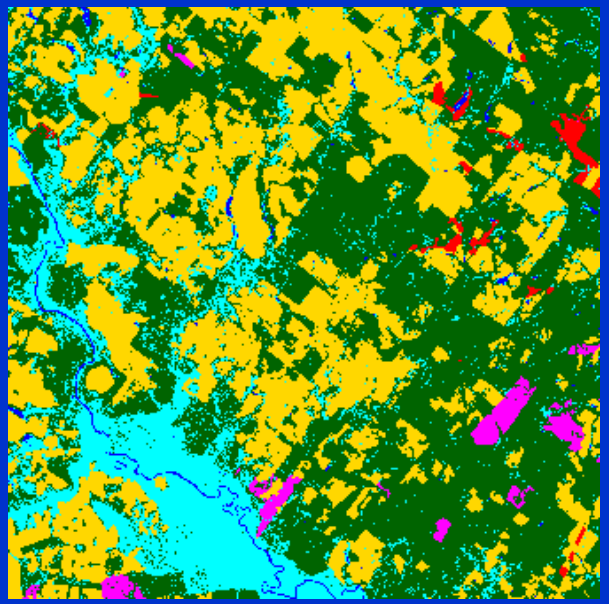
1973



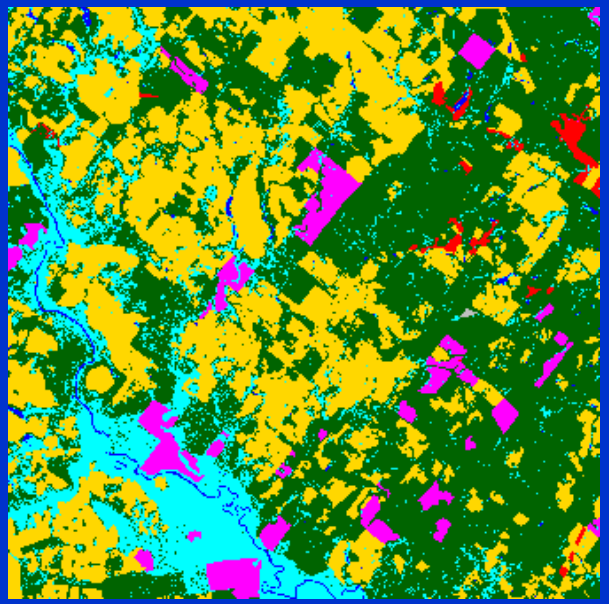
1980



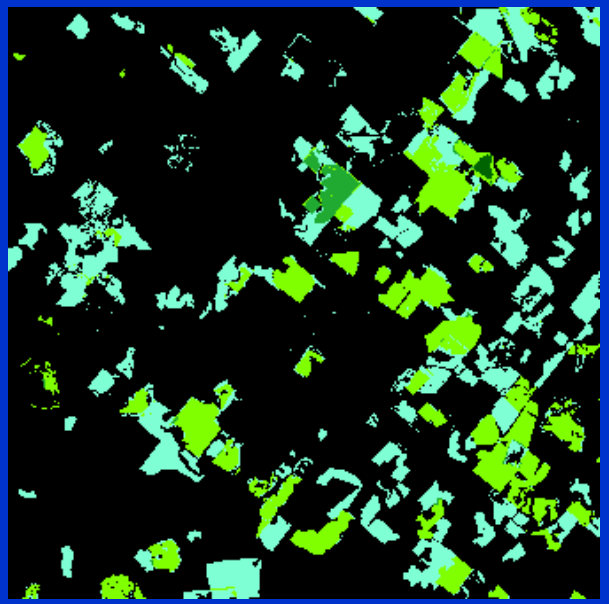
1986



1992



2000



Total Change

Southeastern Plains (Percent Cover)

Category	1973	1980	1986	1992	2000
Water	1.0	1.0	1.1	1.0	1.1
Developed	8.4	8.6	8.9	9.1	9.8
Disturbed	2.2	2.4	2.9	3.8	4.8
Mining	0.1	0.1	0.1	0.1	0.1
Forest	53.4	52.5	52.0	52.7	52.5
Grass/Shrub	0.0	0.0	0.0	0.1	0.0
Agriculture	24.8	25.2	24.8	22.9	21.7
Wetland	10.2	10.3	10.3	10.3	10.0

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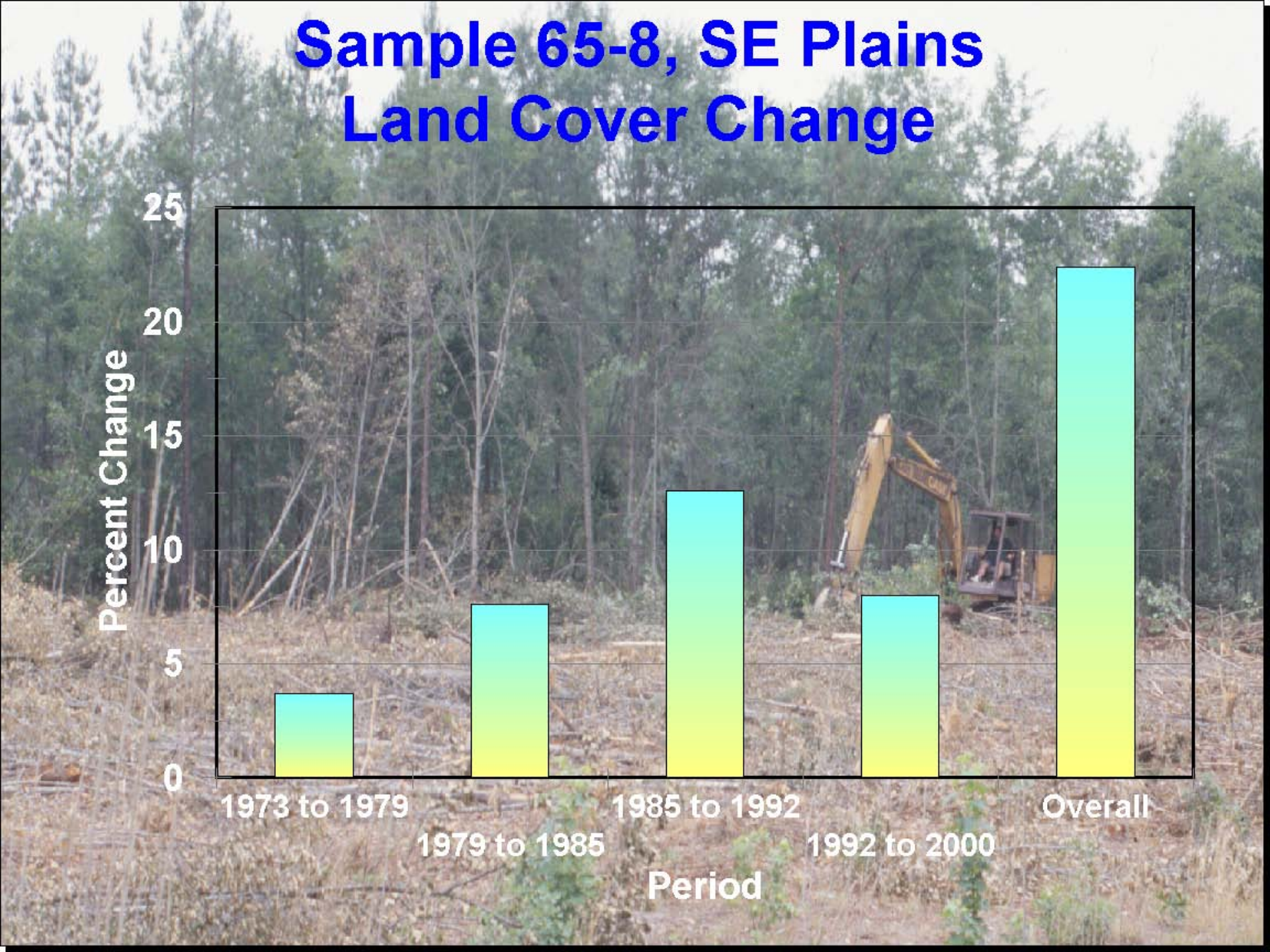
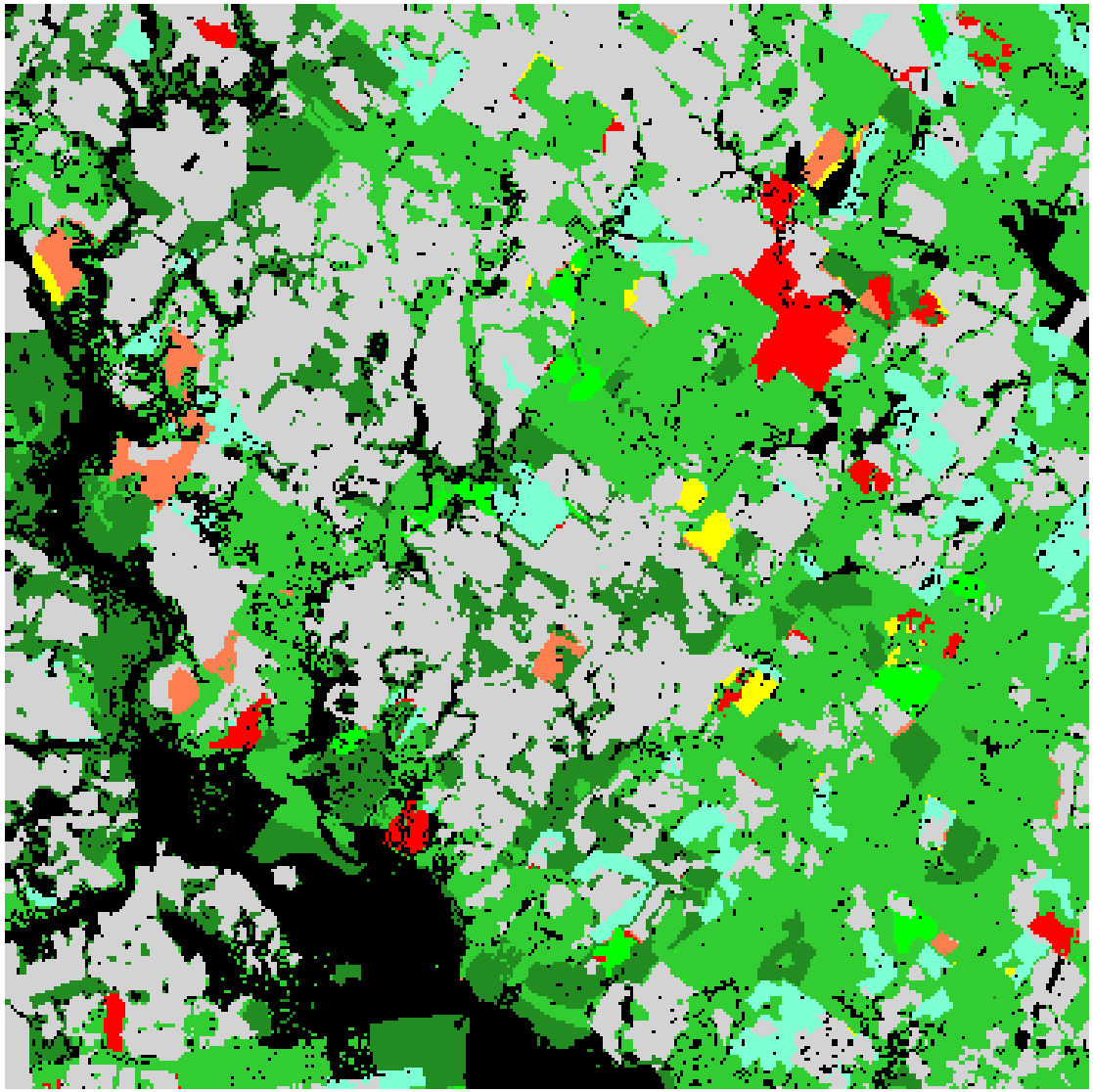
Sample 65-8, SE Plains
Land Cover Change



Forest Biomass C Change

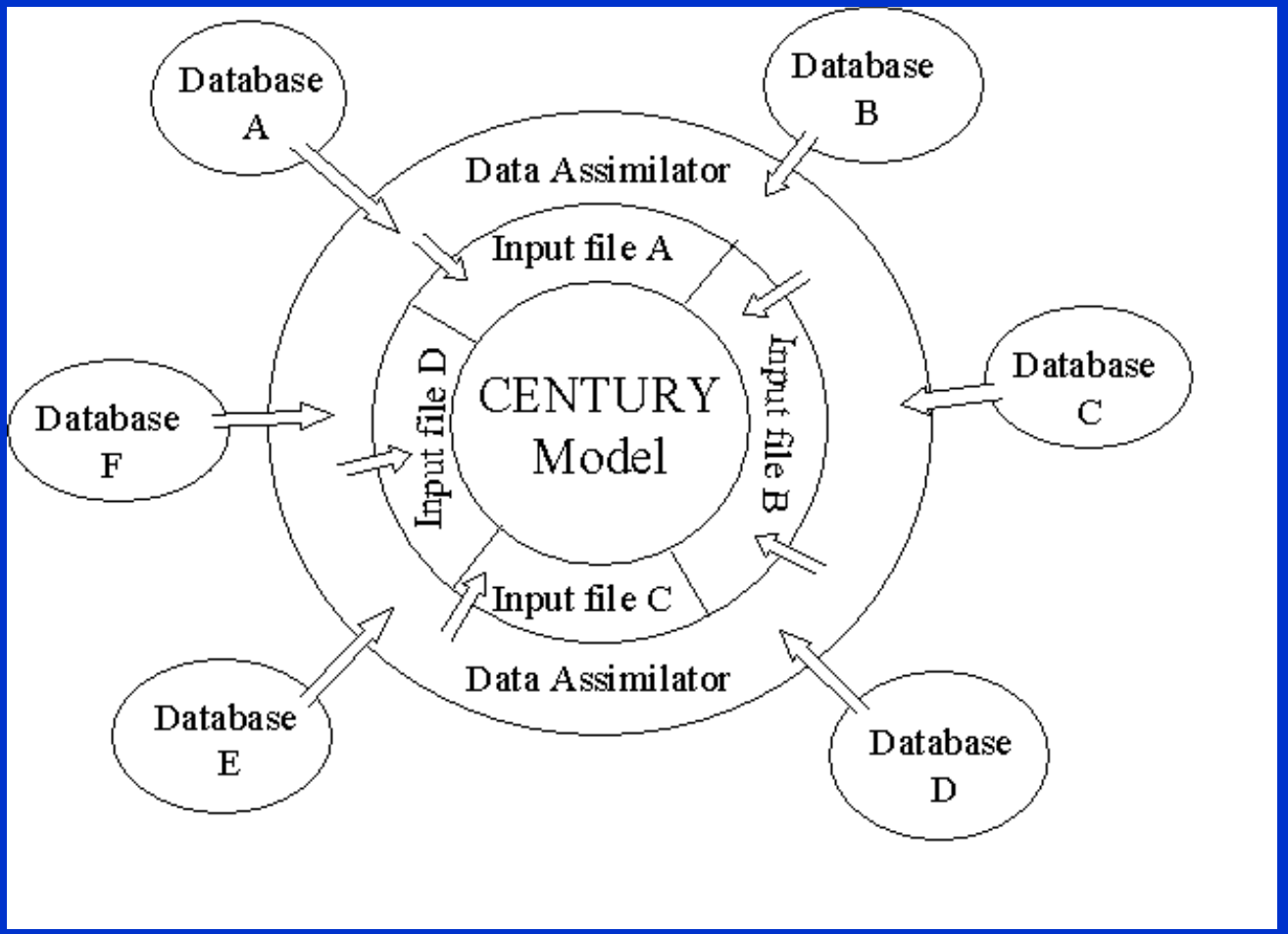


Ecoregion: 65
Block: 08
Time: 74 --- 00

Unit: gC/m2

- <-4000
- -4000 to -2000
- -2000 to -500
- -500 to 500
- 500 to 2000
- 2000 to 4000
- 4000 to 6000
- > 6000
- Water, roads, wetlands, etc.

Structure of EMLA (Ecological Modeling Over Large Areas)



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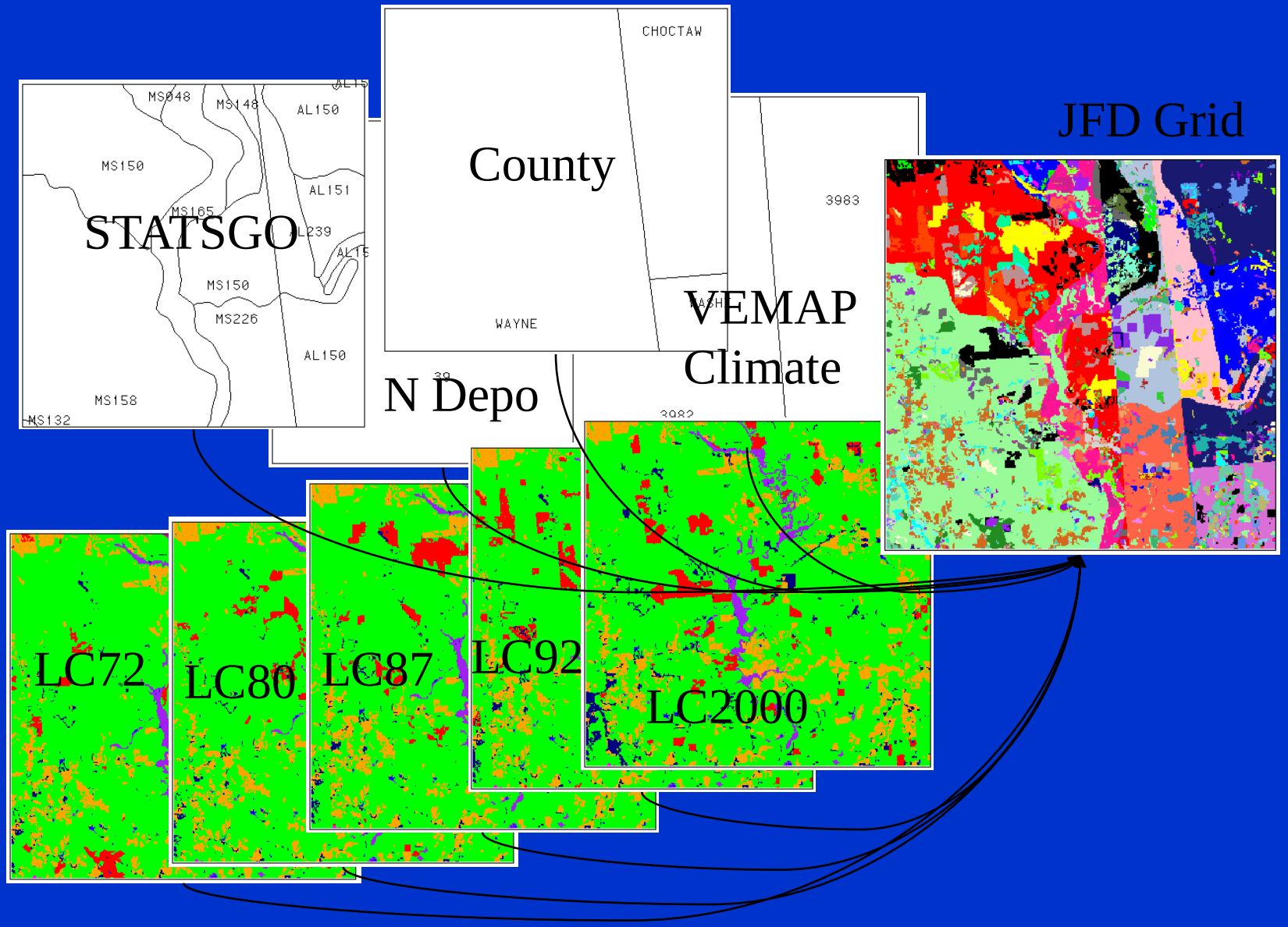
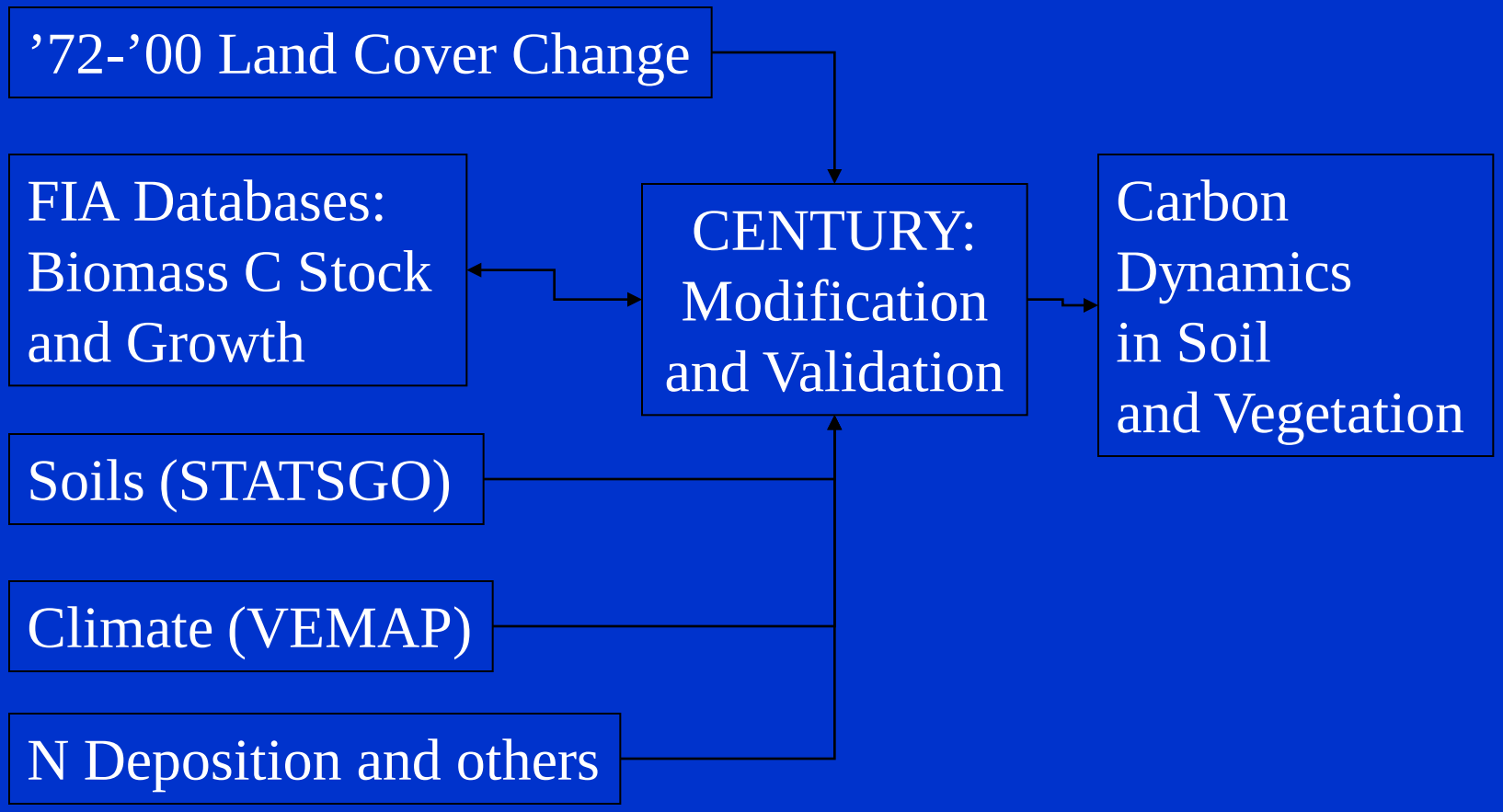
Generation of Joint Frequency Distribution GRID



Carbon Modeling Approach



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FIA Data

A Total of 71,801 plot-year data were analyzed for:

1) Biomass C stock in forests;
2) NPP;
3) Wood growth.

AL(1990), DE(1986), FL(1987,1995), GA(1989,1997), LA(1991), MD(1986), MS(1994), NC(1984,1992), SC(1986,1993), TN(1989,1999), VA(1984,1992)

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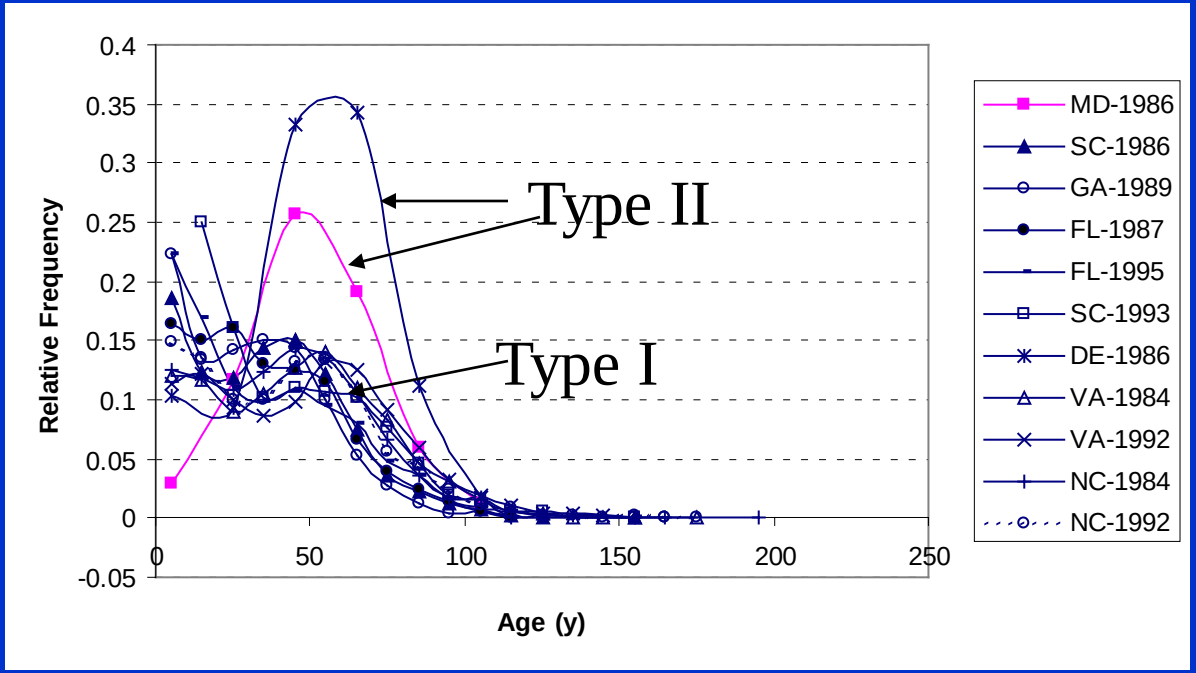
Forest Age Distribution by State

Type I: Resulted from timber production
Type II. Resulted from other uses (MD and DE)



Most forests are younger than 50 years old.

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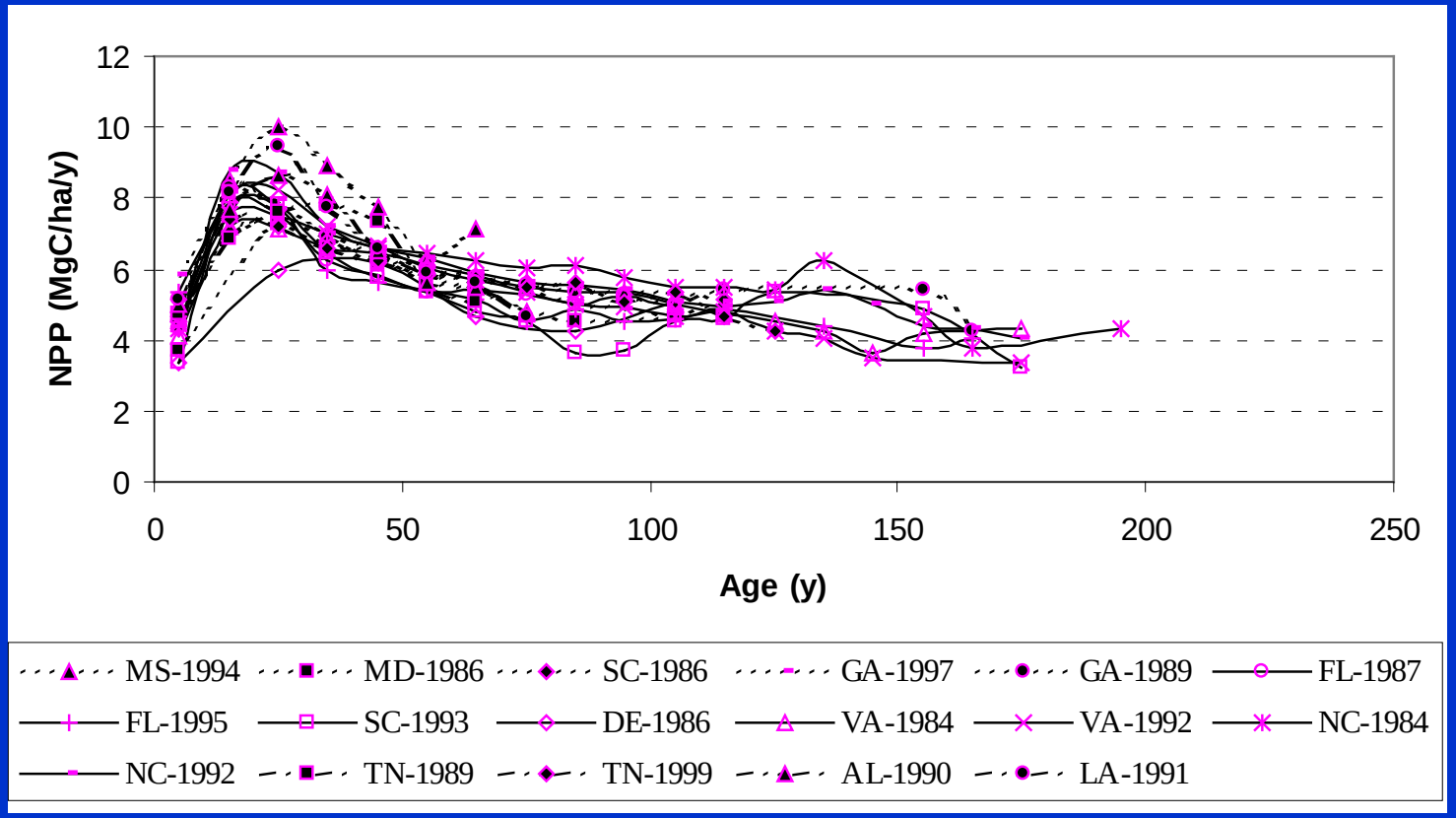
FIA Data

Net Primary Production



NPP decreases over time, which has not generally been included in previous modeling efforts.

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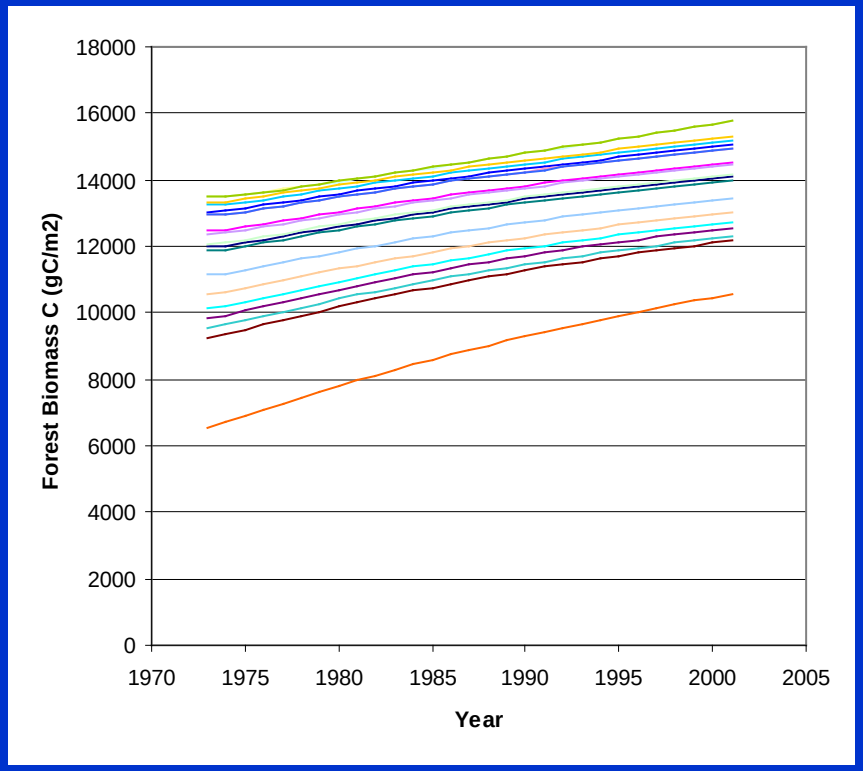
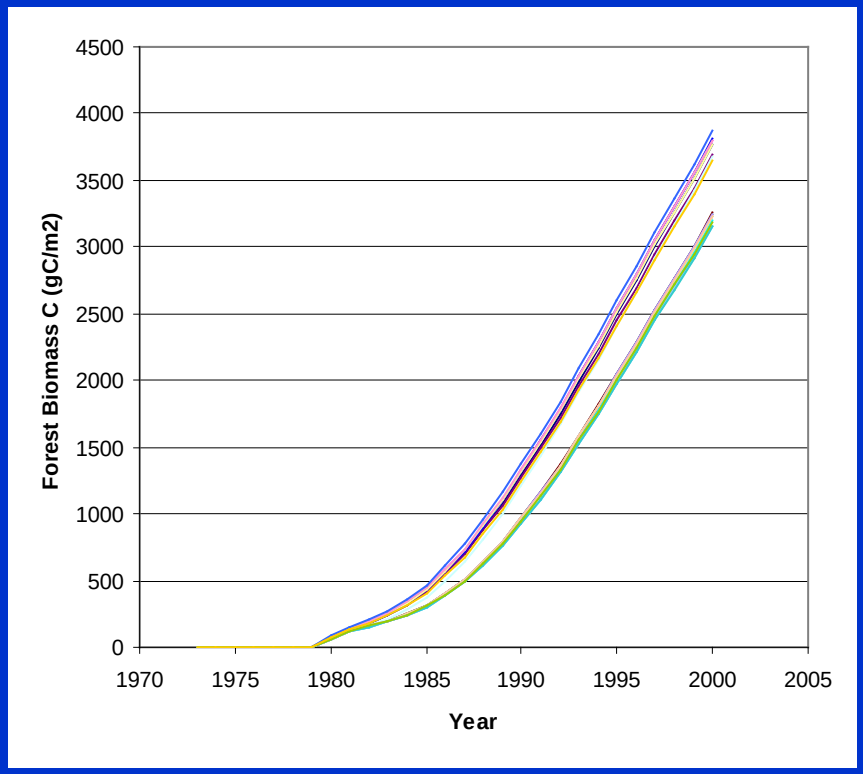
FIA Data

Ensemble Model Simulations With Consideration of Uncertainties

Case A. Growing young forests



Case B. Ag-Forest Conversion



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The variations with in each case are caused by uncertainties in site parameters (e.g., soil and forest age).

Southeastern Plains Samples: Mean Carbon Change Rate in Forest Biomass - 1974 to 2000

Block #	Mean C Sink ($Mg\ C\ ha^{-1}\ yr^{-1}$)
1	1.08
2	1.35
3	0.73
4	1.44
5	1.60
6	1.63
7	2.35
8	1.08
9	1.76
10	3.48
11	1.77

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Next Steps, Carbon Analysis

- Detailed Analysis on C Dynamics in Soils and Agricultural Lands
- Assess the linkage between C dynamics and land cover and land use change
- Uncertainty analysis
- Validation of model simulated results

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Research Challenges

- Automated change detection accuracy too low. Manual interpretation is more accurate – but slower.
- Meeting ± 1 % change detection sampling objective in ecoregions with high change rates. Switch to 10 km2 by 10 km2 samples will improve precision.
- CENTURY parameterization complexity slowed down carbon analysis.

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Future Steps

- Manuscripts in review describing overall strategy, role of ecoregions for environmental analysis.
- Complete all eastern US ecoregions during CY 2002.
- Complete carbon analysis for eastern US ecoregions.

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Programmatic Summary

- Most Significant Results: Measures of rates of deforestation in SE U.S.
- Relevance to NASA ESE Science Questions: Contributes to understanding rates, causes, and consequences (carbon) in conterminous U.S.
- Proportion of Social Science: 25 percent
- Proportion of LCLUC Themes: Carbon (50%); LC change detection (50%)

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