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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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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Research Questions

- **What is the spatial, temporal, and sectoral variability of conterminous U.S. land cover change from 1973 to 2000.**

- **What is the spatial and temporal distribution of carbon sources and sinks, and therefore the dynamics of carbon storage in the conterminous U.S.?**

- **What are the major uncertainties and knowledge gaps associated with regional and national carbon dynamics?**

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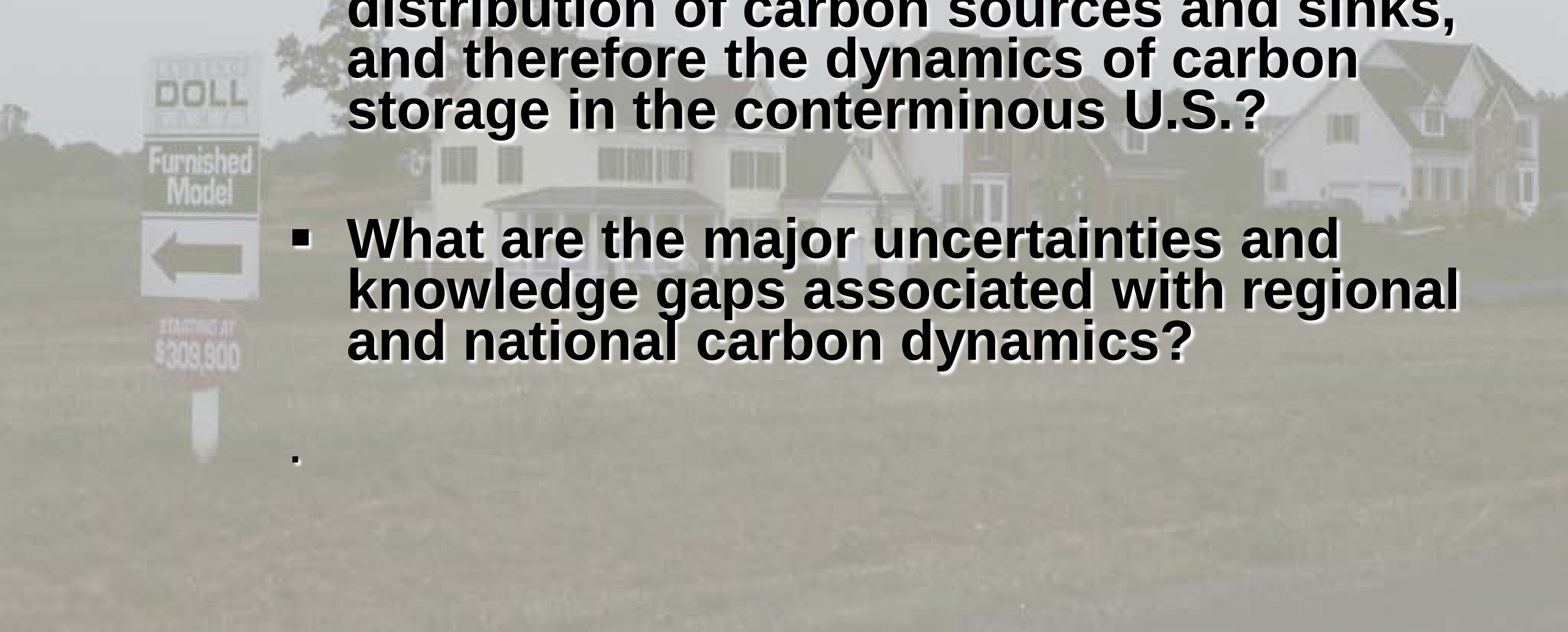
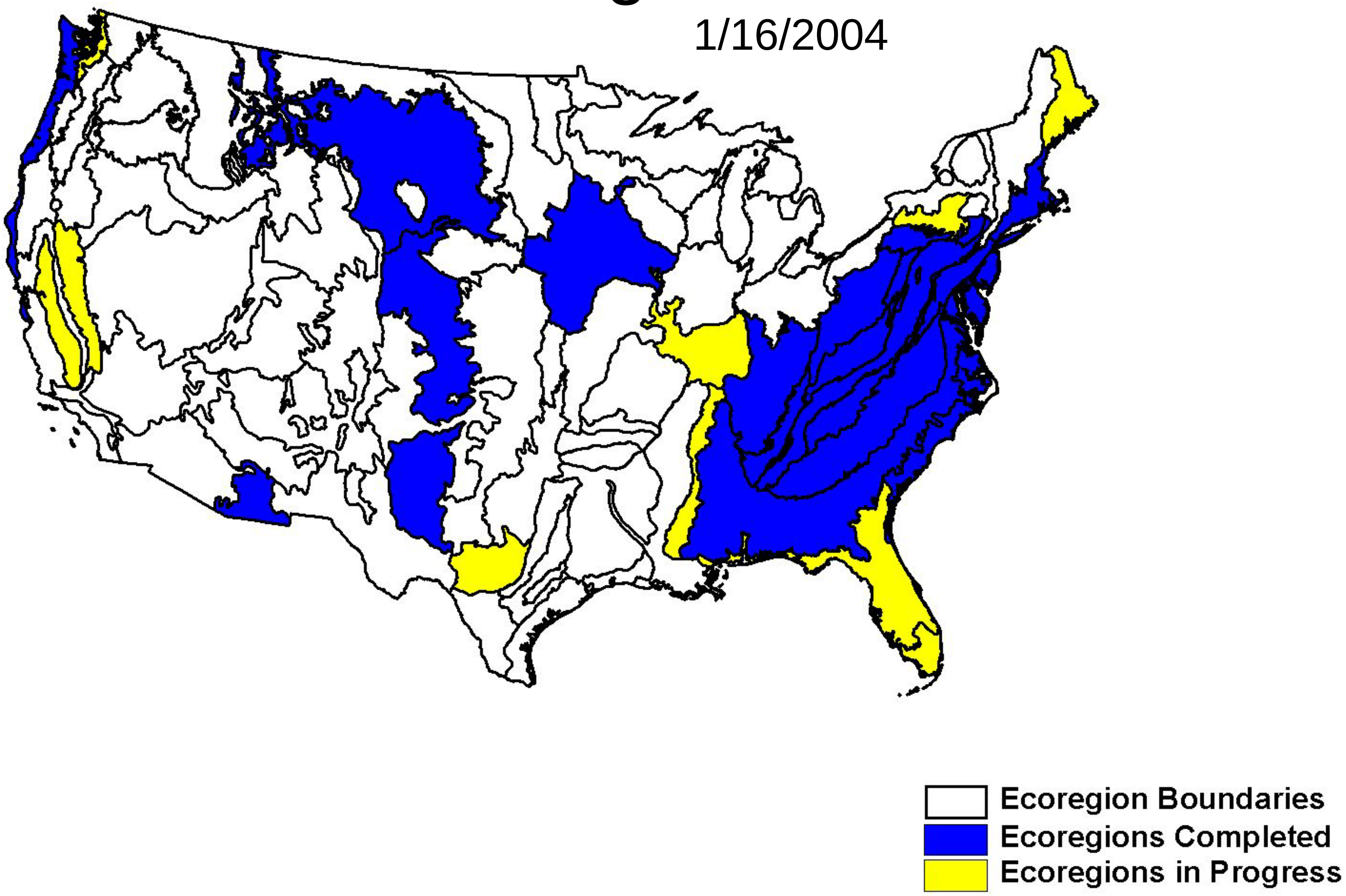


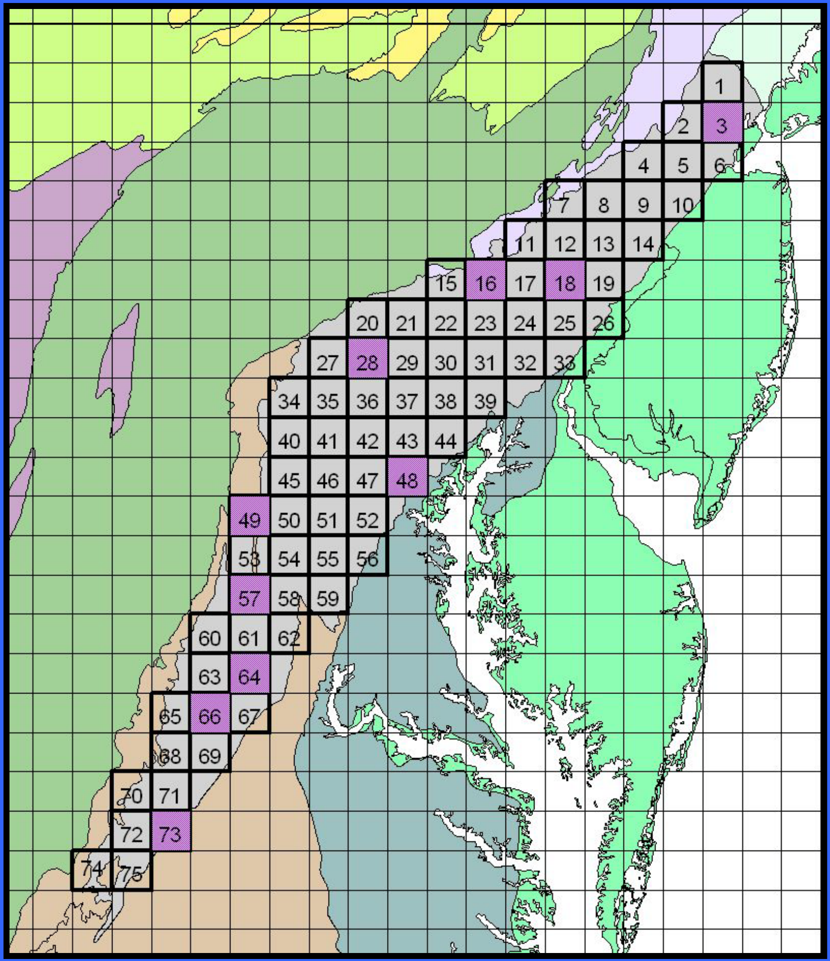
Status of Land Cover Change Assessments

1/16/2004



Probability-based sampling strategy used to provide efficient and reliable estimates of land cover change over large areas.

- Sampling units are 20- or 10-km^2.
- Samples randomly selected within strata.
- Sample size based on expected spatial variability of change in the strata.
- Goal is to detect within one percent of actual change at 85% confidence level.



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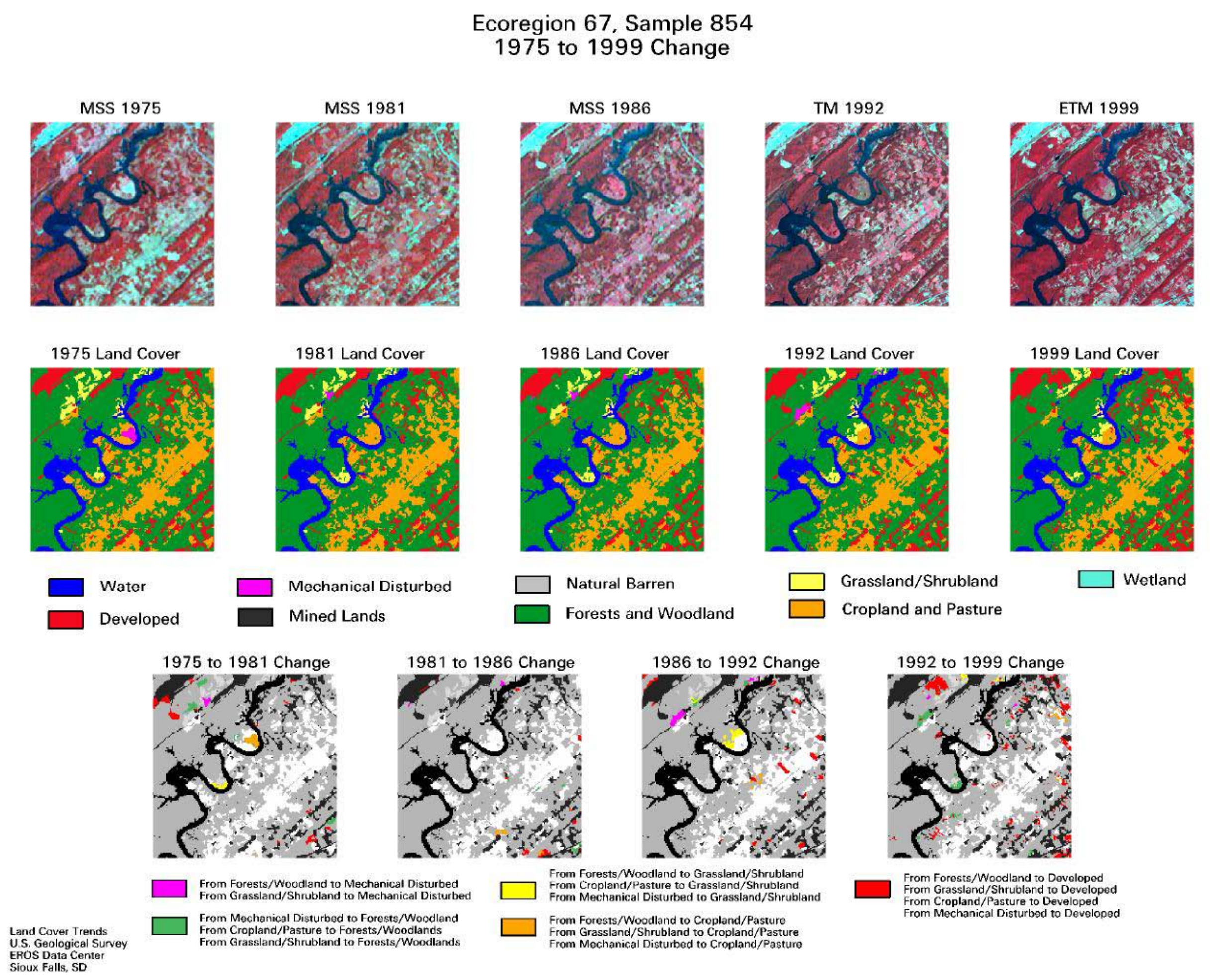
1973, 1980, 1986, 1992, and 2000 Landsat images interpreted to estimate ecoregion land cover change

Manual interpretation minimizes problems associated with:

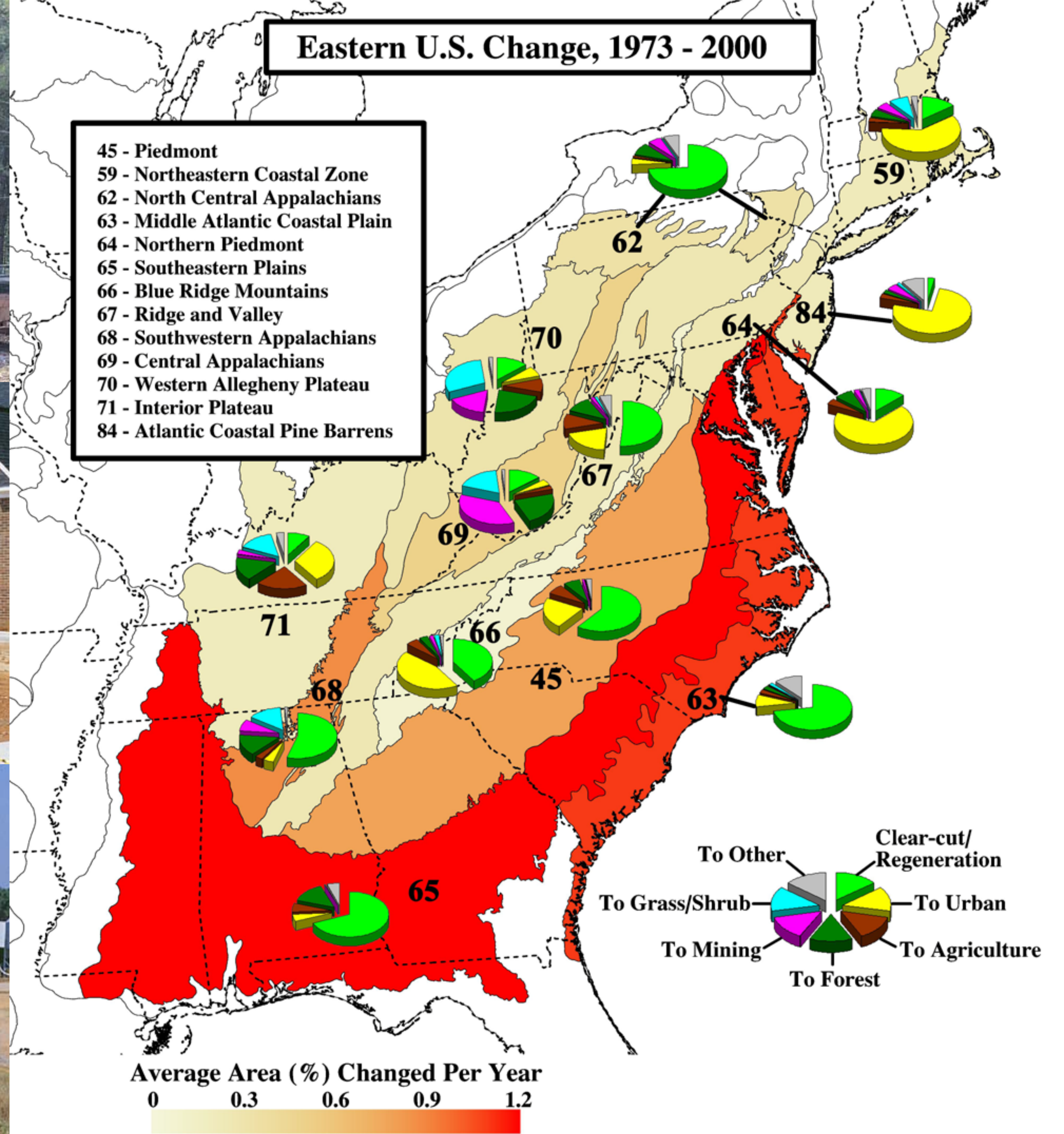
- Sensor differences
- Inter-sensor calibration
- Lack of anniversary date images
- Spectral ambiguities



USGS

For SALE
585-0606
2 BATHS

RESTRICTED AREA
NO VISITORS



Eastern U.S. Change, 1973 - 2000
45 - Piedmont
59 - Northeastern Coastal Zone
62 - North Central Appalachians
63 - Middle Atlantic Coastal Plain
64 - Northern Piedmont
65 - Southeastern Plains
66 - Blue Ridge Mountains
67 - Ridge and Valley
68 - Southwestern Appalachians
69 - Central Appalachians
70 - Western Allegheny Plateau
71 - Interior Plateau
84 - Atlantic Coastal Pine Barrens
59
62
84
64
70
67
69
71
66
45
68
63
65
To Other
Clear-cut/
Regeneration
To Grass/Shrub
To Urban
To Mining
To Agriculture
To Forest
Average Area (%) Changed Per Year
0
0.3
0.6
0.9
1.2

Eastern U.S. - Percent and Area Changed from 1973-2000

Percent Change per Period			
73 to 80	80 to 86	86 to 92	92 to 00
3.21%	3.86%	5.18%	6.08%
0.50%	0.67%	0.86%	0.89%

Average Annual Change per Period			
73 to 80	80 to 86	86 to 92	92 to 00
0.5%	0.6%	0.9%	0.8%

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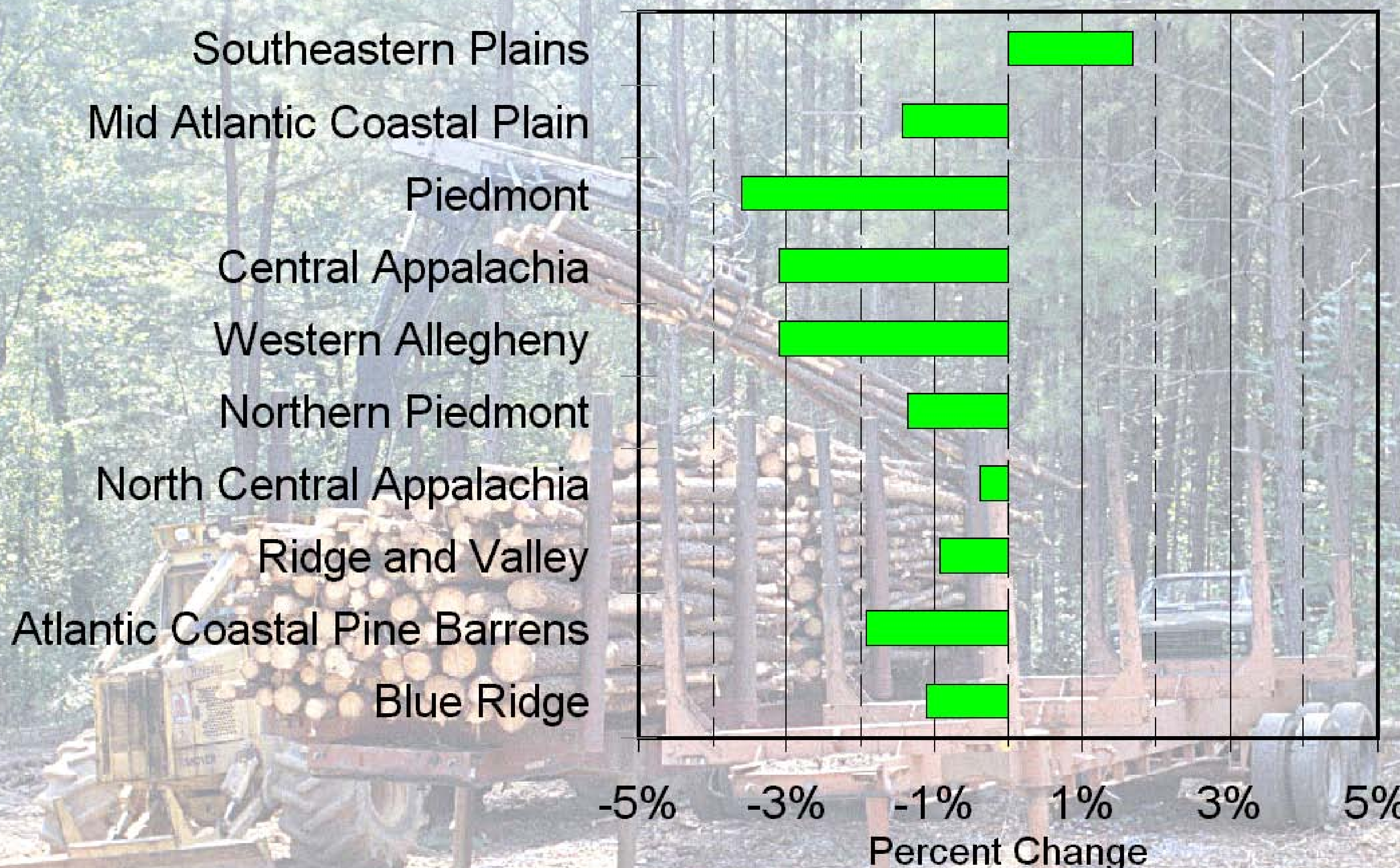
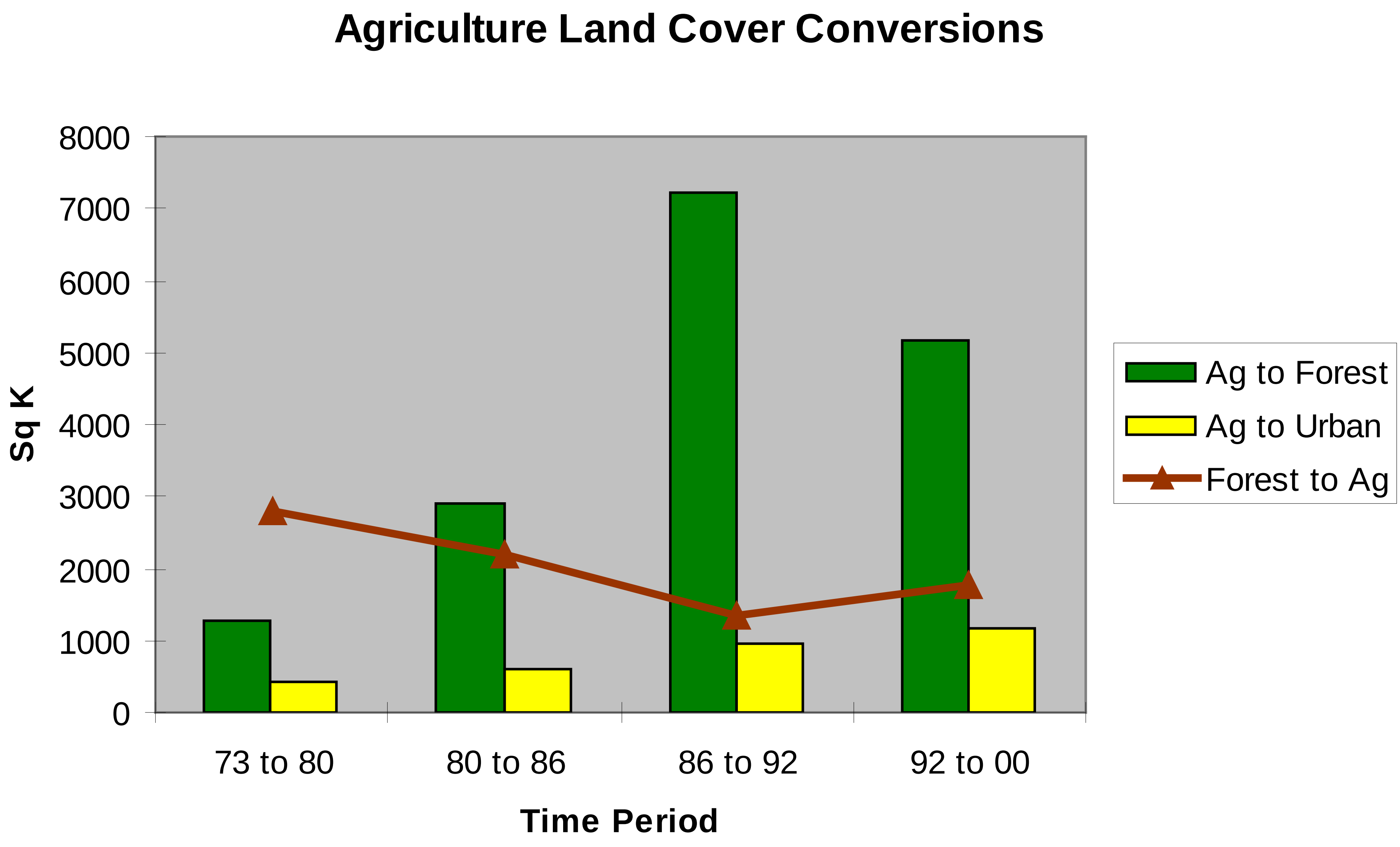
Average change per year (1973-2000) was 0.7%

Eastern U.S. Percent Rates of Land Cover Change

Category/Date	1973	1980	1986	1992	2000
Water	2.1	2.2	2.2	2.2	2.2
Developed	8.6	8.9	9.2	9.7	10.5
Mech. Disturbed	1.1	1.2	1.5	2.0	2.4
Mined Lands	0.3	0.3	0.3	0.3	0.4
Barren	0.0	0.0	0.0	0.0	0.0
Forest	56.1	55.4	55.0	54.7	54.1
Grass/Shrubs	0.3	0.4	0.4	0.5	0.5
Agriculture	26.2	26.2	25.9	25.2	24.7
Wetlands	5.4	5.4	5.3	5.3	5.2
Non-Mech. Disturbed	0.0	0.0	0.0	0.0	0.0

Change in Forest Land Use 1973-2000
Eastern Ecoregions




Agriculture Land Cover Conversions
Sq K
8000
7000
6000
5000
4000
3000
2000
1000
0
73 to 80
80 to 86
86 to 92
92 to 00
Time Period
Ag to Forest
Ag to Urban
Forest to Ag

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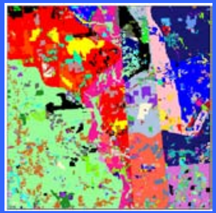
Scaling-Up Approach

Pixel/Site (60 m)

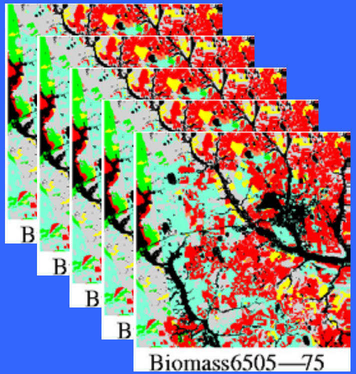
Block (10 km)

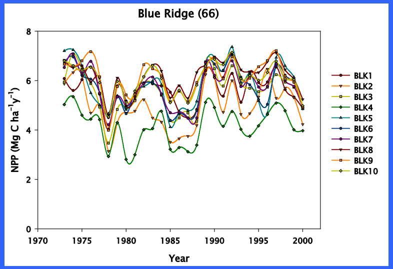


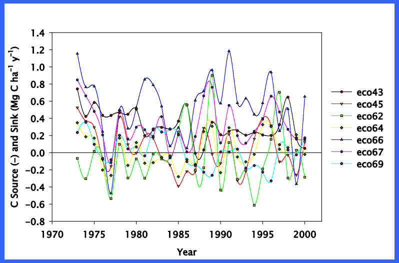
Ecoregion

Nation

Spatial and Temporal Changes of C Stocks, Fluxes, and Uncertainty







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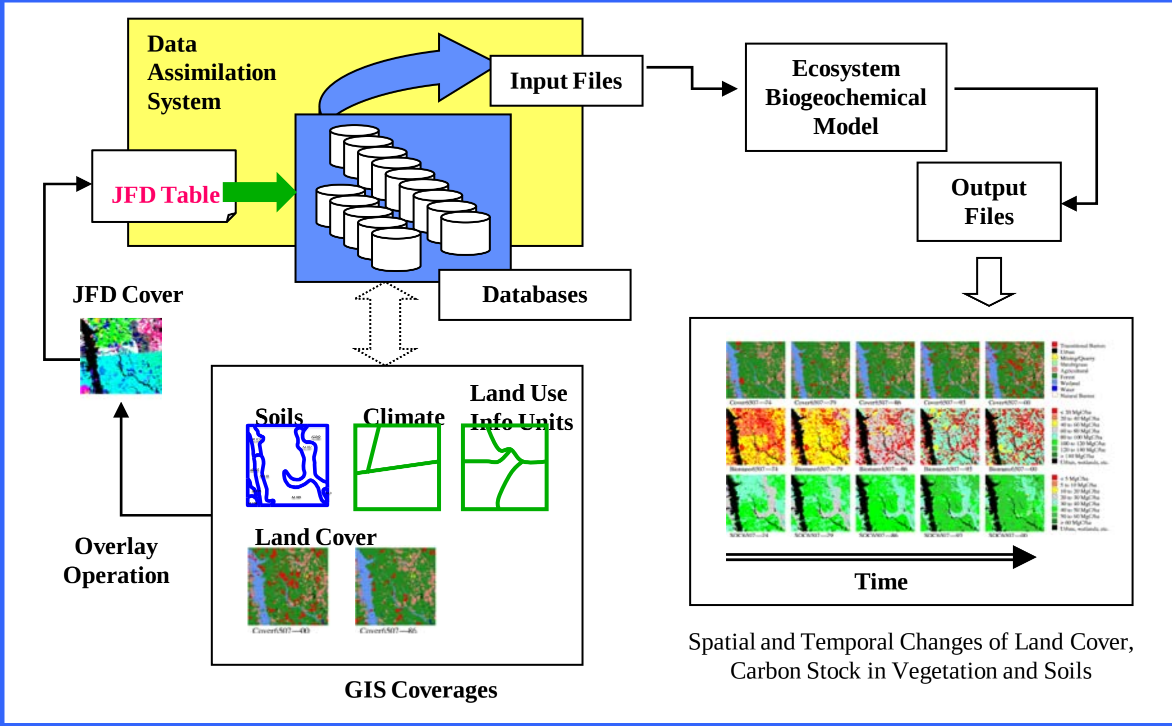
Spatially-Explicit Biogeochemical Modeling

The General Ensemble biogeochemical Modeling System (GEMS) is developed to simulate carbon dynamics within each of the sample blocks. It consists of

- ✓Encapsulated ecosystem biogeochemical model(s).
- ✓Data assimilation system
- ✓Input/output processor
- ✓User-friendly GUI



Spatial Modeling

GEMS (General Ensemble Biogeochemical Modeling System)

- An **advanced** modeling systems for spatially explicit simulations of biogeochemical cycling over large areas
- Developed at USGS **EROS Data Center**
- Deployment of the encapsulated plot-scale model in space is based on a **Joint Frequency Distribution** of the major controlling variables (e.g., land cover, climate, soil, etc.).
- Strong **data assimilation** algorithms
- It includes a **dynamic land cover/use change submodel**
- **Stochastic simulations** to incorporate uncertainties in input data
- **Uncertainty** estimate of carbon dynamics
- Major applications (US, Africa, and Central America)

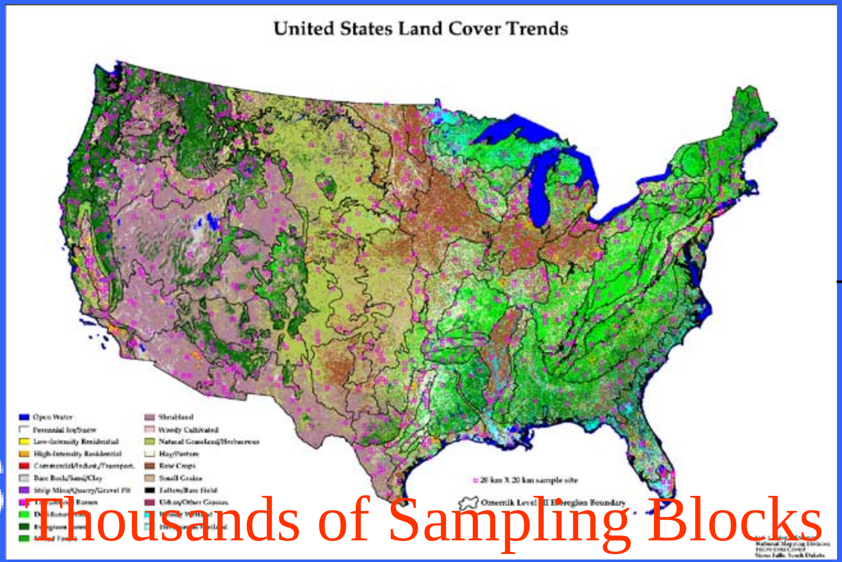
Data Assimilation

National Benchmark Databases

Land Cover: USGS Land Cover Trends
Soil: STATSGO
Climate: CRTUS2.0 (1900 – 2000)
N Deposition: National Atmospheric Deposition Program
Crop Information: USDA Agricultural Census Data
FIA: Forest biomass, NPP, Age Distribution

Data Assimilation

GEMS

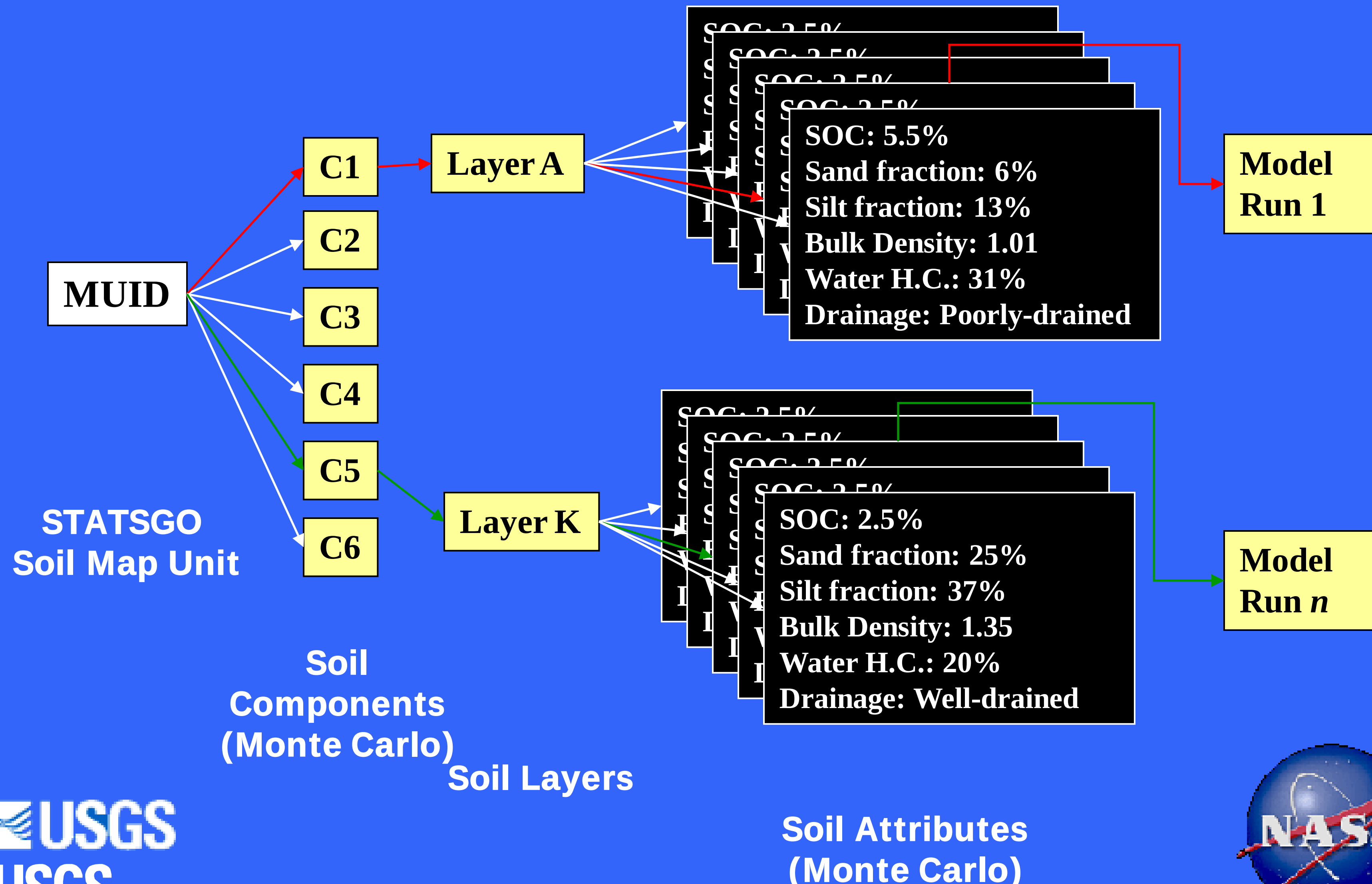


Thousands of Sampling Blocks

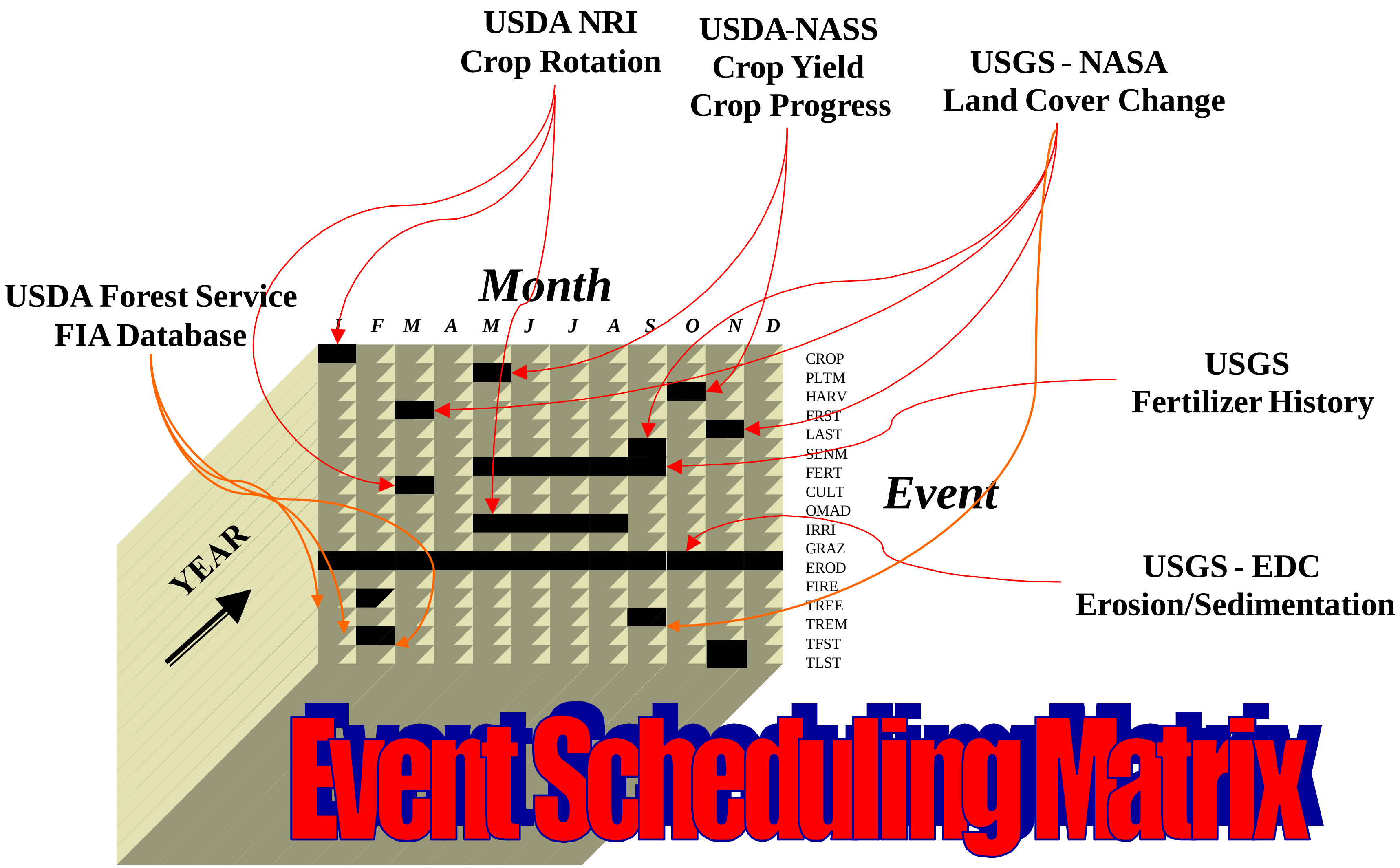
Carbon dynamics simulated at 60 m x 60 m spatial resolution within 20 km x 20 km or 10-km by 10-km sampling blocks

Ensemble Stochastic Modeling

Extracting Soil Data from STATSGO as an Example

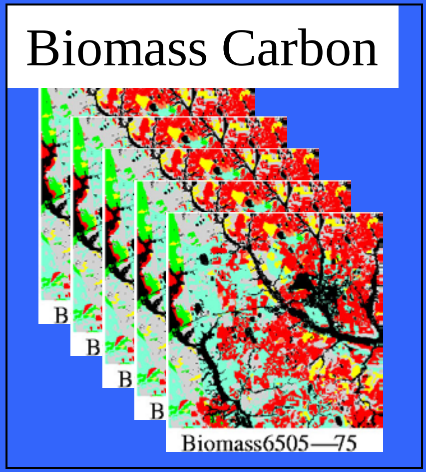


Dynamic Modeling of Land Use

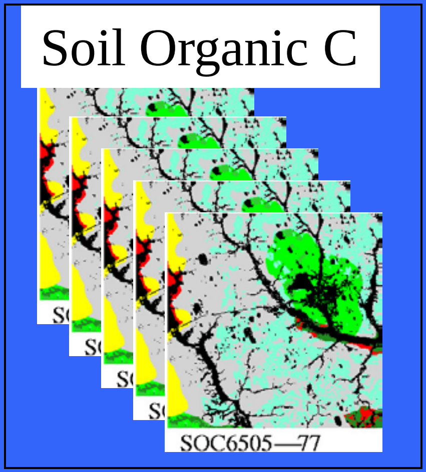


Pixel/Site Scale Carbon Dynamics

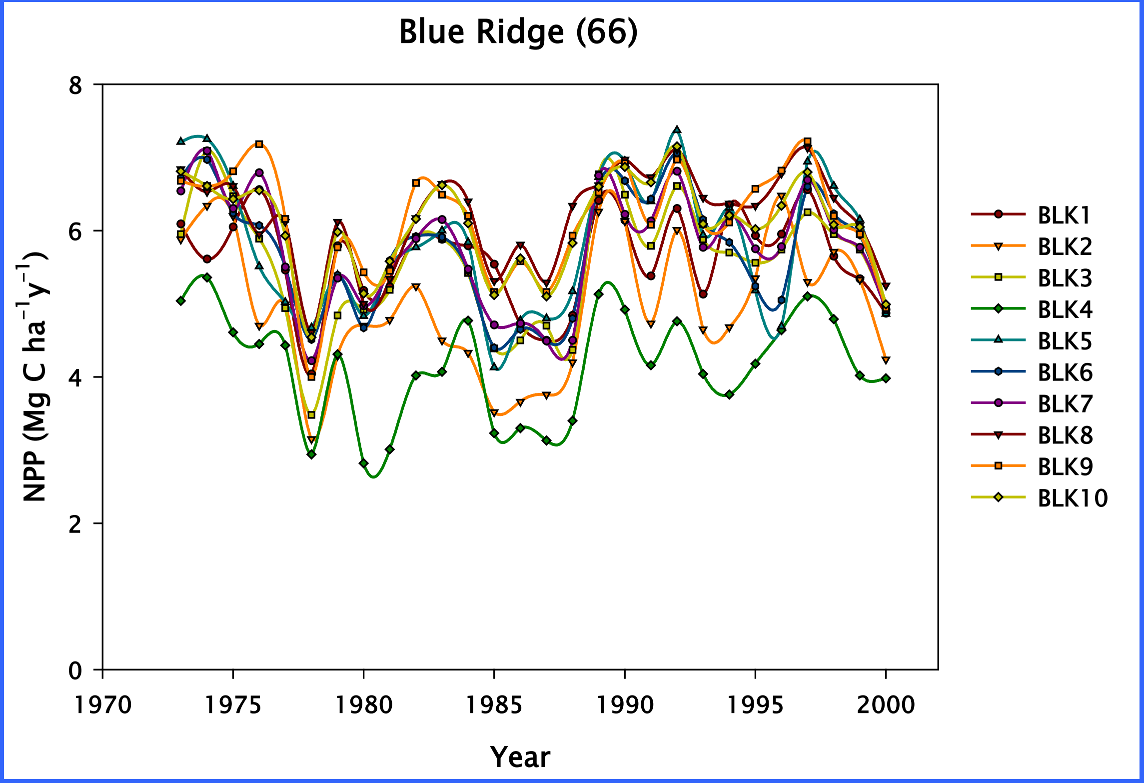
Important to quantify the impacts of detailed land cover/use change dynamics, and the variability and uncertainty of other driving forces (e.g., climate and soil) on carbon dynamics.



Biomass and SOC Dynamics within Sampling Block 5 in the Southeastern Plains Ecoregion



Block-Scale Carbon Dynamics within an Ecoregion



Large Spatial and Temporal Variability

- **Land use and cover change**
- **Climatic variability/change**
- **Soil variability**

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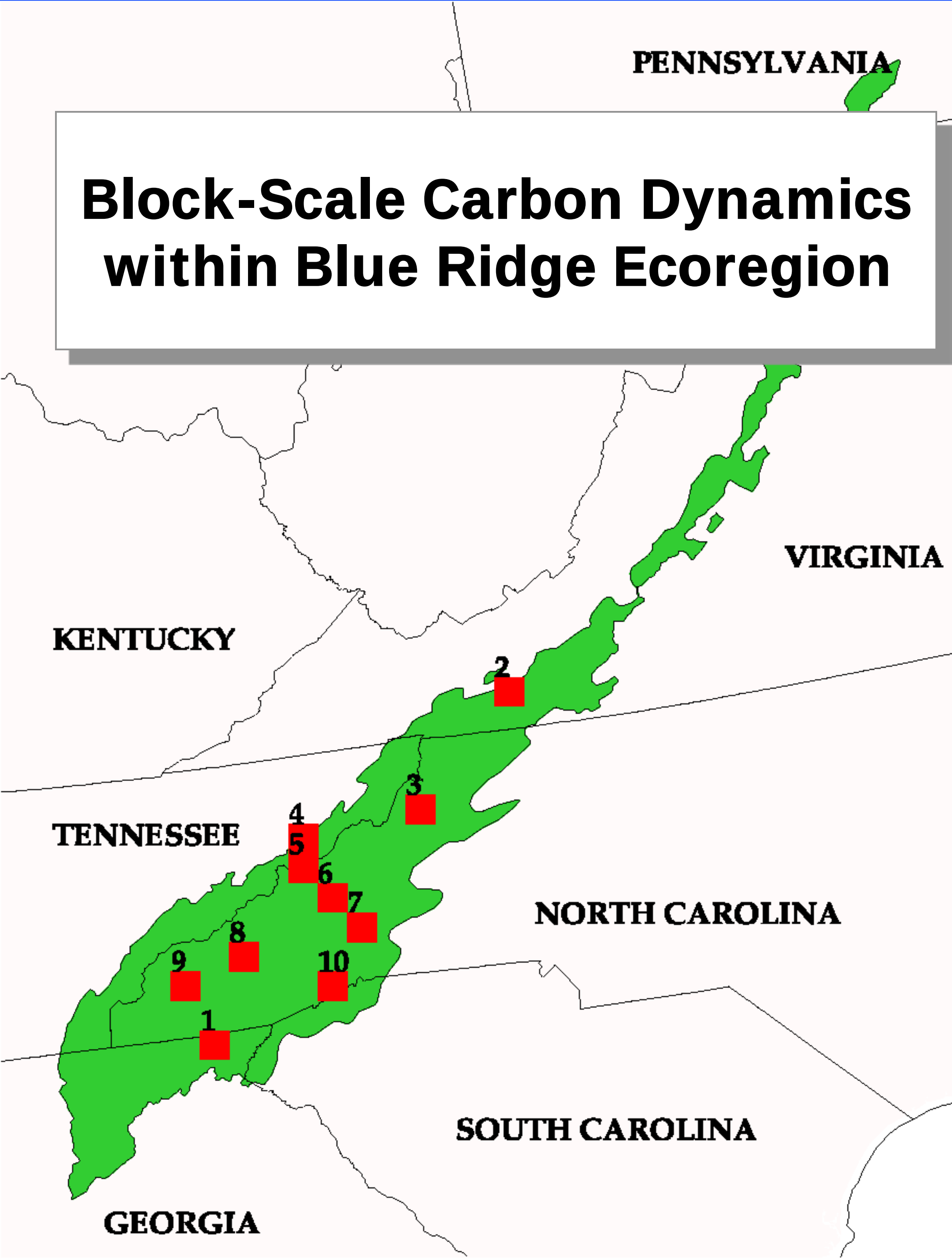
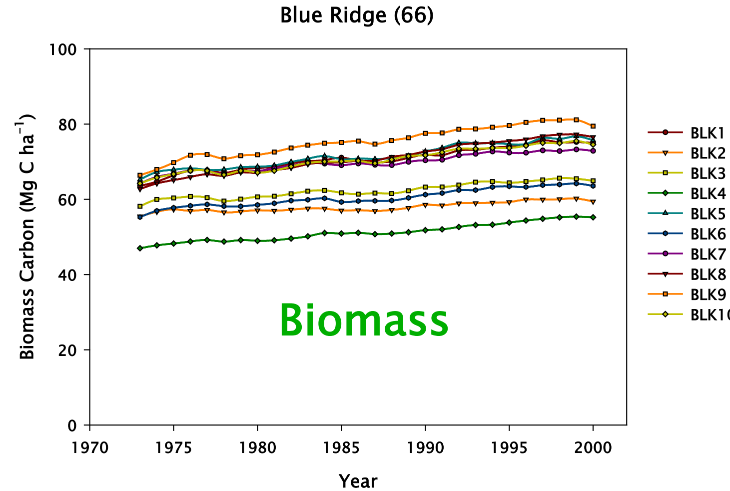
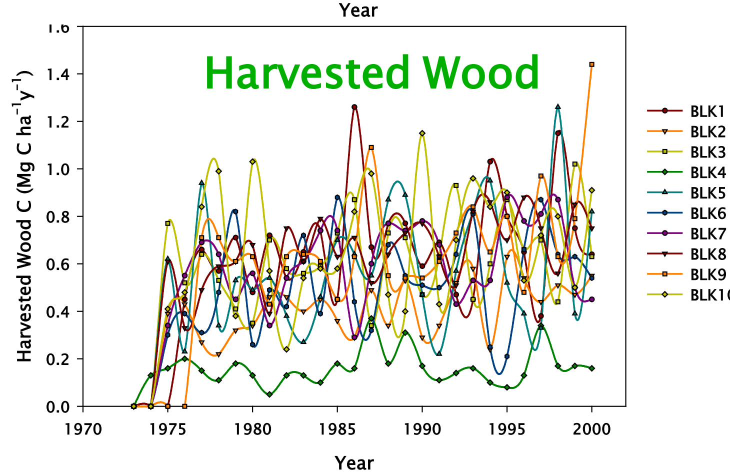
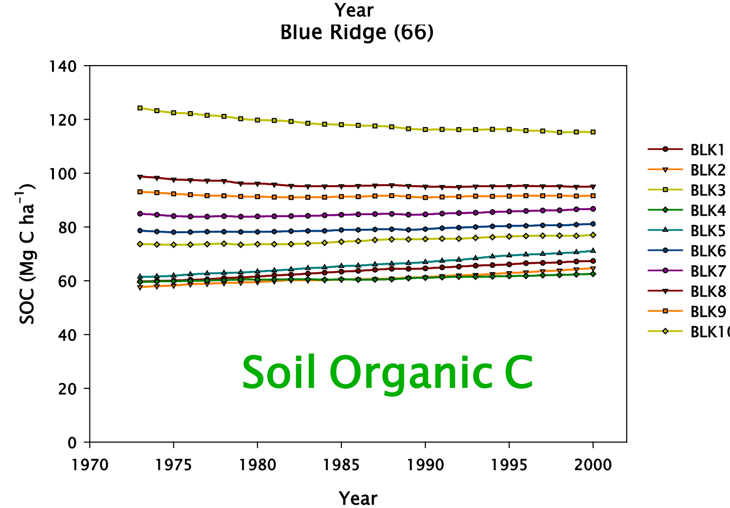
Block-Scale Carbon Dynamics within Blue Ridge Ecoregion

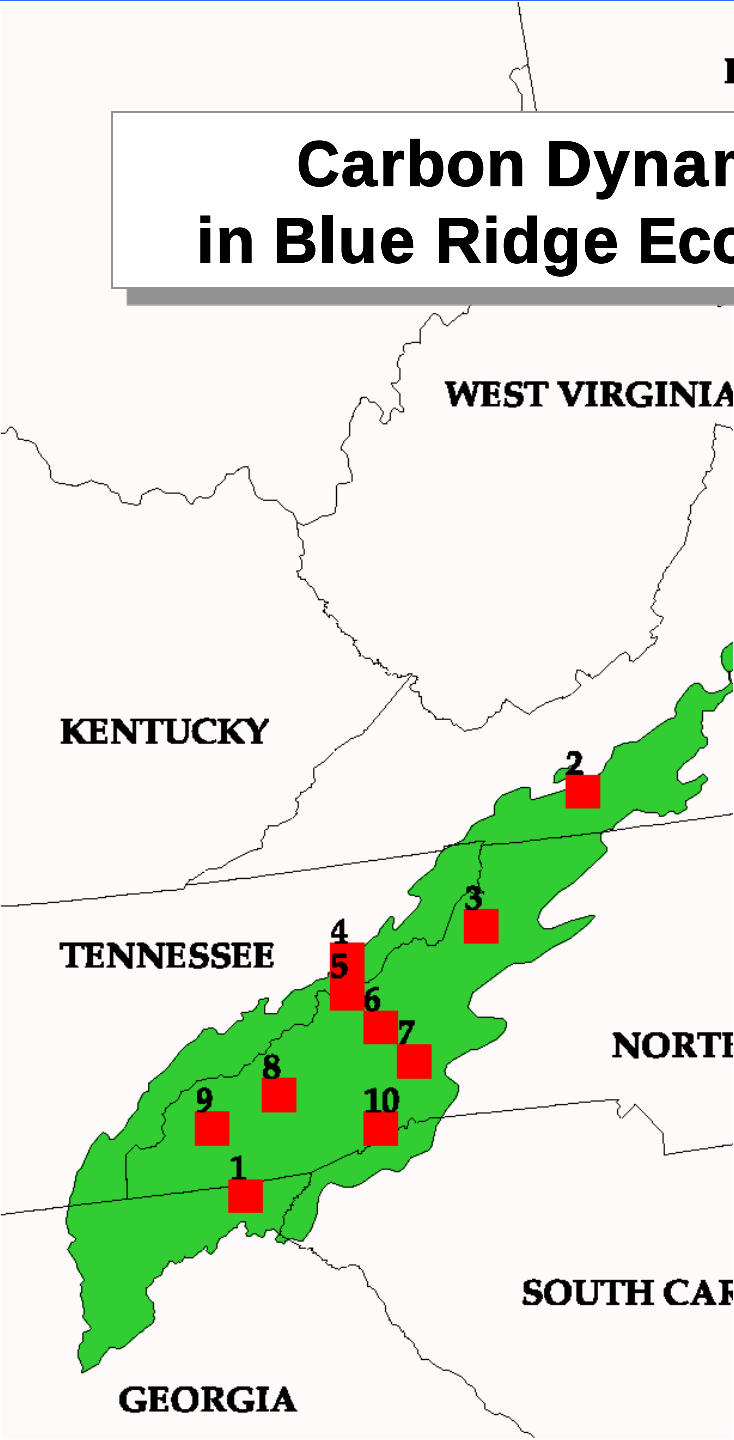


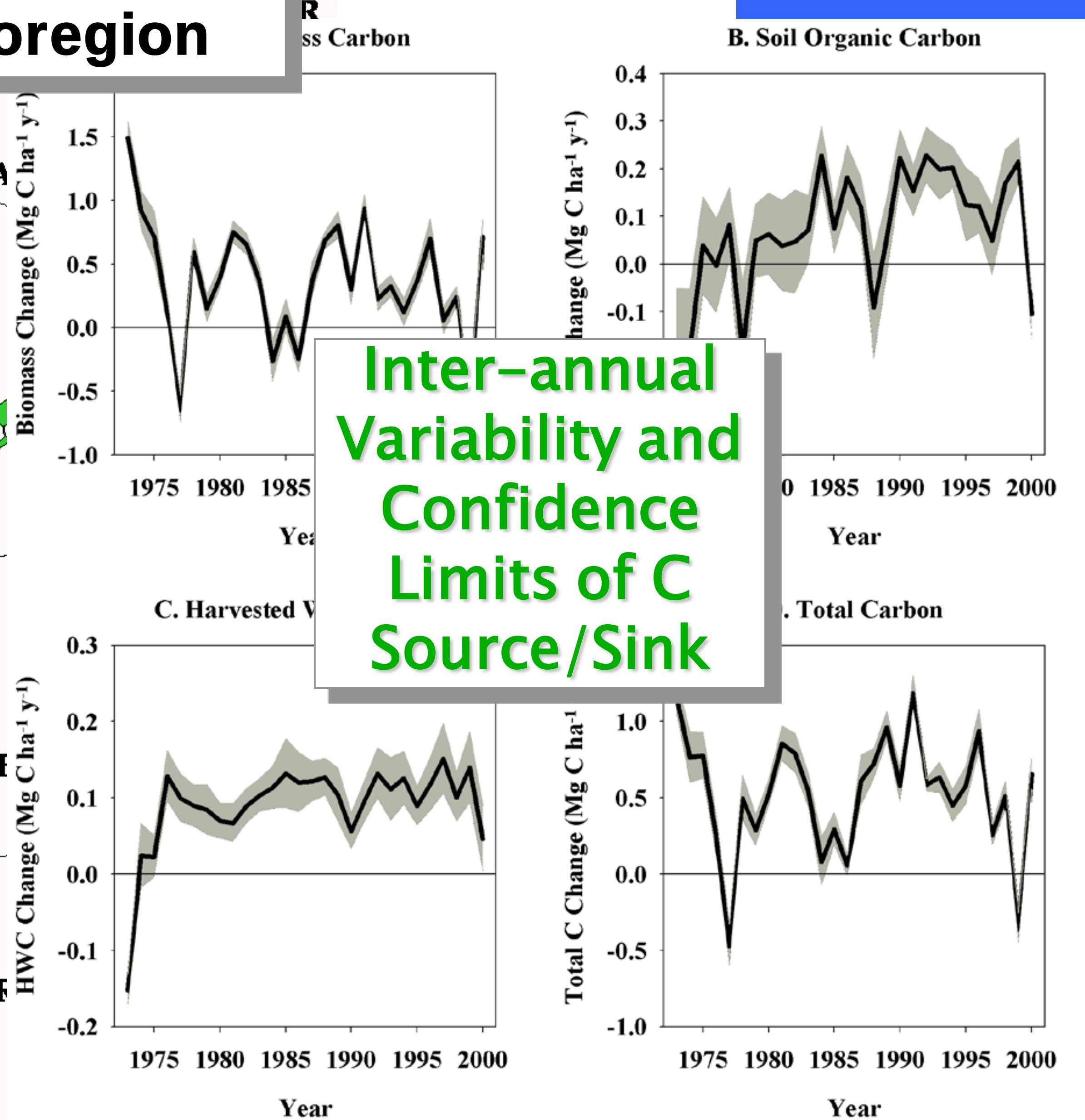






Carbon Dynamics in Blue Ridge Ecoregion

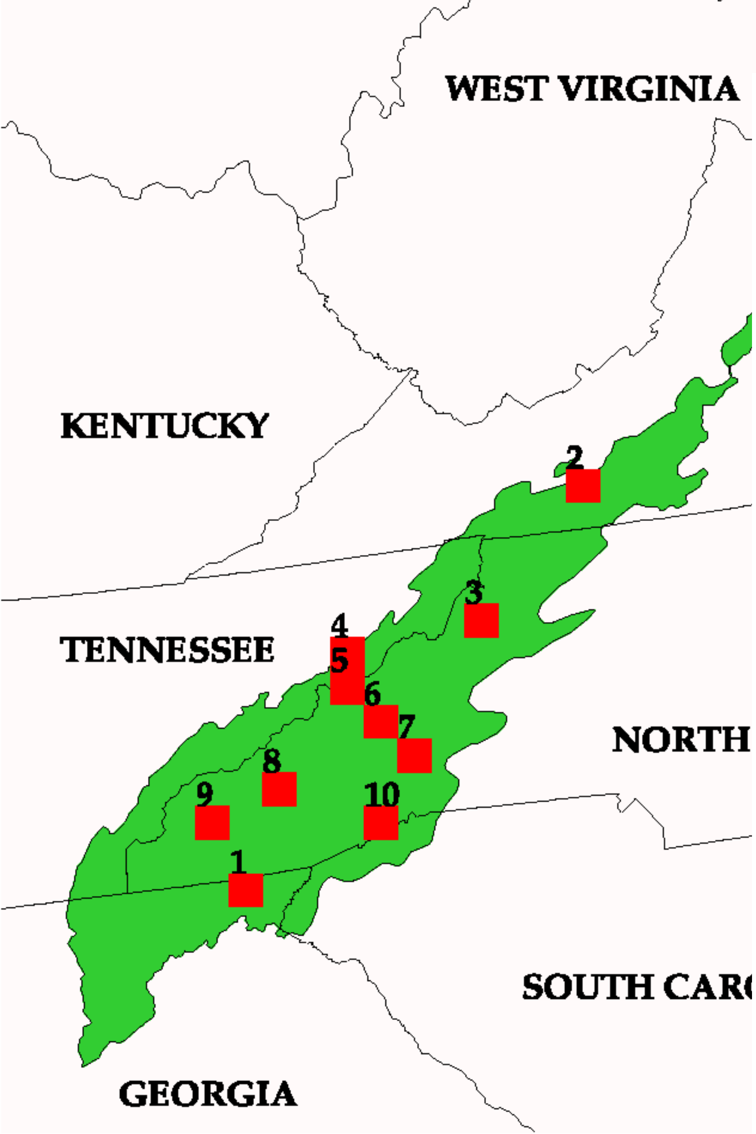


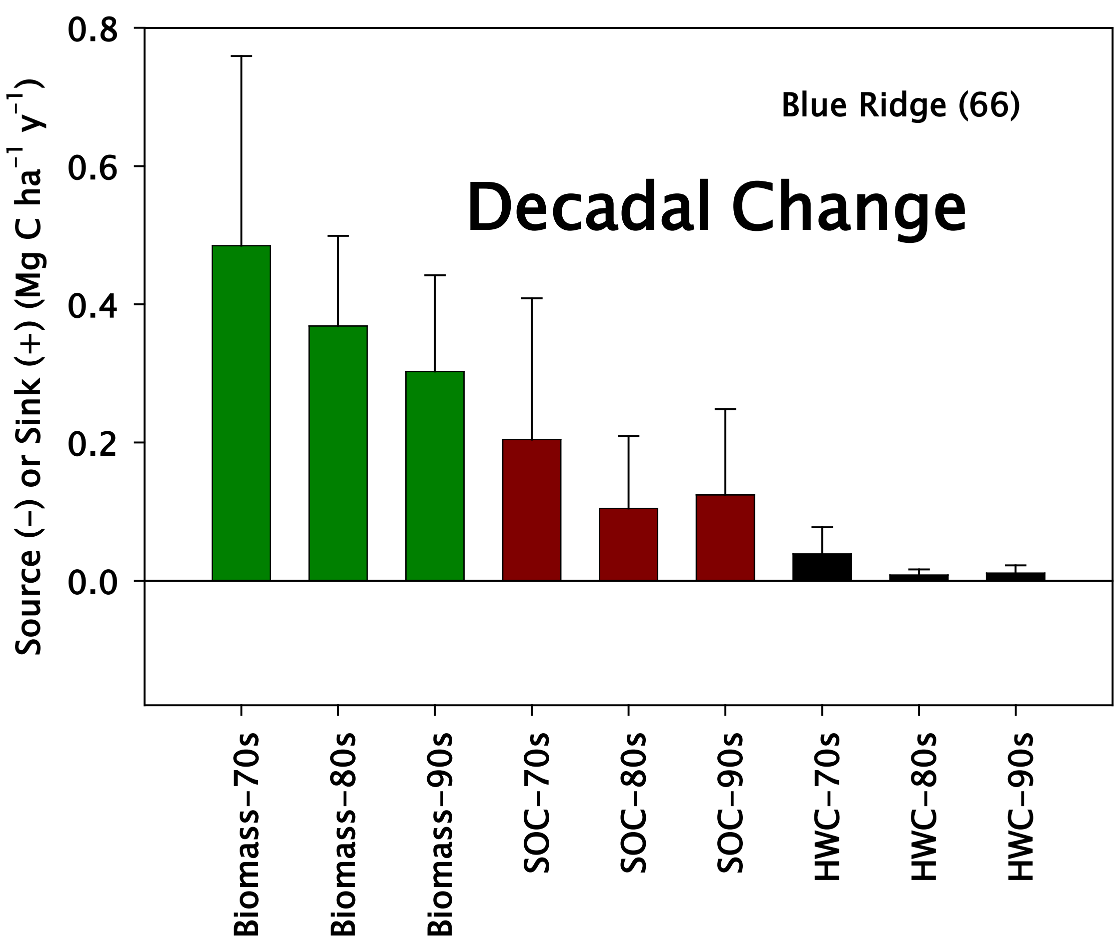


Inter-annual Variability and Confidence Limits of C Source/Sink

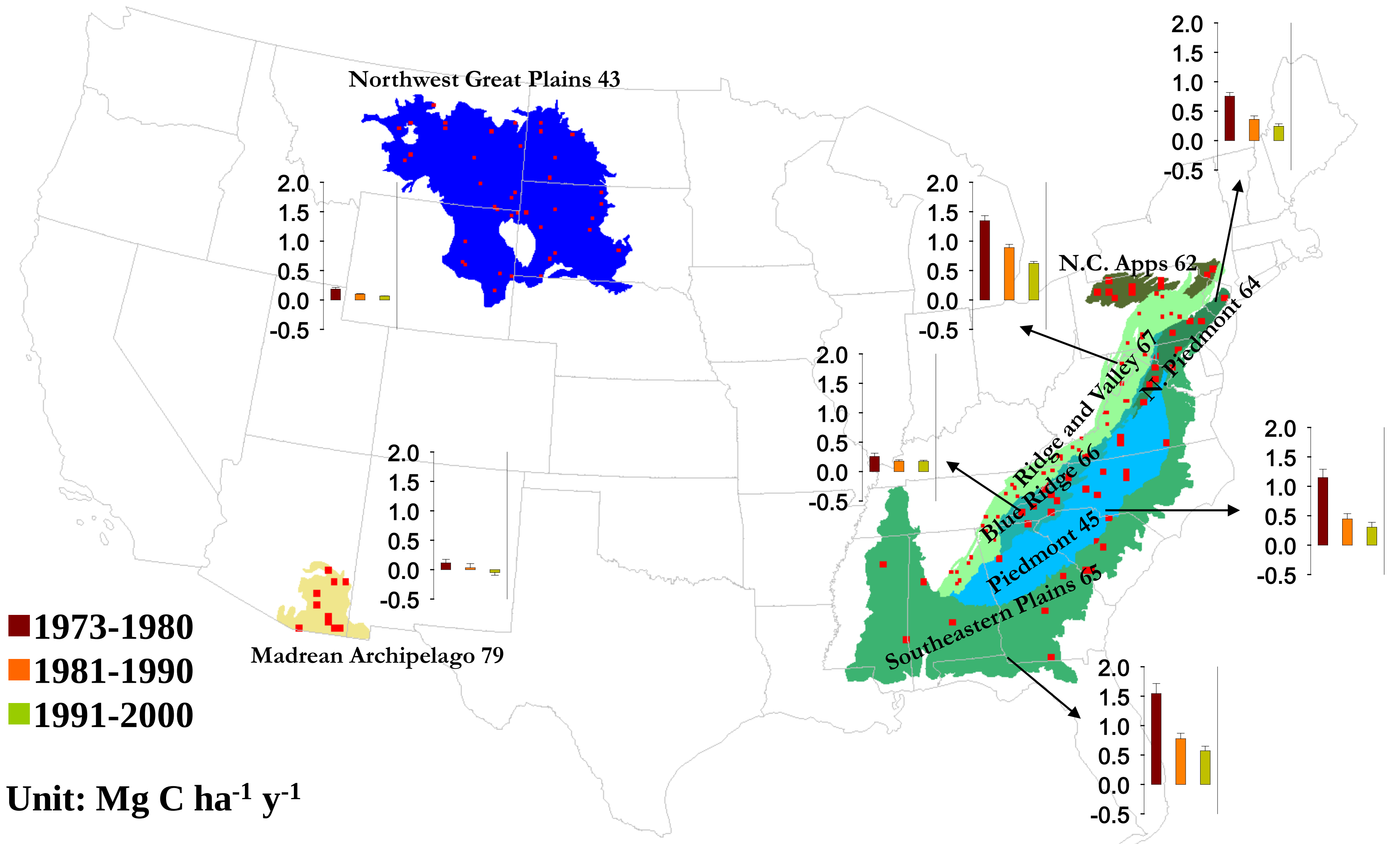
Carbon Dynamics in Blue Ridge Ecoregion

Steady decrease of carbon sink strength





Spatial and Temporal Changes of Carbon Sources and Sinks at the Ecoregion Scale



Summary

The seven ecoregions we have studied so far indicated that:

1. Carbon dynamics varied greatly across ecoregions: from carbon neutral to strong carbon sinks
2. Carbon sink strength has been decreasing
3. The inter-annual variability of carbon dynamics is mainly determined by climatic variability

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Major uncertainties and knowledge gaps:

- Uncertainty in soil database (STATSGO) at the local scale
- Net primary production data of forests (MODIS and FIA)
- Forest structural info (age, tree density, etc.)