Assessing Greenhouse Gas Fluxes from Ecosystems: Linking Science and Data with Land Management Applications

- Current knowledge about fluxes of carbon and other GHG in global and national contexts
- Conducting a national assessment of C stock, C sequestration, and fluxes of other GHG

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Questions to frame the discussion …

- What are the trends of GHG fluxes globally and nationally?
- Are ecosystems mitigating GHG fluxes? Will ecosystem mitigate more GHG fluxes with deliberate policy interventions?
- What are resource *capacities* for mitigating GHG fluxes? (How is “capacity” defined?)
- How effective will changes in land use and land management be in increasing C sequestration and reducing GHG fluxes?

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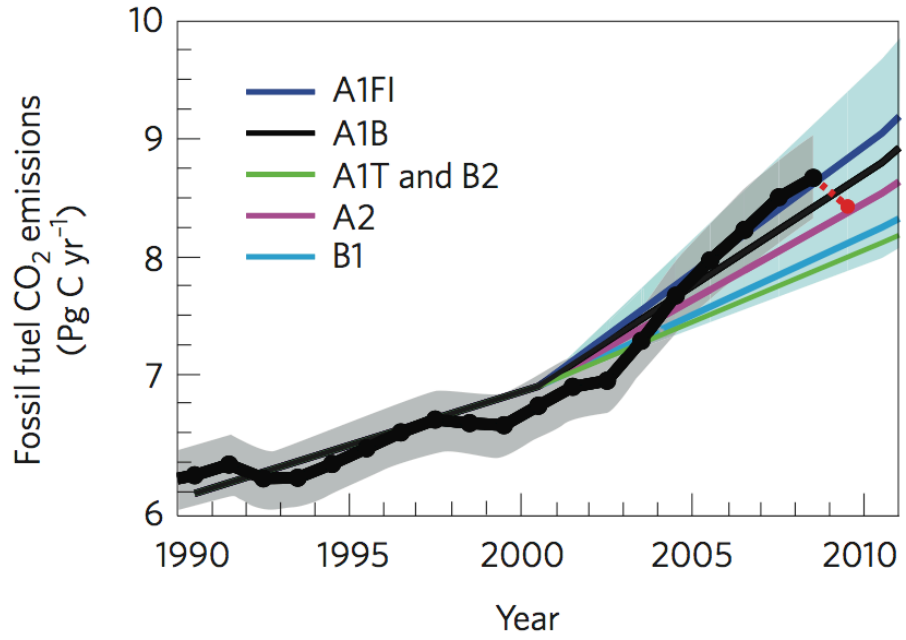
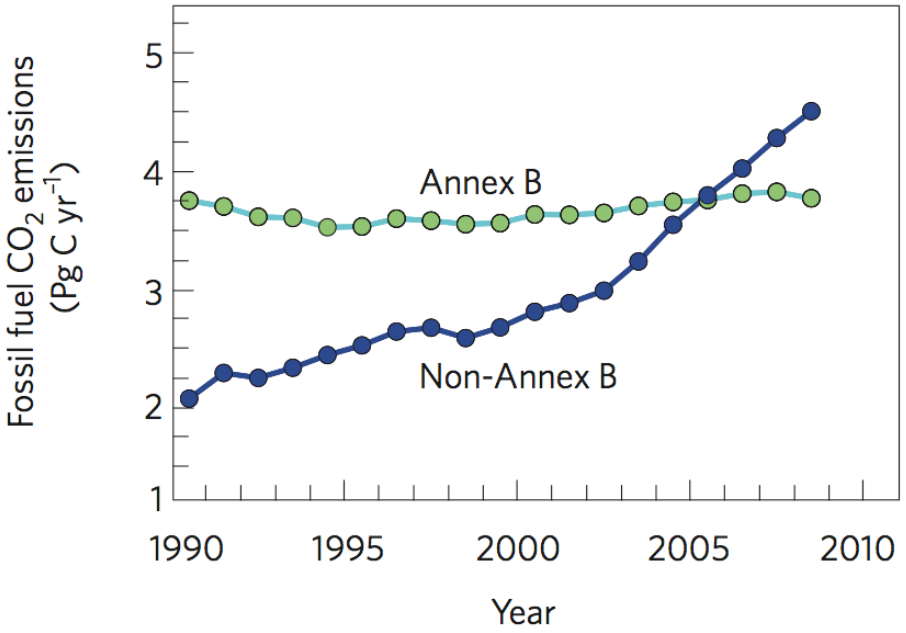
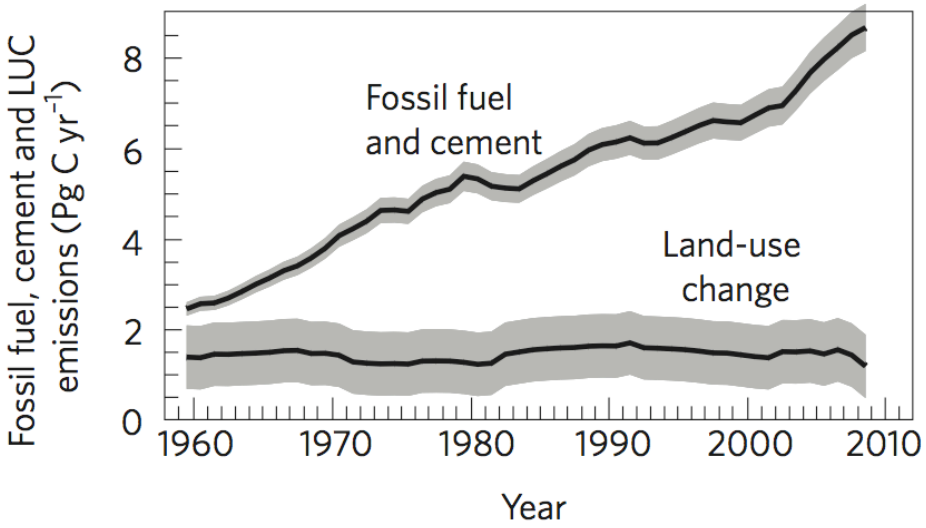
Status and trends of global CO2 fluxes

(Source: Le Quere et al 2009)



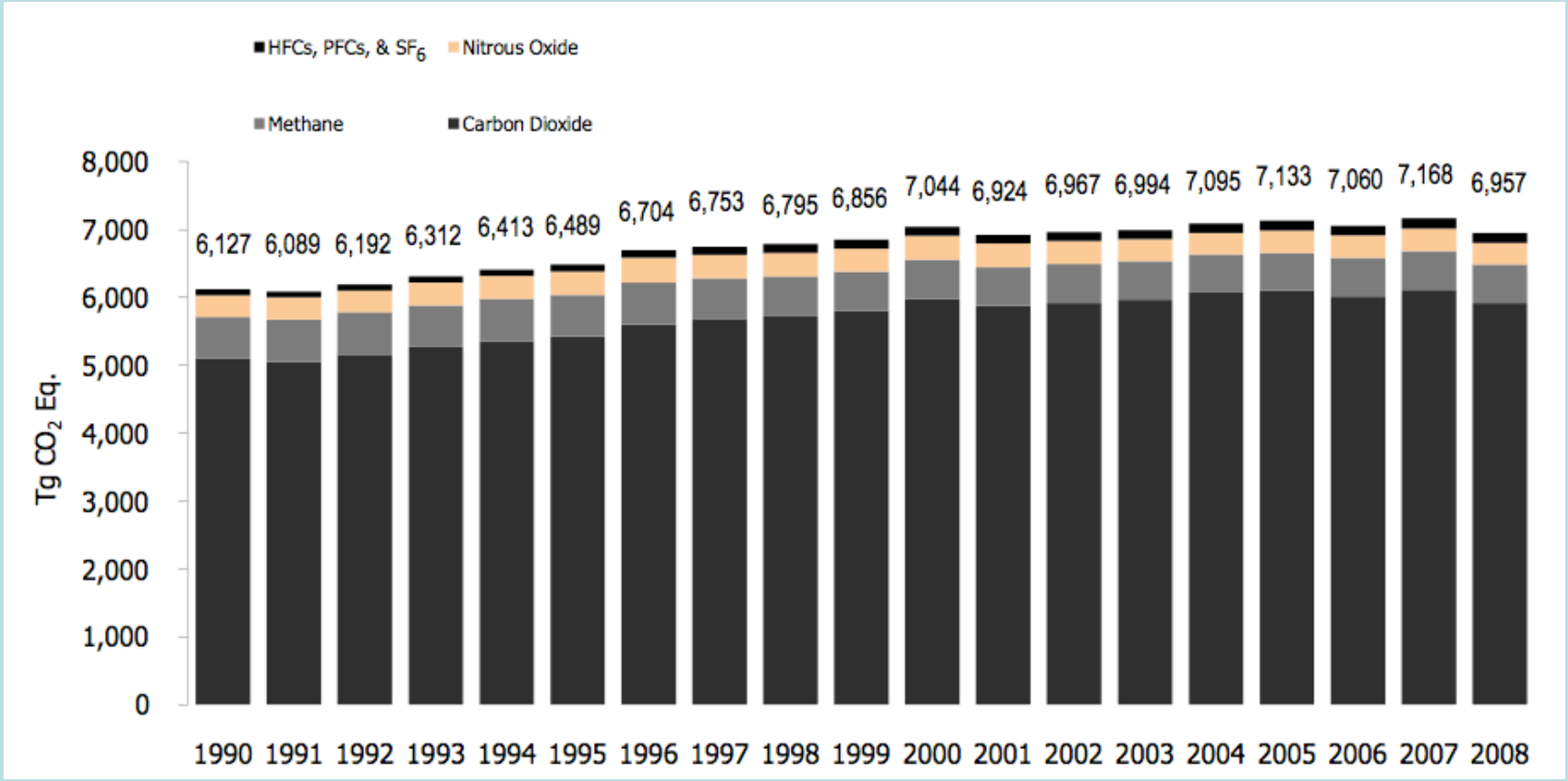




2008 global CO2 net emissions

Major sources/sinks	PgC/yr
Fossil fuel	8.7 ± 6%
Land use, forestry	- 3.5 ± 42%
Ocean uptake	- 2.3 ± 17%

United States greenhouse gas emissions (Source: EPA)



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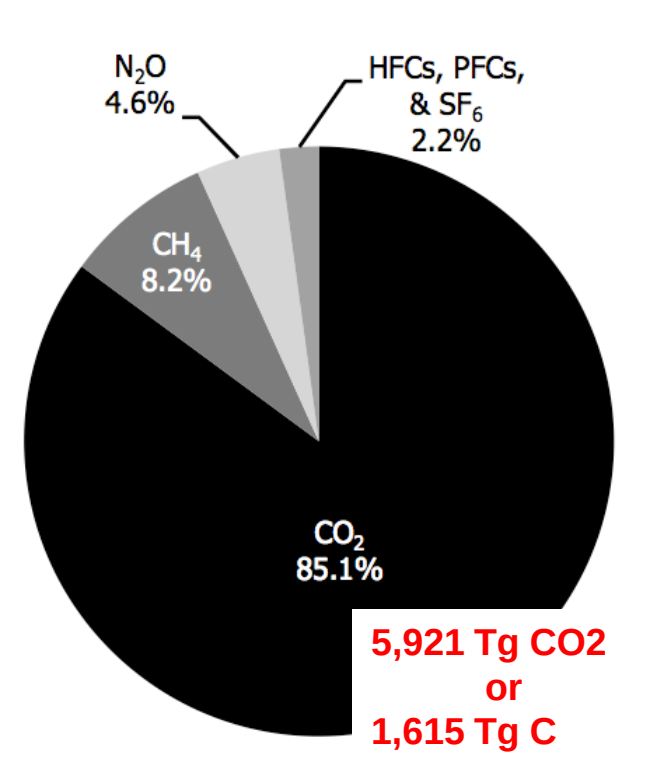
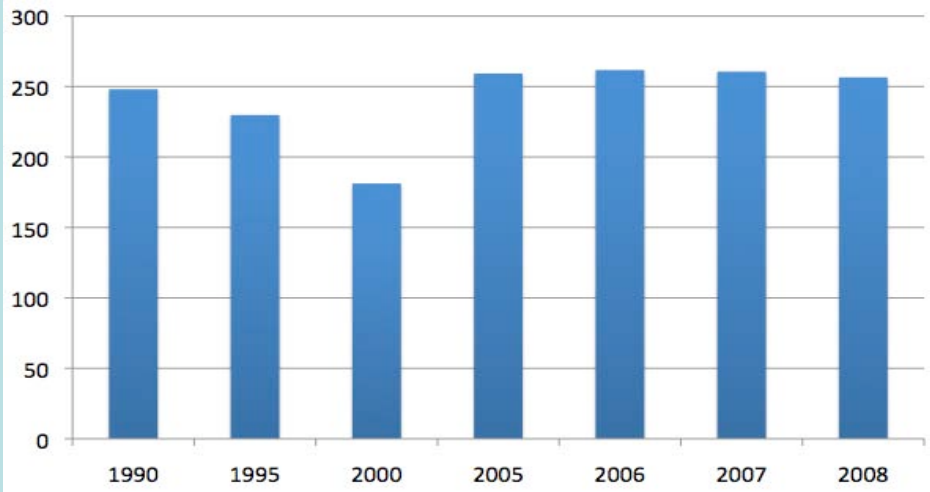
United States greenhouse gas emissions (2008) (Source: EPA)

US GHG emissions 2008



CONUS land use as a C sink, representing ~ 16% of US CO2 emissions (Tg C/yr)



CONUS 2008 C sequestration by major categories (Tg C/yr)

Forest	Cropland	Grassland	Others	Total
-216	-5	-2	-33	-257

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Comparing US with Other Regions for Forest Carbon

Nation	Forest area (M km^2)	Stocks (Bt C)	Source	Forest C stock change (NBP) (Mt C/yr)	% σ	Source	Pools
China	1.75	27.1	Goodale et al 2002	-92	47%	Miao et al 2009	Not clear
EU	1.46	23.1	Goodale et al 2002	-110 (2010)	27%	Luyssaert et al 2010 (Carbo-Europe)	Not clear
CONUS	2.69	41.39	USDA 2005	-162[a] (2010)	18%	EPA 2010 (FIA 2008 data)	Above- and below-ground, floor, SOC

[a] Does not include wood products and urban forestry. If included, it would be 216 Mt C

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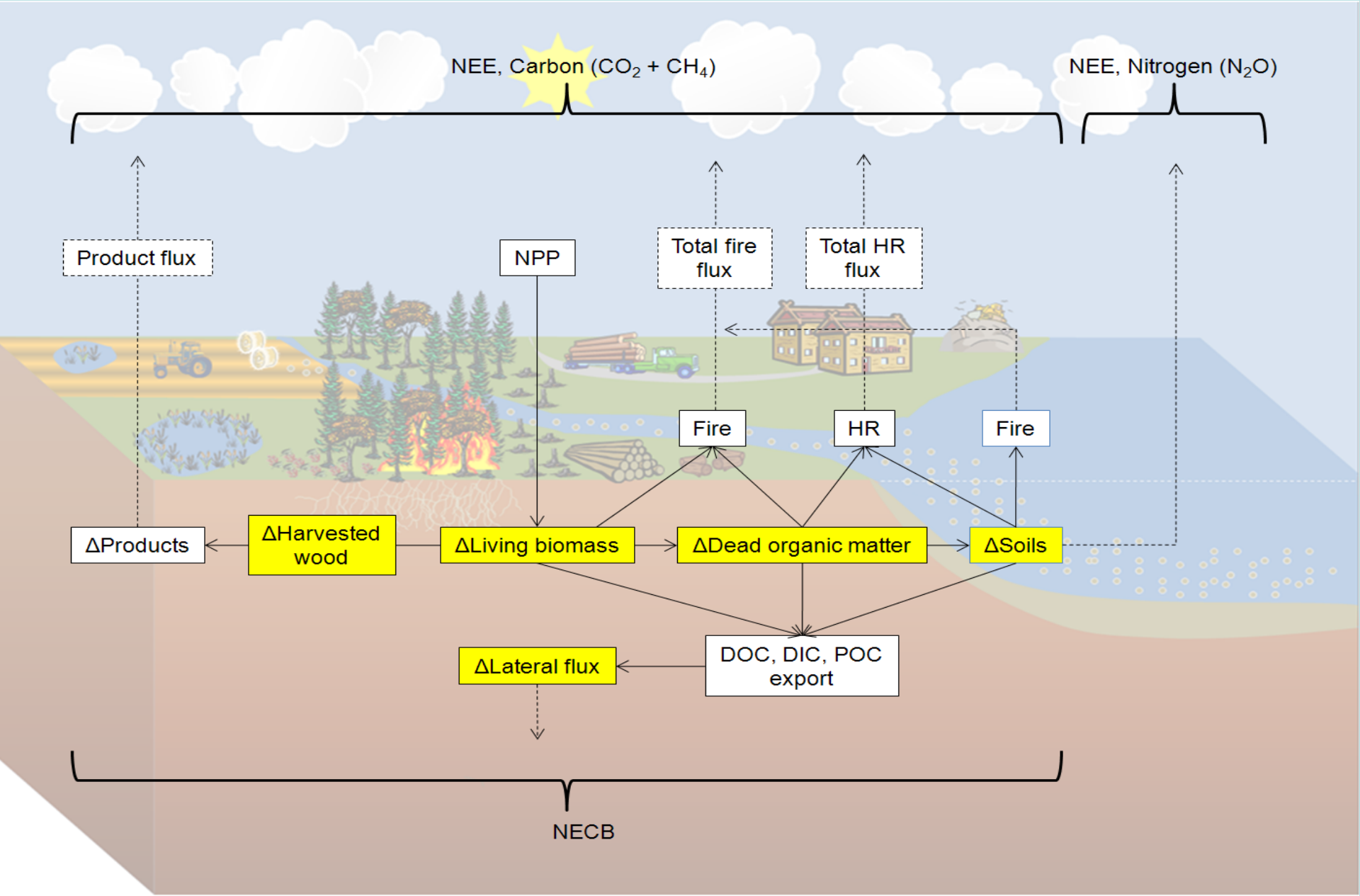
Ecosystem processes, pools, and fluxes



Energy Independence and Security Act of 2007

- Section 711: assess geological capacity of carbon sequestration in geological traps, seams, reservoirs, and other formations

- Section 712: assess biological carbon sequestration and greenhouse gas flux (CO_2, N_2O and CH_4) in all ecosystems of the Nation: uplands, wetlands, freshwater aquatic, and coastal ecosystems

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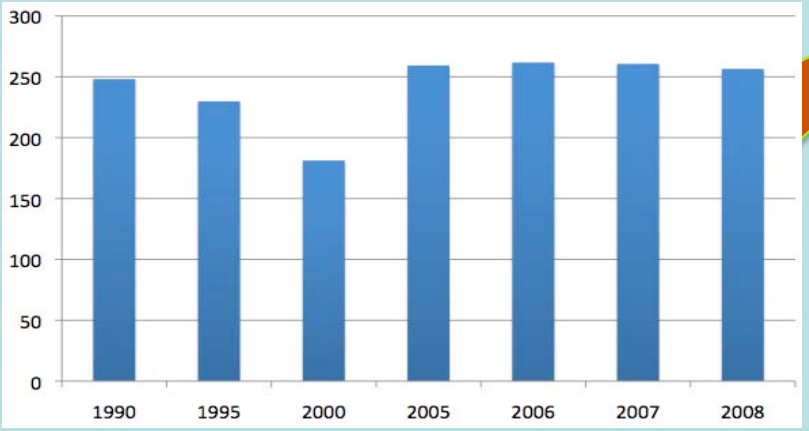
USGS National Assessment for C Sequestration and Greenhouse Gas Fluxes

EPA Annual Inventory Reports, land use net sequestrations



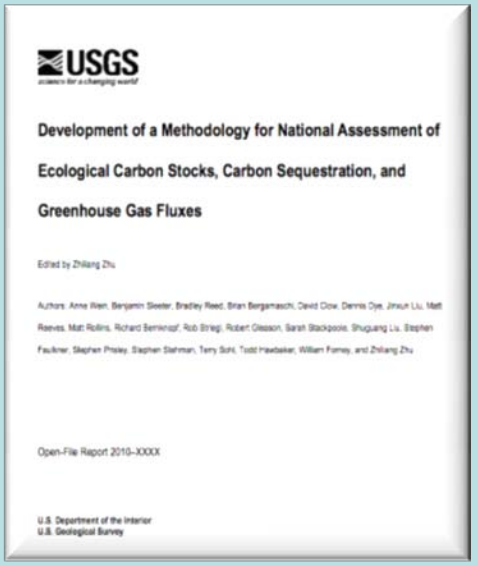
USGS Assessment Motivations:

- What will be the future trend of land sink, given a potentially different set of climate, land use, and disturbance scenarios?
- Will the future trend be different if we manage ecosystems differently (i.e. mitigation actions)?
- How are the GHG fluxes/C sequestration distributed over space and time?

Timeline and Milestones

Summer 2009-summer 2010	Development of assessment methodology
July - September, 2010	Methodology and project plan open for public comments
October, 2010	Begin the national assessment – will take 3-4 years to complete

Public Review Draft: A Method for Assessing Carbon Stocks, Carbon Sequestration, and Greenhouse Gas Fluxes in Ecosystems of the United States Under Present Conditions and Future Scenarios. Z. Zhu (ed.), U.S. Geological Survey Open File Report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Development of a Methodology for National Assessment of Ecological Carbon Stocks, Carbon Sequestration, and Greenhouse Gas Fluxes

Edited by Zhiliang Zhu

Authors: Anne Rein, Benjamin Sleeter, Bradley Reed, Brian Bergamaschi, David Clow, Dennis Dye, Jinxun Liu, Matt Reeves, Matt Rollins, Richard Sernkoraf, Rob Striegl, Robert Gleason, Sarah Stackpoole, Shuguang Liu, Stephen Faulkner, Stephen Prisley, Stephen Stehman, Terry Sohl, Todd Hawbaker, William Forney, and Zhiliang Zhu

Open-File Report 2010-XXXX

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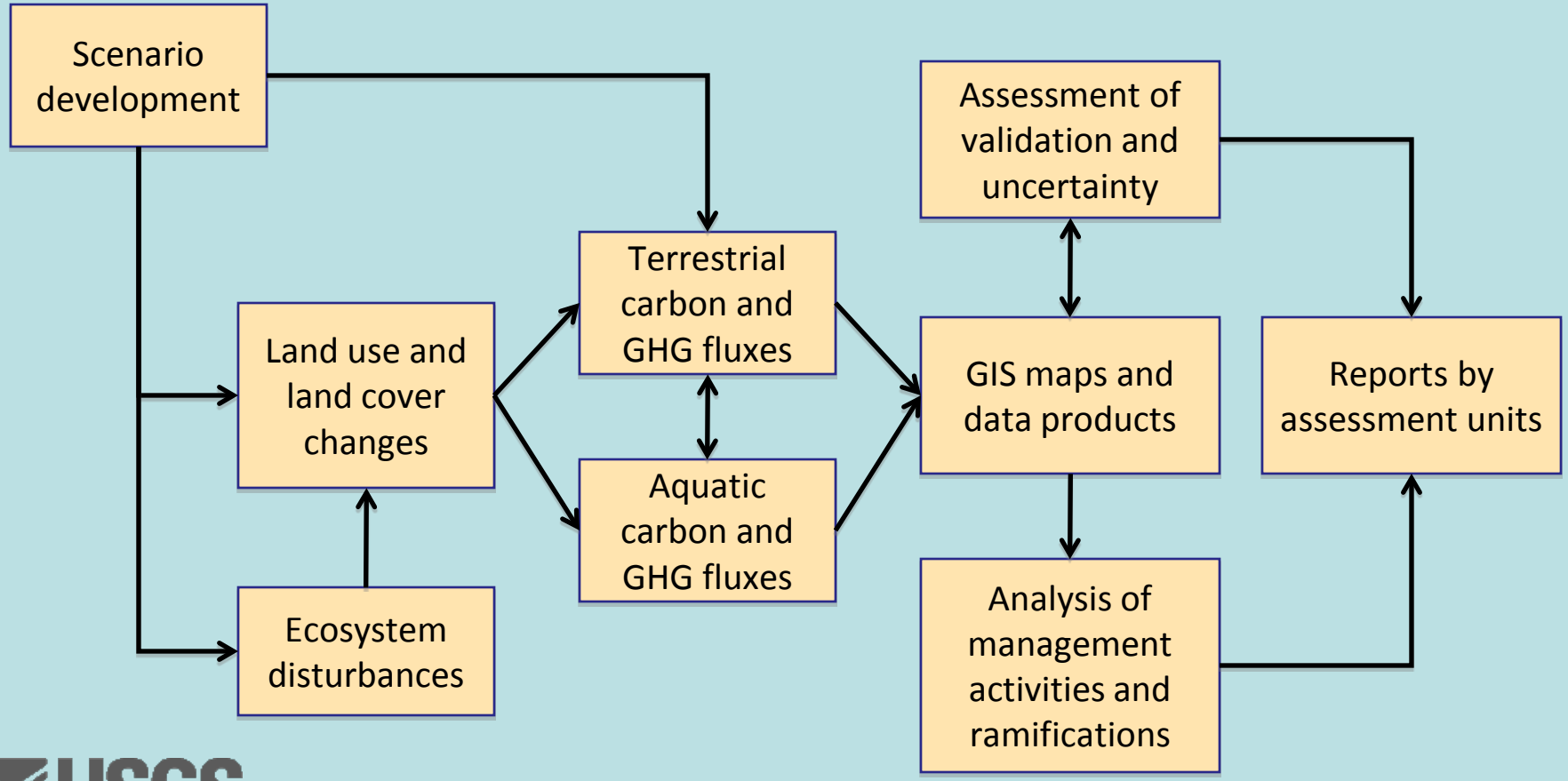
Methodology Design (Approach 3, Tier 3)



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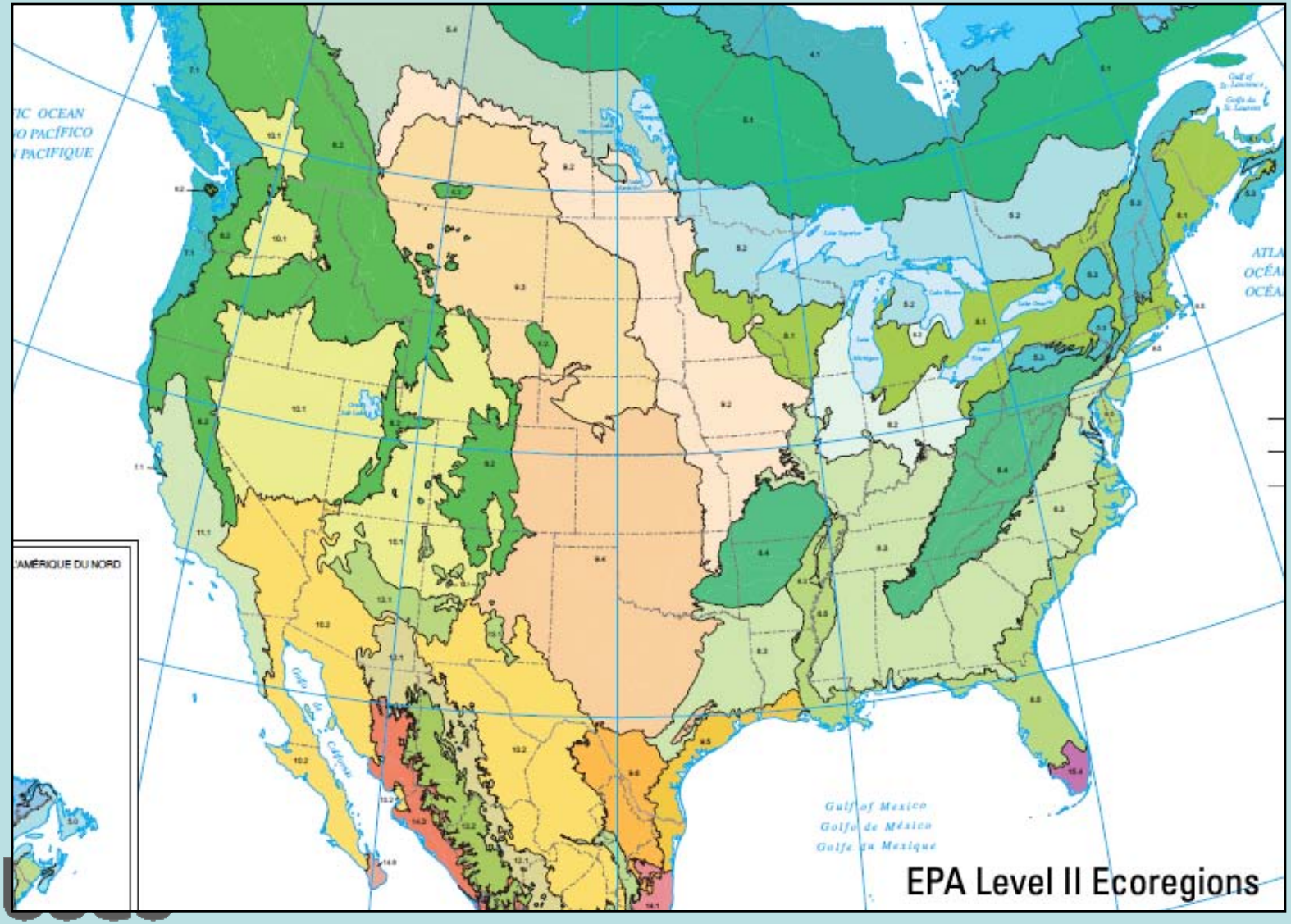
Assessment Units



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Mitigation Strategies (Examples)

- Scenarios of LULC changes and management activities to “directly and ecologically” enhance carbon sequestration and reduce GHG emissions
- Constructing scenarios for both public lands and private lands

Ecosystem	Strategy	Land management change	LULC change
Forests	Carbon sequestration	Change timber harvest-regeneration rotation	Forestation: convert lands to forest
	GHG mitigation	Fuel treatments	Avoid deforestation
	Offsite sequestration	Extend wood product life	
Crop land	Soil carbon sequestration	Increase winter cover crops	Convert to grassland and perennial crop
	CH_4 and N_2O mitigation	Reduce crop tillage	
Grassland Rangeland	Soil carbon sequestration	Reduce grazing pressure and stocking rates	Allow natural succession towards native
	GHG mitigation		Reduce conversion to energy crops
Wetland	Carbon sequestration		Restore wetlands & improve design
	GHG mitigation	Preserve wetlands from agricultural conversions	Avoid drainage and conversion

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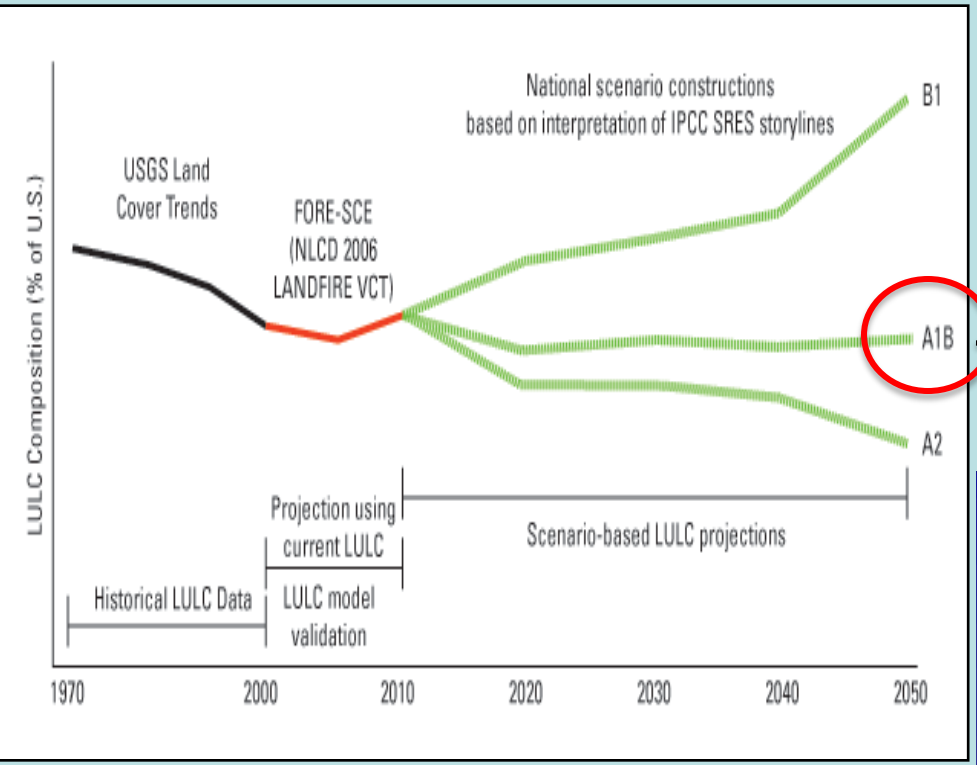
Assessing climate change and mitigation scenarios



IPCC SRES A1B		Management: Carbon Sequestration → Conventional	Management: Carbon Sequestration → Enhanced
LULC: Carbon Sequestration ↓	Reference	**(R)** Reference SRES storyline, with LULC and management consistent with basic SRES assumptions	**(M)** Reference LULC remains constant, but land management is optimized for carbon sequestration
	Enhanced	**(L)** LULC optimized for carbon sequestration, with conventional land management	**(ML)** LULC and land management both optimized for carbon sequestration
	Potential Natural Vegetation	**(PNV)** LULC returns to potential natural vegetation form and structure. Assumption of no anthropogenic alteration of landscape.	

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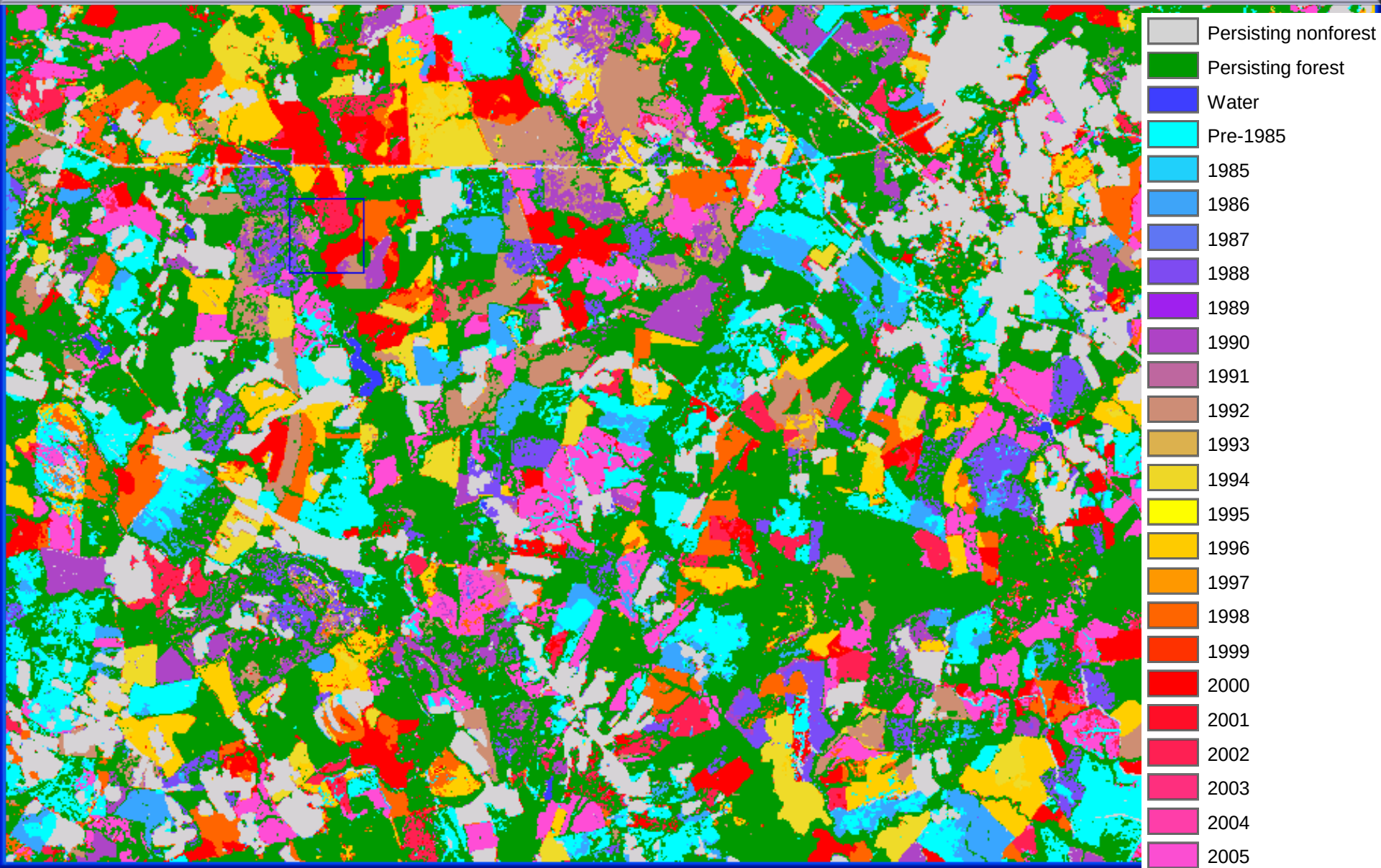
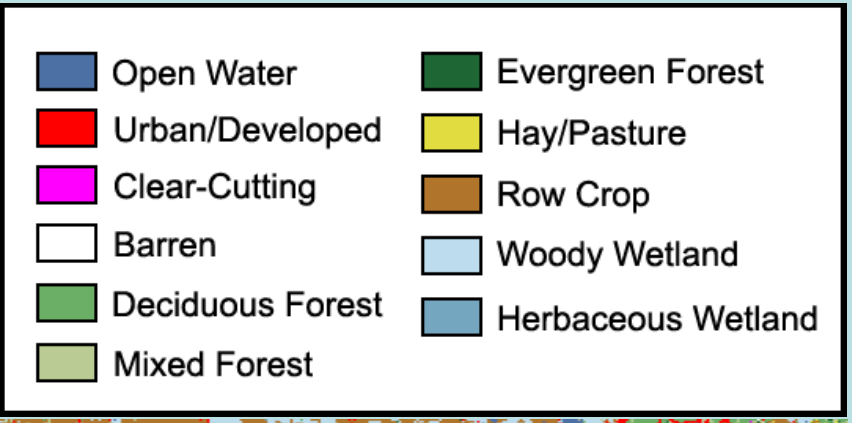
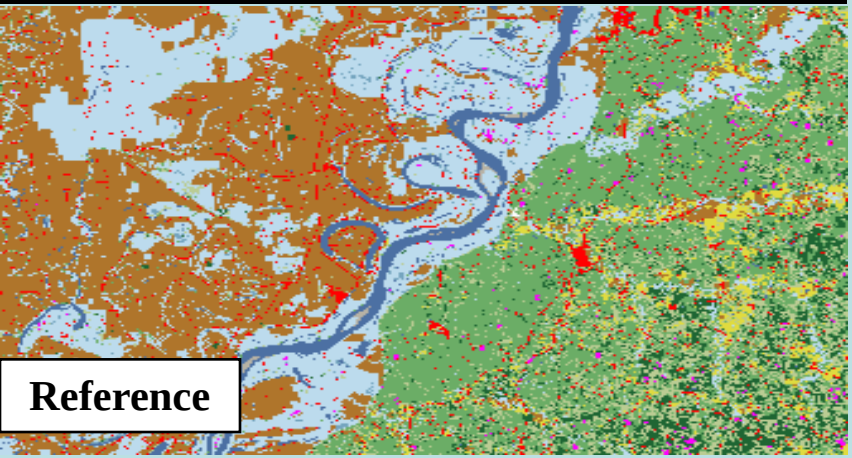
Major controlling processes: LULCC, land management change, ecosystem disturbances

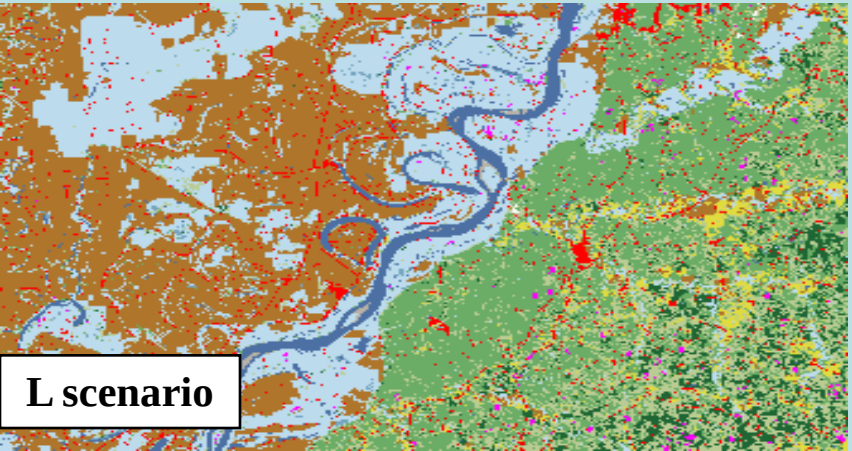


A1B Prototype



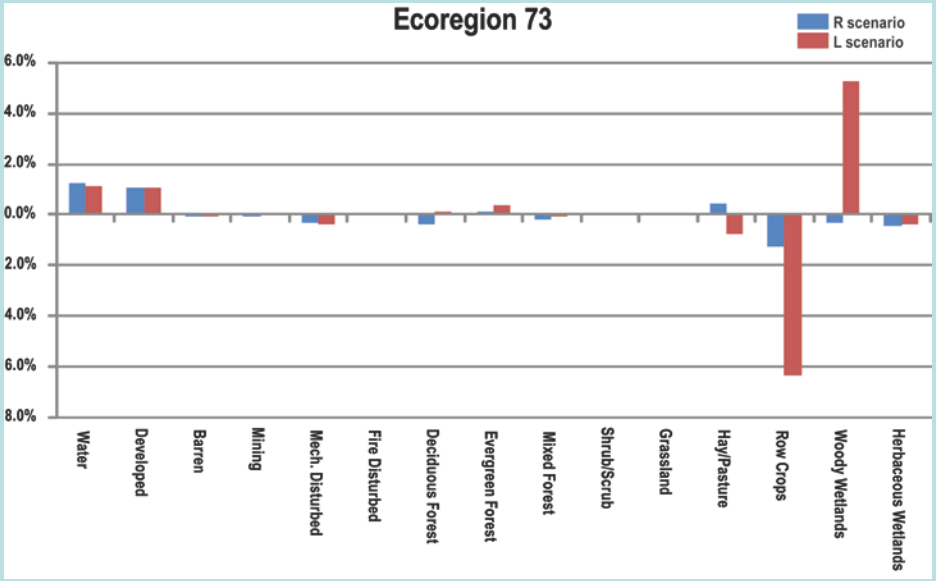


Reference

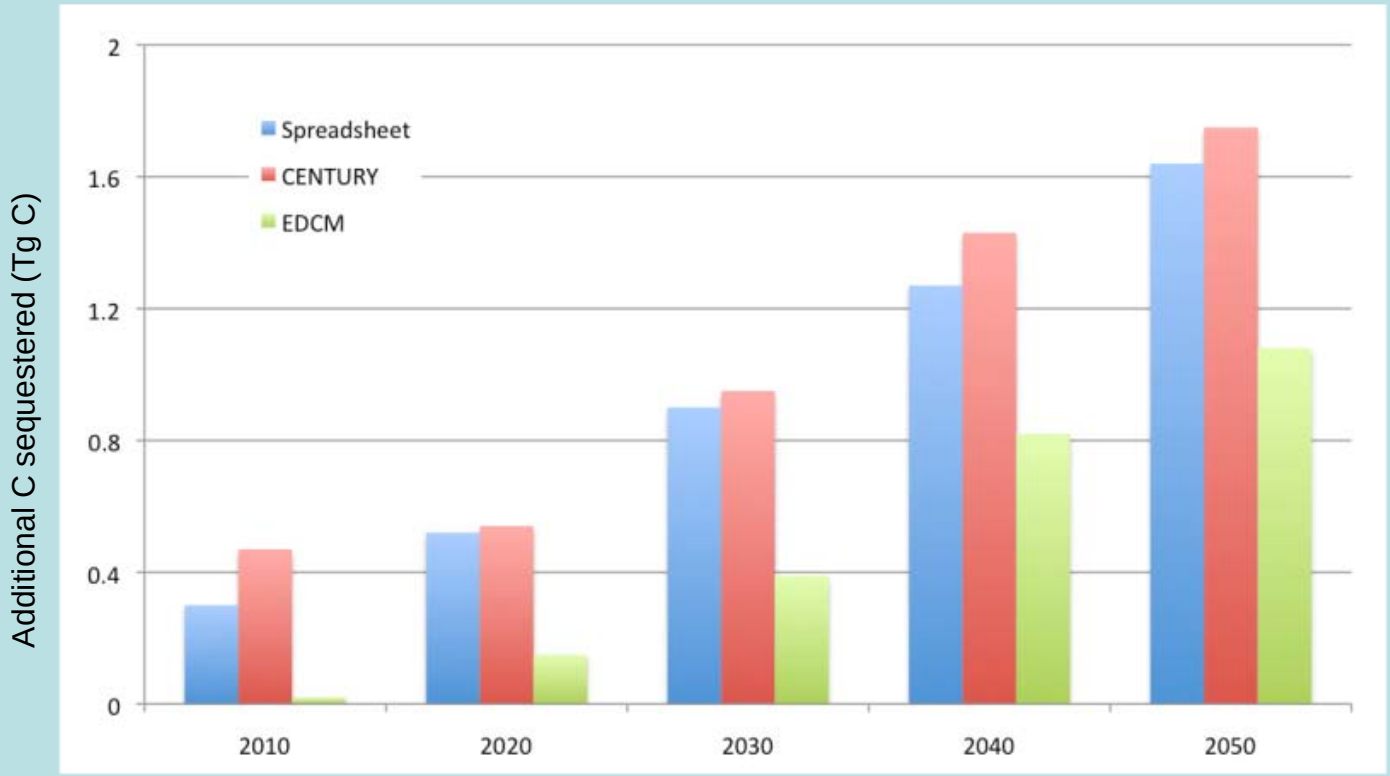


L scenario

- **Model Run 2001 to 2050**
- **Reference Scenario - IPCC A1B**
- **Mitigation scenario includes:**
  - **Forested Wetland restoration in Mississippi Alluvial Plain**
  - **Increased afforestation in Mississippi Loess Plain**
  - **Eliminate deforestation (other than forest harvest and replant**
  - **Eliminate wetland loss**
  - **Increase conservation tillage**
  - **Altered crop rotations**
  - **Increase forest cutting cycle period**



Effectiveness of mitigation scenarios for C sequestration



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Cost Benefit Analysis of Ecosystem Services

- Results from a Prototype County (Tensas County, LA):
  - Timber harvest versus carbon sequestration and nutrient retention
- Primary assumptions: benefit transfer / economic values, discount rate (4%), implementation rate, costs of implementation, particular mitigation activities conducted, and ecosystem services valued.

Outputs	Costs	Benefits	Net Present Value
Market Timber	-$18.5M	~$300K	-$18.2M
C sequestration			+$61.1M
Nitrogen mitigation			+$387.9M

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Products and Deliverables

- Analysis and reports by assessment units
- Maps, geospatial data, tabular data, etc.
- Parameters of current (2001 to 2010) and future potential (2011-2050) carbon stocks and annual GHG fluxes by ecosystems, pools, climate projections, reference and mitigation scenarios
- Effects of mitigation scenarios, effects on other ecosystem services
- Effects of various controlling processes such as wildland fires, land use and land cover changes, conservation status, etc.

An example table reporting assessment results

Carbon and GHG measures	Ecosystems				
	Forest	Cropland	Shrub/grassland	Wetland	Aquatic
Carbon stocks					
NECB					
C flux					
N_2O flux					
CH_4 flux					
Lateral C flux (DOC, DIC, POC)					
GWP					

Results summarized by scenarios and time dimension

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Products

General category	Product name	Data type	Temporal	Spatial
Carbon stock, flux, and sequestration rate by ecosystems and scenarios	Net primary productivity (NPP)	Map series and statistics	Annual for 2001-2050	≥ 250 m
	Net ecosystem productivity (NEP)	Map series and statistics	Annual for 2001-2050	≥ 250 m
	Net biome productivity (NBP)	Map series and statistics	Annual for 2001-2050	≥ 250 m
	Net ecosystem carbon balance (NECB)	Map series and statistics	Annual for 2001-2050	≥ 250 m
	Soil carbon stock	Map series and statistics	Annual for 2001-2050	≥ 250 m
	Fire induced carbon emission	Map series and statistics	Annual for 2001-2050	≥ 250 m
	Tree biomass removal	Map series and statistics	Annual for 2001-2050	≥ 250 m
	Grain yields	Map series and statistics	Annual for 2001-2050	≥ 250 m
	Carbon stock/flux trends	Statistics	Annual for 2001-2050	Assessment unit
	C accumulation in lake/reservoir sediments	Statistics	Annual for 2001-2050	Assessment unit
	C accumulation in coastal oceans	Statistics	Annual for 2001-2050	Assessment unit
GHG flux by ecosystems and scenarios	CH_4 efflux	Map series and statistics	Annual for 2001-2050	≥ 250 m
	N_2O efflux	Map series and statistics	Annual for 2001-2050	≥ 250 m
	Methane flux from lakes, reservoirs	Statistics	Annual for 2001-2050	Assessment unit
	Delivery of organic carbon by rivers to coastal areas	Statistics	Monthly & annual	Assessment unit
	Delivery of inorganic carbon by rivers to coastal areas	Statistics	Monthly & annual	Assessment unit
	CH_4 and N_2O flux from estuaries and coastal waters	Statistics	Monthly & annual	Assessment unit
Data and information products informing mitigation strategies, by ecosystems and scenarios	Land suitability for REDD by NPP, fire disturbance categories, and scenario storylines	Map series and statistics	Annualized average	≥ 250 m, and by assessment unit
	Future soil erosion and surface runoff potential by major ecosystem types and management scenarios	Map series and statistics	Annualized average	≥ 250 m, and by assessment unit
	Greenhouse gas reduction (N_2O, CH_4) by ecosystem types and management scenarios	Map series and statistics	Annualized average	≥ 250 m, and by assessment unit
	Effects of management activities on sequestration summarized in spreadsheet	Tabular data	Annualized average	Assessment unit
	Ancillary effects of management options on ecosystem services.	Tabular data	Annualized average	Assessment unit
Intermediate data products, by scenarios	Updated and modified NLCD land use and land cover data	Map series	Annual for 2001-2010	≥ 250 m
	Projected modified NLCD land use and land cover data	Map series	Annual for 2011-2050	≥ 250 m
	Wildland fire perimeters and severity	Map series	Annual for 2001-2010	≥ 250 m
	Wildland fire perimeters and severity	Map series	Annual for 2011-2050	≥ 250 m
	Sediment and nutrient flux to estuaries and coastal waters	Statistics	Monthly & annual	Assessment unit

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To participate in the USGS assessment …

- Review and comment on the USGS methodology for national ecosystem GHG flux assessment, at:

  www.usgs.gov/global_change/carbon

- Participate in scenario consultation workshops

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