Evaluating the Nation’s Ecosystems for Carbon Stocks and Sequestration Capacities under Present Conditions and Future Scenarios

A story about efforts to holistically quantify opportunities for C sequestration and GHG mitigation

Zhiliang Zhu
Anne Wein
Brian Bergamaschi
Many others
OUTLINE

• Origination of project
• Unique features
• Major questions
• Why it might actually be possible
• Overall approach
• Highlights of methods
The section 712 of the 2007 Energy Independence and Security Act mandated the U.S. Department of the Interior to develop a methodology and conduct an assessment of carbon storage, carbon sequestration, and fluxes of three principal greenhouse gases (GHG) for the Nation’s ecosystems.

- Three principal GHG: carbon dioxide (CO₂), nitrous oxide (N₂O), and methane (CH₄)
- All ecosystems: both terrestrial (forests, shrub and grasslands, croplands, wetlands) and aquatic systems (rivers, lakes, coastal waters)
- Develop a methodology, incorporating components of “quantifying, measuring, and monitoring” GHG in and out of ecosystems
- Conduct a national assessment: all 50 States
- Assess potential capacities of ecosystems for increased carbon sequestration and reduced GHG fluxes by evaluating land management and ecosystem restoration activities and other mitigation strategies
- Address effects of controlling processes such as land use and land cover change, land management change, ecosystem disturbances (wildland fire), and climate change
- Provide assessment results to inform a range of policies in support of land management activities to optimize carbon sequestration
- Observe other requirements such as consultation with other agencies (e.g. USDA, EPA, NOAA, DOE), and the use of native species in mitigation strategies
What is unique about this assessment?

- Spatially explicit
- Forecasts future conditions of land use, climate, population, etc.
- Includes effects of disturbance – fire, insects, etc.
- Includes aquatic system
- Evaluates magnitude of potential mitigation actions
Major questions to be addressed ...

- What may be the current and future trend of ecosystem carbon sequestration capacity and GHG flux, considering their controlling processes?
- Will the future trend be different if we manage ecosystems differently (i.e. evaluating mitigation actions)?
- How are the GHG fluxes/C sequestration distributed over space and time?
- What may be individual effects and effectiveness of various controlling processes such as climate change, land use change, wildland fire, or land management activities?
Collaboration/Partnership

NASA C and GHG monitoring, EPA land change and C study, NOAA coastal water sequestration, NEON GHG monitoring

USDA CCPO mitigation studies, NRCS soil C mapping, NRI land management data, NASS crop production and areas, ERS and ARS

EISA: all ecosystems, 50 states, vertical and lateral fluxes, adaptation & mitigation strategies, baseline and capacities, other GHG. CC, land change as major drivers, and C monitoring

FS FIA inventory-based C baseline estimates, forest & rangelands, CONUS. FS RPA future C projections based on CC and LU change, forest monitoring, fire and Cohesive Strategy C emissions

USGS Landsat, remote sensing, land change R&D, and land/water monitoring programs
1980 - 2009 Climate Trends

Precipitation

Value

Minimum Temperature

Value

A. Flint and L. Flint

Figure 2. Existing forest biomass carbon, based on the USFS forest biomass map by Blackard and others (2008).
Observed Land Change

Each color represents a change event between 1985 and 2008.
Figure 7. Comparison of spatial distribution of simulated SOC stocks within the top 0–20 cm of soil layer across Iowa.
Land Cover Change 1998 - 2007

----- Data from USDA NASS
**Schematic of LandCarbon Process**

**IPCC Scenarios** – Population, Economic activity, etc.

**Economic and environmental policy** – management, incentives, economic activity, etc.

**Climate downscaling** – Temperature, precipitation, streamflow, etc.

**Terrestrial DETERMINISTIC BIOGOCHEMICAL MODELS**

GPP, NPP, Soil C, CH4, N2O

**REGRESSION MODEL** for Lateral Flux DIC, PIC, DOC, coastal oceans

(SPARROW)

**Land use land cover** – Forecasts land use based on population, climate, history, etc.

**Terrestrial BGC Modeling**

Historical and Future Changes

**Regional and Coastal Waters**

Mean annual surface and groundwater nutrient flow estimates via USGS models

GHG emissions

**MODELING BUILD BLOCKS**

Regional and coastal sediment burial of C and export to deep ocean

**REGRESSION MODELS**

1. Production of GHGs in estuarine and coastal waters
2. Coastal sediment burial of C and export to deep ocean

**REGRESSION MODELS**

Production of GHGs by inland impoundments

**Semi-Deterministic Model**

1. Production of GHGs in estuarine and coastal waters
2. Coastal sediment burial of C and export to deep ocean

**USGS**

Science for a changing world

By Zhiliang Zhu (editor), Brian Bergamaschi, Richard Bernknopf, David Clow, Dennis Dye, Stephen Faulkner, William Forney, Robert Gleason, Todd Hawbaker, Jinxun Liu, Shuguang Liu, Stephen Prisley, Bradley Reed, Matthew Reeves, Matthew Rollins, Benjamin Sleeter, Terry Sohl, Sarah Stackpoole, Stephen Stehman, Robert Striegl, Anne Wein, and Zhiliang Zhu

Conifer Age: 1992 to 2050

- Southern Coastal Plain (75) – Flat to declining median age
- Southeastern Plains (65) – Slowly rising then flat median age
- Eco. 74 shows slow increase in median age, with significant drop after these converted areas start to become old enough for harvesting
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
Biogeochemical models

Assess different land management activities (Ft. Benning vs. surrounding area)

Calibrate model results with in-situ observations (Prairie Pothole Region)
SPARROW: TOC Incremental Yield

USGS TOC stations

Baseline results using SPARROW

Smith, Alexander, et al.
Carbon sequestration potential for counties and rural municipalities in the PPR based on wetland restoration.

What will be useful to you?

- Spatial data
  - Inputs
  - Scenarios
- Land use and land cover forecasts
- National streamflow forecasts
- Integrated sea level rise and coastal vulnerability data
- Wetland potential
THANKS!