North America Terrestrial Carbon Budget: A Model Analysis of the Combined Effects of CO2, Nitrogen, Climate, Land Use Changes and Management

Atul K. Jain and Xiaojuan Yang

University of Illinois, Urbana, IL 61801

(Email: jain1@uiuc.edu)

1. Introduction

- **This study presents the concurrent effects of all important ecosystem processes and anthropogenic disturbances and management practices on North America net carbon budget for the 1990s.**
- **Patterns of changes in plant and soil carbon stocks examined using the terrestrial carbon cycle component of the Integrated Science Assessment Model (ISAM).**
- **Since carbon sequestrations in terrestrial ecosystems and soils are accompanied by changes in CO2 concentration, climate, land use, nitrogen deposition and soils management practices, and the interaction between them, which could augment or lessen carbon sequestration, we take a holistic approach to study carbon sequestration by incorporating major environmental changes.**

2. Methods

- **We use the terrestrial component of the Integrated Science Assessment Model (ISAM-2), which simulates carbon and nitrogen fluxes within the terrestrial biosphere at a 0.5º x 0.5º spatial resolution [*Jain and Yang*, 2005] (Figure 1).**
- **The modeled carbon cycle includes feedback processes such as CO2 fertilization, climate effects on photosynthesis and respiration and increased carbon fixation by nitrogen deposition.**
- **Changes in land cover classifications are driven by clearing forest for cropland, reforestation and abandonment (*Jain and Yang*, 2005; *Yang et al*., 2005).**
- **Mineral nitrogen deposition rates are based on chemical transport model (Galloway et al., 2004).**
- **Changes in temperature and precipitation, and CO2 are based on observation data**
- **To estimate carbon sequestration in soils, following a change in cropland management from CT to NT, we use empirically-based sequestration estimates, or CMR curves, which are based on the mean annual change in soil carbon over the expected duration of active sequestration (*Jain et al*., 2005).**

Coupled Terrestrial Carbon-Nitrogen Cycle Component of the Integrated Science Assessment Model (ISAM)

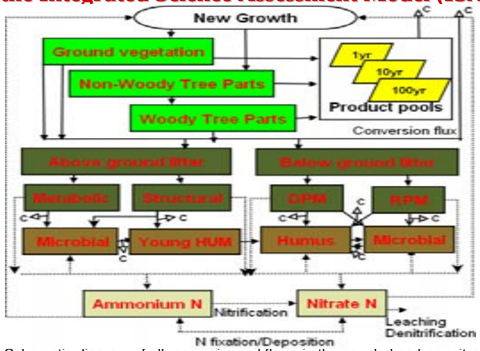

Figure 1: Schematic diagram of all reservoirs and flows in the coupled carbon- nitrogen component of the Integrated Science Assessment Model (ISAM). Most flows between reservoirs (except for the Ammonia and Nitrate) involve transfer of both C and N. Transfers between reservoirs are accompanied by respiratory loss of C. The conversion carbon fluxes are associated with the land cover changes representing slash carbon left on ground that is consecutively transferred to litter pools, and carbon released from burning of plant material. The part of the biomass harvested is transferred to three product pools with different turnover times. The modeled carbon cycle includes feedback processes such as CO2 fertilization, climate effects on photosynthesis and respiration and increased carbon fixation by nitrogen deposition; whereas the model nitrogen cycle includes all the major processes associated with nitrogen, including immobilization, mineralization, nitrification, denitrification, leaching. The carbon and nitrogen dynamics of all model pools are based on *Jain and Yang* (2005) and Yang et al. (2005).

3. Results

ISAM Estimated Biosphere Fluxes for the 1990s ($gCm^{-2}yr^{-1}$)

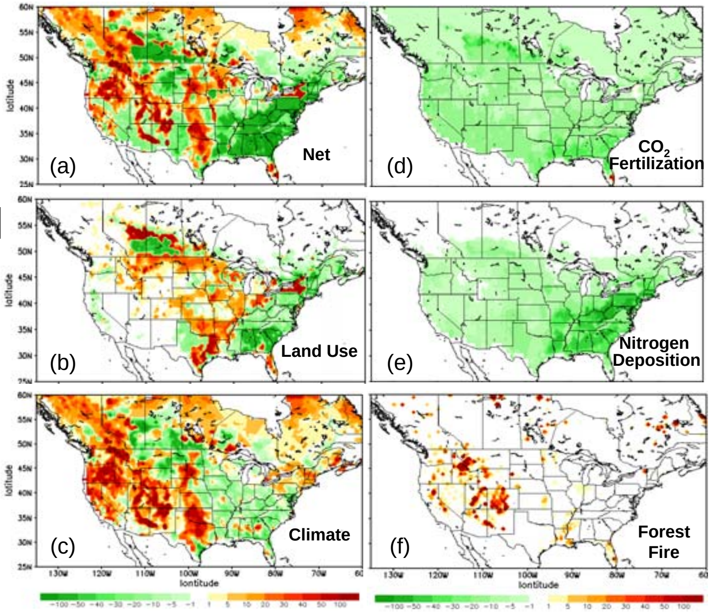

Figure 2: The ISAM estimated distribution of (a) net carbon exchange ($gC\ m^{-2}\ yr^{-1}$) during the 1990s attributed to (b) cropland expansion and abandonment, (c) climate change, (d) increase in CO2 concentrations, (e) nitrogen deposition, (f) forest fire, and carbon management due to no-tillage (Figure 3). Positive values represent net carbon release to the atmosphere and negative values represent net carbon storage in terrestrial biosphere.

Estimated Soil Carbon Sequestration Potential, CT to NT *Averaged Over the Period 1981-2000 (MgC/ha/yr)*

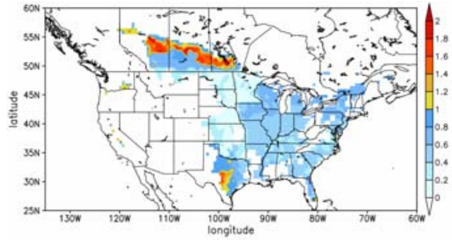

Figure 3: Soil carbon sequestration potential estimated by ISAM, with changes in climate CO2, and nitrogen following a change from conventional tillage to no-till and averaged over the period 1981-2000. Units of sequestration (MgC/ha/yr) are for cropland areas within grid cells that adopted NT during this time period.

Latitudinal distribution of Net Terrestrial C Flux, 1990s (TgC/deg/yr)

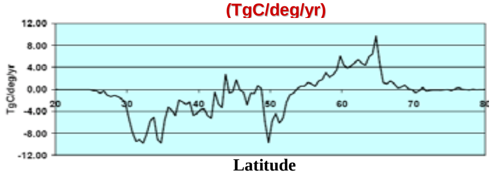

Figure 4: The ISAM estimated latitudinal distributions of net terrestrial C flux (TgC/deg/yr) during the 1990s, which is sum of land use, climate, CO2 fertilization, nitrogen deposition, forest fire, and carbon management fluxes. Positive values represent net carbon release to the atmosphere and negative values represent net carbon storage in terrestrial biosphere.

Various Components of Terrestrial C Fluxes (TgC/deg/yr)

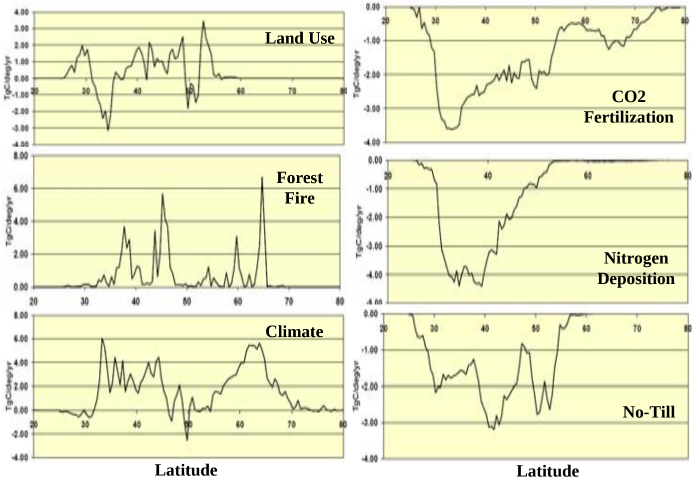

Figure 5: The ISAM estimated latitudinal distributions of various components of net terrestrial C flux (TgC/deg/yr (Figure 4) during the 1990s. Positive values represent net carbon release to the atmosphere and negative values represent net carbon storage in terrestrial.

ISAM Estimated North America Carbon Budget *(Tg C/Year)**

	1980s	1990s
Land Use	31.0	-6.8
Climate	57.6	64.7
Fires (w/o land use)	70.4	70.4
CO2 Fertilization	-109.0	-116
Nitrogen Deposition	-74.9	-76.8
Management (No-Till)	-9.1	-30.9
NET	-34.0	-95.4

****Positive values represent net carbon release to the atmosphere and negative values represent net carbon storage in terrestrial.***

4. References

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5. Acknowledgements

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