ASSESSING THE EFFECTIVENESS OF SOIL CARBON SEQUESTRATION IN NORTH AMERICA AND ITS IMPACT ON NET TERRESTRIAL UPTAKE OF CO_2

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ABSTRACT
Soil carbon sequestration has been shown to be an important part of a portfolio of carbon sequestration strategies in the U.S. and Canada, and one that can be implemented at relatively low costs [*McCarl and Schneider,* 2001]. The purpose of this analysis is to estimate the soil carbon sequestration potential in the North America (Canada and United States) and its impact on net terrestrial CO_2 uptake over the period 1981-2000.

INTRODUCTION
Improved agriculture practices have the potential to accumulate carbon in the cropland soils, thereby reducing CO_2 in the atmosphere. The carbon sink associated with land management is estimated to have a global potential to sequester over 0.4 Pg C y^{-1}. Our analysis focuses on carbon sequestered in soil as a result of a change from conventional plow tillage (CT) to no-till (NT) in North America and the resulting uptake of CO_2 from 1981-2000 using a terrestrial ecosystem model and Carbon Management Response (CMR) curves.

METHODS
We use the terrestrial component of the Integrated Science Assessment Model (ISAM-2), which simulates carbon fluxes within the terrestrial biosphere at a 0.5^o x 0.5^o spatial resolution [*Jain and Yang*, 2005]. The structure, parameterization, and performance of ISAM-2 have been previously discussed [*Jain and Yang*, 2005]. 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 [*West et al.*, 2004; *West and Six*, 2005]. These empirical relationships have been developed for changes from CT to NT over five climate regions: Cold Temperate Dry (CTD), Cold Temperate Moist (CTM), Warm Temperate Dry (WTD), Warm Temperate Moist (WTM), and the tropics (TROP). These climate regions are consistent with those used in the IPCC guidelines for carbon accounting [*IPCC*, 2003; *Eve et al.* 2001]. To calculate sequestration rates in North America, we use the measured area under NT over the period 1981-2000 [*CTIC*, 2000; *Statistics Canada*, 2001].

RESULTS AND CONCLUSIONS
Sequestration rates simulated by ISAM-2 for North America averaged over the period 1981-2000 are 0.58 Mg C ha^{-1} yr^{-1} (0.3 – 0.7)(Table 1). Estimates of the percentage change in soil carbon by the ISAM-2 are relatively low in CTD region and greater in TROP region (not shown here). However, the estimated sequestration potential in the CTD region is relatively high (Table 1) due in part to the higher initial soil C content. Our model results indicate that NT practices between 1981-2000 in North America soils have sequestered about 868 Tg C (or 43.4 TgC/yr) (Table 1). Carbon sequestration in US soil was 575 TgC, which was about twice the amount of sequestration occurred in the Canadian soil (298 TgC). However, sequestration rates in the Canadian soil (20 TgC/yr) were twice the amount of the rates in the US (10 TgC/yr).

It is estimated here that changes in climate and CO_2 between 1981-2000 were responsible 69Tg (8%) of soil carbon sequestered in the U.S. and Canada as a result of conversion to no-tillage.

Table 1. Total cropland area, cropland in NT, and sequestration rates for NT. The cropland and no-tillage (NT area is given for the year 2000, while the sequestration rates are averaged for the period 1981-2000. The sequestration rates are calculated with changes in climate, land use and atmospheric CO_2.

Climate Regions*	Cropland Area (Mha)	NT Area (Mha)	Sequestration Rates	
			(MgC ha^{-1} yr^{-1})	(TgC yr^{-1})
CTD	79.80	21.34	0.694	14.80
CTM	68.11	18.21	0.569	10.36
WTD	31.09	8.31	0.595	4.94
WTM	79.67	21.31	0.445	9.48
TROP	19.31	5.16	0.741	3.82
Total	**279.88**	**74.34**	**0.584**	**43.41**

**CTD: Cold Temperate Dry; CTM: Cold Temperate Moist; WTD: Warm Temperate Dry; WTM: Warm Temperate Moist; TROP: Cold and Warm Tropics.*

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