Estimating Regional Changes in Soil Carbon with High Spatial Resolution:
Integrating Field Measurements, Inventory Data, and Remote Sensing Products

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Methods and Data Integration

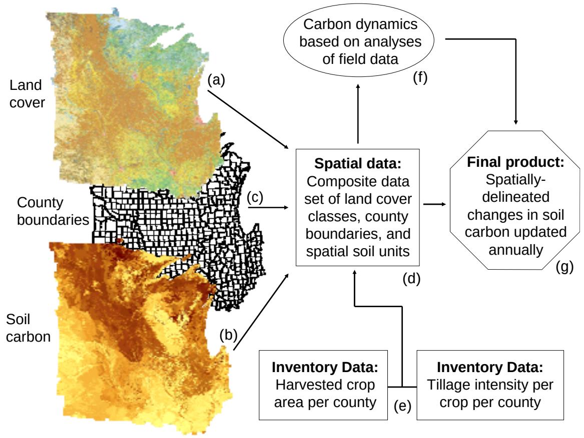

Figure 1. Inventory data and remote sensing products are integrated to form a new data product that approximates the spatial extent of soils, land management, and land production inputs. Changes in soil carbon are estimated using empirical relationships derived from the analysis of field data and applied to annual changes in the unique combinations of soil, crop, and land management at a 900m² resolution (commensurate with Landsat-derived remote sensing products). Land-use classes (a), soil map unit values (b), and county identification values (c) are integrated into one composite layer (d) that summarizes unique combinations of the three aforementioned values. Annual adoption rates of different tillage intensities are applied to the area of respective crop types (e). This new data set is combined with carbon dynamics derived from field experiments (f) using initial soil carbon values (b) to estimate changes in soil carbon that are then distributed over areas of respective cropland classes (a). A final spatial data set of estimated carbon flux is generated (g; see Figure 2).

Overall project summary and future work

- We have completed the soil component of our overall carbon accounting framework (presented here).
- We are near completion on other components, including CO_2 emissions from production inputs, analyses of yield changes associated with carbon management strategies, and development of socio-economic drivers representing real and potential risk associated with the adoption of carbon management strategies.
- Future work includes integration of all components with the POLYSYS agricultural economic model, and the enhanced use of remote sensing products in all components of our carbon accounting framework.

Cumulative change in soil carbon from 1991-2000 caused by changes in crop rotations and tillage intensity

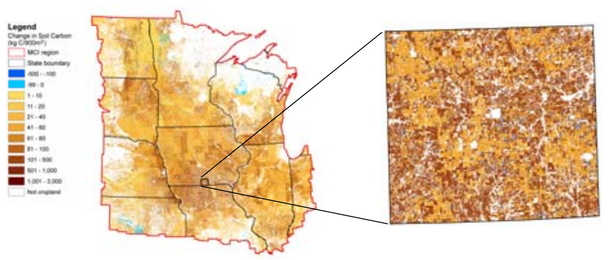

Figure 2. The net cumulative change in soil carbon from 1991-2000 is calculated based on changes in tillage intensity, crop rotations, and soil type. The magnified area is Wayne County, Iowa, representing a diverse set of cropping practices, tillage intensities, and soil types, and illustrating a range of soil carbon gain and loss at a 900m² resolution within a 10-year period.

Abstract

To improve estimates of regional carbon dynamics, it is important to better represent landscape heterogeneity and local land management. We are currently developing a carbon accounting framework that can estimate carbon dynamics and net greenhouse gas emissions associated with changes in land management at a high spatial resolution. One component of this framework integrates field measurements, inventory data, and remote sensing products to monitor changes in soil carbon at a sub-county level (900m² resolution) caused by inter-annual changes in tillage and crop management. We applied this framework component to a mid-western region of the US that consists of 679 counties approximately centered around Iowa. We estimate the 1990 baseline soil carbon for this region to be 4,099 Tg to a 3m maximum depth. Soil carbon accumulation of 57.3 Tg is estimated to have occurred in this region between 1991-2000. Without accounting for soil carbon loss associated with changes to more intense tillage practices, our estimate increases to 66.3 Tg. This indicates that on-site permanence of soil carbon is approximately 86% with no additional economic incentives provided for soil carbon sequestration practices. This carbon accounting framework offers a method to integrate new inventory and remote sensing data on an annual basis, account for alternating annual trends in land management without the need for model equilibration, and provide a transparent means to monitor changes in soil carbon. Our method of integration is capable of estimating regional or national changes in soil carbon while still representing heterogeneity at the sub-county level. Future research will include predictive changes in soil carbon based on socio-economic drivers, and a sensitivity analysis using high-resolution remote sensing products.

Annual change in soil carbon from 1991-2000, by crop

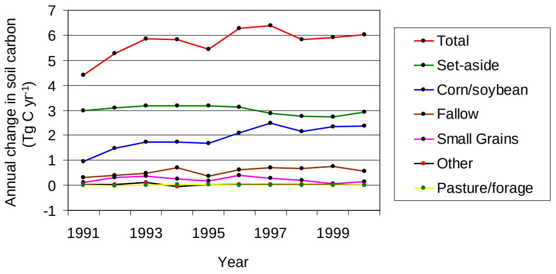

Figure 3. Net annual changes in soil carbon, aggregated here by crop type, include gains and losses in soil carbon caused by annual changes in crop and tillage practices. The category "other" includes sorghum, cotton, sugarcane, sugarbeets, tobacco, peanuts, sunflower, beans, lentils, and potatoes.

Sub-county estimates maintain integrity of county-level inventory data

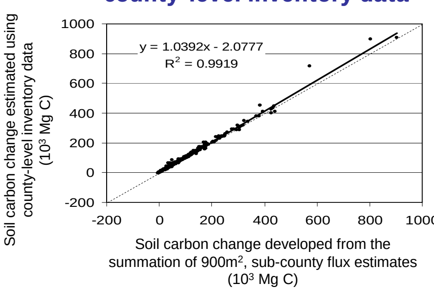

Figure 4. A comparison of soil carbon change using county-resolution inventory data produces similar results that are not significantly different (P=0.10) from our sub-county estimates that incorporate spatially-explicit land-use data and delineation of sub-county soil series. These results indicate that we are maintaining the national cropping survey data, which we consider best represents actual field conditions.

Possibilities for collaboration

We are interested in collaborating with others to complete the following:

- Use different remote sensing products that spatially represent crops and land management
- Use different carbon accounting methods or biogeochemical modeling components
- Compare estimates of net carbon flux and other final products with other relevant estimates based on top-down or bottom-up carbon modeling and on socio-economic drivers of land-use change.