



Base Maps

Political Boundaries

Biophysical Data

Ecosystem Services Metrics - Production

- ▶ Clean Water for Recreation & Aquatic Habitat
- ▶ Water Supply
- ▶ Clean Air
- ▶ Climate Regulation
- ▶ Cultural and Aesthetic Value
- ▶ Natural Hazard Mitigation
- ▶ Habitat & Maintenance of Biodiversity
- ▶ Food, Fiber & Fuel

Ecosystem Services Metrics - Demand

Ecosystem Services Metrics - Stressors



# Providing New Soil Survey Products to the GIS Modeling Community- *Gridded SSURGO*

## National Atlas of Ecosystem Services Project

2010 National Cooperative Soil Survey (NCSS) Northeast Regional Meeting  
 June 8, 2010  
 Elizabethtown, PA

Anne Neale, Geographer Landscape Ecology Branch, USEPA, Research Triangle Park, NC  
 and

Sharon W. Waltman, Soil Scientist National Soil Survey Center-Geospatial Research Unit, USDA-NRCS, Morgantown, WV





- Base Maps
- Political Boundaries
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- Ecosystem Services Metrics - Production
  - Clean Water for Drinking
  - Clean Water for Recreation & Aquatic Habitat
  - Water Supply
  - Clean Air
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  - Cultural and Aesthetic Value
  - Natural Hazard Mitigation
  - Habitat & Maintenance of Biodiversity
  - Food, Fiber & Fuel
- Ecosystem Services Metrics - Demand
- Ecosystem Services Metrics - Stressors

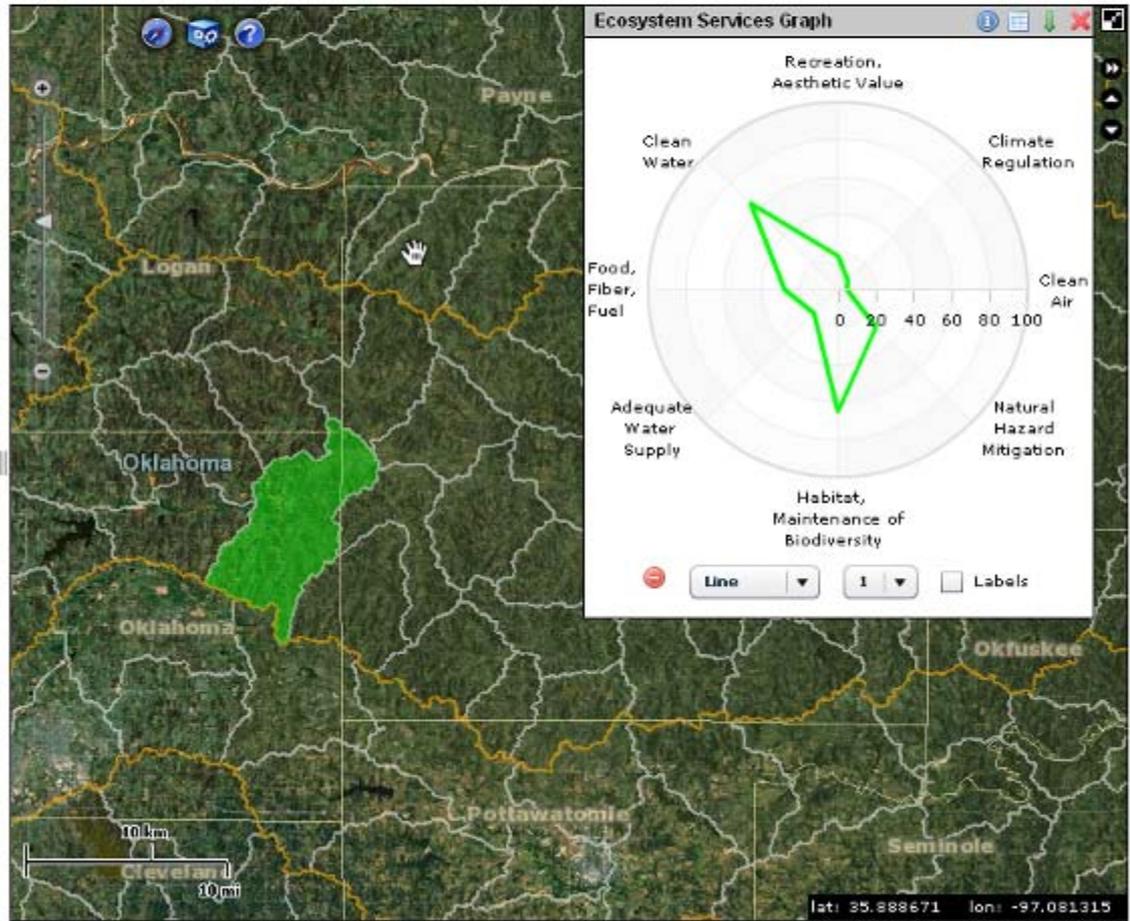


# National Atlas of Ecosystem Services

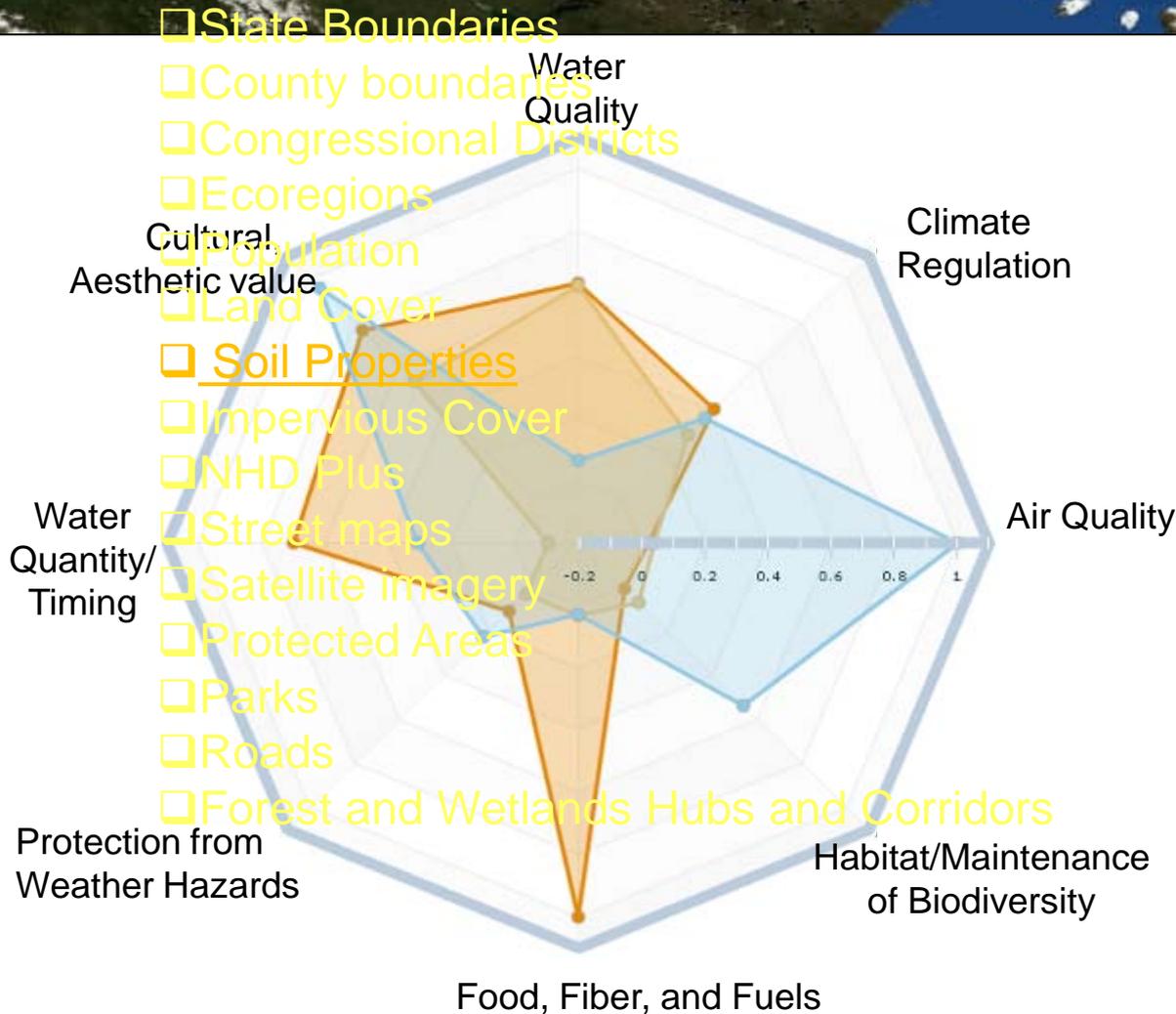
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# Atlas Vision/Implementation



- Contain series of clickable background maps

Select ecosystem services from Table of Contents

Allow “stacking” of multiple services

Multiple metrics for each category

Ancillary data

Include potential and future scenarios

- Allow user to place their “area” in context of others

## *Soil Contribution to Atlas – Gridded SSURGO*

Deep root zone soils (left) provide greater available water capacity (AWC) than shallow root zone soils (right) Hagerstown soils, Centre Co, PA.



*A key concept is using a nation-wide detailed soil survey geographic database (SSURGO) layer in a “value added” gridded format.*



# Soil Contribution to Atlas – Gridded SSURGO

Deep root zone soils (left) provide greater available water capacity (AWC) than shallow root zone soils (right) Hagerstown soils, Centre Co, PA.



## National vector SSURGO layer

- 35+ million polygons and 150+ GB in size
- requires SQL Server ArcSDE and powerful computing environments for access
- Can take several hours to draw on screen
- Requires a GIS projection step for analyses
- Makes National views/analyses of SSURGO out of reach for NCSS soil scientists and their customers



# Soil Contribution to Atlas – Gridded SSURGO

## Gridded SSURGO

- Is created by a simple GIS technique that “grids” the SSURGO polygon using the mukey (integer)
- Uses a map projection that can be used across Lower 48 states (Albers Equal Area, NAD83)
- Gridded SSURGO resolutions: 10, 30\*, 90 or 100 meters (100 meter creates a 1 hectare cell size)
- Is created from an annual or semi-annual Soil Data Mart (SDM) SSURGO snapshot (12/30/2009)
- R&D SSURGO grids prepared by NSSC (Lincoln and Morgantown) to aid in *Rapid Assessment of Carbon and Deepwater Oil Spill*
- Utilized by USGS EROS Data Center and EPA to prepare the Value added Gridded SSURGO layer with standardized layers

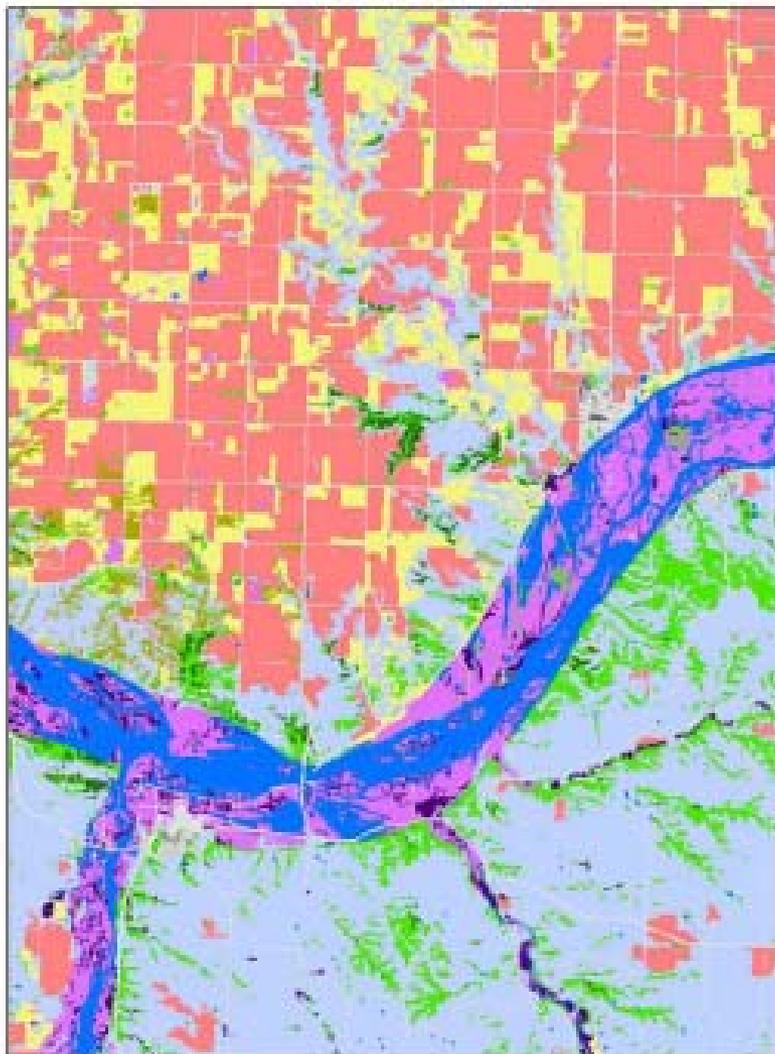
# Gridded SSURGO

Deep root zone soils (left) provide greater available water capacity (AWC) than shallow root zone soils (right) Hagerstown soils, Centre Co, PA.

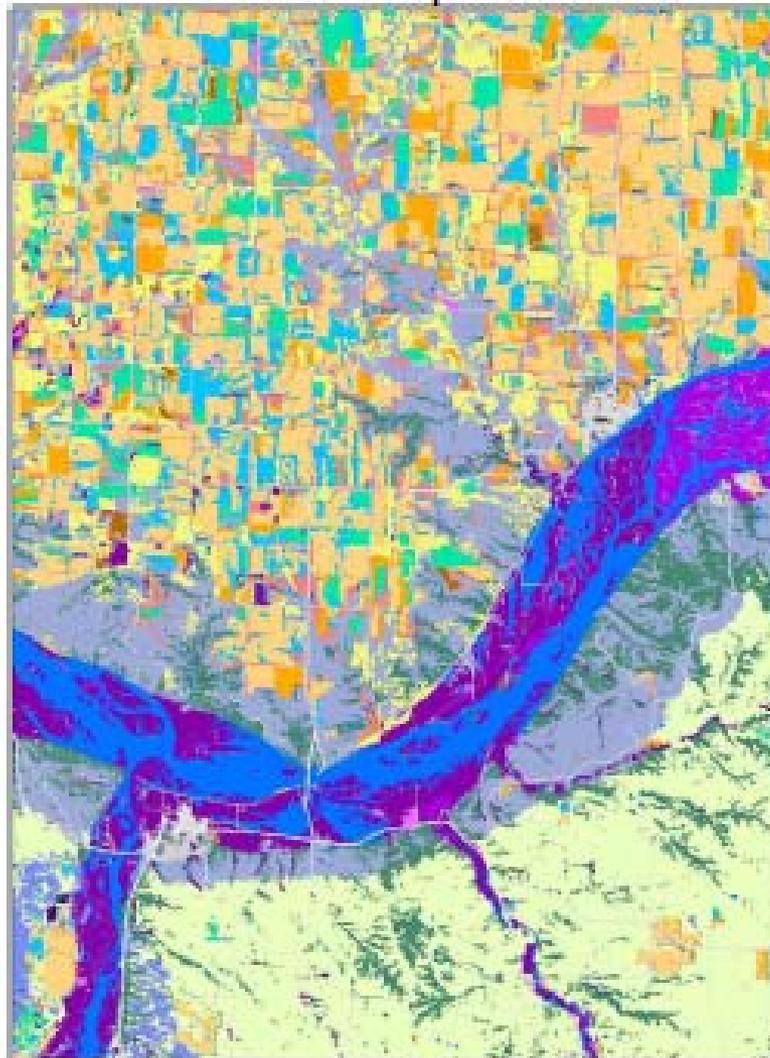
*Is preferred by the GIS Modeling Community because:*

- It draws rapidly for easy visualization and nation-wide GIS analyses
- It can be combined with other national gridded data layers (National Land Cover Database or NLDC; NASS Crop Data Layer or CDL; National Elevation Database or NEDS DEM, other remotely sensed data, etc.)
- It can be used for Geospatial Decision Support Systems (provides geography to otherwise attribute-only fuzzy interps – set rules for proximity to water bodies or streams, etc.)

NLCD 2001



NASS – Crop Data Layer (CDL)  
NLCD Expanded 2001



Yellow Pasture Red Row crops

Orange Corn monoculture Yellow Pasture  
Green Alfalfa/Hay  
Cyan Soybean in rotation  
Light orange Corn in rotation





# Detailed Mapping of Soil Organic Carbon Stocks in the United States Using SSURGO

Norman B. Bliss\*, Sharon W. Weltman†, Larry West‡

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B51F-0367

## Introduction

The quantity of soil organic carbon (SOC) stocks forms a foundation for understanding potential sequestration or release of carbon to the future in response to changes in land management and climate. We have made new maps and databases of SOC stocks for the conterminous United States from the Soil Survey Geographic (SSURGO) database developed by the U.S. Department of Agriculture's Natural Resources Conservation Service (NRCS). These data have much greater spatial detail than the previous maps formed from the State Soil Geographic (STATSGO) data developed by NRCS in 1994. The SSURGO data are now 85% complete for the conterminous United States (CONUS). We show relationships between the SOC stocks and other spatial data such as Federal land ownership status. The new data are expected to improve spatial accuracy of SOC stocks, and reduce the uncertainty of estimation for scenarios of future soil organic carbon as the carbon stock for the soils of the conterminous United States.

## Conclusions

We calculate the stock of soil organic carbon in the conterminous United States as 73.43 petagrams (Pg). This is greater than the estimate of 61 Pg made from the State Soil Geographic (STATSGO) database in 2003, although the differences represent improvements to the database rather than changes in the carbon on the ground.

## Methods

The SOC for each map on the maps are for the conterminous United States. The primary data source was the SSURGO database (NRCS Soil Survey Geographic Database). The SOC was calculated using the version of SSURGO data that were available on lands controlled by Federal agencies. The SSURGO data were not available for lands on which similar analysis using the SSURGO data structure is given in Figure 1. The analysis of soil organic carbon stocks at the horizon (chorizon) level at the level of the component (mapunit) is the standard to the component to the maps available, and the mapping sequence from the mapunit to the spatial data.

The basic SSURGO data structure is given in Figure 1. The analysis of soil organic carbon stocks at the horizon (chorizon) level at the level of the component (mapunit) is the standard to the component to the maps available, and the mapping sequence from the mapunit to the spatial data.

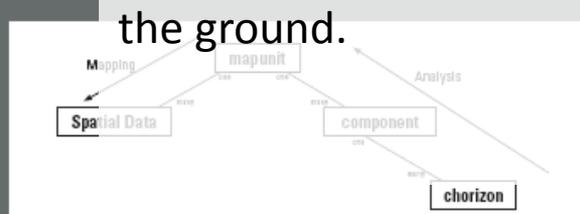


Figure 1. Overview of the SSURGO data structure. The data analysis sequence proceeds from the standards to the component to the maps available, and the mapping sequence from the mapunit to the spatial data.

Ideally, the component percentage would add to 100 percent for each mapunit, however this occurs for only 54 percent of the mapunits. If the sum of the component percentages was greater than or equal to 55 percent, then the results were extended to the unreported soil area, otherwise the mapunit was recorded as "No Data" for SSURGO and information was substituted from the GSM.

The carbon content of a horizon ( $C_c$ , g C m<sup>-2</sup> of horizon area)  
 $C_c = ODRT$

where  
 $D$  = Organic carbon content,  
 $R$  = Bulk density,  
 $D$  = Rock fragment conversion factor, and  
 $T$  = Thickness of the layer.

The attributes used in the analysis include:

- mapunit\_key, link results from attributes to the spatial data
- component\_percent, area proportion within a mapunit
- organic\_matter\_representative\_percent, (percentage by weight)
- bulk\_density, at a moisture content of 150 bar (23.15%)
- percent\_weight\_of\_rock\_fragments\_0\_10\_inches, (0-10 cm)
- percent\_weight\_of\_rock\_fragments\_0\_10\_inches\_7\_5\_to\_25\_cm, (7.5 to 25 cm)
- percent\_weight\_of\_rock\_fragments\_0\_10\_inches\_2\_to\_10\_inches, (2 to 10 inches)
- depth\_to\_top\_of\_the\_horizon, (cm)
- depth\_to\_the\_bottom\_of\_the\_horizon, (cm)
- The data on rocks and the size percentage are used to compute  $R$ , the "Rock fragment conversion factor" (NRCS Soil Survey Staff, 2004), and the horizon depths are used to compute the thickness,  $T$ .

The results presented here are for the carbon content of the total profile, reflecting all soil horizons for which carbon could be calculated, rather than flood depth limits.

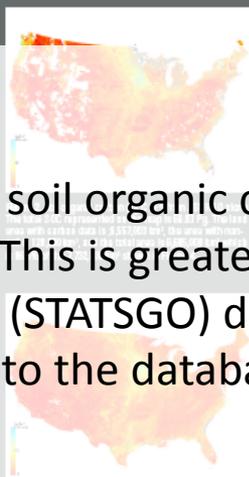


Figure 3. Soil organic carbon (g C m<sup>-2</sup>) from the General Soil Map alone. The total SOC represented on the map is 61.56 Pg. The land area with carbon data is 7,980,000 km<sup>2</sup>, the area with non-soil requirements is 41,000 km<sup>2</sup>, and the total area is 7,730,000 km<sup>2</sup>.

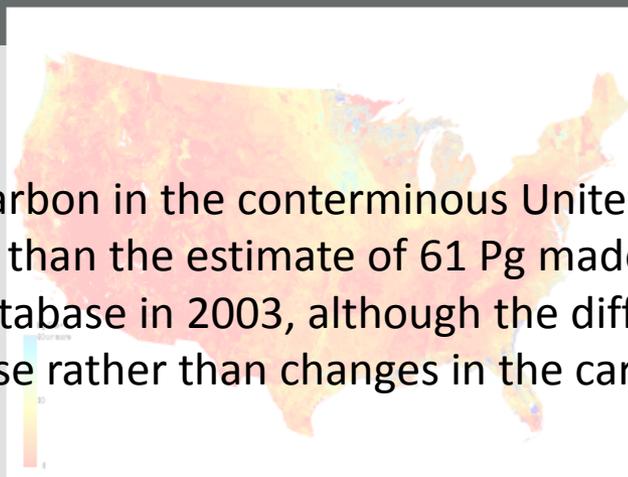


Figure 4. Soil organic carbon (g C m<sup>-2</sup>) from SSURGO, with gaps filled from the GSM. The total SOC represented on the map is 73.43 Pg. The land area with carbon data is 7,930,000 km<sup>2</sup>, the area with non-soil is 150,000 km<sup>2</sup>, and the total area is 7,730,000 km<sup>2</sup>.

## Results and Discussion

### SOC in Conterminous United States

The SOC calculated from the SSURGO data alone (Fig. 2) represents a carbon stock of 69.03 Pg for the CONUS. The gaps in the data are areas where the mapping at the detailed level is not complete. Areas of no-soil (e.g., water, bare rock, gravel pits, etc.) are coded with zero SOC.

The SOC calculated from the GSM data alone (Fig. 3) represents a carbon stock of 51.5 Pg for the CONUS. It remains to be investigated why this estimate is considerably lower than the more detailed estimate from SSURGO. One possibility is that wetland areas that have high soil carbon contents are under-represented in the GSM database. Many of the wetlands are very small, and not appropriate for mapping at the coarse scale of the GSM (original compilation at 1:250,000 map scale).

The SOC calculated from the SSURGO data with gaps filled using the GSM data (Fig. 4), represents a carbon stock of 73.43 Pg. The land area for the combined dataset is 7,730,000 km<sup>2</sup>, of which approximately 150,000 km<sup>2</sup> represents non-soils. The average soil carbon per unit area is 9.459 g C m<sup>-2</sup> for the total area, or 9,456 g C m<sup>-2</sup> based on just the soil area.

### Distribution of SOC

In general, SOC is high where soils are wet and/or cold, and low in mountains and deserts. The highest SOC values are in areas with poor drainage of water, such as wetlands, former wetlands, and past bays. There are substantial areas of wetlands along the East and Gulf Coasts, and in Northern states (e.g., Minnesota,

Michigan, and Maine). The high SOC in the coastal areas of Washington and Oregon are related to temperate rainforest conditions. The areas that experienced continental glaciations may have either high or low SOC. High SOC is found in southern Minnesota and central Iowa, where the Des Moines lobe of a continental glacier left large areas that are relatively flat and have generally wet soils. Continental glaciations may also contribute to low SOC soils where till or outwash resulted soils with a high rock content, some of which are well drained. Many other factors of topography, microclimates, and vegetation contribute to the SOC content of soils. For example, in some areas clay or volcanic ash may attack to the organic matter, forming a complex that is resistant to decomposition of the organic matter.

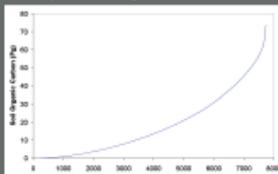


Figure 5. Relationship between cumulative land area and cumulative soil carbon for CONUS. The relationship shown in Fig. 5 is strongly non-linear, as can be illustrated from two points on the graph. Dividing the graph in half along the horizontal axis at point (3685,

14.3), half the land area has 14.3 Pg (19.5%) of the soil carbon and the other half of the land area has 59.1 Pg (80.5%) of the soil carbon. Dividing the graph in half along the vertical axis at point (3685, 39.8), the SOC (39.8 Pg) is on 5,445,000 km<sup>2</sup> (70.4%) of the land, and the other half of the soil carbon is on 1,287,000 km<sup>2</sup> (16.4%) of the land. Strategies to manage land to promote carbon sequestration and avoid carbon release will need to account for the variation in carbon stocks in conjunction with other land qualities, management opportunities, and climatic conditions.

### Federal Lands

A geographic information system can be used to overlay the SOC map with many other factors such as land cover, elevation, slope, aspect, relief, landscape position, and Federal land ownership status. Table 1 shows the results of overlaying the SOC map from Figure 4 with the Federal Lands derived from the National Atlas of the United States (National Atlas, 2005). Many Federal agencies are exploring how to incorporate management for carbon sequestration into their land management plans.

Table 1. SOC and area by Federal Agency or Bureau, calculated by the overlay of the SOC map (Fig. 4) with the National Atlas Federal Lands dataset (USDA - United States Department of Agriculture, DOI - Department of the Interior)

Federal Agency or Bureau	SOC (Pg C)	Area (1000 km <sup>2</sup> )
USDA Forest Service	1,500	683
BID Bureau of Land Management	2,700	728
DOI Fish and Wildlife Service	700	68
Department of Defense	600	161
DOI National Park Service	600	113
Bureau of Indian Affairs	70	25

## Conclusions

We calculate the stock of soil organic carbon in the conterminous United States as 73.43 petagrams (Pg). This is greater than the estimate of 61 Pg made from the State Soil Geographic (STATSGO) database in 2003, although the differences represent improvements to the database rather than changes in the carbon on the ground. The soil data were developed between the 1960s and the present. It is likely that most of the data reflect the understanding of soil scientists within the last 20 years, but it is not possible to specify a single date to which the estimates, but we consider a study that the true value is within a 20 percent of the estimate. Efforts are ongoing to update the database with attribute data for the SSURGO database. Recommendations observed in national databases can lead to improvements.

We consider the results from SSURGO (compiled at 1:250,000 scale) to be much more accurate than the GSM (compiled at 1:250,000 scale). The NRCS and cooperating agencies have invested considerable resources in upgrading the quality of the soil databases in recent years and these efforts are reflected in the SSURGO data.

The SSURGO database has over 400 attributes, of which perhaps 30 will be useful for biogeochemical modeling. Future work includes distribution of selected attributes in formats that will enable nationwide data to be easily available for modelers.

## References

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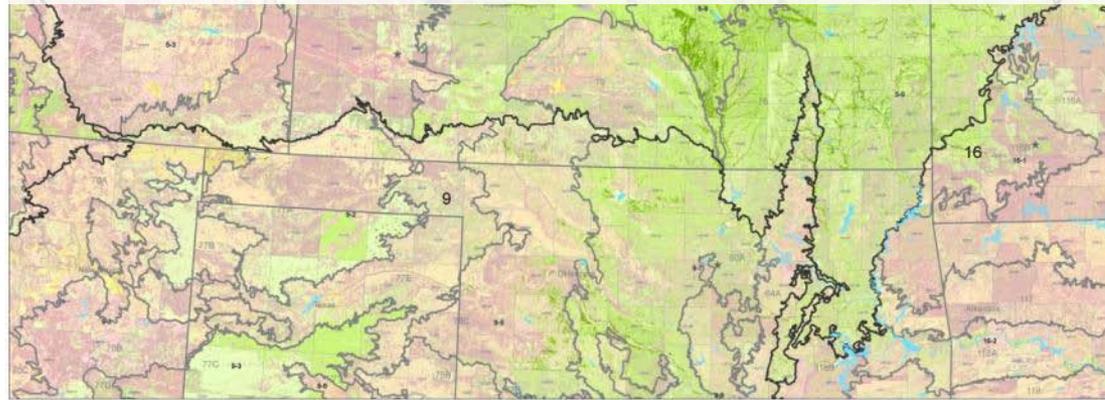
## Acknowledgments

This work was supported by the USGS Global Change Program and by the USDA Global Change Program through the USDA/NRCS Soil Survey Program and data data collected under the National Cooperative Soil Survey.

# Soil Organic Carbon 100 cm Depth (om\_r, Kg per square meter) Central Great Plains Soil Survey Region (MO 5)



## Rapid Assessment of Carbon Project to support the Resource Conservation Act (RCA)



Location of Central Great Plains Soil Survey Region (MO5)

**Base Layers**

- ★ MO Office
- ⊕ MLRA ESO
- 5 MO Boundaries
- MO MLRA Regions
- MO MLRA SSA
- State Boundaries
- SSA Boundaries

**Soil Organic Carbon 100 cm Depth (om\_r in Kg C per meter squared)**

- 0 - 0.5
- 0.51 - 1
- 1.01 - 1.7
- 1.71 - 2.7
- 2.71 - 4.2
- 4.21 - 5.8
- 5.81 - 7.8
- 7.81 - 9.7
- 9.71 - 18
- 18.01 - 24
- 24.01 - 40
- 40.01 - 70
- 70.01 - 118
- 118.01 - 300+
- 300.01 - 300+
- Water Bodies
- Zero, Misc. or Null Areas

Map prepared by USDA-NRCS National Soil Survey Center, Geospatial Research Unit, 2042 University Ave., Ames, IA 50011, Morganthau, WI 20020

Original Map Scale: 1:1,000,000

NRCS National Resource Conservation Service

Map Date: 08/10/2017

# Gridded SSURGO

Deep root zone soils (left) provide greater available water capacity (AWC) than shallow root zone soils (right) Hagerstown soils, Centre Co, PA.

## *Is used by traditional NCSS Customers:*

- **USDA Economic Research Service (ERS)** grids SSURGO at 30 meters and combines with various land cover sources for Farm Bill model runs
- **USDA Farm Service Agency (FSA)** desires county and state SSURGO mukey (map unit) acreage values
- **USDA Agricultural Research Service (ARS)** for geospatial modeling for soil organic carbon and biomass production



# Gridded SSURGO

Deep root zone soils (left) provide greater available water capacity (AWC) than shallow root zone soils (right) Hagerstown soils, Centre Co, PA.

## *Could be used by relatively new clients*

- USDA-NRCS (Conservation Planning Decision Support Systems)
- USDA-NASS (Crop mapping)
- USEPA (ecosystem services)
- USGS-Water Resources (water quality)
- USGS-Mapping Division (GIS data makers/keepers/disseminators)
- University Researchers (carbon, biomass production/ecosystem services)
- Private sector
  - e.g. Monsanto, Syngenta (genotype x environment)

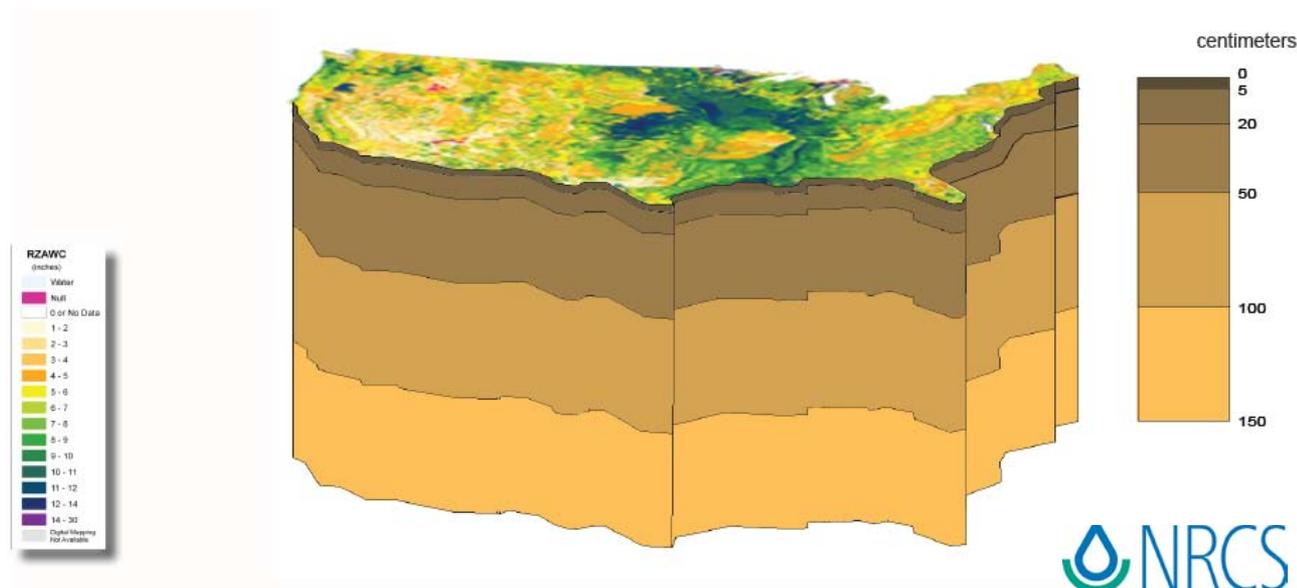
The Atlas of Ecosystems Services Gridded SSURGO project takes a similar approach to the successful CONUS-SOIL project (Miller and White, 1997) that created a 3-dimensional soil physical properties geographic database for the Conterminous United States (1 km resolution)

([http://www.essc.psu.edu/soil\\_info/index.cgi?soil\\_data&conus](http://www.essc.psu.edu/soil_info/index.cgi?soil_data&conus) )

based upon the USDA-Natural Resources Conservation Service State Soil Geographic Database (STATSGO-Soil Survey Staff,1994).

Fig.4 Gridded SSURGO - Standard Layers Product (5 layers proposed)

Difference would be focus on the detailed soil survey geographic data base called SSURGO (10 or 30 m resolution )rather than the general STATSGO or STATSGO2



# Ecosystem Services Gridded SSURGO

- Proposed summary levels
  - Component Horizon or Standard Layer Level
  - 0-5, 5-20, 20-50, 50-100, 100-150 cm?
    - SOC/SIC and calculation parameters
      - (SOM, rock fragment conversion factor, bulk density...)
    - %S, %Si, %C (fine earth fraction)
    - Rock Fragment Content
    - Soil texture class (e.g. silty clay loam)
    - Restrictive layer presence/absence

# Ecosystem Services Gridded SSURGO Themes

- Summary levels
  - Soil Map unit/Component Level (series/phase of series)
    - Component percentage of map unit
    - SOC (Kg per square meter)
    - SIC (Kg per square meter)
    - RZAWC and AWC for reported depth
    - Rooting Depth (crops, trees, range, etc.)
    - Bedrock Depth
    - Reported Depth and others
    - Hydrologic group
    - National Commodity Crop Productivity Index (NCCPI)



## National Atlas of Ecosystem Services

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**Dark Map**

**Political Boundaries**

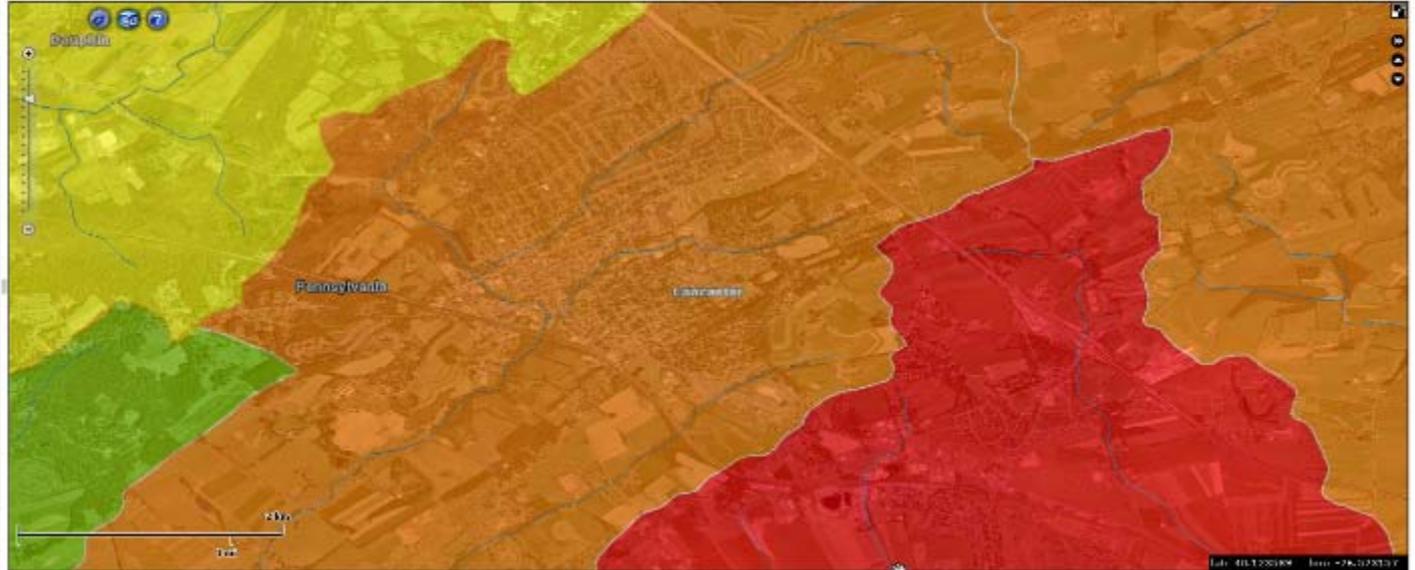
**Biophysical Data**

- NHD Flowline 100k
- 8 Digit Watershed Boundary
- 12 Digit Watershed Boundary

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**Base Maps**

**Political Boundaries**

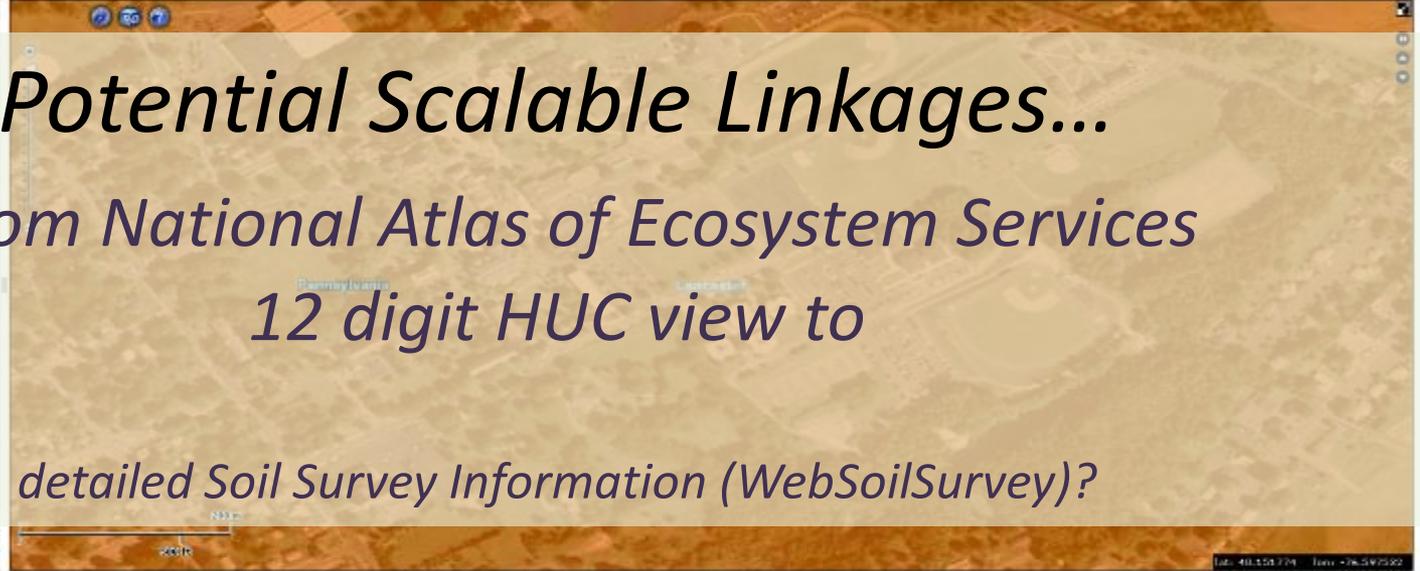
Biophysical Data

- NHD Flowline 100K
- 6 Digit Watershed Boundary
- 12 Digit Watershed Boundary

Ecological Services: Nitric - Production

Ecological Services: Nitric - Demand

Ecological Services: Nitric - Missions



*Potential Scalable Linkages...  
from National Atlas of Ecosystem Services  
12 digit HUC view to  
detailed Soil Survey Information (WebSoilSurvey)?*



**Search**

**Suitabilities and Limitations Rating**

Building Site Development

Construction Materials

Disaster Recovery Planning

**Land Classifications**

Conservation Tree and Shrub Growth

Ecological Site ID

Ecological Site Name

Farmland Classification

Forage Suitability Group ID (Com)

Hydric Rating by Map Unit

Irrigated Capability Class

Irrigated Capability Subclass

**Nonirrigated Capability Class**

View Description

**View Options**

Map

Table

Description of Rating

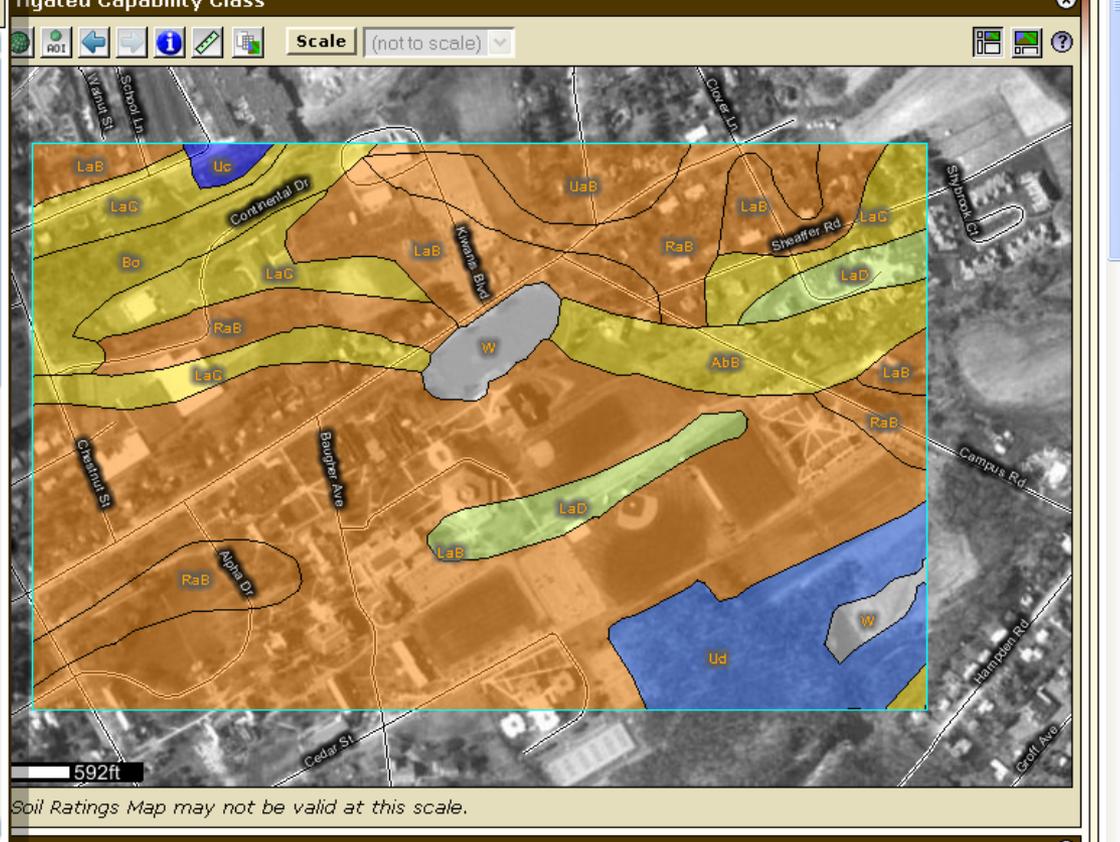
Rating Options

Advanced Options

View Description View Rating

**Map Legend**

- Area of Interest (AOI)
  - Area of Interest (AOI)
- Soils
  - Soil Survey Areas
  - Soil Map Units
  - Soil Ratings
    - Capability Class - I
    - Capability Class - II
    - Capability Class - III
    - Capability Class - IV
    - Capability Class - V
    - Capability Class - VI
    - Capability Class - VII
    - Capability Class - VIII
    - Not rated or not available
  - Special Point Features
  - Special Line Features
  - Political Features
    - States
    - Counties



**Tables - Nonirrigated Capability Class - Summary By Map Unit**

**Summary by Map Unit - Lancaster County, Pennsylvania**

Map unit symbol	Map unit name	Rating	Area in AOI	Percent of AOI

- END



*What do you get when you provide soils data in the gridded SSURGO format that the client desires?*

