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

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

EPA NATIONAL GEOGRAPHIC NRCS USGS

- Base Maps
- Political Boundaries
- Biophysical Data
- Ecosystem Services Metrics - Production
  - Clean Water for Drinking
  - 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

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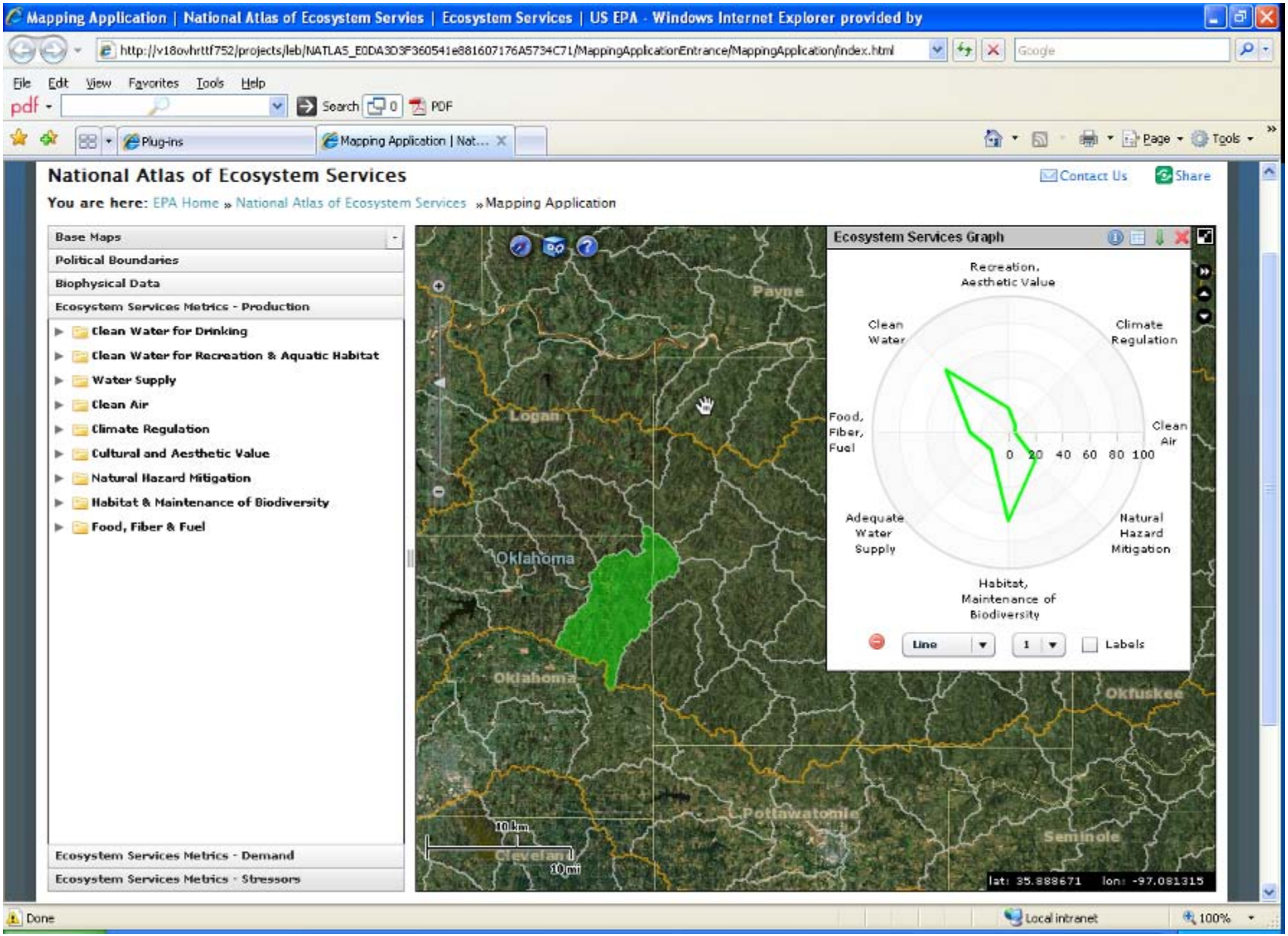
Mapping Application | National Atlas of Ecosystem Services | Ecosystem Services | US EPA - Windows Internet Explorer provided by
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Ecosystem Services Metrics - Demand
Ecosystem Services Metrics - Stressors
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Adequate Water Supply
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Pottawatomie
Seminole
Cleveland
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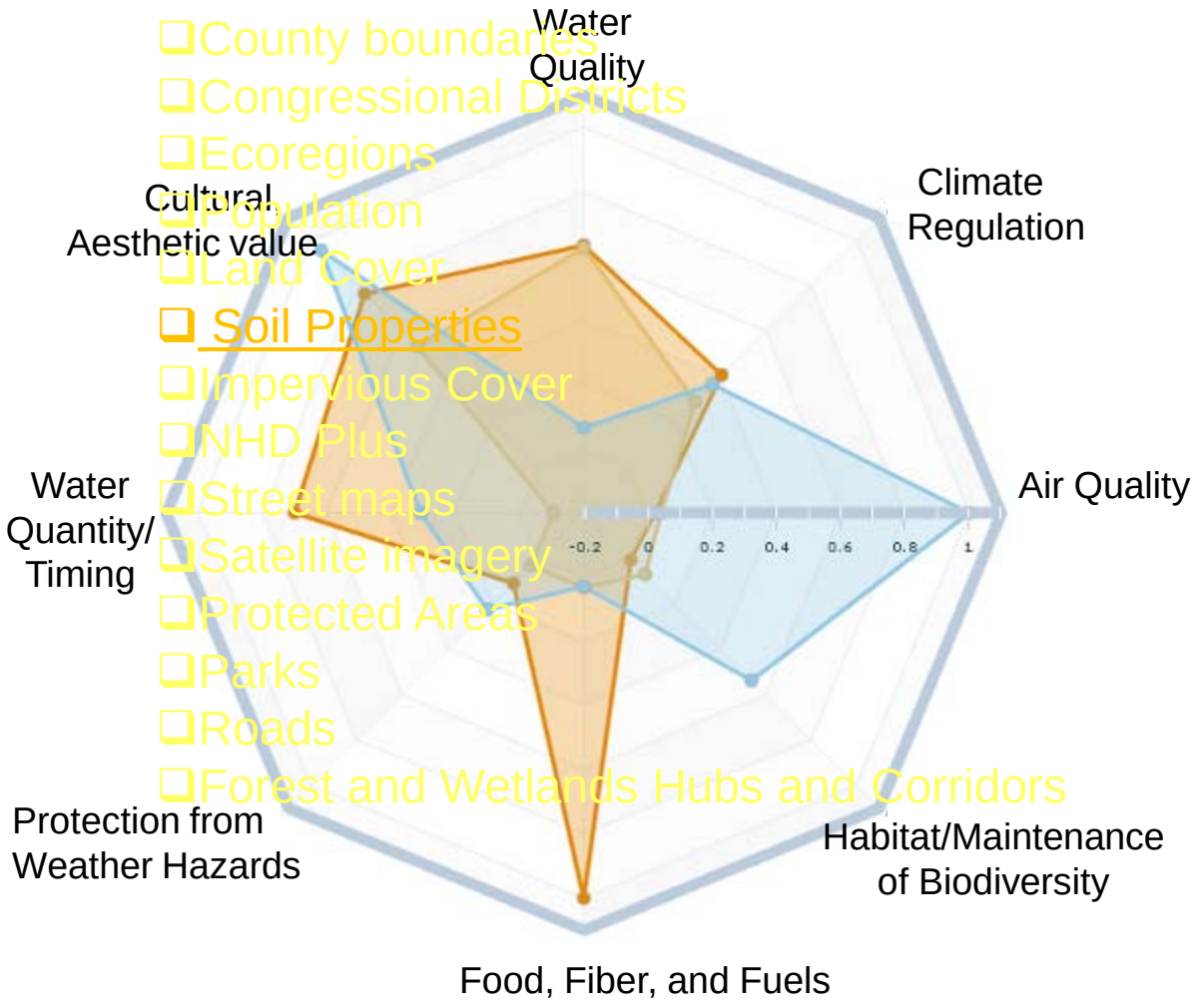
10 mi
lat: 35.888671 lon: -97.081315
Done
Local intranet
100%

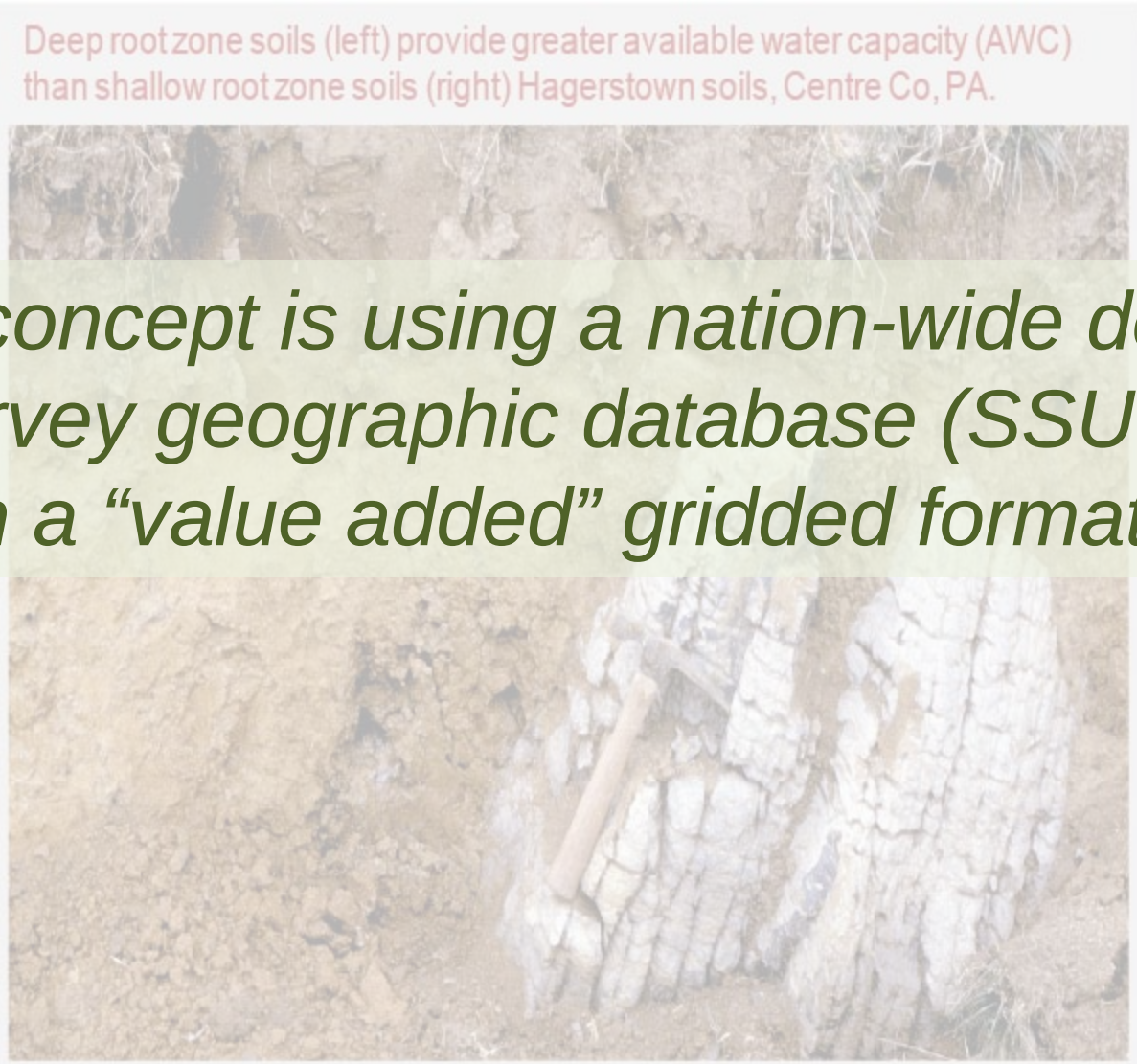
Atlas Vision/Implementation

- State Boundaries
- County boundaries
- Congressional Districts
- Ecoregions
- Population
- Land Cover
- Soil Properties
- Impervious Cover
- NHD Plus
- Street maps
- Satellite imagery
- Protected Areas
- Parks
- Roads
- Forest and Wetlands Hubs and Corridors



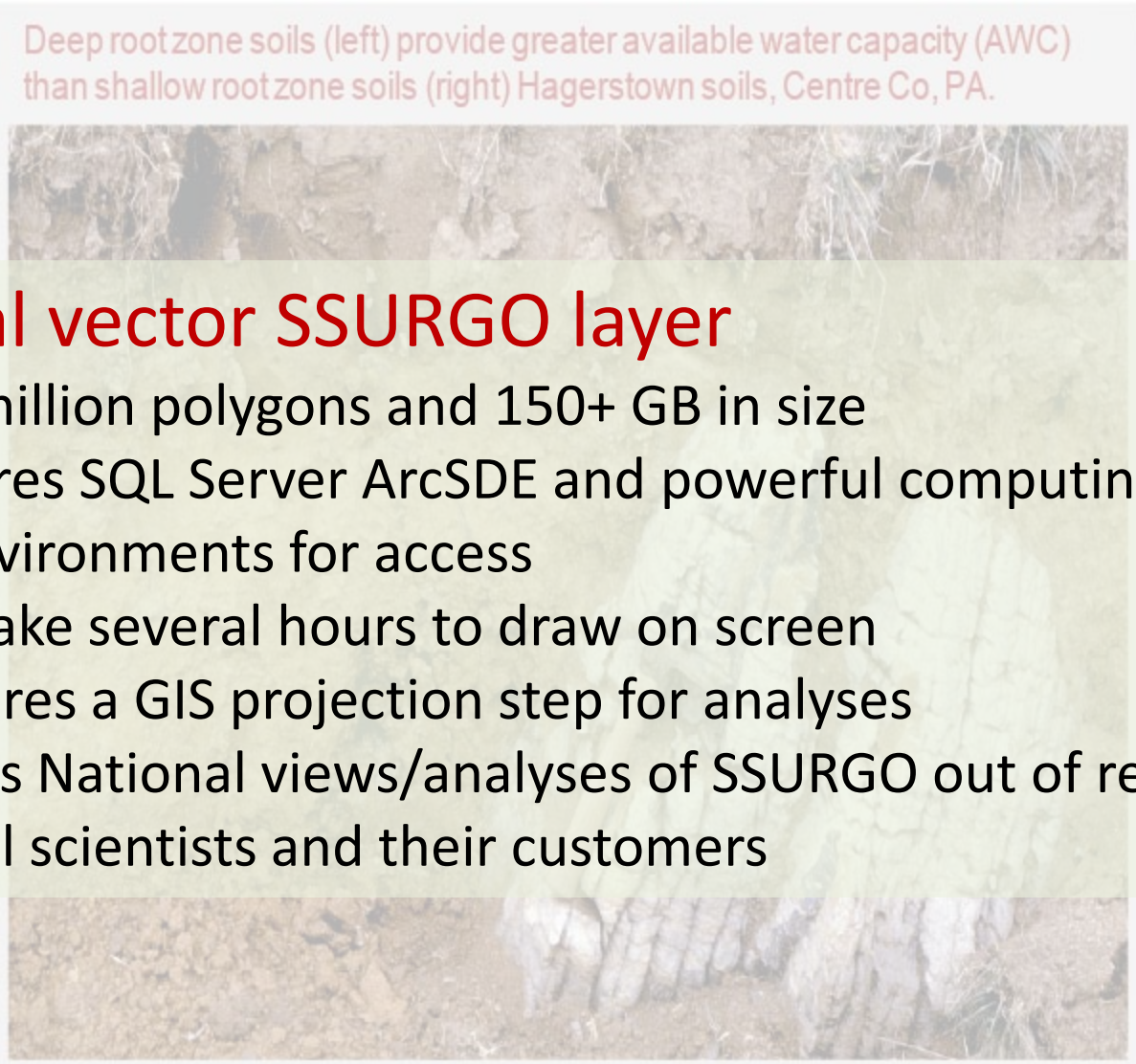
- **Contain series of clickable background maps**
- **Select ecosystem services from Table of Contents**
- **Allow "stacking" of multiple services**
- **Multiple metrics for each category**
- **Ancillary data**
- **Include potential and future scenarios**
- **Allow user to place their "area" in context of others**

Soil Contribution to Atlas – Gridded SSURGO



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



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

NRCS

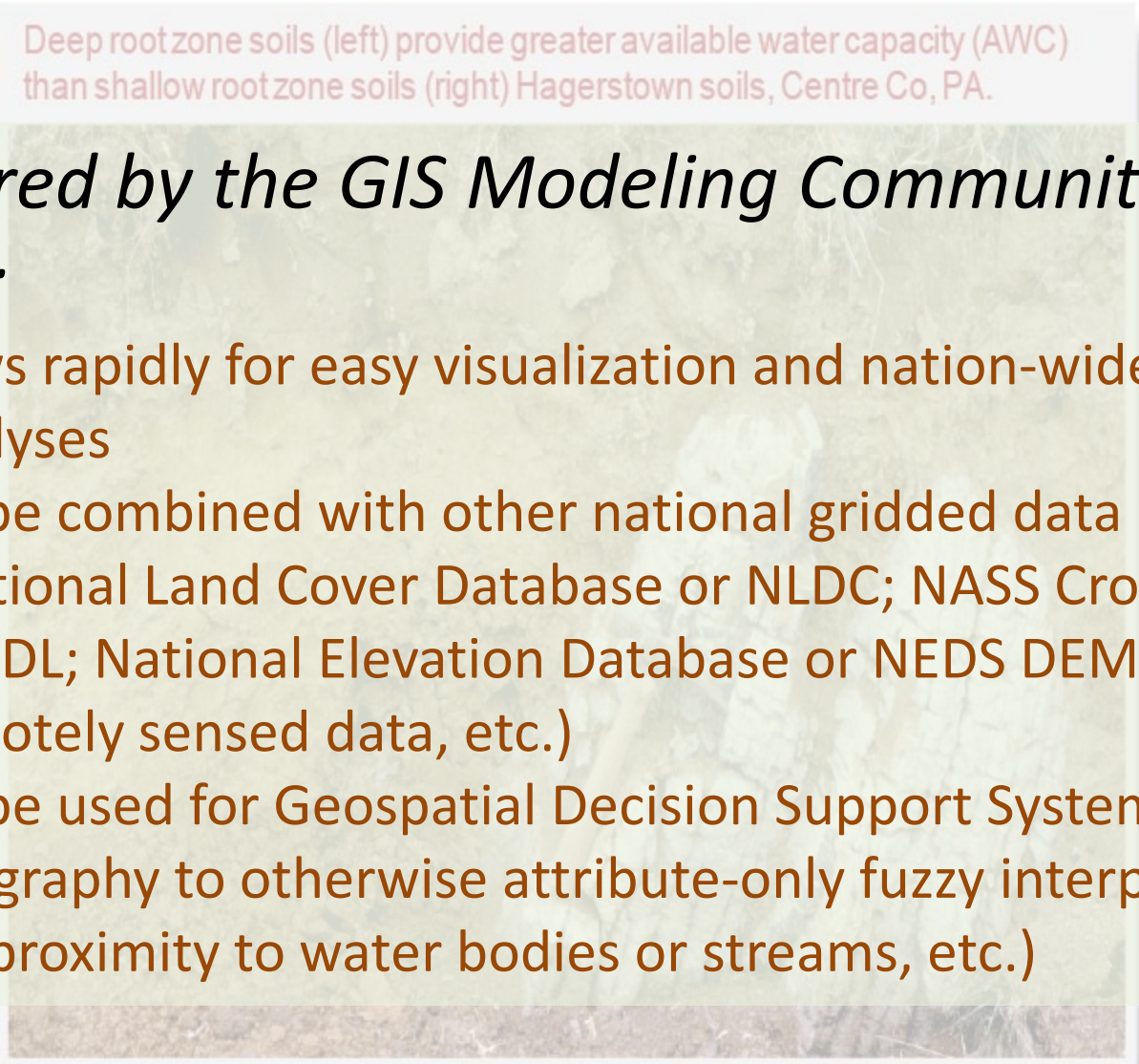
Soil Contribution to Atlas – Gridded SSURGO

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*

NRCS

Gridded SSURGO

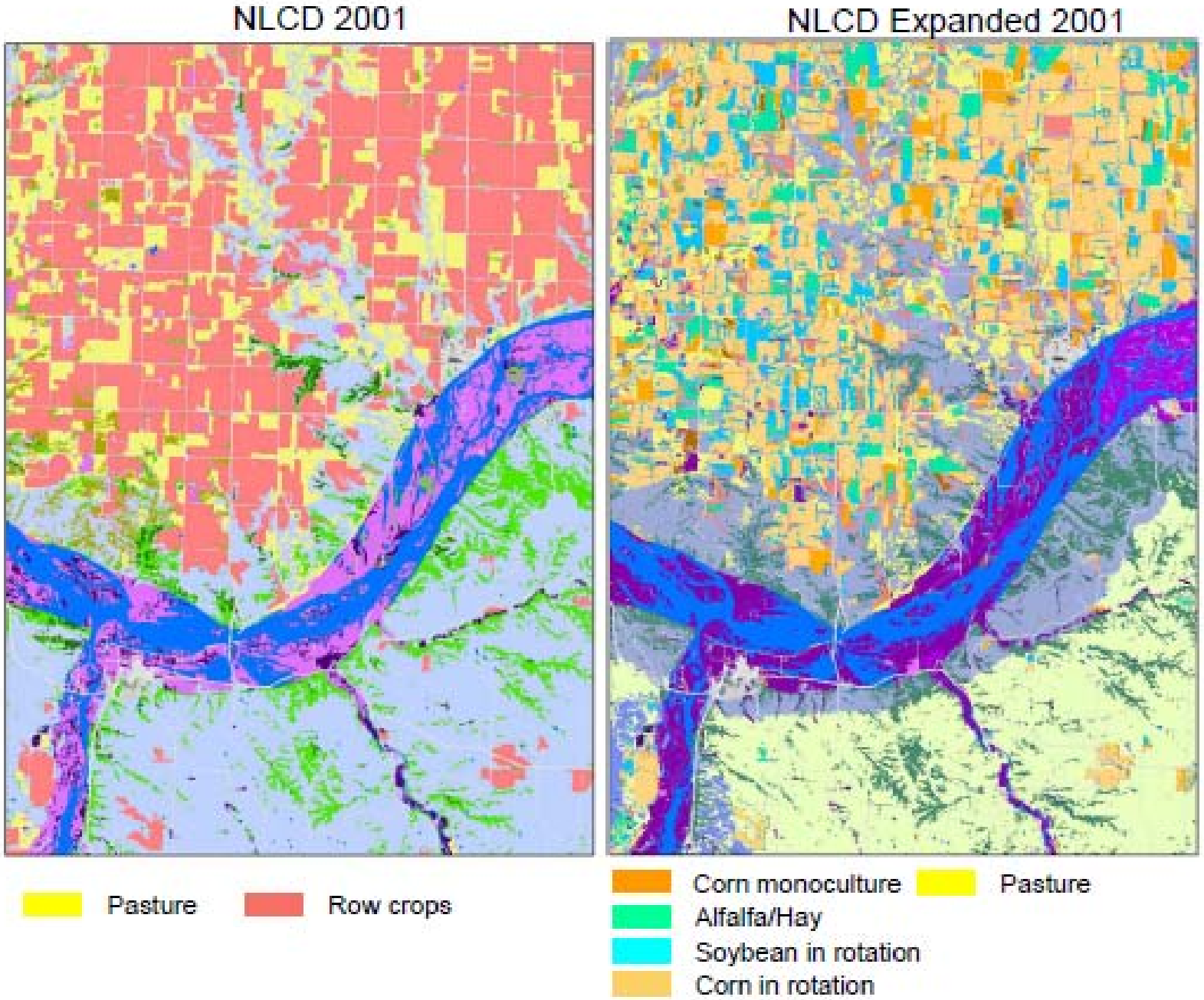


Is preferred by the GIS Modeling Community because:

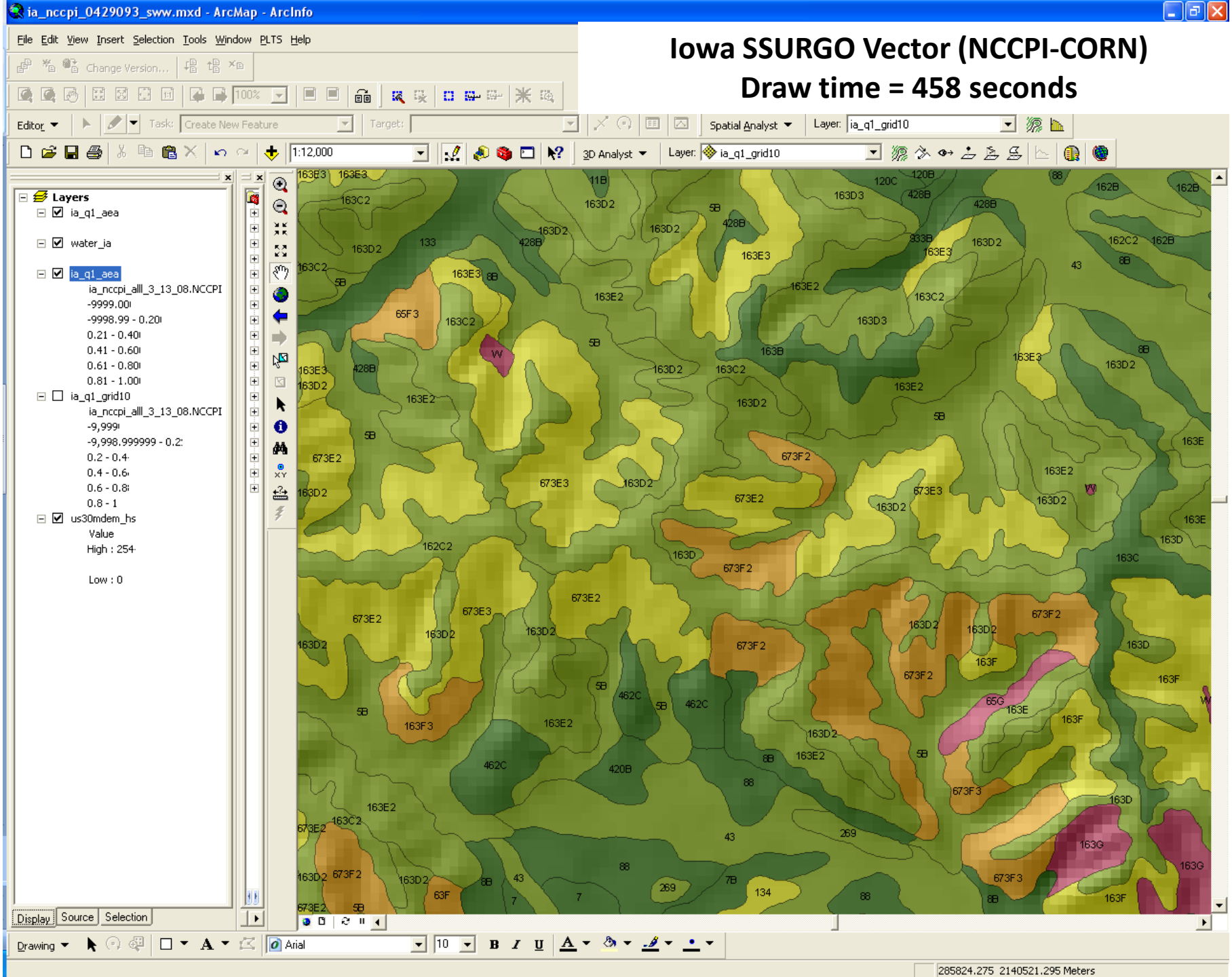
- It draws rapidly for easy visualization and nation-wide GIS analyses
- It can be combined with other national gridded data layers (National Land Cover Database or NLDC; NASS Crop Data Layer or CDL; National Elevation Database or NEDS DEM, other remotely sensed data, etc.)
- It can be used for Geospatial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

NRCS

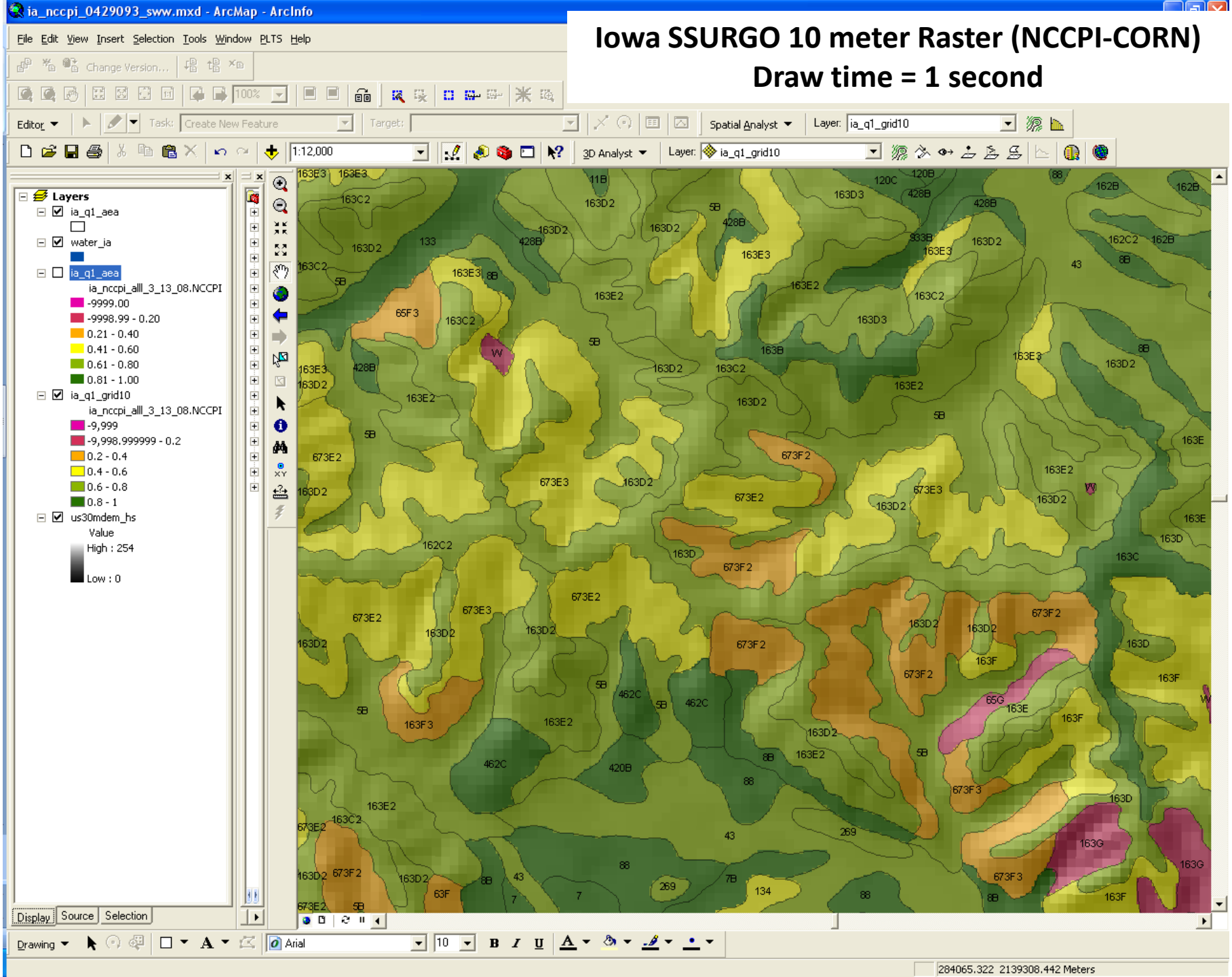
NASS – Crop Data Layer (CDL)



Iowa SSURGO Vector (NCCPI-CORN)
Draw time = 458 seconds



Iowa SSURGO 10 meter Raster (NCCPI-CORN)
Draw time = 1 second



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

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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 in 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 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 65% 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 spatially explicit carbon cycle models and reduce the uncertainty of estimation for scenarios of future land use and climate change. We use soil organic carbon as the carbon stock for the soils of the conterminous United States.

Methods

The SOC for each mapunit on the maps are for the total soil profile (all horizons present in the database). The primary data source was the SSURGO database (NRCS Soil Survey Staff, 2004). The SSURGO database has a relational database structure, so estimates of SOC were calculated by table and was multiplied by the version of SSURGO on lands controlled by Federal agencies. Where SSURGO data were not available, the results were substituted from a similar analysis using

The basic SSURGO horizon (chorizon) table, aggregates the carbon over the appropriate layers for a given analysis, and stores the result at the level of the representative component of the mapunit (mu

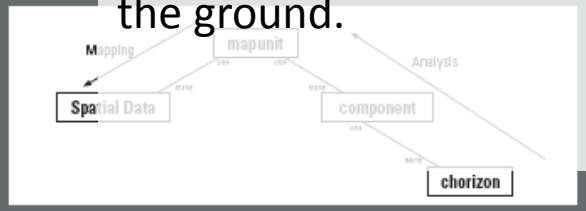

Figure 1. Overview of the SSURGO data structure. The data analysis sequence proceeds from the chorizon to the component to the mapunit tables, and the mapping sequence from the mapunit table to the spatial data.

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 65 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_v, g C m^{-2} of horizon area)

$C_v = ODRT$

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

The attributes used in the analysis include:

mukey	mapunit key, link results from attributes to the spatial data
comppct	component percentage, area proportion within a mapunit
om_r	organic matter, representative (percentage by weight)
dbthirdbar_r	bulk density, at a moisture content of 1/3 bar (33 kPa)
fraggt10_r	percentage by weight of rock fragments > 10 inches (25 cm)
frag3to10_r	percentage by weight of rock fragments 3 to 10 inches (7.5 to 25cm)
sieveno10_r	percentage by weight passing No. 10 sieve (2 mm sieve size)
hzdept_r	depth to the top of the horizon (cm)
hzdepb_r	depth to the bottom of the horizon (cm)

The data on rocks and the sieve 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 fixed depth limits.

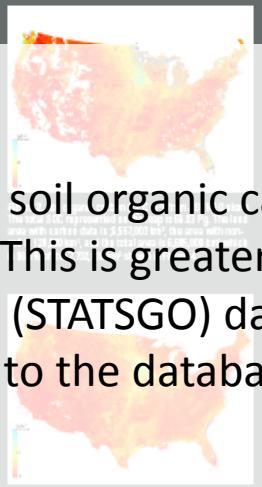

Figure 3. Soil organic carbon (kg C m-2) from the General Soil Map states. The total SOC represented on the map is 51.59 Pg. The land area with carbon data is 7,661,000 km^2, the area with non-soil mapunits is 44,000 km^2, and the total area is 7,713,000 km^2.

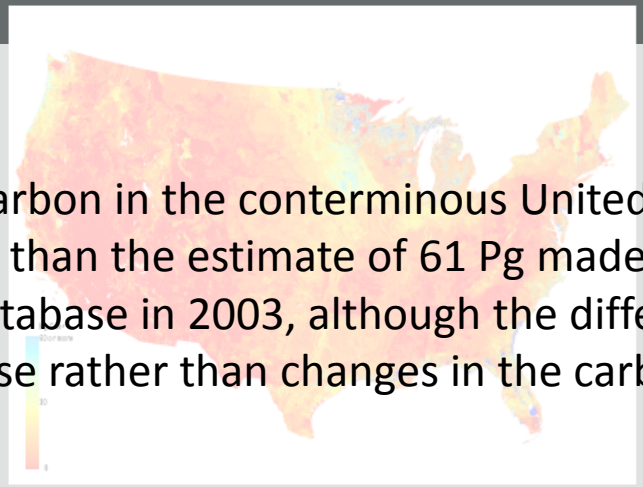

Figure 4. Soil organic carbon (kg C m^{-2}) from SSURGO, with gaps filled from the GSM. The total SOC represented on the map is 73.43 Pg. The land area with carbon data is 7,632,000 km^2, the area with non-soil is 158,000 km^2, and the total area is 7,713,000 km^2.

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 non-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 7,731,000 km^2, of which approximately 150,000 km^2 represents non-soils. The average soil carbon per unit area is 9,499 g C m^{-2} for the total area, or 9,686 g C m^{-2} 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 peat bogs. There are substantial areas of wetlands along the Eastern 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, microclimate, and vegetation contribute to the SOC content of soils. For example, in some areas clay or volcanic ash may attach to the organic matter, forming a complex that is resistant to decomposition of the organic matter.

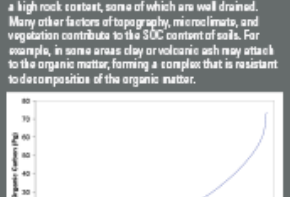

Figure 5. Relationship between cumulative land area and cumulative soil carbon for CONUS.

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 (3695, 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 (6464, 36.8), half the SOC (36.8 Pg) is on 6,464,000 km2 (83.6%) of the land, and the other half of the soil carbon is on 1,267,000 km2 (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^2)
USDA Forest Service	5,888	865
DOI Bureau of Land Management	2,256	720
DOI Fish and Wildlife Service	758	68
Department of Defense	658	104
DOI National Park Service	611	113
Other Federal Land	77	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

There are several sources of uncertainty in these estimates, but we consider it likely that the true [illegible] within ± 30 percent of the [illegible]. Efforts are ongoing to update [illegible] attribute data for the SSURGO database. Inconsistencies observed in national [illegible] can lead to improvements.

We consider the results from SSURGO (compiled [illegible] 1:12,000 map scales) to be much [illegible] those from the GSM (compiled at [illegible]). 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 300 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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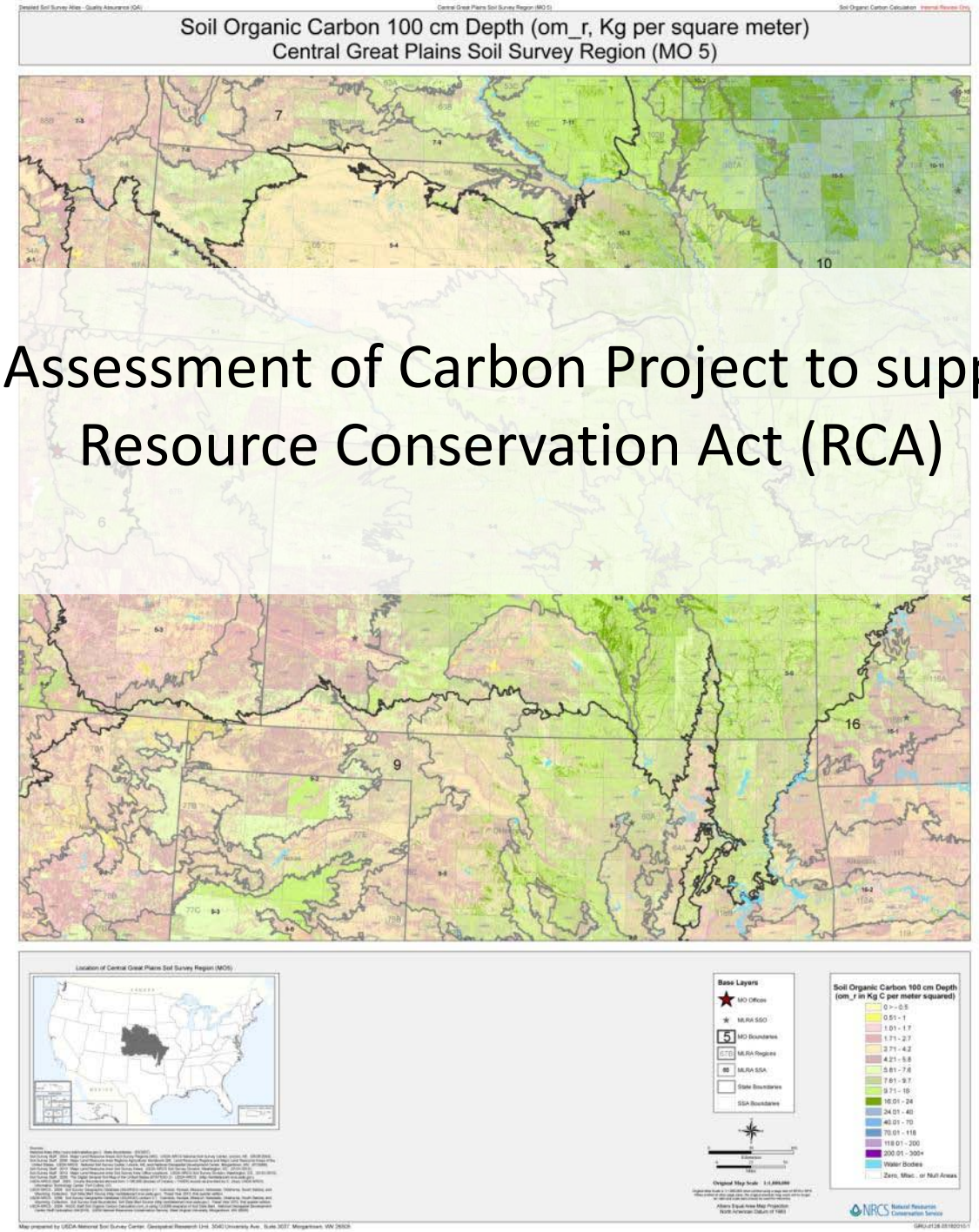
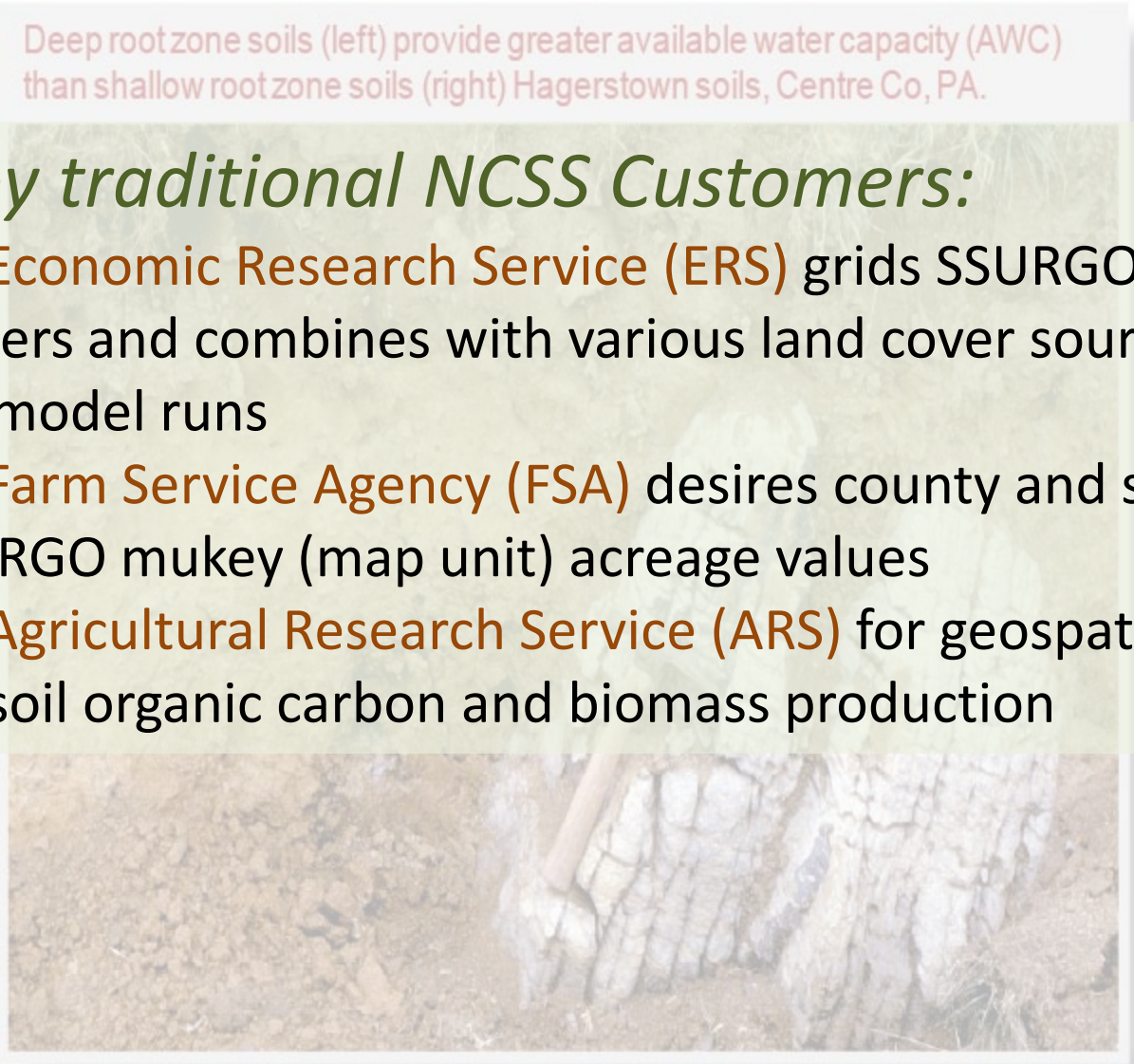
Acknowledgments

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 uses data collected under the National Cooperative Soil Survey.



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

Gridded SSURGO

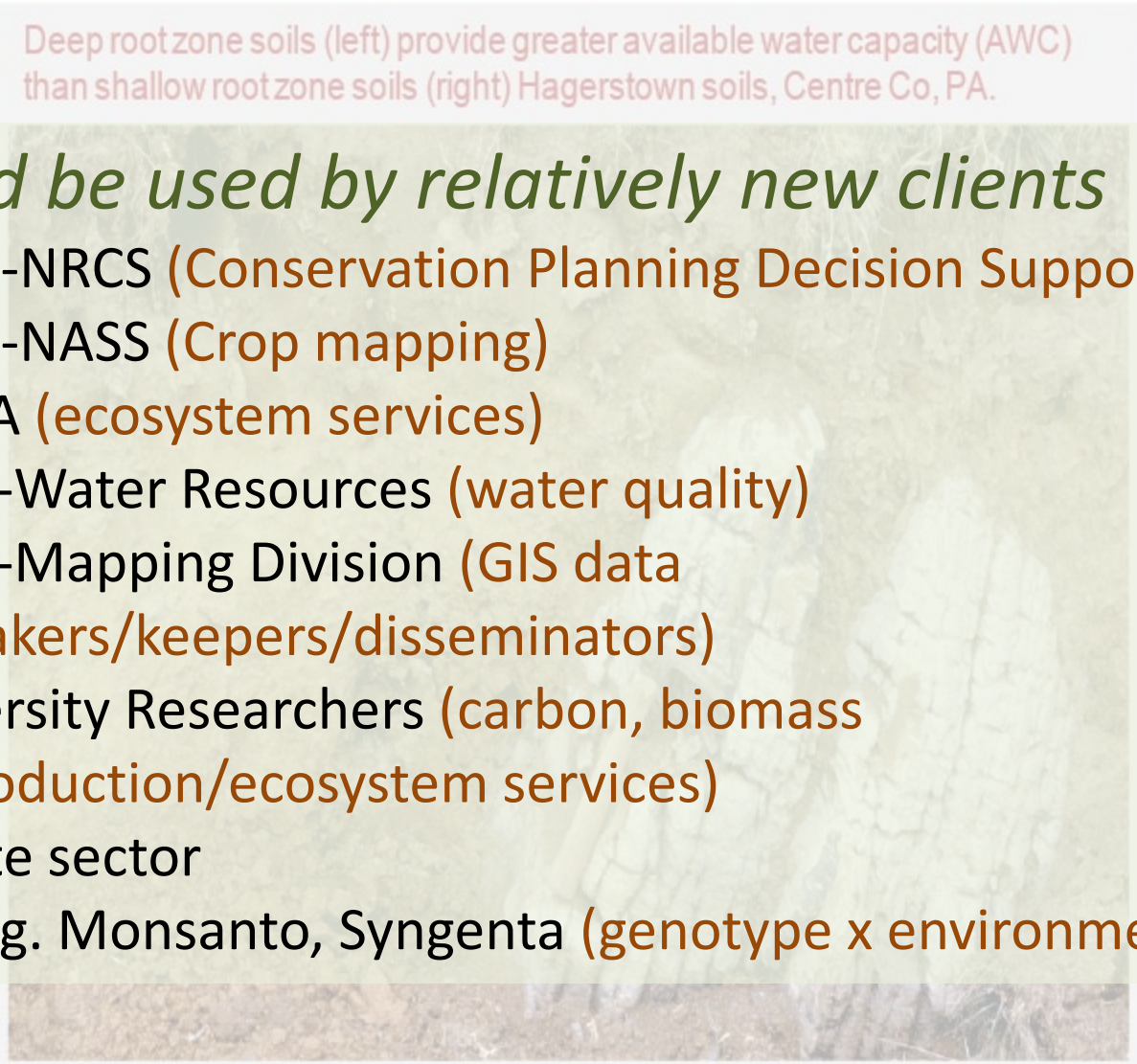


Is used by traditional NCSS Customers:

- 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

NRCS

Gridded SSURGO



Could be used by relatively new clients

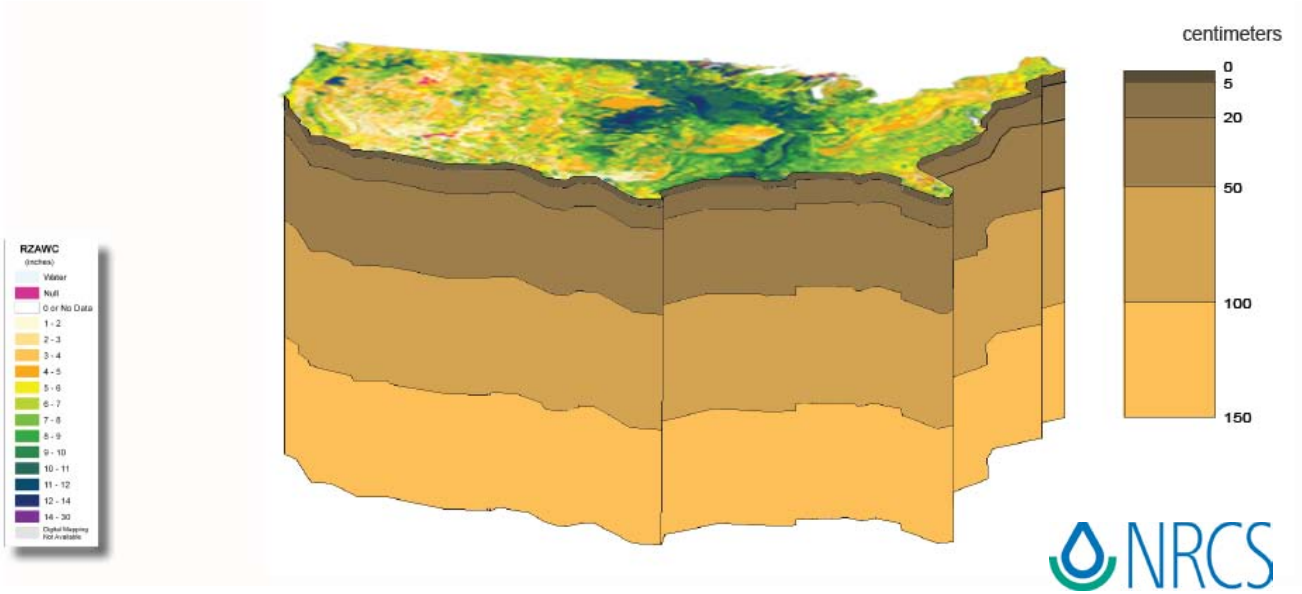
- USDA-NRCS (Conservation Planning Decision Support Systems)
- USDA-NASS (Crop mapping)
- USEPA (ecosystem services)
- USGS-Water Resources (water quality)
- USGS-Mapping Division (GIS data makers/keepers/disseminators)
- University Researchers (carbon, biomass production/ecosystem services)
- Private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

NRCS

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)
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



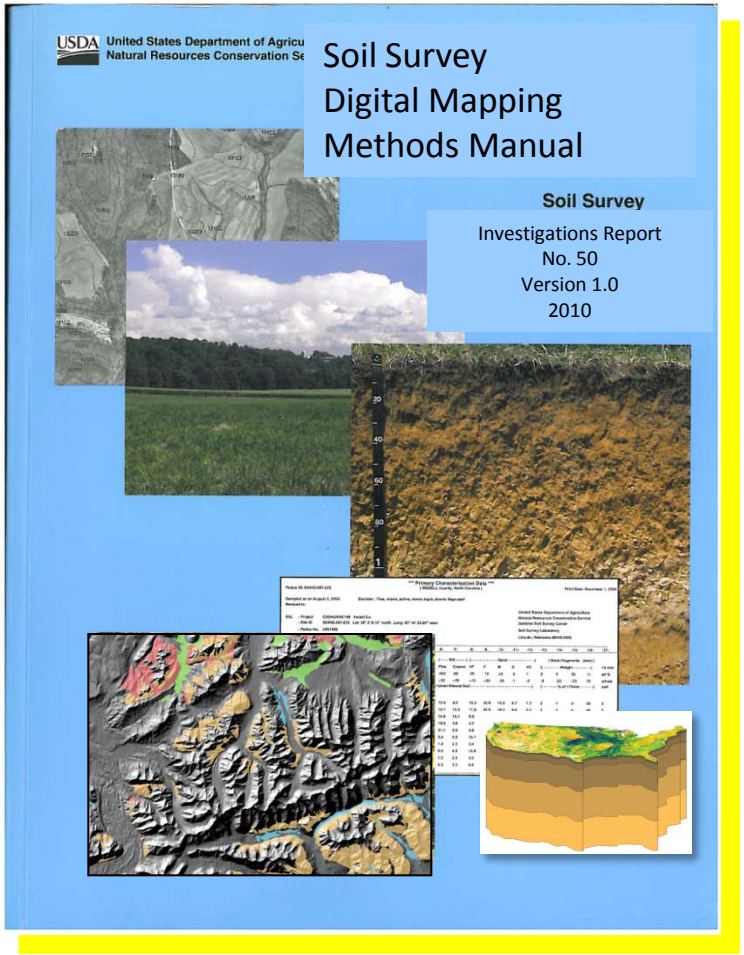
Ecosystem Services Gridded SSURGO

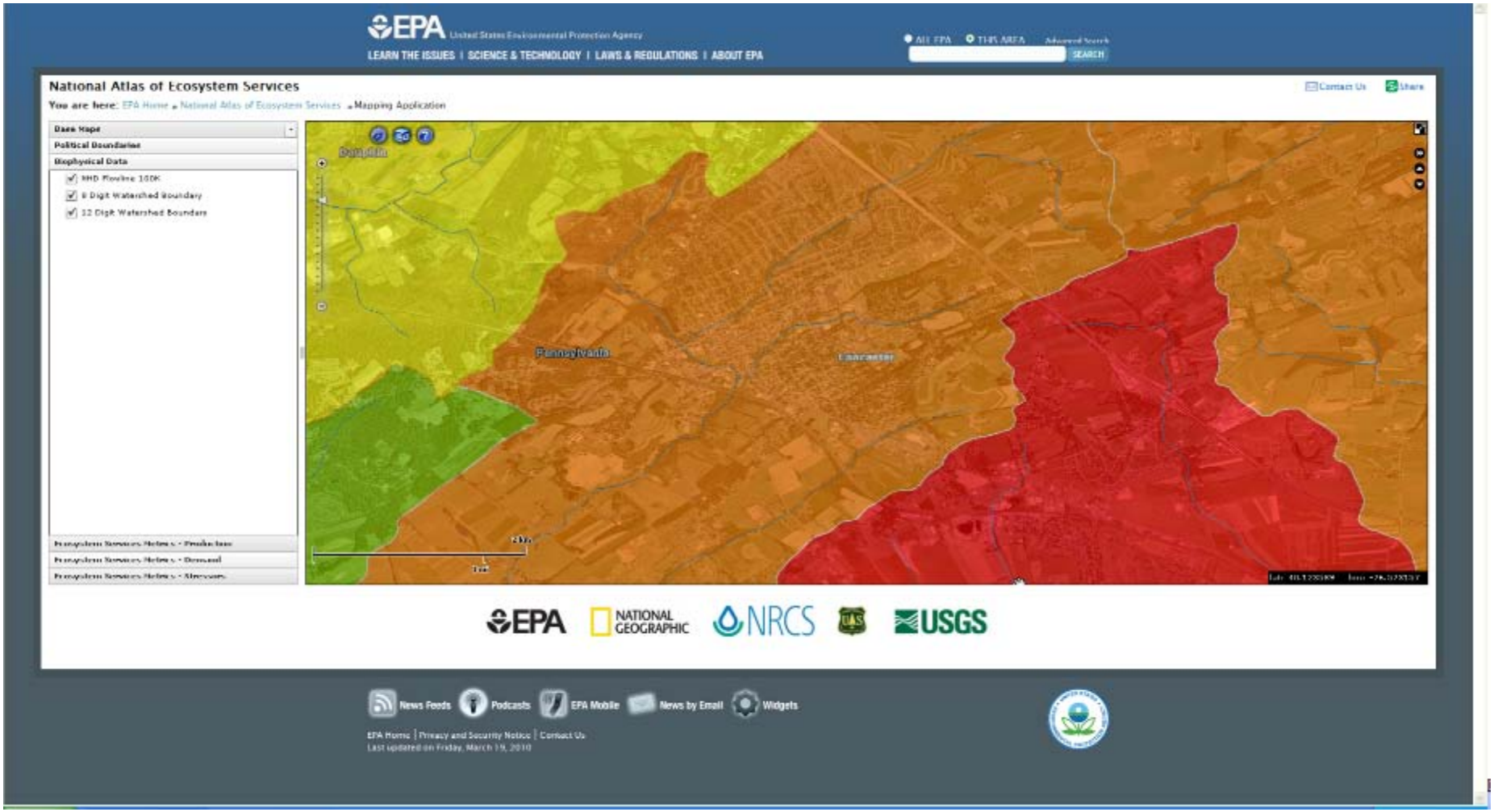
- Proposed summary levels
  - Component Horizon or Standard Layer Level
  - 0-5, 5-20, 20-50, 50-100, 100-150 cm?
    - SOC/SIC and calculation parameters
      - (SOM, rock fragment conversion factor, bulk density…)
    - %S, %Si, %C (fine earth fraction)
    - Rock Fragment Content
    - Soil texture 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)

NCSS "Best Practices" for Gridded SSURGO Data Summary Methods Documented…

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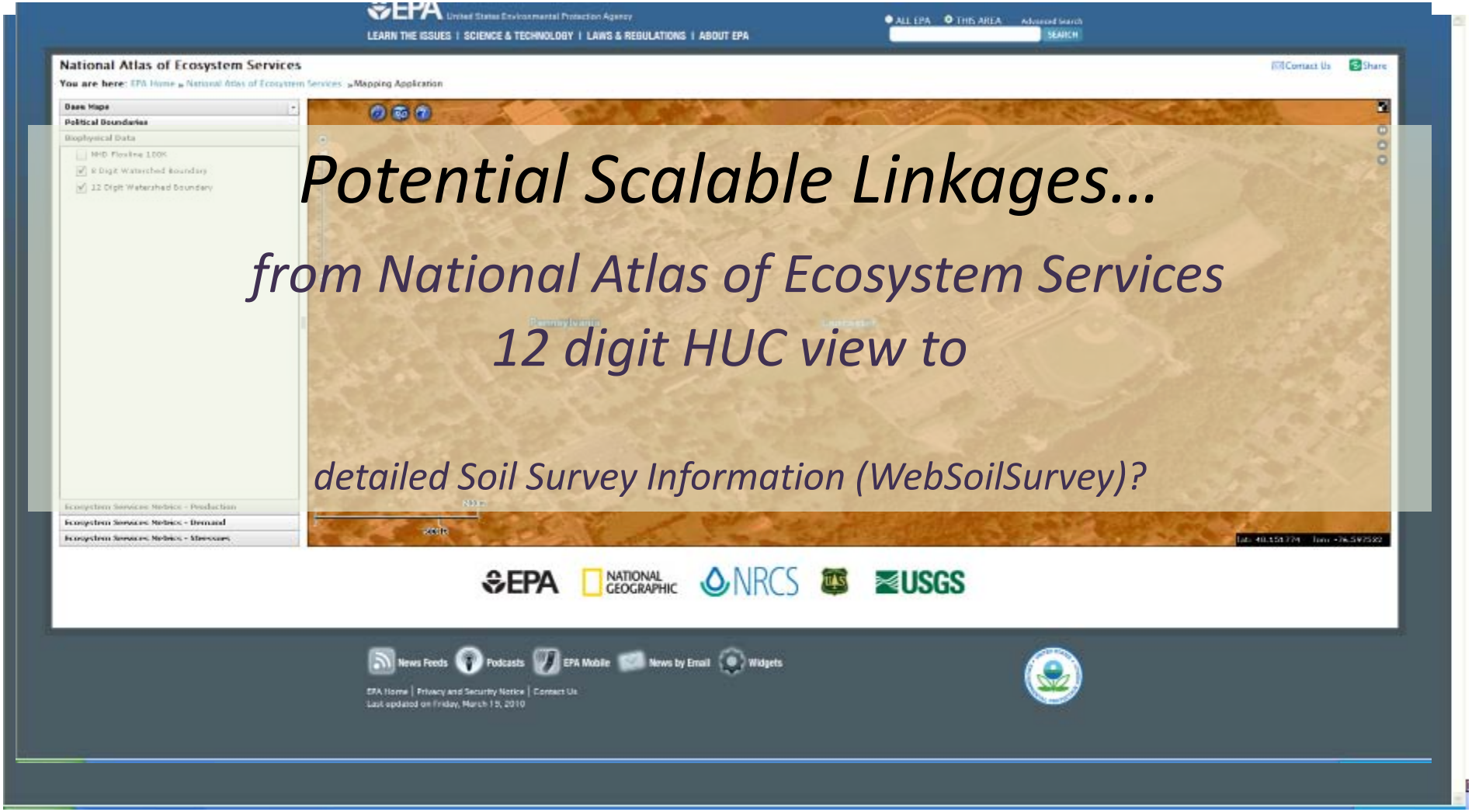
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Search

Suitabilities and Limitations Rat

Building Site Development
Construction Materials
Disaster Recovery Planning

Land Classifications

Conservation Tree and Shrub Gr
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 Descr

View Options

Map
Table
Description of Rating
Rating Options

Advanced Options

View Description | View Rating

Map Legend

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

rigated Capability Class

Scale (not to scale)

Uc LaB LaG Bo RaB W AbB UaB LaD

Walnut St | School Ln | Continental Dr | Kiwanis Blvd | Sheaffer Rd | Clover Ln | Skybrook Ct | Chestnut St | Baugher Ave | Alpha Dr | Campus Rd | Hamilton Rd | Cedar St | Croft Ave

592ft

Soil Ratings Map may not be valid at this scale.

Tables — Nonirrigated Capability Class — Summary By Map Unit

Summary by Map Unit — Lancaster County, Pennsylvania

Done

- END

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