Emerging Trends in Soil Mapping and Interpretation

North Central Regional Soil Survey Conference

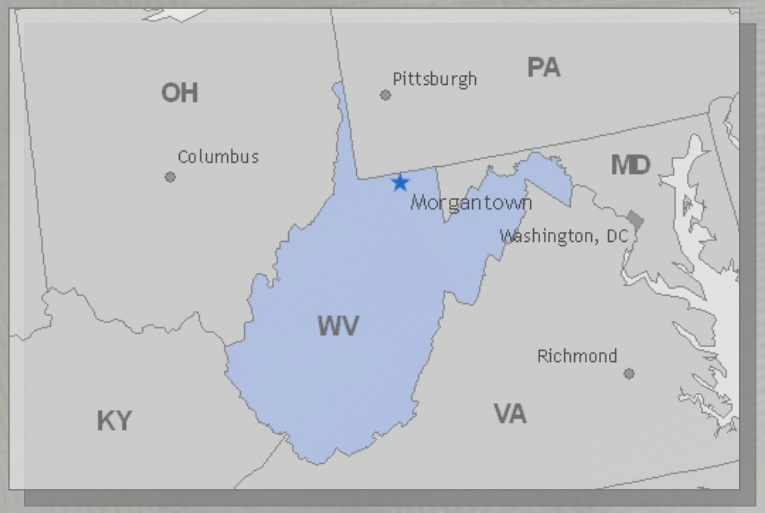
Amanda C. Moore
Natural Resources Conservation Service - National Geospatial Development Center
Morgantown, West Virginia

Medora North Dakota June 25-30 2007

- Overview of National Geospatial Development Center Staff and Functions
- Project Proposals
- NGDC Project Highlights
  - Series Extent Mapping, National Soil Geospatial Database, and Soil Resource Inventory Toolbox
- Creating and Using Data in the New Soil Survey
  - Digital Soil Mapping Processes and Standards
  - Spatial soil interpretations and soil decision support systems

National Geospatial Development Center

- Established in 2004 as a collaboration between NRCS and West Virginia University
- Located in Morgantown, WV on the WVU Downtown Campus
- Mission is to support business needs of the NRCS-Soil Survey and Resource Assessment Deputy Area through development and application of GIS and other technology tools



NGDC Organization

- ***NRCS Co-Director*** **– Jon Hempel**
  - **Reports to the Soil Survey Division Director**
- ***NRCS Staff*** **– 7 additional full time (1 term) positions**
  - **Jill Arnott, Administrative Assistant**
  - **David Arthur, Natural Resources Specialist ("01"-liasion)**
  - **Henry Ferguson, Soil Scientist/Database Specialist**
  - **Darrell Kautz, SSRA Business Analyst**
  - **Melissa Marinaro, Cartographer (Term)**
  - **Amanda Moore, Soil Scientist/GIS Specialist**
  - **Sharon Waltman, Soil Scientist/Spatial Data Analyst**
- ***NRCS Student Employees*** **– Two STEP Students**
  - **Soil Science and Geography**
- ***Contractors*** **– Two full time programmers on site**
  - **Sal Magnotta and Kirk VanGorkum, SAIC**
  - **Supported by West Texas Telecommunications Project**

NGDC Organization

- ***WVU Co-Director*** **– Dr. Jim Thompson, Assistant Professor, Plant and Soils Division, Davis College of Agriculture, Forestry, and Consumer Economics (started 5/2006)**
  - **Reports to Dean, Eberly College of Arts and Science**
- ***WVU Staff*** **– 1 additional full time position and 1-2 post-doc positions**
  - **Jim Canon, Network Administrator**
  - **Post-docs – currently unfilled**
- ***WVU Student Employees*** **– Currently 3**
  - **"NGDC Interns"**
  - **Includes undergraduate and graduate students (Masters and PhD) from Geography, Computer Science, and Creative Arts**

Collaboration with WVU

- ***Decision Support Systems to Support Interpretation and Use of Soil Survey Data*** **(Natural Resources Analysis Center, Dr. Mike Streger)***
- ***Cost/Benefit Analysis of Soil Survey Information*** **(Ag Economics, Dr. Jerry Fletcher)**
- ***Visualization Tools for Soil Survey*** **(Geology and Geography, Dr. Trevor Harris)**
- ***Multi-scale Terrain Analysis for Predicting Soil Distribution*** **(Plant and Soil Sciences Division, Dr. Jim Thompson)***

Other Collaboration

- **Within NRCS**
  - **Funding and business analysis for interpretation data join issues**
  - **Funding for continued development of "NASIS 2007"**
  - **Funding and input for continued development of Web Soil Survey and for hardware upgrades for the Web Farm**
  - **Funding to the Conservation Effects Assessment Program (CEAP) to develop Soil Quality Index tool**
  - **With NCGC, funding and evaluation of tablet PCs for field use**
  - **With NSSC, funding and collaboration to develop LIMS interface for inclusion of University soil lab data**
  - **Support travel for soil scientists to attend conferences, meetings, training, and details**

Data Acquisition

- NGDC occasionally acquires high resolution digital elevation data to support soil survey activities
- Intent of these acquisitions is to test various elevation data sources in a variety of landscapes to better understand their utility for soil mapping applications
- Data sets have been acquired for:
  - LiDAR: Essex County, VT; Winston County, AL; Pine County, MN (on-going); Jefferson County, WV
  - IFSAR: Johnson County, CA; Malheur County, OR; 5 county area in SD
- LiDAR datasets are freely available to all interested parties; IFSAR data can be freely distributed within NRCS and may be available to other cooperators on a case by case basis.

Project Proposals

- NGDC occasionally solicits research proposals in areas related to our mission
  - 2006 solicitation for digital soil mapping methods
  - Solicitation advertised through Cooperative Ecosystem Studies Unit (CESU) network infrastructure
    - Not as effective as we had hoped
    - Will pursue additional distribution methods for future solicitations
- Funding is arranged through the CESU Network
  - At least one investigator on a project has to be affiliated with an institution in the CESU network to be eligible for funding
- Key Issues
  - Support of NRCS State Soil Scientist
  - Technology Transfer from University to Local NRCS Soil Scientists and others
  - Student Training and Recruitment
- Proposals are reviewed by the NRCS National Leader for Soil Investigations and the NCSS Research Needs committee

Soil Series Extent Web Mapping Tool

- **A Macromedia Flash-based web application that allows users to *query for the geographic extent of a particular soil series or taxa***
- **Currently under development at the *Penn State University Center for Environmental Informatics***
- ***Provides interactive national maps* of individual soil series and other soil taxa extents based on the land area of series mapped in SSURGO 2.1 data provided by the Soil Data Mart**

Soil Extent Mapping Tool

NRCS PENNSTATE

Classification

Subgroup

Soil Order: VERTISOLS

Suborder: USTERTS

Great Group: HAPLUSTERTS

Subgroup Modifier: UDIC

Family

Particle Size: FINE

Particle Size Modifier:

Mineralogy: SMECTITIC

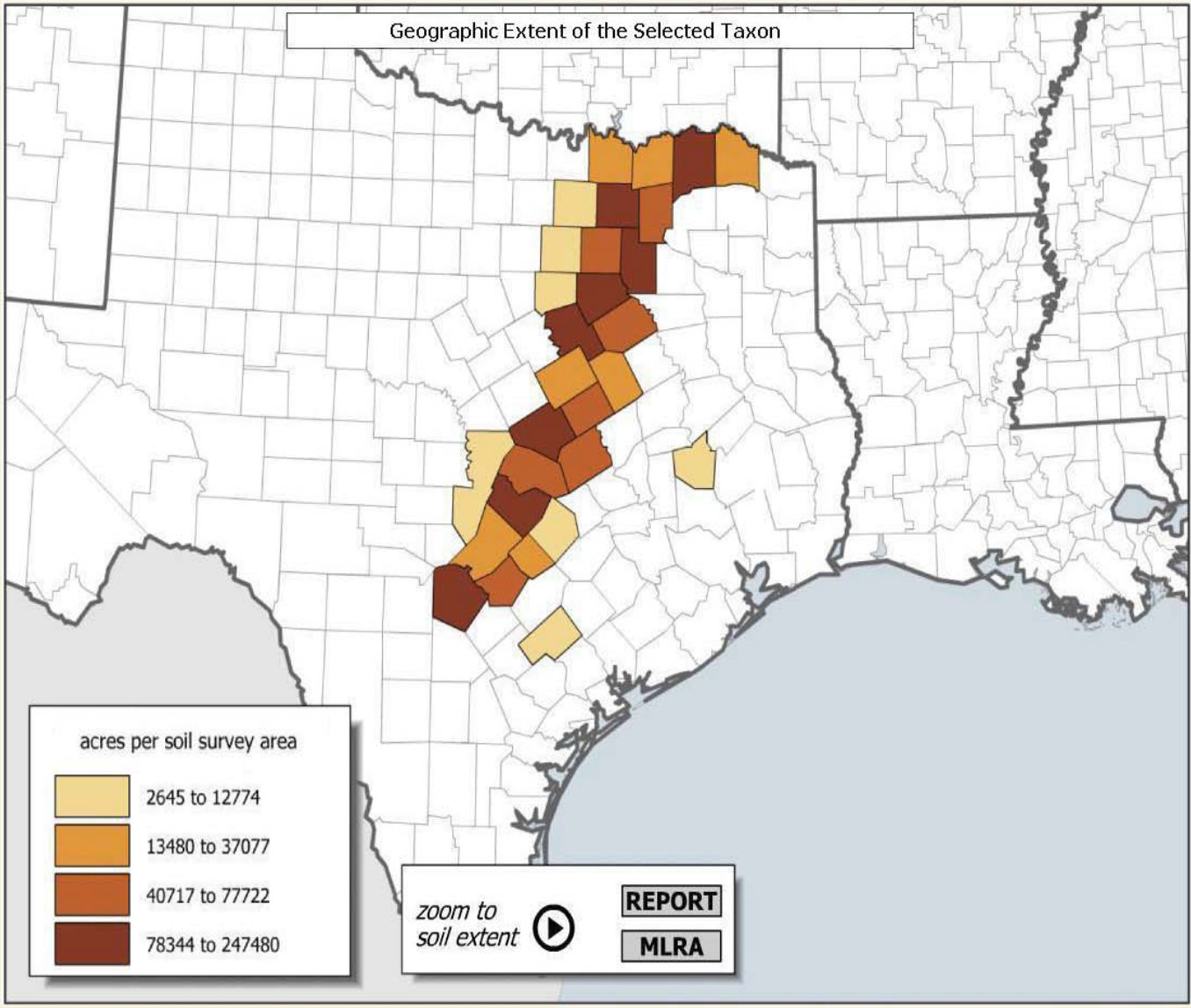
CEC Activity:

Reaction:

Soil Temperature: THERMIC

Other:

SEARCH



http://ortho.ftw.nrcs.usda.gov/cgi-bin/osd/TEST_osdnamequery.cgi

Soil Resource Inventory Toolbox

- ***A suite of tools designed to facilitate the process of capturing, analyzing, and evaluating soil survey information***
  - **Includes tools for Acquisition and Integration of Geospatial Data, Soil Spatial Data Check Out/Check In, Digital Data Editing, Geospatial Data Analysis, and Point Data Collection and Analysis**
- **SRITB is an off-shoot of the West Texas Telecommunications Project**
- **Current effort is a collaboration between NGDC, NCGC, soil scientists and GIS specialists from across the Soil Survey Division, and the private sector (SAIC – programmers)**
  - **An effort has been made to build on existing applications, rather than start from scratch**

Soil Resource Inventory Toolbox

- ***PedonPC (laptops, tablets) and PedonCE (PDA)*** **– tools for recording soil observations that allow direct import into NASIS –** ***were the first product*****.**
  - **These are available for download from NGDC**
- **Other tools in various stages of development include:**
  - ***Auto-population Tools*** **for automatically recording geographic information (based on ArcGIS) in Pedon PC/CE**
  - ***Point Data Analysis Tools*** **for querying, analyzing, and displaying point data from NASIS**
  - ***Streamlined ArcGIS editing tools*** **based on Digital Soil Survey and Mapping Course protocols optimized for laptops and tablet PCs (e.g. compact toolbar footprints)**

SSURGO Data and the MLRA Soil Survey Office

- ***National Soil Geospatial Database*** **(NSGD) including "Check out/Check in" functionality**
- **Supports the Soil Survey Division strategic goal of achieving a *national, seamless soil geographic database***
  - **For pedons, detailed soil survey maps, general soil maps, major land resource area maps, and higher level soil region maps with their associated attributes**
- **Goal of the NSGD is a *science-based, geospatially-enabled National Soil Informational System* that improves performance in meeting NRCS conservation mission, as well as general public need, for useful, defensible, and scalable (in space and time) soil geographic information**

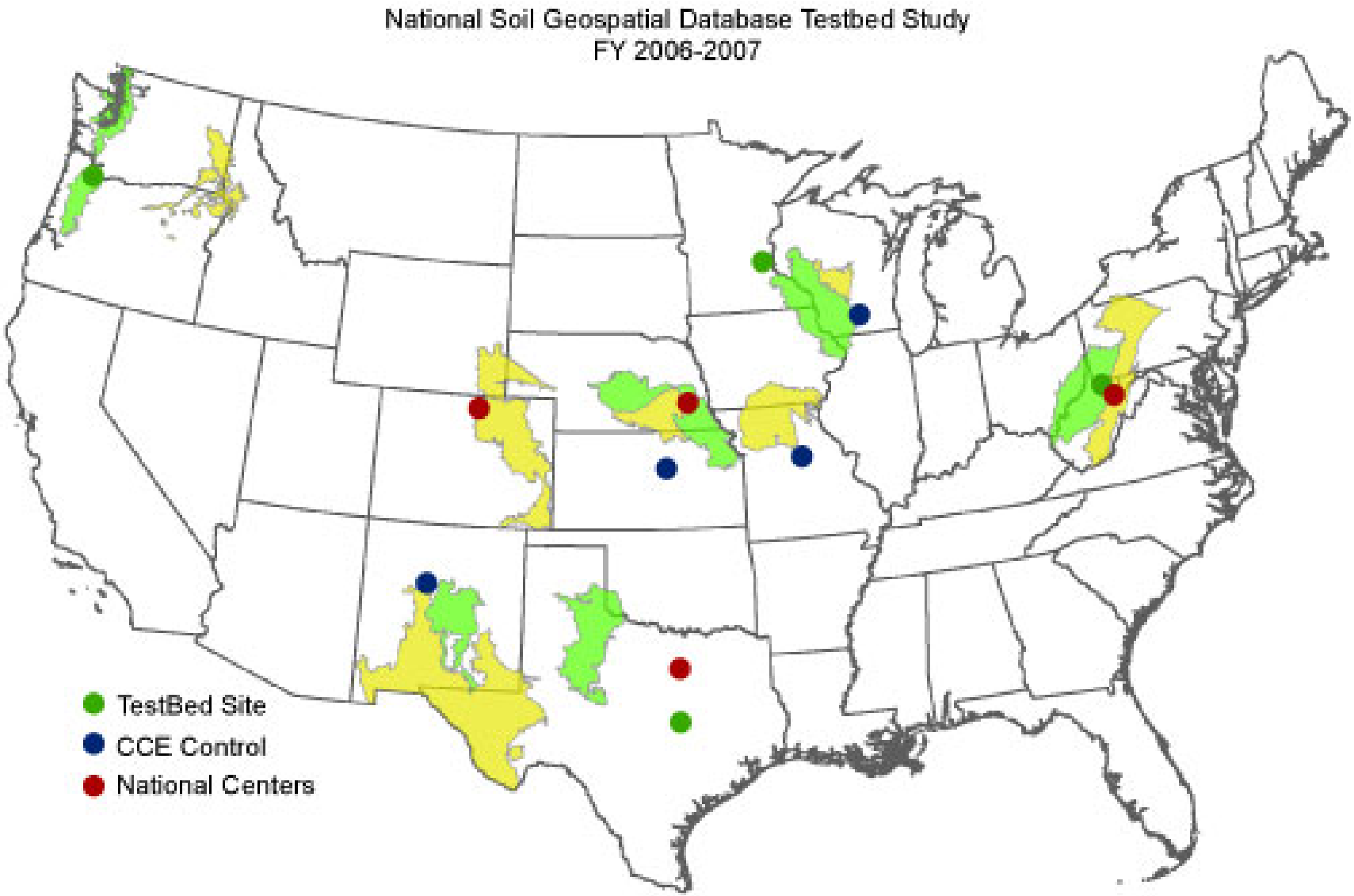
National Soil Geospatial Database

- **Working Definition:**
  - ***A national collection of soil geographic vector data needed to conduct soil survey operations (includes QA/QC) and that meets most users' requirements. Connection and processes between spatial and tabular data are transparent to the user and allow the user to obtain timely, consistent, accurate, and reliable soil geographic data products.***

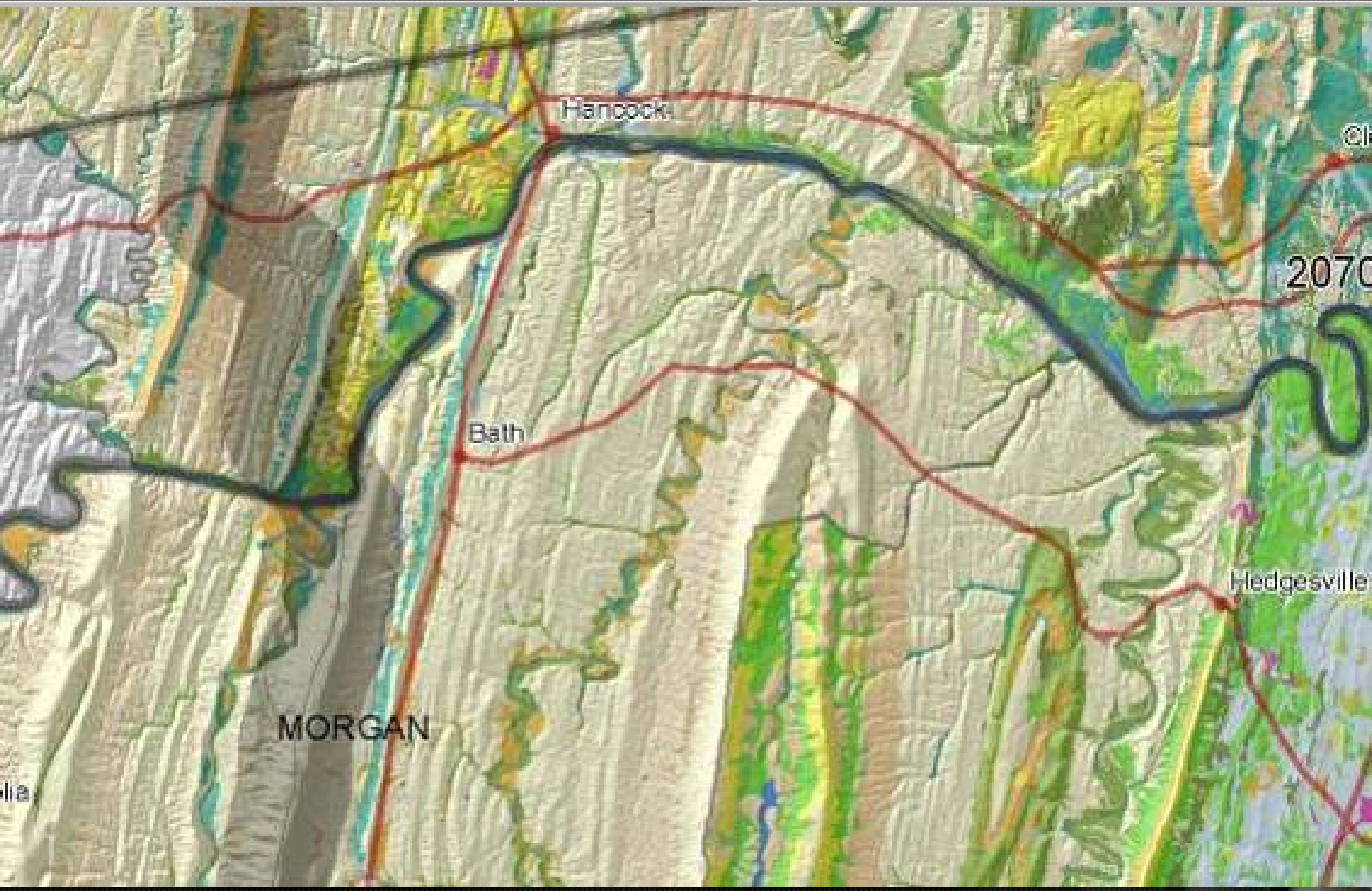
National Soil Geospatial Database

- **Implementation**
  - **An ArcGIS environment (centralized and distributive) for geographic development (digitizing line work and point data locations) or evaluation (correlation) of existing SSURGO data linked to NASIS legends and attributes, NSSL laboratory data, pedon descriptions using terrain analysis, visual examination, simulation models, and predictive soil modeling with the purpose of providing seamless map unit concepts across MLRAs.**
  - **Based on ESRI ArcSDE/Microsoft SQL Server framework**

Locations of SDE Test Sites



Root Zone Available Water Capacity computed using SSURGO



Digital Soil Mapping

- **A variety of digital soil mapping (predictive soil modeling) methods are rapidly being incorporated into NRCS soil survey procedures across the US**
  - **Methods range from *on-screen digitizing* of soil lines, use of *GPS* to capture point observation locations, *GIS analysis of digital elevation models and multispectral imagery* to produce preliminary soil maps, to the *development and application of formal predictive soil models***
- **Current NRCS Predictive Soil Modeling efforts favor a knowledge-based approach to modeling the distribution of soil series or soil map units across a geographic area**

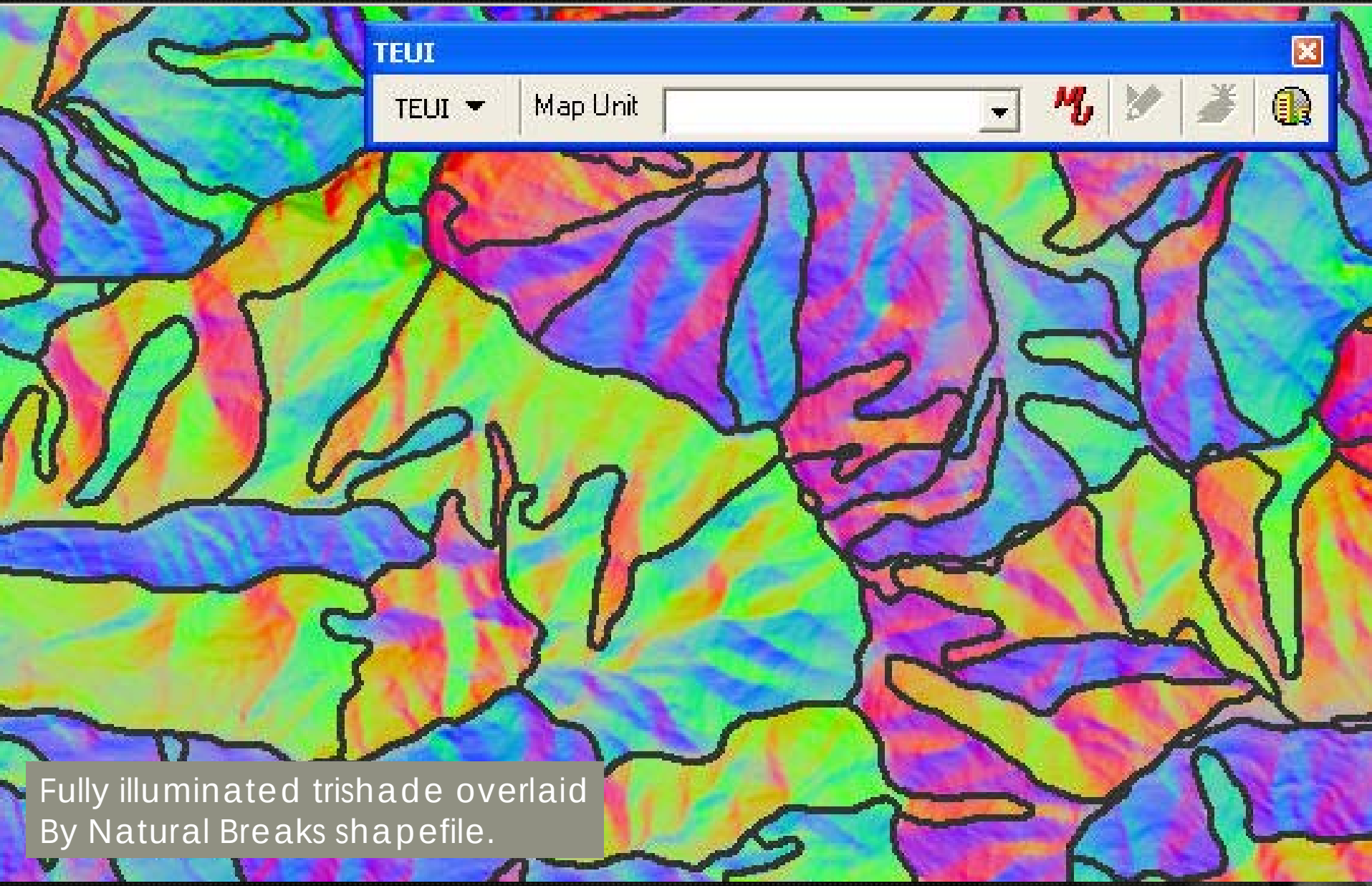
Digital Soil Mappig

- Currently funding several predictive soil modeling projects
  - Essex County, VT-Dr. Xun Shi, Dartmouth University, Vermont NRCS
  - Chester County, PA-Dr. Rick Day, Penn State University, Pennsylvania NRCS
  - Dane County, WI-Dr. A-Xing Zhu, Dr. Jim Burt, Dr. Cynthia Stiles (evaluation of inferenced data for Dane County), Wisconsin NRCS
  - North Cascades National Park Remote Area Soil Proxy(RASP)-Dr, Bruce Frazier, Washington State University
  - TEUI (Terrestrial Ecological Unit Inventory) toolkit-Pilot projects in Alabama, Texas and Nevada
  - Solicitation for FY 06 for predictive modeling (we hope to fund as many as 5 projects)
- In the process of initiating a cooperative project to develop the business requirements an inclusive, integrated suite of tools and methods that will allow for the widespread implementation of PSM within NRCS

Digital Soil Mapping Toolkit

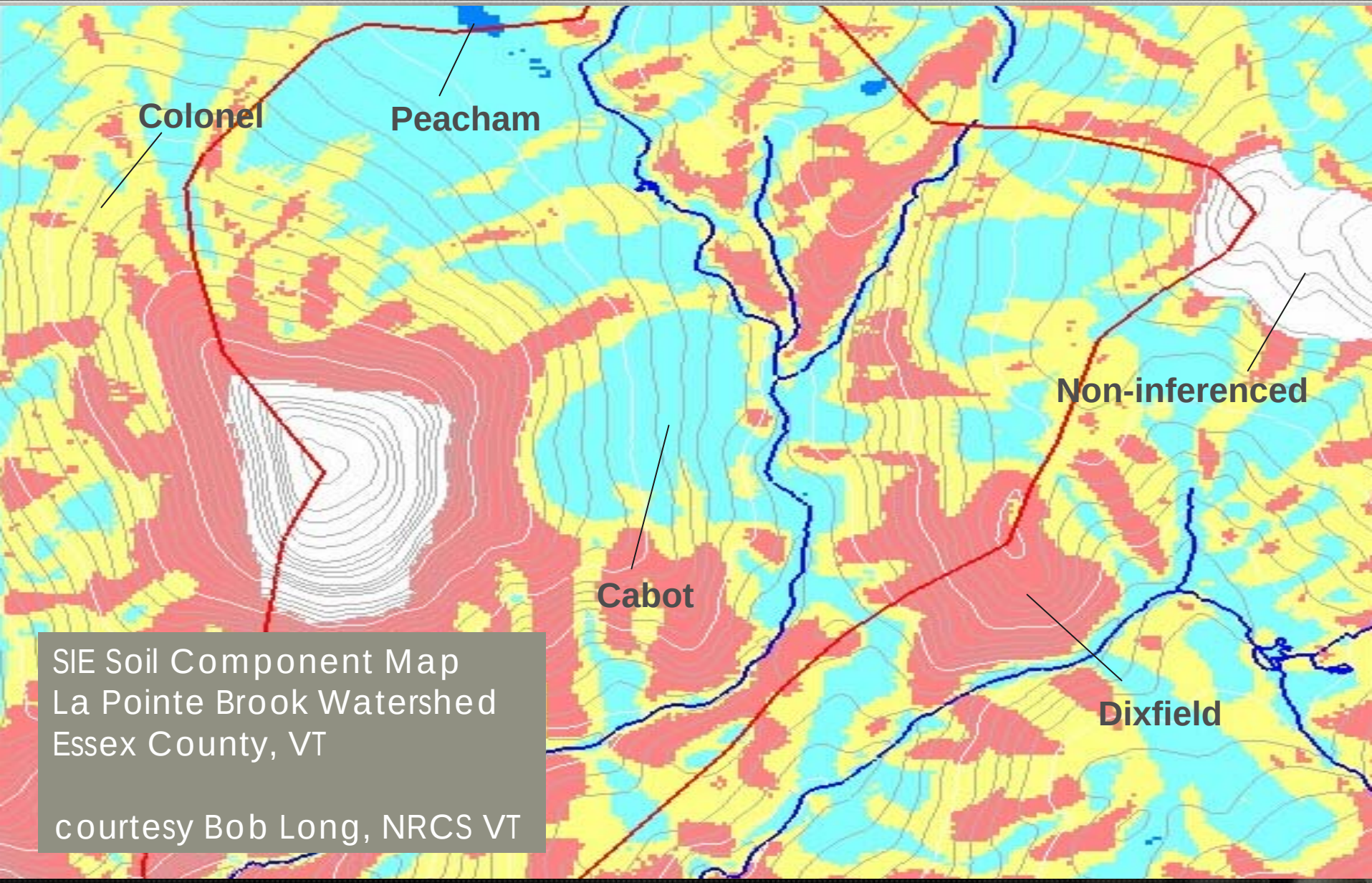
- ***Terrain and image analysis tools*** **and/or instructions to assist with preparation of GIS data layers for use in subsequent modeling processes**
- ***Knowledge acquisition tools*** **and/or instructions to acquire detailed information about soil-landscape relationships from soil scientists or other experts**
- ***Data mining and exploration tools*** **and/or instructions to extract knowledge of soil-landscape relationships from existing soil survey data and to develop knowledge in previously unmapped areas (e.g. guided sampling approaches, landscape segmentation, etc.)**
- ***Modeling routines to combine GIS data layers into soil maps*** **based on information about soil-landscape relationships discovered from knowledge acquisition and data mining tools. Routines would include fuzzy and crisp logic implementations and would allow for a variety of combination methods and knowledge inputs.**
- ***Map validation tools*** **and/or instructions to aid in the selection of sample points and analysis of data to determine the accuracy of raster and vector soil map products.**
- ***Aggregation and vectorization tools*** **and/or instructions to facilitate the grouping of individual pixels into regions or polygons (e.g. map units) based on survey requirements.**

USFS Terrestrial Ecosystem Unit Inventory Toolkit



Fully illuminated trishade overlaid
By Natural Breaks shapefile.

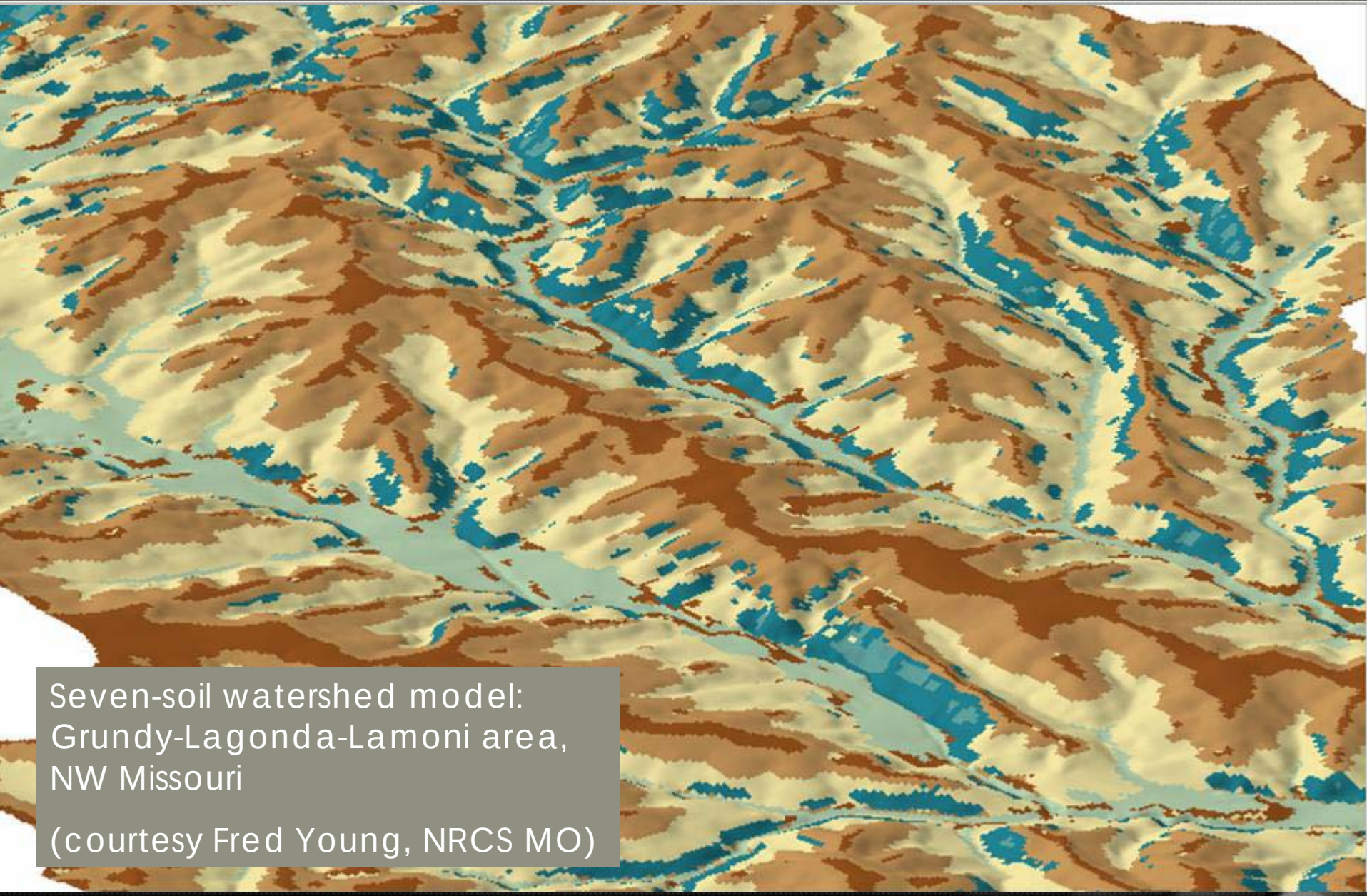
Soil Inference Engine (SIE) Output



SIE Soil Component Map
La Pointe Brook Watershed
Essex County, VT

courtesy Bob Long, NRCS VT

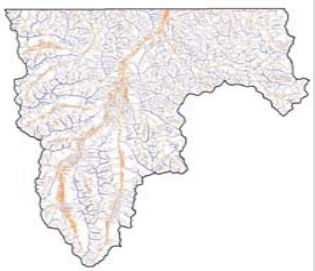
Soil Land Inference Model (SoLIM) Output

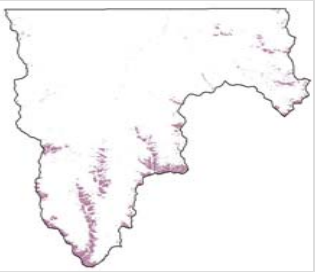


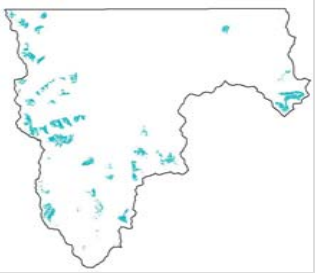
Seven-soil watershed model: Grundy-Lagonda-Lamoni area, NW Missouri

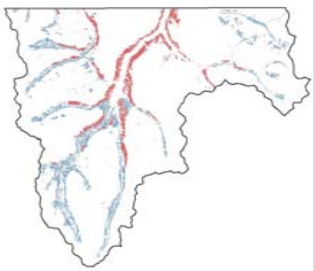
(courtesy Fred Young, NRCS MO)

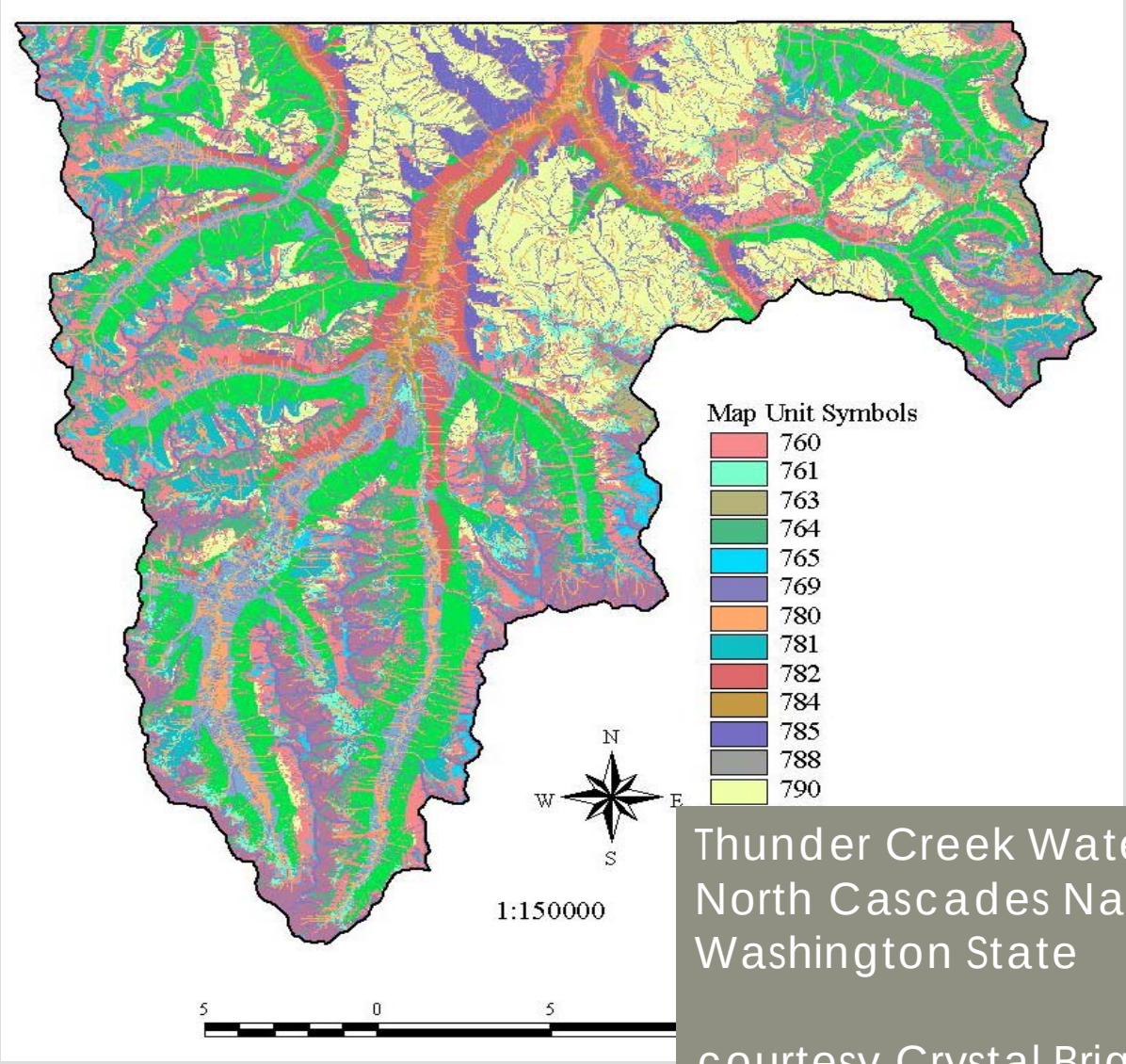
Remote Access Soil Proxy Output

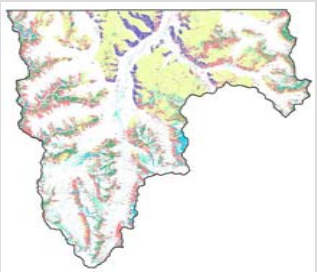


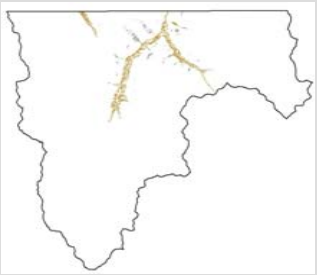












Thunder Creek Watershed
North Cascades National Park
Washington State

courtesy Crystal Briggs, NRCS WA

Framework for Digital Soil Mapping

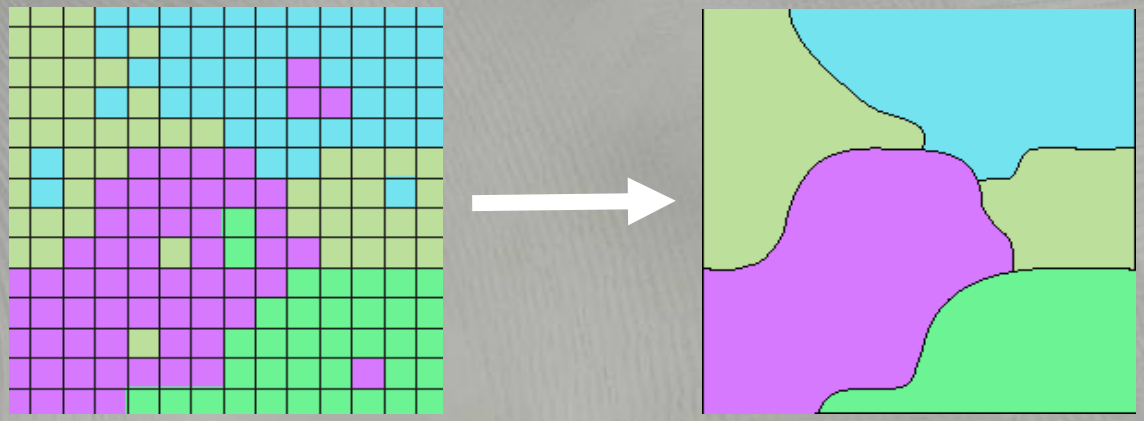
- ***Digital Soil Mapping Guidelines are needed to effectively and efficiently integrate digital soil mapping methods into the NCSS on a national basis*, and subsequently to support the appropriate use, management, and maintenance of the resulting data.**
- **The *primary objectives of a DSM framework are to maintain consistency and enhance scientific credibility of digital soil map products* through the development of guidelines and recommendations for producing and using digital soil map products.**
- **This issue is being addressed at the regional NCSS meetings, and we hope that it will be elevated to the national New/Applied Technology and Standards committees as a charge for the 2007 NCSS meeting**

Framework for Digital Soil Mapping

- **Appropriate DEM Resolution/Neighborhood Size for computing terrain attributes remains an important question**
  - **Differs based on:**
    - **Kinds of landscape features present**
    - **Amount of variability**
    - **Order and scale of soil survey**
  - **Can dramatically affect the computed terrain values and subsequently the predicted soil values**

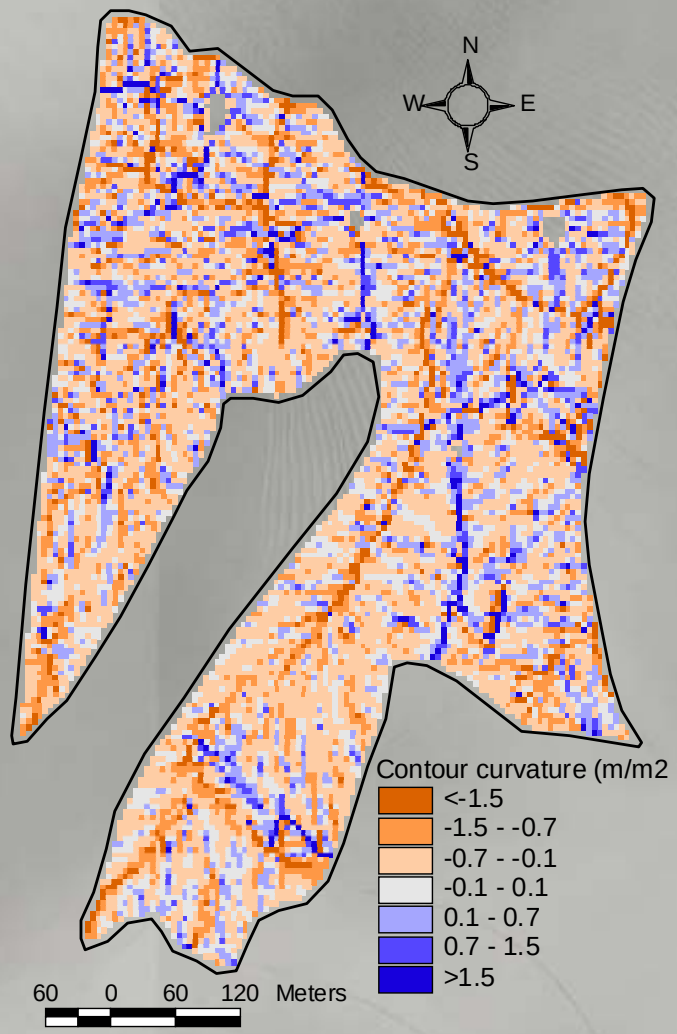
Soil Survey Interpretation and Use

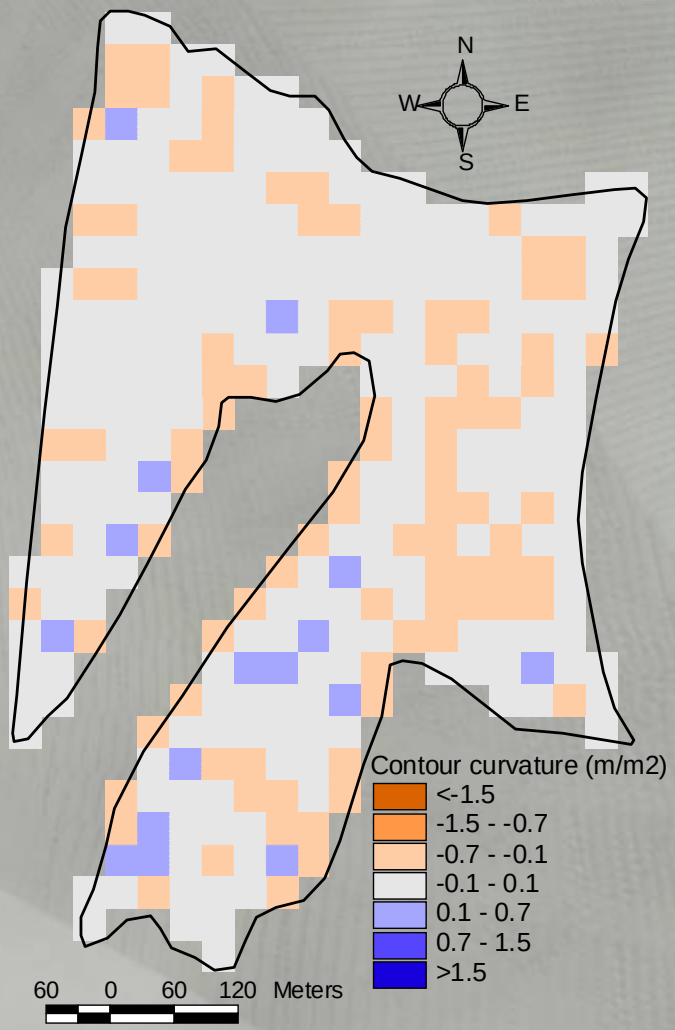
- **Initial output of many digital soil mapping methods – especially those based on terrain and image analysis – is in raster format**



- **As we begin building a high resolution raster database of soil survey information (regardless of the data model used to represent the official soil survey data), the NCSS has an opportunity to transform the interpretation, use, and display of soil survey data as well.**

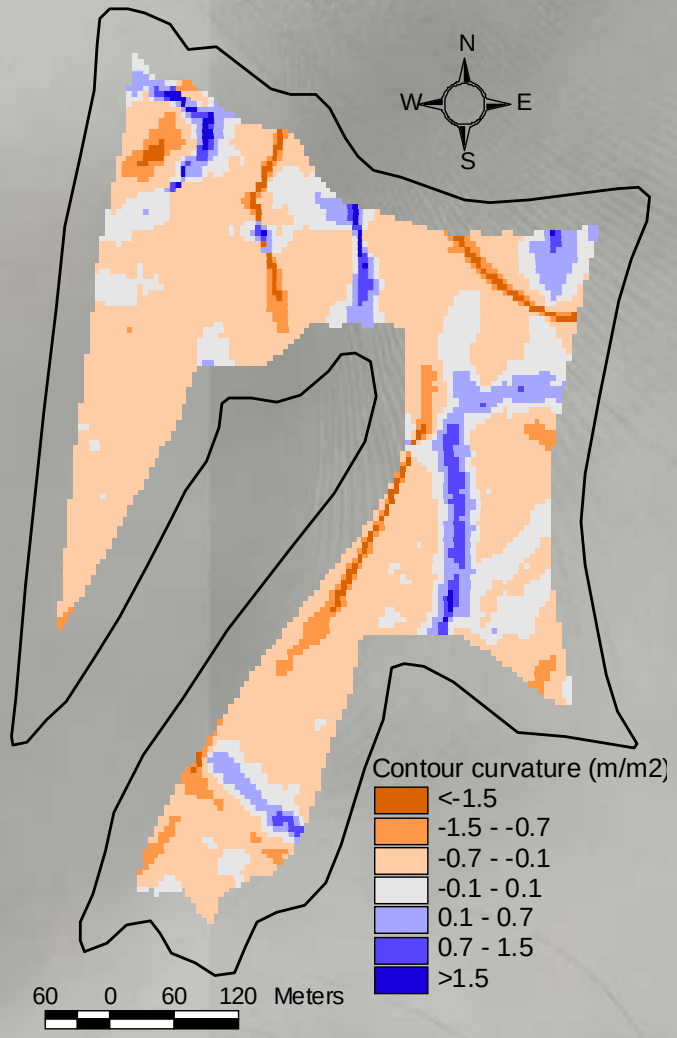
Resolution Effects

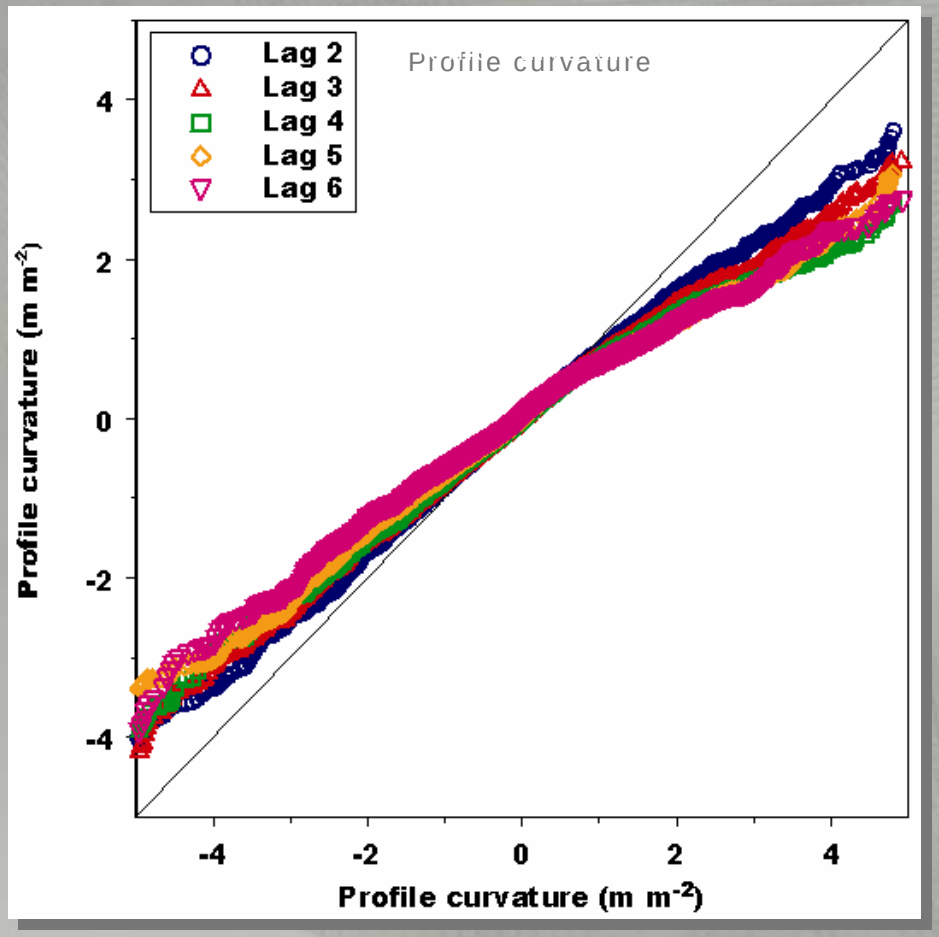




Courtesy of Jim Thompson

Terrain Attribute Calculation





Courtesy of Jim Thompson

Soil Survey Interpretation and Use

- **Feature-specific attribution**
  - **Allow for variations in map unit properties across the geographic extent of the map unit (e.g. % composition, representative slope)**
- **Explicit spatial representation of soil components**
  - **Facilitates understanding and use of soil survey data – especially by non-expert users**
  - **Eliminates need to aggregate complicated multi-component soil map units to single value prior to GIS analysis (e.g. aggregate by dominant component, most limiting condition, etc.)**
  - **Provides more realistic representation of soil distribution**

Soil Survey Interpretation and Use

- **Soil Decision Support Systems**
  - **Typically focused on exploring and solving a specific problem or type of problem**
    - **Optimal locations for wetland restoration**
    - **Locations for emergency disposal of animal carcasses**
  - **Allow multiple criteria to influence the decision**
    - **Social considerations**
    - **Environmental considerations**
    - **Economic considerations**
  - **And, in a GIS, can allow for SPATIAL considerations**
    - **That is, regardless of soil characteristics, the middle of an elementary school playground is not a good place to bury a bunch of dead chickens**

Questions?

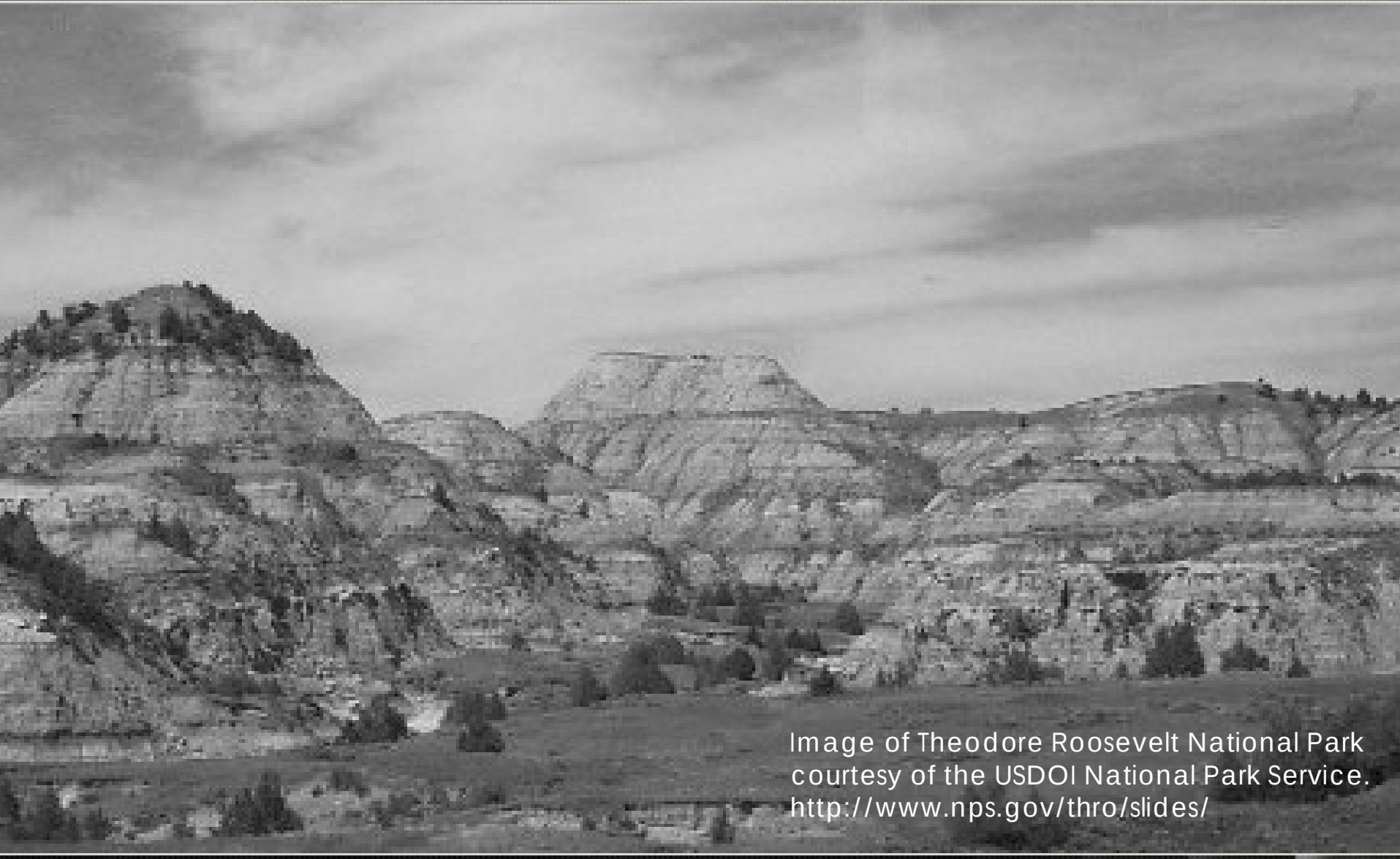


Image of Theodore Roosevelt National Park
courtesy of the USDOI National Park Service.
http://www.nps.gov/thro/slides/