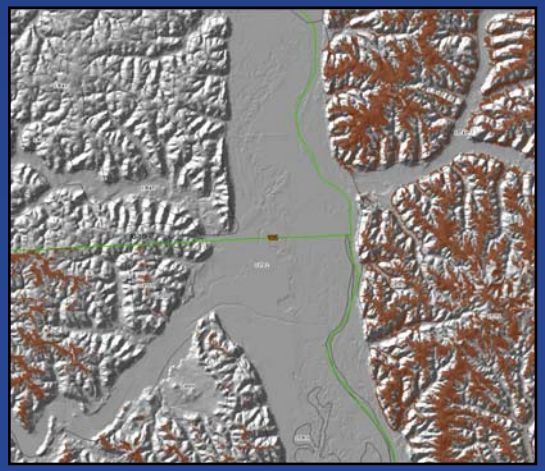
United States Department of Agriculture
Natural Resources Conservation Service

USDA NRCS

GIS Assessment and Modeling to Support Soil Landscape Correlation

Southern Regional Cooperative Soil Survey Conference

July 17, 2008



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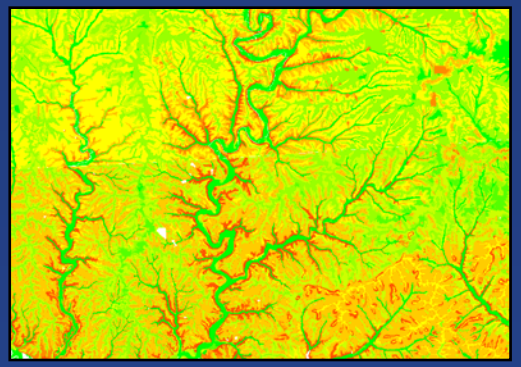
USDA-NRCS
National Geospatial Development Center
Morgantown, WV

Introduction



- Laws of Krynine
  - Let us see things in their proper places
  - Let us know what we are talking about
  - Let us think straight
  - Let us not fool ourselves

P.D. Krynine, known as the Father of Sedimentology, practiced Sedimentary Petrology in the 1930's - 1950's

Abstract

- A review of GIS methods for modeling and performing MLRA-wide landscape assessments that support soil landscape correlation decision making is presented.
- These methods include use of the USDA-NRCS Soil Survey Program Core Data Layers in ArcGIS File Geodatabase format to conduct various spatial and attribute queries.

- Examples of spatial queries include the intersection of MLRA / MLRA Soil Survey Area perimeters with Soil Survey Geographic Database (SSURGO) polygons to create selected sets for the purpose of interrogating the published Soil Data Mart (SSURGO) attributes.

- Examples of attribute queries include dominant component queries for specific soil series within the US General Soil Map or GSM (aka STATSGO2) map and the SSURGO map layers.
- In addition, summed component percentage queries for a given soil series plus selected soil taxonomic queries are demonstrated.

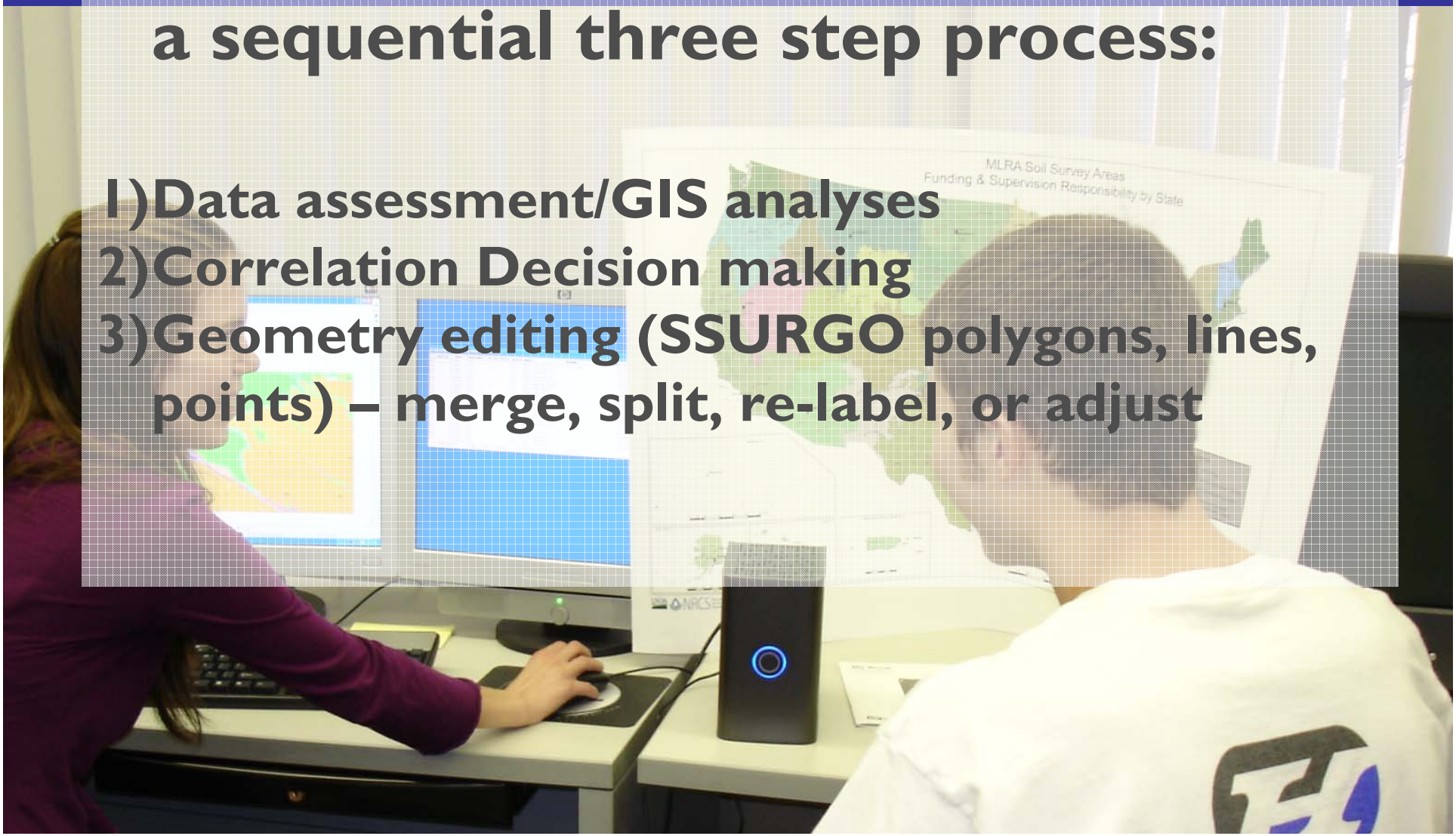
- An example of Digital Soil Mapping (DSM) modeling called soil map unit disaggregation is examined for Alaska landscapes.
- Gridded landform metrics are modeled to predict the "un-mappable" SSURGO vector map unit components. The result is the mapping of the "un-mappable" SSURGO vector map unit polygon components in a raster map layer.

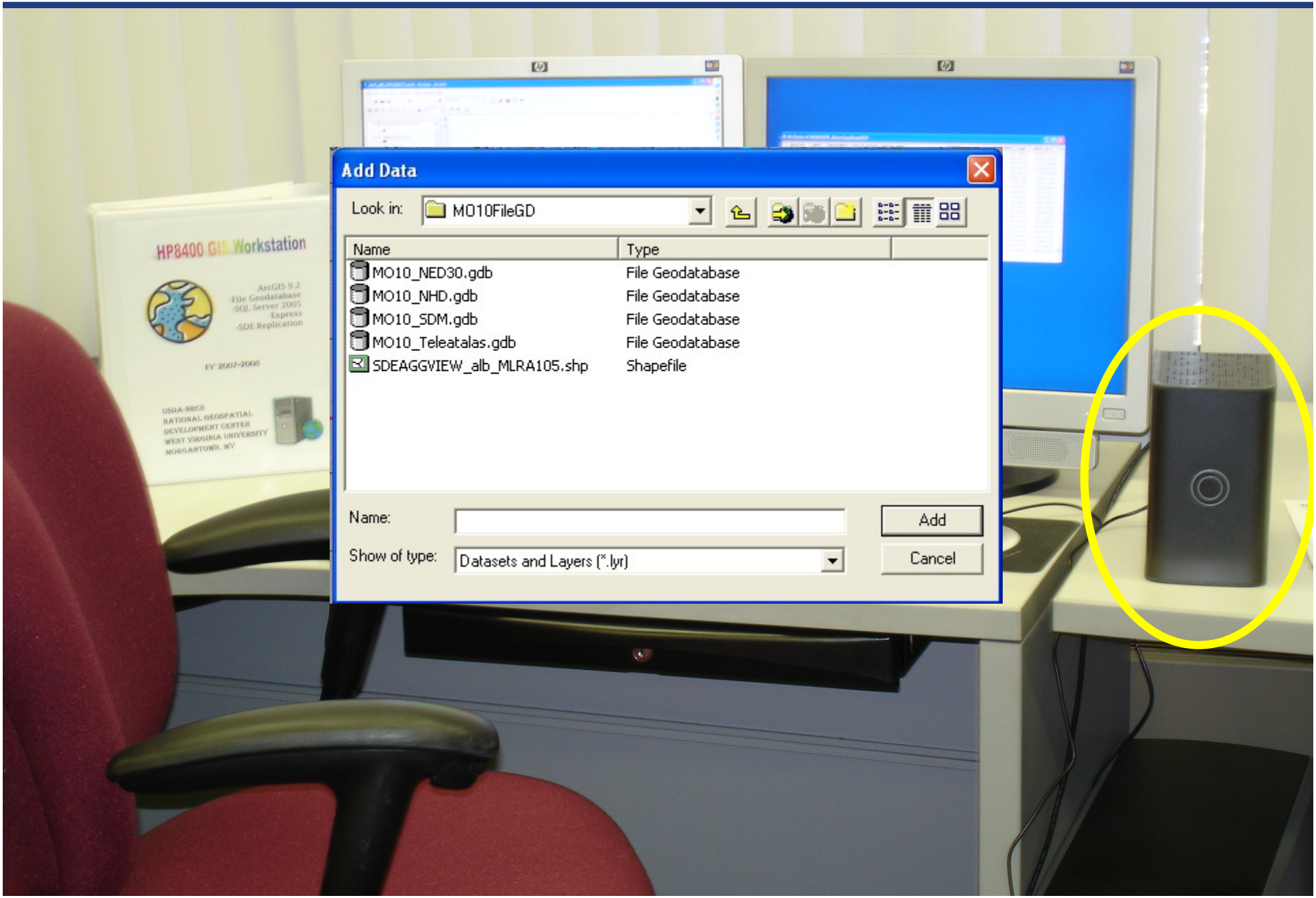
- Revised polygon level SSURGO vector map unit components are summarized to enhance overall map unit composition for the study area
- The described GIS methods are recommended for use during evaluation of the existing published digital soil survey or historic record to assist in soil landscape correlation decision making during MLRA Update soil survey project.

- This process is outlined in the newly developed Management of Soil Survey by MLRA course.

Geospatial Data assessment is part of a sequential three step process:

1) Data assessment/GIS analyses
2) Correlation Decision making
3) Geometry editing (SSURGO polygons, lines, points) – merge, split, re-label, or adjust




Add Data
Look in: MO10FileGD
Name
Type
MO10_NED30.gdb
File Geodatabase
MO10_NHD.gdb
File Geodatabase
MO10_SDM.gdb
File Geodatabase
MO10_Teleatalas.gdb
File Geodatabase
SDEAGGVIEW_alb_MLRA105.shp
Shapefile
Name:
Show of type: Datasets and Layers (*.lyr)
Add
Cancel
HP8400 GIS Workstation

Introduction

- FGDB of core data layers
  - DEM (NEDS)
  - Hydrography (National Hydrology Dataset-NHD)
  - Soils (SDM FY07 Q3 – next edition soon)
  - TeleAtlas reference layers (roads, zip codes, counties, states, etc.)
- Combine with Web Map Service through NCGC (e.g DOQQ imagery)

Management of Soil Survey by MLRA Course

- Marc Crouch is point of contact
- Roles/Responsibility and Soil Correlation
- Evaluation of historic soil survey
- Prioritization and planning
  - MLRA (long range) work plan (e.g. MLRA 105)
  - Project (mid range) plan (MLRA SSA 10-10)
  - Annual work plan (plan of operations)

Management of Soil Survey by MLRA Course

- Project Management
- Role of Benchmark Soils
- Assessment/Evaluation/Validation
  - geospatial and attribute
- Correlation Decision Making
- Certification and publication

Working with File Geodatabases (new in ArcGIS 9.2)

- A set of instructions introduces relationship classes and provides examples of how to use them.
- http://www.ngdc.wvu.edu/software

Microsoft Word Document

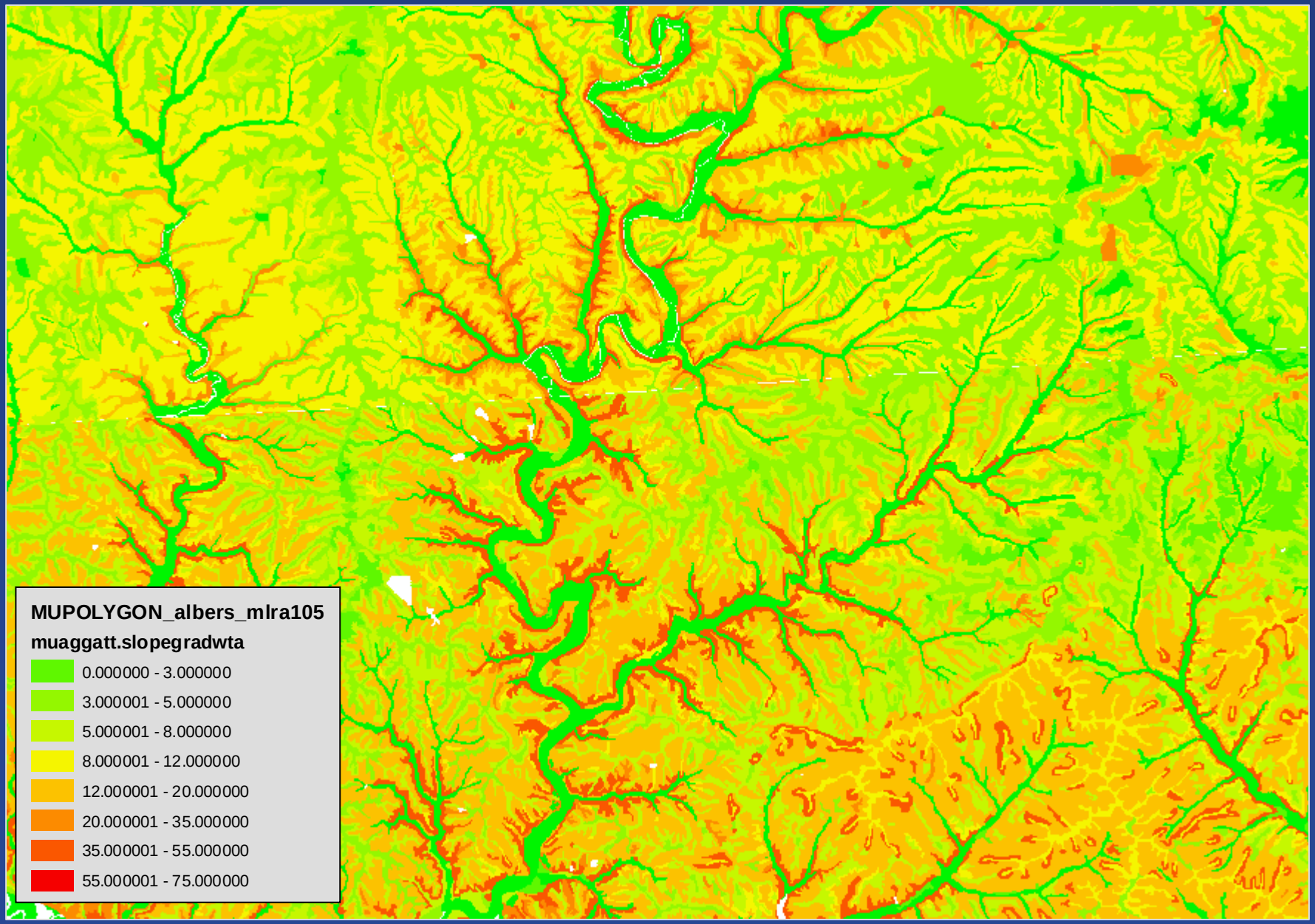
Using the Mapunit Aggregate Table

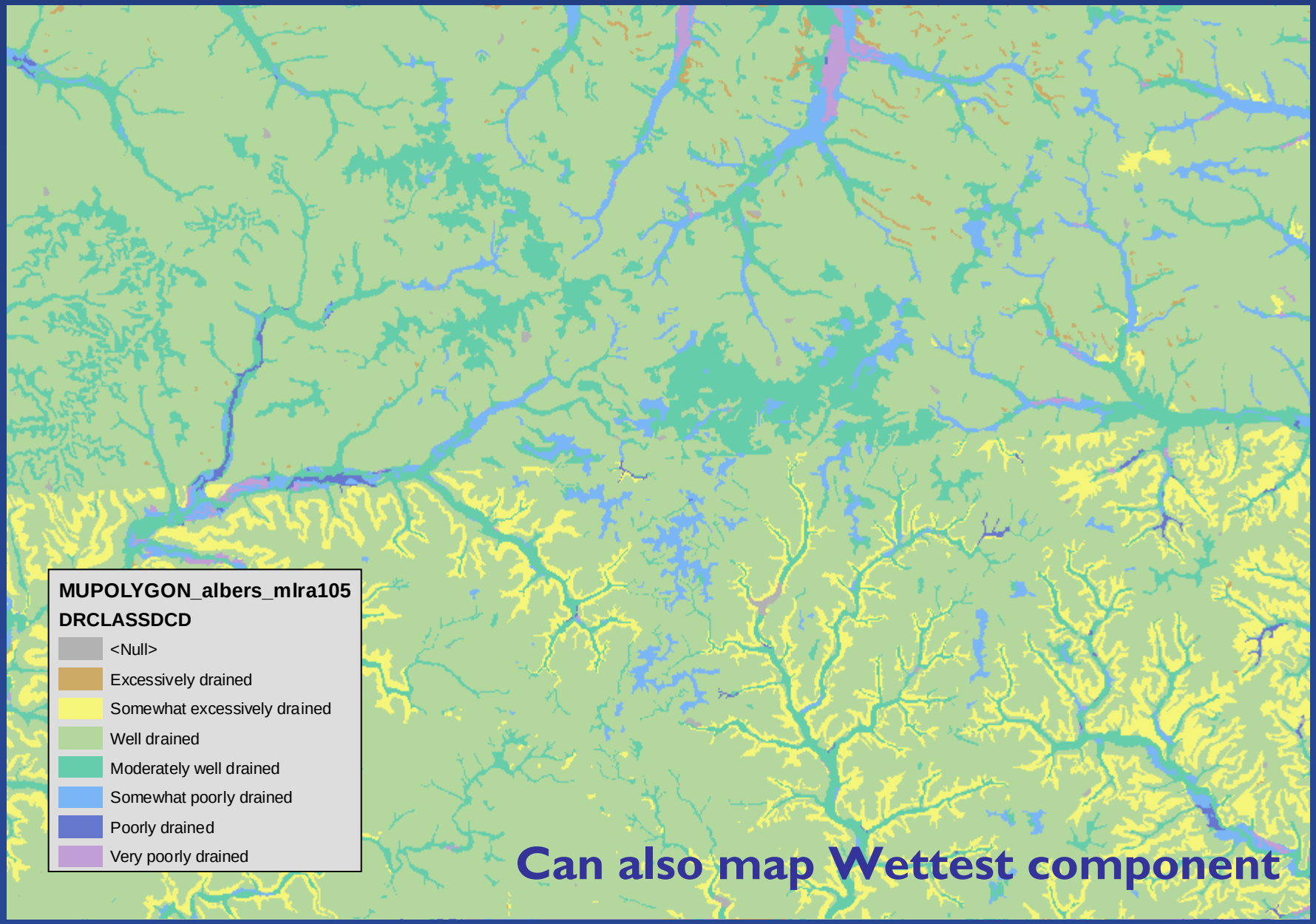
- Part of the standard SSURGO download
  - Included in MO-wide file geodatabase
- Includes variety of soil attributes and interpretations that have been aggregated from the component level to a single value at the map unit level
- Can be joined to the MUPOLYGON feature class for easy mapping

Using the Mapunit Aggregate Table

- Fields include
  - Slope gradient, bedrock depth, water table depth, flooding frequency, ponding frequency, available water storage, drainage class, hydrologic group, et.c…
- Refer to the SSURGO Metadata Table Columns Description report for a complete list of columns and their associated aggregation methods
- http://soildatamart.nrcs.usda.gov/documents/SSURGOMetadataTableColumnDescriptions.pdf

Slope Gradient and Drainage Class


MUPOLYGON_albers_mlra105
muaggatt.slopegradwta
0.000000 - 3.000000
3.000001 - 5.000000
5.000001 - 8.000000
8.000001 - 12.000000
12.000001 - 20.000000
20.000001 - 35.000000
35.000001 - 55.000000
55.000001 - 75.000000



Can also map Wettest component

Analyzing Data Outside of ArcGIS

- Soil attribute data can be analyzed and summarized in
  - NASIS
  - MS Access (SSURGO Template), 2 GB limit
  - SQL Server Enterprise, no size limit
  - SQL Server Express, 4 GB limit
  - Excel .xls and Dbase4 .dbf (~60,000 record limit)
  - Other…

Analyzing Data Outside of ArcGIS

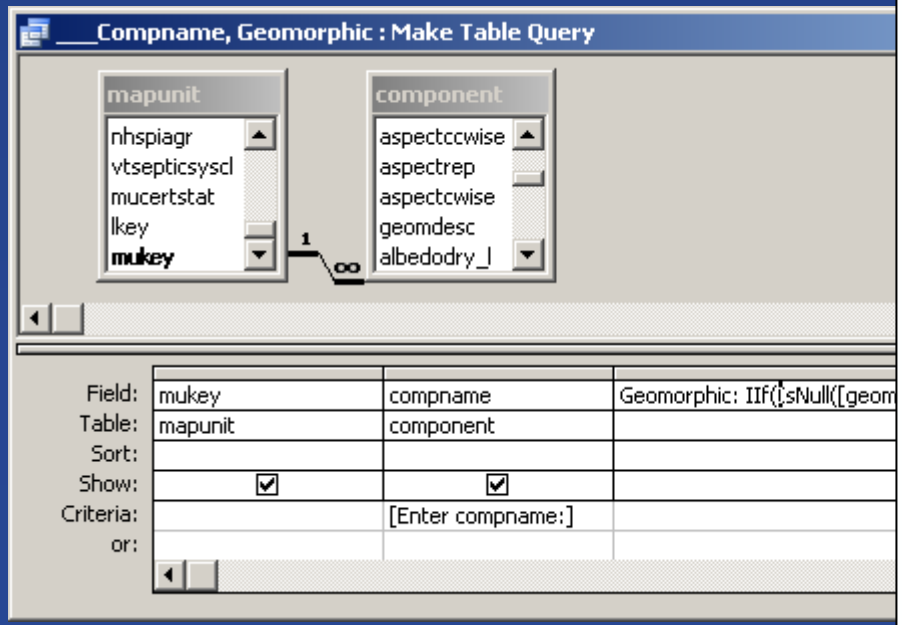
- Tables and queries developed in these systems can be mapped in ArcGIS, provided that MUKEY is included and the attribute summarized or aggregated to the map unit level
- Save or export queries and reports as *.dbf files, then join (or relate) using the MUKEY to the MUPOLYGON feature class for visualization
  - Can join all records or only matching records

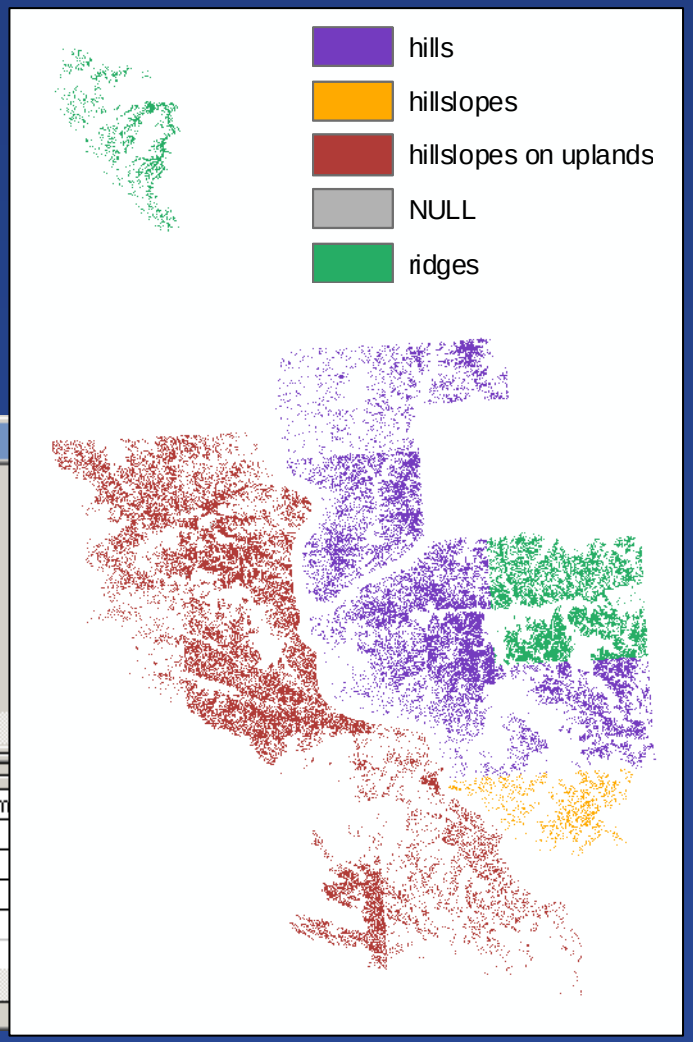
Working with Soil Data Mart Data in Raster Format

- At small scales (large extents), raster data may display more quickly in ArcMap than vector data
  - Depends on pixel size
- In ArcGIS 9.2, rasters in various formats can be joined directly to other tables (*.dbf files, tables in file geodatabases, etc.)
- MUPOLYGON_AlbersEqualAreaUSGS feature class
  - Grid on MUKEY (this is possible in Arc 9.2)
  - 10 or 30 meter cell size is recommended
  - Join to *.dbf / *.xls files on MUKEY

Raster Data Images

- MLRA 105
- Geomorphic Description, Dubuque Soils



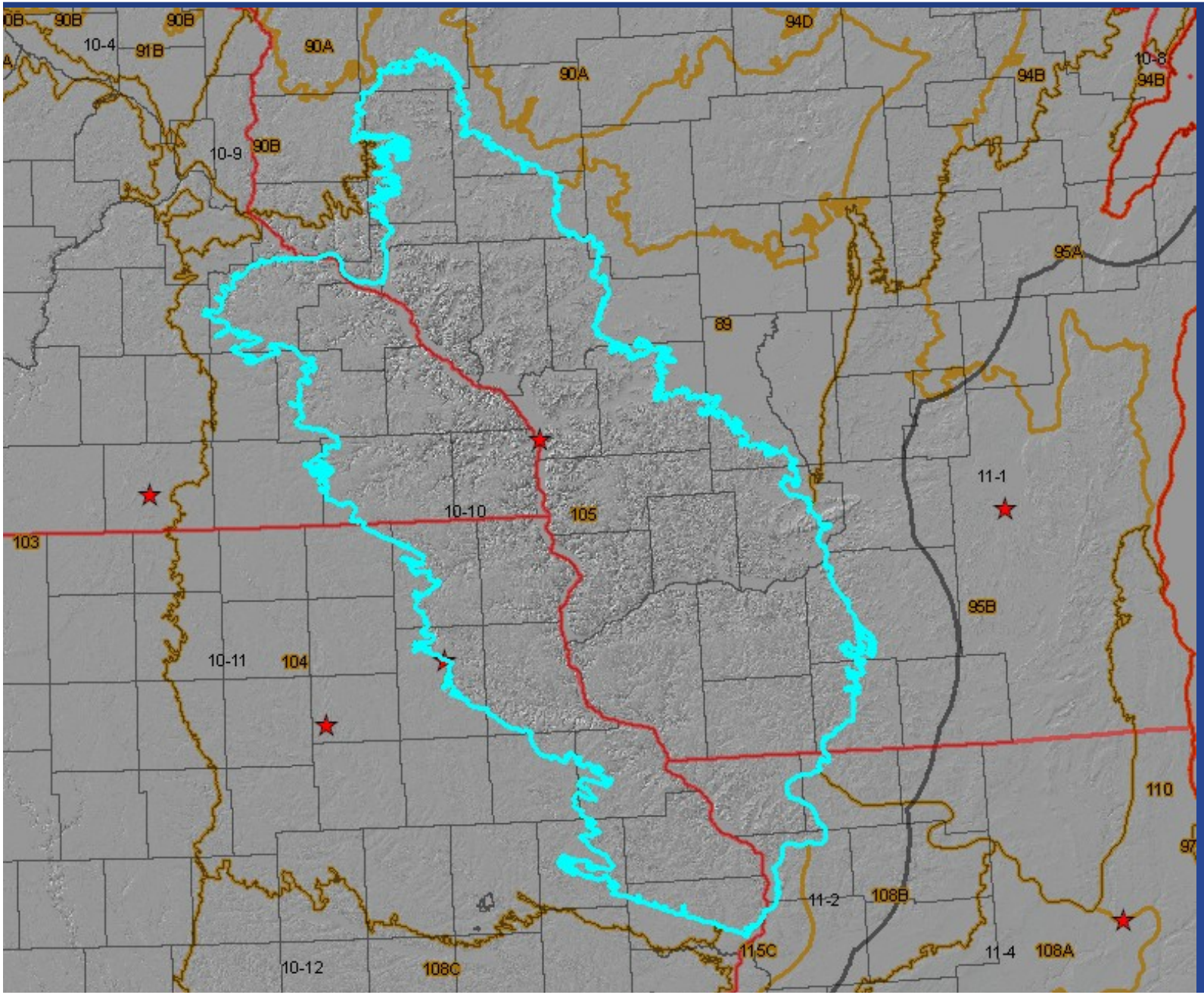


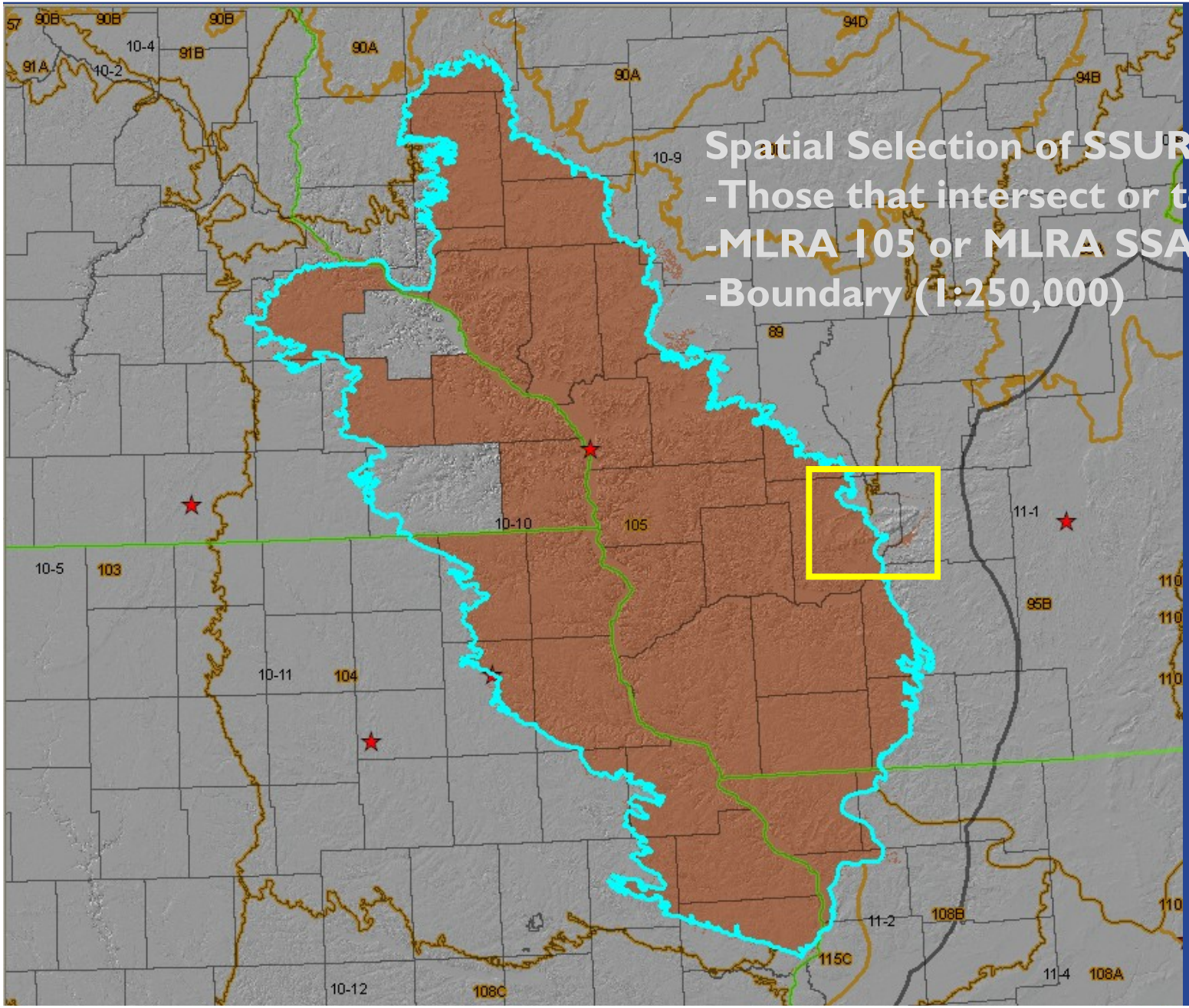
Analyzing Data Outside of ArcGIS

- Using MS SQL Server Enterprise or MS SQL Server Express to prepare MO-wide and Nation-wide queries
  - Major Component queries – Series
  - All component queries – Series
    - Summed Component Percent for each map unit
  - All component queries – Taxonomic
    - Summed component Percent for each map unit

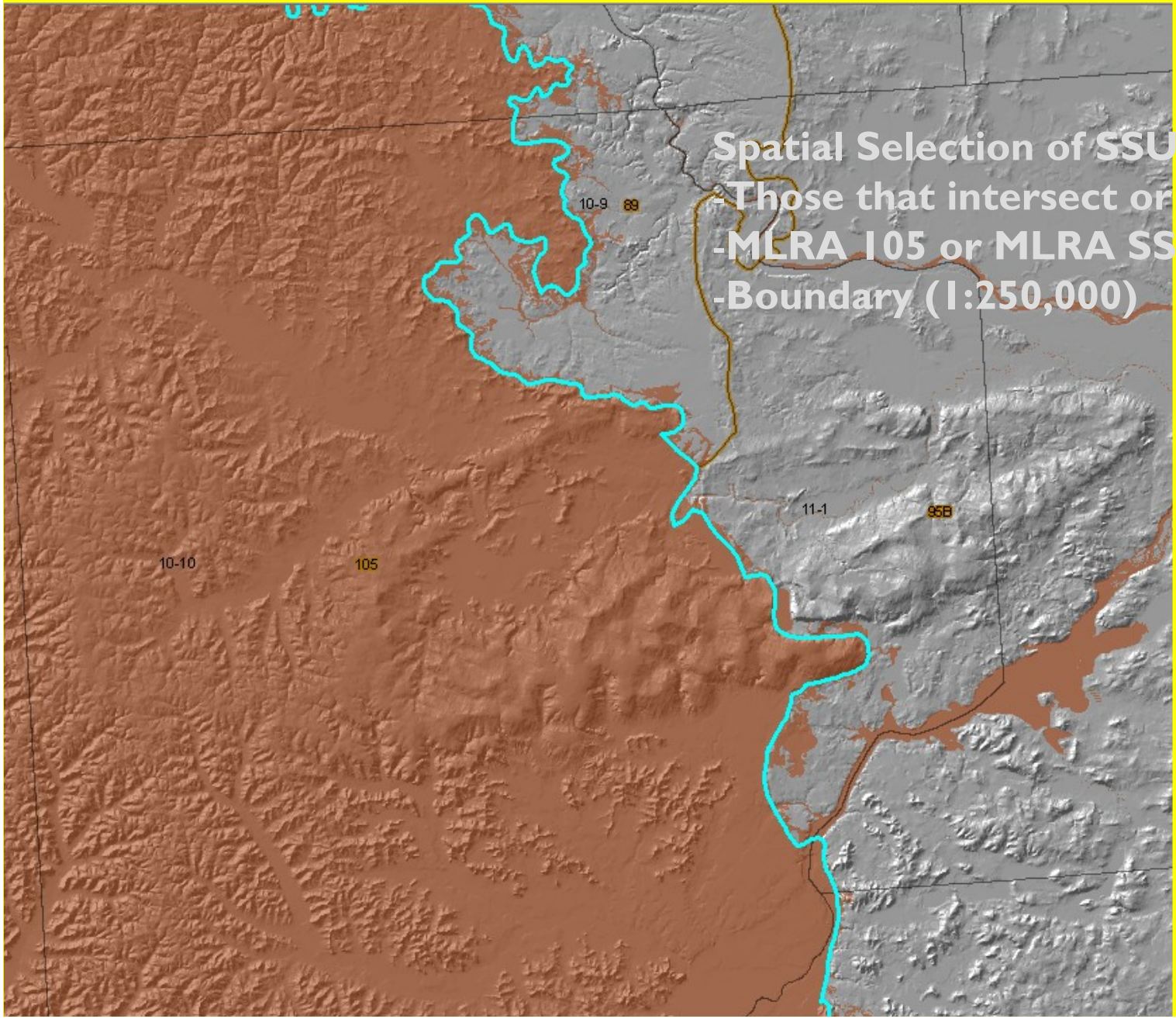
Spatial selection of SSURGO or General Soil Map (GSM) polygons

- Those polygons that intersect or touch the MLRA SSA or MLRA line
- In the MLRA 105 example, the MLRA SSA coincides with the Ag Handbook 296 MLRA region called 105
- Note: this is not always the case across the nation


90B
10-4
91B
90B
90A
90A
94D
94B
10-8
94B
10-9
90B
95A
89
11-1
10-10
105
103
95B
10-11
104
110
11-2
108B
115C
11-4
108A
10-12
108C



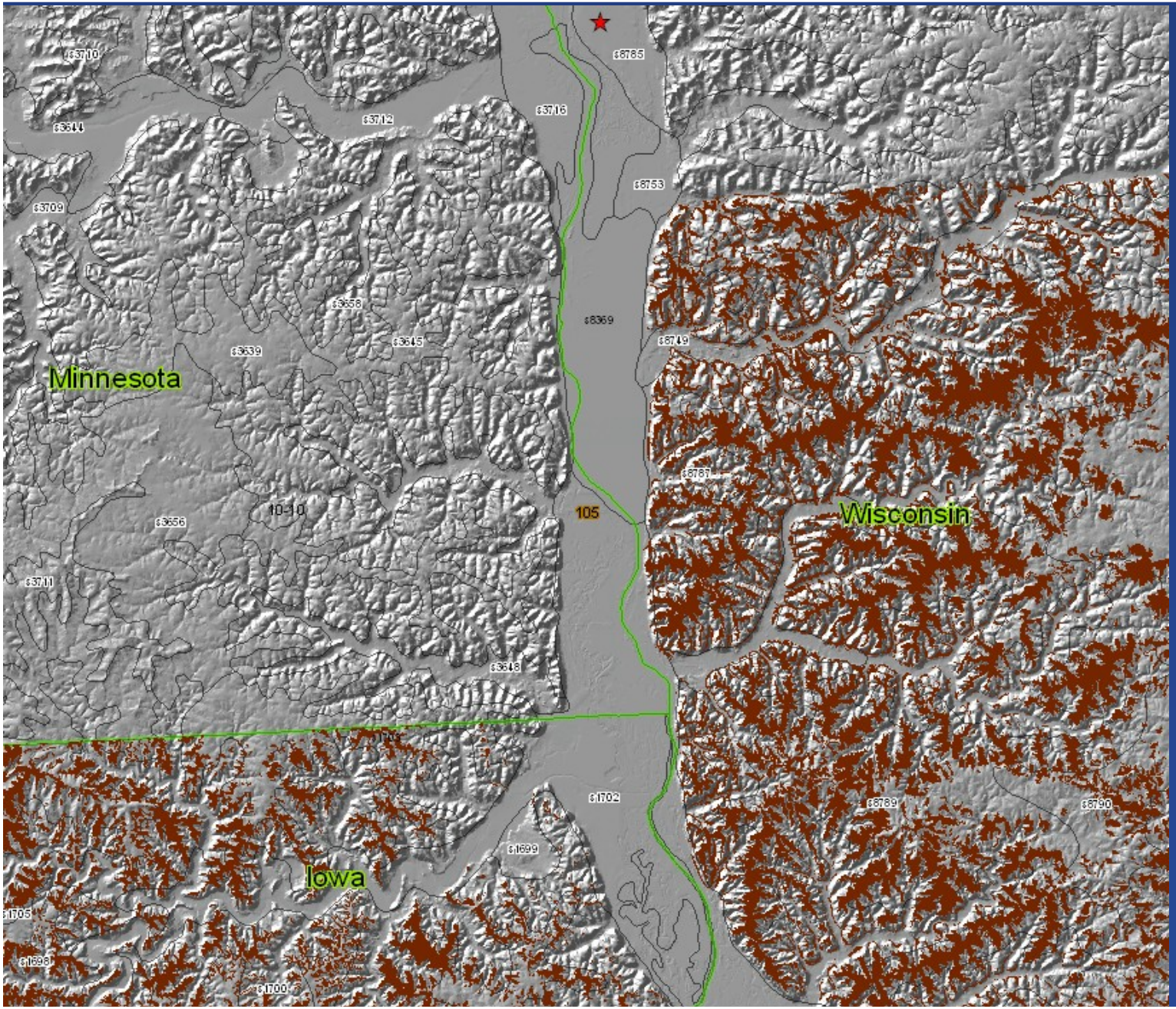
Spatial Selection of SSURGO Polygons
-Those that intersect or touch the
-MLRA 105 or MLRA SSA 10-10
-Boundary (1:250,000)



Spatial Selection of SSURGO Polygons
-Those that intersect or touch the
-MLRA 105 or MLRA SSA 10-10
-Boundary (1:250,000)

1:250,000

1:250,000 Scale

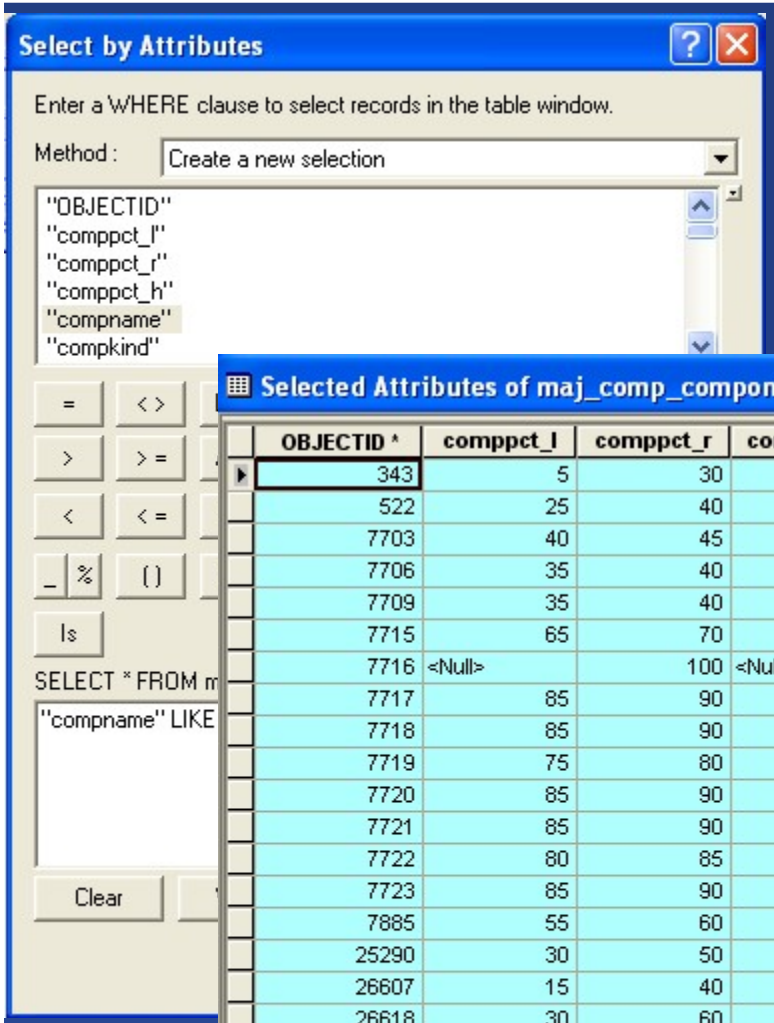

Minnesota
Wisconsin
Iowa
105
10-10

Attribute selection of soil polygons joined to the MO-wide File GDB

- Major component queries can be performed and joined to MO-wide soils core layer using the MUKEY
- This will illustrate the MO-wide extent of the attribute in question
- These queries can be performed on the National Soil Data Mart attribute tables using MS SQL Server Enterprise

Major Component attribute query joined to MUPOLYGON

- Query for component like ‘Fayette%’ and major component flag = ‘Yes’



Selected table records are exported And later linked to MO10 MUPOLYGON

Selected Attributes of maj_comp_component

OBJECTID *	comppct_l	comppct_r	comppct_h	compname	compkind	majcompflag	otherph
343	5	30	40	Fayette	Series	Yes	MAAT<50, ERODED
522	25	40	55	Fayette	Series	Yes	MAAT<50
7703	40	45	50	Fayette	Series	Yes	ERODED,MAAT>50
7706	35	40	45	Fayette	Series	Yes	MAAT>50
7709	35	40	45	Fayette	Series	Yes	ERODED,MAAT>50
7715	65	70	75	Fayette	Series	Yes	ERODED,MAAT>50
7716	<Null>	100	<Null>	Fayette	Series	Yes	MAAT>50
7717	85	90	95	Fayette	Series	Yes	ERODED, MAAT<50
7718	85	90	95	Fayette	Series	Yes	ERODED,MAAT>50
7719	75	80	85	Fayette	Series	Yes	SEV ER,MAAT>50
7720	85	90	95	Fayette	Series	Yes	MOD ER,MAAT>50
7721	85	90	95	Fayette	Series	Yes	ERODED,MAAT>50
7722	80	85	90	Fayette	Series	Yes	MOD ER,MAAT>50
7723	85	90	95	Fayette	Series	Yes	ERODED,MAAT>50
7885	55	60	65	Fayette	Series	Yes	SEV ER, MAAT>50
25290	30	50	70	Fayette	Series	Yes	MAAT<50
26607	15	40	60	Fayette	Series	Yes	MAAT<50,NORTH,ERODED
26618	30	60	80	Fayette	Series	Yes	MAAT<50,NORTH,ERODED
26994	<Null>	55	<Null>	Fayette	Series	Yes	ERODED, MAAT>50
27156	<Null>	95	<Null>	Fayette	Series	Yes	ERODED, MAAT>50
28509	<Null>	95	<Null>	Fayette	Series	Yes	ERODED, MAAT>50

Record: 1 Show: All Selected Records (679 out of 388153 Selected) Options

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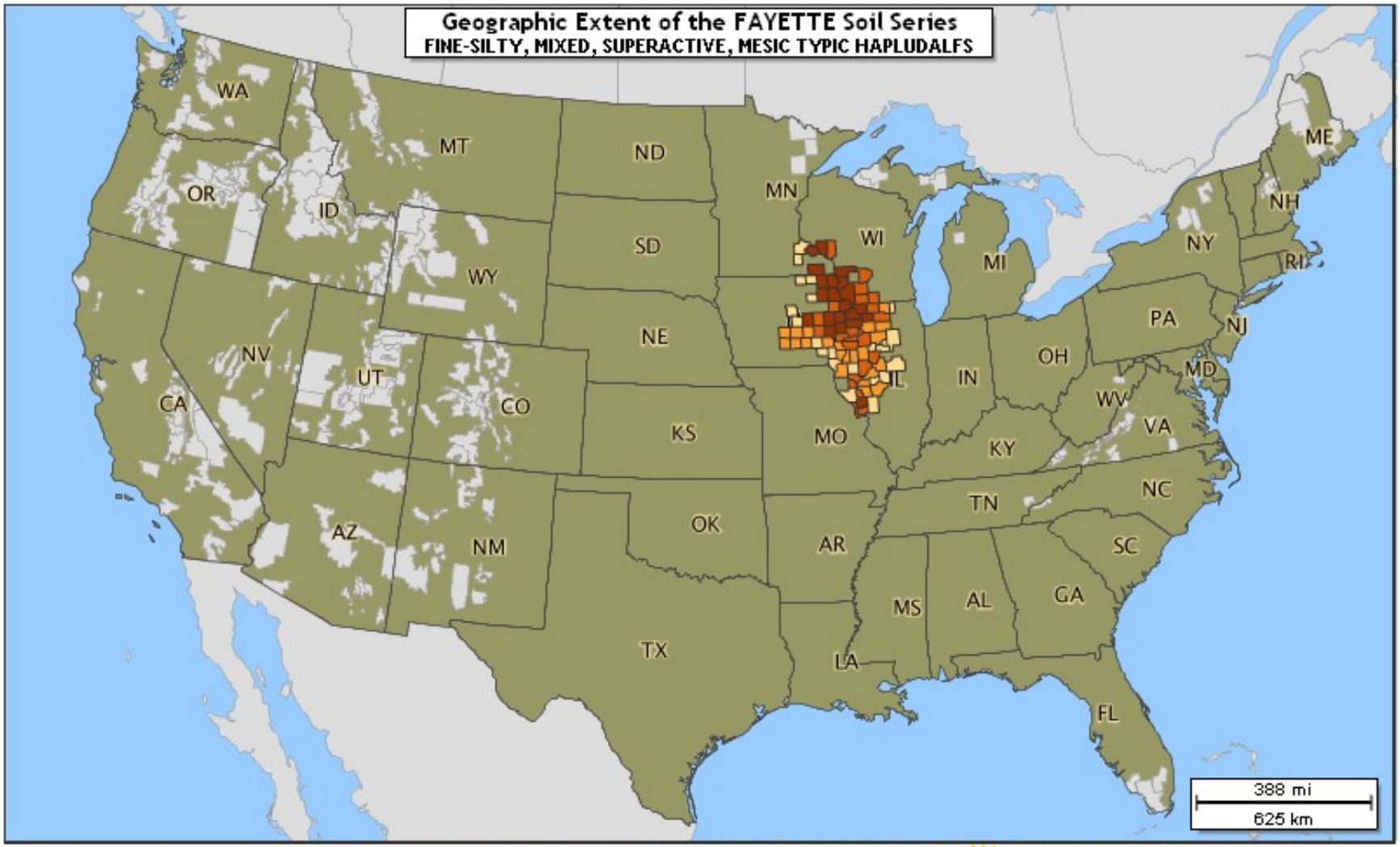
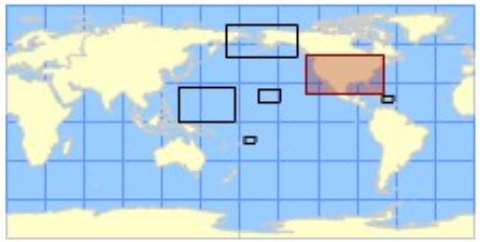




SERIES NAME EXACT MATCH | SERIES NAME SEARCH | TAXONOMIC LEVEL | CLASSIFICATION SEARCH

fayette

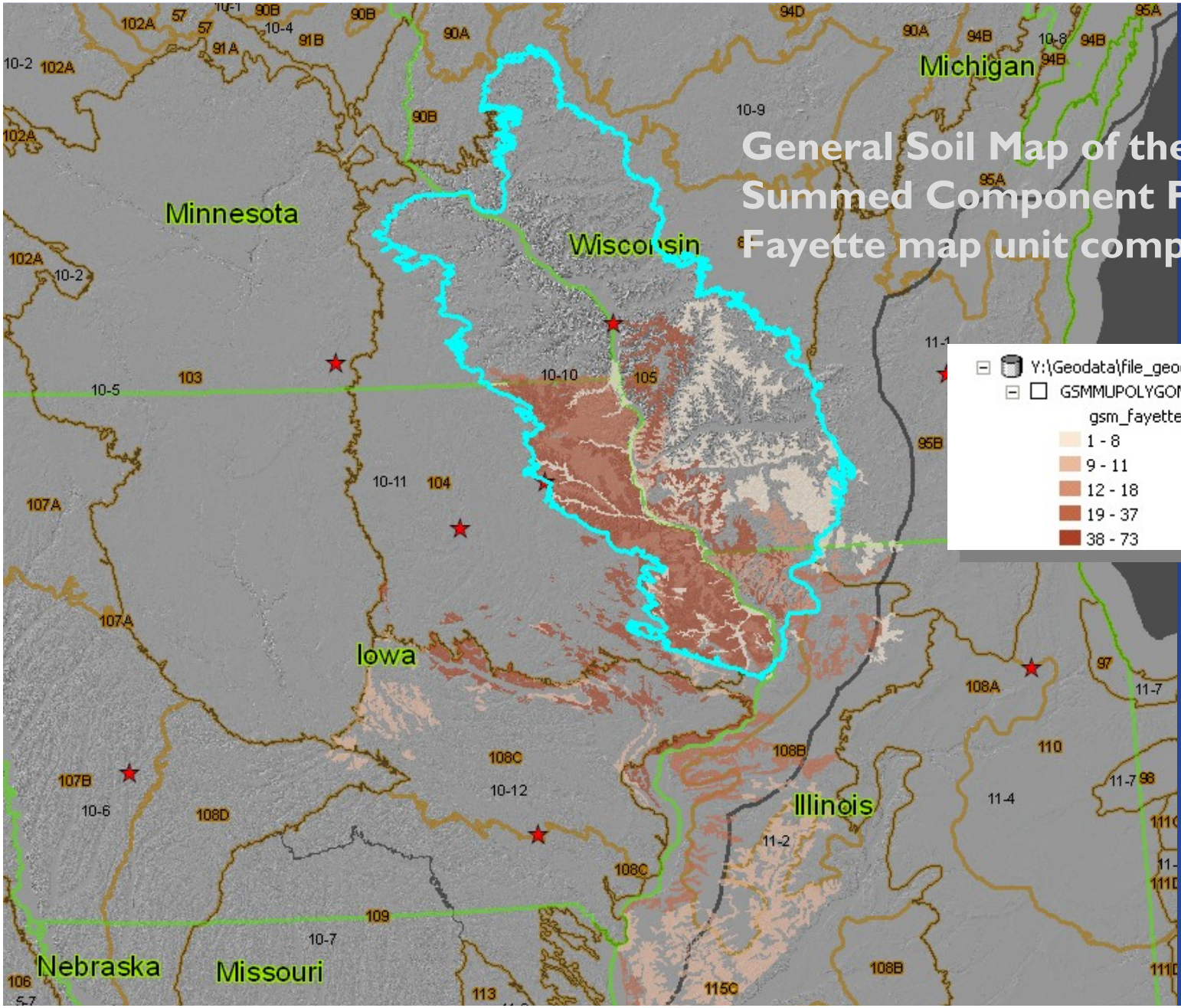
MAP SERIES

☐ MLRA layer visible
☑ Soil Series fill visible

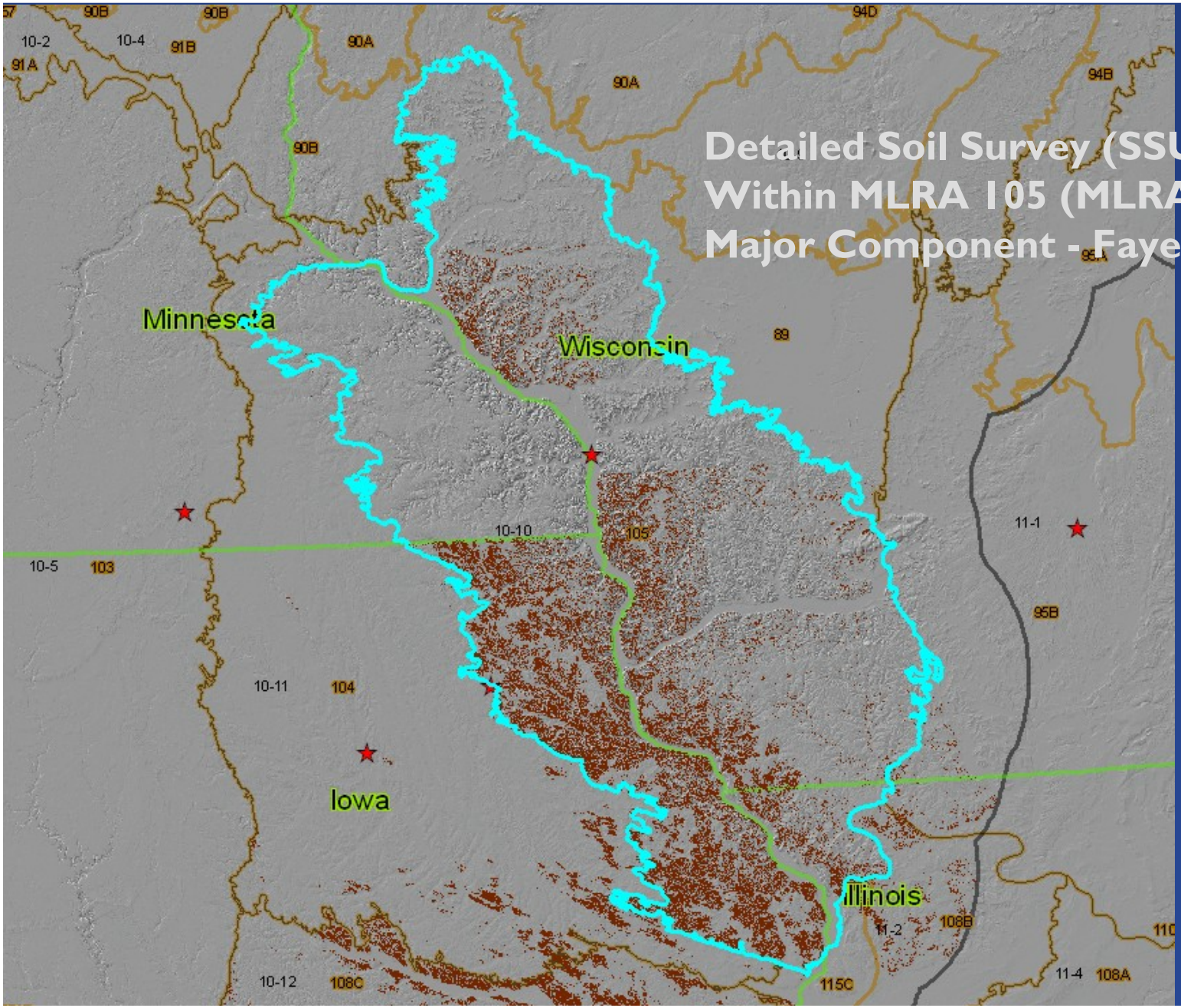
acres per soil survey area (total = 2737598)

Acres not reported	less than 2909	3007 to 13069	13521 to 40231	41416 to 192346

General Soil Map of the US (GSM) Summed Component Percent Fayette map unit components



Detailed Soil Survey (SSURGO) Within MLRA 105 (MLRA SSA 10-10) Major Component - Fayette



United States Department of Agriculture
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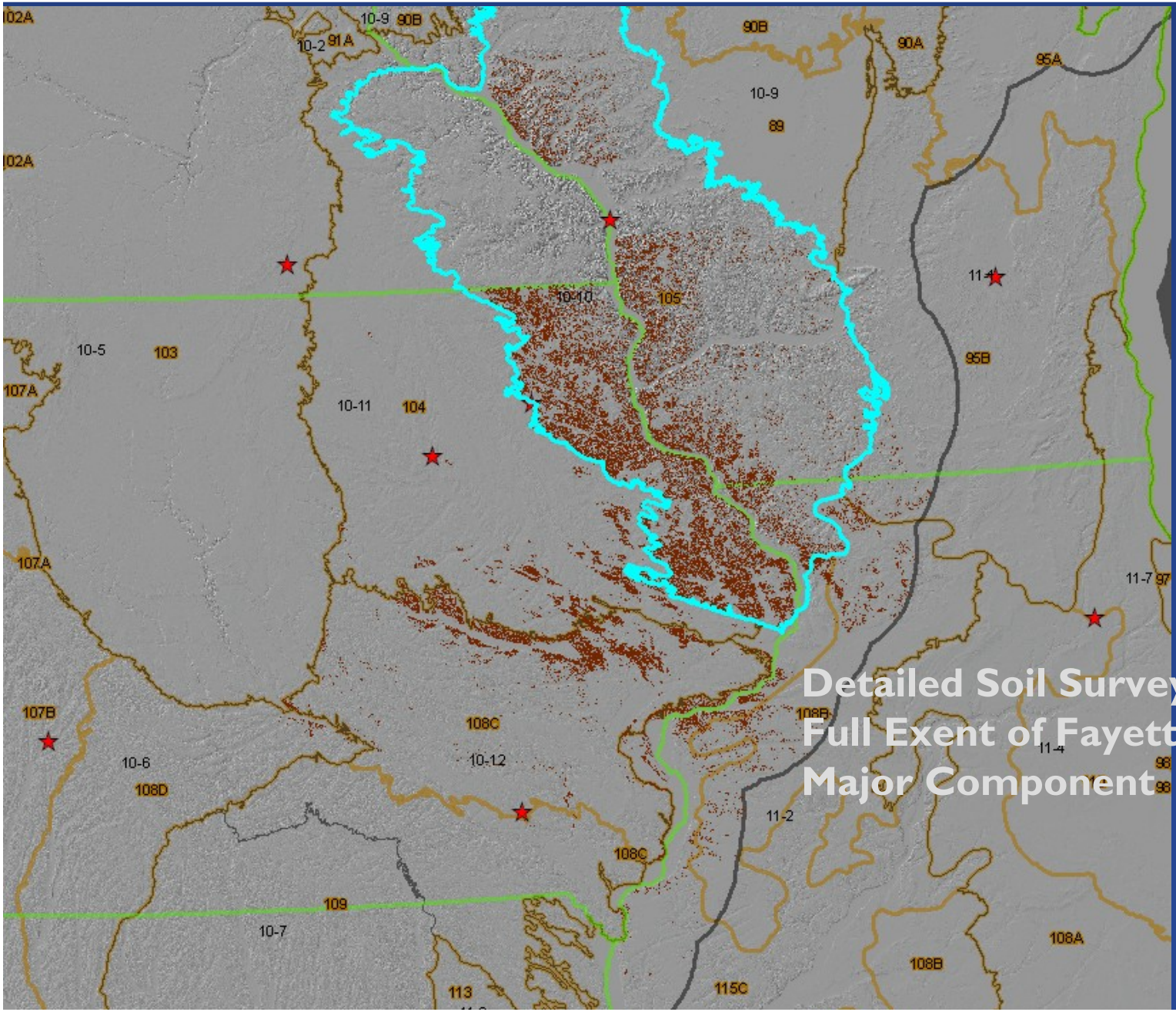
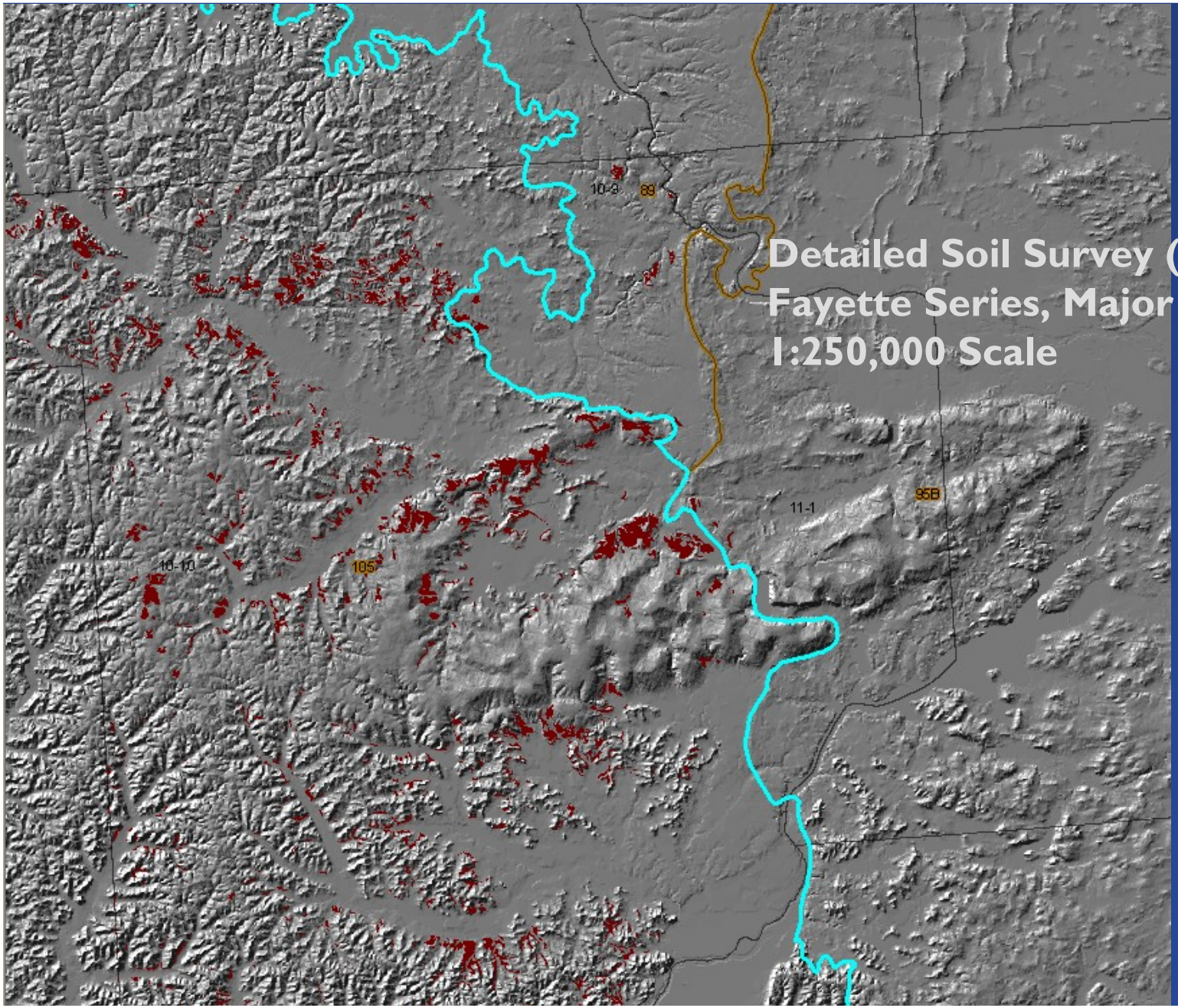


Detailed Soil Survey (SSURGO)
Full Exent of Fayette Series
Major Component



Detailed Soil Survey (SSURGO)
Fayette Series, Major Component
1:250,000 Scale

All Components attribute query joined to MUPOLYGON

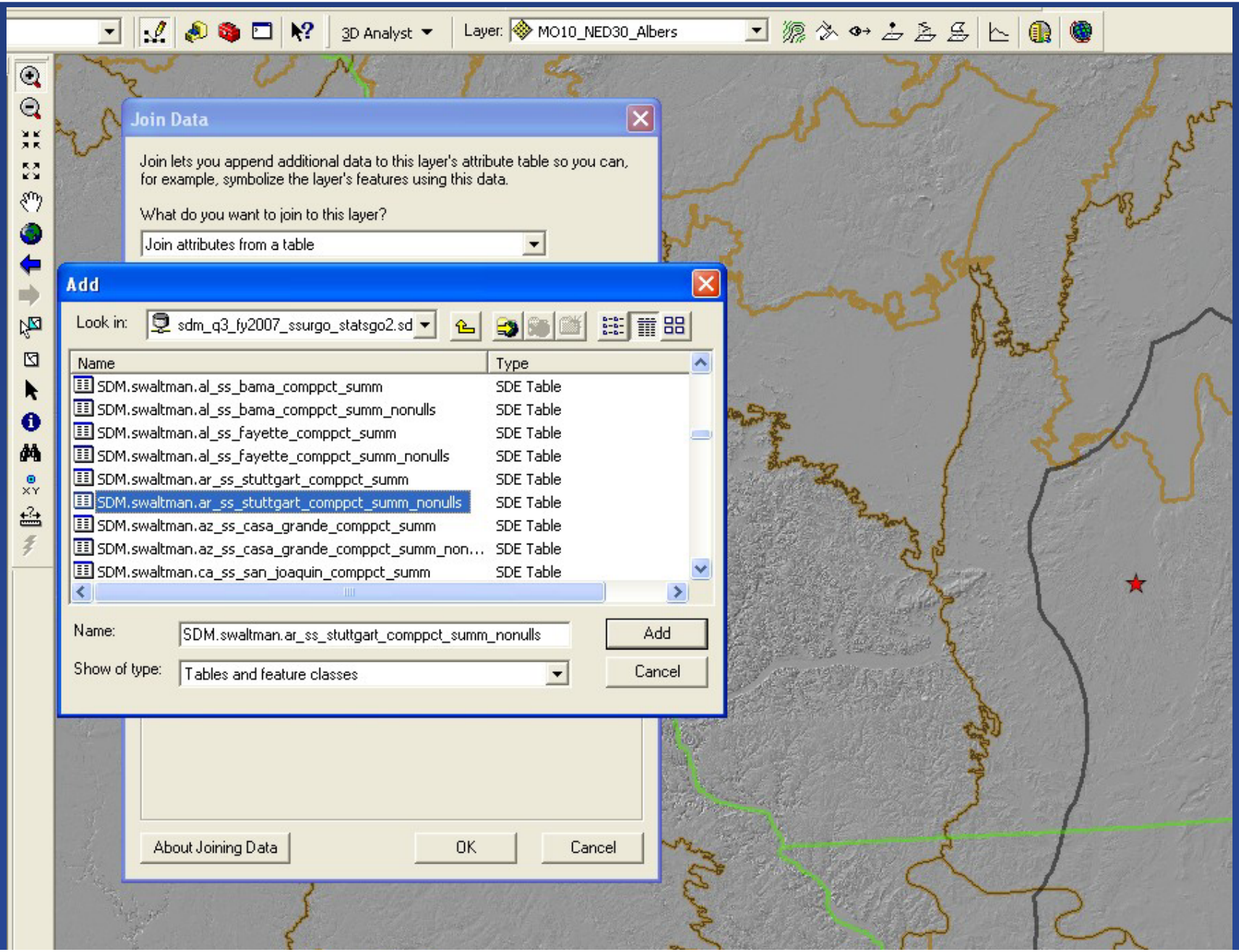
- Query for component like 'Fayette%' and comppct summed for those flagged components by map unit

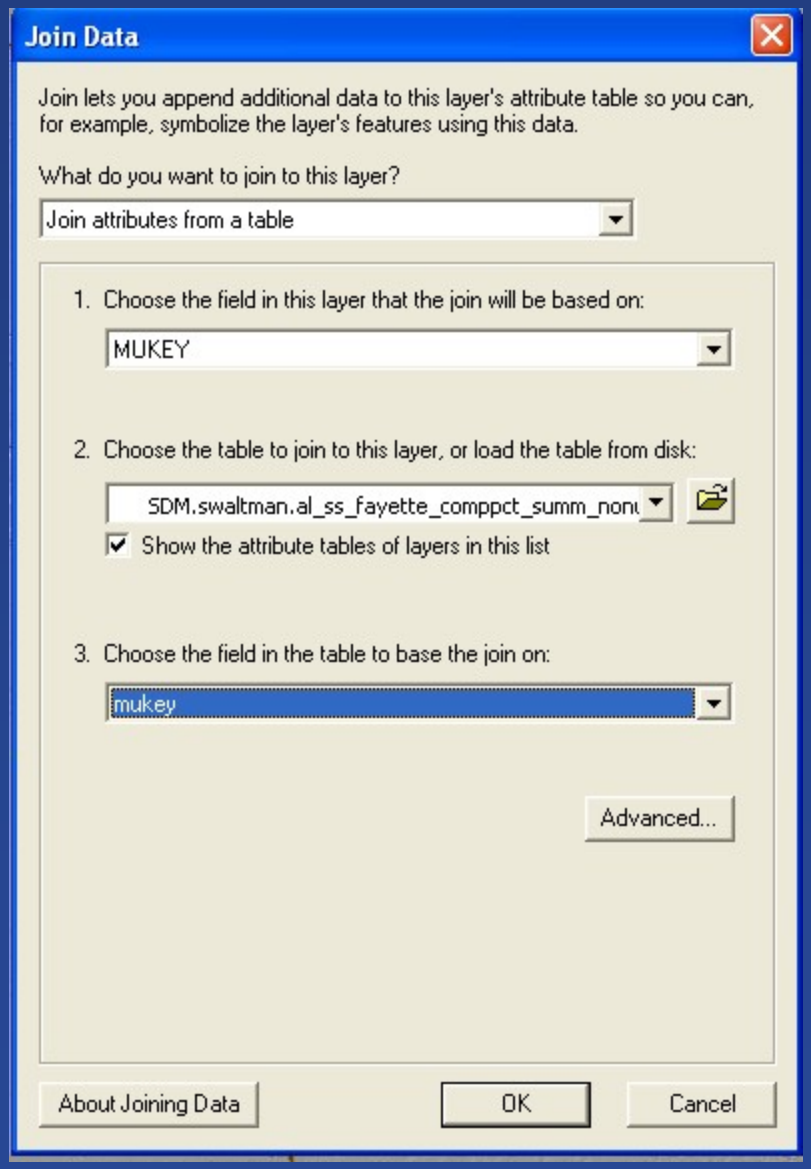
SDESERVER-SQ..._flag_nonulls | SDESERVER-SQL...nt_031508.sql | Object Explorer Details

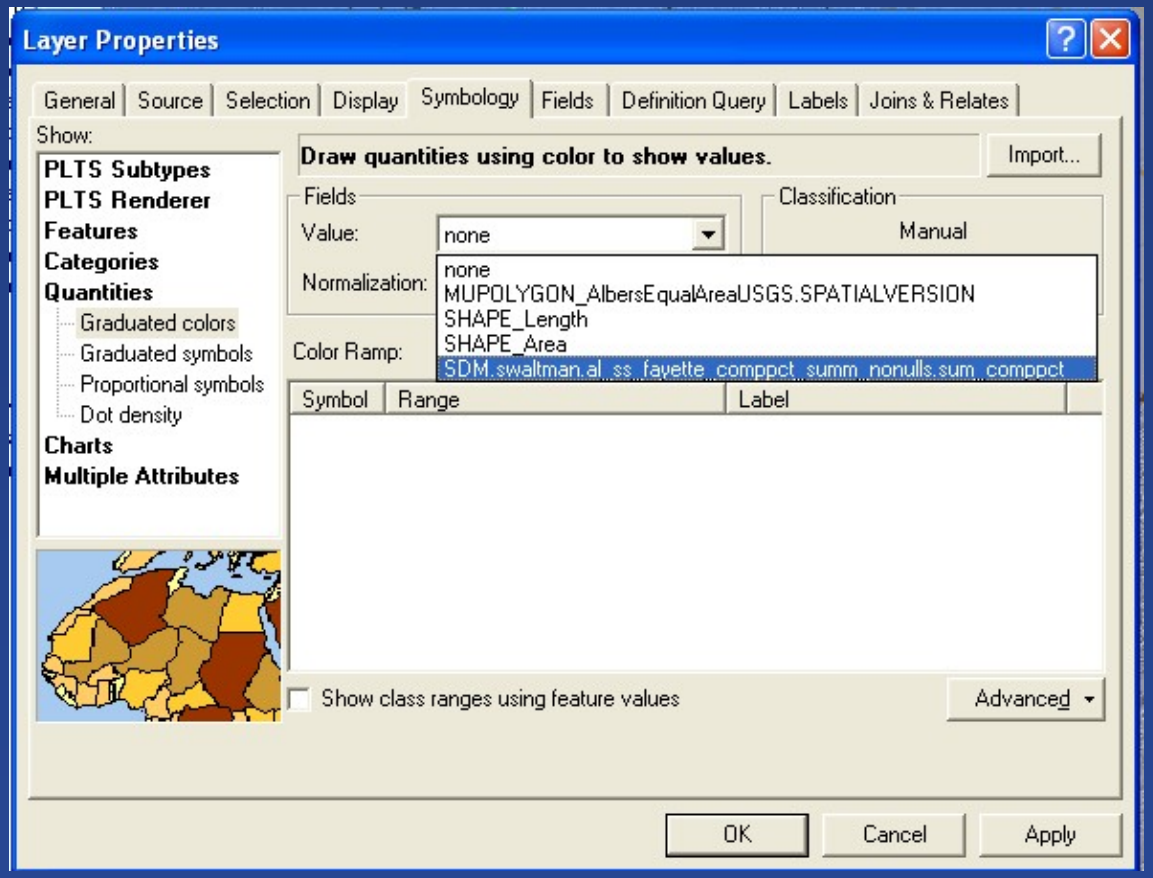
```
--creates a roll-up table for individual state soil
USE SDM
SELECT mukey, musym, muname, compname, SUM(comppct_r) AS sum_comppct
 INTO al_ss_fayette_comppct_summ
FROM ssurgo_mu_comp
   WHERE compname LIKE 'fayette%'
     GROUP BY mukey, musym, muname, compname
       WITH ROLLUP
     ORDER BY mukey,sum_comppct --DESC
GO
SELECT * from al_ss_fayette_comppct_summ

--removes nulls from rollup table above to create new table
USE SDM
SELECT * INTO al_ss_fayette_comppct_summ_nonulls FROM al_ss_fayette_comppct_summ
 WHERE compname != 'NULL'
GO
SELECT * FROM al_ss_fayette_comppct_summ_nonulls
GO
----
```

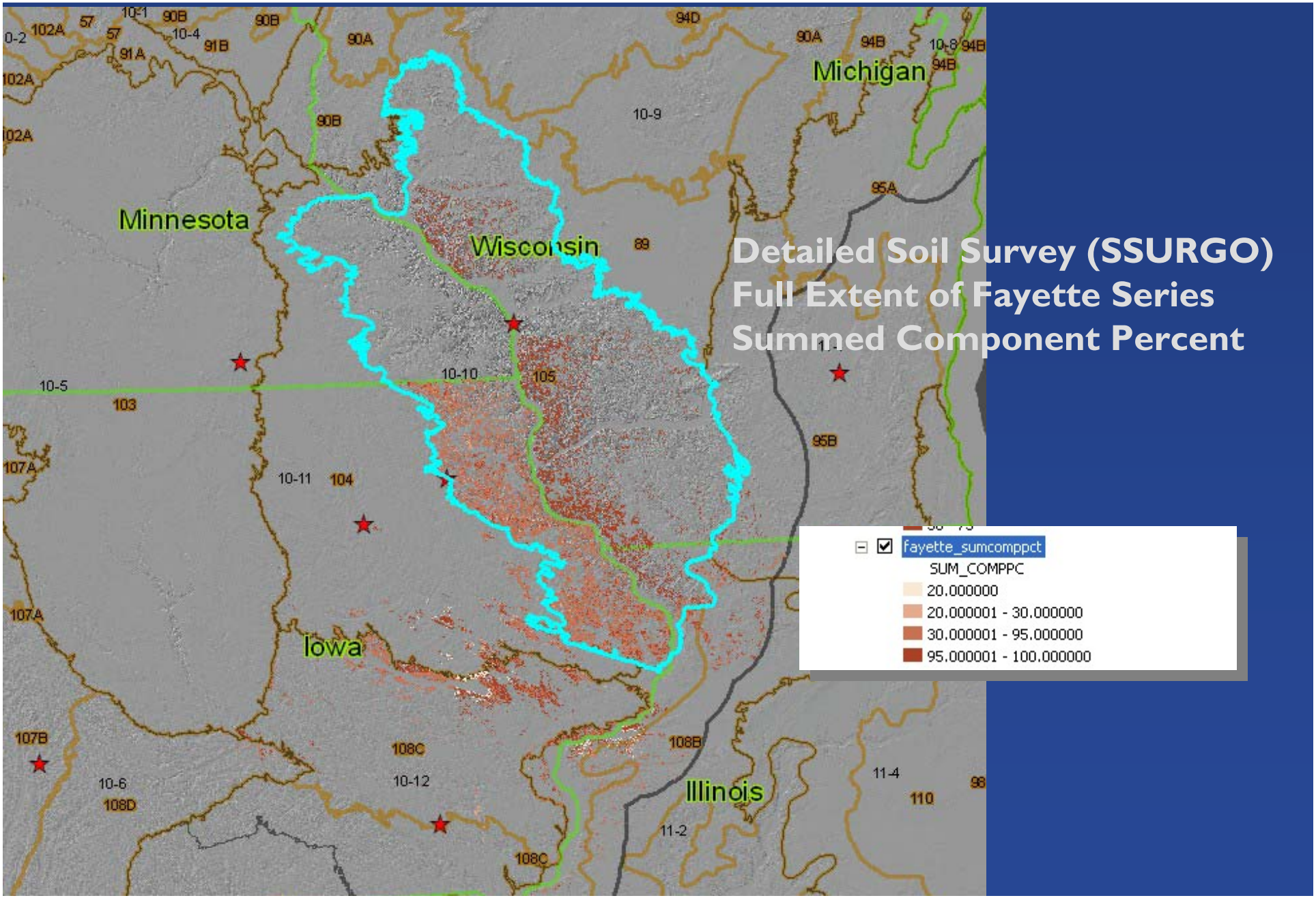
Results | Messages

	mukey	musym	muname	compname	sum_comppct
1	1008301	965E2	Dubuque-Fayette complex, 14 to 18 percent slope...	Fayette	30
2	1008421	965G	Dubuque-Fayette complex, 18 to 30 percent slopes	Fayette	40
3	1015757	61A	Atterberry silt loam, 0 to 2 percent slopes	Fayette	NULL
4	1017218	s1702	Dorchester-Chaseburg-Caneek (s1702)	Fayette	8
5	1144333	61A	Atterberry silt loam, 0 to 2 percent slopes	Fayette	NULL
6	1144380	293D2	Fayette-Chelsea-Tell complex, 9 to 14 percent slo...	Fayette	45
7	1144384	293G	Fayette-Chelsea-Tell complex, 18 to 40 percent sl...	Fayette	40
8	1144387	293E2	Fayette-Chelsea-Tell complex, 14 to 18 percent sl...	Fayette	40
9	1144400	163F2	Fayette silt loam, 18 to 25 percent slopes, moderat...	Fayette	70
10	1144401	463B	Fayette silt loam, terrace, 2 to 5 percent slopes	Fayette	100
11	1144402	463C2	Fayette silt loam, terrace, 5 to 9 percent slopes, m...	Fayette	90
12	1144403	463D2	Fayette silt loam, terrace, 9 to 14 percent slopes, ...	Fayette	90


3D Analyst
Layer: MO10_NED30_Albers
Join Data
Join lets you append additional data to this layer's attribute table so you can, for example, symbolize the layer's features using this data.
What do you want to join to this layer?
Join attributes from a table
Add
Look in: sdm_q3_fy2007_ssurgo_statsgo2.sd
Name
Type
SDM.swaltman.al_ss_bama_comppct_summ SDE Table
SDM.swaltman.al_ss_bama_comppct_summ_nonulls SDE Table
SDM.swaltman.al_ss_fayette_comppct_summ SDE Table
SDM.swaltman.al_ss_fayette_comppct_summ_nonulls SDE Table
SDM.swaltman.ar_ss_stuttgart_comppct_summ SDE Table
SDM.swaltman.ar_ss_stuttgart_comppct_summ_nonulls SDE Table
SDM.swaltman.az_ss_casa_grande_comppct_summ SDE Table
SDM.swaltman.az_ss_casa_grande_comppct_summ_non... SDE Table
SDM.swaltman.ca_ss_san_joaquin_comppct_summ SDE Table
Name: SDM.swaltman.ar_ss_stuttgart_comppct_summ_nonulls
Add
Show of type: Tables and feature classes
Cancel
About Joining Data
OK
Cancel


Join Data
Join lets you append additional data to this layer's attribute table so you can, for example, symbolize the layer's features using this data.
What do you want to join to this layer?
Join attributes from a table
1. Choose the field in this layer that the join will be based on:
MUKEY
2. Choose the table to join to this layer, or load the table from disk:
SDM.swaltman.al_ss_fayette_comppct_summ_non
Show the attribute tables of layers in this list
3. Choose the field in the table to base the join on:
mukey
Advanced...
About Joining Data
OK
Cancel


Layer Properties
General
Source
Selection
Display
Symbology
Fields
Definition Query
Labels
Joins & Relates
Show:
PLTS Subtypes
PLTS Renderer
Features
Categories
Quantities
Graduated colors
Graduated symbols
Proportional symbols
Dot density
Charts
Multiple Attributes
Draw quantities using color to show values.
Import...
Fields
Value:
none
Normalization:
none
MUPOLYGON_AlbersEqualAreaUSGS.SPATIALVERSION
SHAPE_Length
SHAPE_Area
SDM.swaltman.al_ss_fayette_comppct_summ_nonulls.sum_comppct
Classification
Manual
Color Ramp:
Symbol
Range
Label
Show class ranges using feature values
Advanced
OK
Cancel
Apply



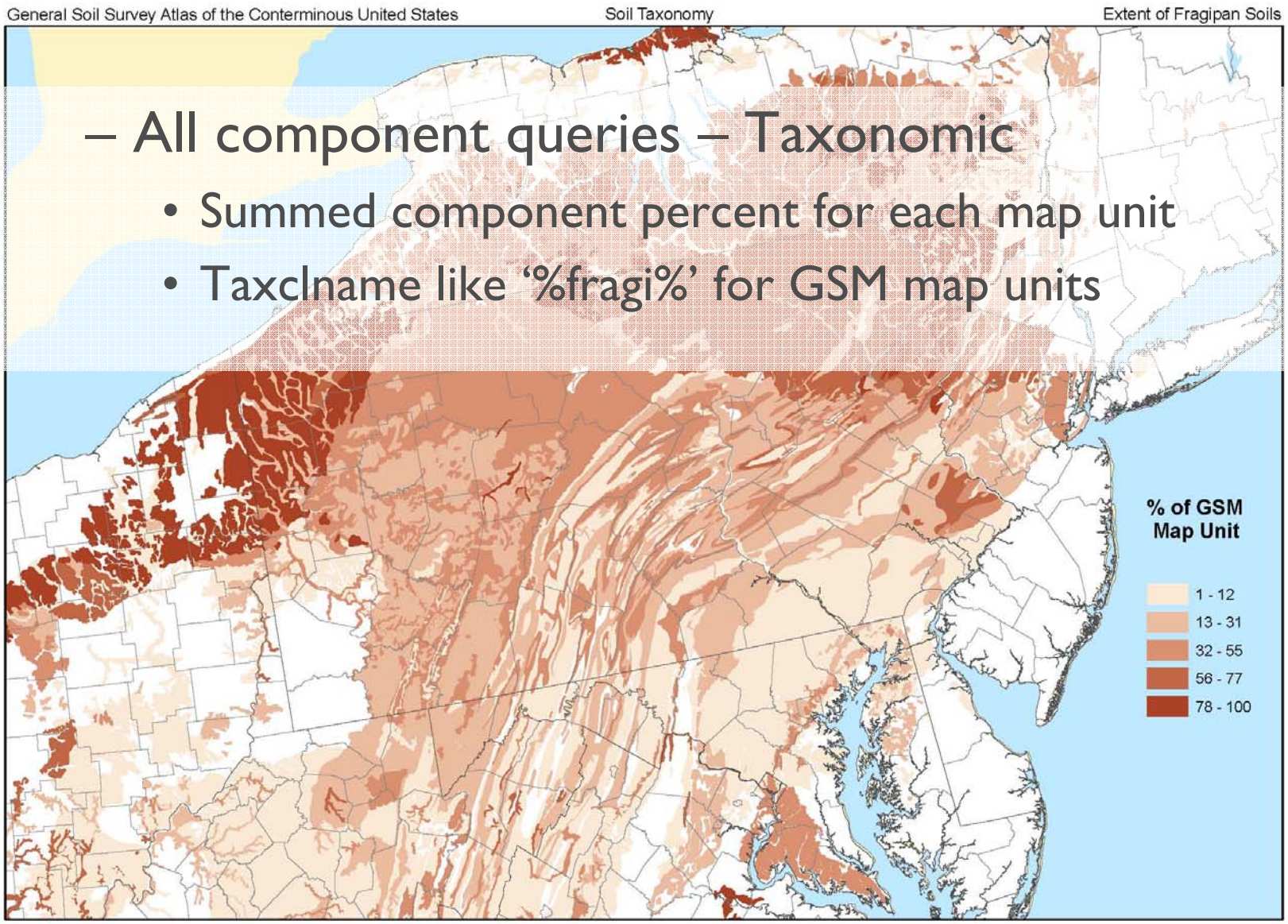
Detailed Soil Survey (SSURGO) Full Extent of Fayette Series Summed Component Percent

Taxonomic Queries

- All component queries – Taxonomic
  - Summed component Percent for each map unit

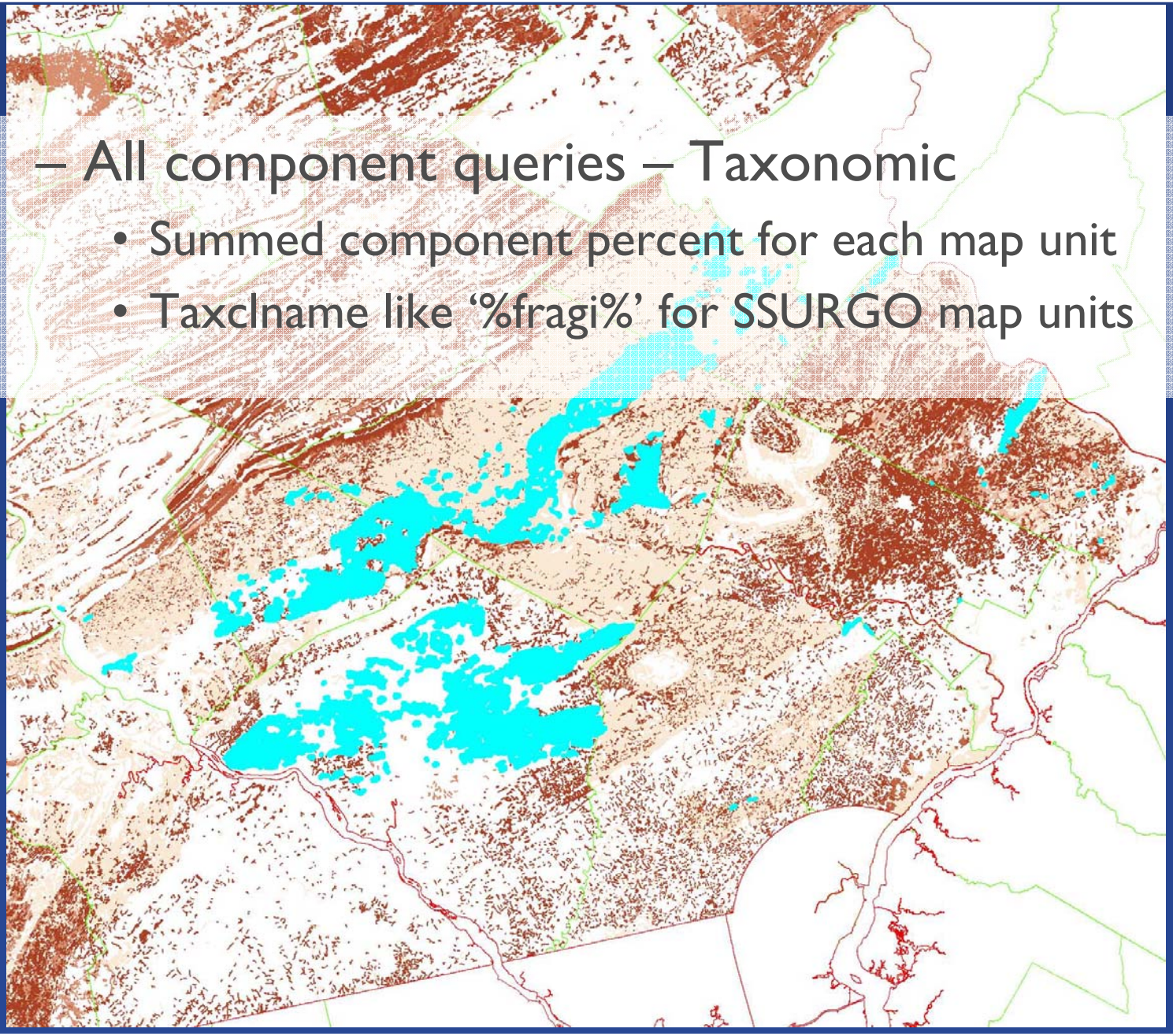
– All component queries – Taxonomic

- Summed component percent for each map unit
- Taxclname like '%fragi%' for GSM map units



– All component queries – Taxonomic

- Summed component percent for each map unit
- Taxclname like '%fragi%' for SSURGO map units



Spatial Disaggregation Techniques for Visualizing and Evaluating Map Unit Compostion

- What is Spatial Disaggregation?
- Case Study
  - Denali National Park and Preserve, AK
- Conclusions

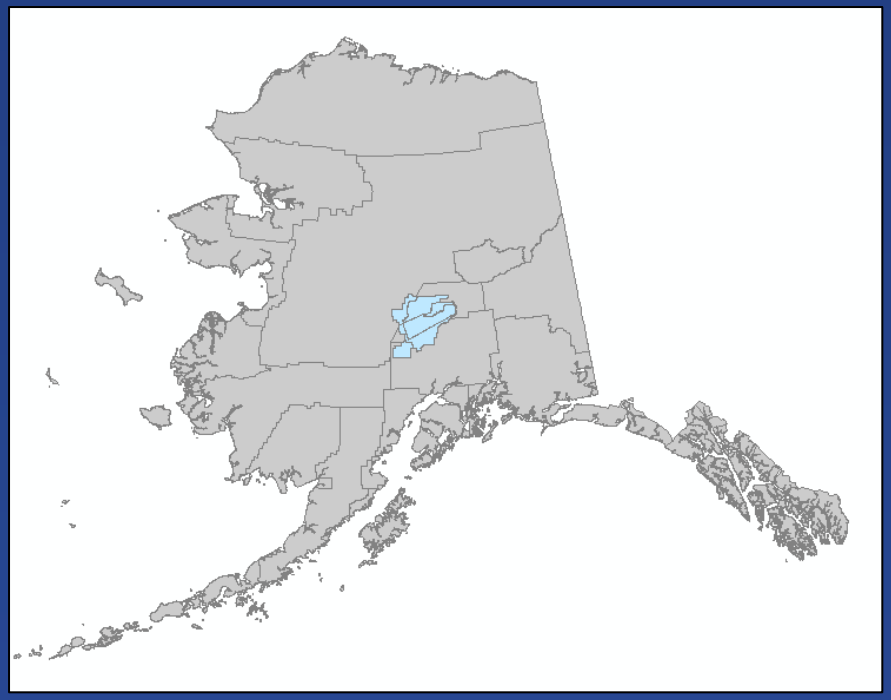
Spatial Disaggregation

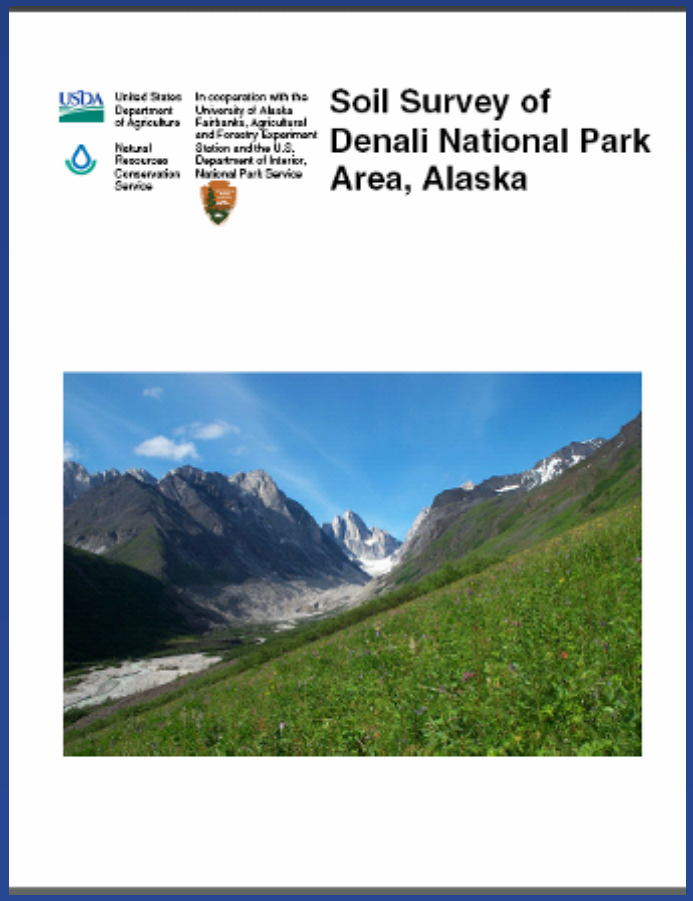
- The process of *separating an entity into component parts based on implicit spatial relationships or patterns*

- Soil map units can be disaggregated into individual components based on soil-landscape relationships documented in existing soil surveys
  - Soil-landscape models are commonly embedded in soil map unit descriptions in soil survey reports or stored as a series of values within the aggregate database
  - These values can be extracted and used to develop quantitative representations of soil-landscape models
  - The resulting models can be extrapolated (e.g., mapped) using any number of ancillary data layers and GIS and/or remote sensing methods

- Model distribution of individual components within a map unit in order to:
  - Visualize and evaluate soil-landscape relationships documented in our aggregate data
  - Enable more precise estimation of map unit properties
  - Assist with correlation across multiple survey areas within an MLRA
  - Provide support component-level interpretations (e.g., ecological site maps)

Denali National Park, AK



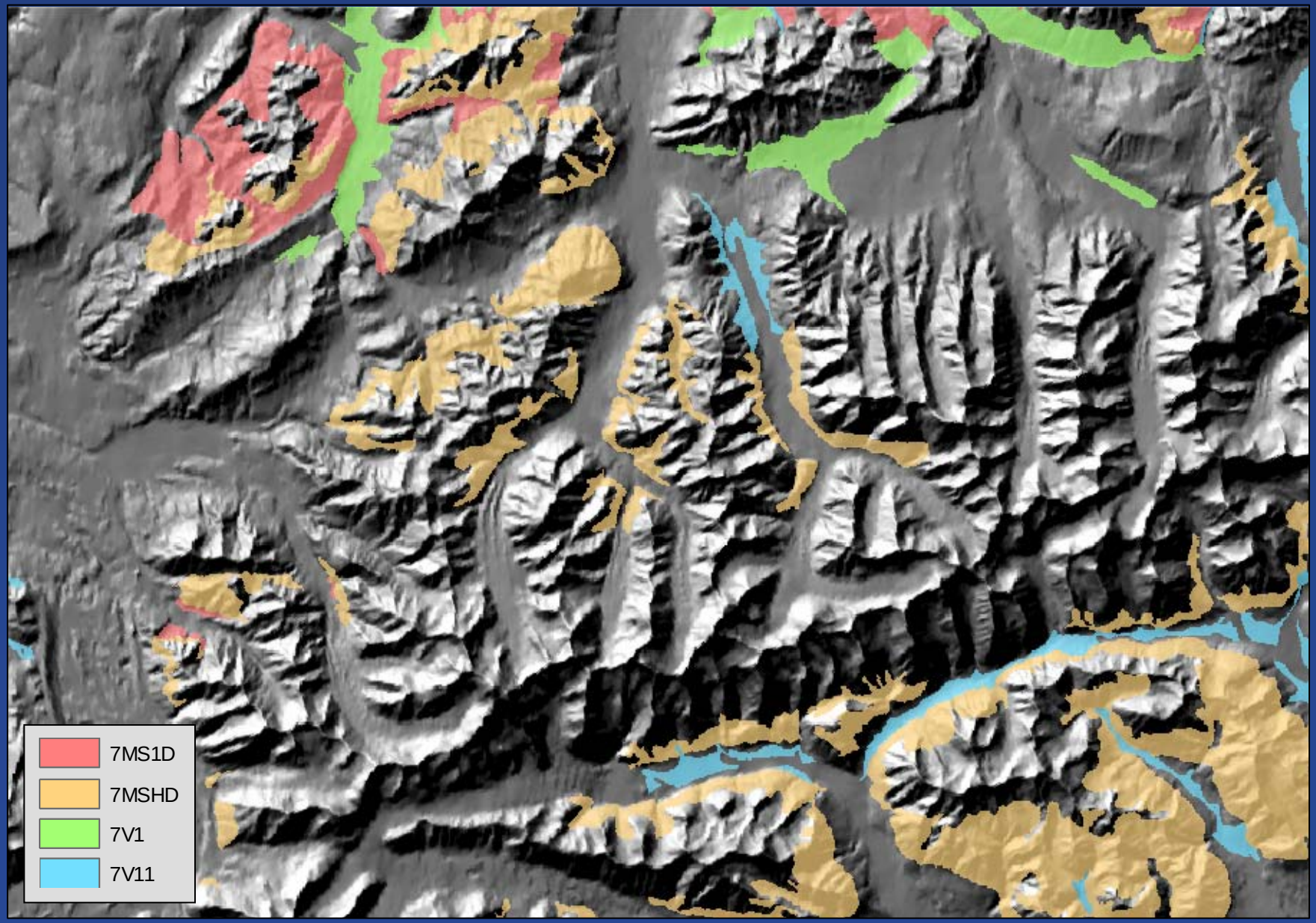


Map Unit Selection Criteria

- Have well-documented soil-landscape relationships;
- Have appropriate geospatial data layers available; and
- Have soil-landscape relationships that can be adequately characterized by available geospatial data.

Selected Soil Map Units

- 7MS1D – Alpine Dark Sedimentary Mountains
- 7MSHD – Alpine Dark Sedimentary Mountains, High Elevation
- 7V1 – Alpine Lower Mountain Slopes and Fans with Discontinuous Permafrost
- 7V11 – Alpine Fans


7MS1D
7MSHD
7V1
7V11

Soil Landscape Model Development

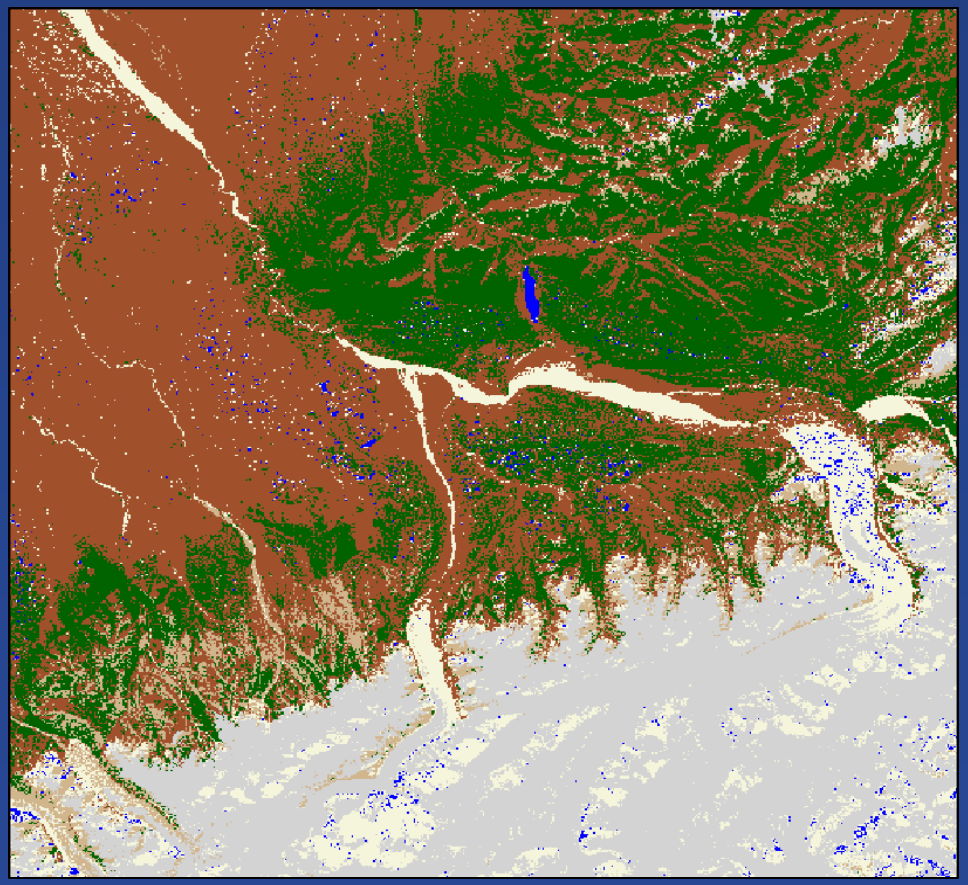
- Identified attributes that might contain useful information about the soil forming environment
  - Slope gradient, Elevation, Aspect, Mean Annual Precipitation, Potential Vegetation, Geomorphic Description (Feature Type and Feature Name), Hillslope Profile, Slope Shape Across, Slope Shape Up/Down, Parent Material Group
  - Recorded values for selected data elements by map unit and component (major and minor)

Soil Landscape Model Development

- Looked for unique values that could be used to model individual components in a map unit
  - For instance, if a map unit consists of two components and the first is found predominantly on north-facing slopes and the second on south-facing slopes, aspect can be used to predict the distribution of these soils within the map unit
- Selected (or created) GIS data layers to represent key landscape characteristics

Key GIS Data Layers

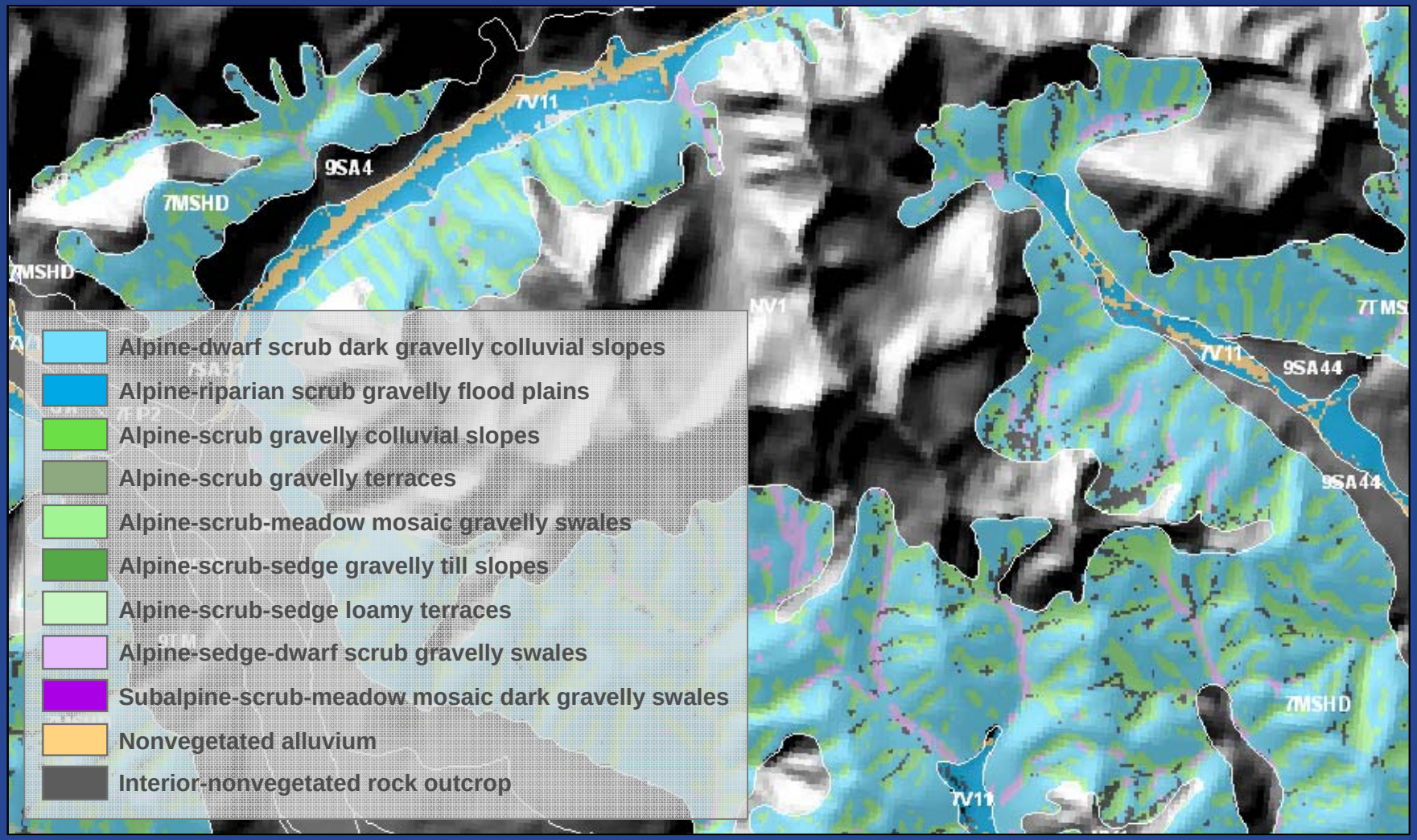
- 60 meter DEM
  - Elevation
  - Slope gradient
  - Slope aspect
  - Planform curvature
  - Profile curvature
  - Fuzzy backslope
  - Wetness Index
- Landsat Scene
  - 15 class landcover map



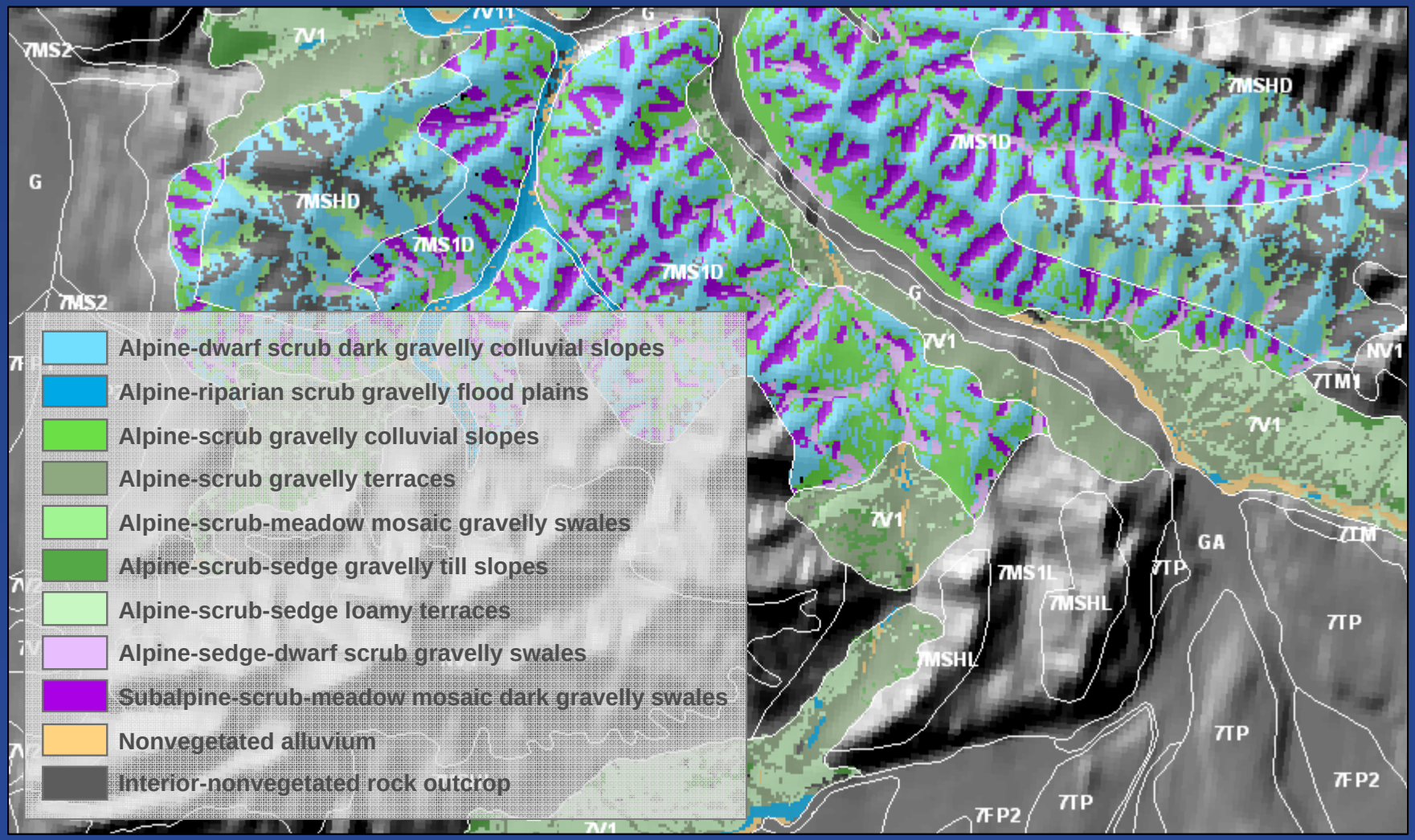
Soil Landscape Model Development

- Developed quantitative rules for each map unit and implemented them in a GIS
  - 7MS1D: Alpine-scrub dark gravelly colluvial slopes = < 3700 ft elevation and linear planfrom curvature OR linear profile curvature
- Reviewed maps, and edited rules based on comments from the MO 17 Senior Regional Soil Scientist

Soil Components



Soil Components



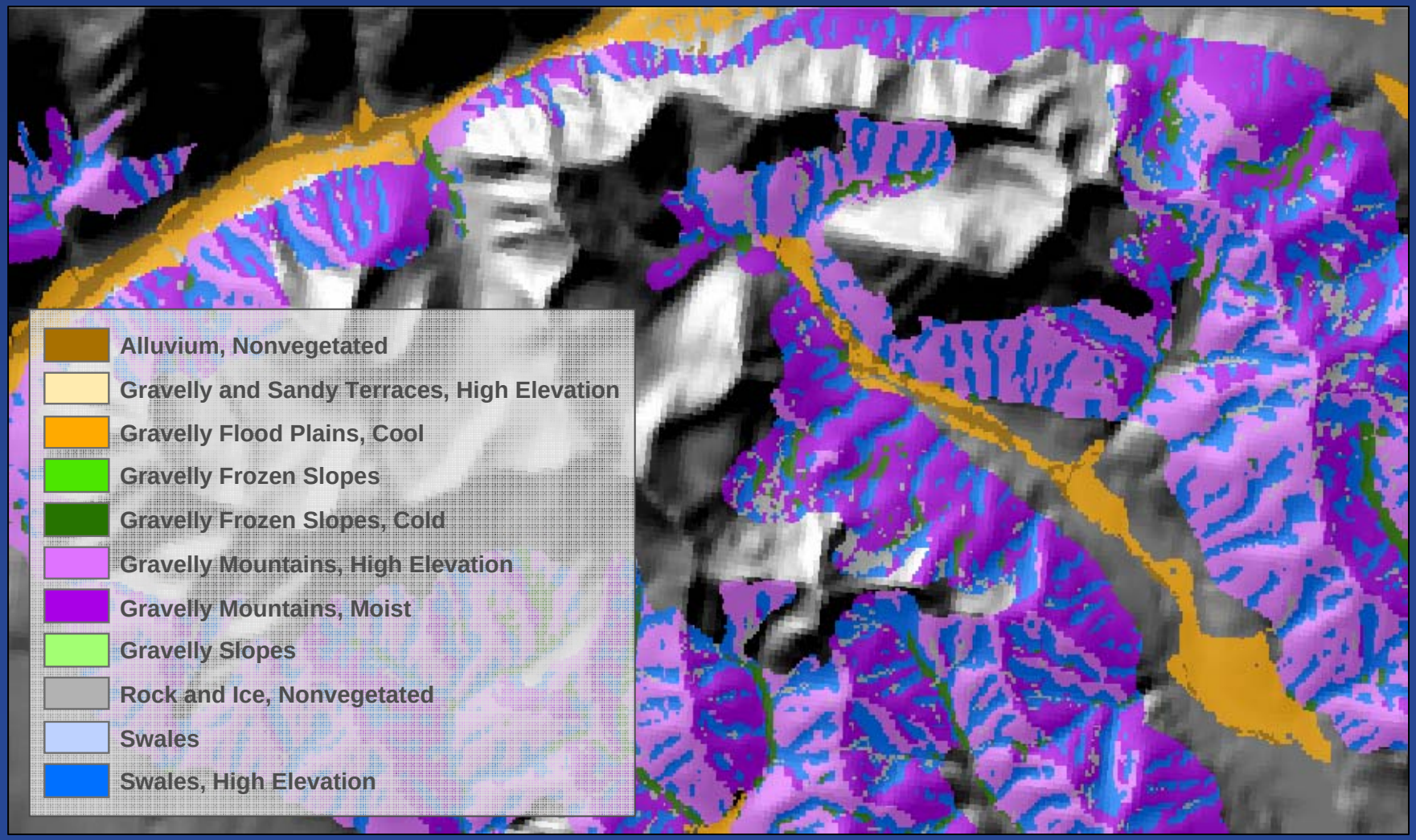
7MSHD – Alpine Dark Sedimentary Mountains, High Elevation

Component	% Composistion NASIS	% Composition Component Map
Interior-nonvegetated rock outcrop, ice, talus, and/or drift	25 – 60	16
Alpine-dwarf scrub dark gravelly colluvial slopes	15 – 40	30
Alpine-dwarf scrub dark gravelly colluvial slopes - moist	15 – 30	29
(minor) Alpine-scrub-meadow mosaic gravelly swales	5 – 15	21
(minor) Alpine-sedge-dwarf scrub gravelly swales, frozen	0 – 5	4
Other	0	0

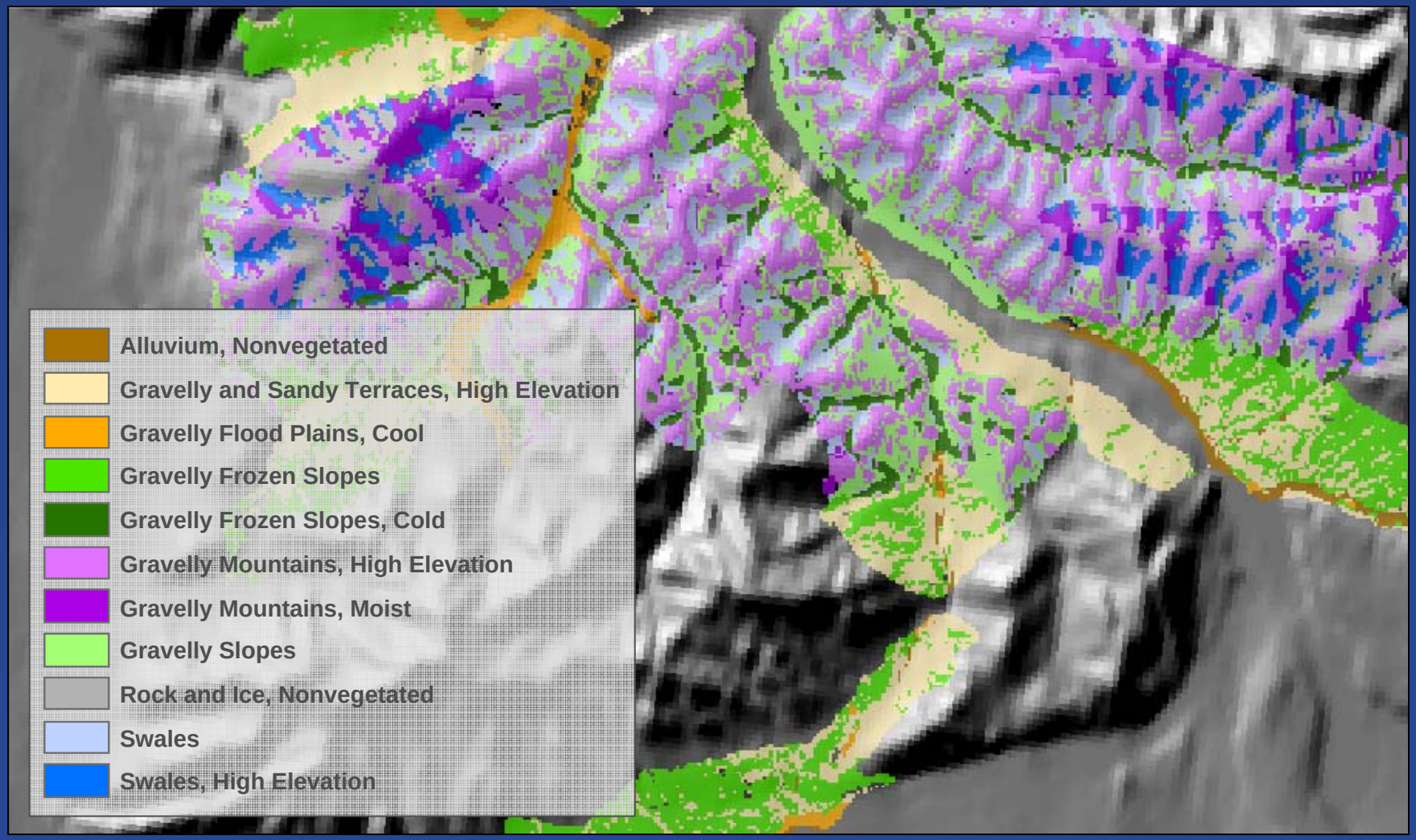
7V11 – Alpine Fans

Component	% Composistion NASIS	% Composition Component Map
Alpine-riparian scrub gravelly flood plains	20 – 55	48
Alpine-scrub gravelly terraces	15 – 40	29
Nonvegetated alluvium, riverwash	10 – 40	14
(minor) Alpine-riparian scrub gravelly flood plains, moderately wet	10 – 35	Not Modeled
(minor) Alpine-riparian scrub loamy flood plains	5 – 15	Not Modeled
(minor) Alpine-dwarf scrub gravelly fan terraces	5 – 15	Not Modeled
Other	0	9

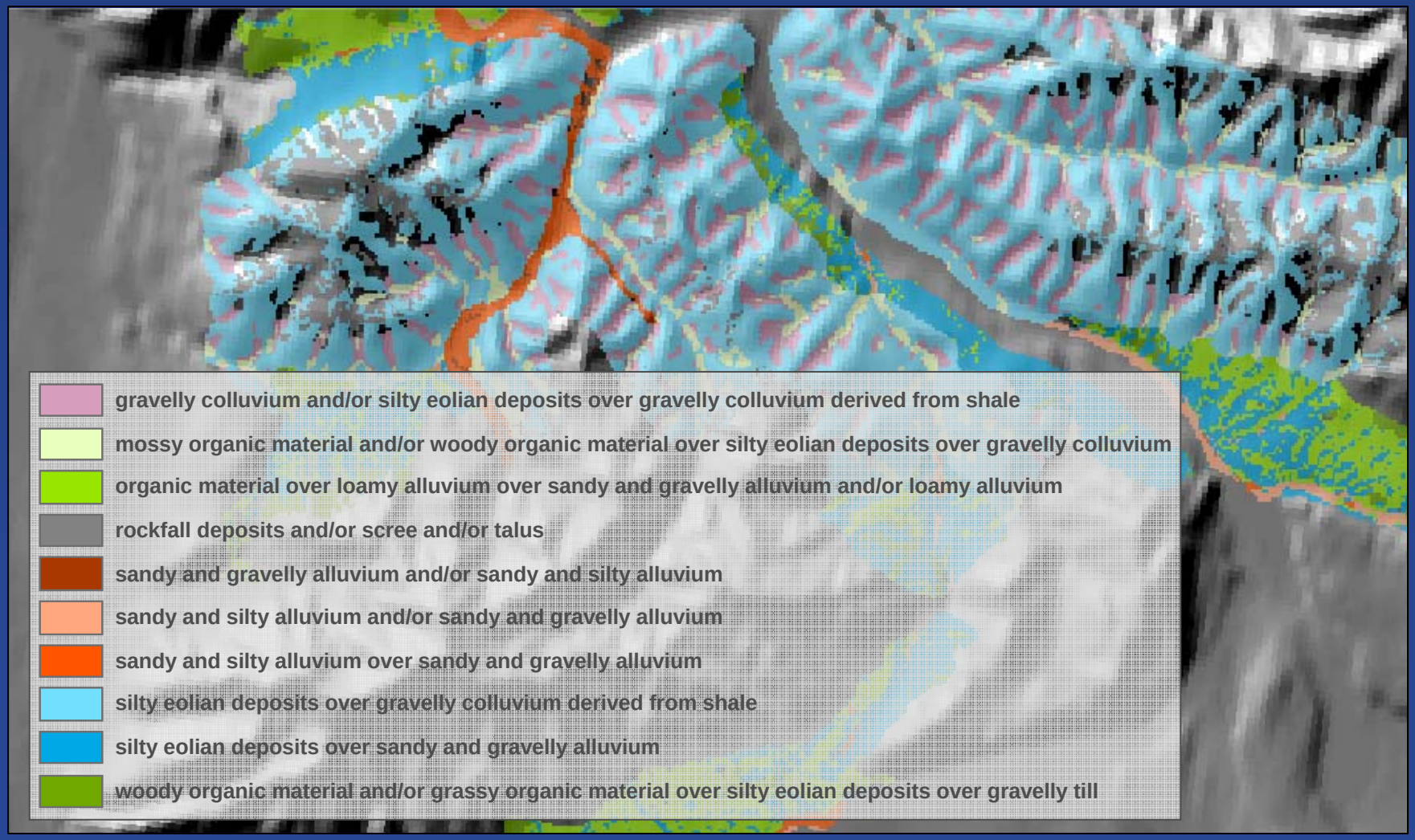
Ecological Sites



Ecological Sites



Parent Material



Conclusions

- Development of soil component maps from SSURGO data allows one to
  - visualize the distribution of soil components on the landscape and within a map unit
  - visualize component-level properties
  - see a spatial representation of soil-landscape information stored in the NASIS aggregate data

Conclusions

- Ability to develop reasonable soil-landscape models from attribute data depends on the completeness and accuracy of data in the database
- Expert knowledge is required to resolve errors or conflicts

Acknowledgements

- Mark Clark, Senior Regional Soil Scientist, MO-17
- Darrell Kautz, Business Analyst, NGDC

Questions?