Know the Earth…Show the Way

Use of Shuttle Radar Topography Mission (SRTM) Data to Facilitate Soils Mapping

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Briefing Overview

- Soils Requirements and Background
- Project Sources
- Soil Boundary Enhancement Procedures
- Summary

Current Soils Requirements for Army Applications

Military Construction: Roads, Airfields, Construction and Construction Resources

Bivouac

Helicopter Landing and Drop Zones

Mine and Countermine Operations

What Can Happen Without Soils Information?

Problems with Cross Country Mobility in Moist & Wet Med- to Fine-textured Soils…

…and Dry Sands

What Can Happen Without Soils Information?

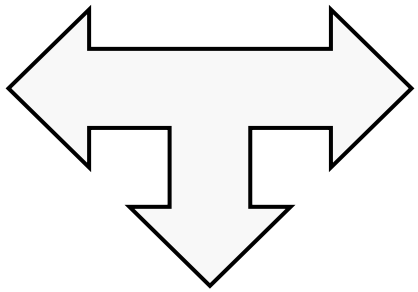
“Brownout” at Helicopter Landing Zone

Unexpected Problems at Improvised Landing Strip

Background

PROBLEM

Army requirement for planning-level soils coverage to augment and enhance Foundation Feature Data for mobility analyses



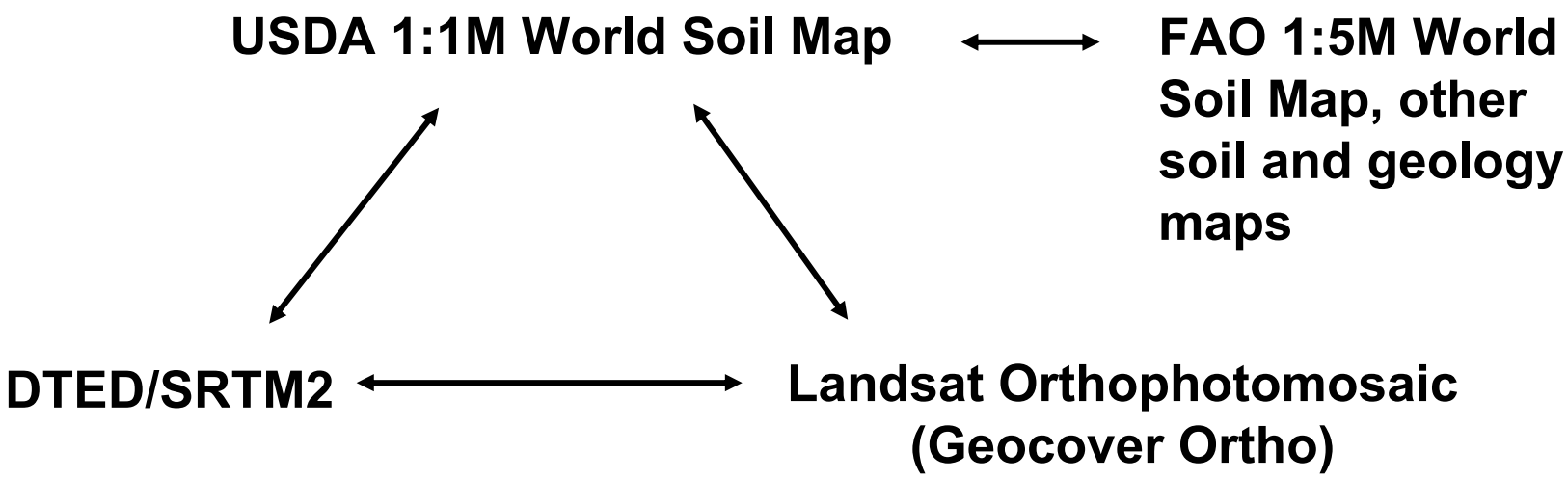
SOLUTION

NGA develop a Cooperative Agreement with Texas A&M BREC to produce a digital Global Soils Database

APPROACH

- **Digitize the previously unpublished USDA 1:1M World Soils Maps to serve as soils foundation data (Qualified Data)**
- **Determine feasibility and develop procedures to enhance the soil boundaries and densify the soils data for mission specific data needs**

Global Soils Database Project Sources

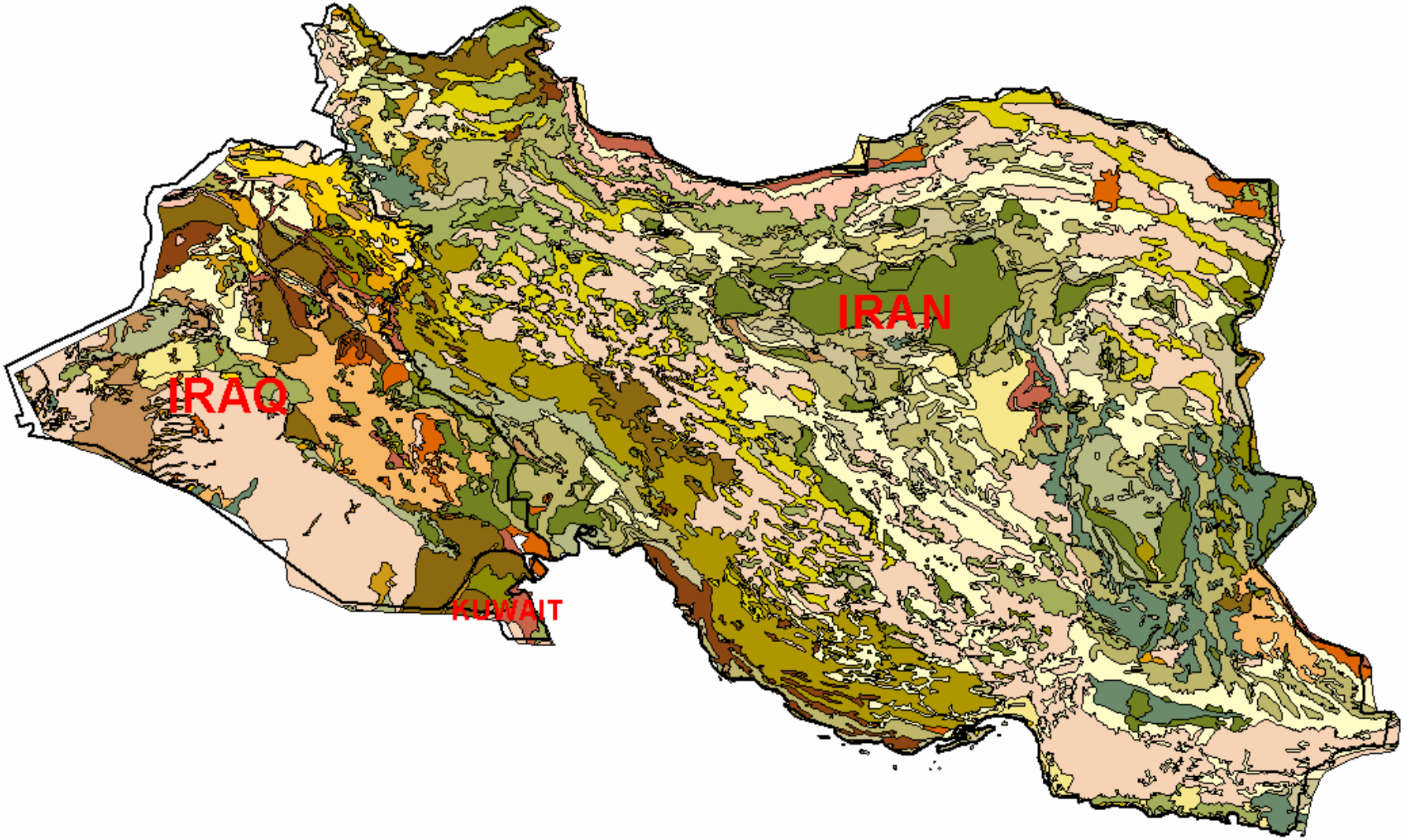


USDA 1:1M World Soil Map: Excellent interpretation and correlation (250+ man-years of analysis), near-global coverage, concerns with cartographic quality, e.g. base maps from 1940s-1960s (FAO 1:5M has same problems).

DTED/SRTM2: Accurate, quantitative data that can be used to derive relief, slope, drainage density, landform, and physiography.

Landsat Orthophotomosaic: Mosaic using 7/4/2 band combination for geologic applications; orthorectified with NGA control points and DTED.

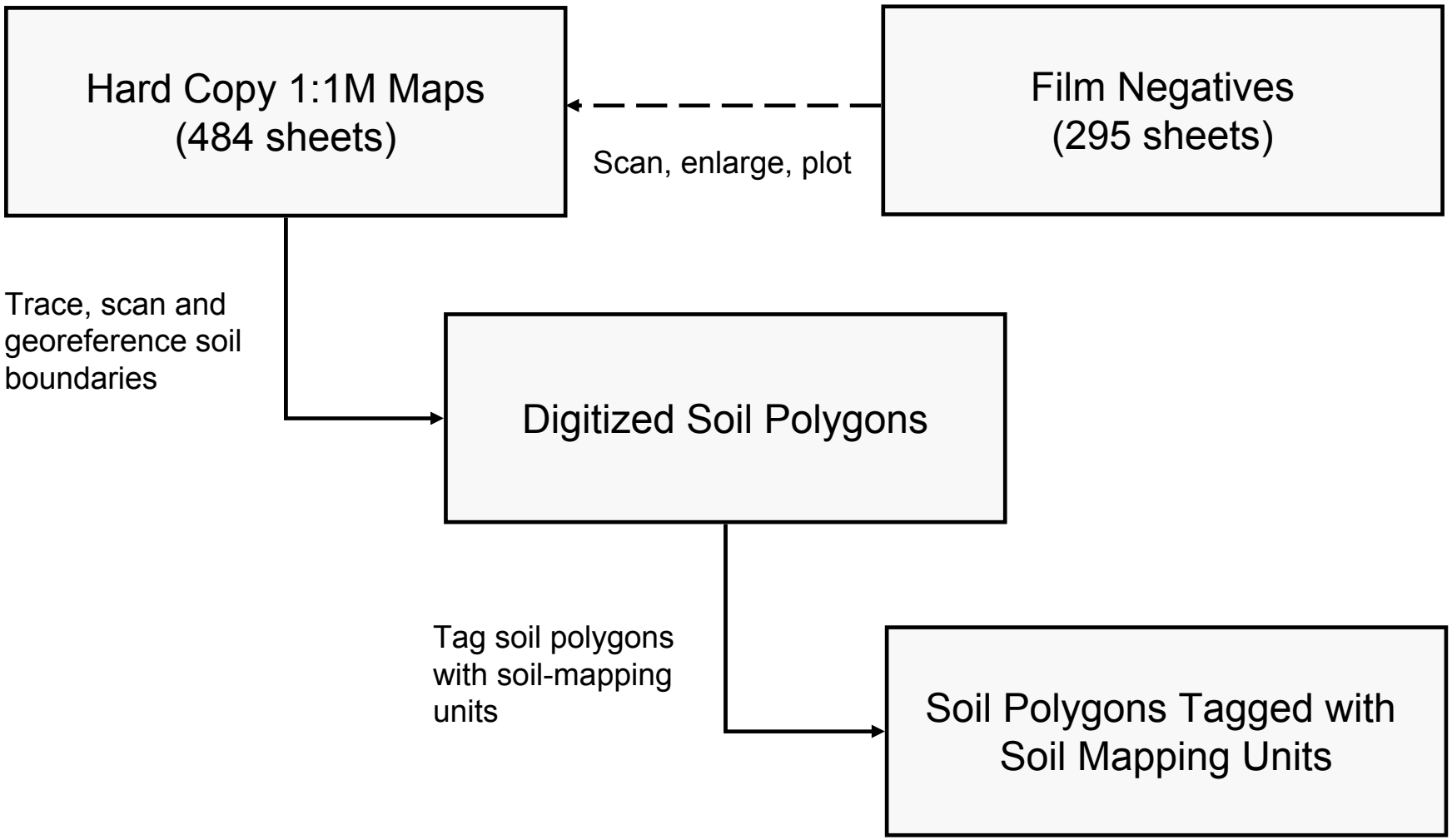
1:1M World Soil Map over Iraq, Iran, and Kuwait



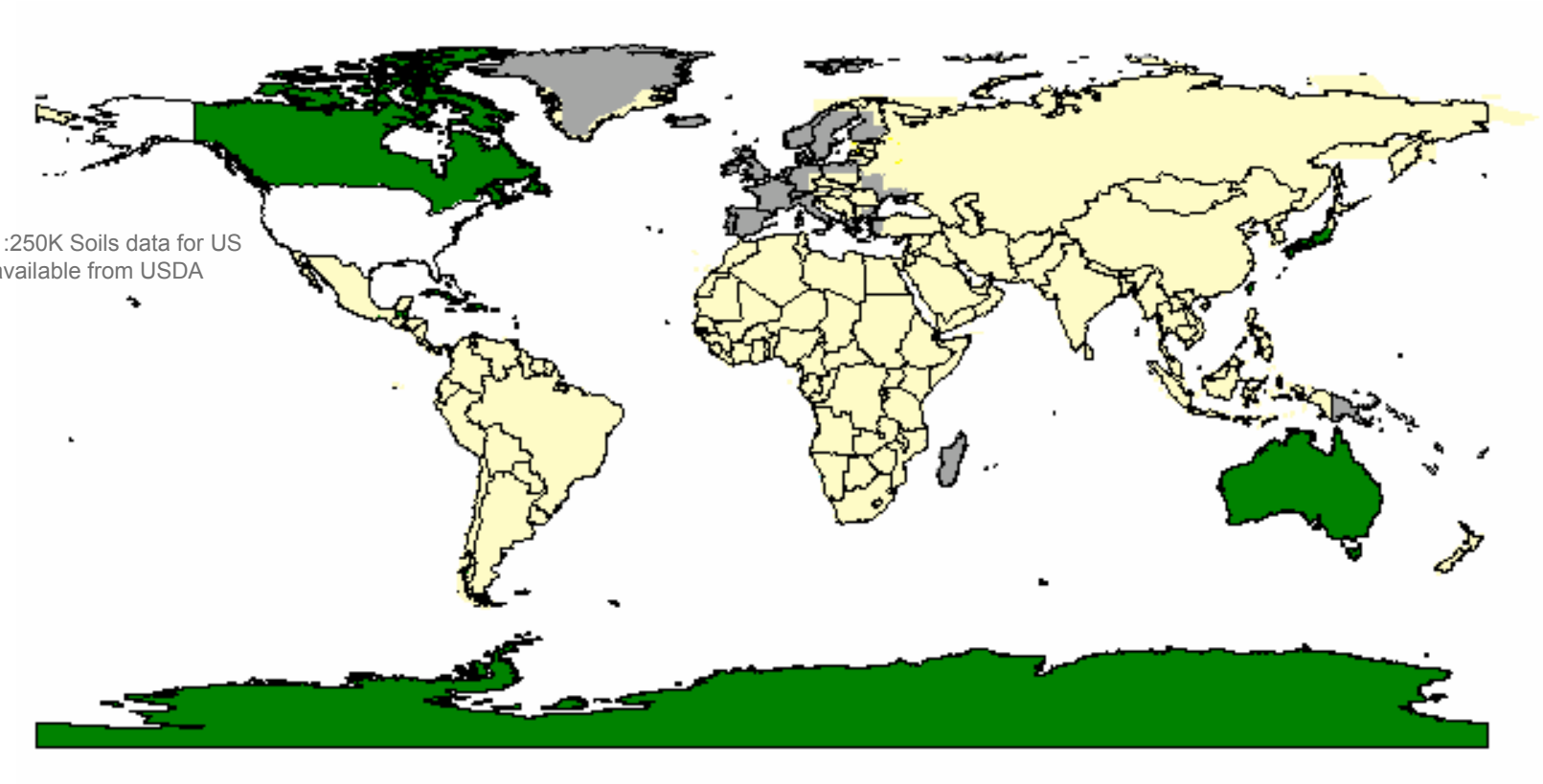
World Soil Mapping Units

- **Sample Mapping Unit: L H/Sd**
  - **Great Soil Group: L - Lithosols and associated soils**
  - **Landform/Relief: H - Hilly terrain**
  - **Parent Material/Geology: Sd - Sandstone**
  - **Modifying Symbol: none**
  - **Textual Description:**
    - **Composition:** Hilly lands of desert regions with a high proportion of bare rock or very shallow and stony soils. ***Zonal soils of the region occur locally on gentle protected slopes, and Solonchak and Solonetz occur in small depressions.*** Areas are almost barren of vegetation. The rocks are dominantly sandstones.
    - **Physiography:** Rocky hills. Local relief several tens to hundreds of feet. Slopes are dominantly 15 to 35 percent with numerous precipitous rock ledges.
    - **Iraq:** An area is mapped on the Iran-Iraq boundary in southeastern Iraq. The rock is mainly red sandstone, and ***locally there are sandy Red Desert soils.*** The average annual precipitation is between 8 and 10 inches, nearly all of which falls in winter and spring. Occasional frosts occur in winter; summers are very hot and dry. The hills are largely barren, but ***desert shrubs persist on the local areas of red desert soils*** and these are occasionally grazed.

Soil Boundary Digitization Process



1:1M World Soil Map Digitization Status



Soil Mapping Unit Descriptions Status:

- All descriptions captured (100% complete) and ready to be linked to soil polygon boundaries.

Completed

In Work – scanned, tagged, not edge matched

Unprocessed

Soil Polygon Boundary Enhancement Study

Background

- 1:1M World Soil Map has a wealth of information that can be used to increase the density of soil polygons
- Soil boundaries are delineated using soil landscape relationships and other indicators of different soil types and conditions
- Landscape features that provide the greatest utility for delineating soils include physiography and landforms, geology, surface drainage, and vegetation and land use

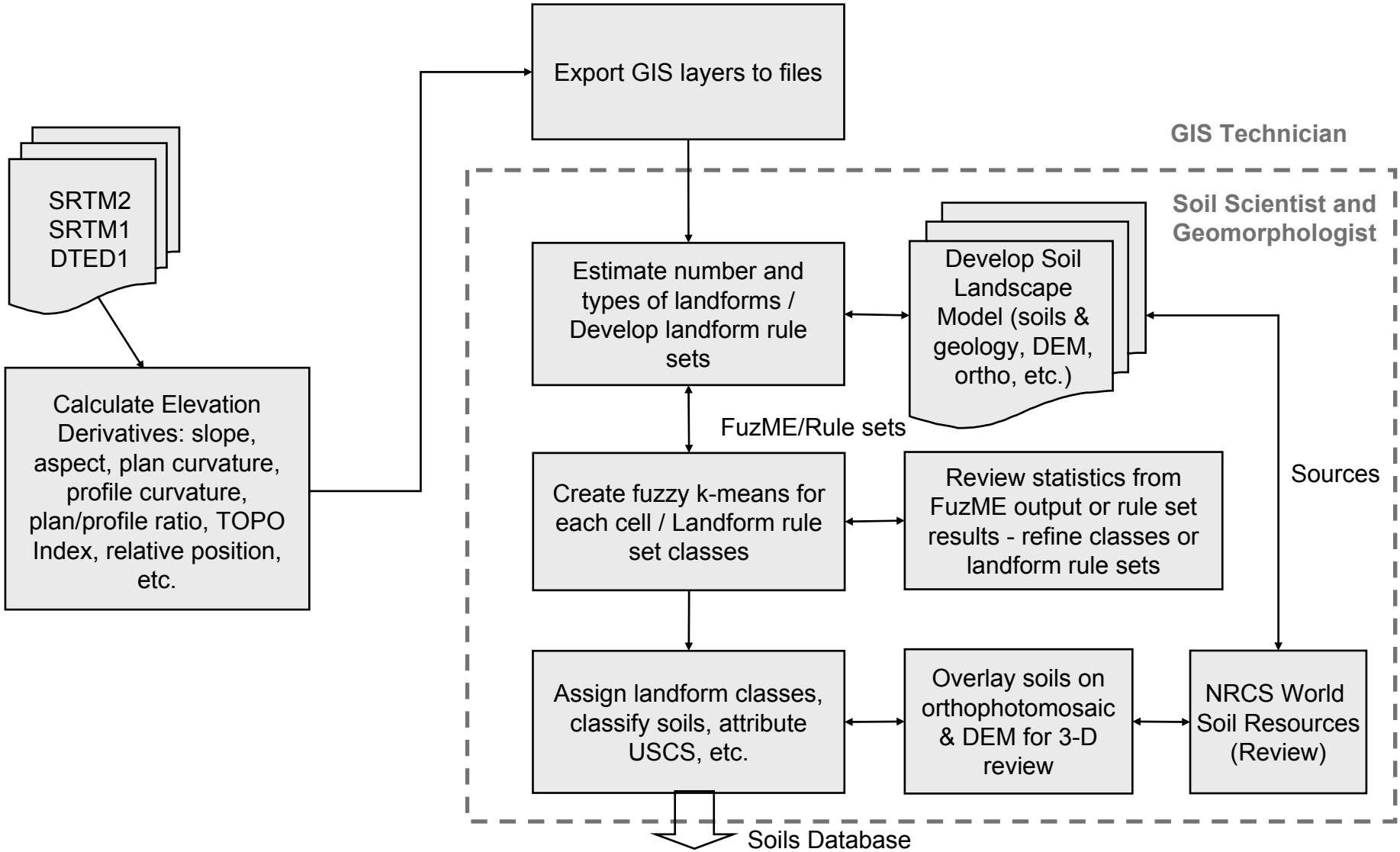
Approach

1) Use SRTM DTED2 and derivative values to identify and delineate physiography and landforms

2) Exploit World Soil Map soil mapping unit descriptions and other sources to develop soil landscape models and assign soil types to different landforms and their landform elements

3) Develop GIS techniques to semi-automate and accelerate the delineation of soil polygons

Process Flow for Enhancing Soil Boundaries



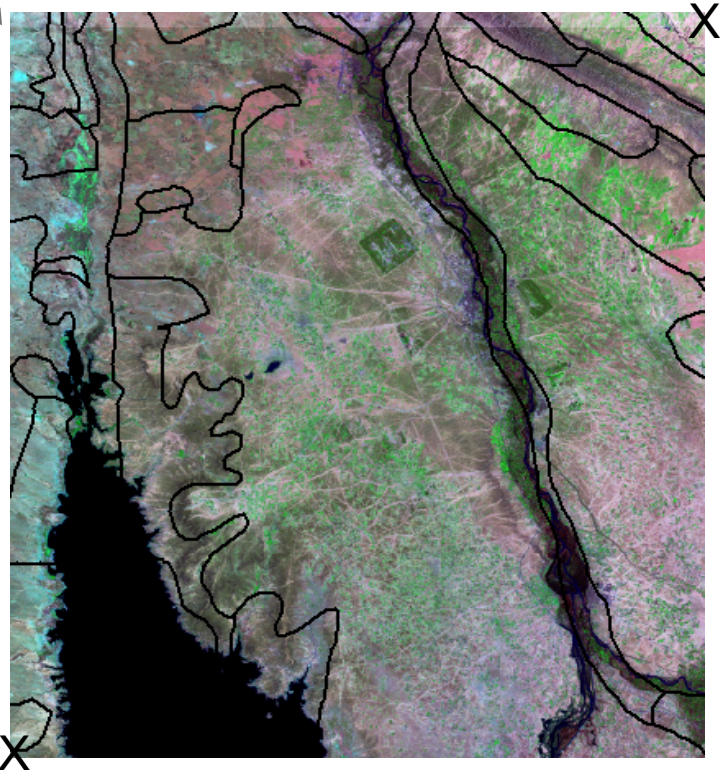
Soil Boundary Enhancement Example

- Background
  - Worst case scenario
  - Area (1^0 cell) in Iraq chosen - need 1:250K soils data in 8 hours
  - Sources
    - 1:1M Soils
    - SRTM1
    - LANDSAT Orthophotomosaic
    - Information from web
- Results
  - 2 hrs to process 1 degree cell SRTM1, generate derivatives, and run algorithms
  - 8 hrs to interpret soils, develop landscape models, and assign soil classes

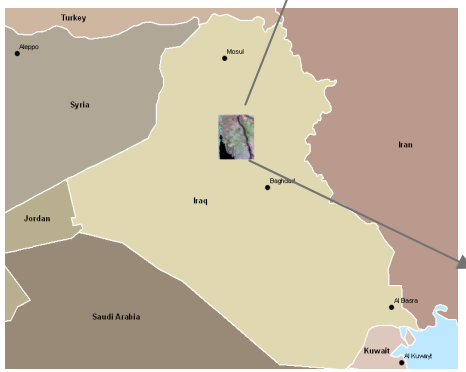
1:1M Soil Boundaries over LANDSAT Ortho

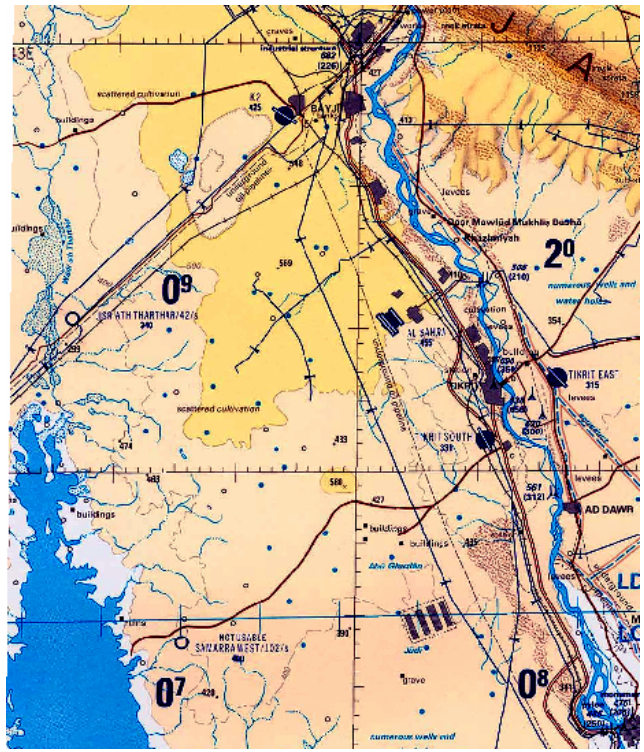
Exercise Scenario Area

35^0 N 44^0 E

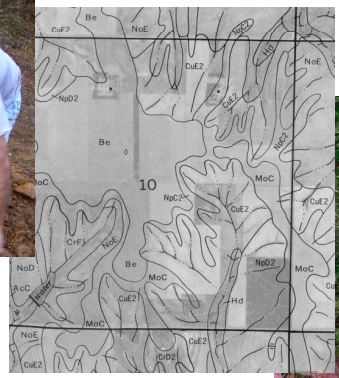


34^0 N 43^0 E

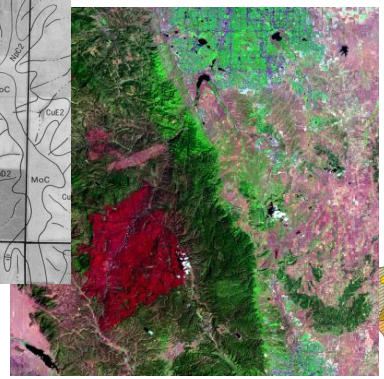




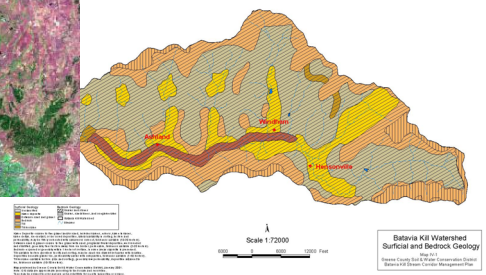
Ancillary Sources and Information from Web



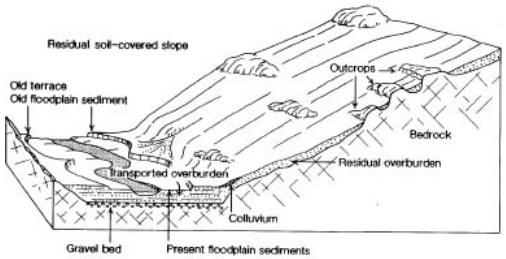
Larger Scale Soil Surveys/Soil Maps



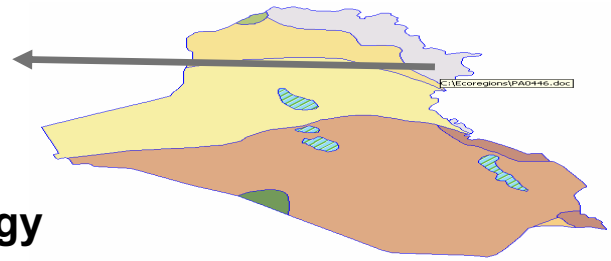
Vegetative Cover



Geology/Parent Material



Soil Landscape Studies



General Ecology

Develop Landscape Model from 1:1M World Soil Map Units and Ancillary Sources

L H/Sd:
- **L - Lithosols and associated soils**
- **H - Hilly terrain**
- **Sd - Sandstone**
- **Textual Description:**

Composition: Hilly lands of desert regions with a ***high proportion of bare rock*** or very shallow and stony soils. ***Zonal soils of the region occur locally on gentle protected slopes, and Solonchak and Solonetz occur in small depressions.*** Areas are almost barren of vegetation. The rocks are dominantly sandstones.
Physiography: Rocky hills. Local relief several tens to hundreds of feet. Slopes are dominantly 15 to 35 percent with numerous precipitous rock ledges.
Iraq: An area is mapped on the Iran-Iraq boundary in southeastern Iraq. The rock is mainly red sandstone, and ***locally there are sandy Red Desert soils.*** The average annual precipitation is between 8 and 10 inches, nearly all of which falls in winter and spring. Occasional frosts occur in winter; summers are very hot and dry. The hills are largely barren, but ***desert shrubs persist on the local areas of red desert soils*** and these are occasionally grazed.

Process

- **Review soil-mapping unit descriptions and ancillary materials**
- **Develop Landscape Model Matrix**
- **Validate model using 3-D visualization of terrain using LANDSAT orthophotomosaic and/or SRTM2 shaded relief**

Soil	Landscape Position	Parent Material	Relief	Vegetation	Attribution/ Comments
Lithosol	Hills	Sandstone	8-100m	Barren	Stony, Dry, <0.5m, GM, SM
Bedrock	Hills	Sandstone	8-100m	Barren	Rock Outcrop
Red Desert	Gentle protected slopes	Sandstone	8-100m	Desert Shrubs	Dry, >0.5m, SM
Solonetz	Depression	Alluvium-Colluvium	1-2m	Barren - Halophytic Plants	Dry, >0.5m, ML, CL
Solonchak	Depression	Alluvium-Colluvium	1-2m	Barren - Halophytic Plants	Dry – Moist, >0.5m, CL, Salt Crusts

Terrain Derivatives Available for Physiography and Landform Algorithms

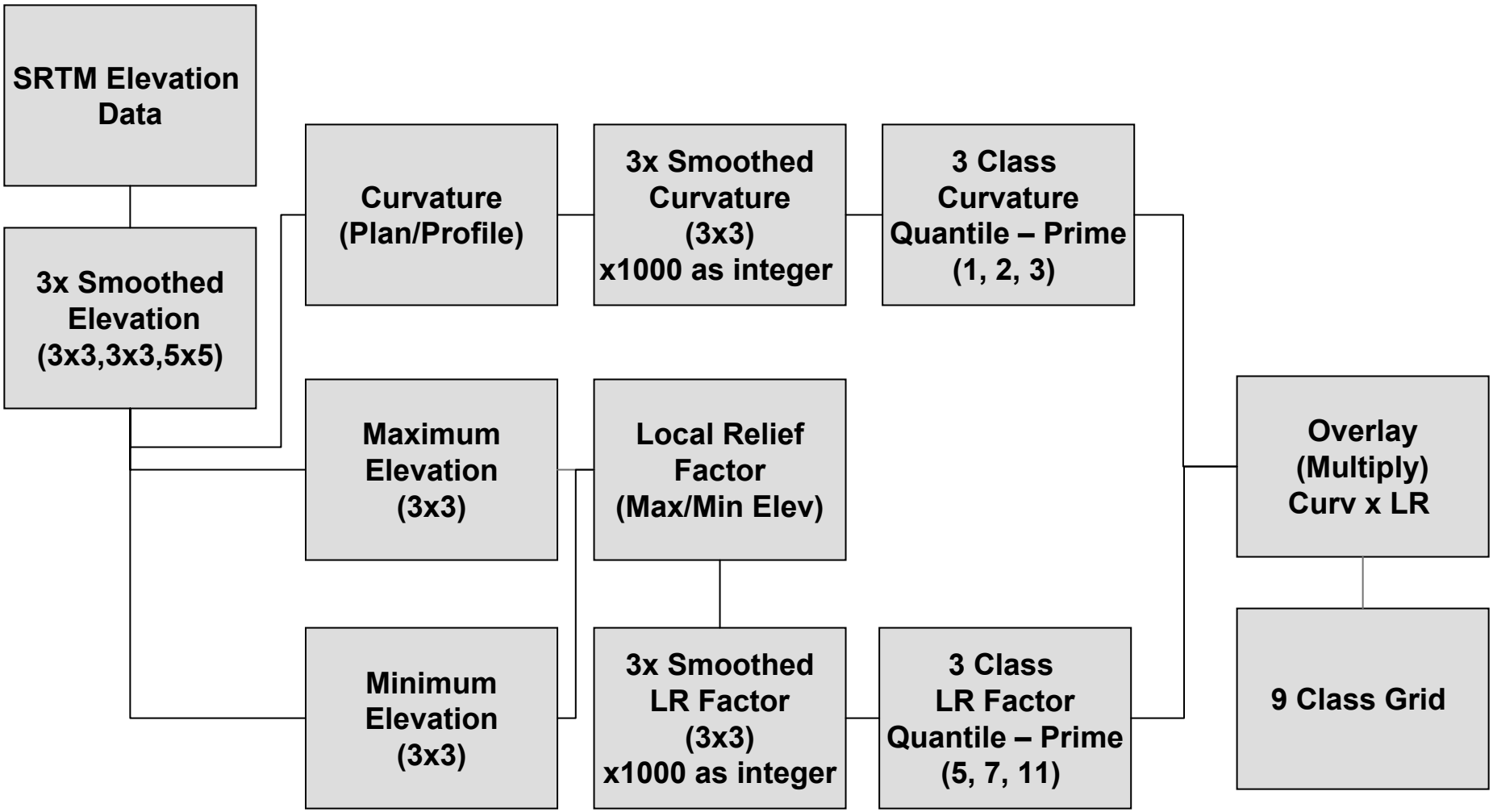
- Elevation
- Slope
- Plan Curvature
- Profile Curvature
- Ratio: Plan Curvature/Profile Curvature
- Slope Position
- Wetness Index
- Stream Power Index
- Saturation Index
- Roughness (Local Relief Factor)
- Change in Elevation Above/Below Base Physiography
- Relative Landscape Position
- Long Curvature of Landscape
- Long Landscape Grade
- Presence and Percentages of Landform Elements

Landform Algorithm Methodologies

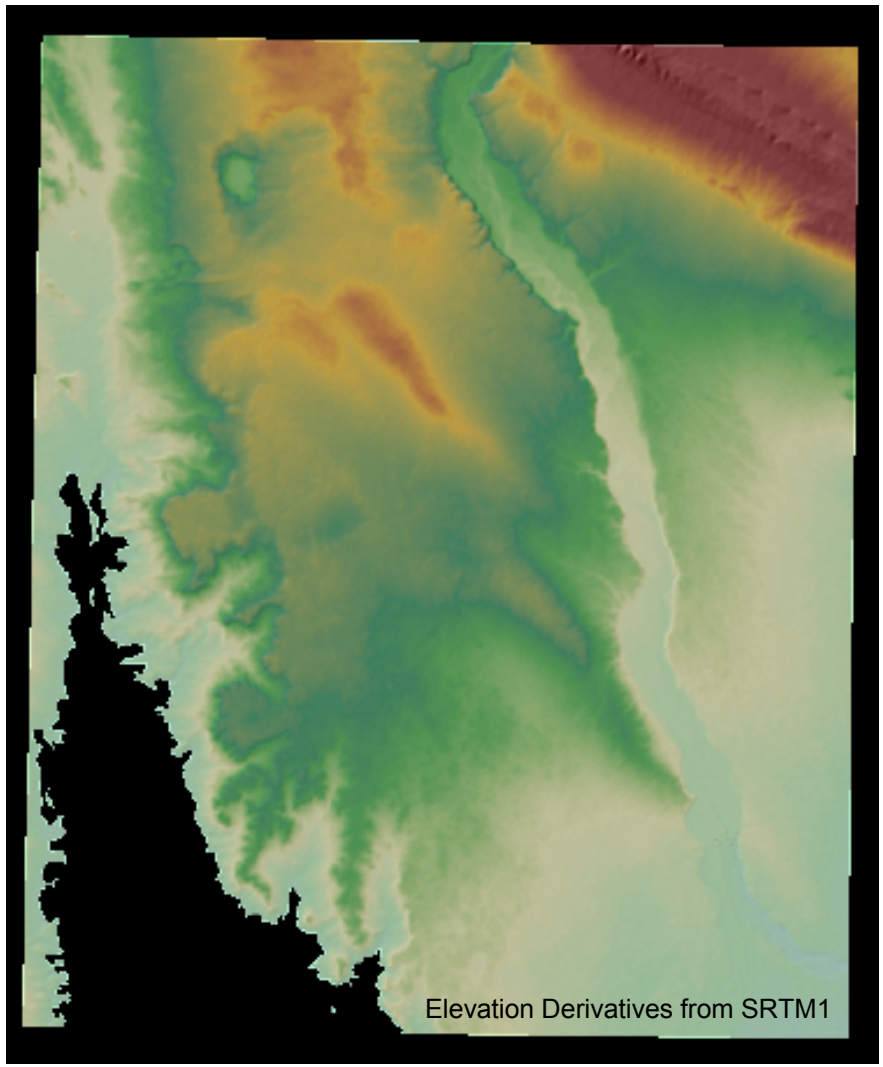
- *Fuzzy Logic Procedures Use Statistics Derived from Multiple Attributes*
- *Landform Rule Sets Use Predetermined Rules for a Specific Physiographic Region*
  - Slope Breaks
  - Curvature Breaks
  - Elevation Breaks
  - Roughness Categories
  - Topographic Wetness
  - Other Terrain Derivatives

Process Flow for 9-Class Landform Algorithm

(Derived from plan/profile curvature and relative relief)



Smoothed SRTM1 – 90m Resolution

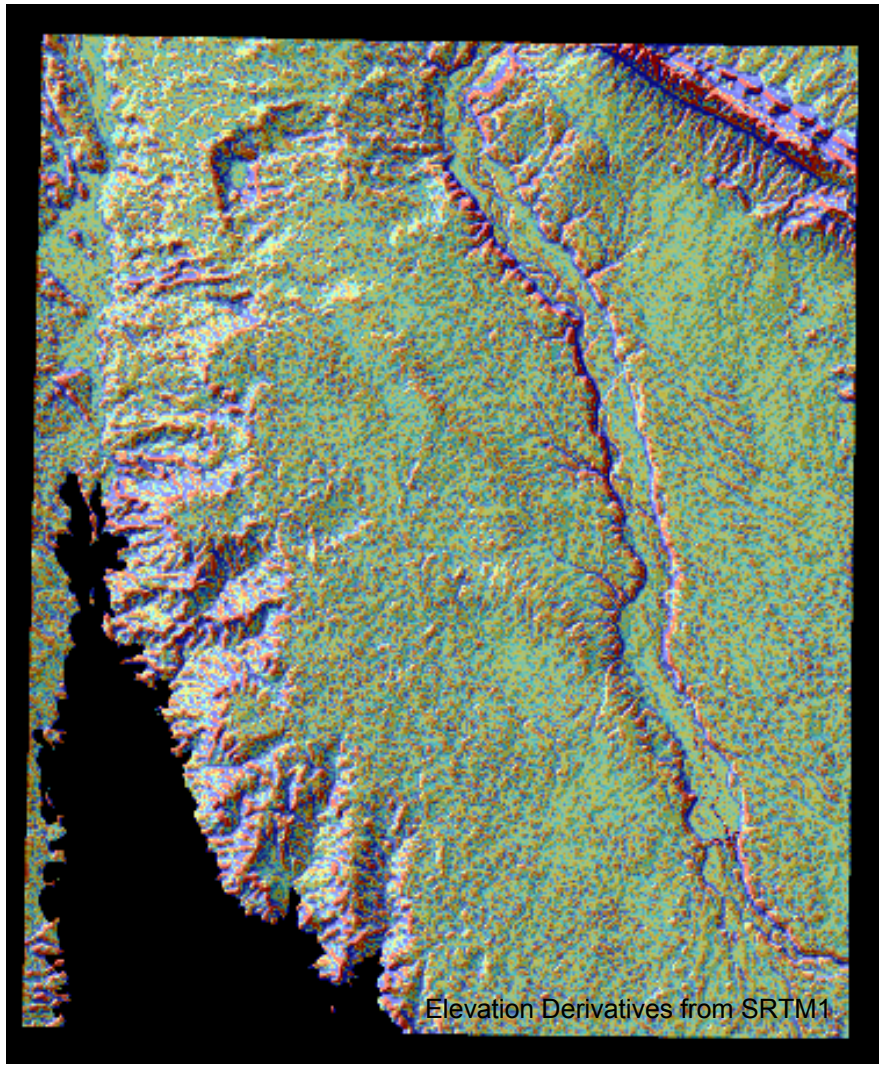


Elevation (meters)

High : 488.691772

Low : 47.829136

Curvature

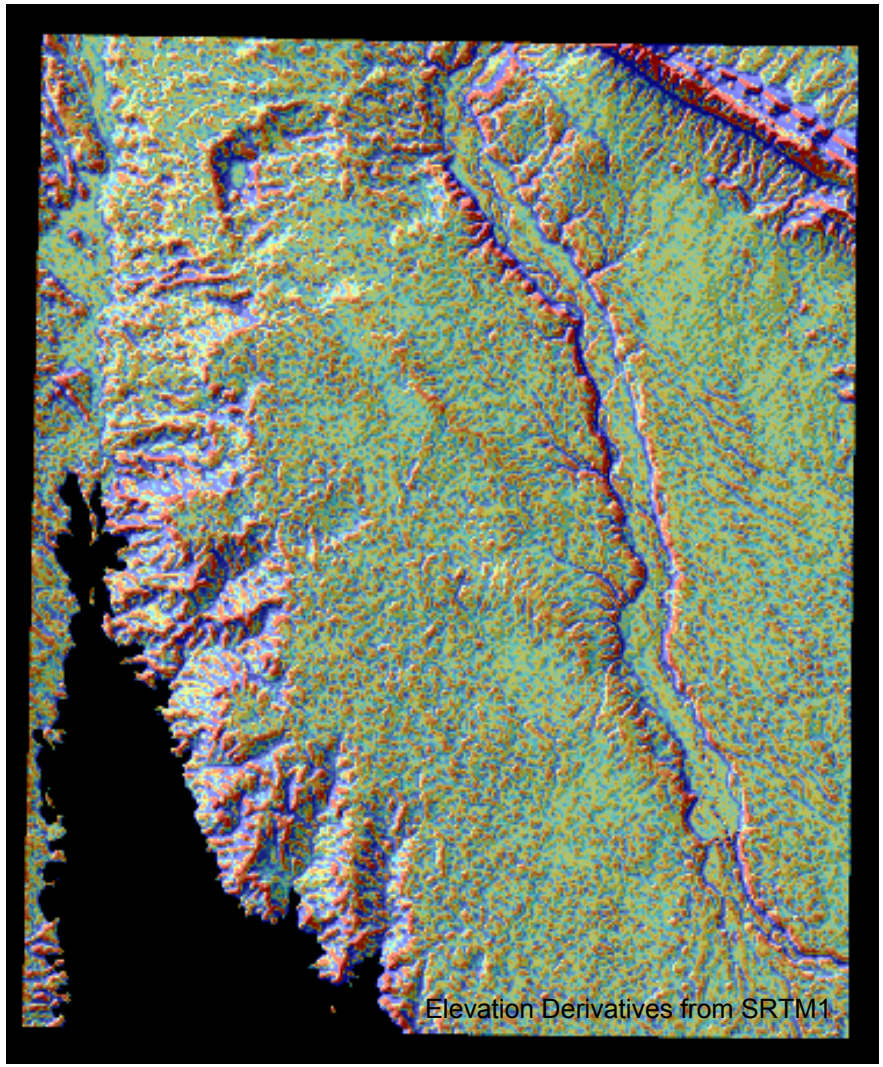


Curvature

High : 0.134533

Low : -0.282755

Smoothed Curvature

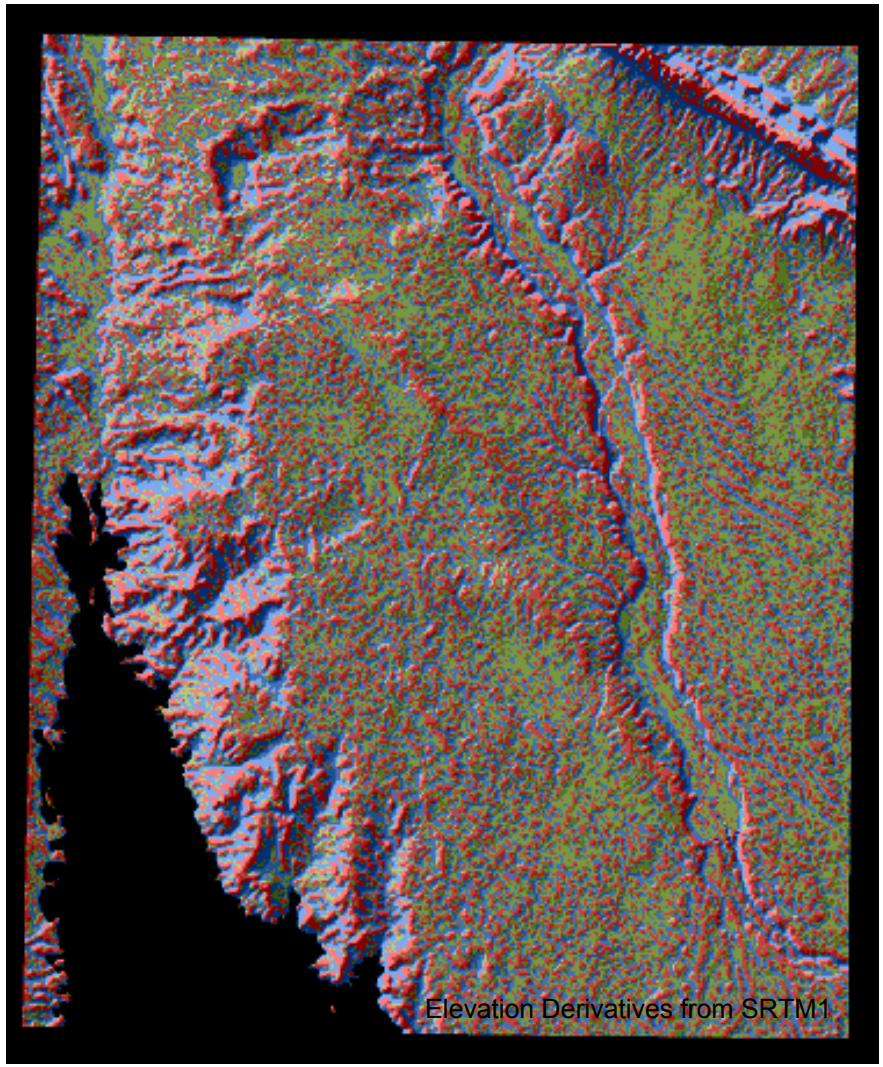


Curvature

High : 0.086605

Low : -0.062695

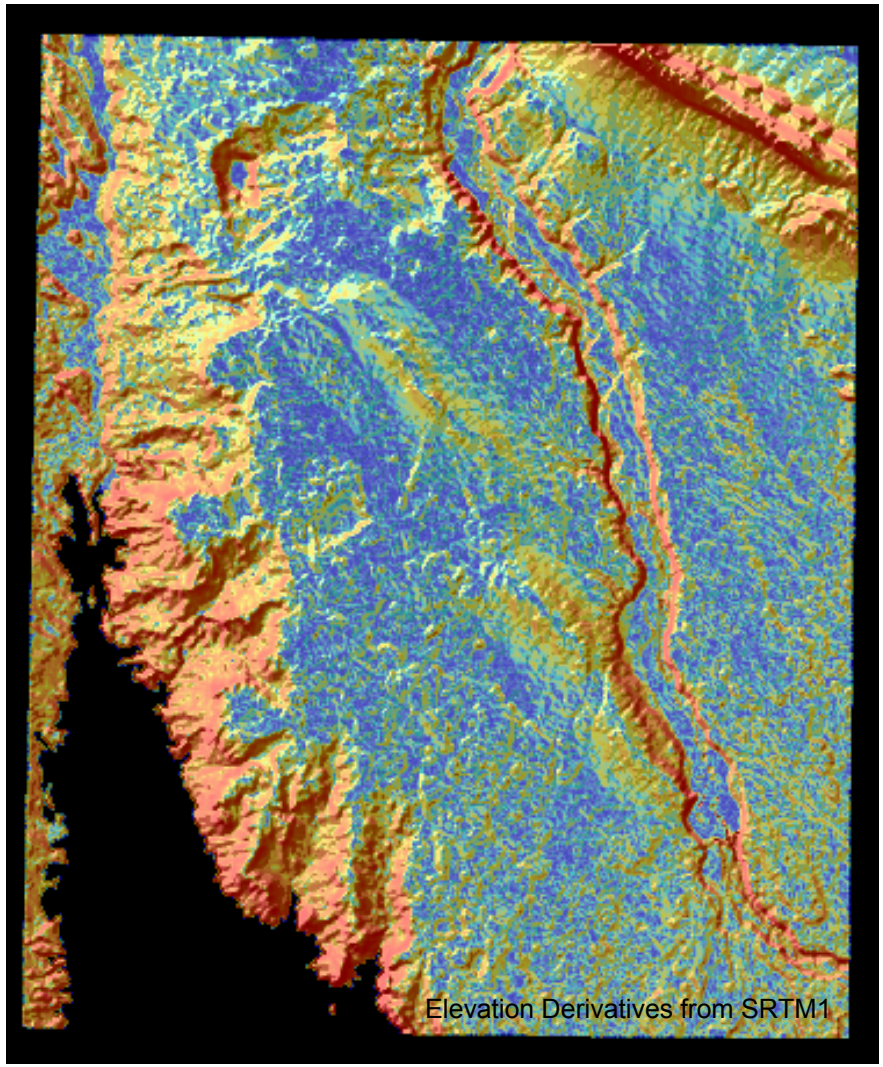
3 Class Curvature



Curvature

- Negative
- Nil
- Positive

Local Relief Factor – Max/Min Elevation

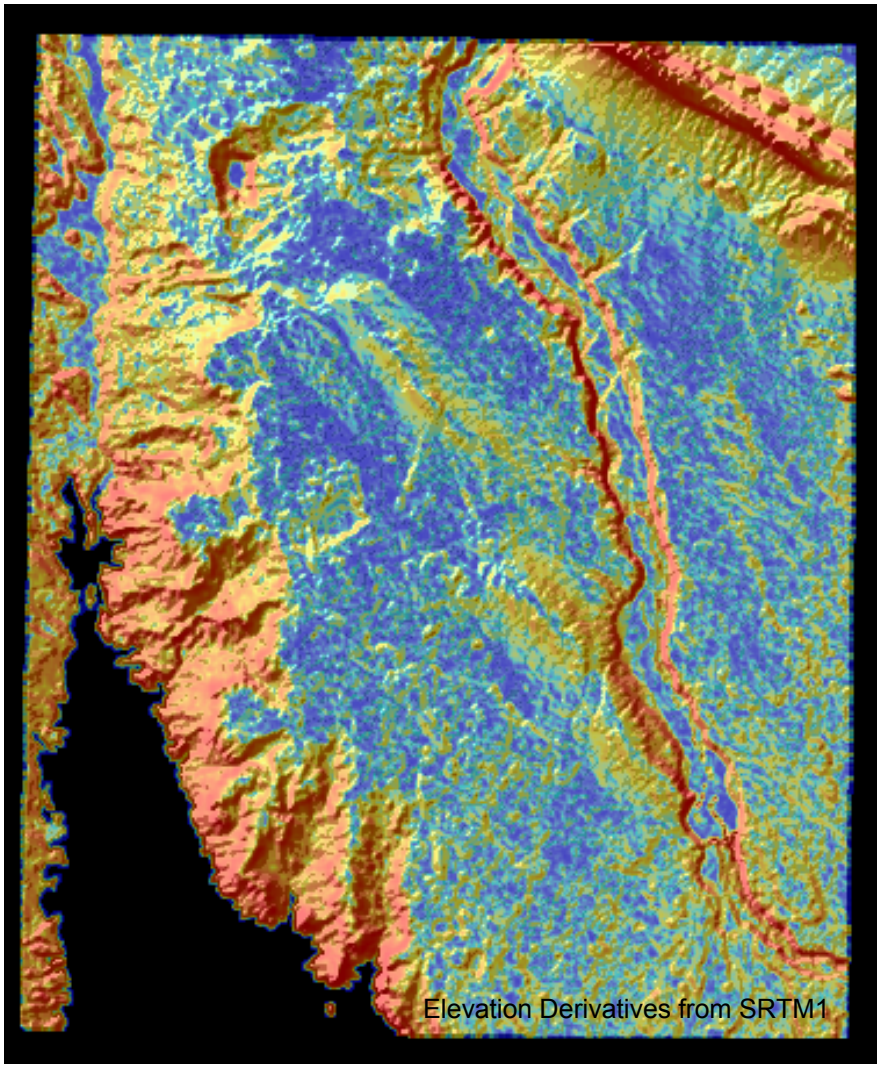


Local Relief

High : 1.233999

Low : 1.000000

Smoothed Local Relief Factor

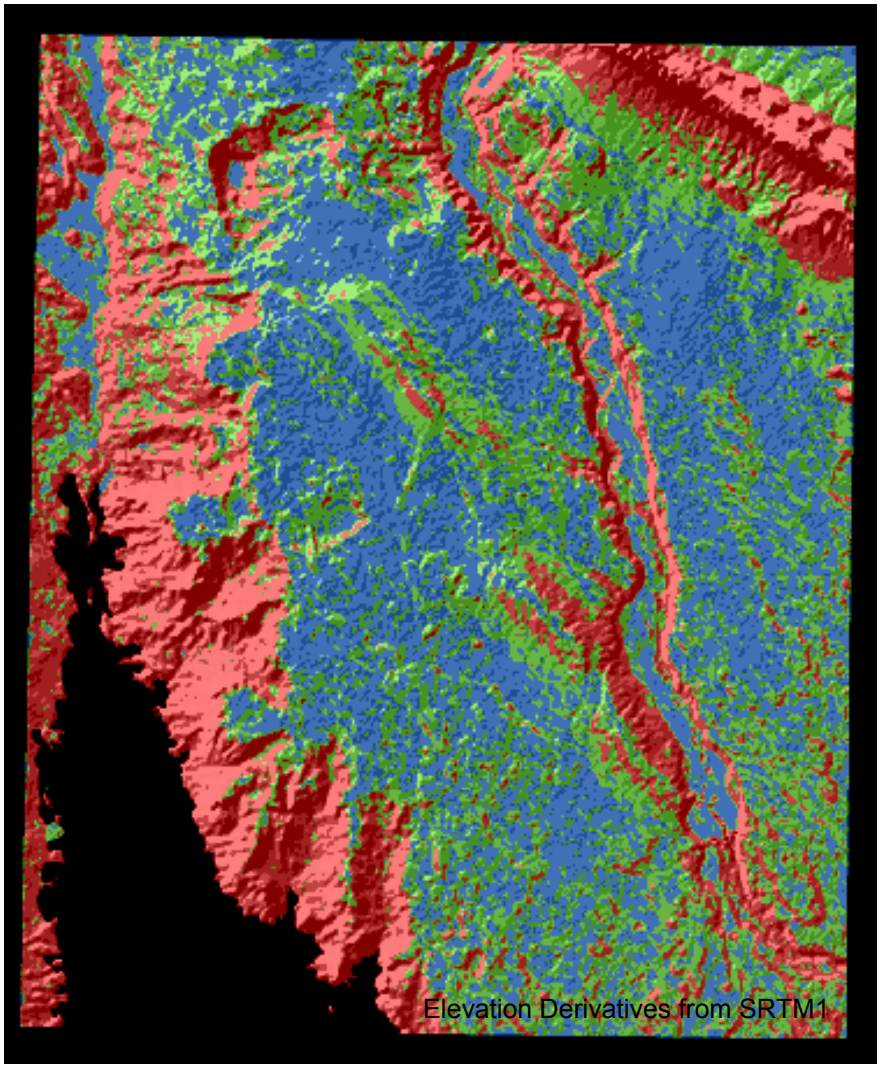


Local Relief

High : 1.196655

Low : 1.000000

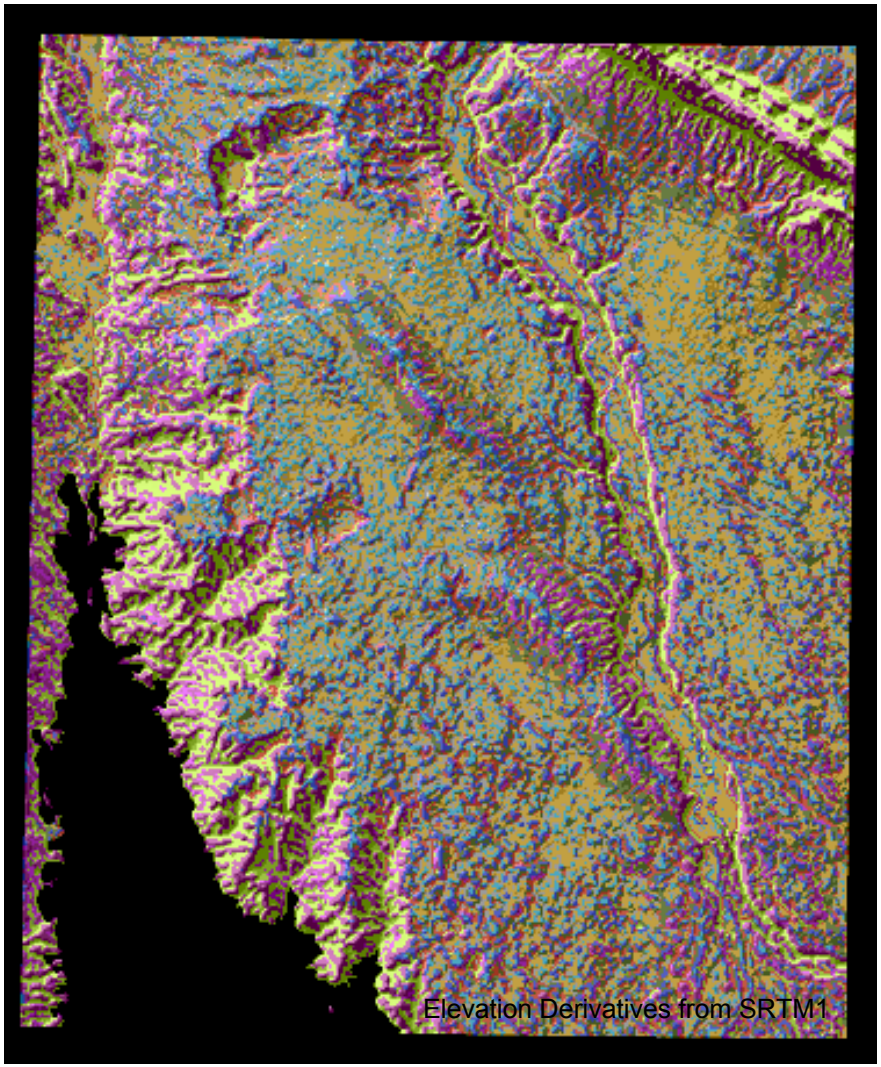
3 Class Local Relief Factor



Local Relief

- Low
- Moderate
- High

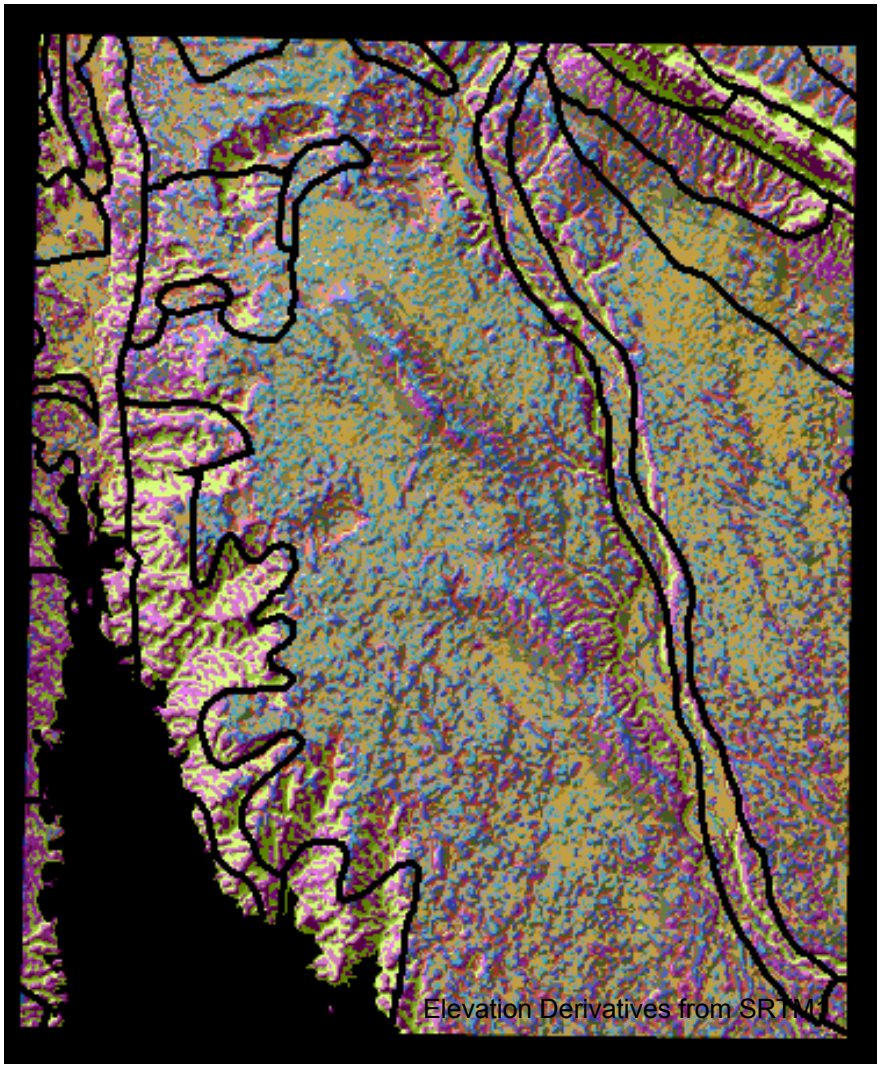
9 Class Landform Position - Curvature x Local Relief Factor



Landform Position

- Negative/Low
- Negative/Moderate
- Nil/Low
- Negative/High
- Nil/Moderate
- Positive/Low
- Positive/Moderate
- Nil/High
- Positive/High

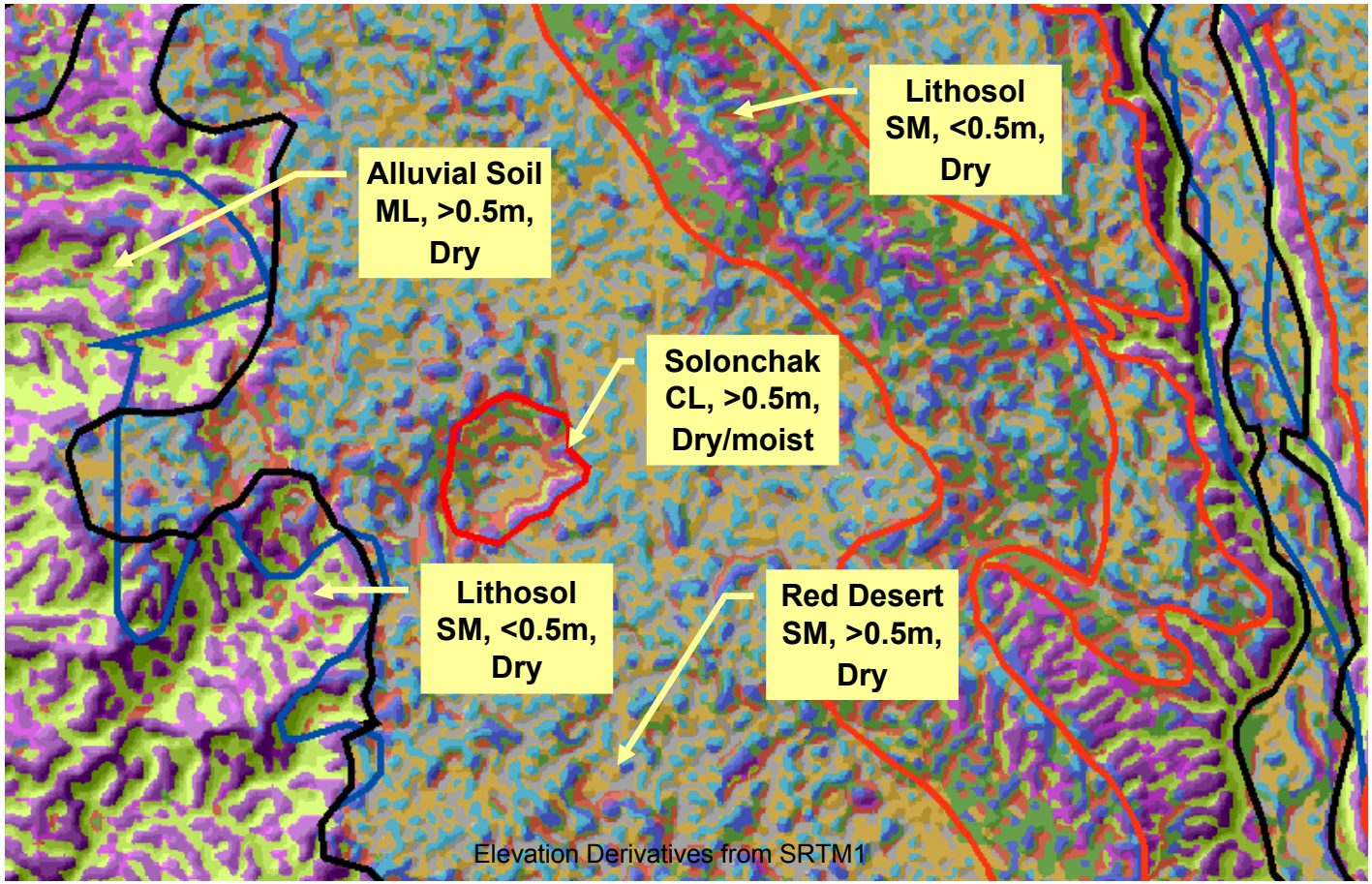
9 Class with 1:1M Soil Polygons



Landform Position

- Negative/Low
- Negative/Moderate
- Nil/Low
- Negative/High
- Nil/Moderate
- Positive/Low
- Positive/Moderate
- Nil/High
- Positive/High

1:1M Soil Boundaries over 9 Class Landforms

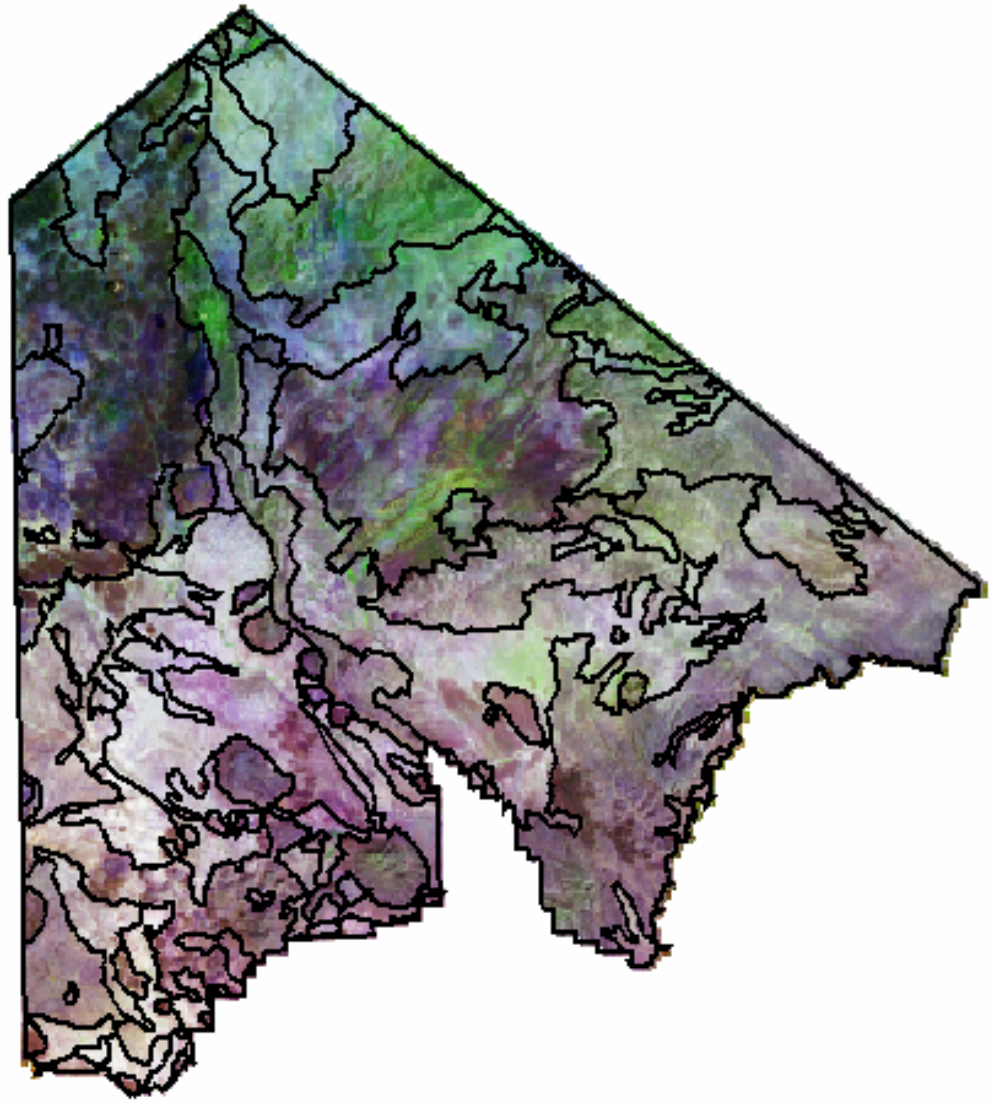


1:1M Soil Polygons

- Original
- Hand Repositioned
- Inclusions

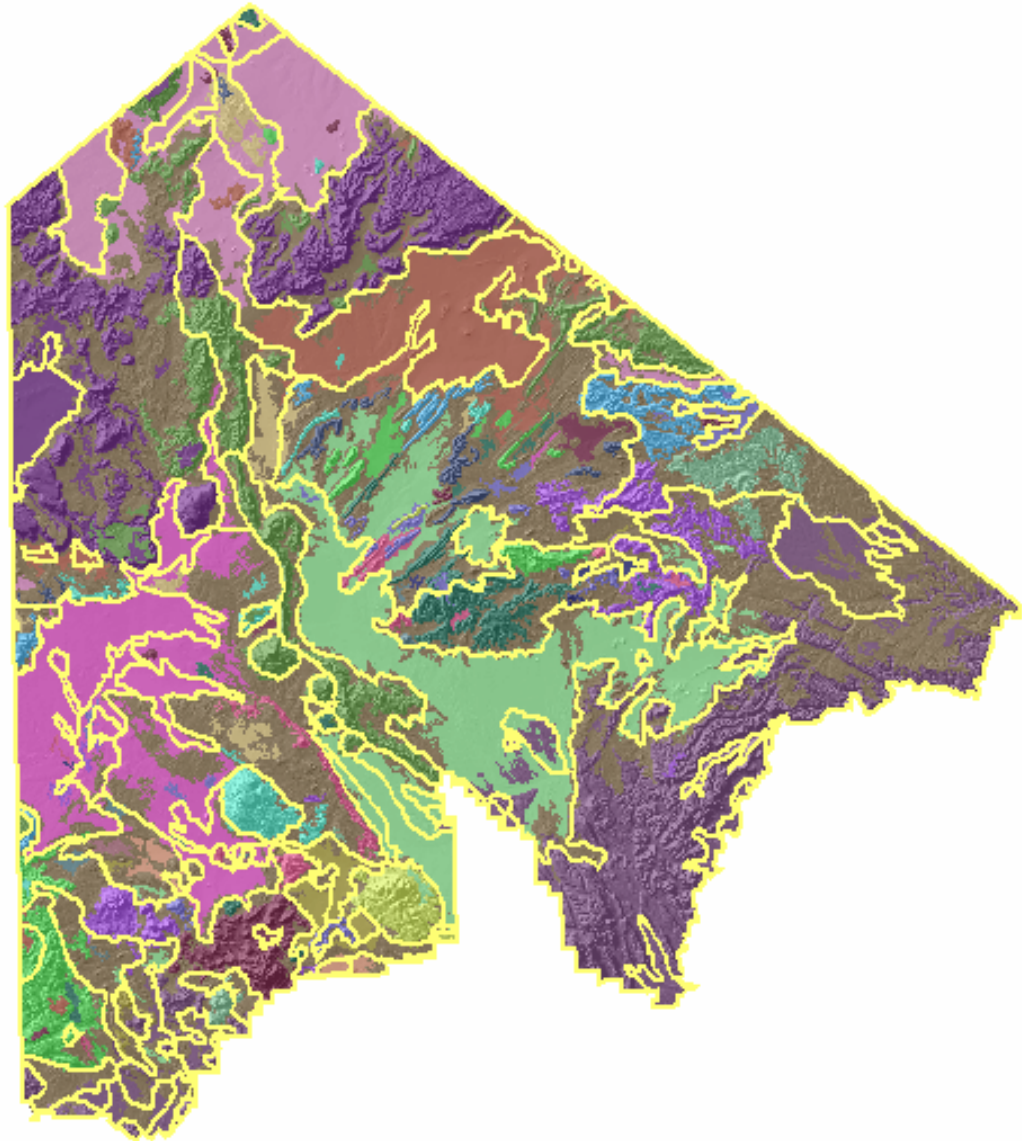
Comparison to STATSGO Dataset

- Brewster County, Texas was selected as a test area
- STATSGO soil polygons for Brewster county over satellite imagery, in this case a Landsat 7 ETM+ composite (bands 7, 4, and 2) image at 30m resolution



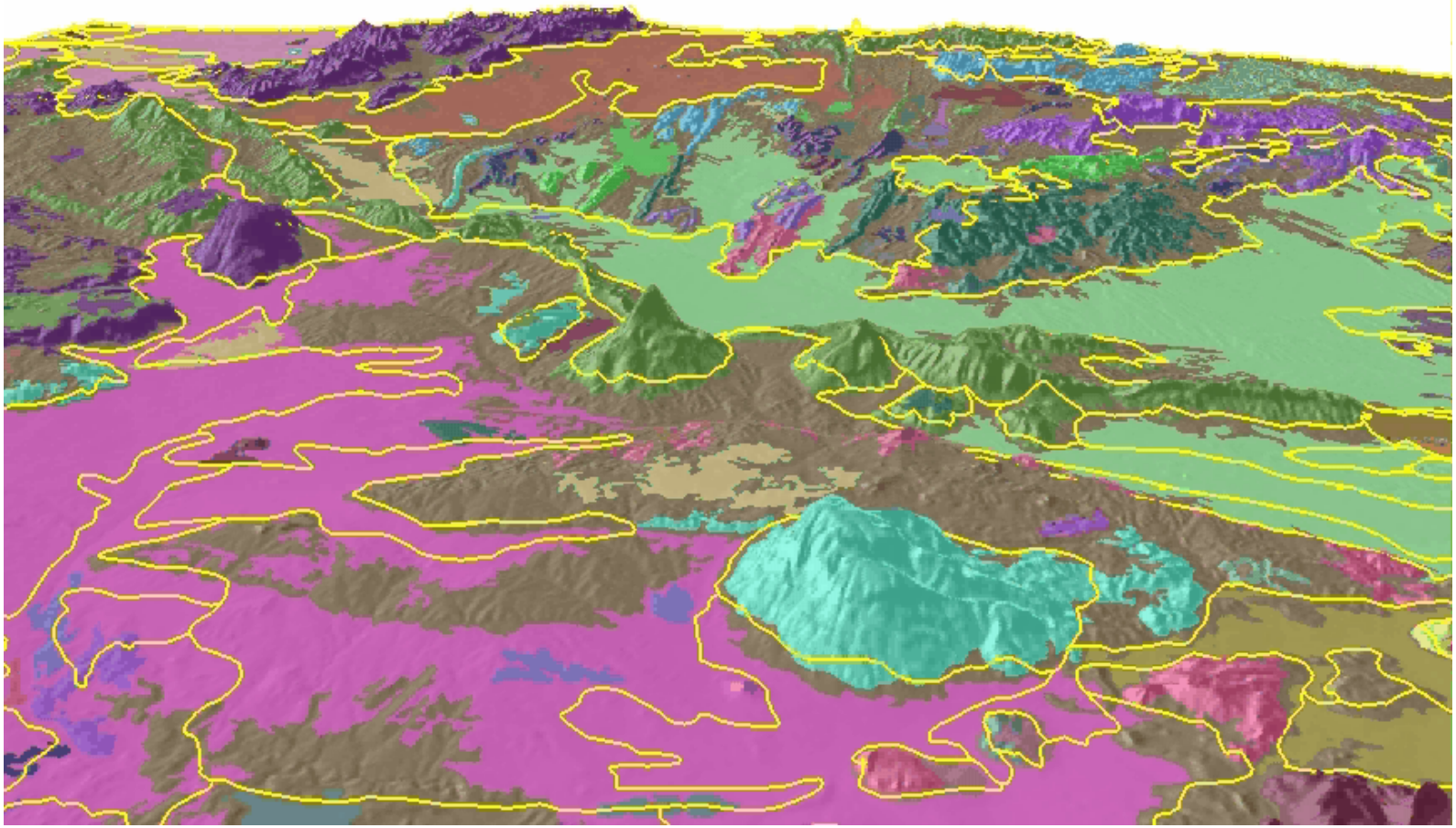
Comparison to STATSGO Dataset

- Relief and slope attributes were used to delineate unique homogenous physiographic regions
- This slide shows the correlation between these regions and the STATSGO soil polygons for Brewster County



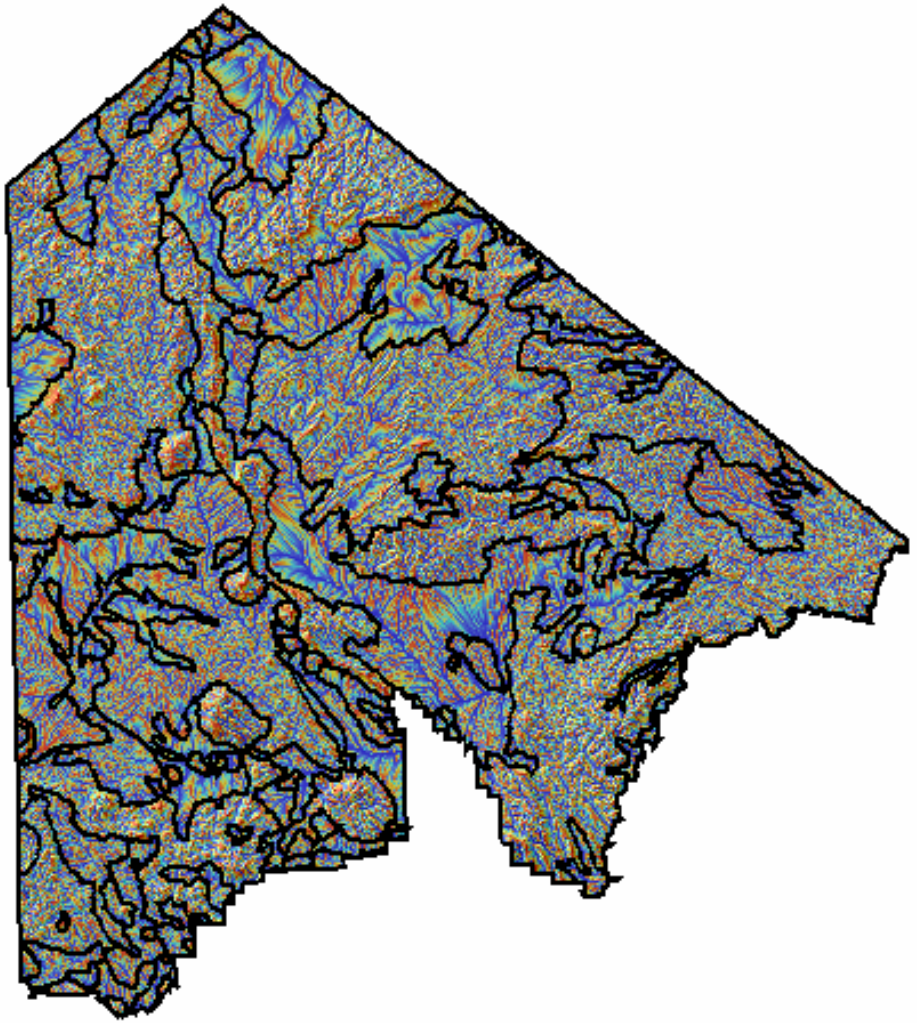
Comparison of Landforms with STATSGO Dataset

STATSGO soil boundaries in yellow over the physiographic regions



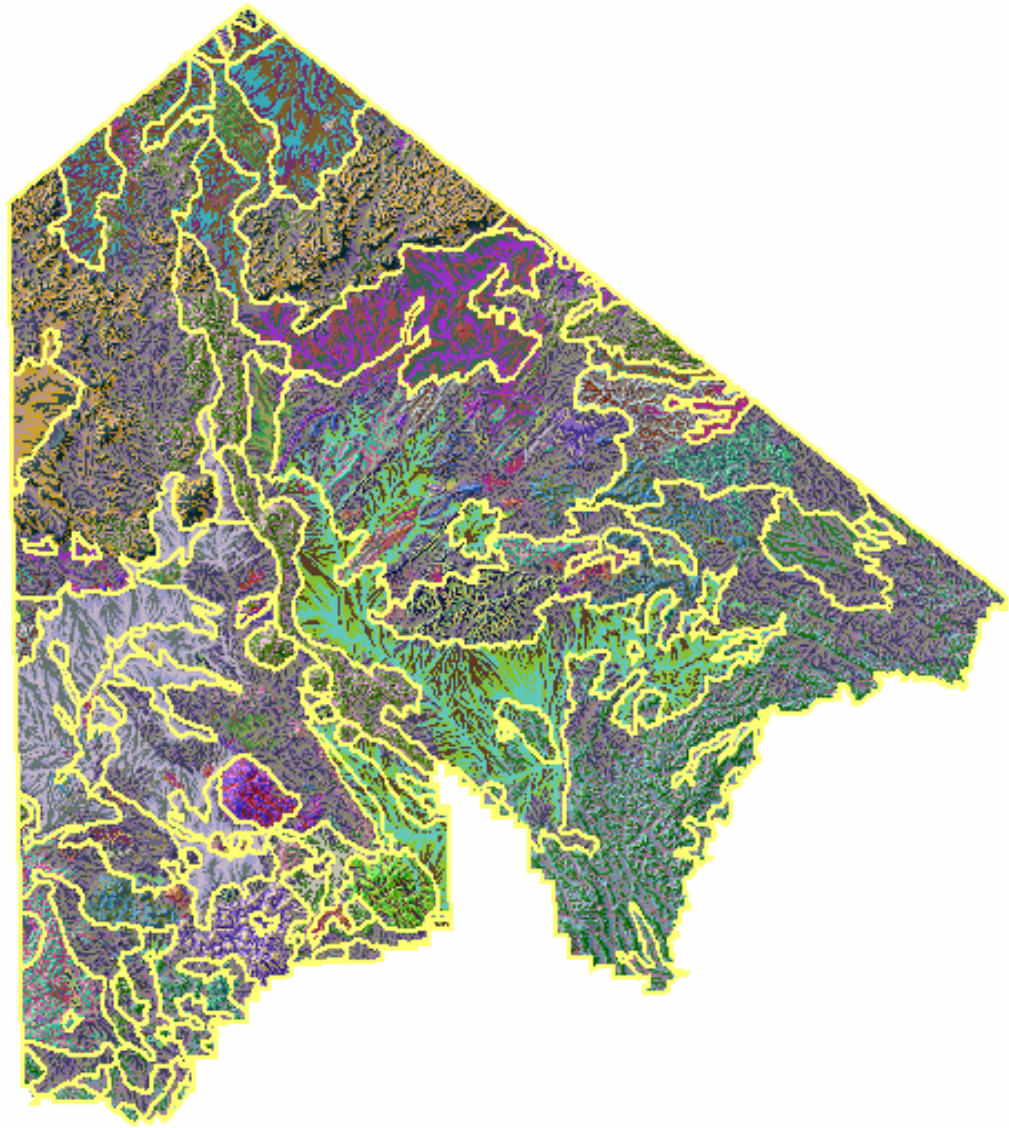
Comparison to STATSGO Dataset

- Slope position is an important elevation derivative in many areas
- The slope position for Brewster County shows the distinct drainage patterns that occur within each STATSGO soil polygon
- This continuum ranges from blue on the channels and lower slopes to red on the ridges and upper slopes



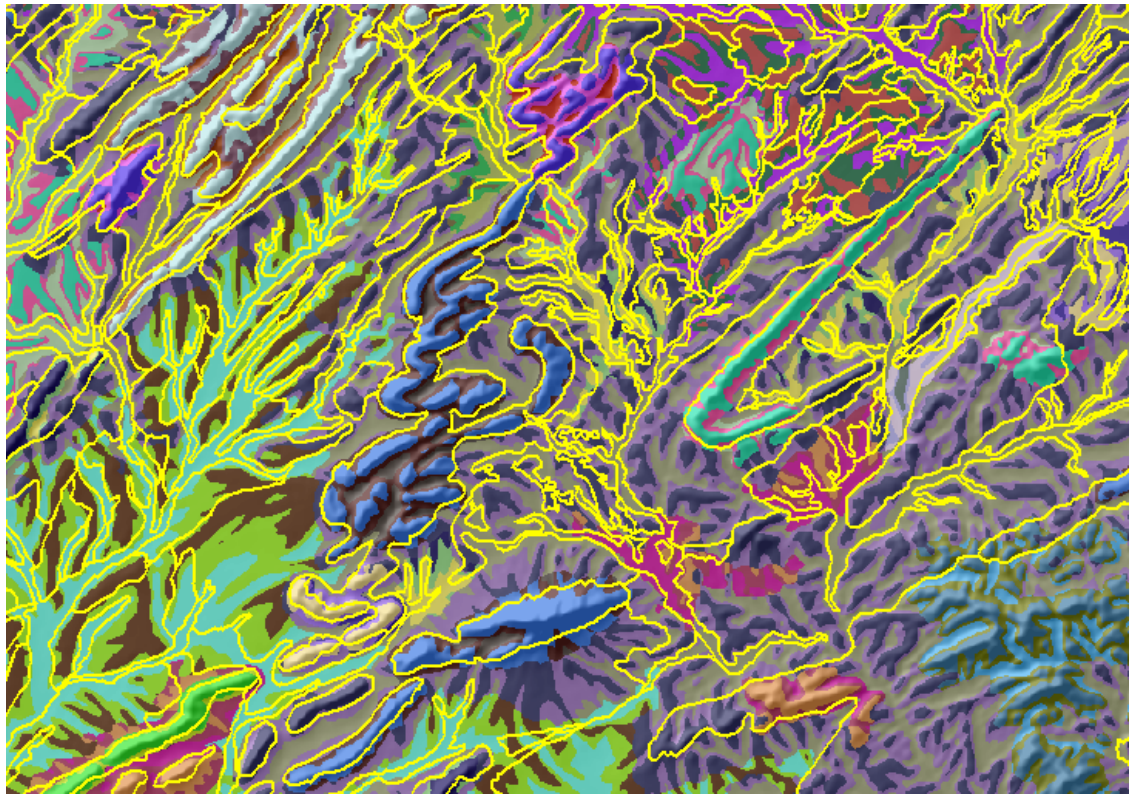
Comparison to STATSGO Dataset

- Slope position is integrated with the derived landforms to enhance the landscape description
- The output displayed represents 72 unique landscape positions based on the larger physiographic region and the local slope position description

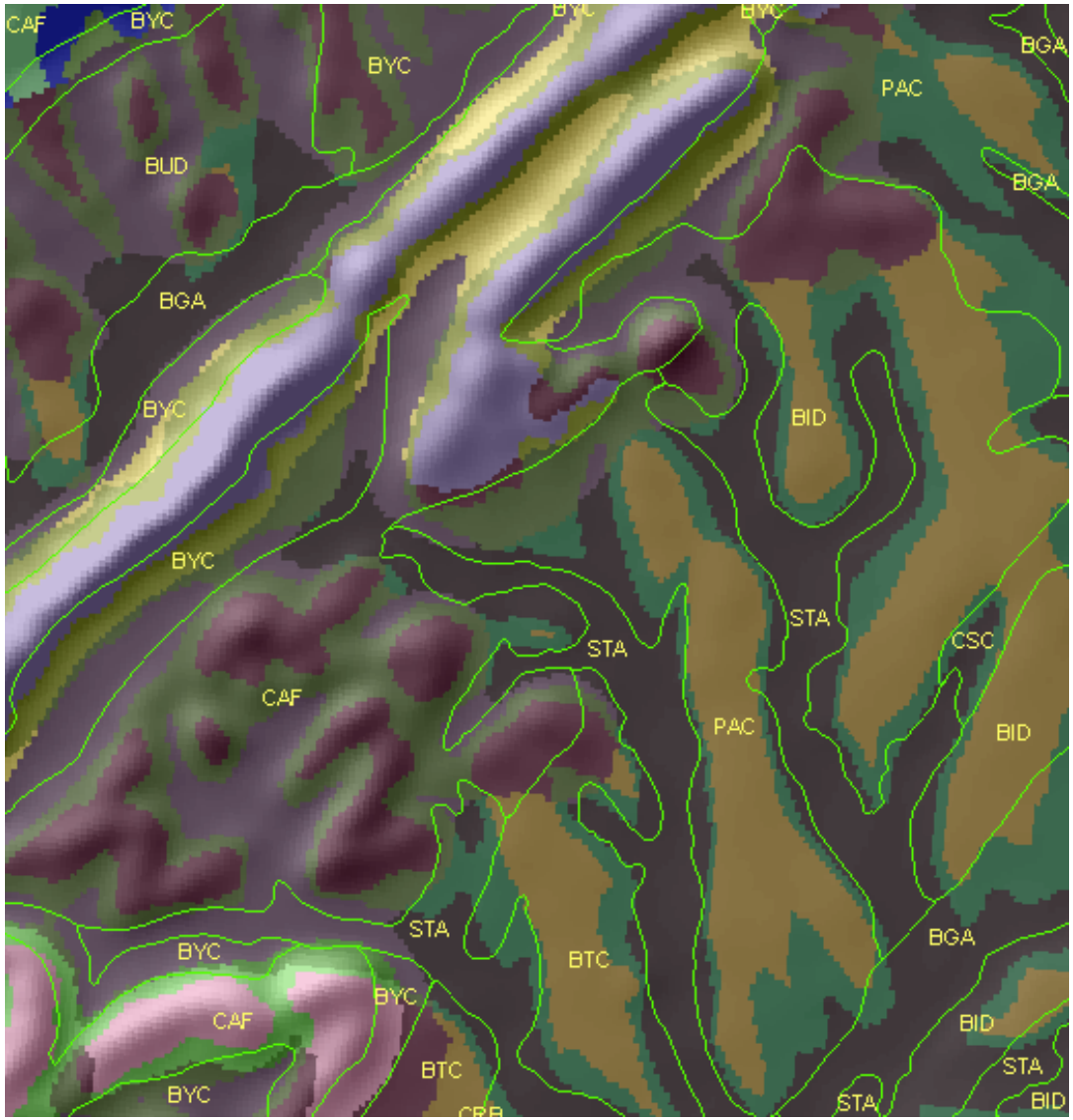


Comparison to SSURGO Dataset

- The resulting combination of physiographic regions and slope position are displayed at approximately 1:150K
- Note the agreement between SSURGO soil boundaries and the landscape model

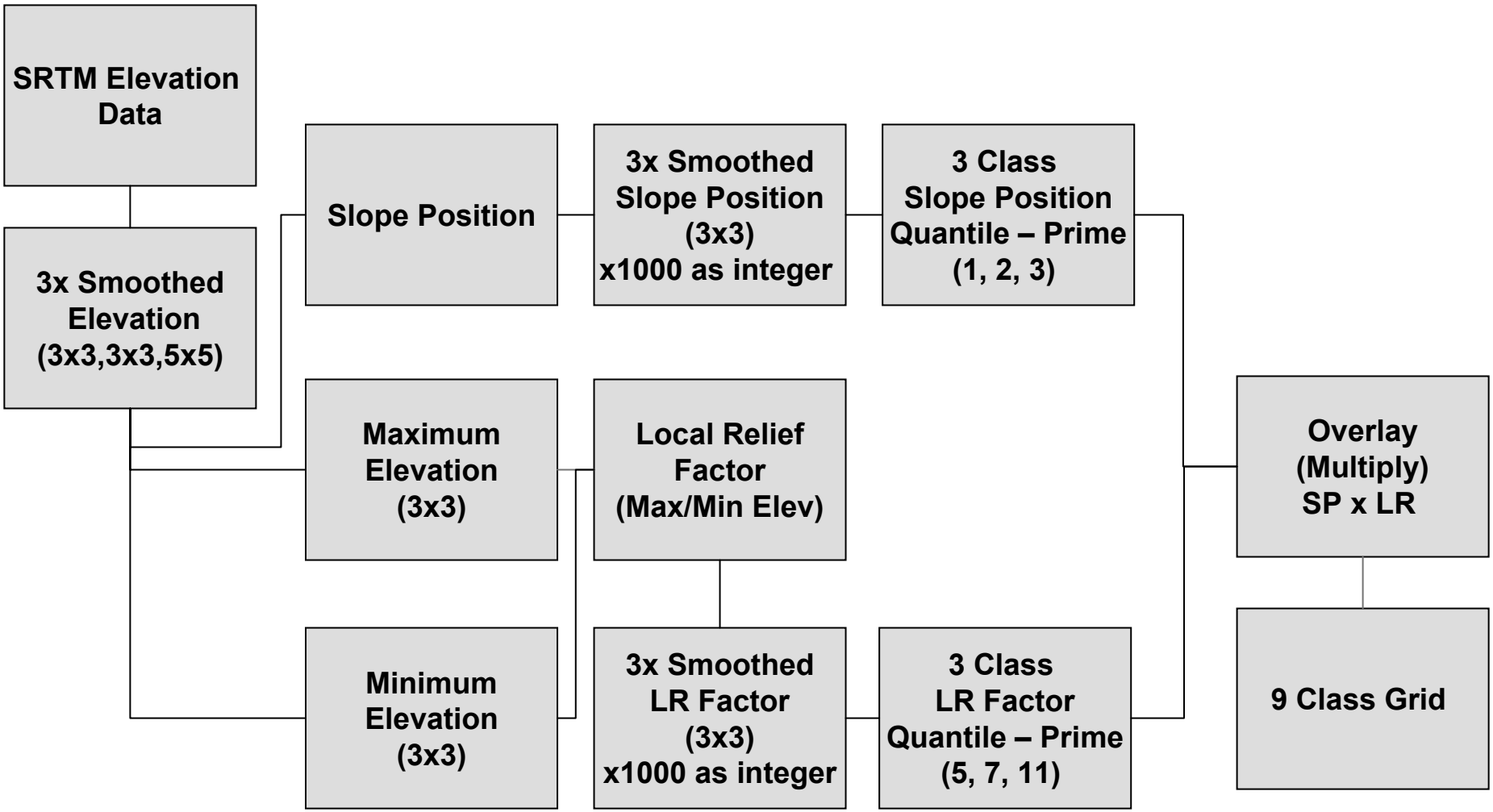


Comparison to SSURGO Dataset



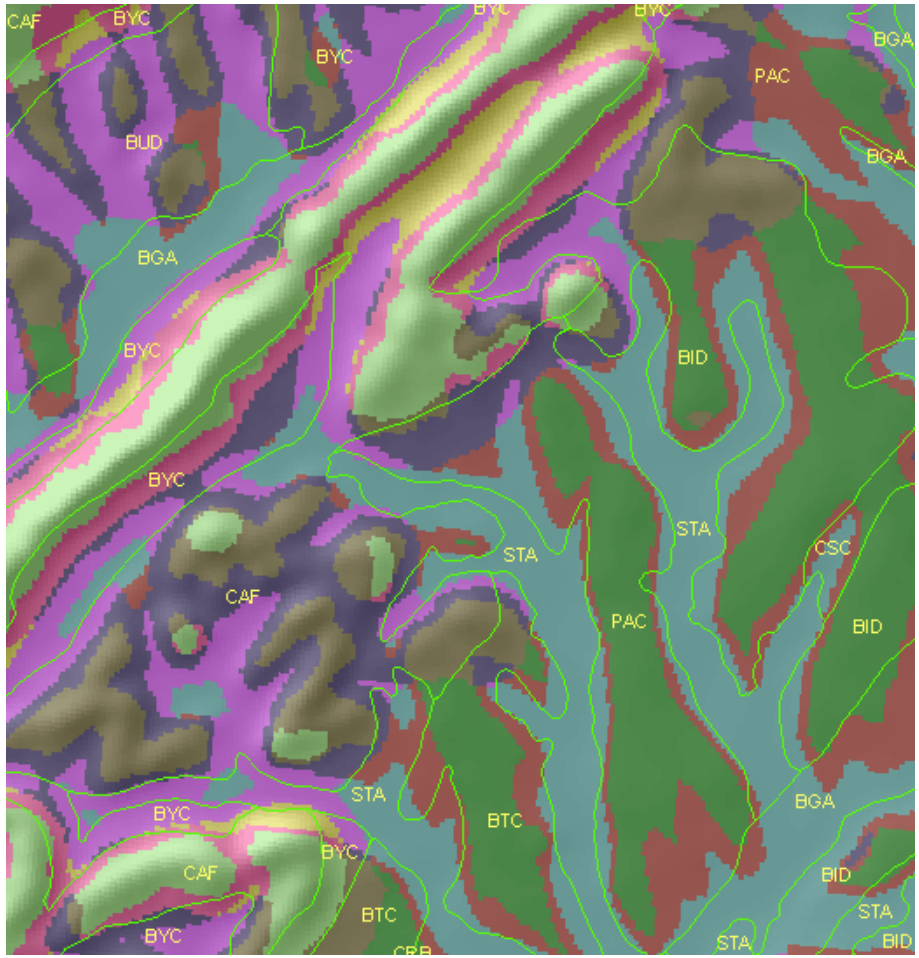
Process Flow for 9-Class Landform Algorithm

(Derived from slope position and local relief)

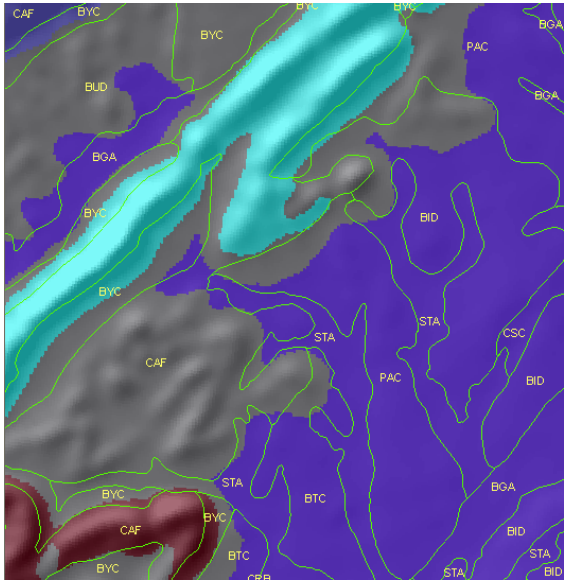


SSURGO Comparison

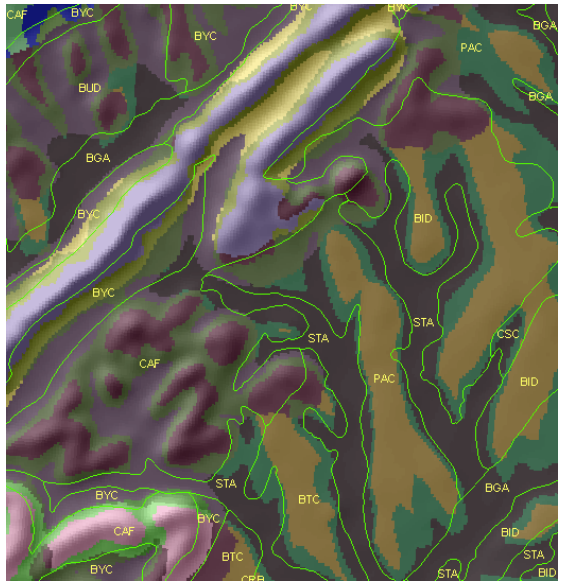
9-Class Landform Algorithm (slope position and local relief)



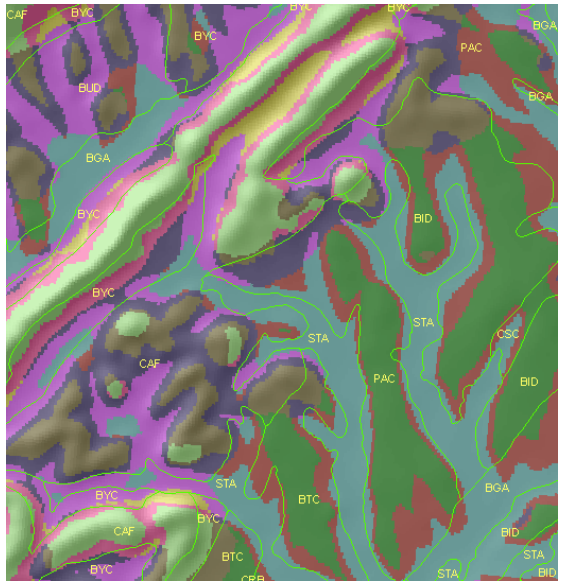
SSURGO Comparisons



Landform Regions



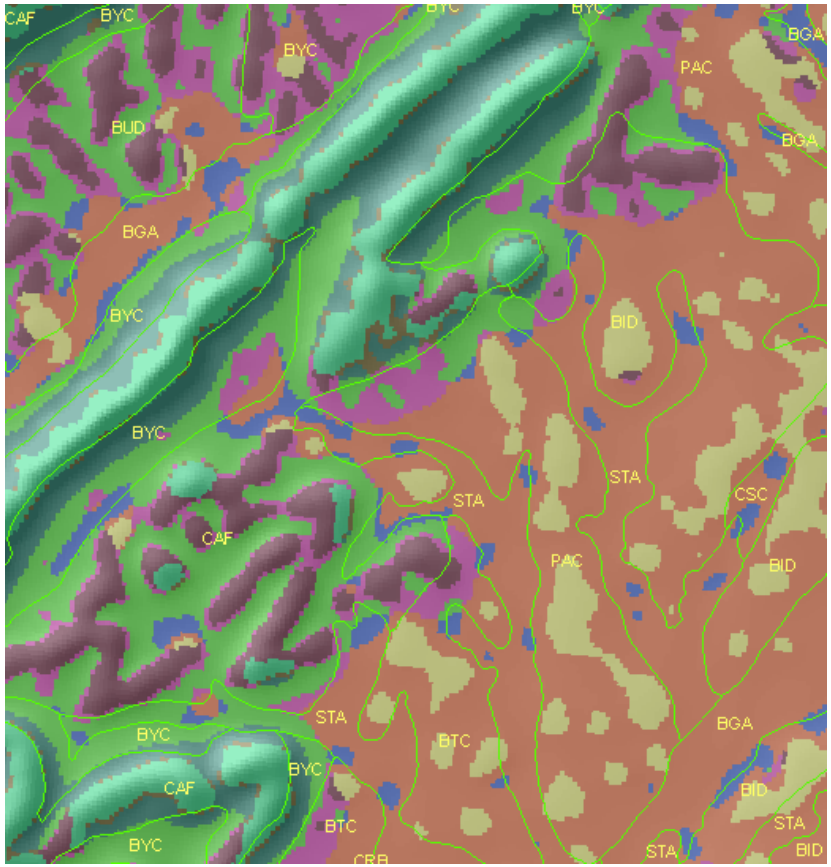
Landform Regions
with Slope Positions



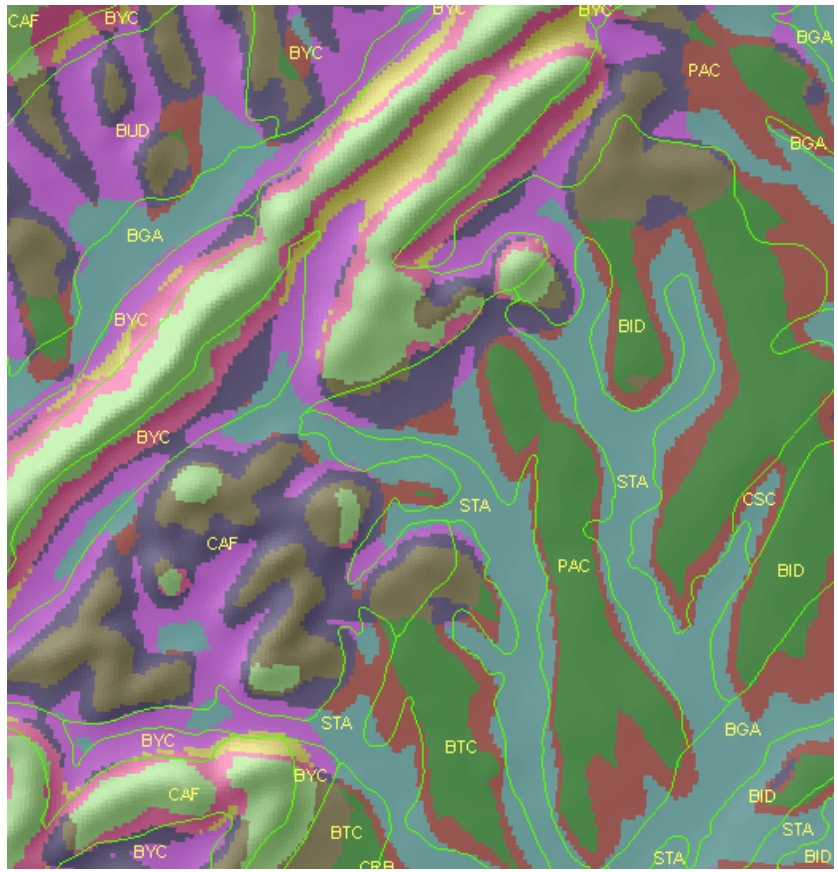
9 Class Local Relief
and Slope Position

Comparison of Different 9 Class Procedures

9 Class-Local Relief and Curvature

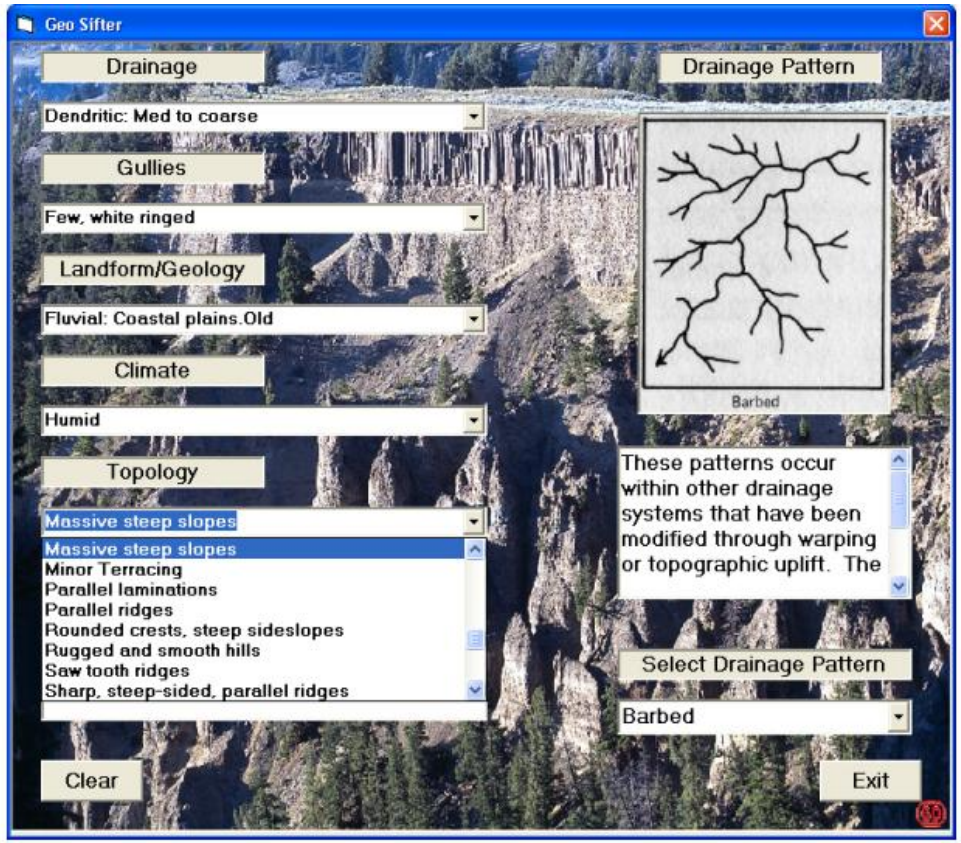


9 Class-Local Relief and Slope Position



Knowledge Based System for Soils Interpretation and Mapping

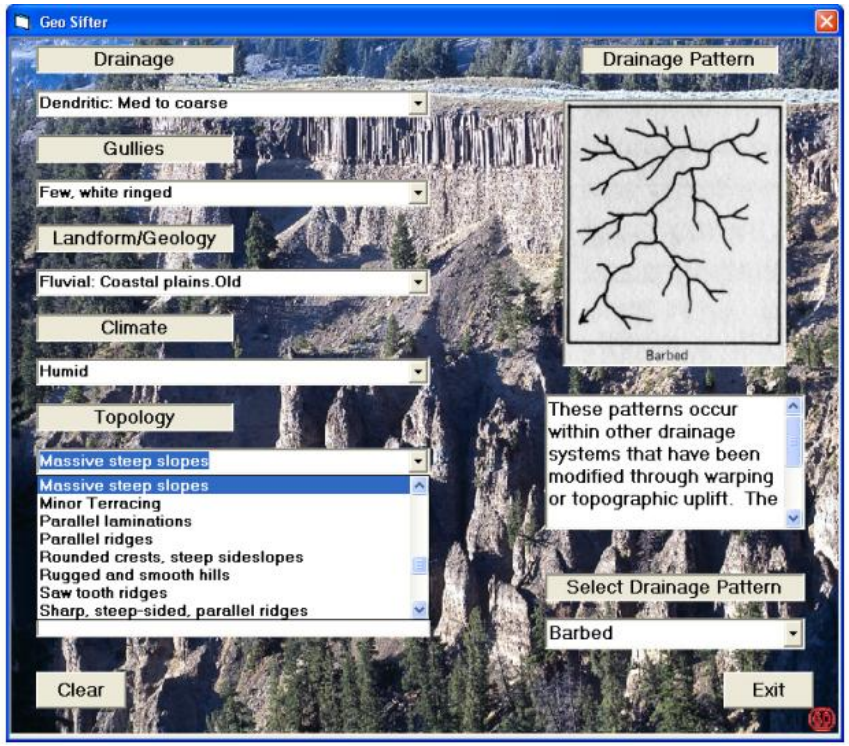
- Developing KBS for soils interpretation and mapping
  - Coding rule sets from PI keys, terrain analysis books and training materials, military geographic documentation, and soil scientist knowledge and experience
  - Will be used to attribute physiography and landforms derived from SRTM 1 and 2



Captures legacy knowledge and techniques

Knowledge Based System for Soils Interpretation and Mapping

- The drop-down boxes are loaded from Access database when the program starts
- The final product will take your first selection (in any order), and sort the other fields, displaying in their appropriate boxes all the values that match your first selection
- You narrow the final selection a box at a time, and the final output will display in the text box at the bottom
- To the right, the image box uses a similar drop down to display the image and description of the selected drainage pattern



Intent is to add field for suggested terrain derivatives and procedures for each geomorphological environment

Benefits of Using Soil Landscape Models and Landforms Derived from SRTM for Soils Mapping

- Soils are mapped to NGA Earth Reference Model
- Consistent mapping over project area
- Soil polygons can be remapped and/or reattributed if landscape model is revised
- SRTM terrain derivative files for 1:250K soils can be stored for use during subsequent larger scale soil mapping
- Single line drainage network from SRTM is generated (can be merged with SRTM double line drains), and can be used as quick response surface drainage information
- Topographic wetness and flow accumulation files can be used to delineate potential soil moisture conditions for mobility models

NATIONAL GEOSPATIAL-INTELLIGENCE AGENCY

Questions?

Know the Earth…Show the Way