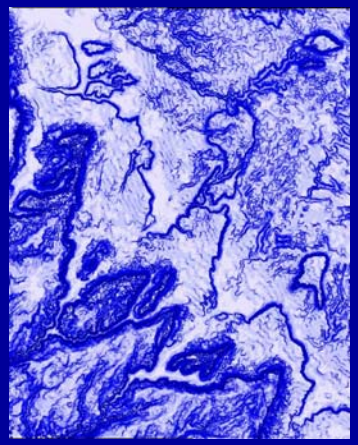
GIS-Based Landscape Analysis for Advancing Soil Survey



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Outline

- Phase I
  - Circle Cliffs project
    - Exploration of GIS landscape analysis for soil survey
- Phase II
  - Protocol for applying GIS landscape analysis to traditional soil survey
  - Examples from current projects

Why GIS-based analysis for soil survey?

- Improve efficiency and quality of traditional soil survey methods
  - Fewer soil scientists, same workload and quality expected
  - Visualize landscape patterns at multiple spatial scales
  - Allows information used to create soil map to be preserved in GIS layers
  - Allows quantitative descriptions of map unit concepts

Phase I - Circle Cliffs Project

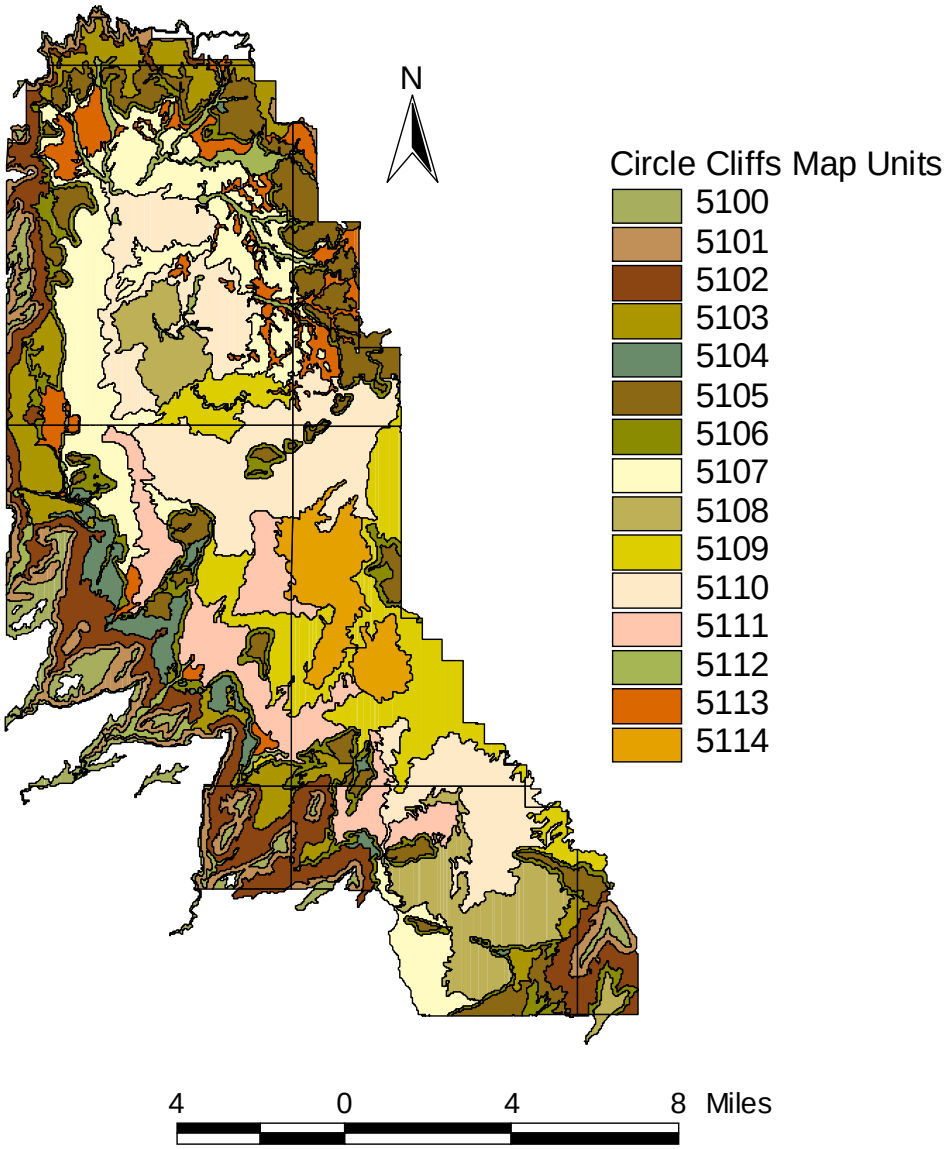
- Objectives
  - Conduct a soil survey using traditional methods
  - Develop GIS-based methods to improve efficiency and quality of soil survey
    - Increase efficiency and quality of soil survey documentation
    - Quantify and validate soil map unit concepts

Study Area

http://www.ut.blm.gov/gsenm/index.html

http://personal.riverusers.com/~das22/circle-a30.htm

Circle Cliffs Soils



Documentation Analysis

- Question
  - How does the soil scientist know when a map unit has adequate documentation?
- Objective
  - Develop a simple method to represent and analyze soil map unit documentation using GIS

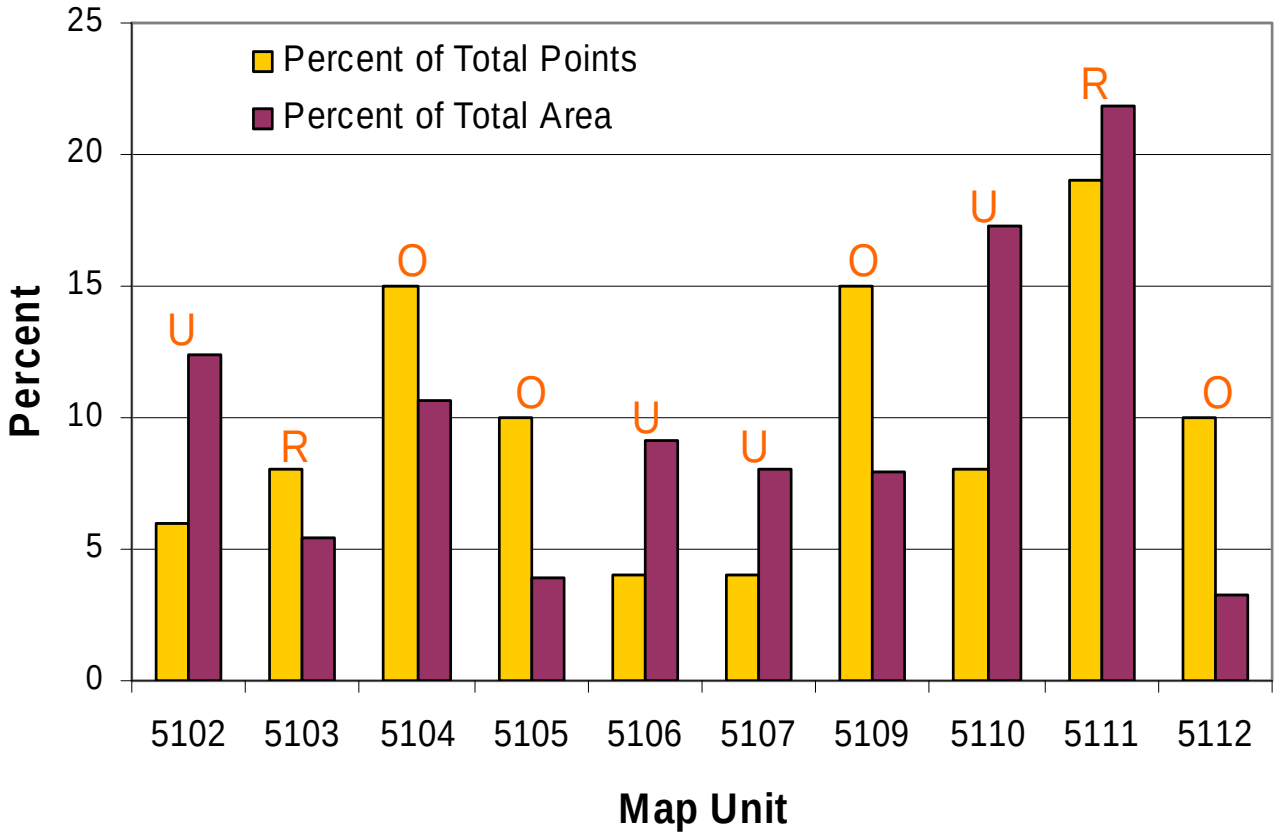
Documentation Analysis

- Method compares percent of total area covered by each map unit to the percent of total points occurring in each map unit
- Method assumes that a map unit is accurately represented if:

% of soil data collection points	=	% of the total area covered by the map unit

- Method can be adjusted for map unit complexity as needed
- Analyzed in *ArcView*

Results



- Method useful in determining the representation of each map unit
- Most map units are not accurately represented

Discussion

- Perform analysis during different mapping stages
  - Pre-mapping
    - Determine minimum number of data points
  - Field mapping
    - Track progress
    - Allocate resources efficiently
    - Refine data collection according to map unit complexity

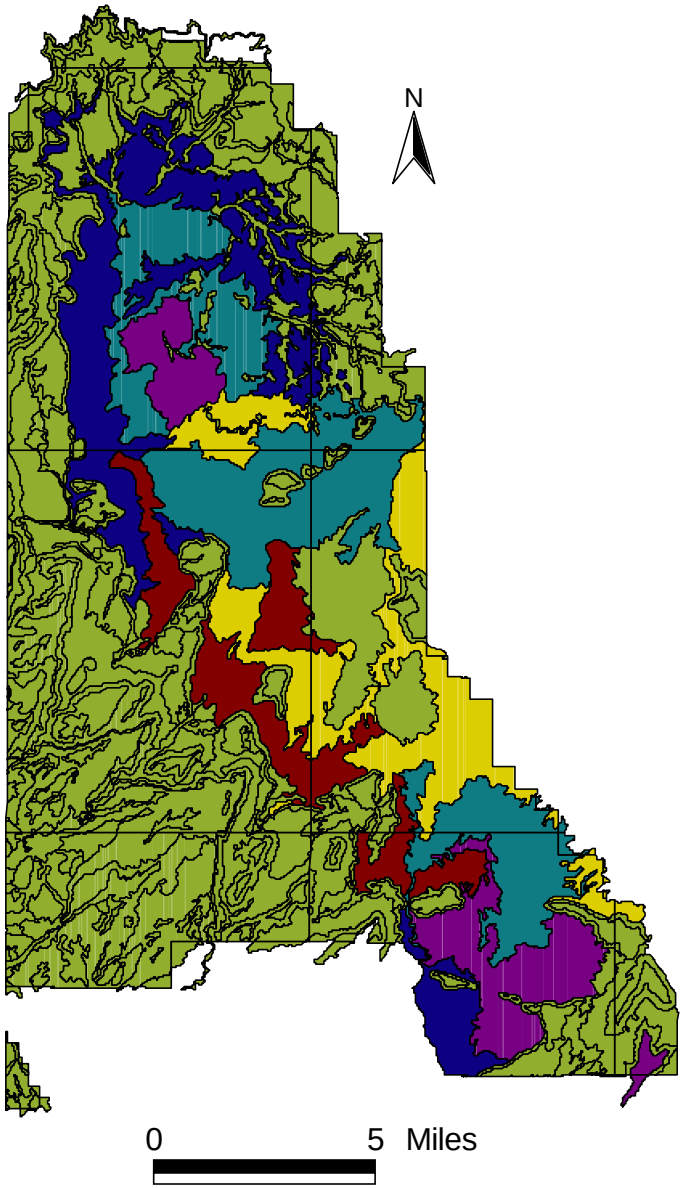
Conclusion

- This rapid GIS method is relatively simple to complete
- Method would provide
  - Accurate representation of the soils in a survey area
  - Consistency
    - between soil scientists in data collection
    - between their respective areas of the survey

Landscape Analysis for Defining and Validating Map Unit Concepts

- Questions
  - How can the landscape characteristic degree of dissection (drainage density), low or high, be defined quantitatively?
  - Can map unit concepts be validated using landscape analysis?

Moenkopi Soils



Moenkopi – Landscape Analysis

- Objective
  - Test and develop methods that employ GIS as a landscape analysis tool for quantitatively defining and validating Moenkopi map unit concepts
    - Average slope and slope distribution by map unit as a proxy for degree of dissection
    - Drainage density as a measure of degree of dissection

Methods

Slope Analysis

- Create a slope grid from DEMs
- Calculate average slope and slope distribution histogram for each map unit

Drainage Density Analysis

- Create plan curvature grid from DEMs
- Separate area in drainages for each map unit
- Calculate percent area in drainages

Methods

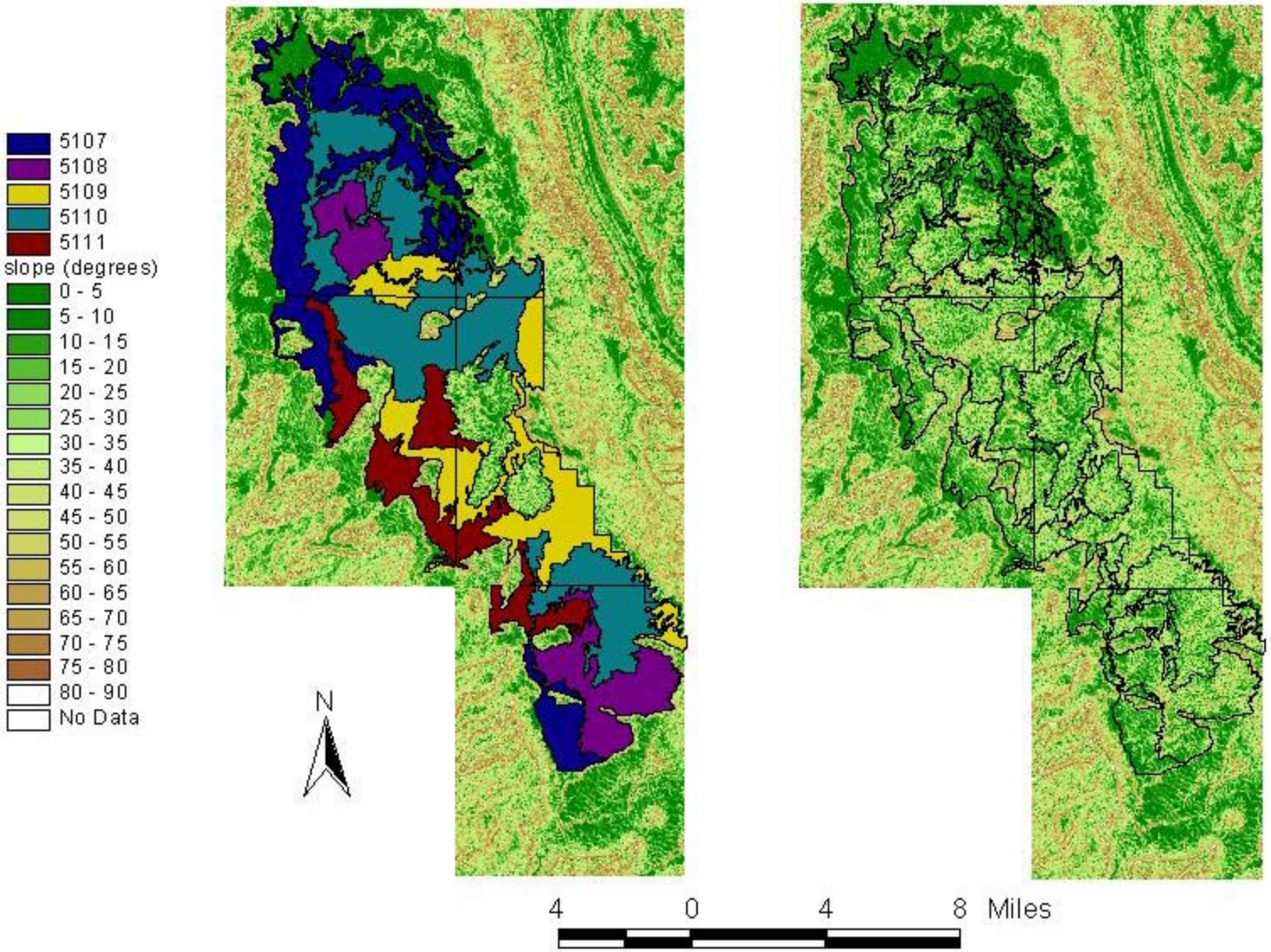
Slope Analysis

- Compare average slope and slope distribution between map units
- Assign low or high degree of dissection to map units
- Compare results to initial degree of dissection determination from aerial photography

Drainage Density Analysis

- Compare drainage density between map units
- Assign low or high degree of dissection to map units
- Compare results to those from aerial photography analysis and slope analysis

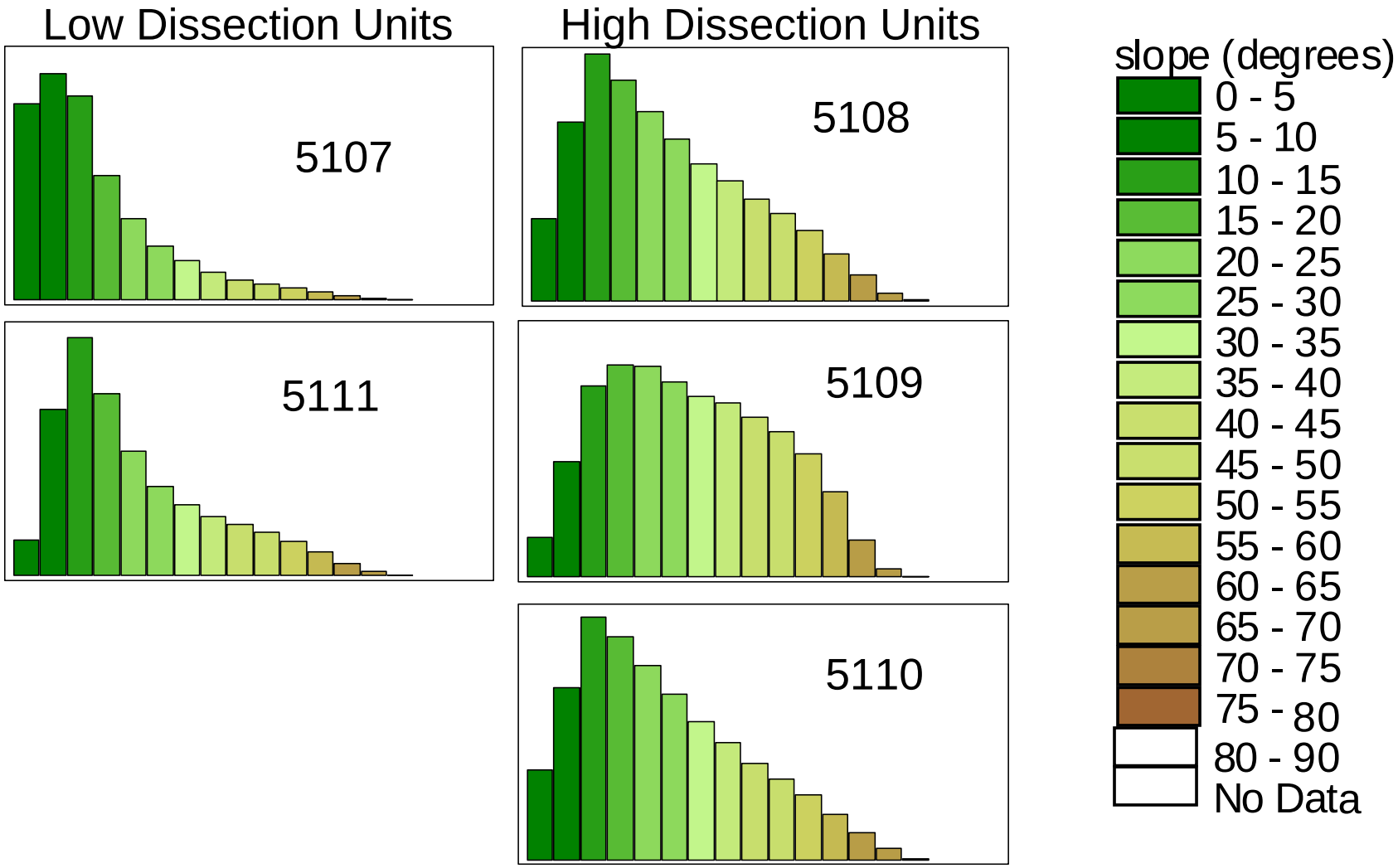
Results – Slope Map



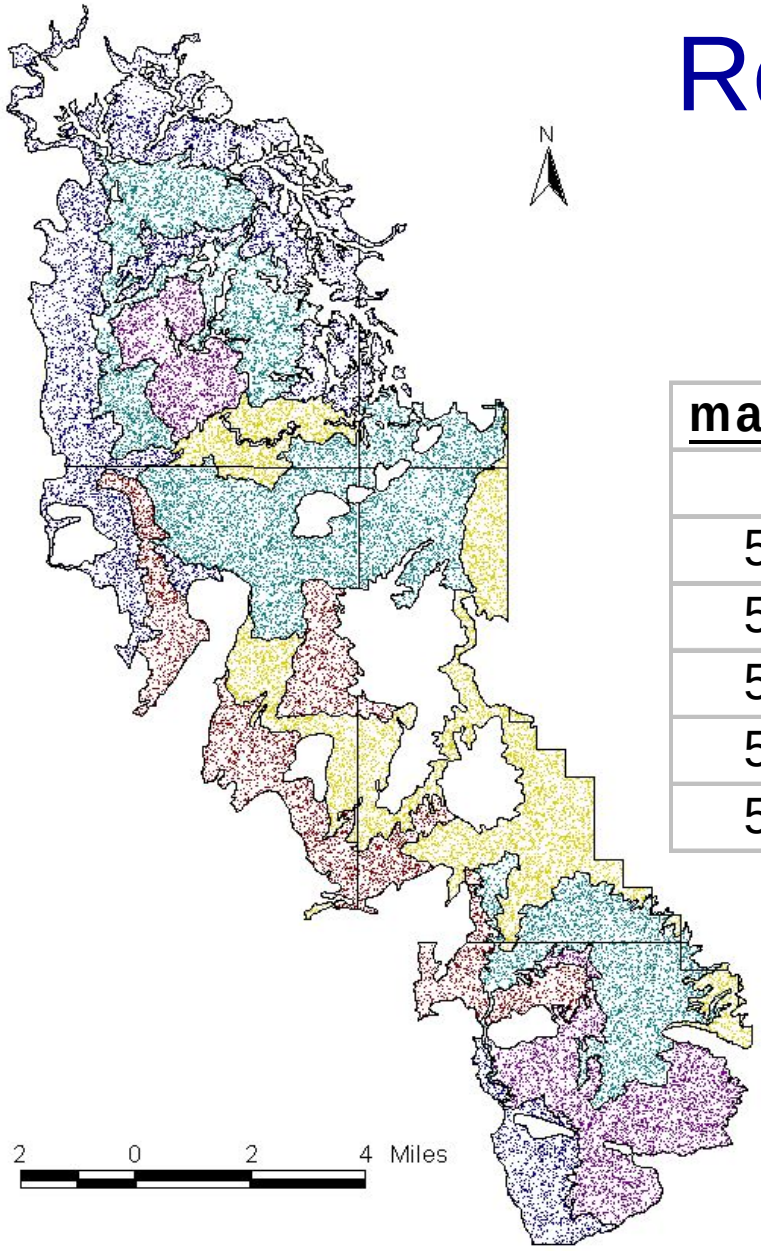
Results – Average Slope

map unit	average slope (degrees)	average slope (percent)
5107	15.5	27.7
5108	25.8	48.3
5109	30.7	59.4
5110	25.6	47.9
5111	22.8	42.0

Results- Slope Distribution Histograms



Results - Drainage Density



map unit	% area in drainages
5107	20
5108	26
5109	26
5110	26
5111	24

Results – Comparison of Analyses

	degree of dissection		
map unit	**initial**	**slope analysis**	**drainage density analysis**
5107	low	low	low
5108	high	high	high
5109	high	high	high
5110	high	high	high
5111	low	low	low or mod

Conclusion – Moenkopi Landscape Analysis

- Landscape anlaysis useful for quantitatively defining and validating Moenkopi soil map unit concepts
  - Average slope and slope distribution are a valid proxy for degree of dissection
  - Drainage density valid measure of degree of dissection

Phase II - Protocol

- Developed as a result of Circle Cliffs project
- Combines traditional soil survey methods with GIS landscape analysis methods
- Uses simple GIS analyses and resources currently available
- Guideline for soil scientists
  - Allows creative freedom

Protocol

1. Compile data
2. Analyze data
3. Digitize initial soil lines
4. Collect field observations
5. Develop and refine map unit concepts

- Iteration of steps as needed

Protocol

1. Compile digital data
   - Digital elevation models (DEMs)
   - Digital orthophoto quads (DOQs)
   - Geology
     - Bedrock and/or surficial
   - Vegetation
   - Remotely sensed spectral data

Protocol

2. Complete initial analyses
   - DEMs
     - Slope, aspect
     - Hydrological properties
       - Flow accumulation, direction, curvature, etc.
     - Combinations plus many other possibilities!
   - Remotely sensed spectral data
     - Unsupervised and supervised classifications for vegetation, wetness, salts, etc.

Protocol

3. Heads-up digitizing
   - Create initial soil lines from information gained from initial analyses
   - Run documentation analysis
     - Allocation of resources in field
   - Create maps from steps 1 and 2 for use in the field

Protocol

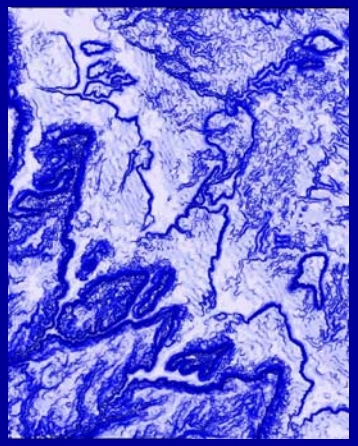
4. Collect field observations

Protocol

5. Develop and refine map unit concepts
   - Define, validate, and quantify concepts throughout mapping process
   - Store data and map unit concepts in GIS layers

❖ Iteration of steps as needed

Examples From Current Projects

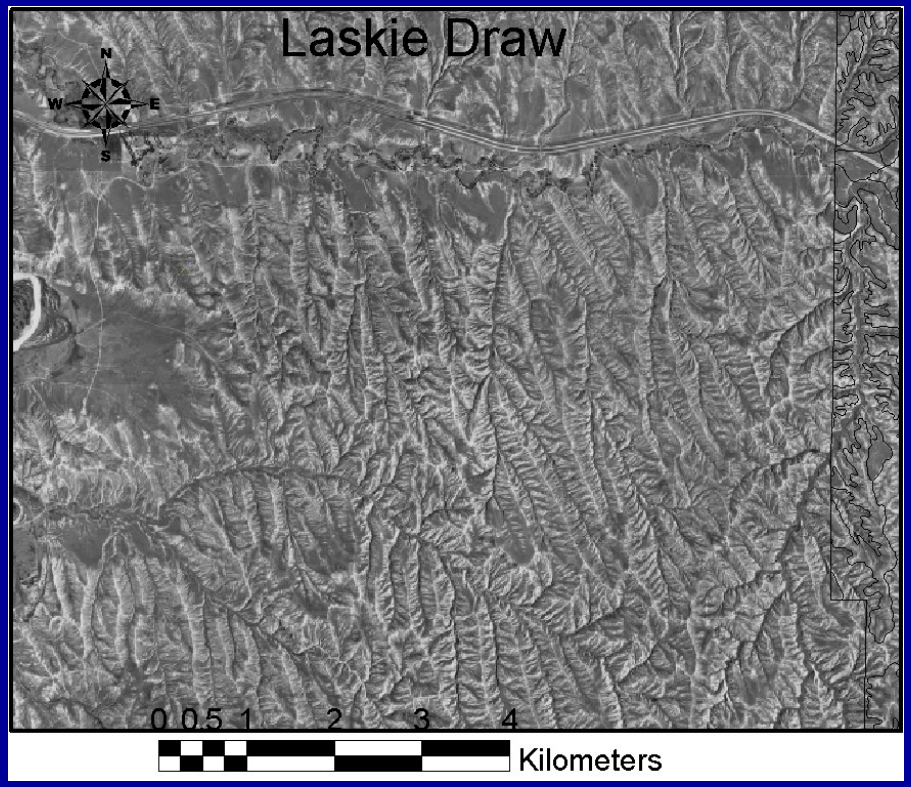


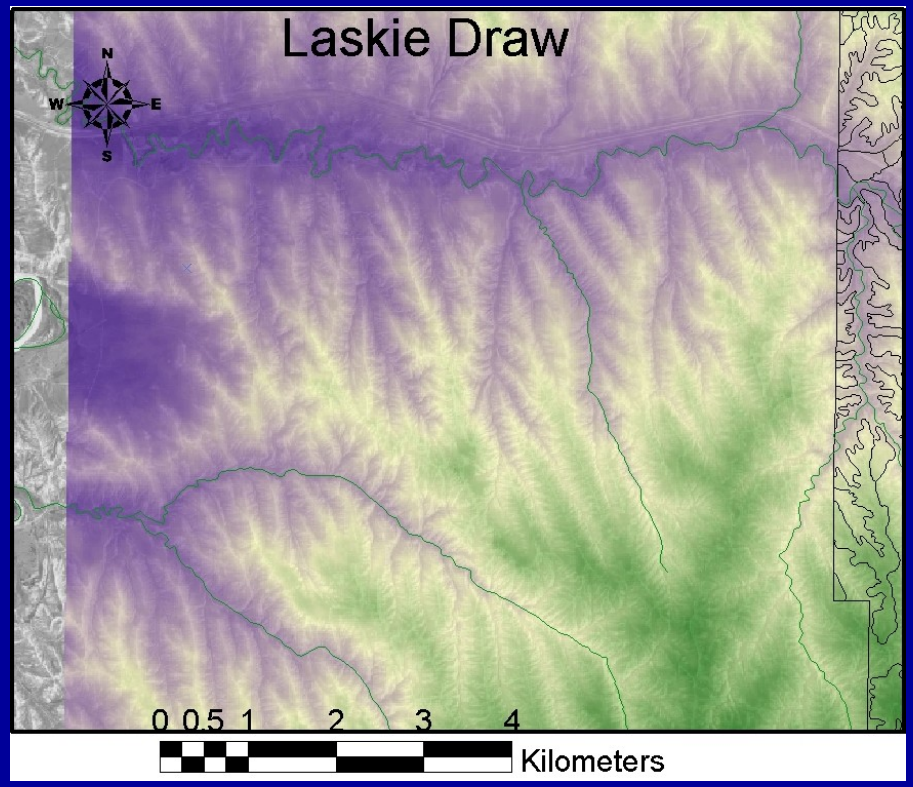
Johnson County, WY

- New soil survey area
- Sedimentary rocks
  - Siltstone vs. sandstone
- Wide range: topography and vegetation

Johnson County

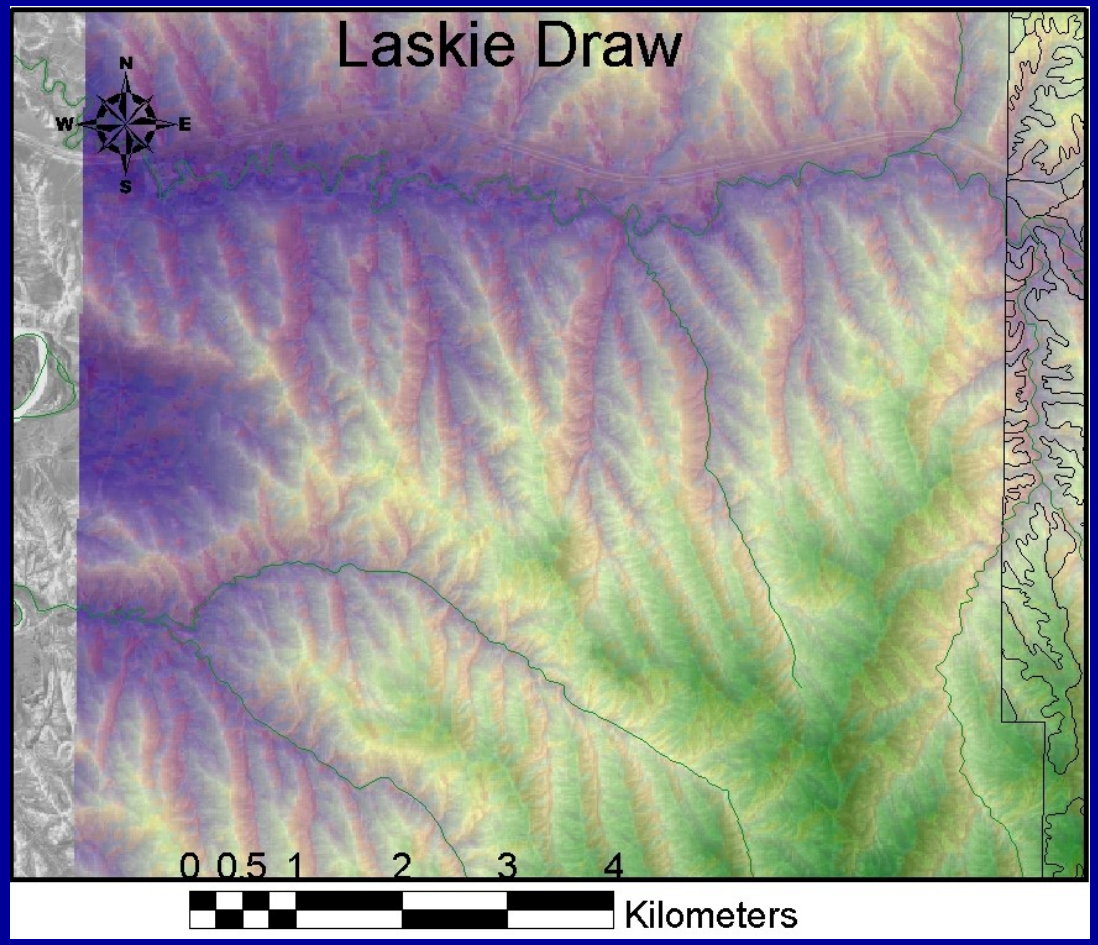
Data layers: DOQ, 30m DEM, and stream coverage





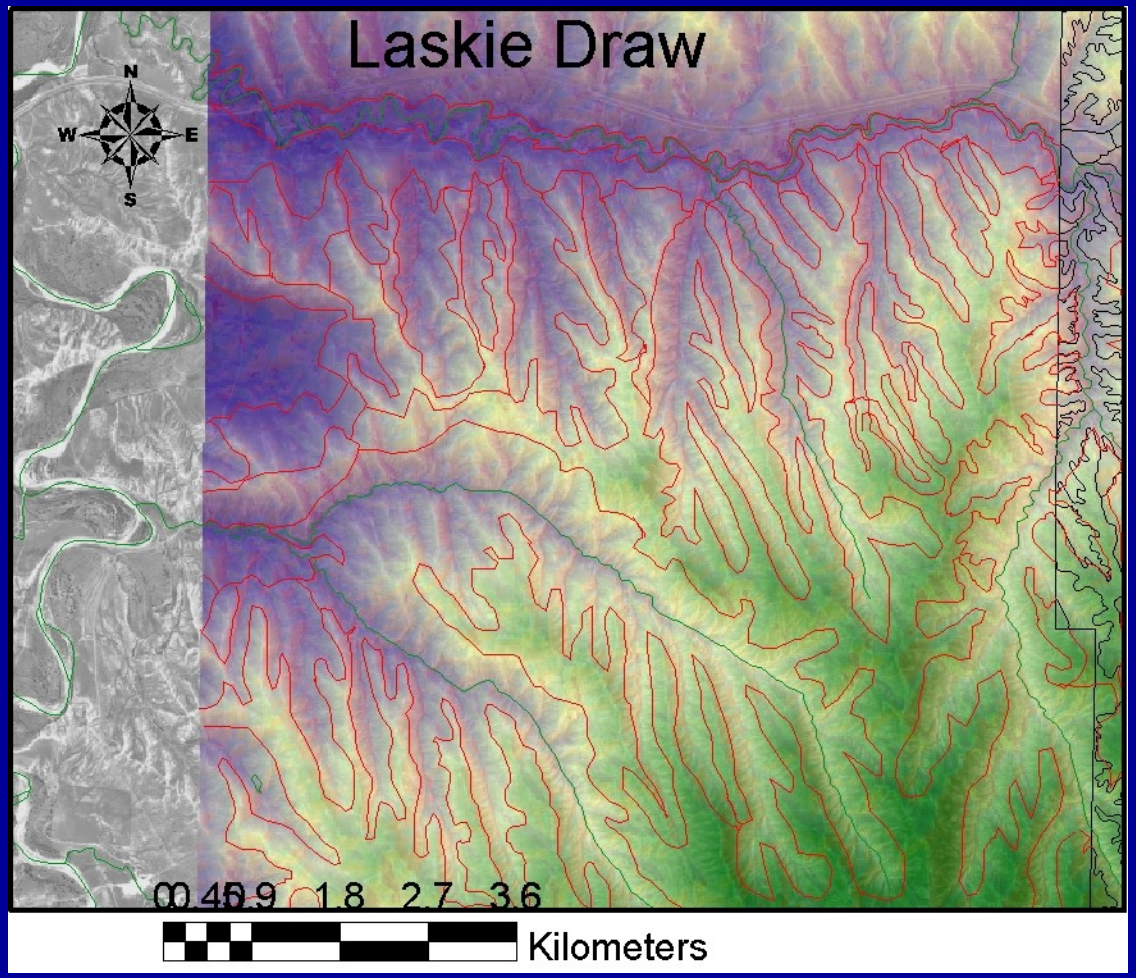
Johnson County

- Analyses
  - Slope
  - Aspect
- Combine slope, aspect, and DEM
- Enhance landscape features



Johnson County

- Digitize initial soil lines
- Provides map for use in field

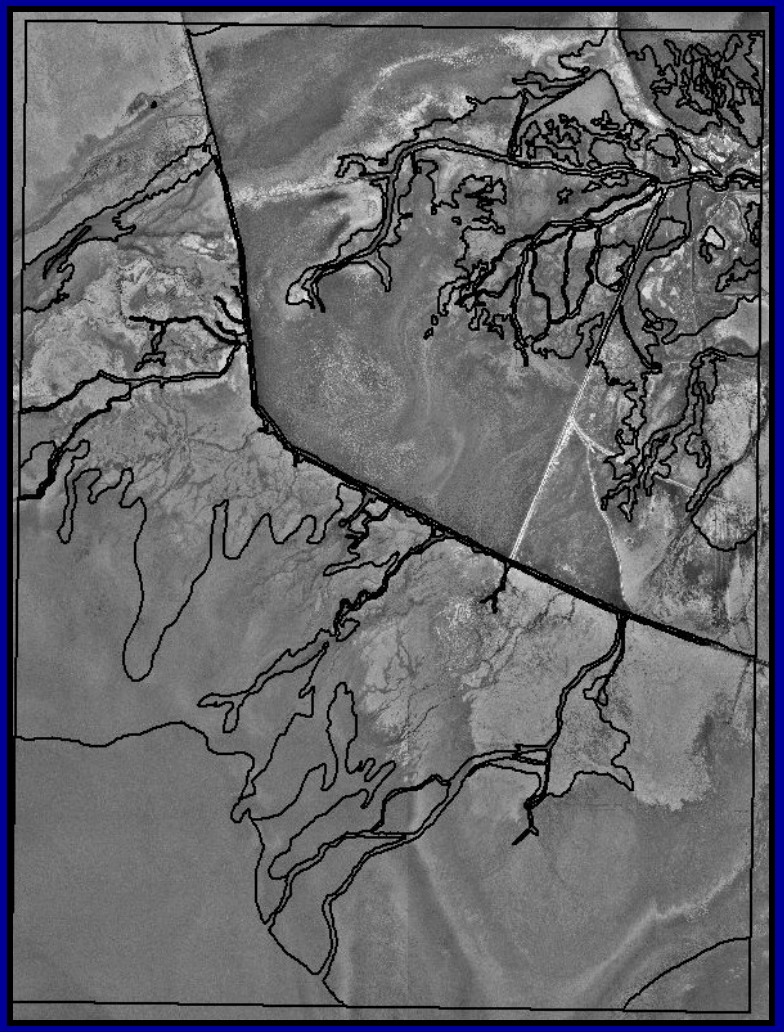


Johnson County

- Initial analyses and field observations prompt more questions and ideas
- Iteration of steps for refining lines and developing map unit concepts
  - Use 10m DEMs (recently available!)
  - More analyses
    - Curvature: degree of dissection
  - Quantify landscape characteristics and map unit concepts

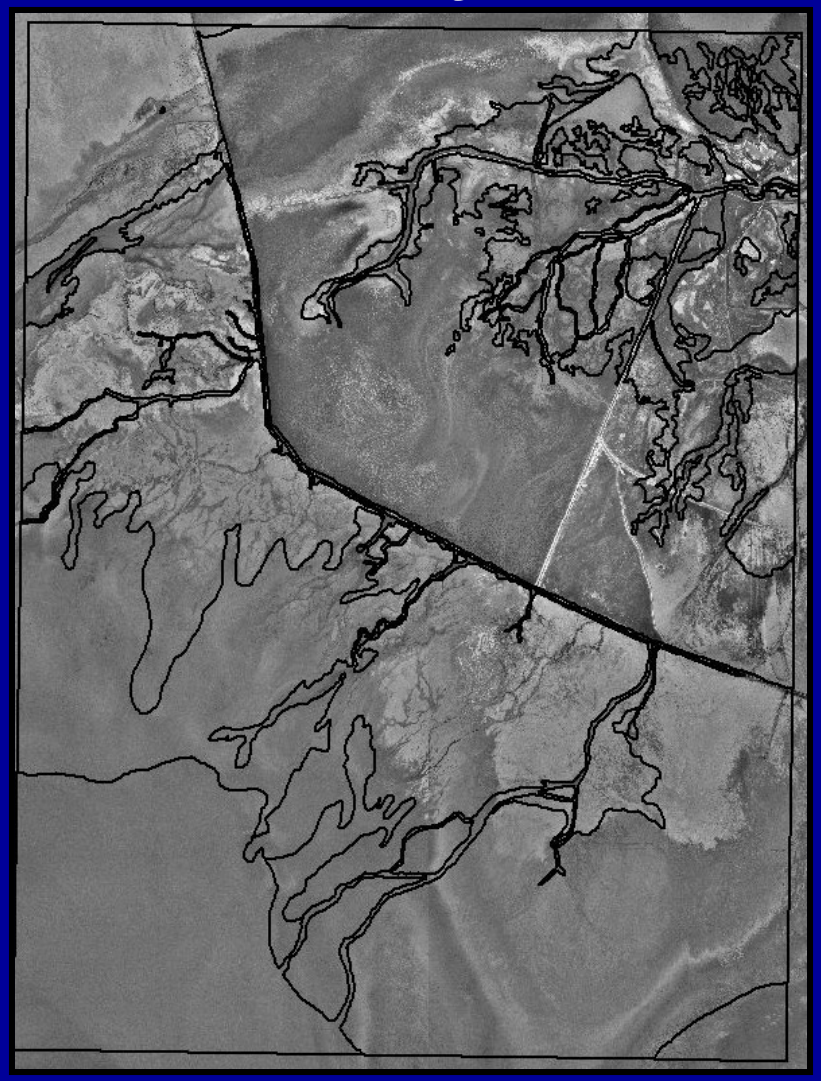
East Shore Area of the Great Salt Lake

- Update soil survey
- Mainly concerned with refining map units with wet and saline components
  - Soil/ecologic
  - Site/hydrologic
- Lake plain sediments
- Very little topography

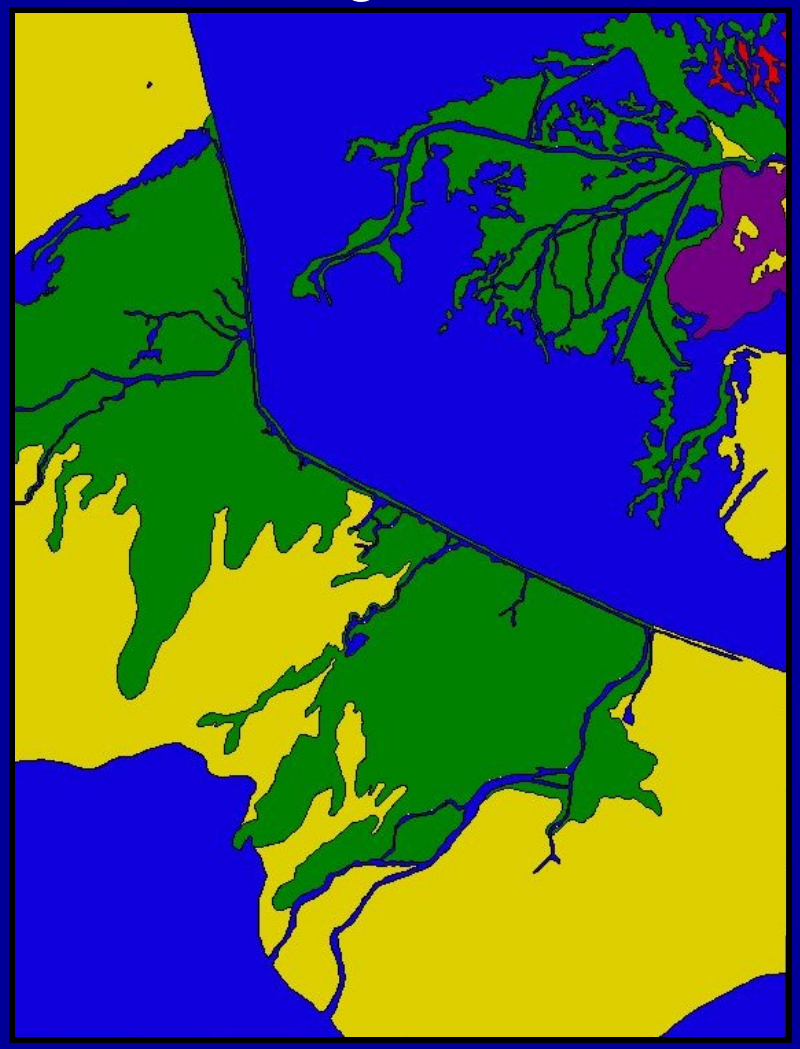


East Shore Area

DOQ

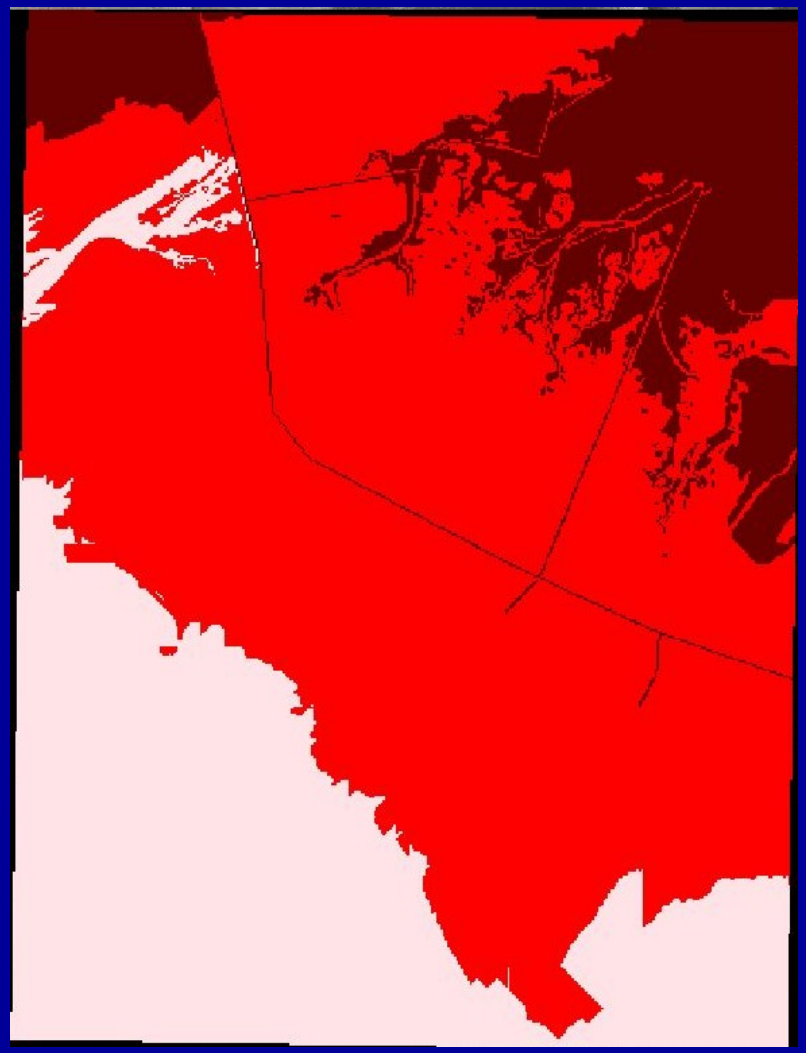


Existing soil lines

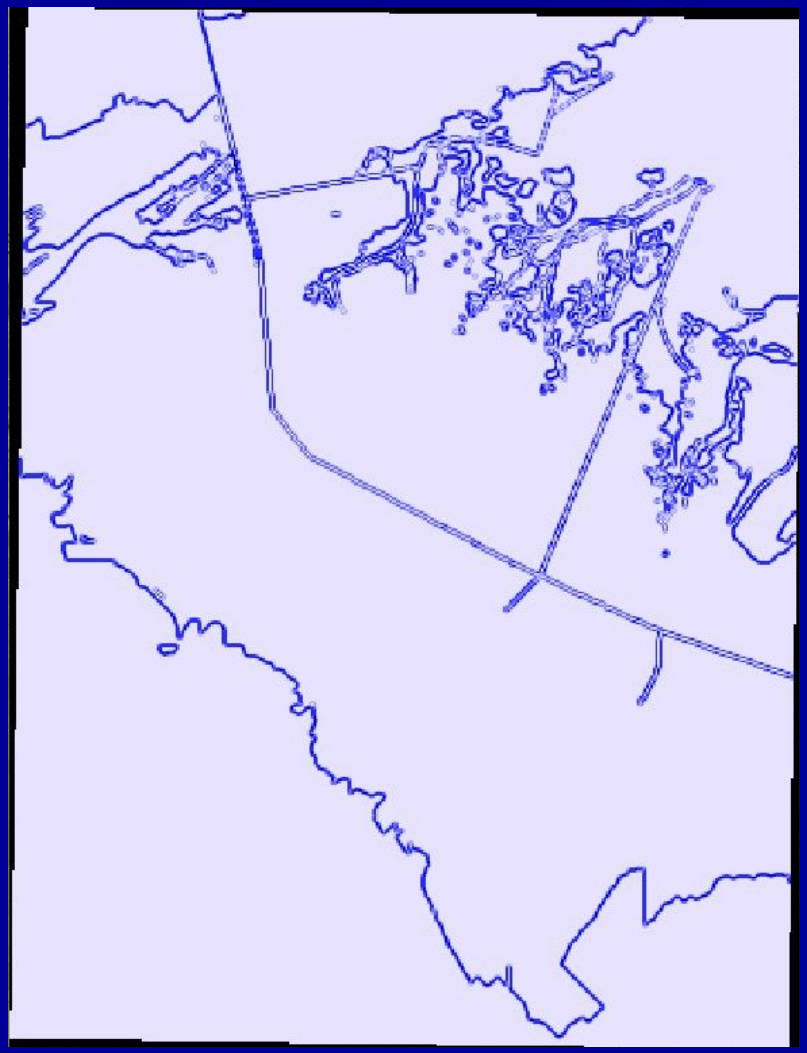


East Shore Area

30m DEMs



Slope range: 1-11%



East Shore Area

- DEMs will not provide information needed for refining map units
  - Resolution
  - Topography
- Remotely sensed spectral data
  - Unsupervised and supervised classification
    - Wet areas
    - Salt crusts
    - Vegetation

GIS-Based Landscape Analysis

- Use as TOOL for soil survey
  - Incorporate GIS work and field work
    - Iterative process
- Provides better sense of landscape characteristics prior to field work
  - Larger spatial scale
- Increase efficiency in the field

GIS-Based Landscape Analysis

- Provides a better product more efficiently
  - Develop digital product through mapping process
  - Document tacit knowledge
    - Soil-landscape model
  - Quantify map unit concepts
  - Storage of information
  - Easy to revise