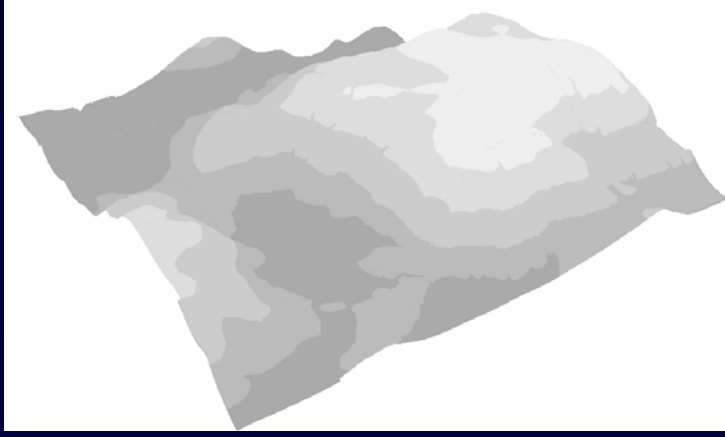
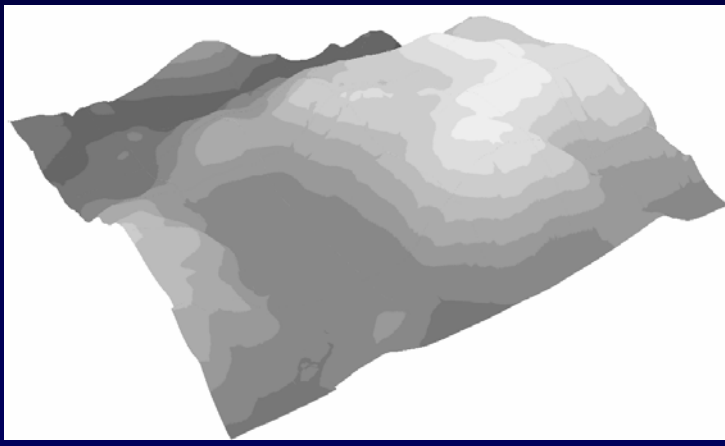
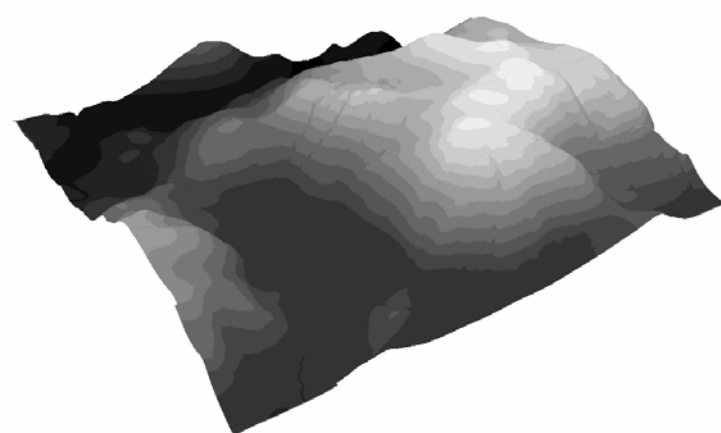
Using Scientific Visualization to Represent Soil Hydrology Dynamics

Jay Bell
Depart. of Soil, Water, and Climate
University of Minnesota

John Beck
Joel Nelson
Holly Dolliver



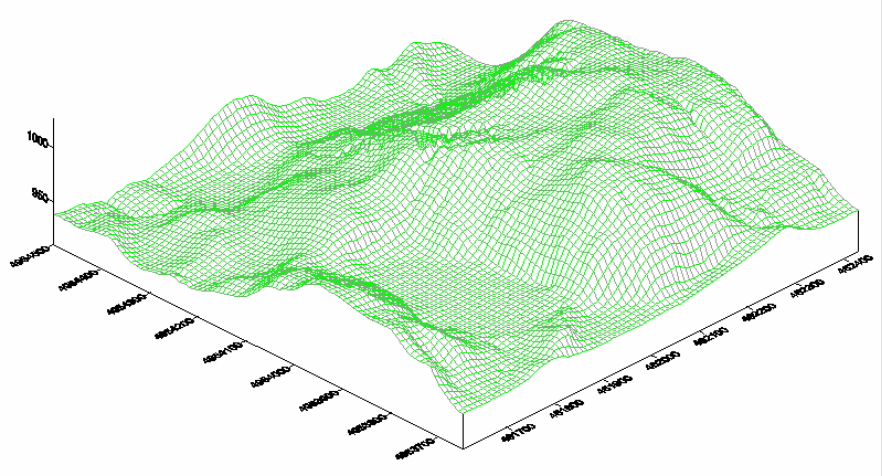


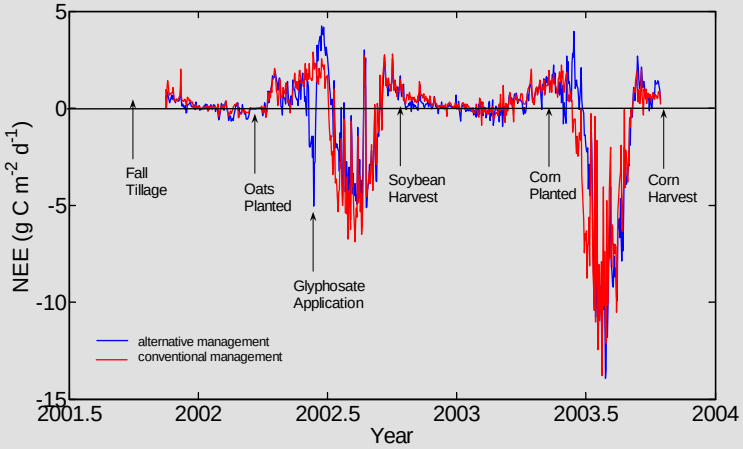


Mapping Soil Space-Time Continuum

Space

Time





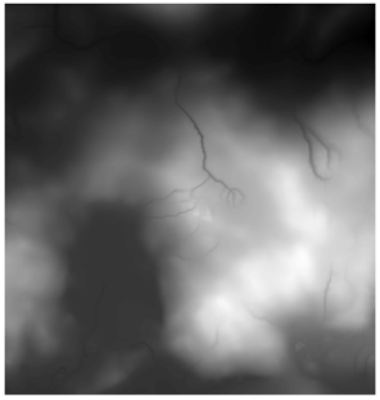
Space

Environmental Correlation

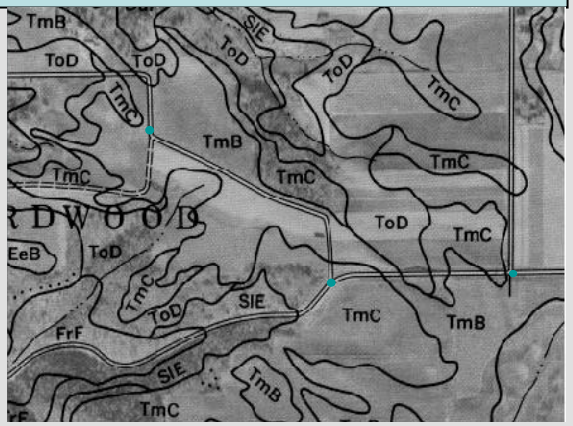
Geostatistical Approaches

Expert Systems

Isarithmic Map
Smoothed Surface

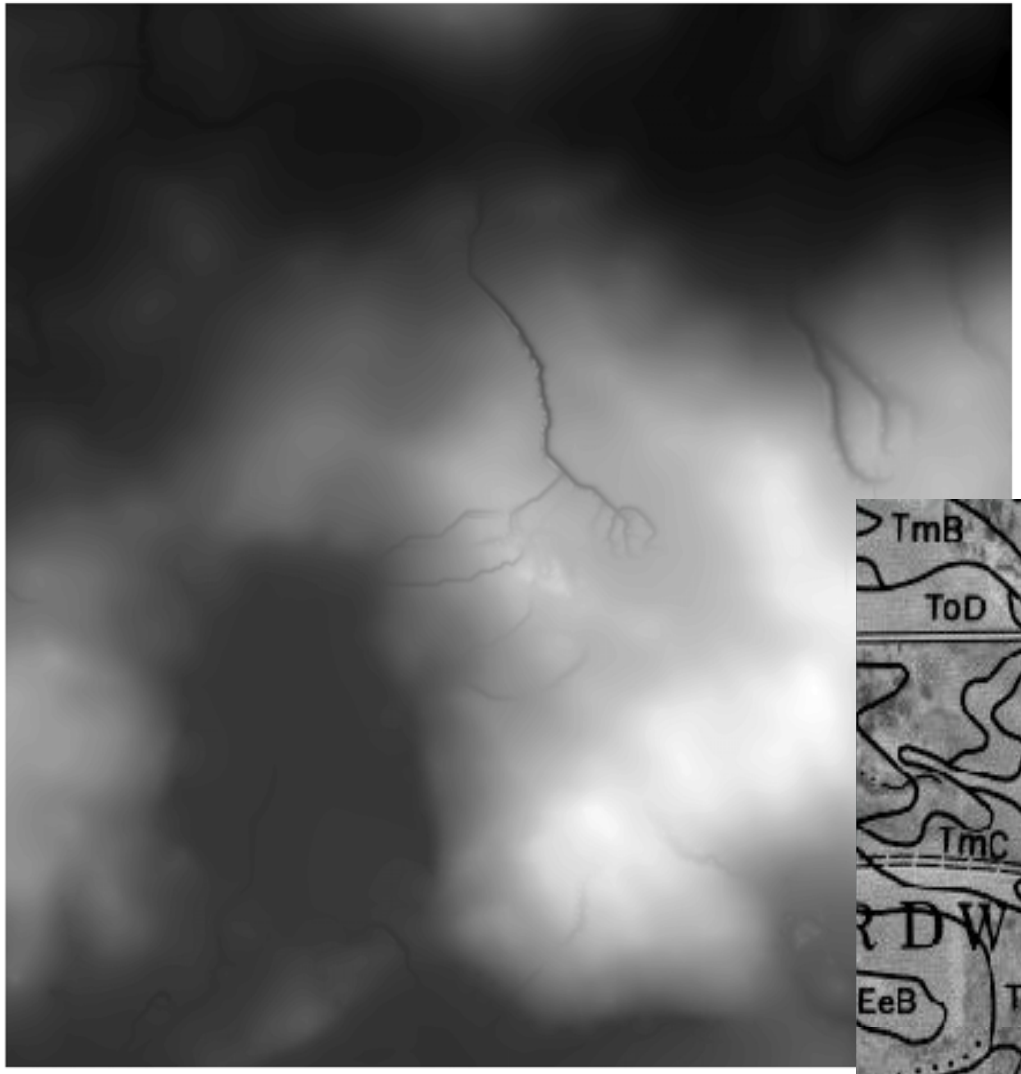


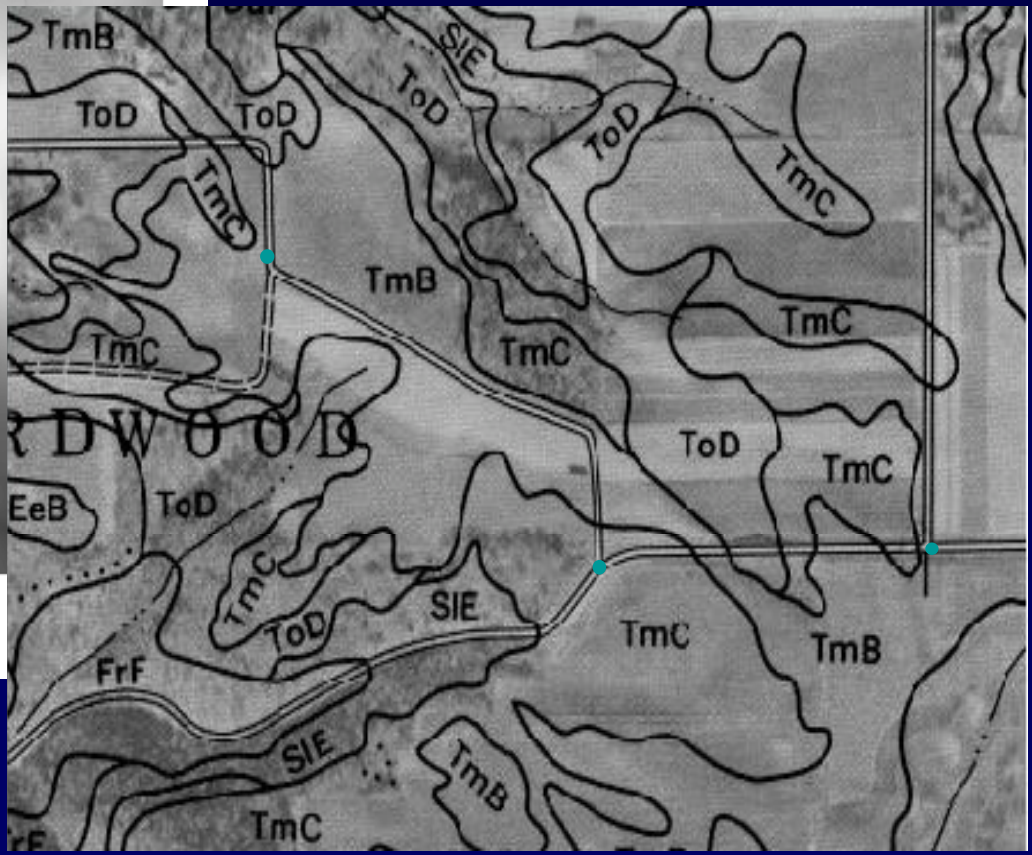
Choropleth Map
Discrete Areas



Spatially Explicit

Temporally Static





Time

Models

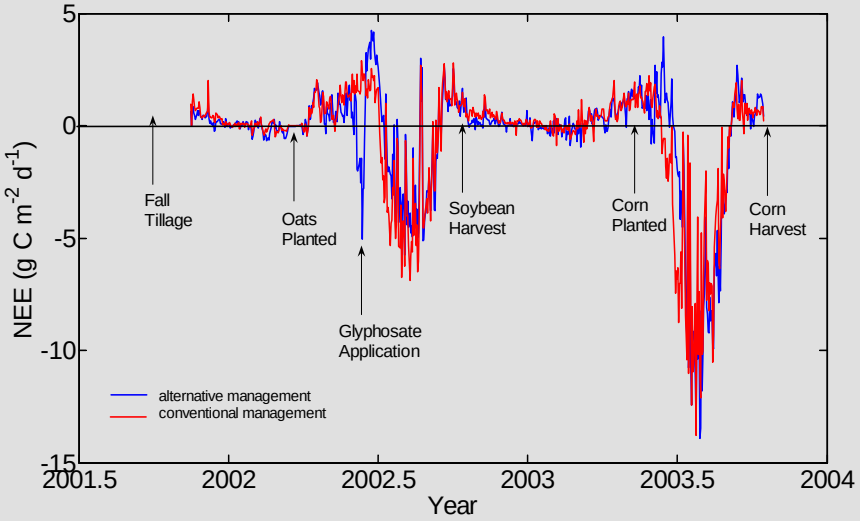
Data

Deterministic

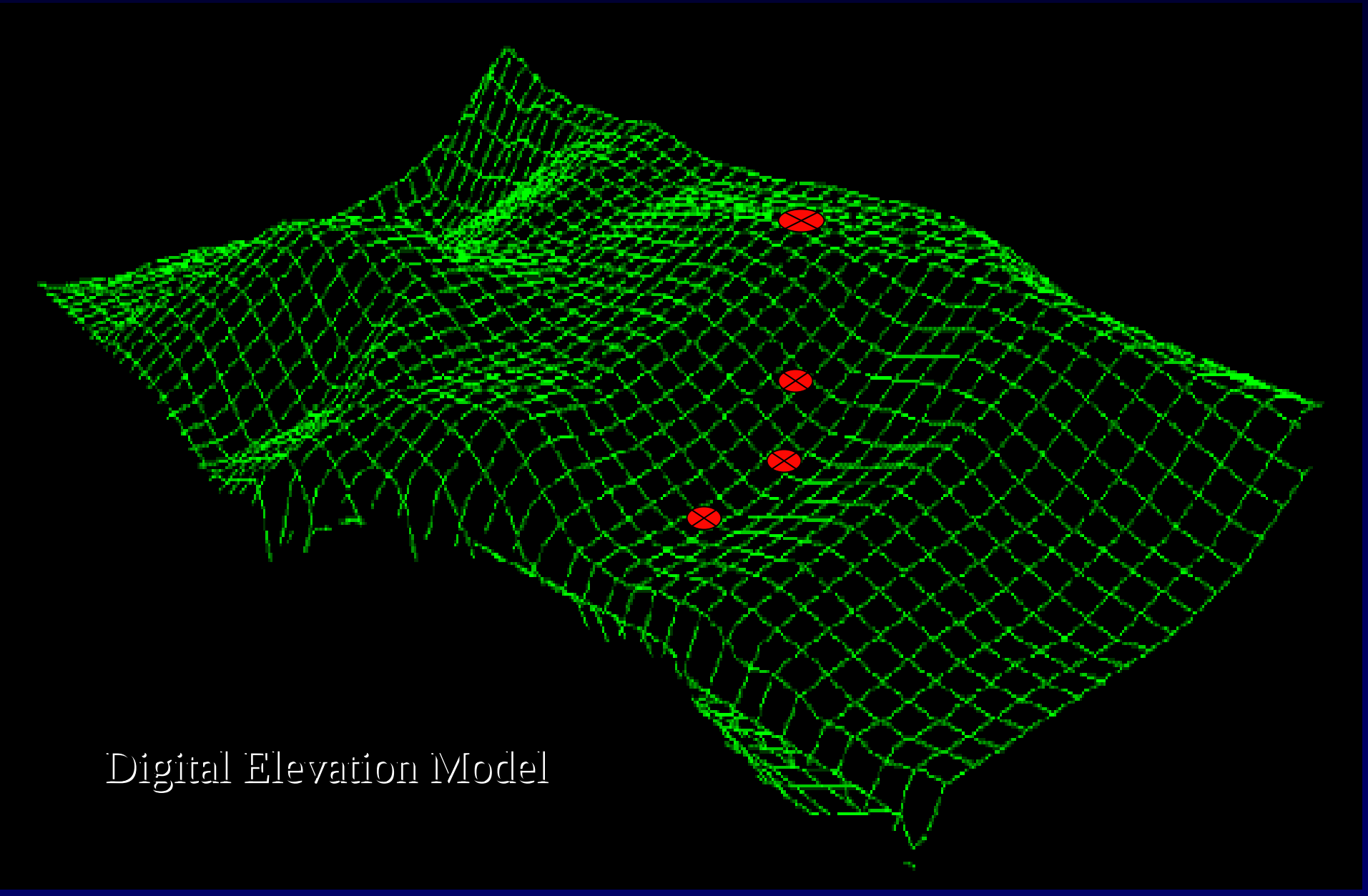
Stochastic

Empirical

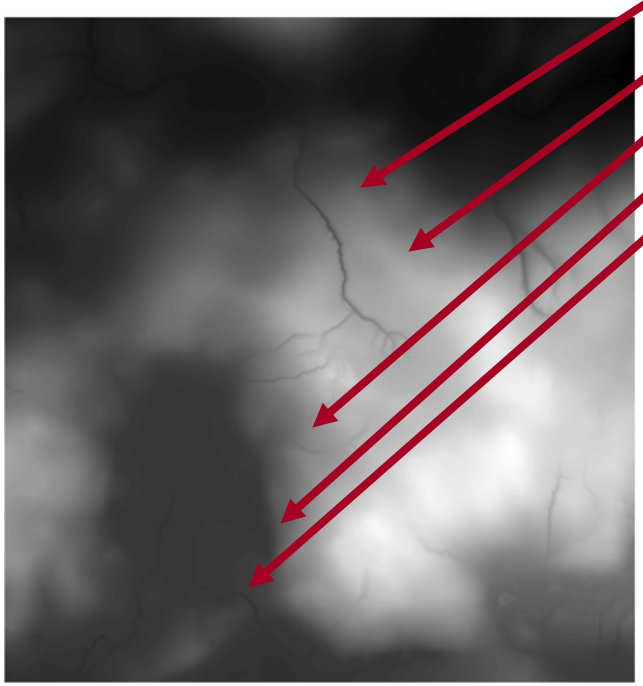
Conceptual

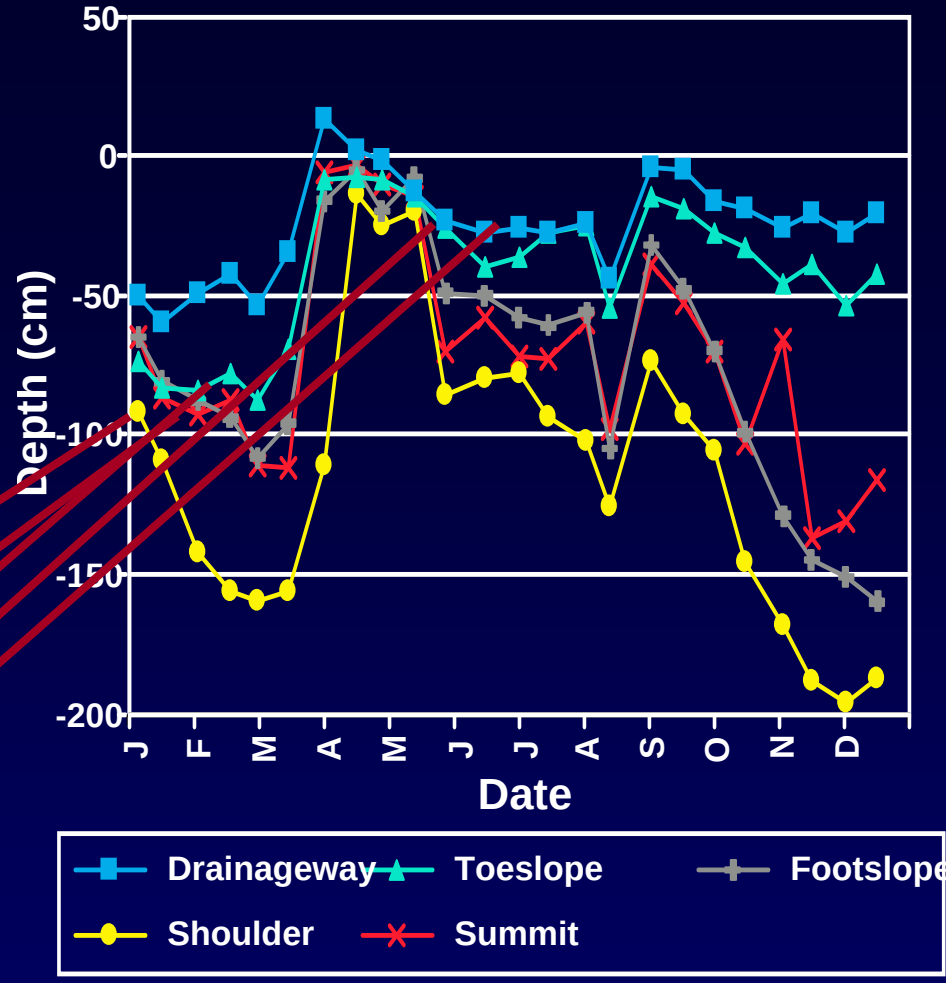


Waseca, Minnesota

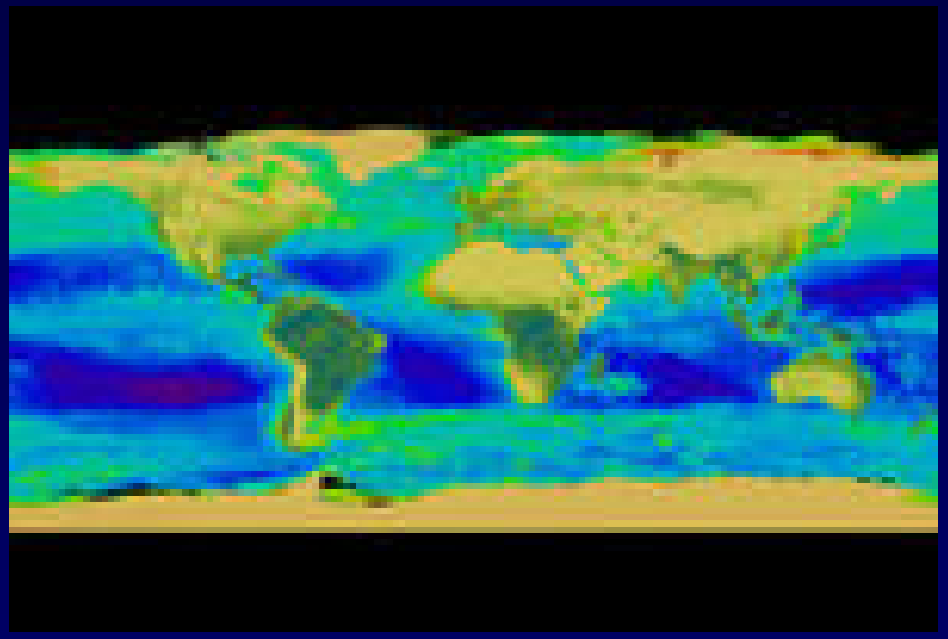


Time + Space



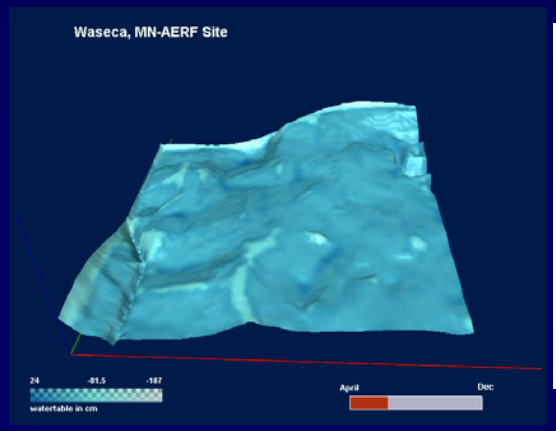

50
0
-50
-100
-150
-200
Depth (cm)
J
F
M
A
M
J
J
A
S
O
N
D
Date
Drainageway
Toeslope
Footslope
Shoulder
Summit

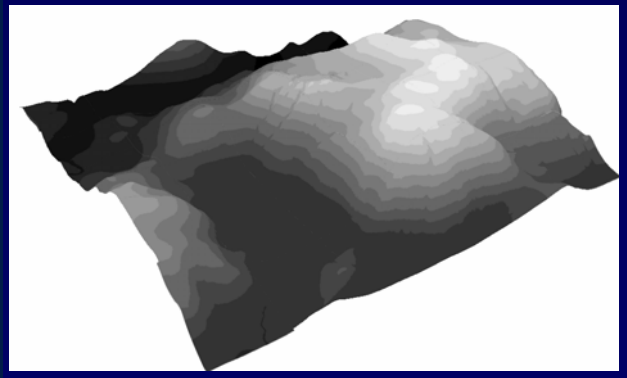
Scientific Visualization Animations

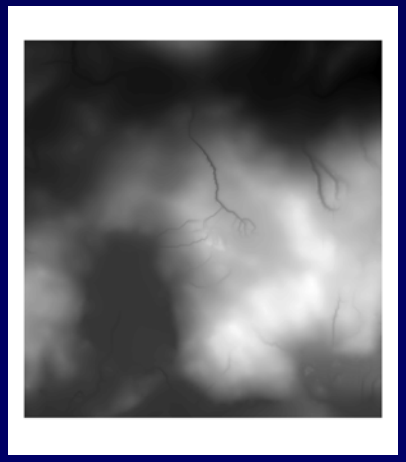


Applications

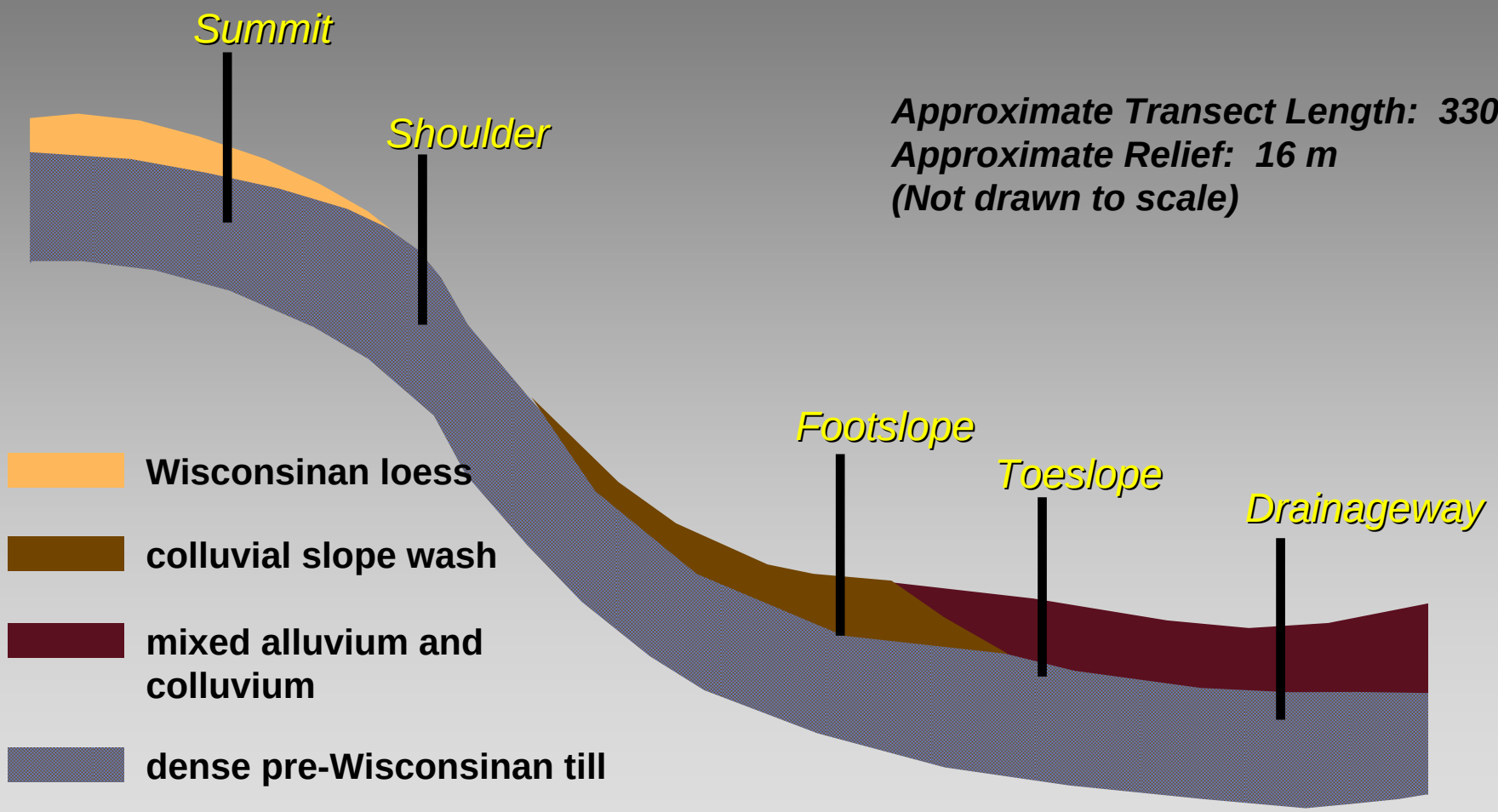
- Teaching
- Research
- Soil Resource Management







Hillslope Transect



Approximate Transect Length: 330 m
Approximate Relief: 16 m
(Not drawn to scale)

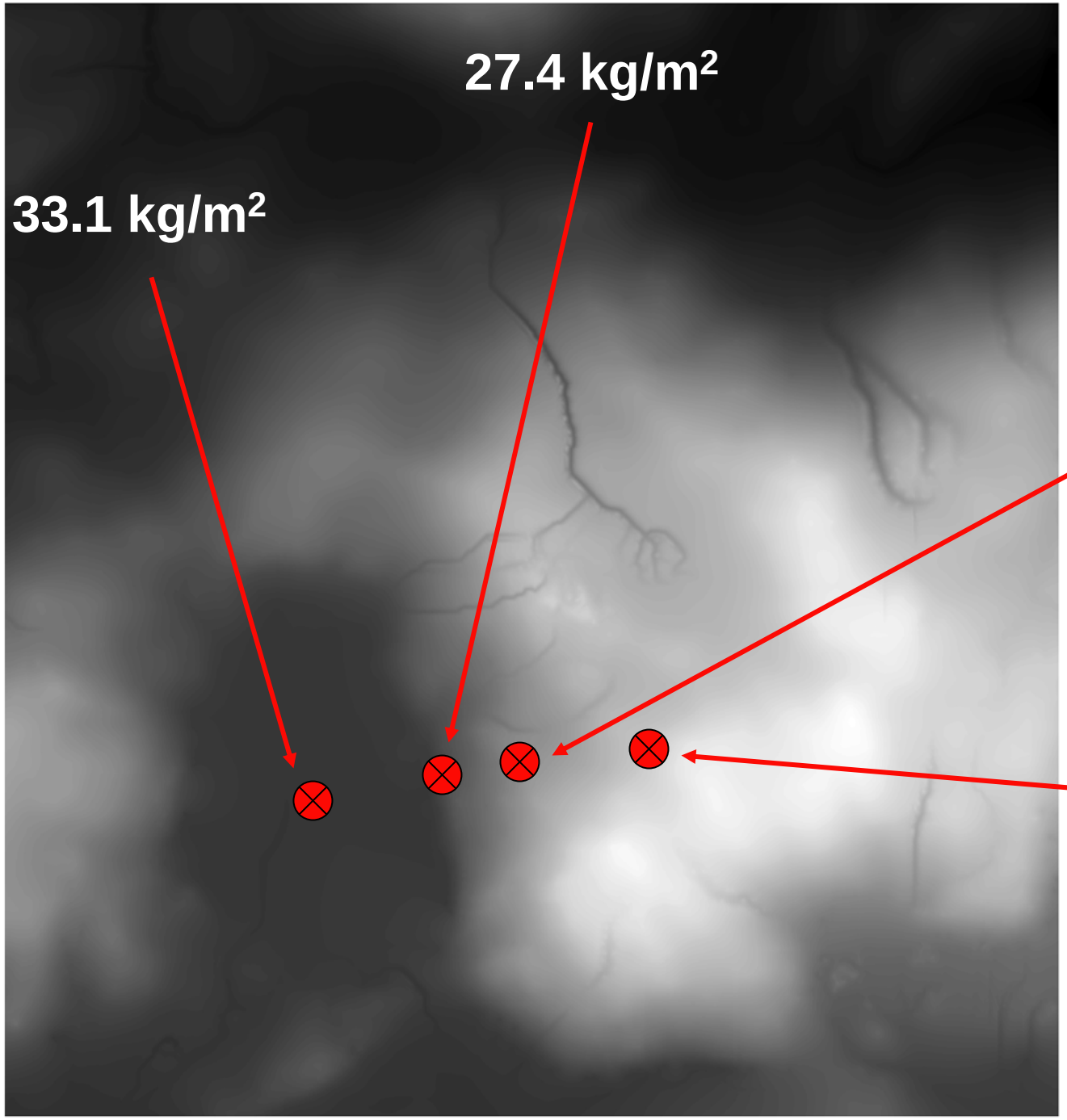
Toposequence

Summit

Shoulder

Footslope

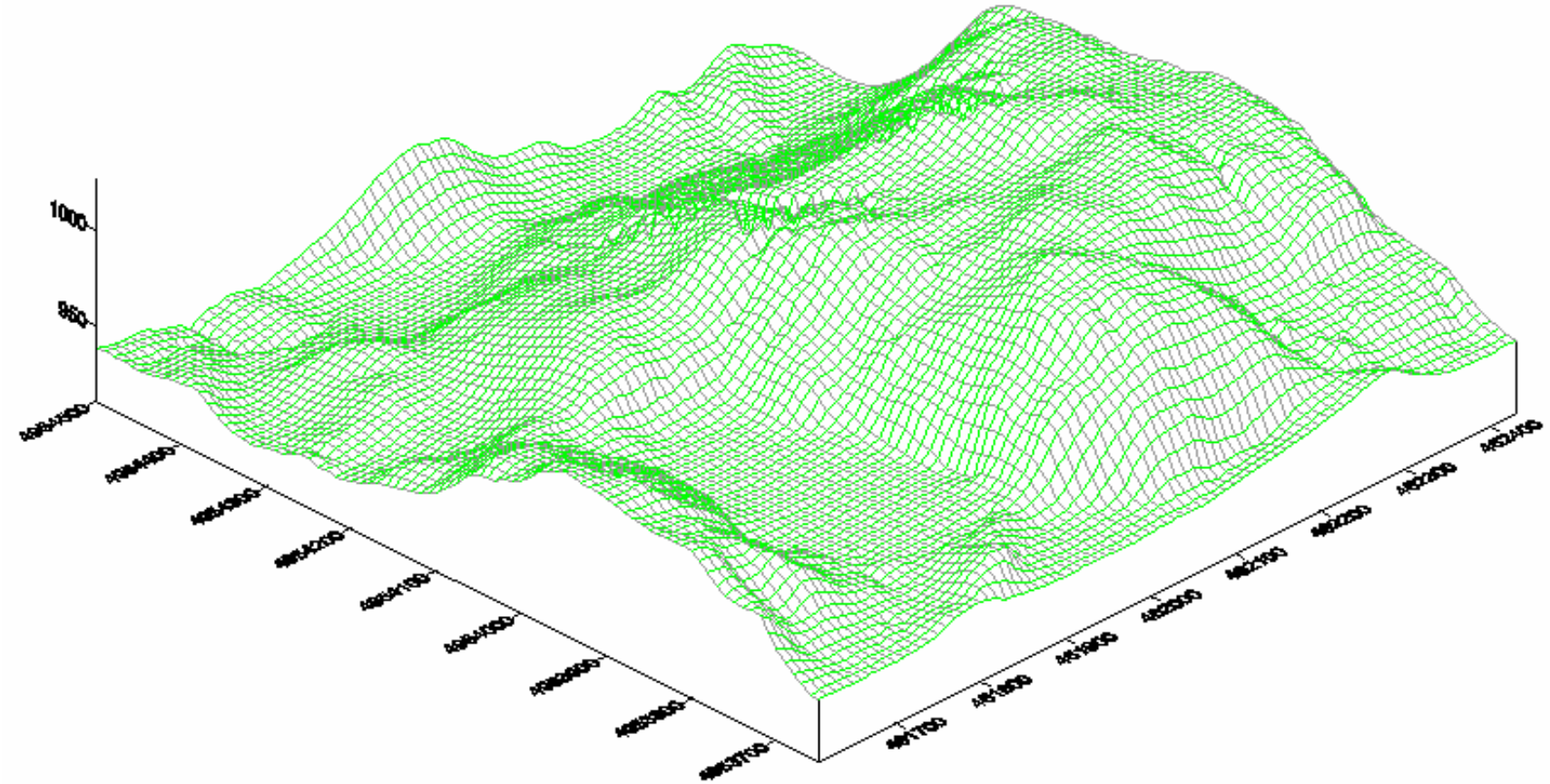
Toeslope



Soil Organic Carbon

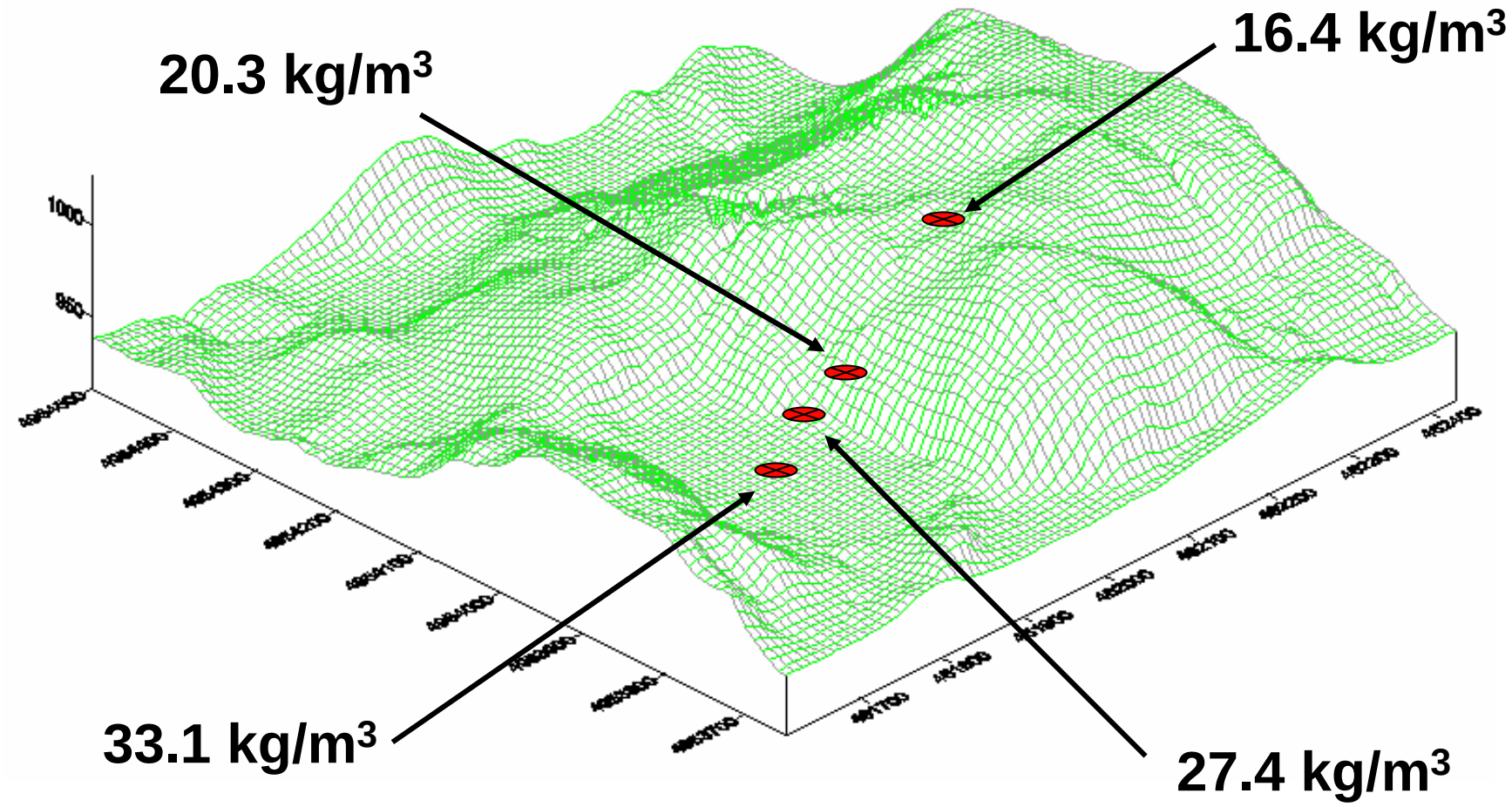
65 hectares

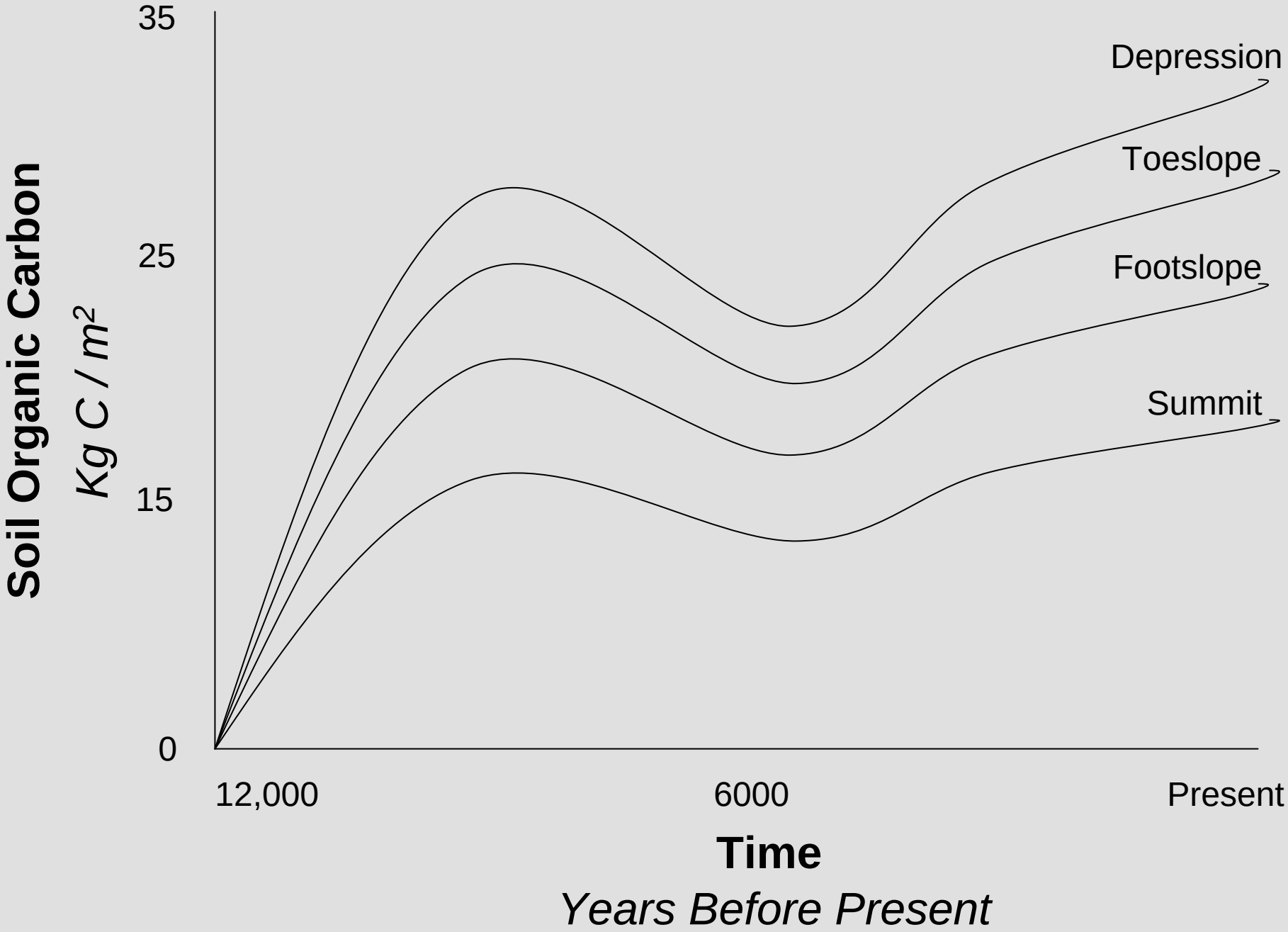
Topography

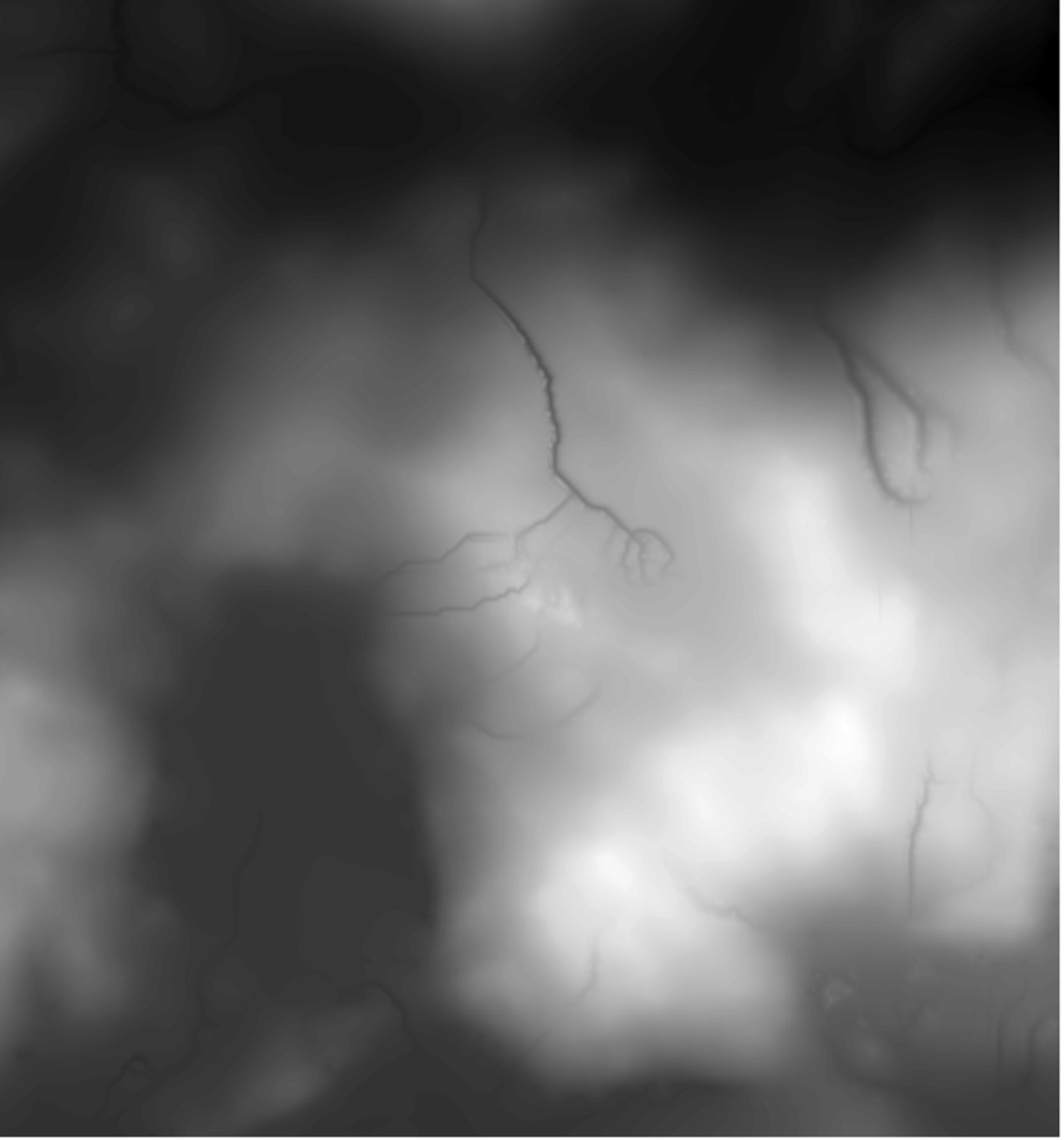


Soil Organic Carbon

Present




Soil Organic Carbon
Kg C / m2
35
25
15
0
Depression
Toeslope
Footslope
Summit
12,000
6000
Present
Time
Years Before Present



Spatial-Temporal Animation Soil Organic Carbon

Low High

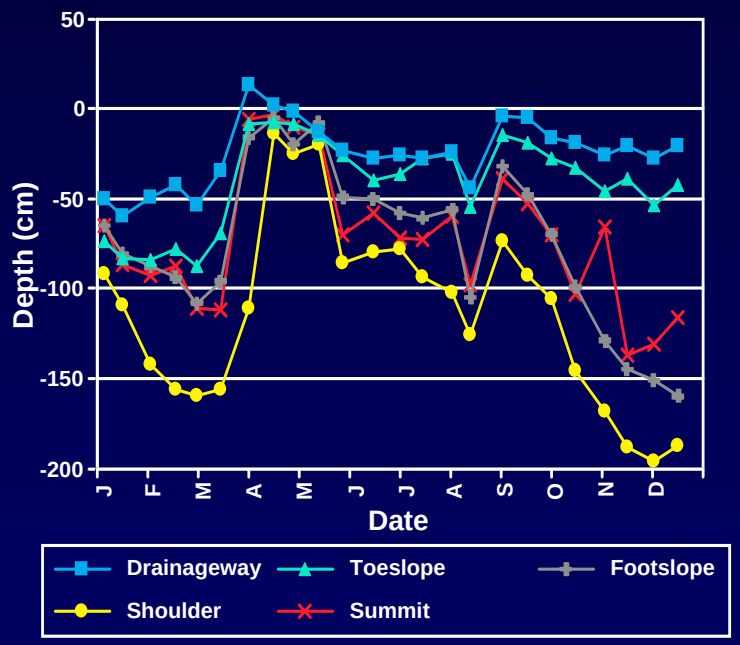
12,000 ybp

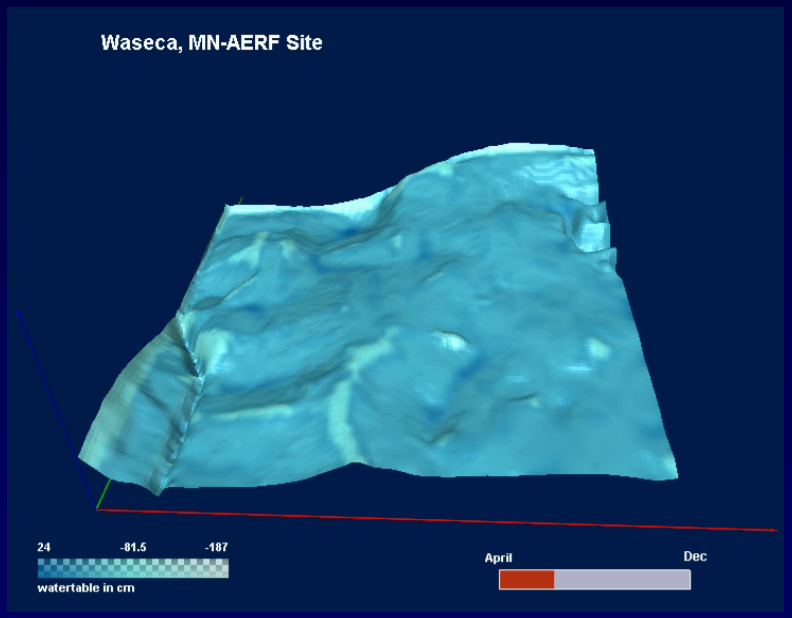
6000 ybp

Present

65 hectares

Annual Time Scale



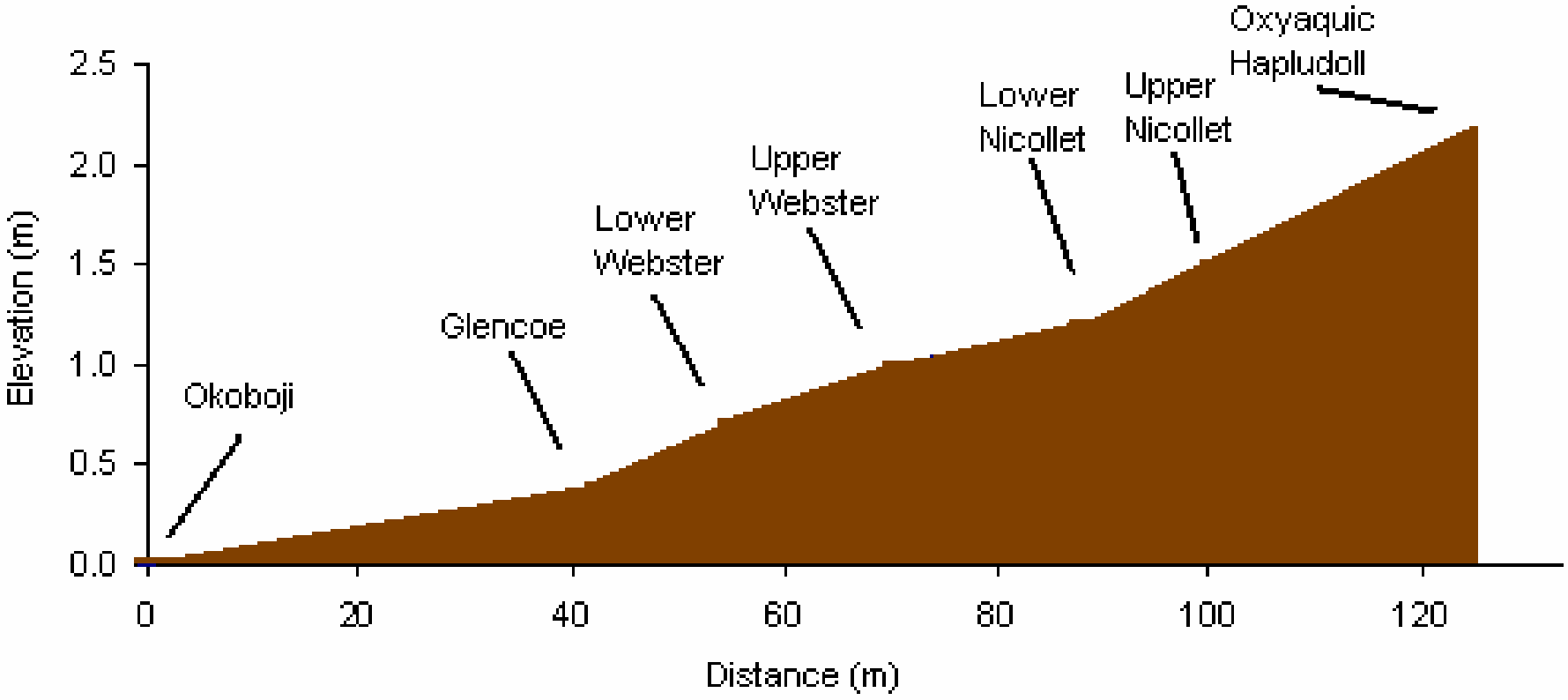


Soil Hydrology

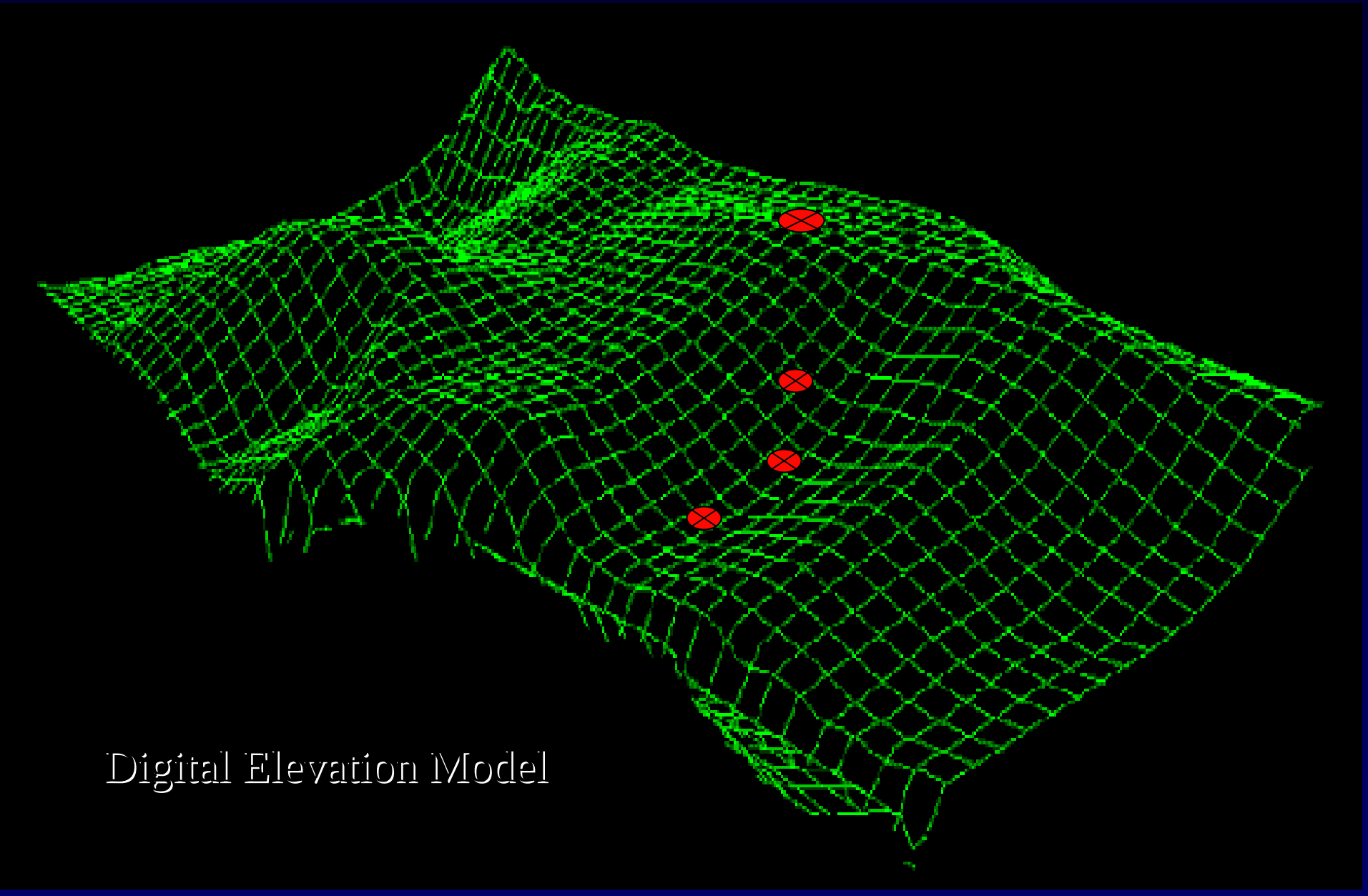
N
Minneapolis/ St. Paul
Minnesota
Waseca
Ground Moraine
Stagnation Moraine
Alluvium
Glacial Lake Sediments
Peat
5 0 5 10 15 20 Miles

Southern Minnesota Topography

Monitoring Transect – Waseca, MN



Waseca, Minnesota



Waseca, Minnesota
Soil Toposequence

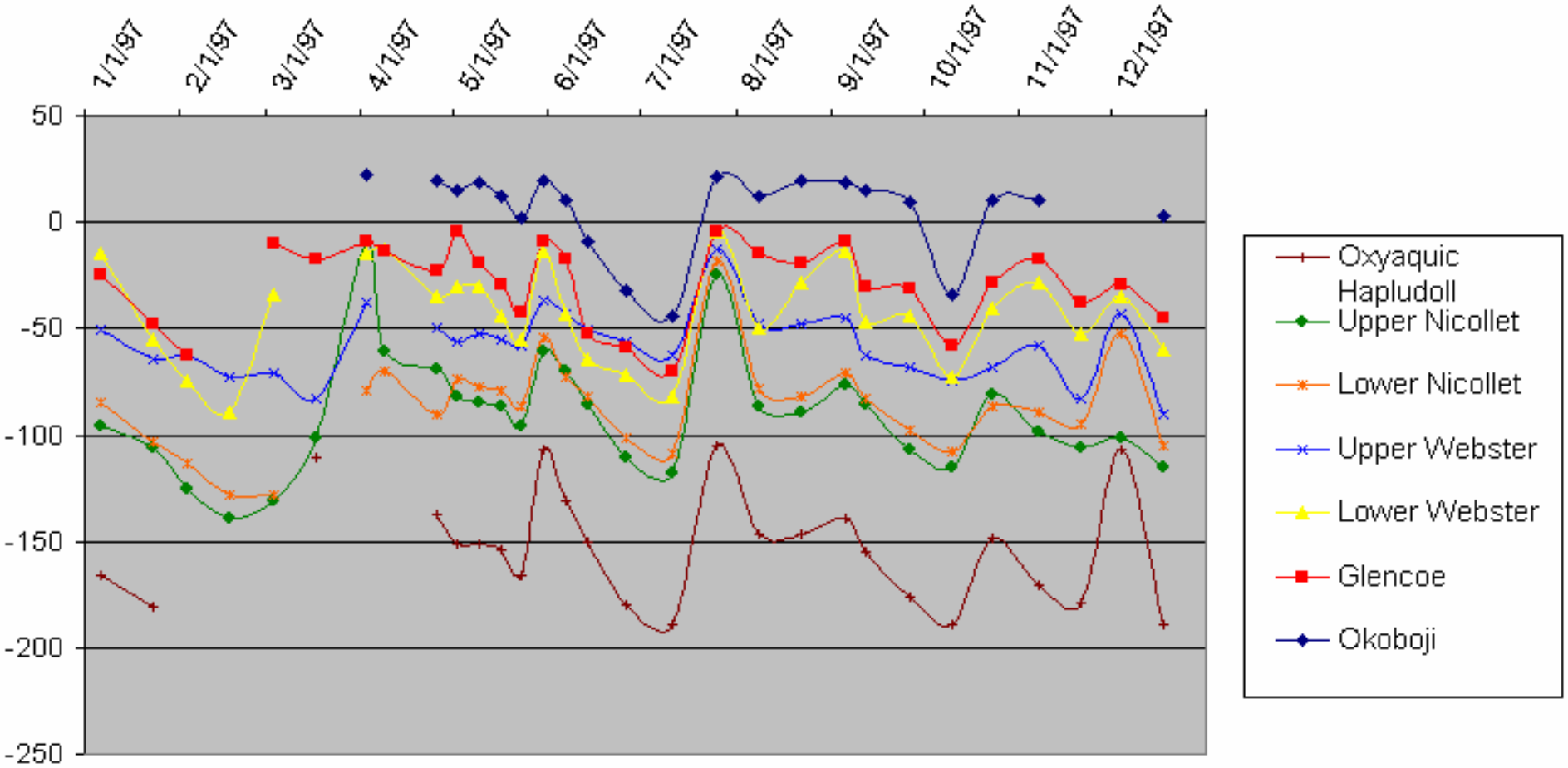
Summit

Lower Sideslope

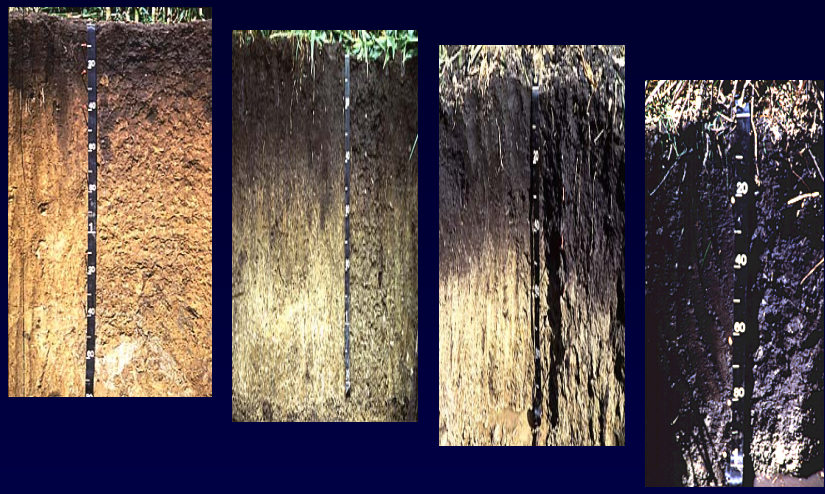
Footslope

Toeslope

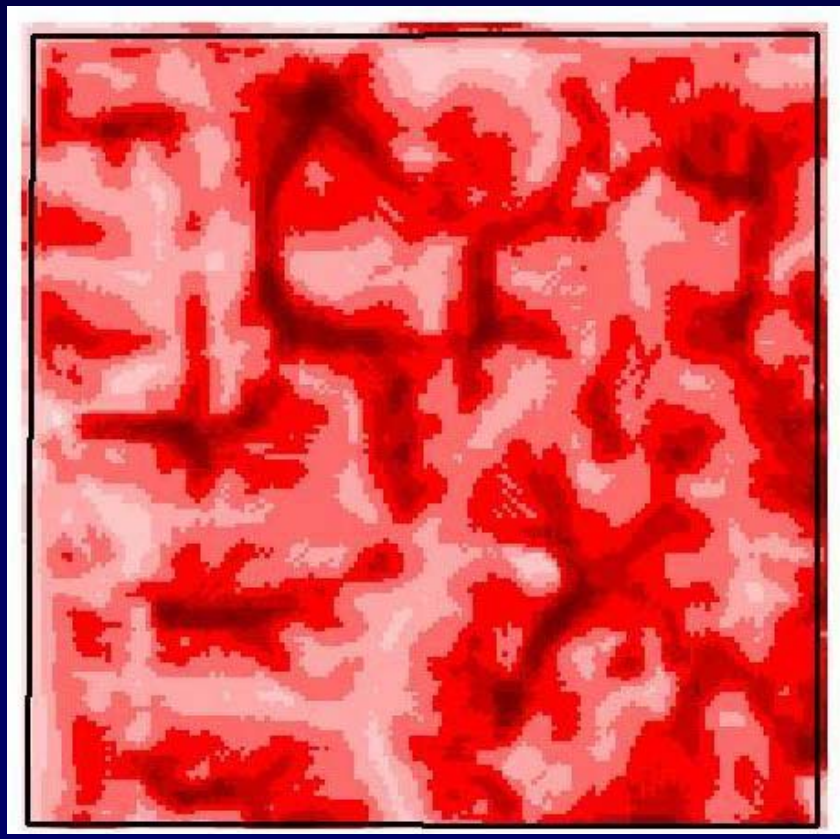
1997


1/1/97
2/1/97
3/1/97
4/1/97
5/1/97
6/1/97
7/1/97
8/1/97
9/1/97
10/1/97
11/1/97
12/1/97
50
0
-50
-100
-150
-200
-250
Oxyaquic Hapludoll
Upper Nicollet
Lower Nicollet
Upper Webster
Lower Webster
Glencoe
Okoboji

Extrapolating to the 3-D Landscape

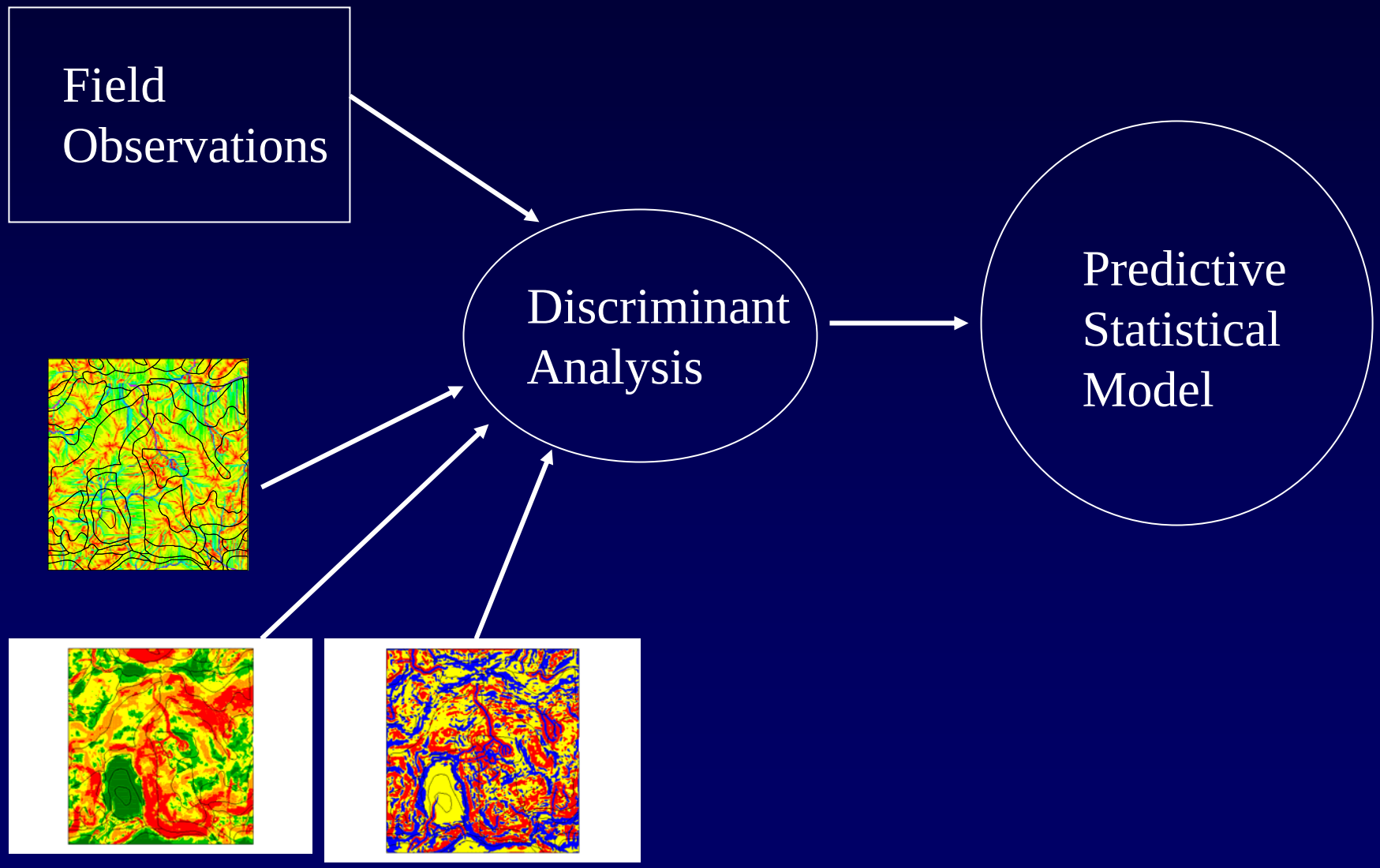


Soil-Landscape Modeling



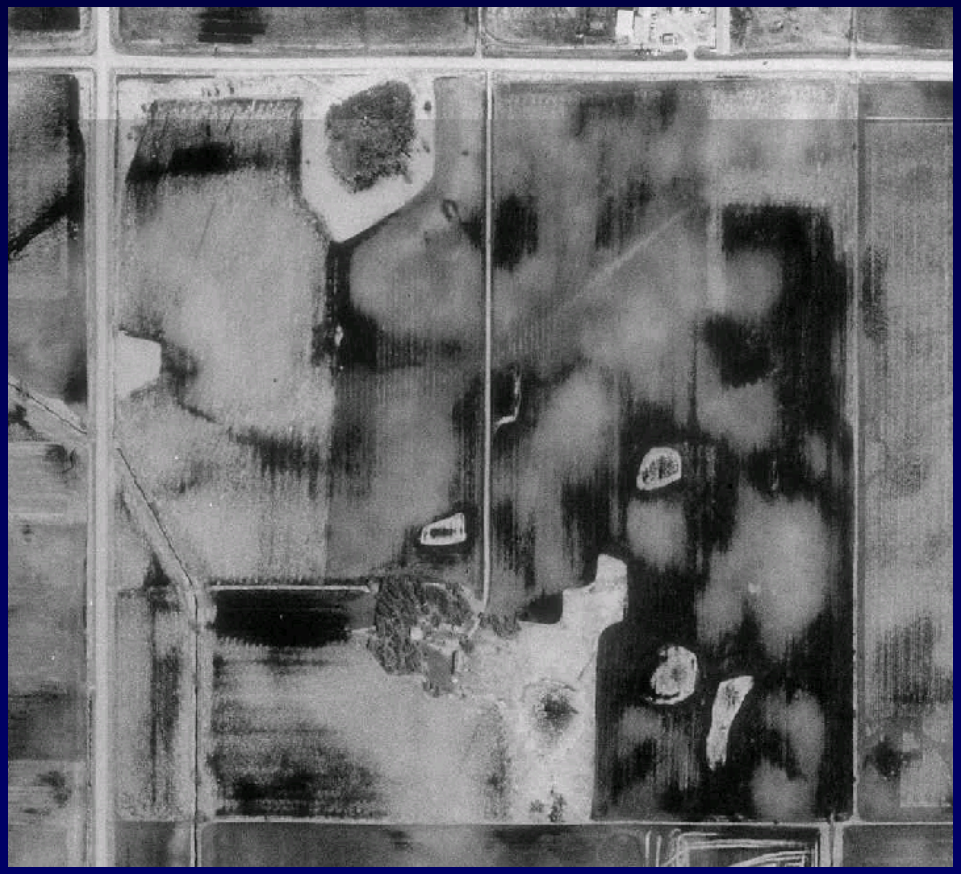
Soil Drainage Class Prediction

Model Development



Field Sampling

- Grid soil sampling: 302 points



Drainage Class Prediction

$$C_j = c_{j0} + C_{j1}X_1 + C_{j2}X_2 + \ldots + C_{jp}X_p$$

C_j=Probability of Class j

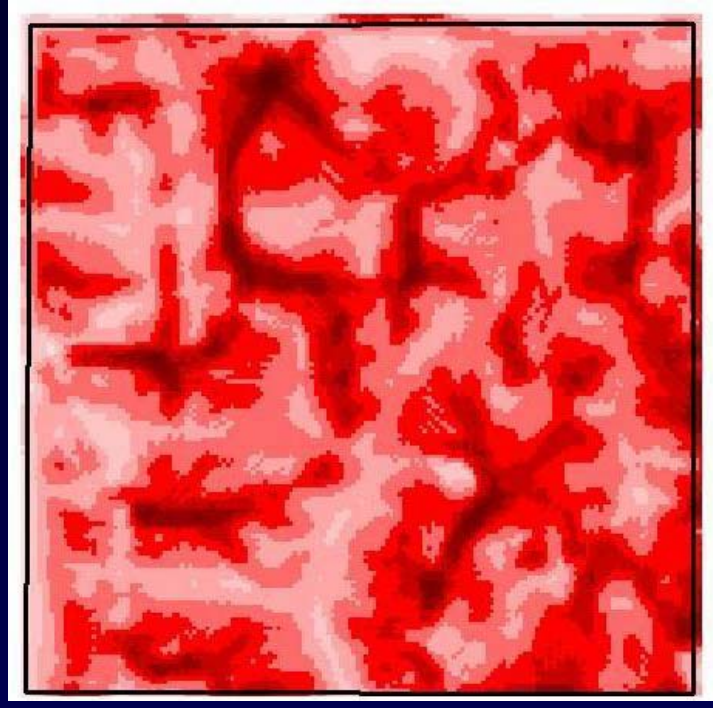
X= terrain attribute

C= classification coefficient (matrix)

j= drainage class

c_{j0} = constant

Model Calibration

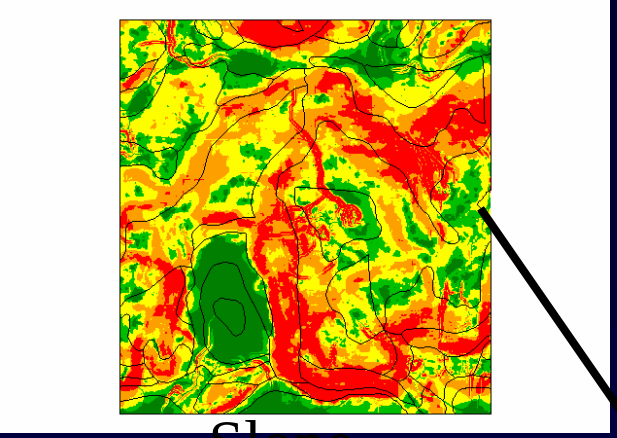


- Drainage class separation
  - Weakest: poorly and very poorly
  - Strongest: moderately well/somewhat poorly and very poorly

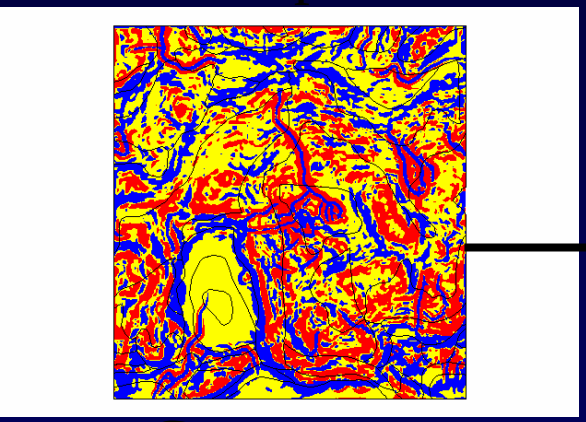
Model Validation
(Bootstrap Validation Approach)

- Soil-Landscape Model
  - 15-m DEM: best predictive capability
  - Classification Accuracy: 74%
  - 3% misclassified >1 drainage class away

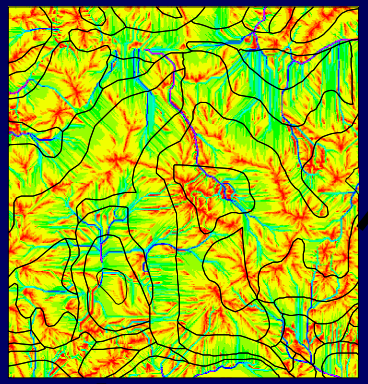
Model Application



Slope

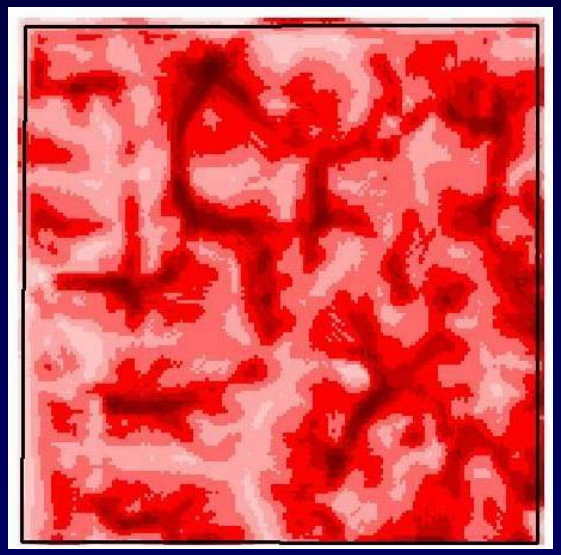


Curvature



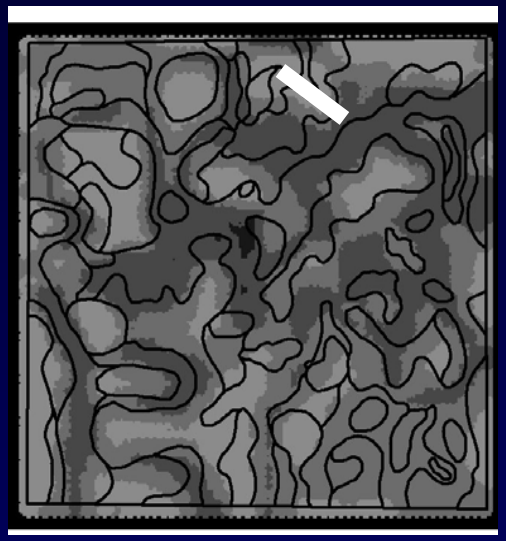
Catchment Area

Model

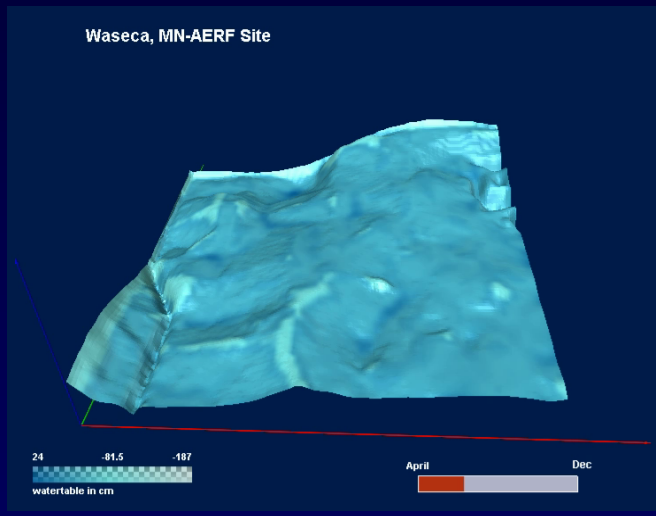


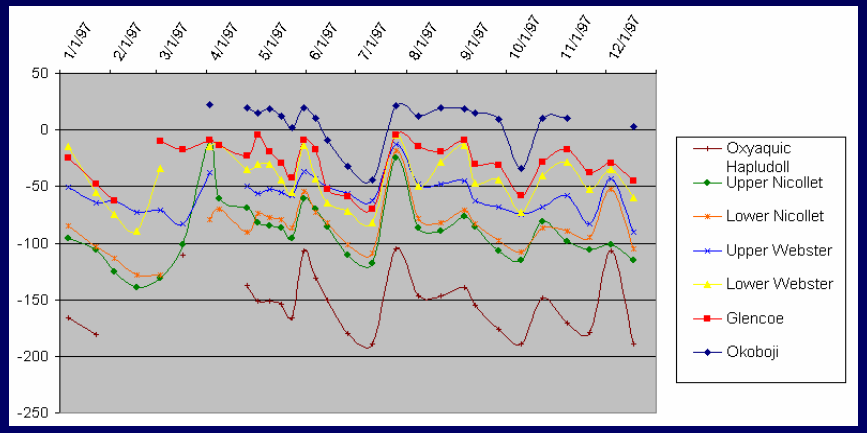
Class Probability Map

Probability of Poorly Drained Soil For Each Monitoring Site



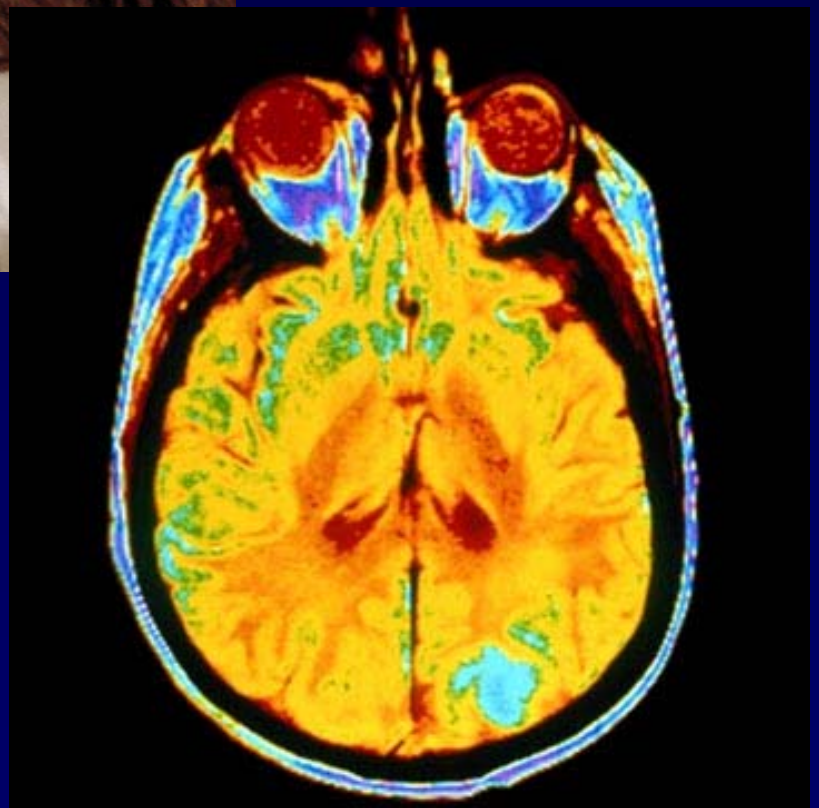
Interpolate





Magnetic Resonance Imaging (MRI) Analysis Software

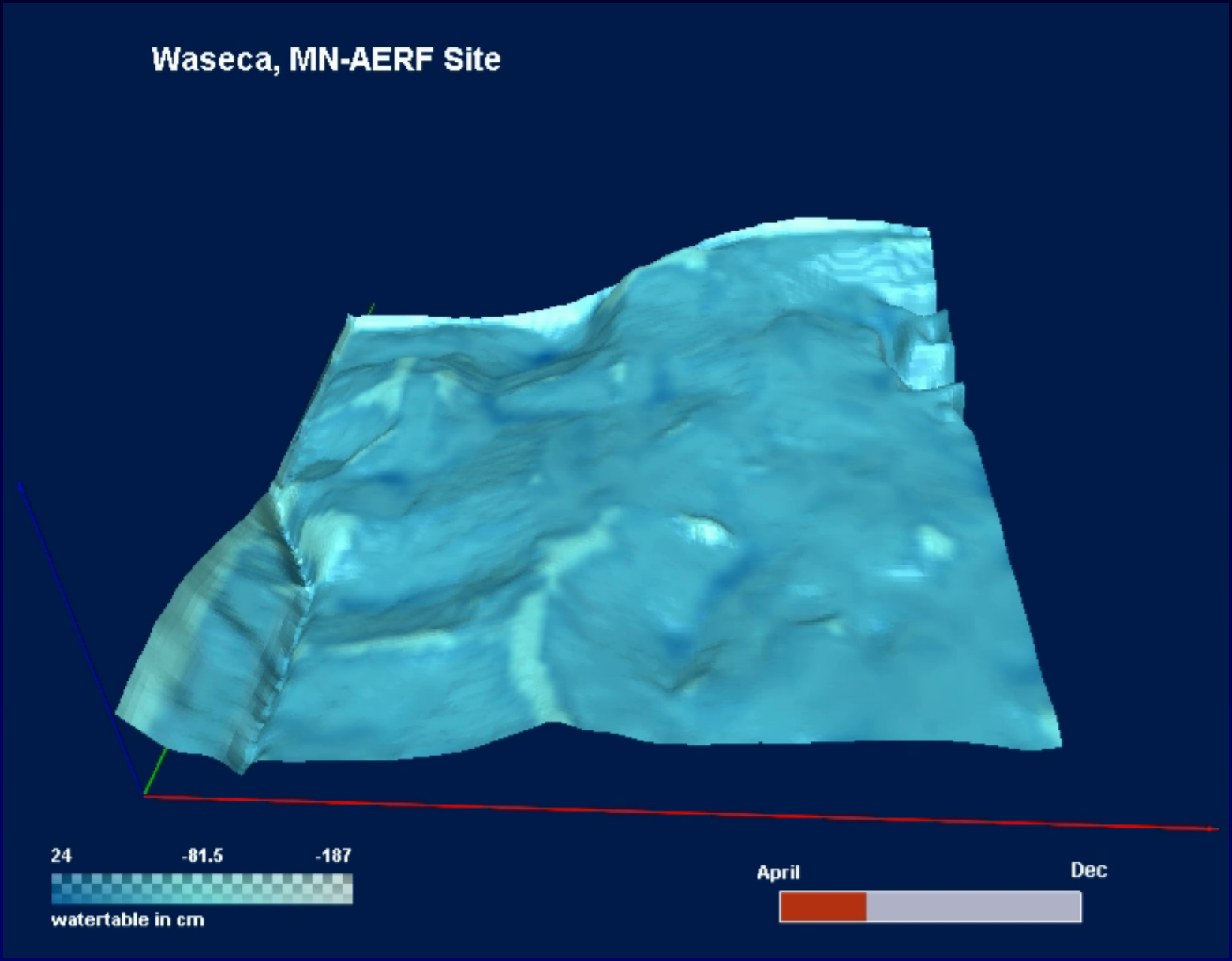
Amira

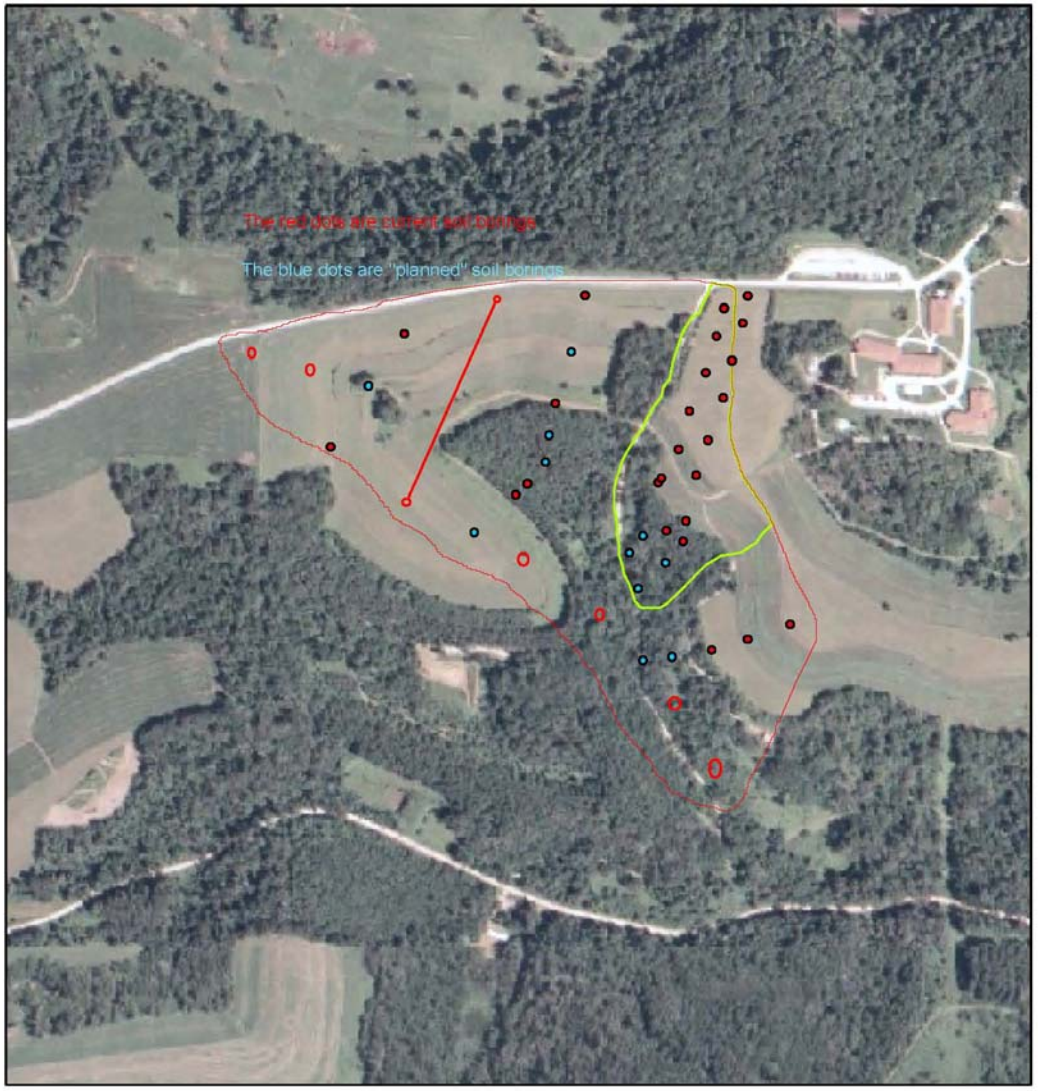


Brain Scan

Supercomputing Institute

University of Minnesota


Waseca, MN-AERF Site
24
-81.5
-187
watertable in cm
April
Dec



Proposed_Soil_Borings_point
Est_eagle_bluff_boundary
site_boundary
Soil_Borings_ALL
2005 Imagery

Carrolton T103 R010 S02
Fillmore County, MN
1:6,000

0 330 660 1,320 1,980 Feet

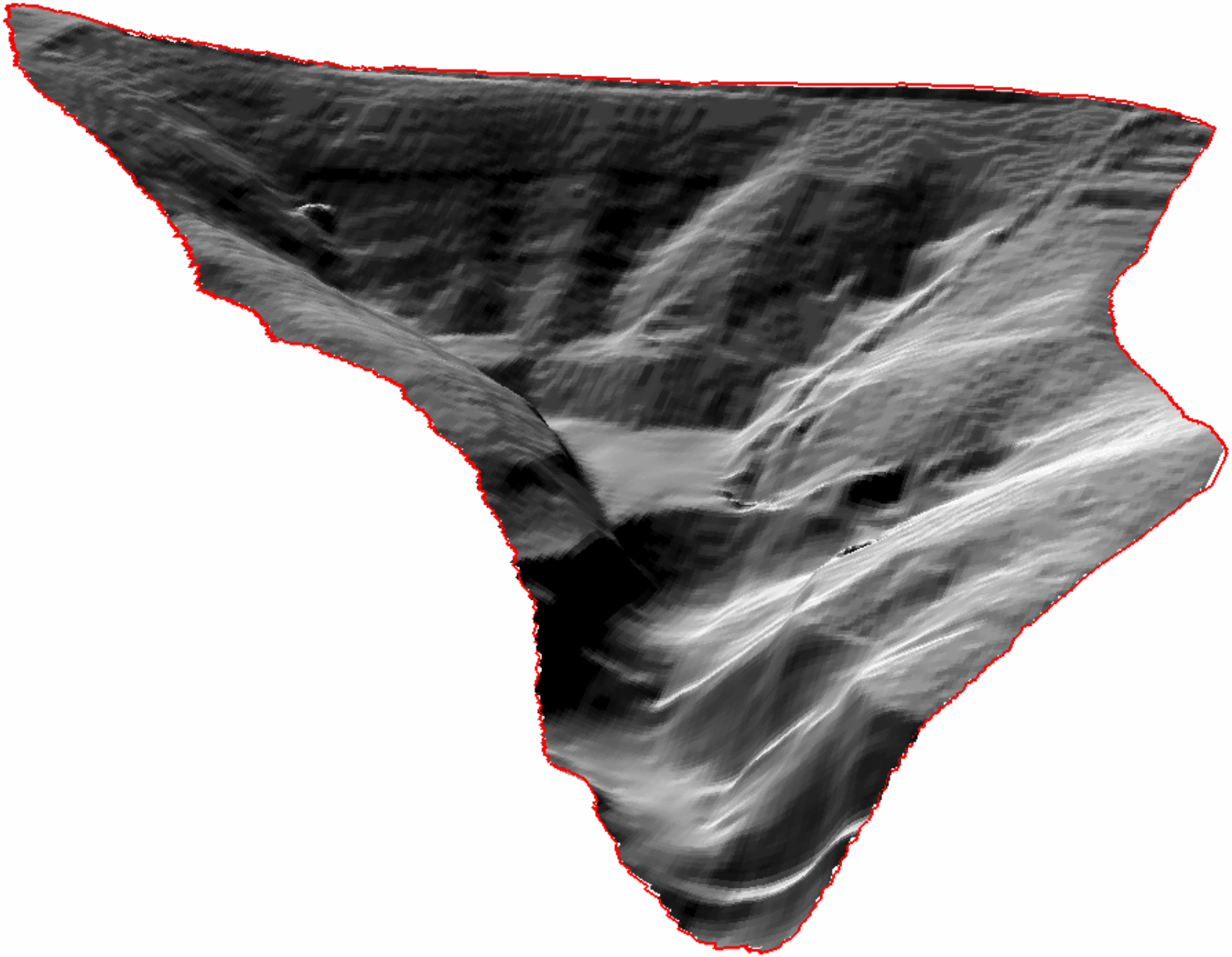
N

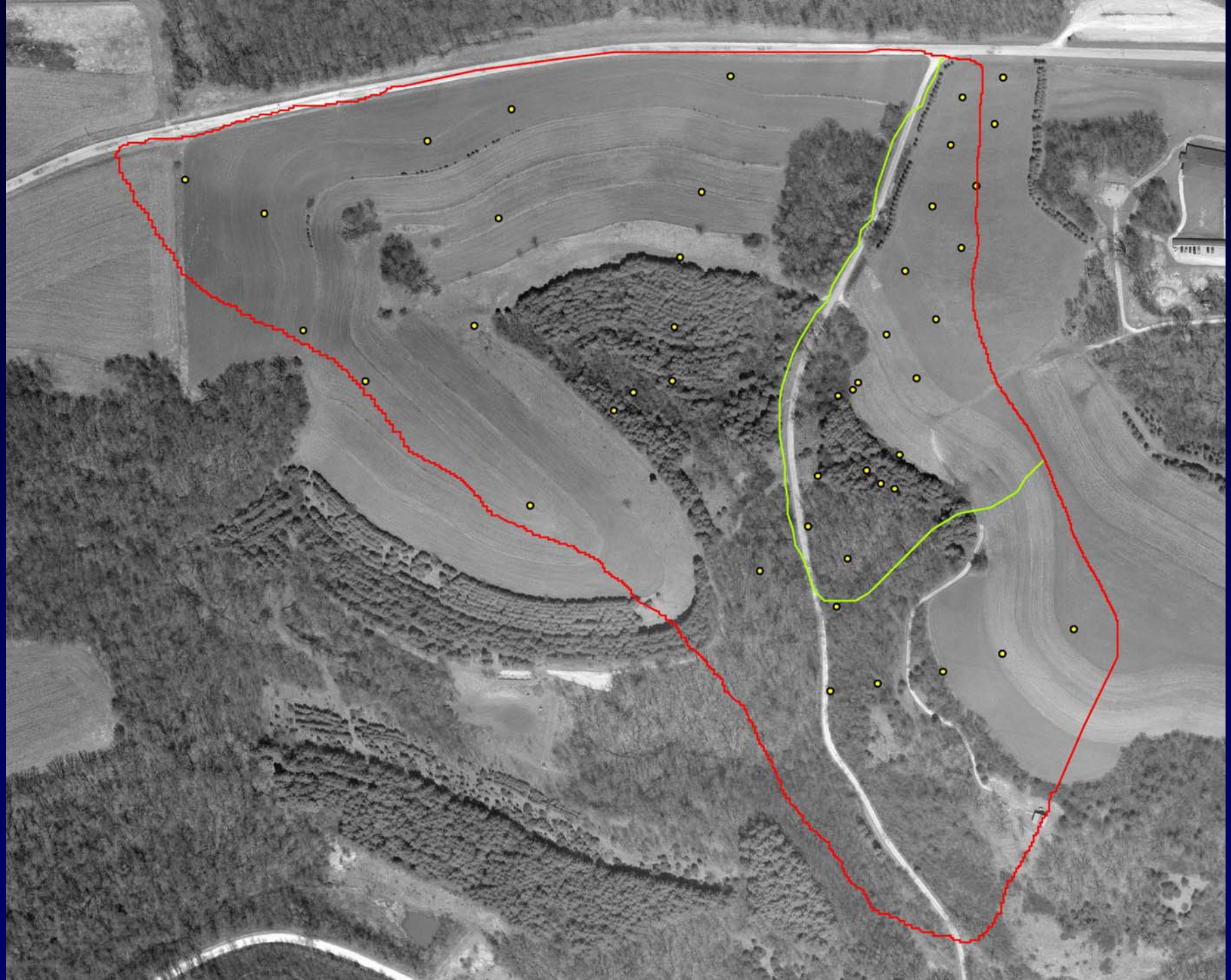
2003 Ortho-Imagery

Jun 06, 2006

Maps are for graphical purposes only. They do not represent a legal survey. While every effort has been made to ensure that These data are accurate and reliable within the limits of the current state of the art, NRCS cannot assume liability for any damages caused by any errors or omissions in the data, nor as a result of the failure of the data to function on a particular system. NRCS makes no warranty, expressed or implied, nor does the fact of distribution constitute such a warranty.

- John Beck
- Joel Nelson
- UM Supercomputer Institute
- NRCS National Geospatial Development Center
- National Soil Survey Lab





Minor
Lateral
Flow

Major
Lateral
Flow

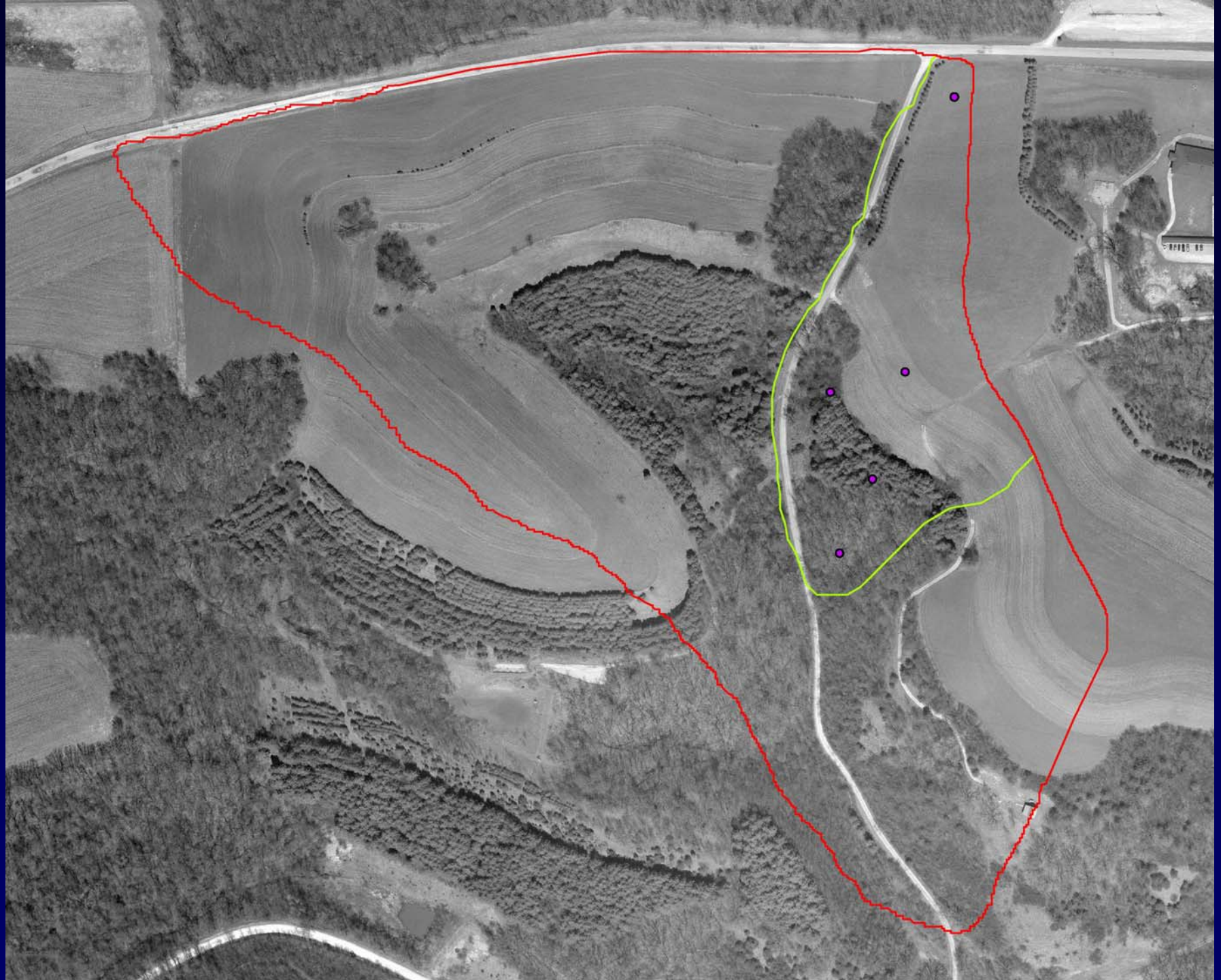
A

Bt

BC

C - loess

Depleted Loess

Old Red Till

88
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