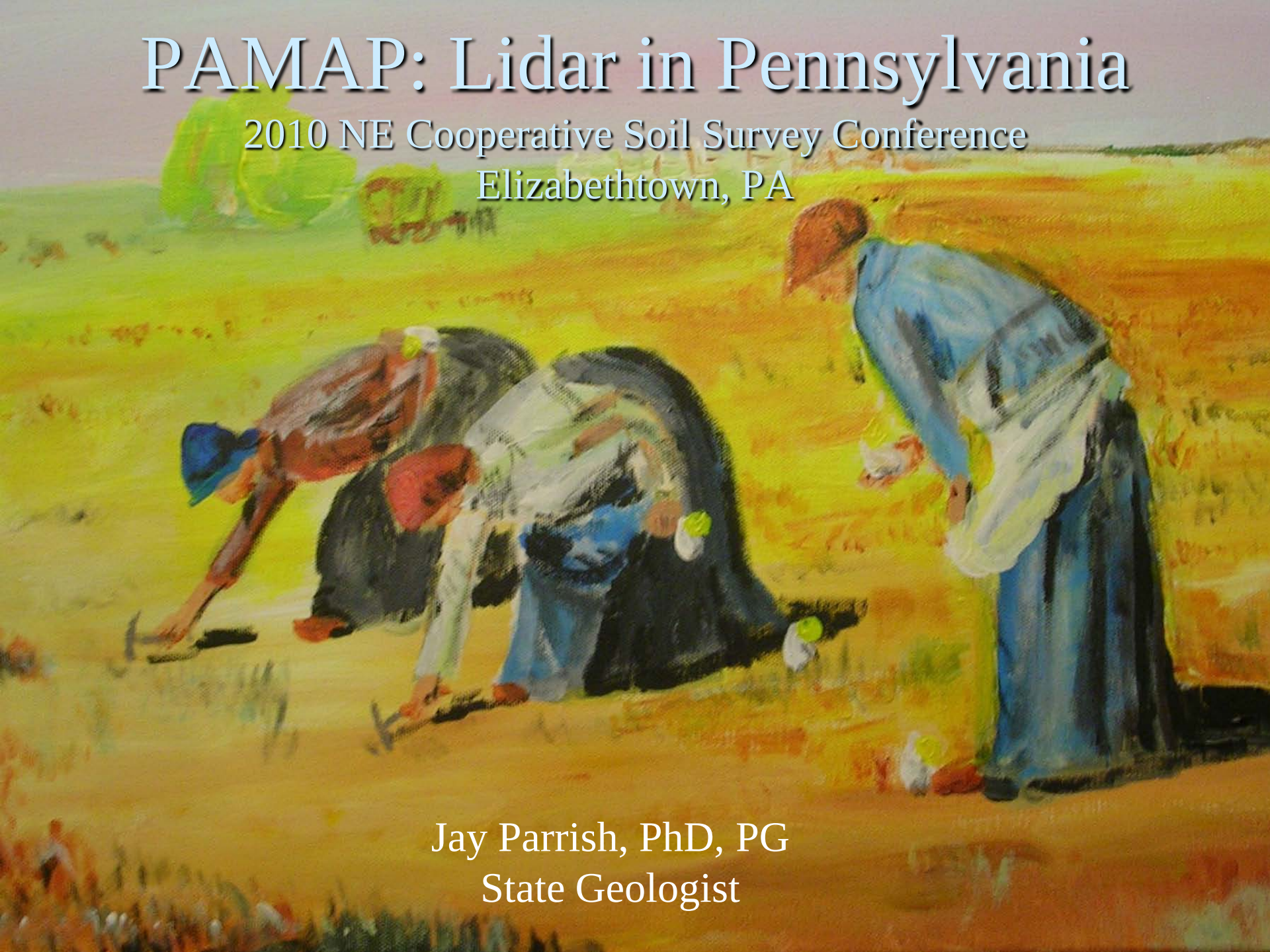
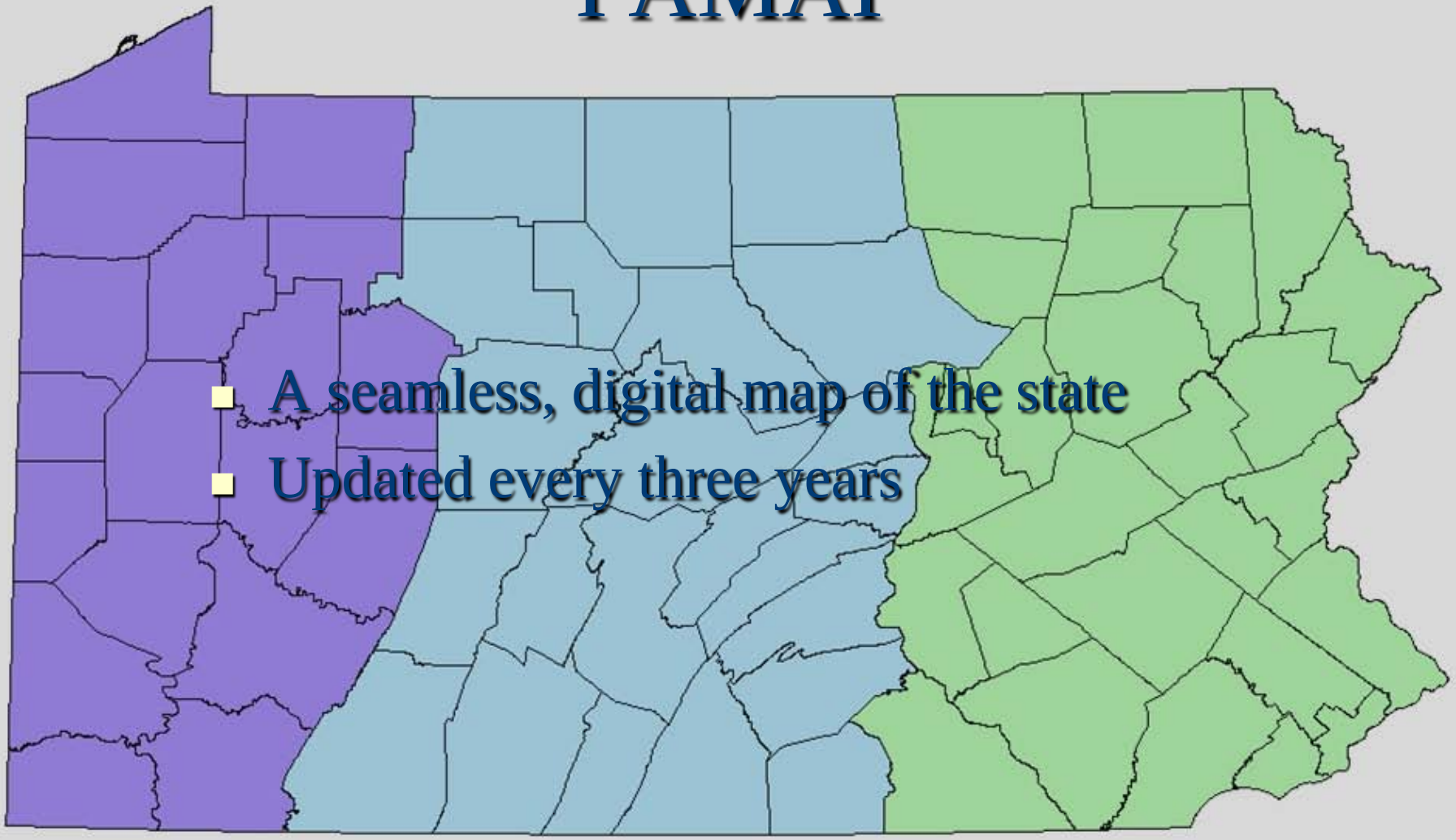
PAMAP: Lidar in Pennsylvania

2010 NE Cooperative Soil Survey Conference
Elizabethtown, PA



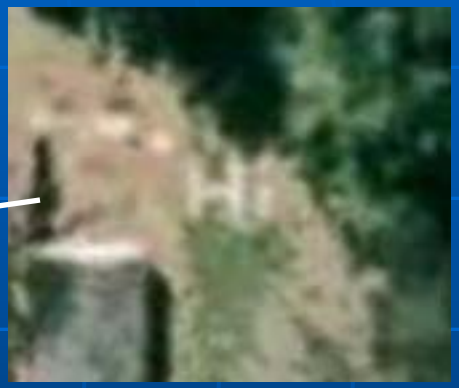
Jay Parrish, PhD, PG
State Geologist

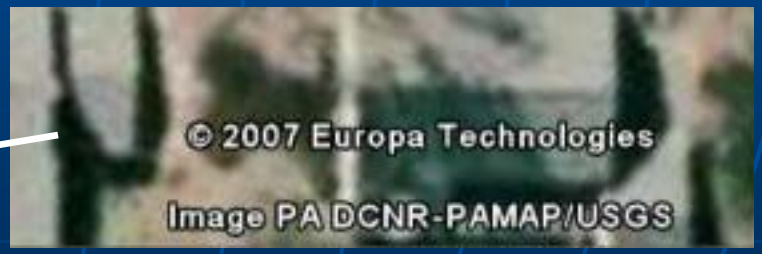
PAMAP



- A seamless, digital map of the state
- Updated every three years

Google





LIDAR is the acronym for Light Detection and Ranging.

It is an active remote sensing system using laser light to illuminate the target area.

- Uses its own energy source, rather than reflected natural light or naturally emitted energy

- LIDAR systems produce accurate measurements of surface elevation to digital elevation models (DEM)'s with vertical accuracies as high as 15 cm.

It is not all-weather, as the target must be 'visible' in the instrument's EM range

- Some haze is manageable; fog is not able to 'see through' trees

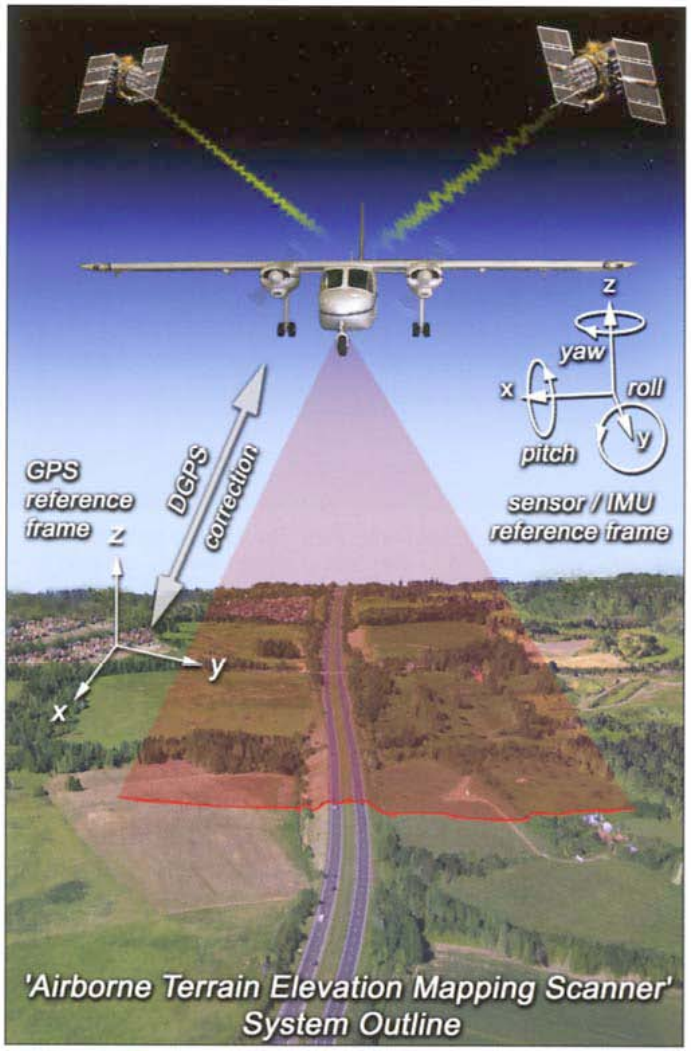


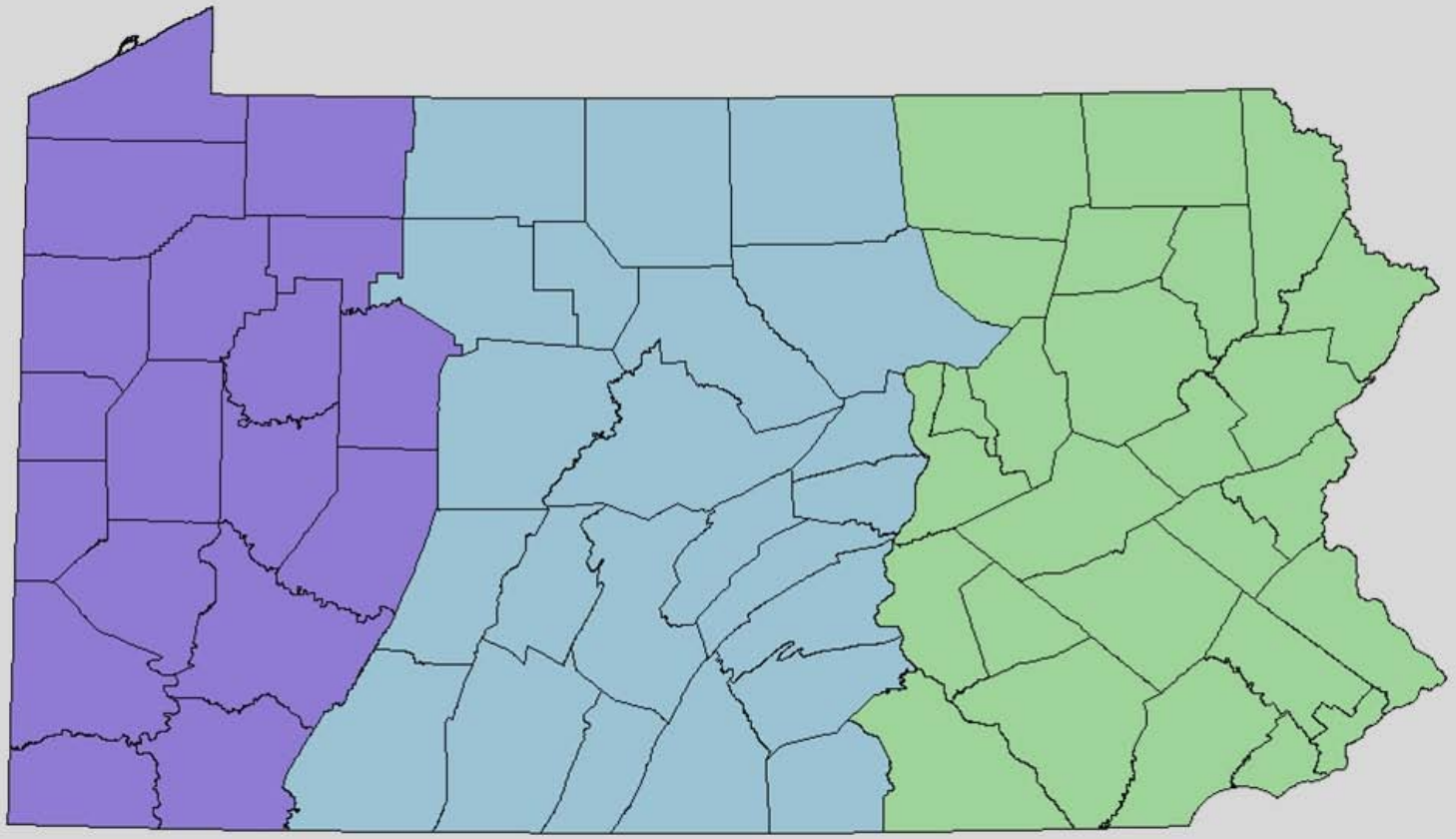
Figure 8.59 Principles of lidar system operation. A lidar system includes a scanning instrument that generates laser pulses and records the reflected returns, an on-board GPS to record sensor position, and an inertial measurement unit (IMU) to measure sensor orientation. A second GPS located at a known ground position collects data at the same time as the overflight for later differential correction of the on-board GPS data (DGPS).

Source: © Precision Terrain Surveys, Ltd.

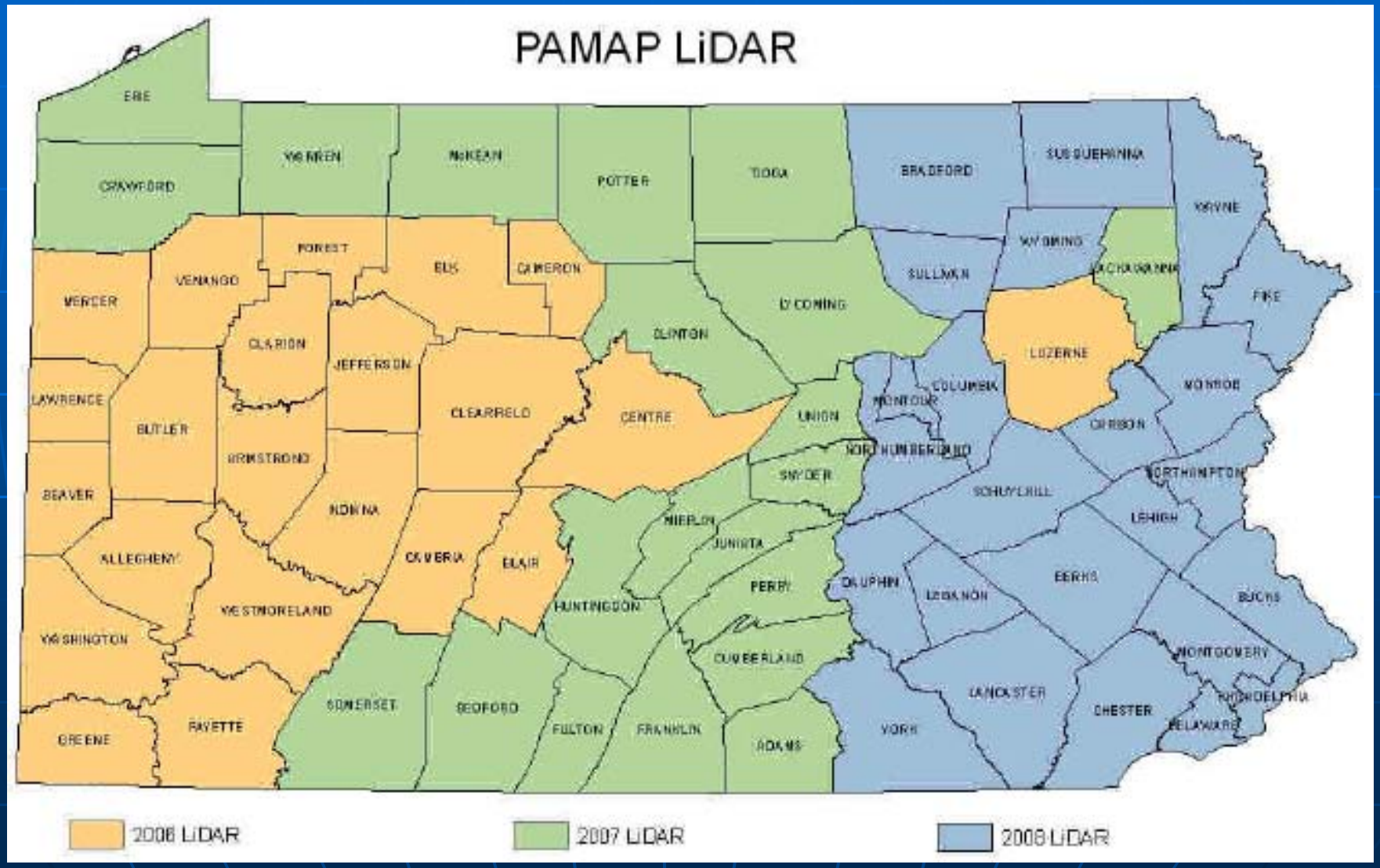
PAMAP

- At first there was little interest in a topo layer
- DCNR Bureau of Topographic and Geologic Survey decided to acquire lidar in 2005
- Cost estimates went down, making it a possibility
- Supported by DCNR Secretary and most of the funding came from DCNR

PAMAP-three year plan



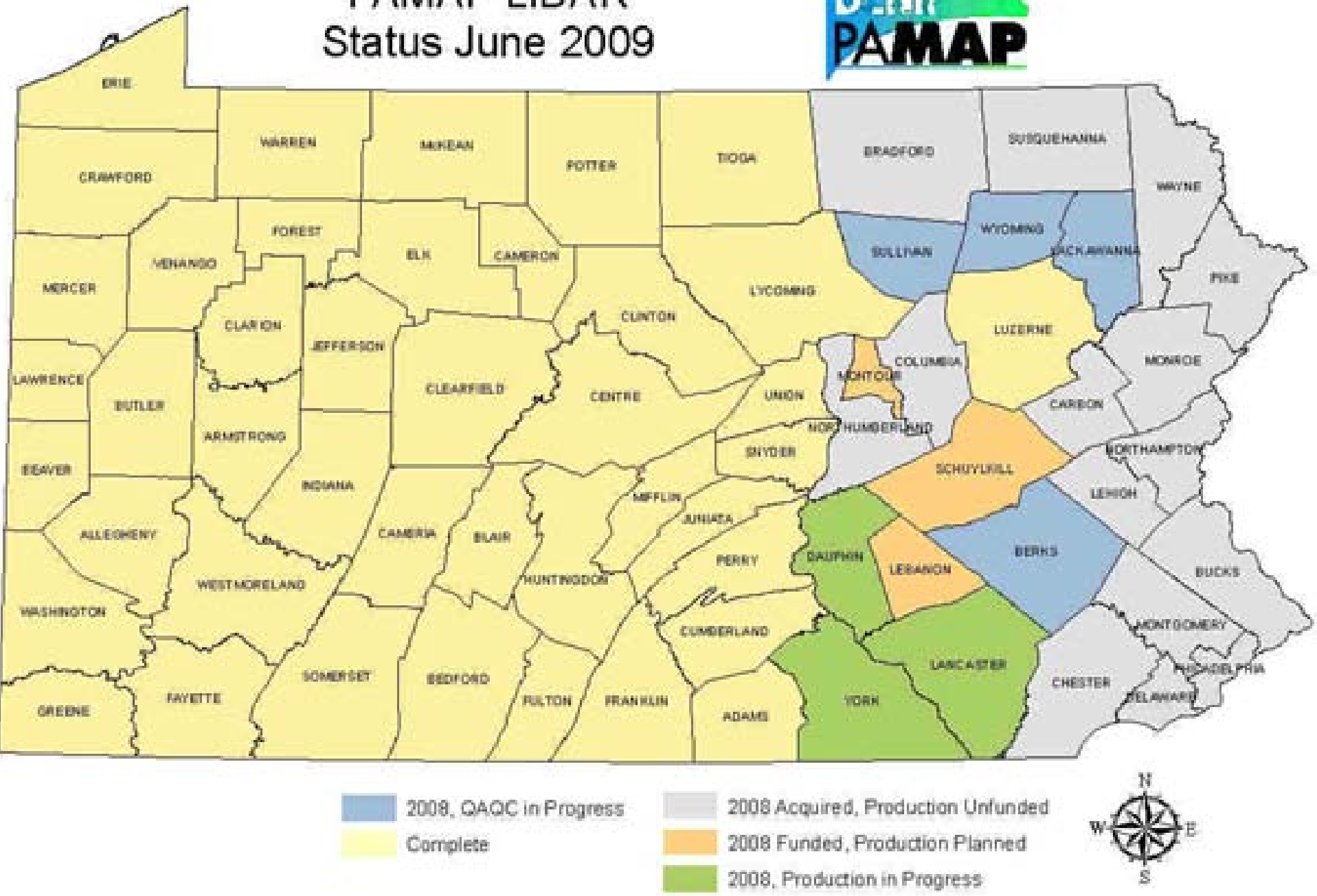
Reality


PAMAP LiDAR
ERIE
CRAWFORD
WARREN
McKEAN
POTTER
TIOGA
BRADFORD
SUSQUEHANNA
WAYNE
FOREST
ELK
CAMERON
WYOMING
SULLIVAN
LACKAWANNA
PIKE
MERCER
VENANGO
CLARION
JEFFERSON
CLINTON
LUZERNE
LAWRENCE
BUTLER
CLEARFIELD
CENTRE
UNION
COLUMBIA
MONROE
CARBON
ARMSTRONG
SNYDER
SCHUYLKILL
NORTHAMPTON
BEAVER
INDIANA
MIFFLIN
JUNIATA
LEHIGH
ALLEGHENY
CAMBRIA
BLAIR
PERRY
DAUPHIN
LEBANON
BERKS
BUCKS
WESTMORELAND
HUNTINGDON
WASHINGTON
CUMBERLAND
MONTGOMERY
LANCASTER
CHESTER
PHILADELPHIA
SOMERSET
BEDFORD
FULTON
FRANKLIN
ADAMS
YORK
DELAWARE
GREENE
FAYETTE
2006 LIDAR
2007 LIDAR
2008 LIDAR

Cost

- $8 million from DCNR, OA, PennDOT, FEMA, PEMA, DEP, USGS
- But the funding was delayed by other parts of government
- As a result $3 million of appropriated money was lost in 2008.
- All of the 2008 data then had to be processed using money that was donated in small chunks
- This meant smaller processing units and higher costs
- As a result we have paid more, and taken an extra two years to complete the processing

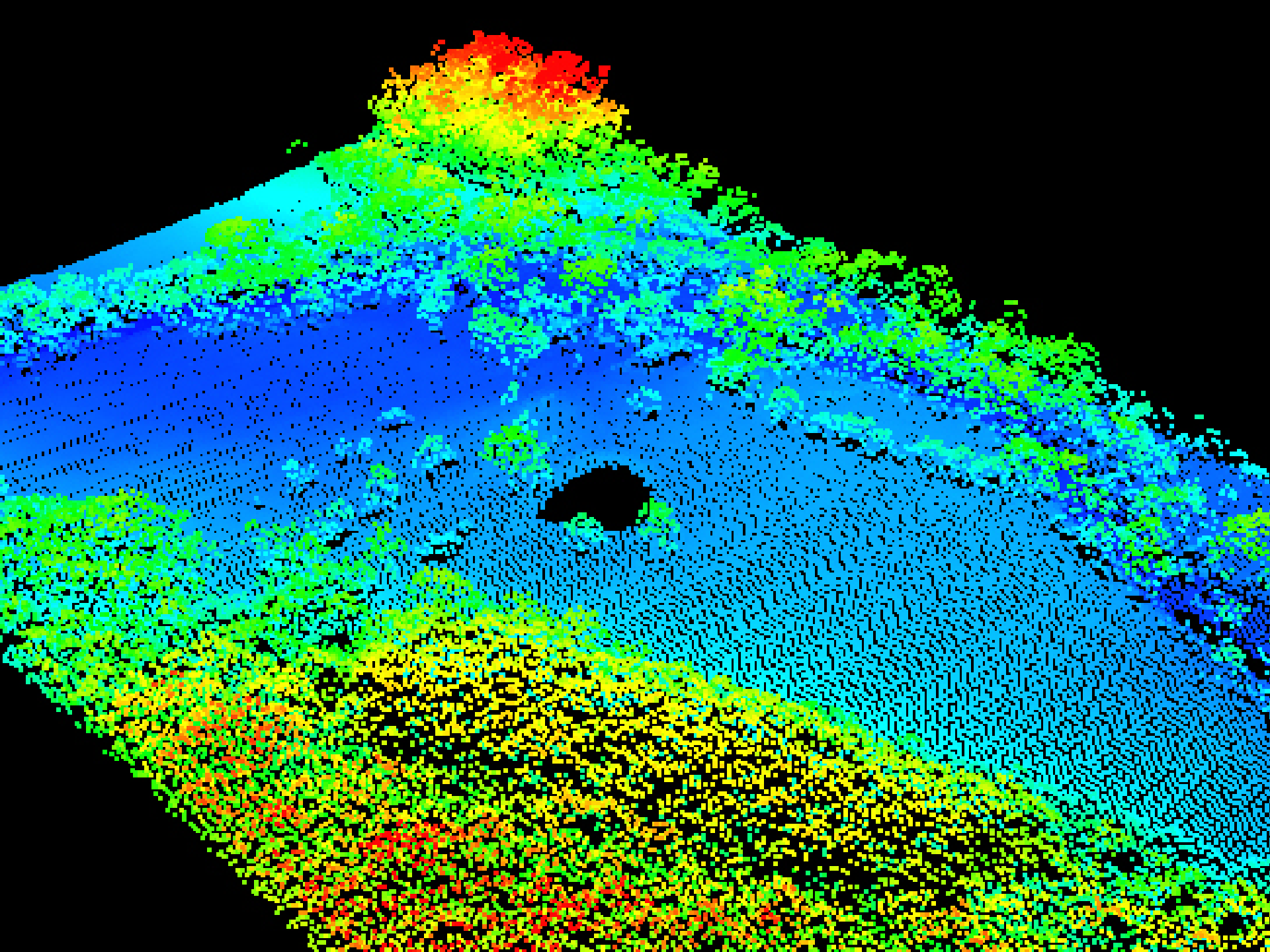
PAMAP LiDAR
Status June 2009



PAMAP Lidar
Status May 2010

Products

- LiDAR Point Cloud – the LiDAR points are distributed in the binary LAS format (www.lasformat.org). Each point is attributed for intensity, classification, etc. according to the LAS standard and PAMAP specifications. The metadata distributed with the LAS file provides details on the classification. The size of each LAS file varies based on terrain and features, among other variables.



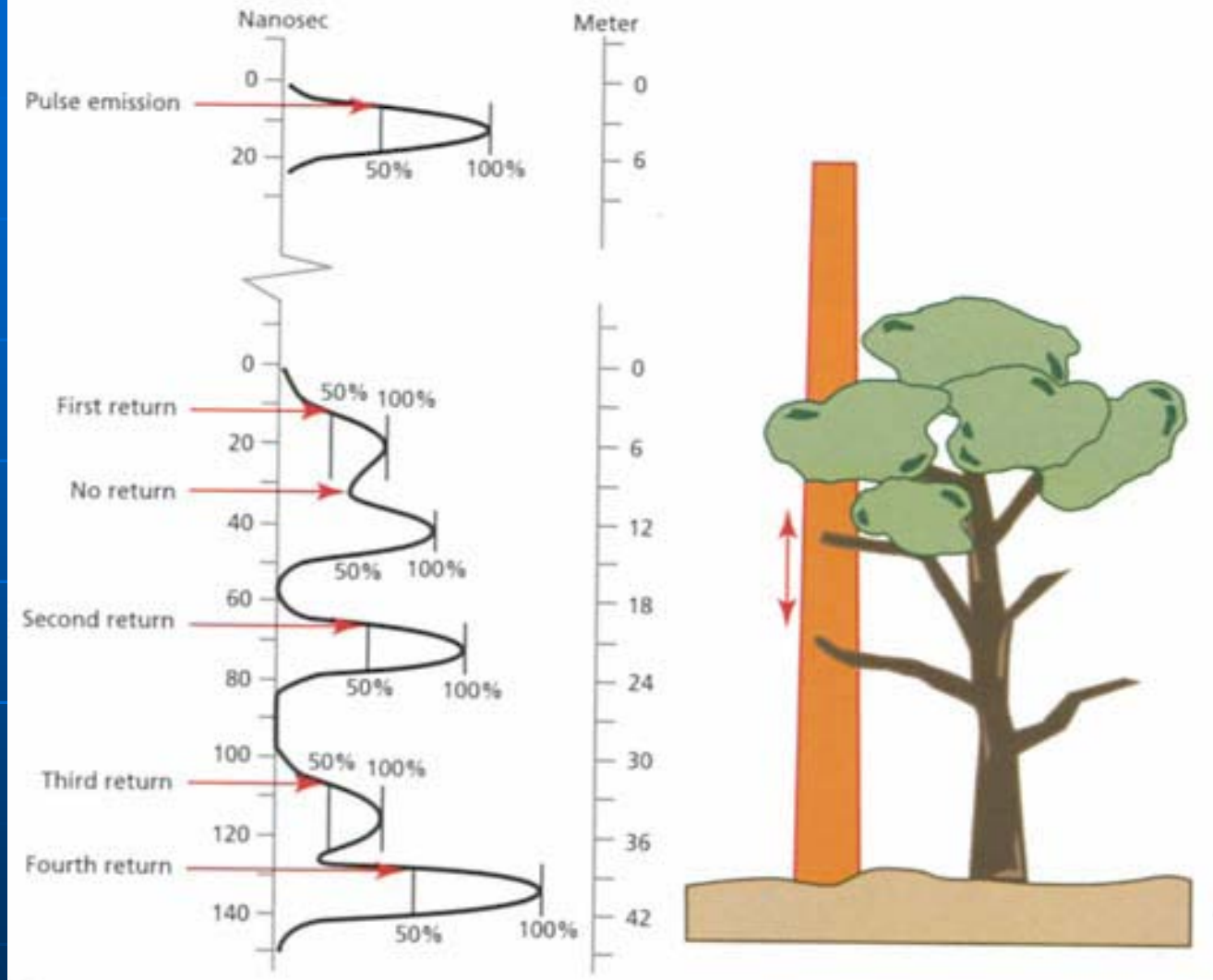
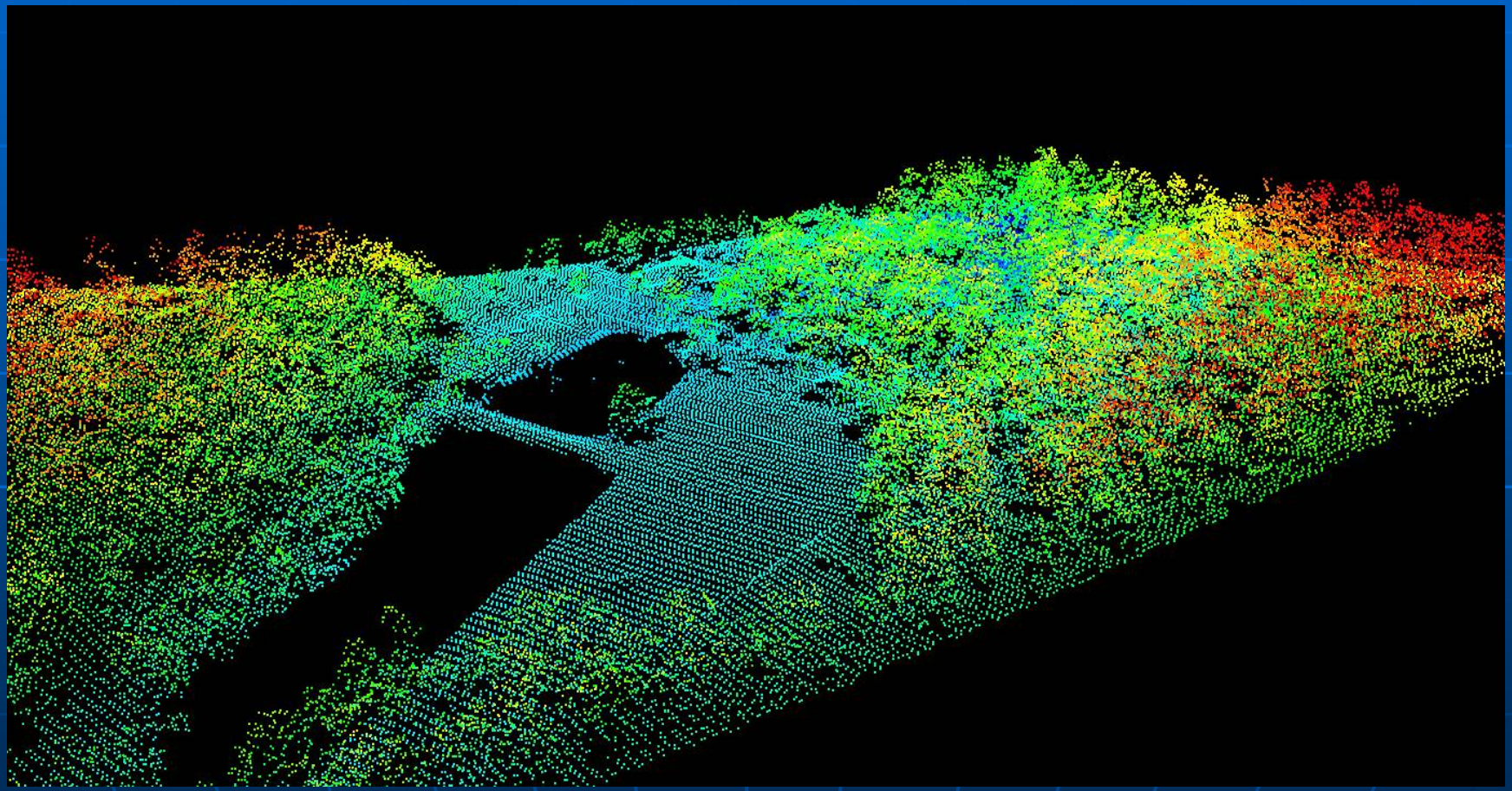
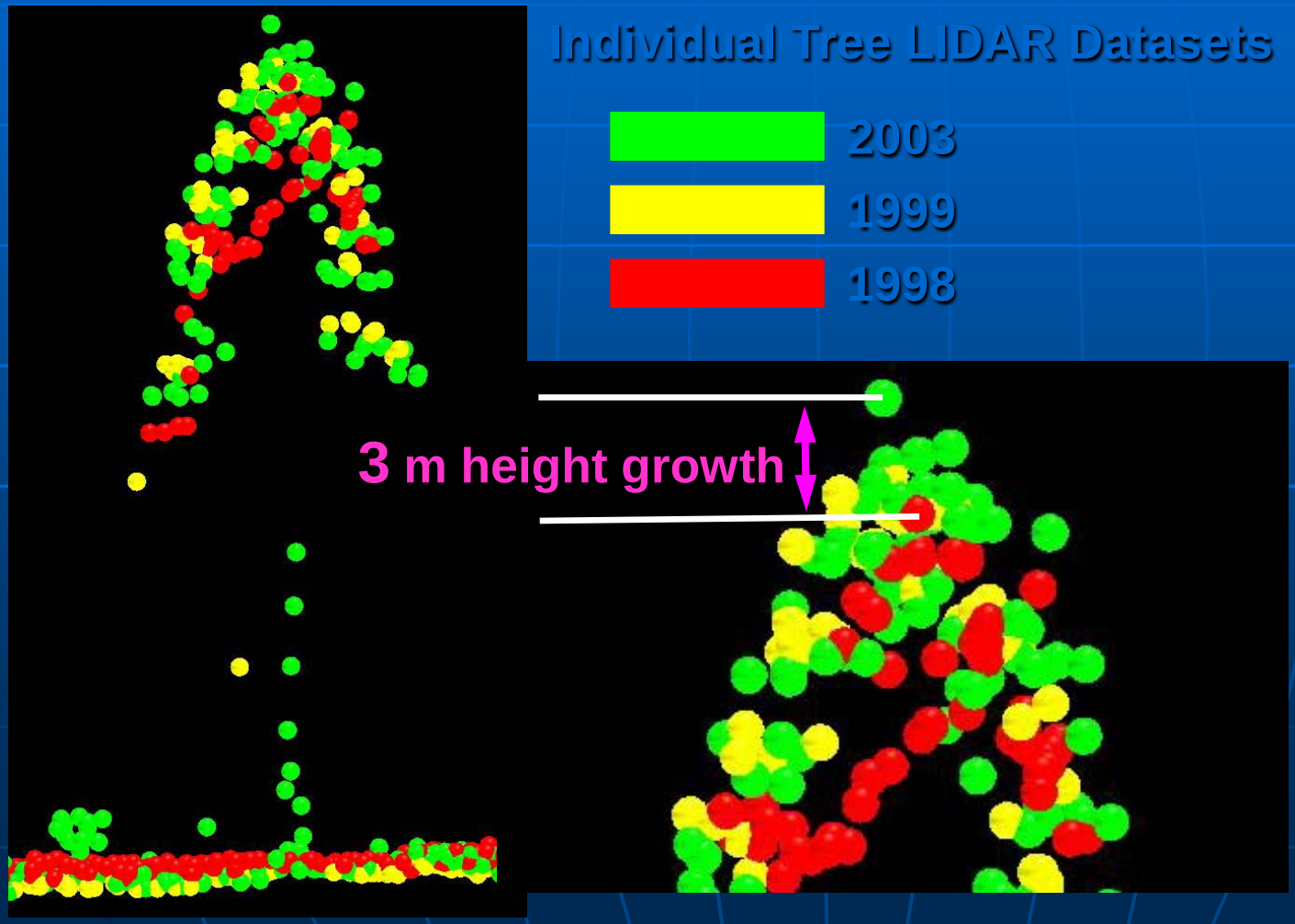


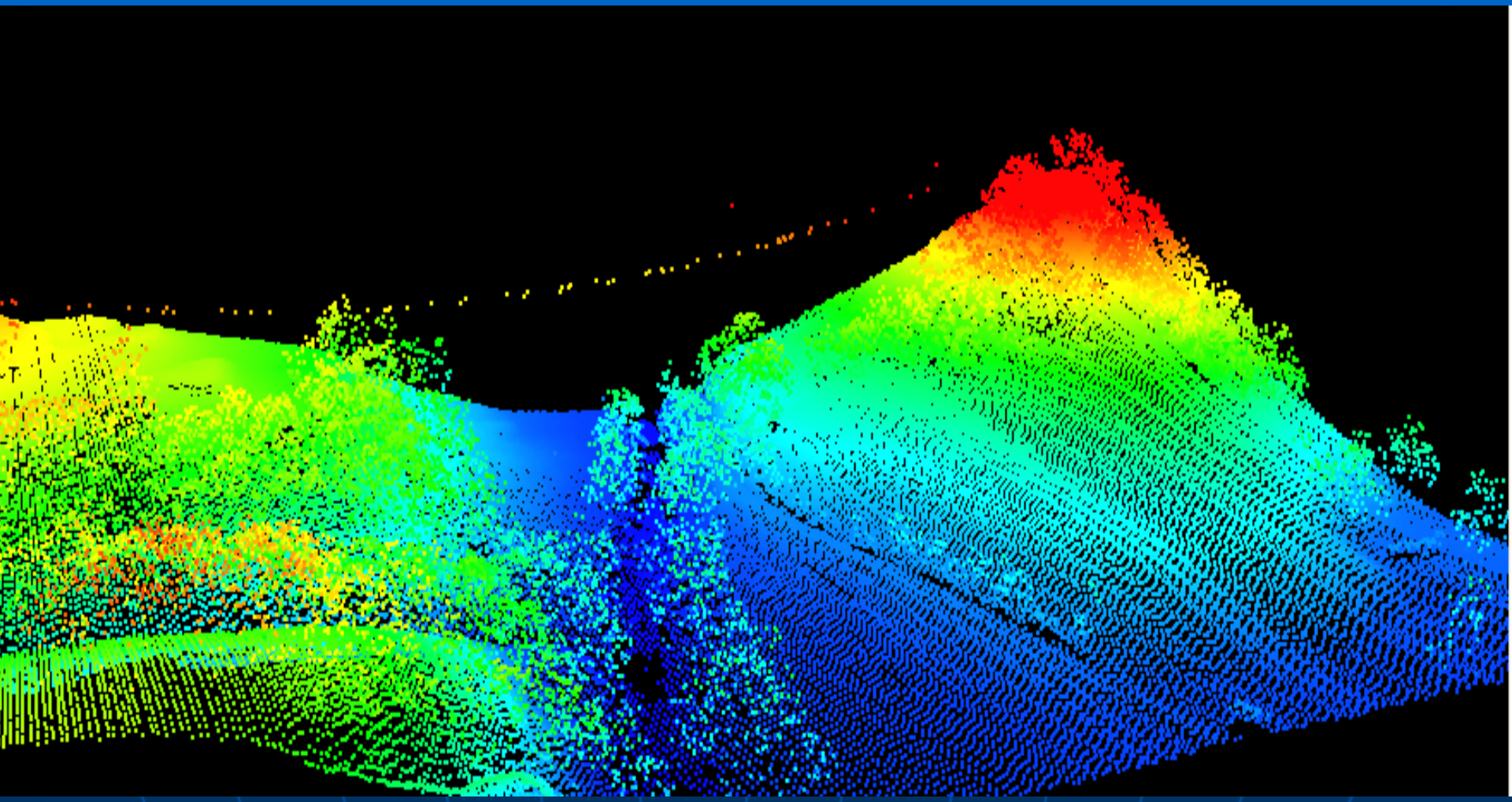
Figure 8.62 Multiple lidar returns. Sophisticated processing algorithms define multiple reflective surfaces by analyzing intensity variations within each pulse reflection.

Biomass



Monitoring Growth with LIDAR

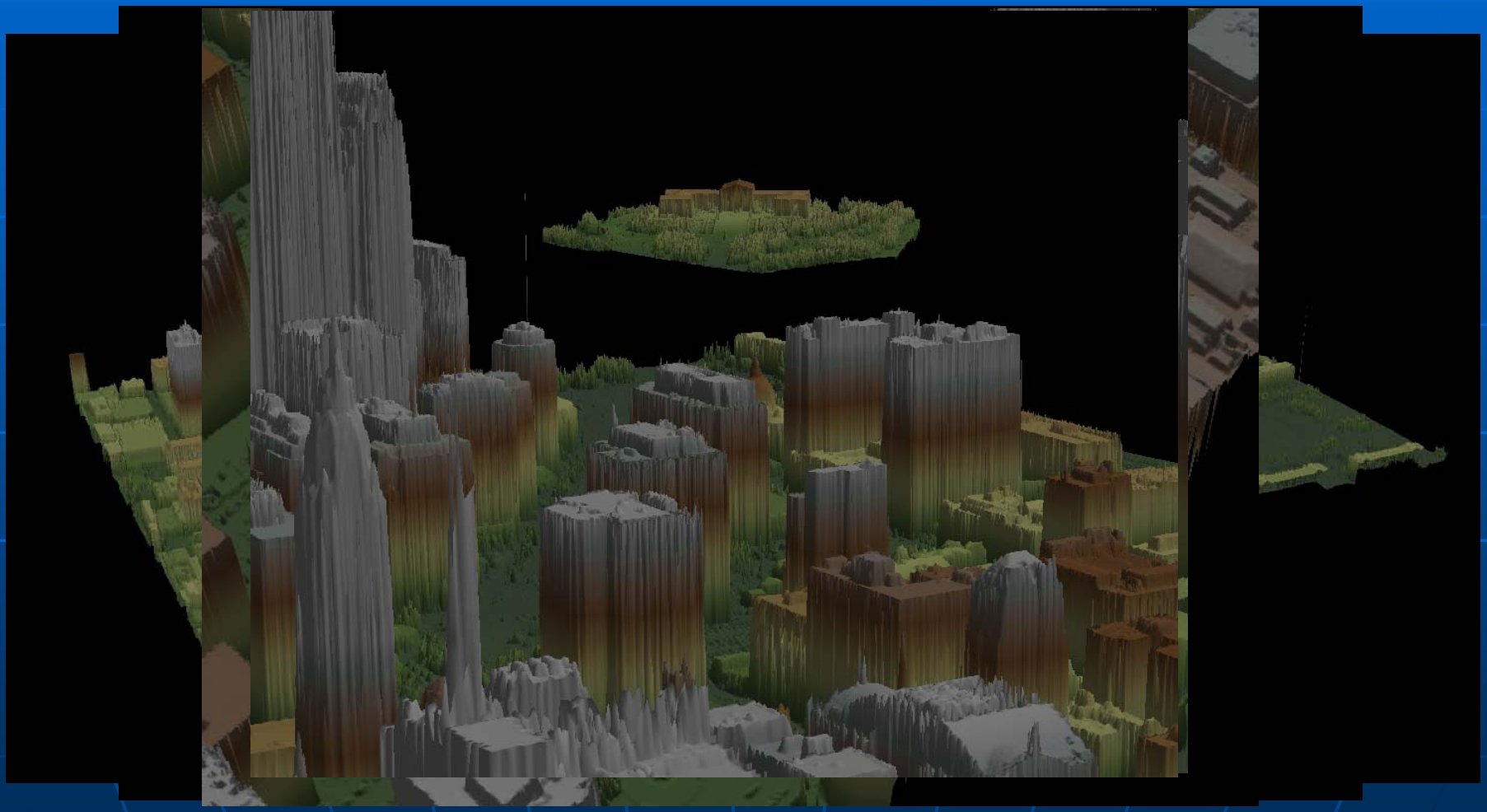




How many beams hit ground?

- 2006
  - average ratio all:ground = 1.78
  - std. dev. = 0.42
  - n = 4774 tiles
- 2007
  - average ratio all:ground = 1.89
  - std. dev. = 2.78
  - n = 4699 tiles

City of Philadelphia- LiDAR Pilot



Products

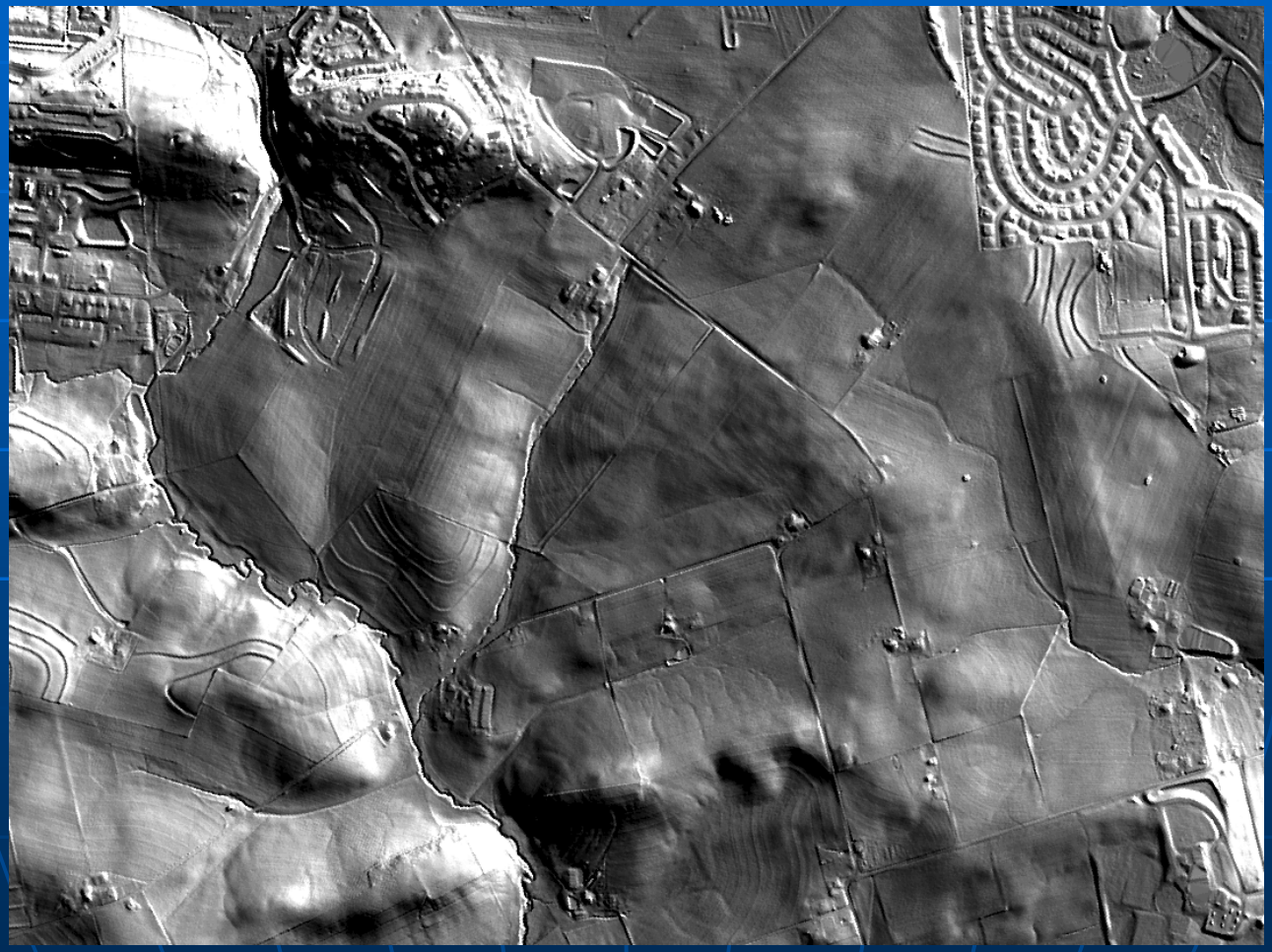
- Digital Elevation Model – a 3.2-foot pixel (1-meter equivalent) raster GeoTIFF Digital Elevation Model (DEM). Each pixel in the DEM has an interpolated elevation value. Each DEM is approximately 37.5 MB in size.

Products

- Contours – a 3D shapefile of 2-foot contours is provided for each tile. Each contour is attributed with its elevation value and whether it is an intermediate (2- foot interval) or index (10-foot interval) contour. The size of each shapefile varies.

- Breaklines – a 3D shapefile of breaklines is provided for each tile. The breaklines are interpreted from the PAMAP orthophotos and the LiDAR data is used to provide elevation (z-values) to each line. The breaklines are produced for the classification of the LiDAR data and enhancement of the contours. The breaklines are not produced for engineering use. Each breakline is attributed for feature type (e.g. edge of road); the feature types are documented in metadata. The size of each shapefile varies.

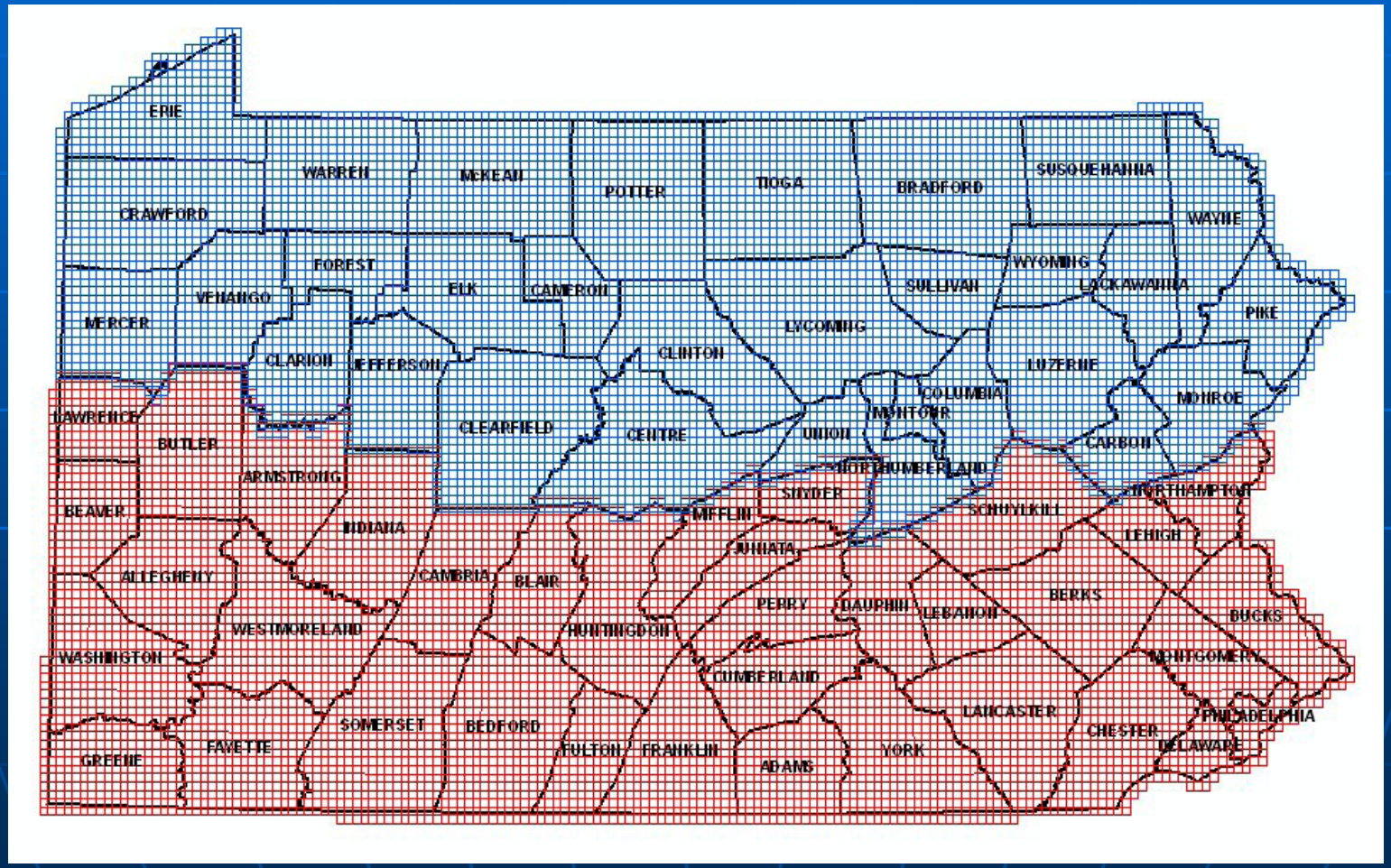
DEM



Availability

- DEMs, contours and breaklines are provided through FTP and map services at the Pennsylvania Spatial Data Access Clearinghouse (PASDA).
- The LAS point cloud data as well as contours and DEMs are available for bulk and/or offline acquisition from the Pennsylvania State Data Center at http://cgis.hbg.psu.edu/pdf/PAMAP_Bulk_Order.pdf, an authoritative source.
- The LAS point cloud data is also available from the USGS Center for Lidar Information Coordination and Knowledge (CLICK), an authoritative source.

Tiling Scheme



Accuracy

- The LiDAR data has a vertical (z) accuracy specification of 18.5 cm in open areas, and 37 cm in forested areas.
- The PAMAP imagery has a horizontal accuracy specification of 5 feet or less.

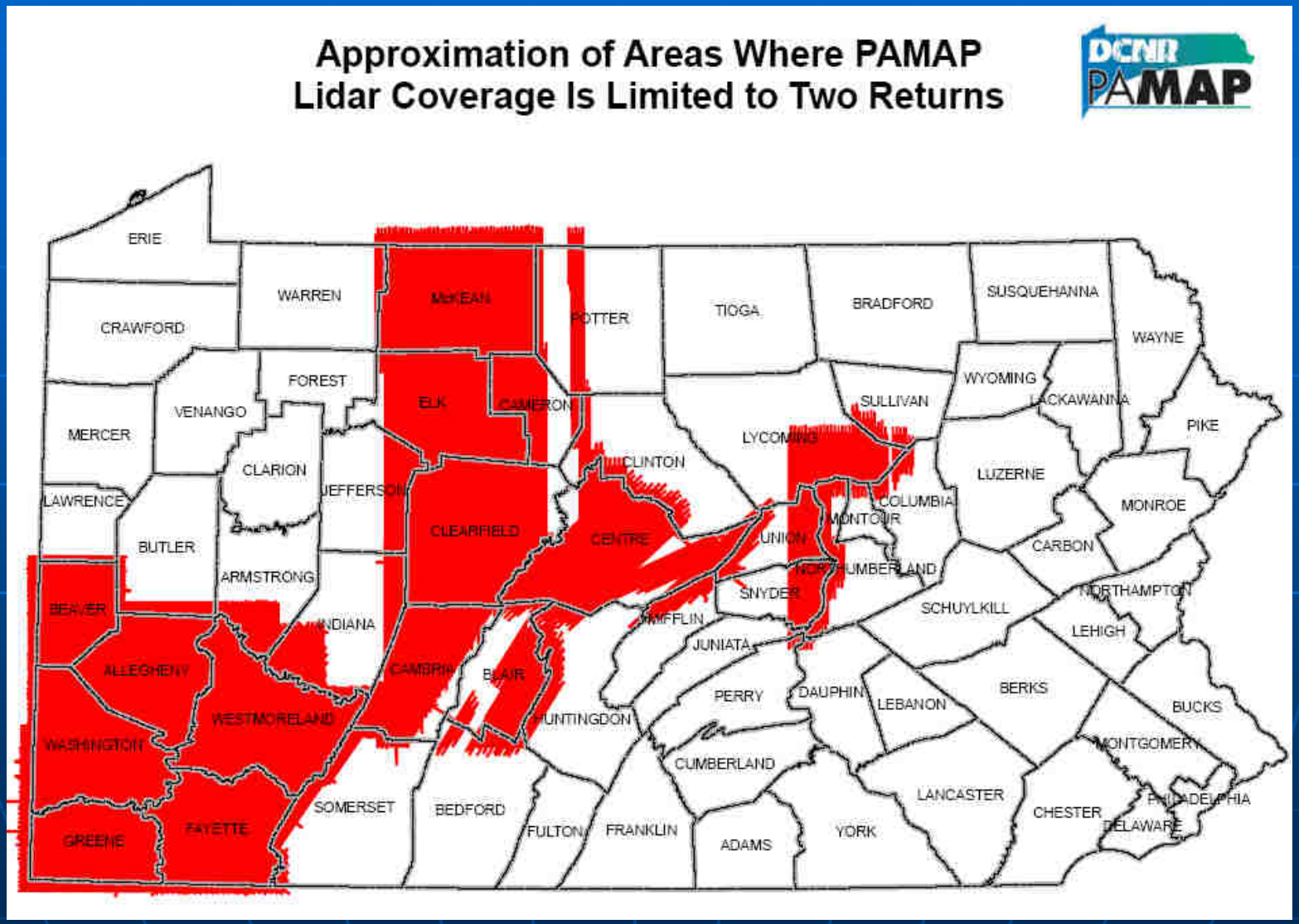
Accuracy

- • **Horizontal and vertical accuracy check of LiDAR**: HRG, Inc. conducted a field survey of checkpoints used by Dewberry to perform quantitative accuracy assessment following American Society for Photogrammetry and Remote Sensing (ASPRS) Guidelines and 1998 NSSDA reporting standards for LiDAR data and derived products (i.e. contours and raster DEMs). Data were assessed within the following cover types: (1) bare earth and low grass; (2) high grass, weeds, and crops; (3) brush lands and low trees; (4) forest; and, (5) urban areas.

Accuracy

- • **Qualitative review of LiDAR products**: Dewberry inspected every PAMAP tile of LiDAR and derived data for anomalies and artifacts such as data voids, discontinuities between adjacent flight lines or mission areas, over smoothing, incomplete removal of LiDAR points on water bodies, and incomplete removal of buildings, vegetation, bridges, etc. from the bare earth surface.

One oddity



In some areas, laser pulse rate/power were modified in order to achieve specified point spacing.

We were wrong

- **What are some of the key uses for PAMAP's LiDAR data?**
  - • Updating state flood insurance rate maps (FEMA)
  - • Flood risk analysis and flood control projects
  - • Natural gas exploration, extraction, and transmission
  - • Wind farm siting
  - • Other uses include water and flow management, mapping habitat, subsidence evaluation, riparian studies, forestry, emergency response, recreation, transportation planning, telecommunications planning, land development.

Marcellus

- Largest user of PAMAP data, especially lidar

Geology/Soil Science Applications

Active Limestone mine

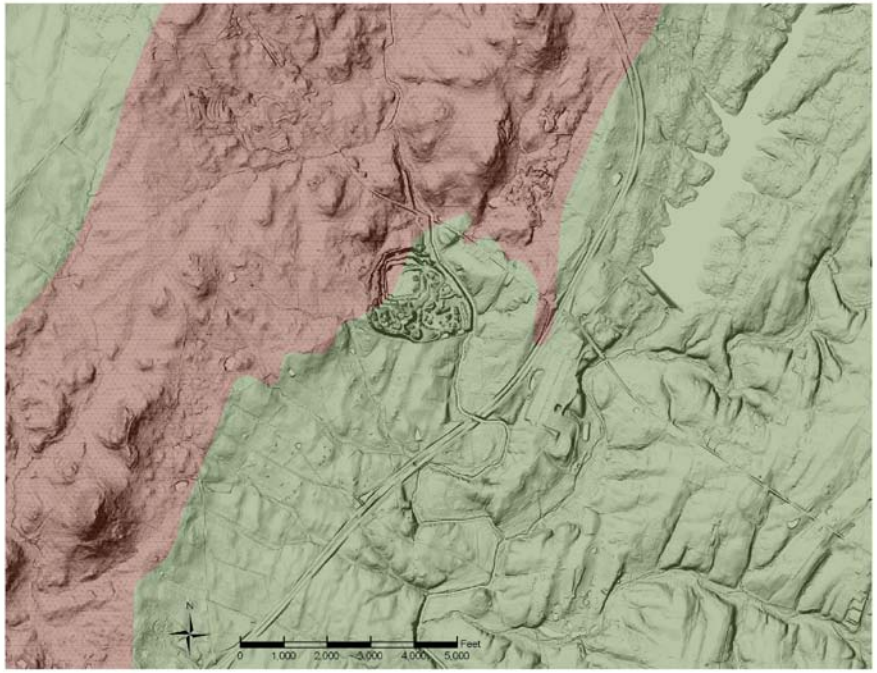
Abandoned Clay mine

Abandoned iron/
sandstone mine

Comparison of Lidar DEM derived hillshade (above) and orthoimagery (below) of same area in Middleburg Quadrangle, Snyder County showing three different mines.
Image by Rose-Anna Behr

This area around the Gettysburg Quarry illustrates differences in land surface texture and relief with different geology. Top Right: Orthophoto with hillshade. Lower Right: Hillshade with geologic map overlay.

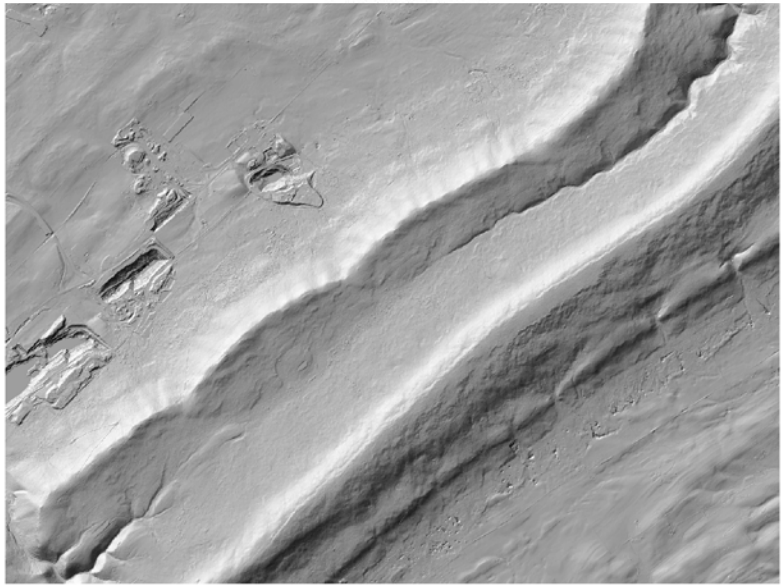
Intrusive diabase (red-orange on geologic map) shows as irregular topography with higher relief and rounded hills. Adjacent Gettysburg Formation sandstone and shale dips to the northwest, and is more easily eroded, as shown by drainage patterns.



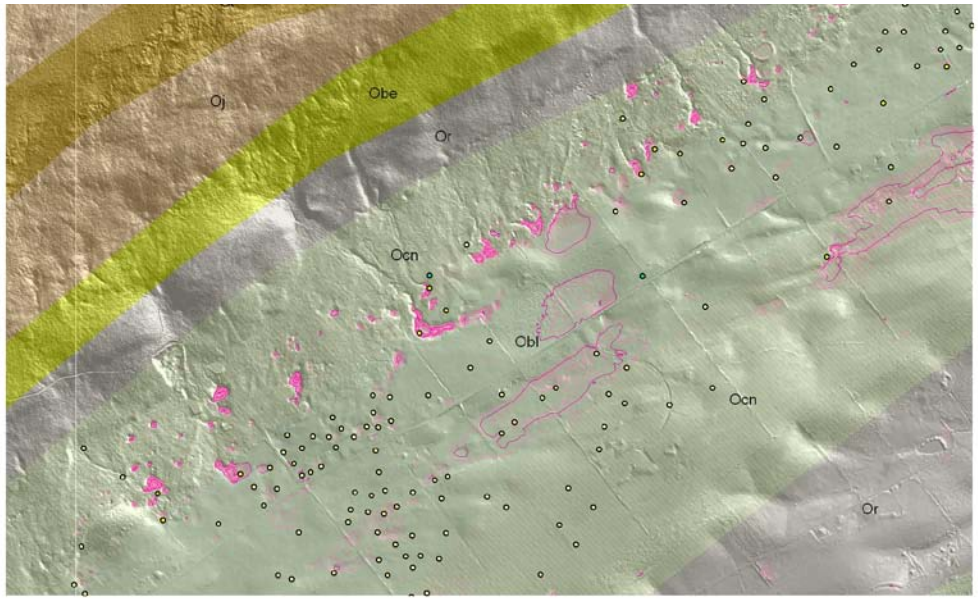
Karst features.

Synclinal ridge in Centre County Orthophoto (top left) shows mines and vegetation patterns. Lidar derived hillshade (lower left) shows land surface features, including sinkholes and karst depressions along southeast flank of ridge. Lower image of a portion of area, shows geology, closed depression 2-foot contours (in pink) and points from Pa. Geologic Survey karst database in yellow. Many karst features were obscured by forest during inventory—but are revealed by lidar.

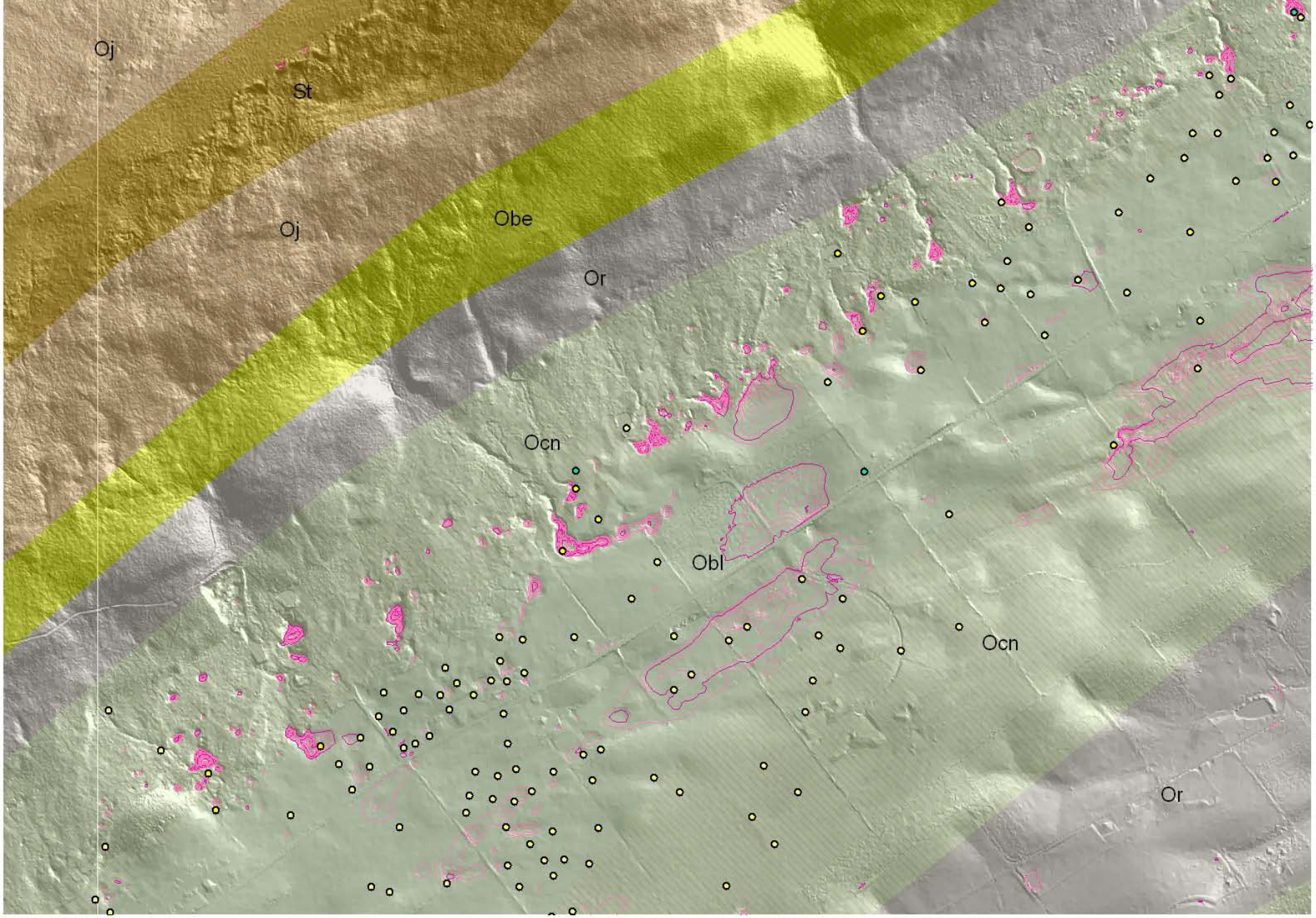
PAMAP Orthoimage 2006- Portion of Centre County, PA



Hillshade image from PAMAP Lidar 2006- Portion of Centre County, PA



Hillshade made from 2006 PAMAP Lidar data - Portion of Centre County, PA with 1:250,000 geology overlay
Pink- Closed depression contours from Lidar data
yellow - features from Kochanov's karst features database



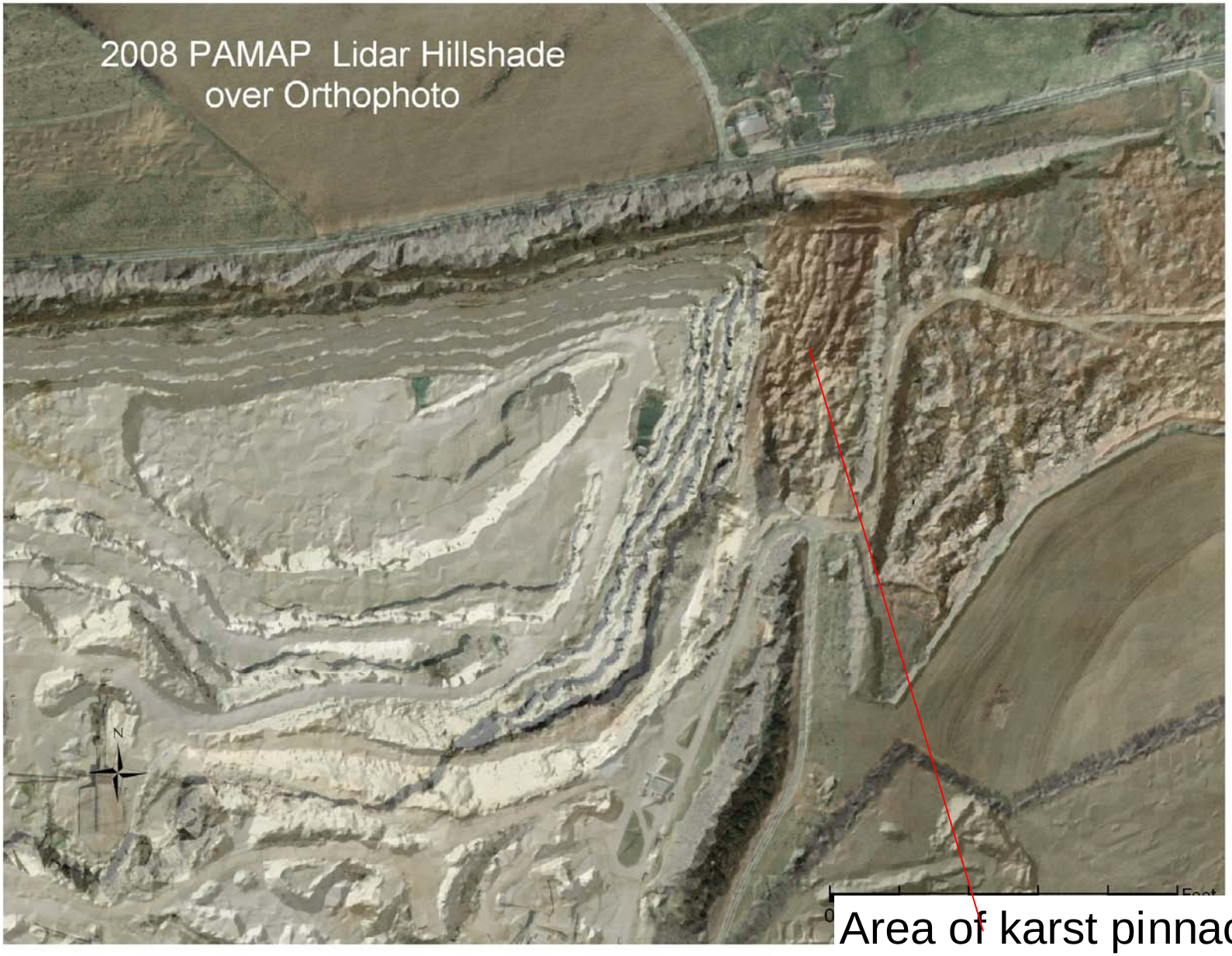
Hillshade made from 2006 PAMAP Lidar data - Portion of Centre County, PA with 1:250,000 geology overlay
Pink- Closed depression contours from Lidar data
yellow - features from Kochanov's karst features database

N

0 1,000 2,000 3,000 4,000 5,000 Feet

N
0
1,000
2,000
3,000
Feet

The Point cloud is the full resolution data, including all the information collected. We have only begun to learn how to use it, but the examples below show a portion of the Magnesita quarry we will visit on the Tuesday field trip. The point cloud data allows manipulation of a 3-D model. Data points can be colored in various ways: by elevation, intensity of reflected laser return, or to mach an orthophoto. These images were made in Fusion, software developed by the U.S. Forest Service for manipulating and measuring using Lidar LAS files.



Area of karst pinnacles stripped of residuum.

Former clay mine at Toland, Cumberland County. Lidar derived shaded slope map reveals multiple progressive scarps of landslide above mine. Landslide is obscured by trees in the plain orthoimage. Modern quarry mines sandstone northeast of old pit (out of this image).

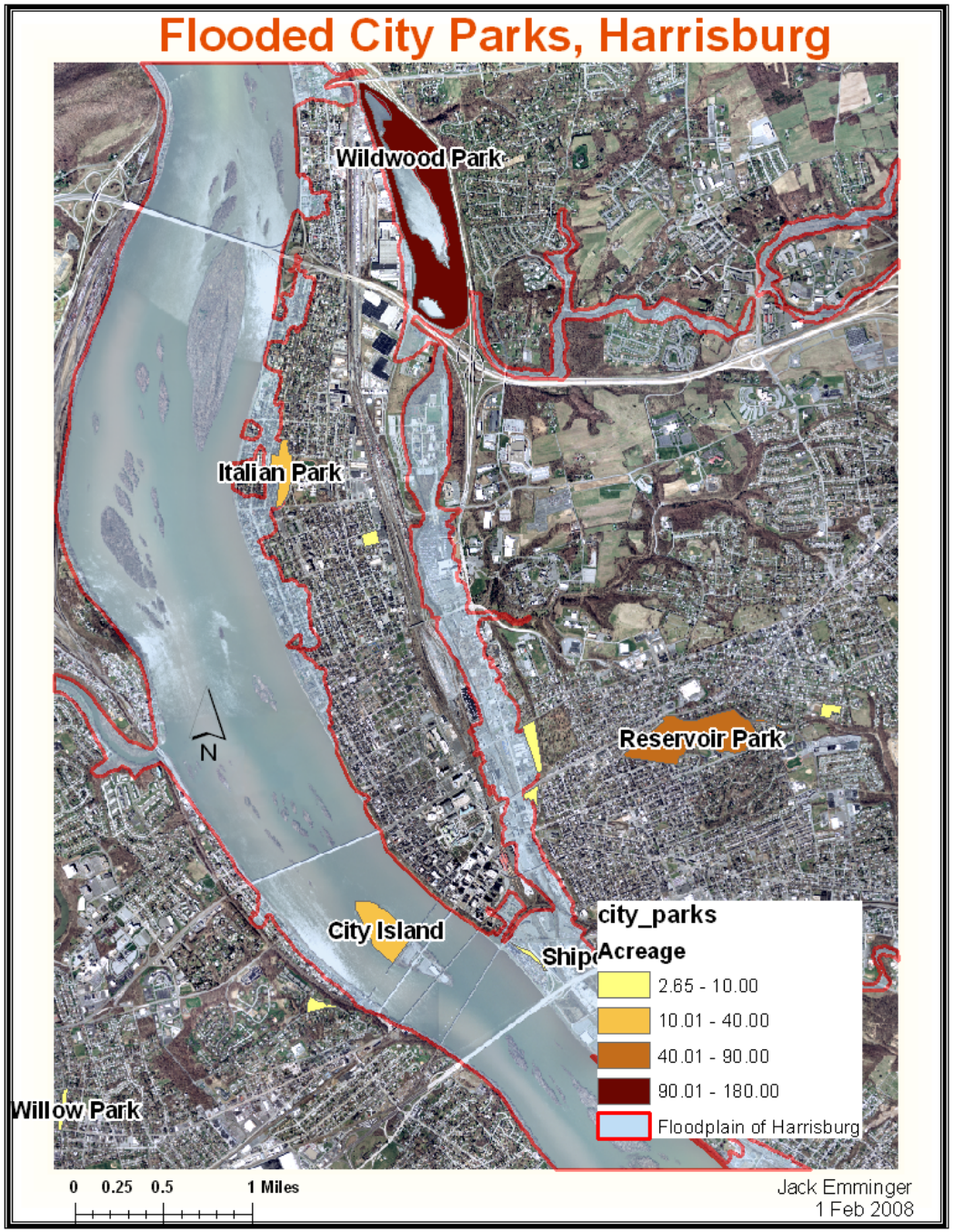
200 0 200 400 600 800 1,000 Feet

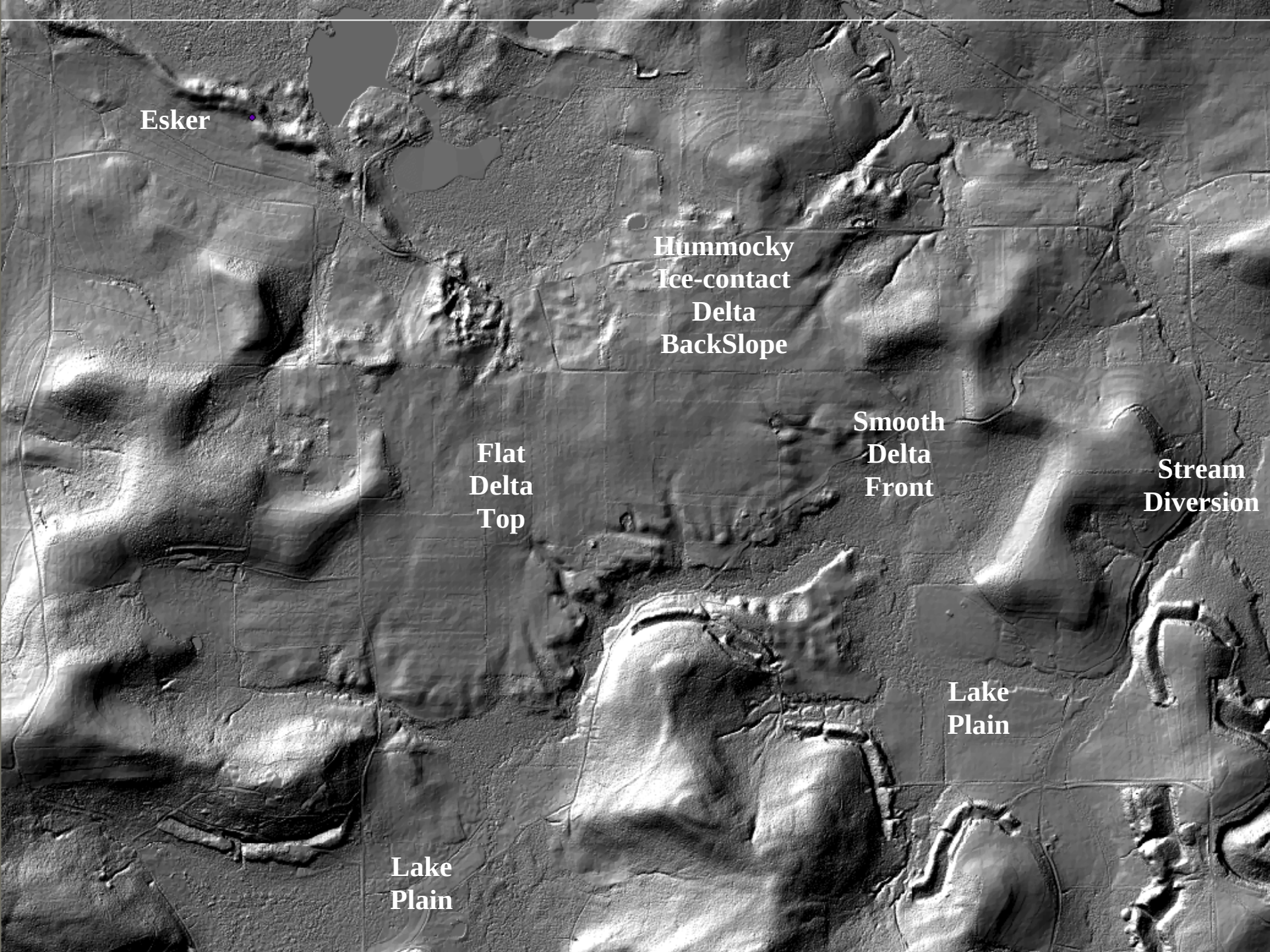
Portion of Mansfield Quadrangle, Tioga County, PA
PAMAP imagery and elevation data
slopeshade map

N

900
800
D
Cem
700
687
668
657
EAGLE
26
JOSEPH
CORP
SAYERS
BDY
664
Howard
Cem
700
700
PENN CENTRAL

ard


Flooded City Parks, Harrisburg
Wildwood Park
Italian Park
Reservoir Park
City Island
Willow Park
N
city_parks
Acreage
2.65 - 10.00
10.01 - 40.00
40.01 - 90.00
90.01 - 180.00
Floodplain of Harrisburg
0 0.25 0.5 1 Miles
Jack Emminger
1 Feb 2008


Esker
Hummocky
Ice-contact
Delta
BackSlope
Smooth
Delta
Front
Flat
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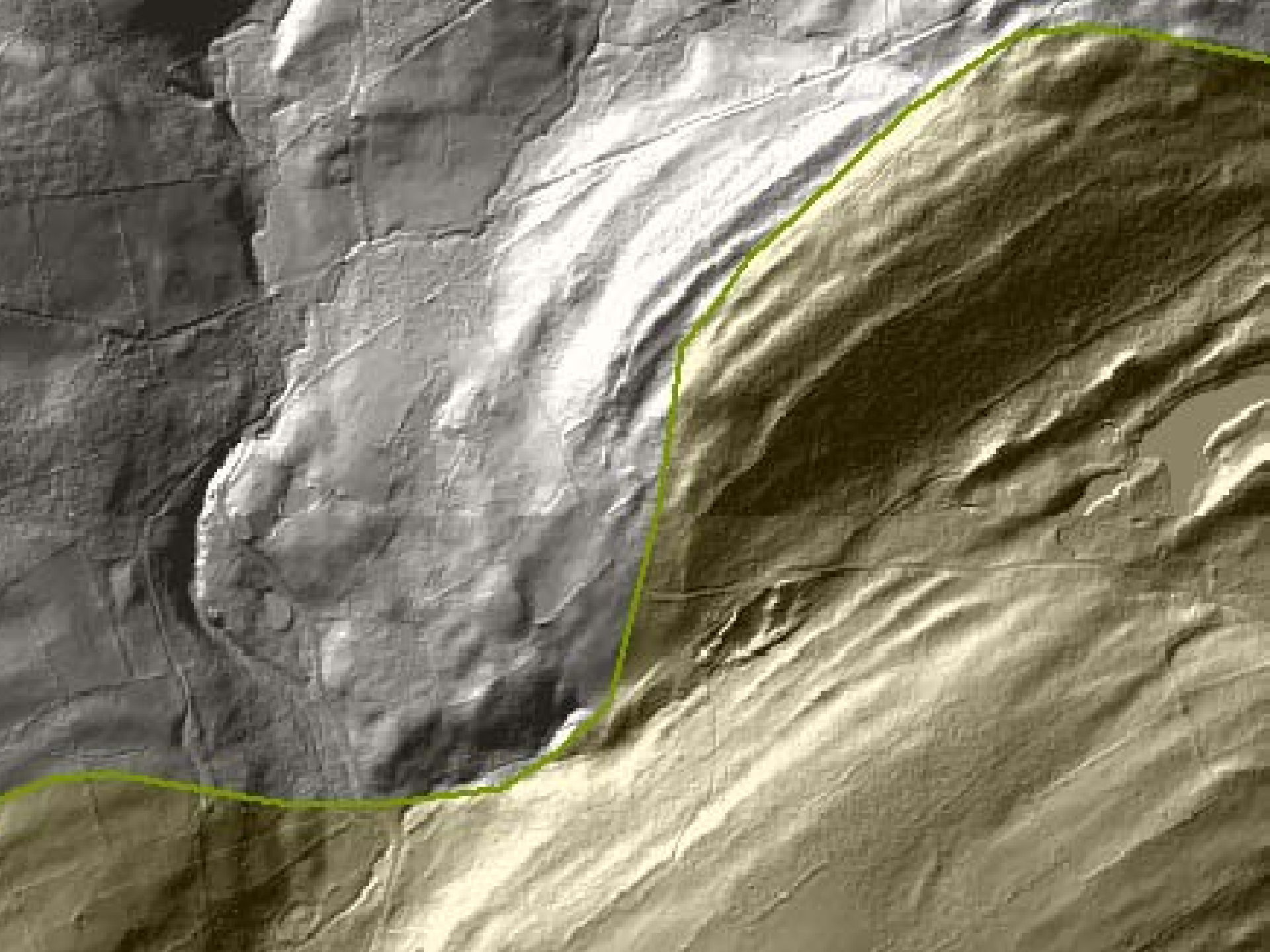
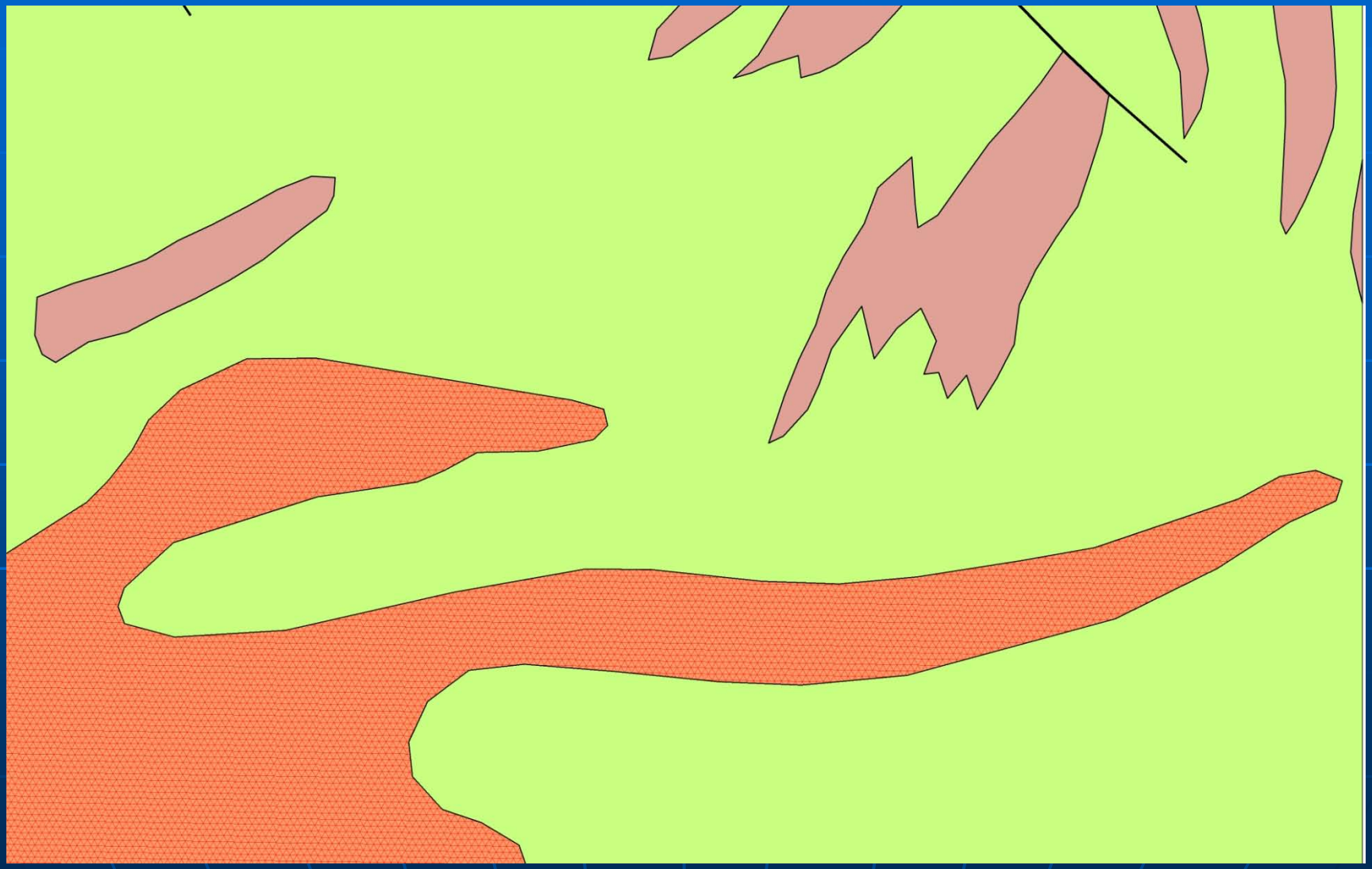
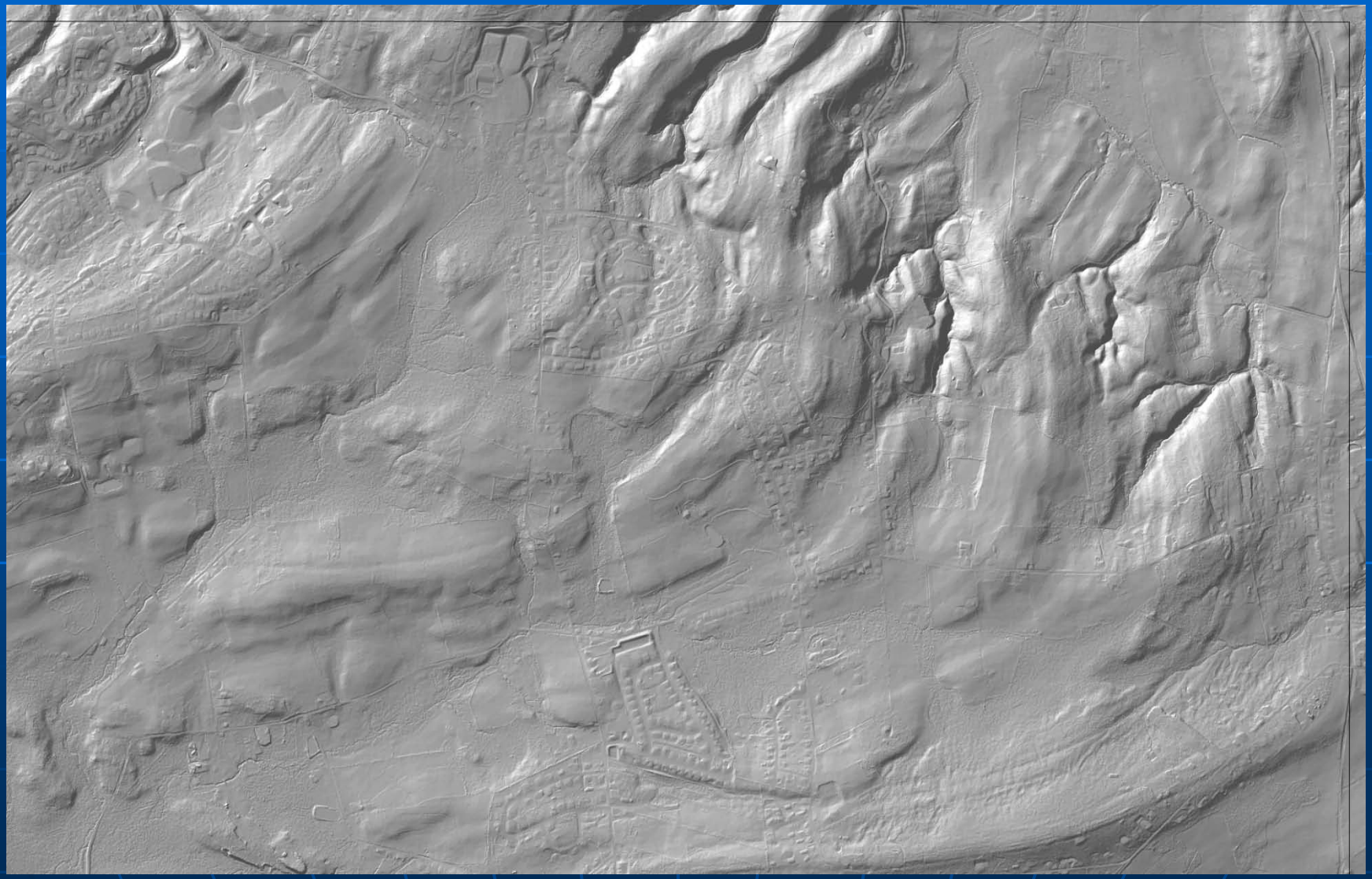
Top
Stream
Diversion
Lake
Plain
Lake
Plain

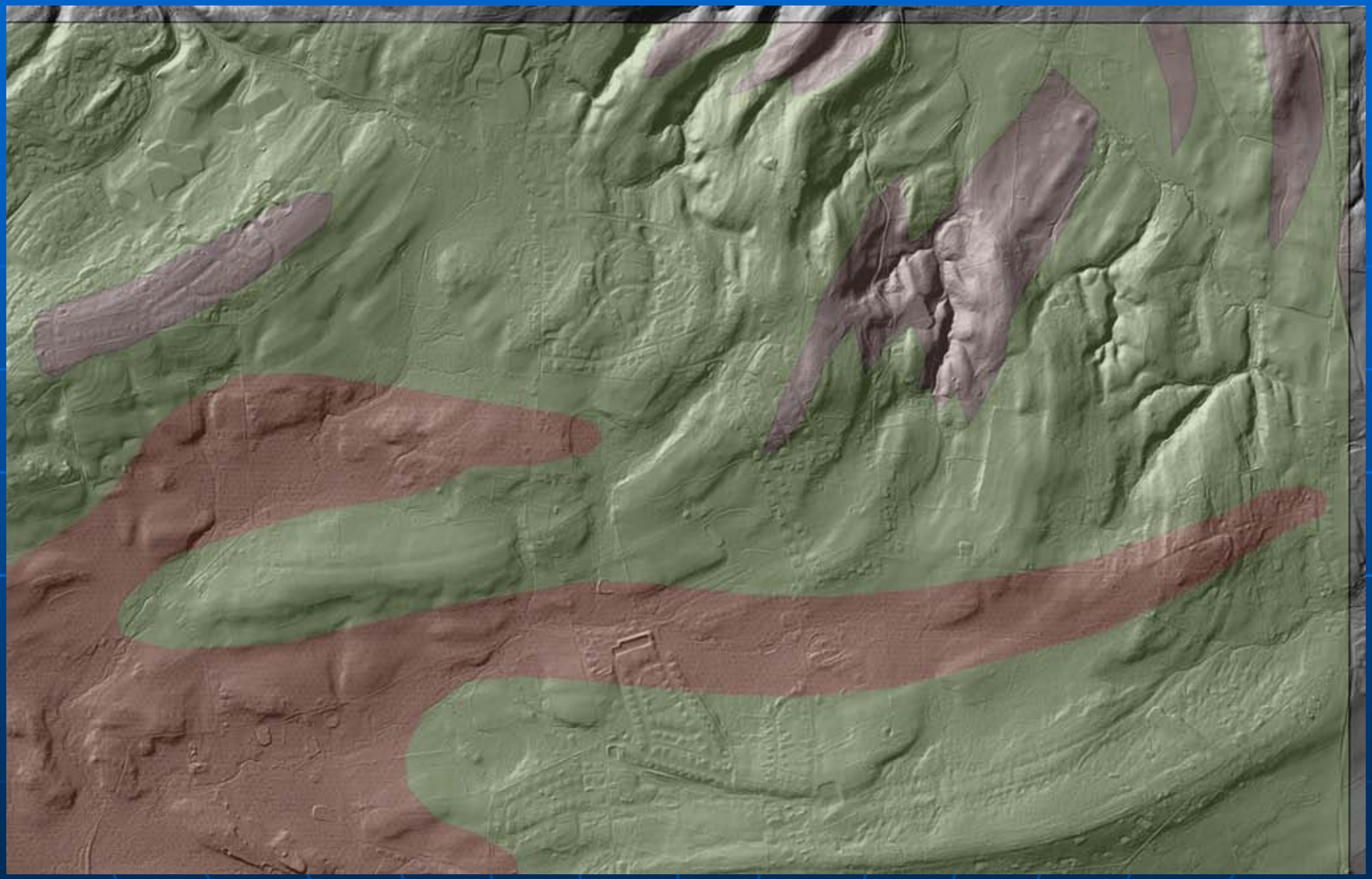


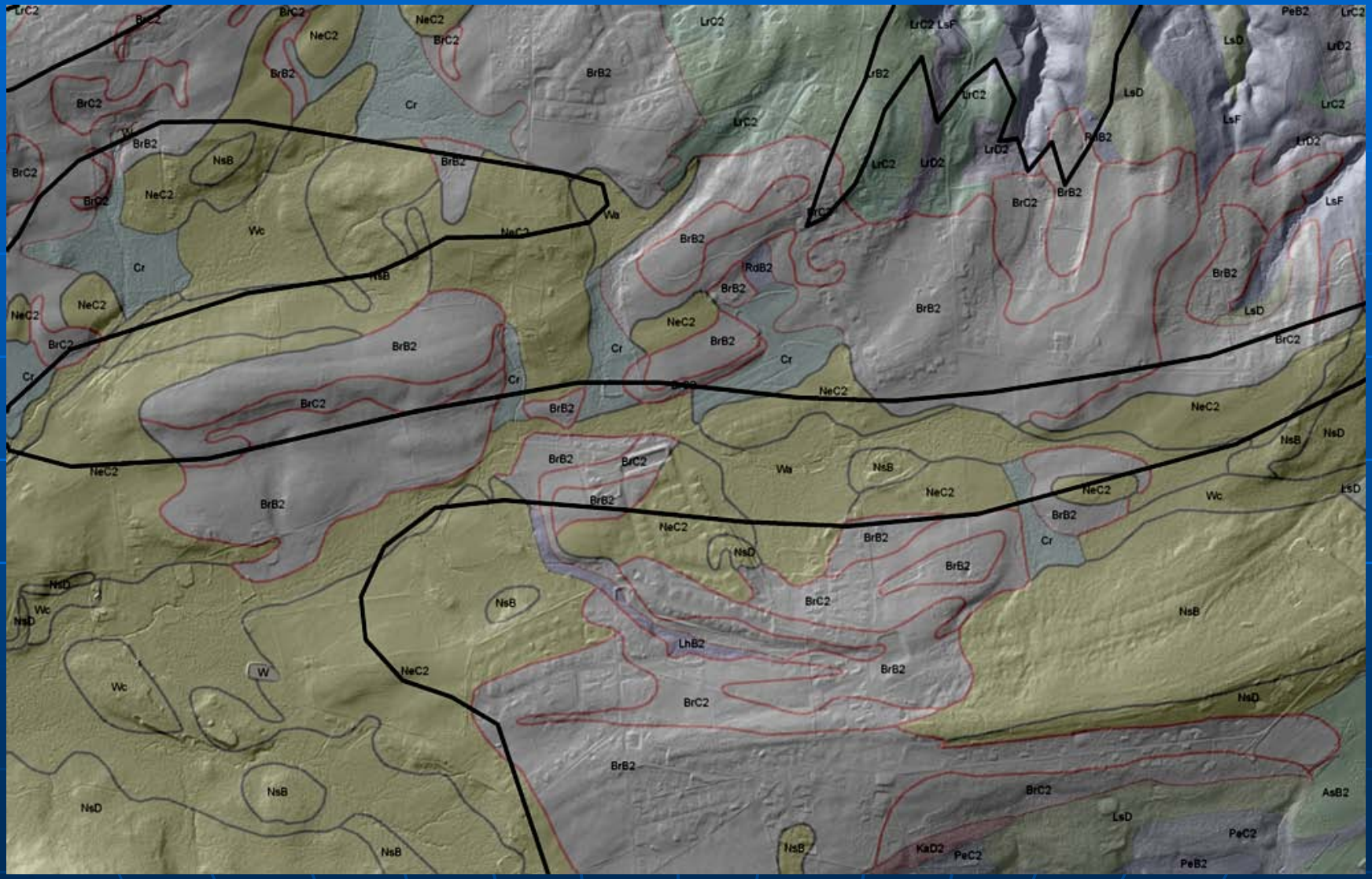
Explosive combination

Geology



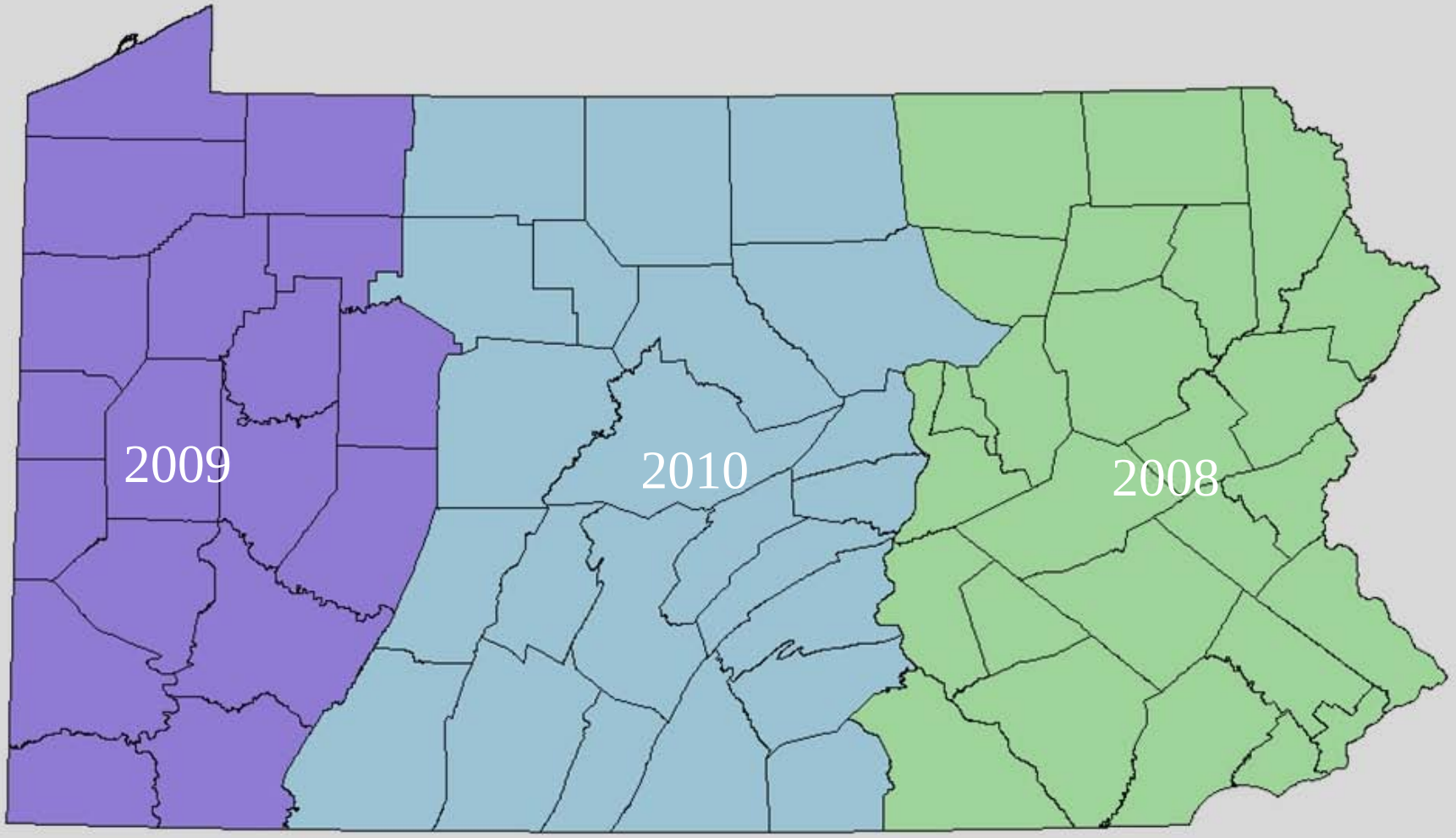





LrC2
BrC2
NeC2
BrB2
Cr
NsB
Wc
Wa
RdB2
LrC2 LsF
LrB2
LrD2
LsD
LsF
PeB2
NsD
LhB2
W
AsB2
PeC2
KaD2

TRANS

- jayparrish@state.pa.us
- www.dcnr.state.pa.us/topogeo

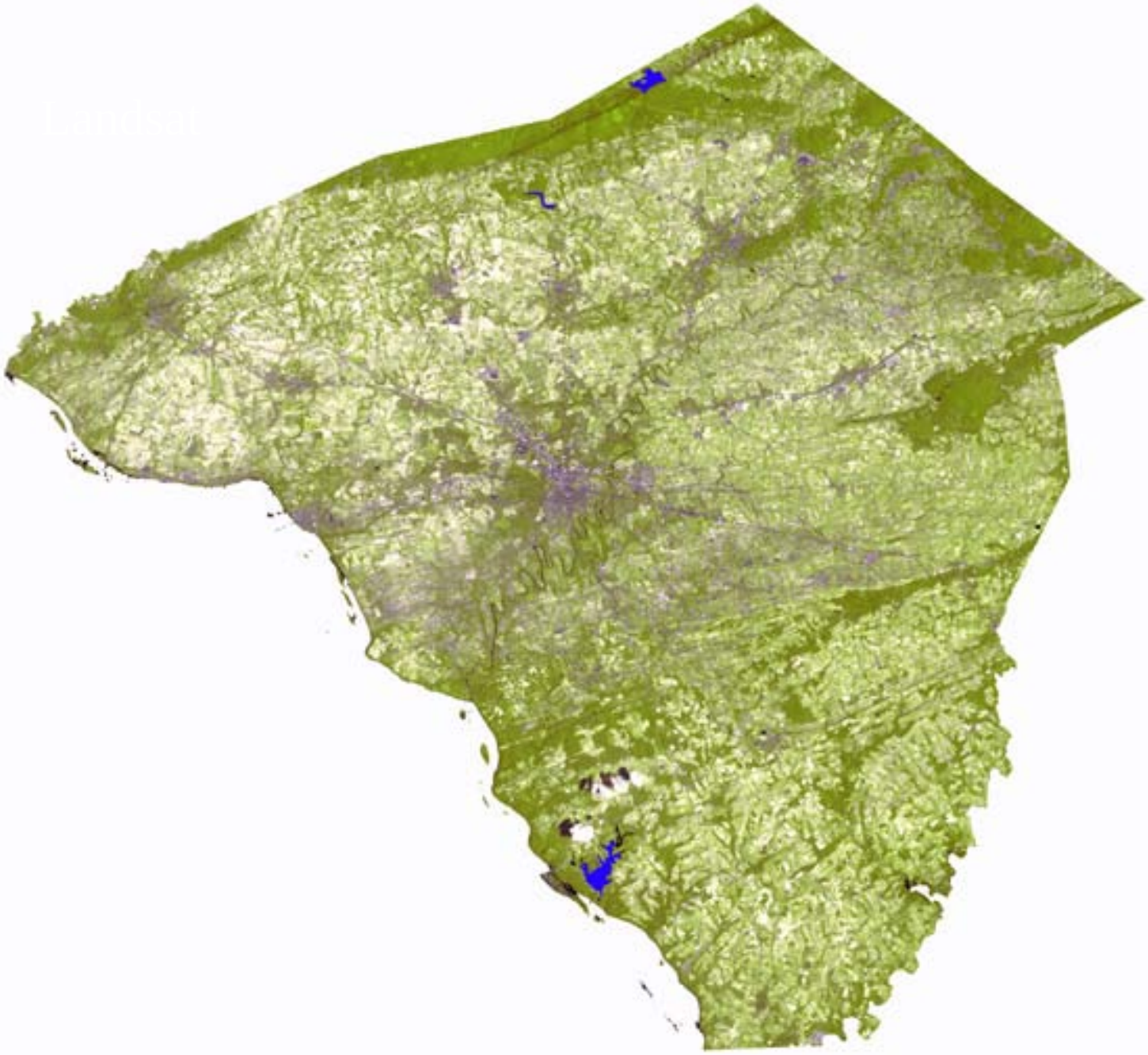

2009
2010
2008

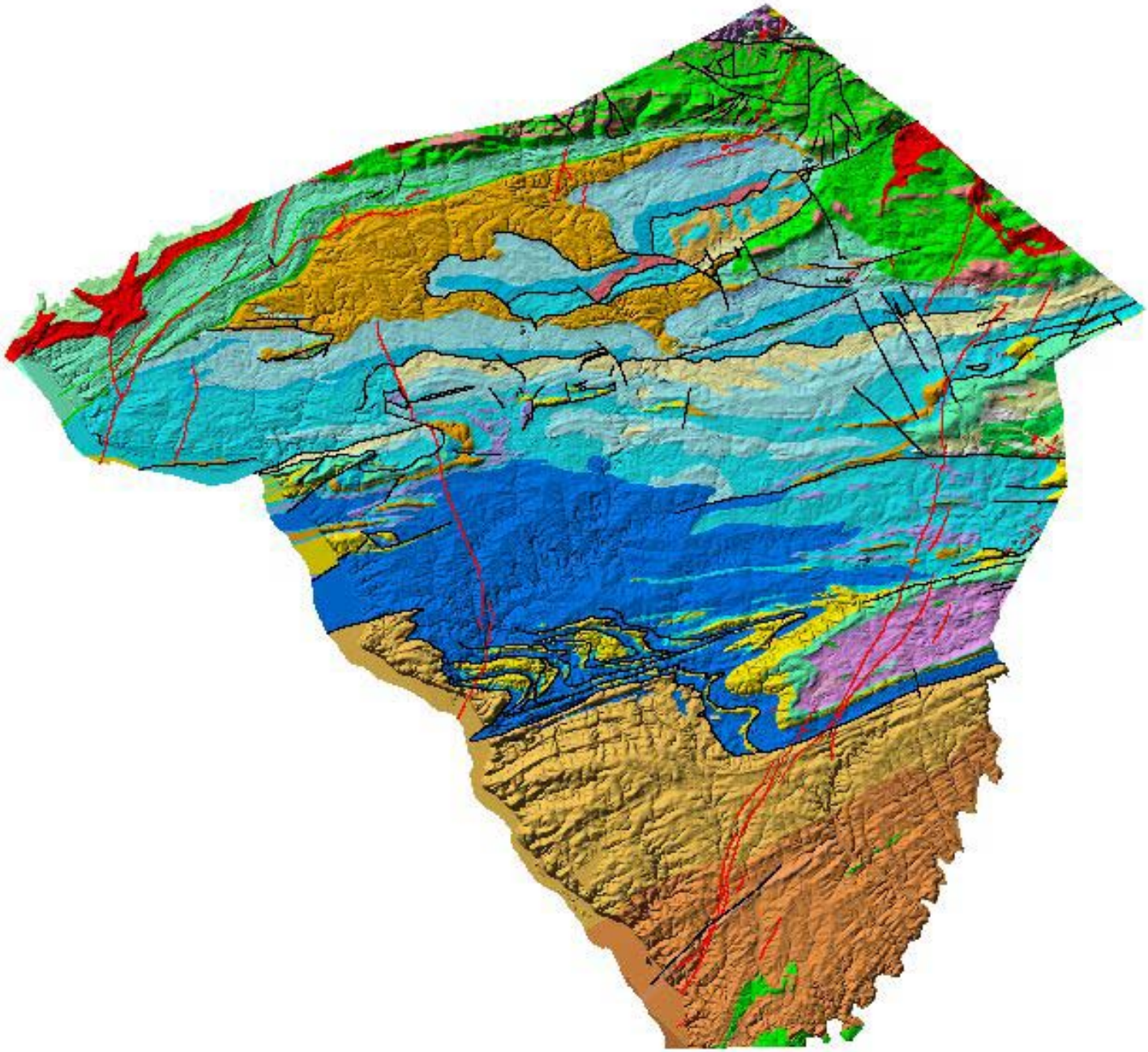
NEW ACCENT $7,995
VICTOR HYUNDAI
EXIT NOW!
705-8500
MADISON BLVD. at HUGHES RD.
PEPSI
FIREWORKS WORLD
SUPER CENTER
WORLDS LARGEST SELECTION
OPEN TO THE PUBLIC FACTORY DIRECT

MARSHMALLOW FARM

MARSHMALLOWS READY FOR SHIPMENT

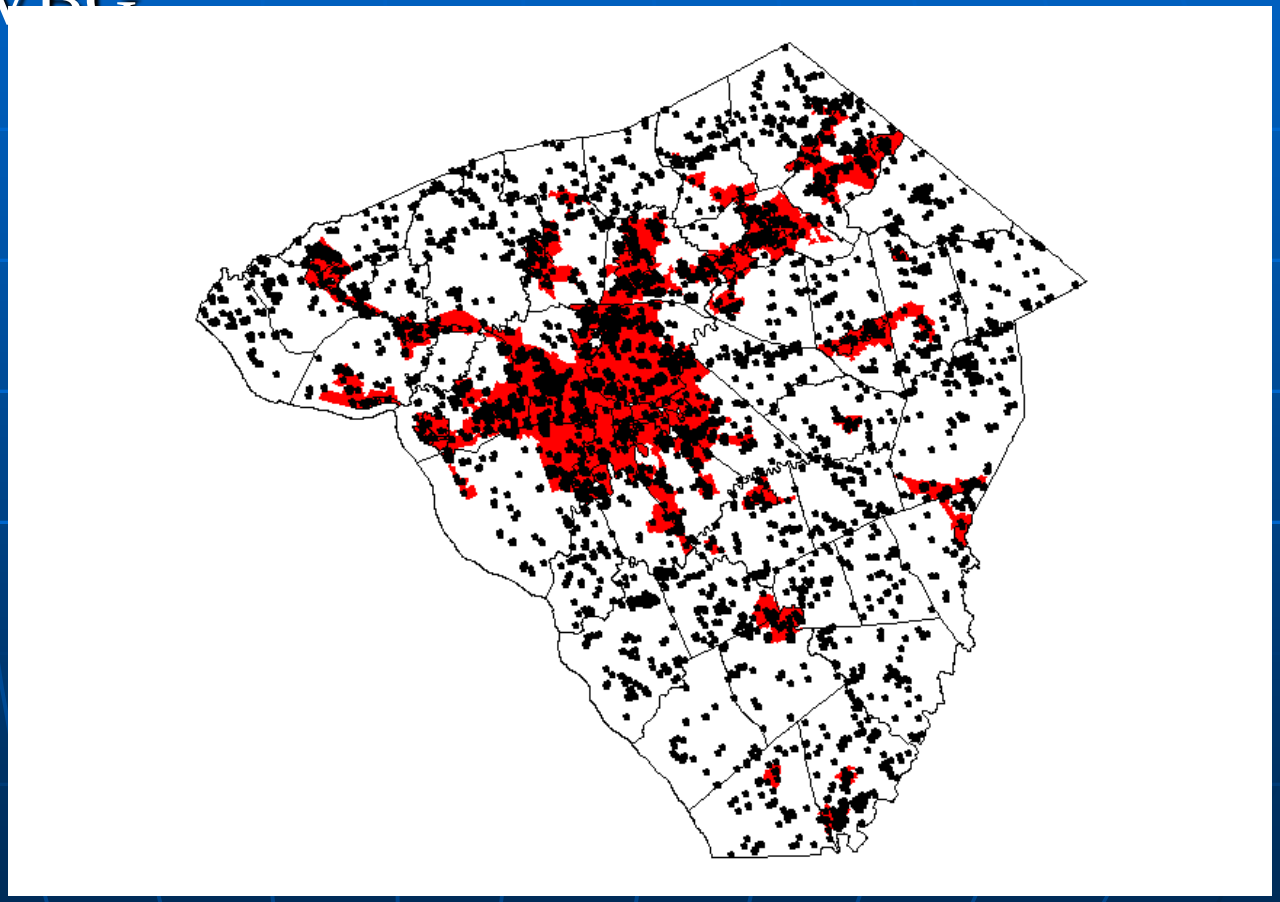
Landsat



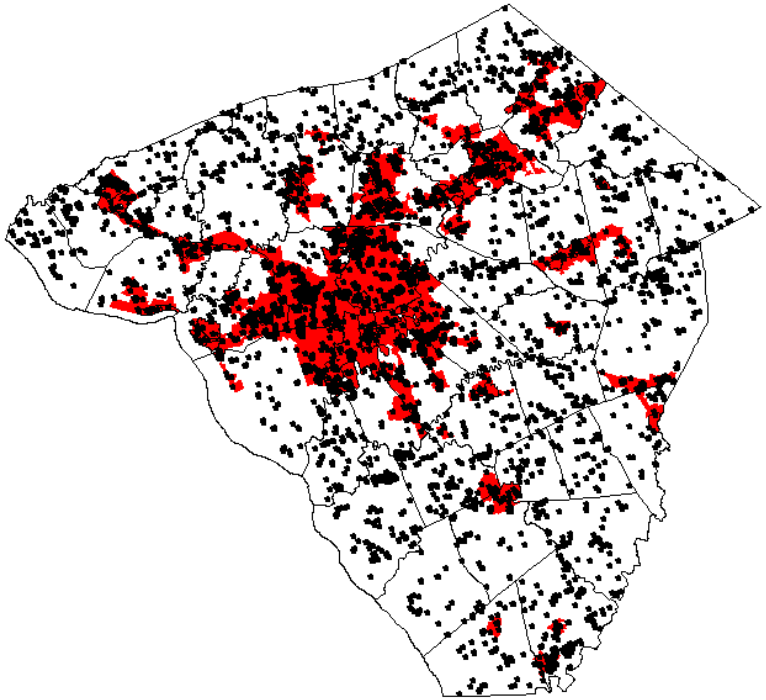


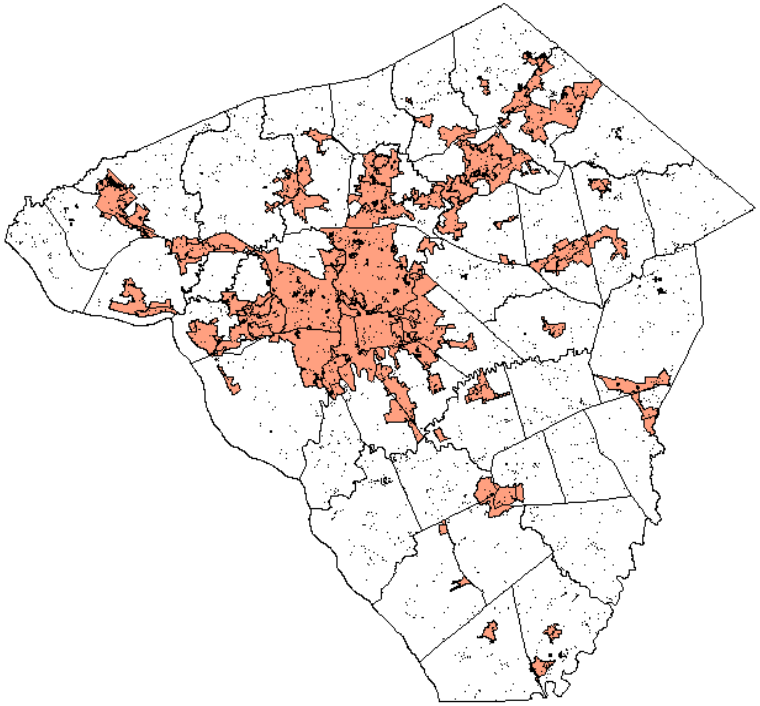
New Buildings

- With UGB/VBG



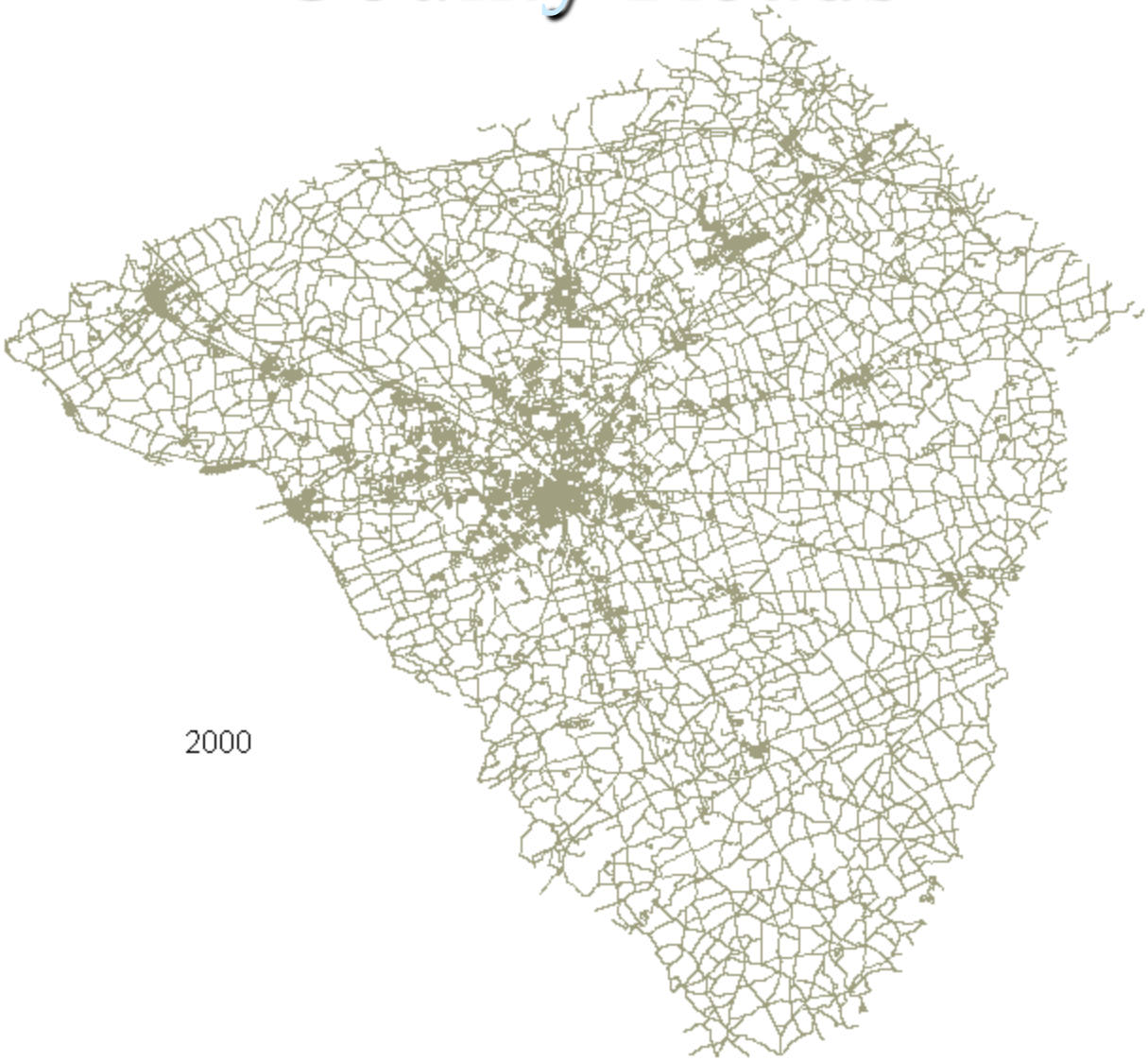
How to lie with maps

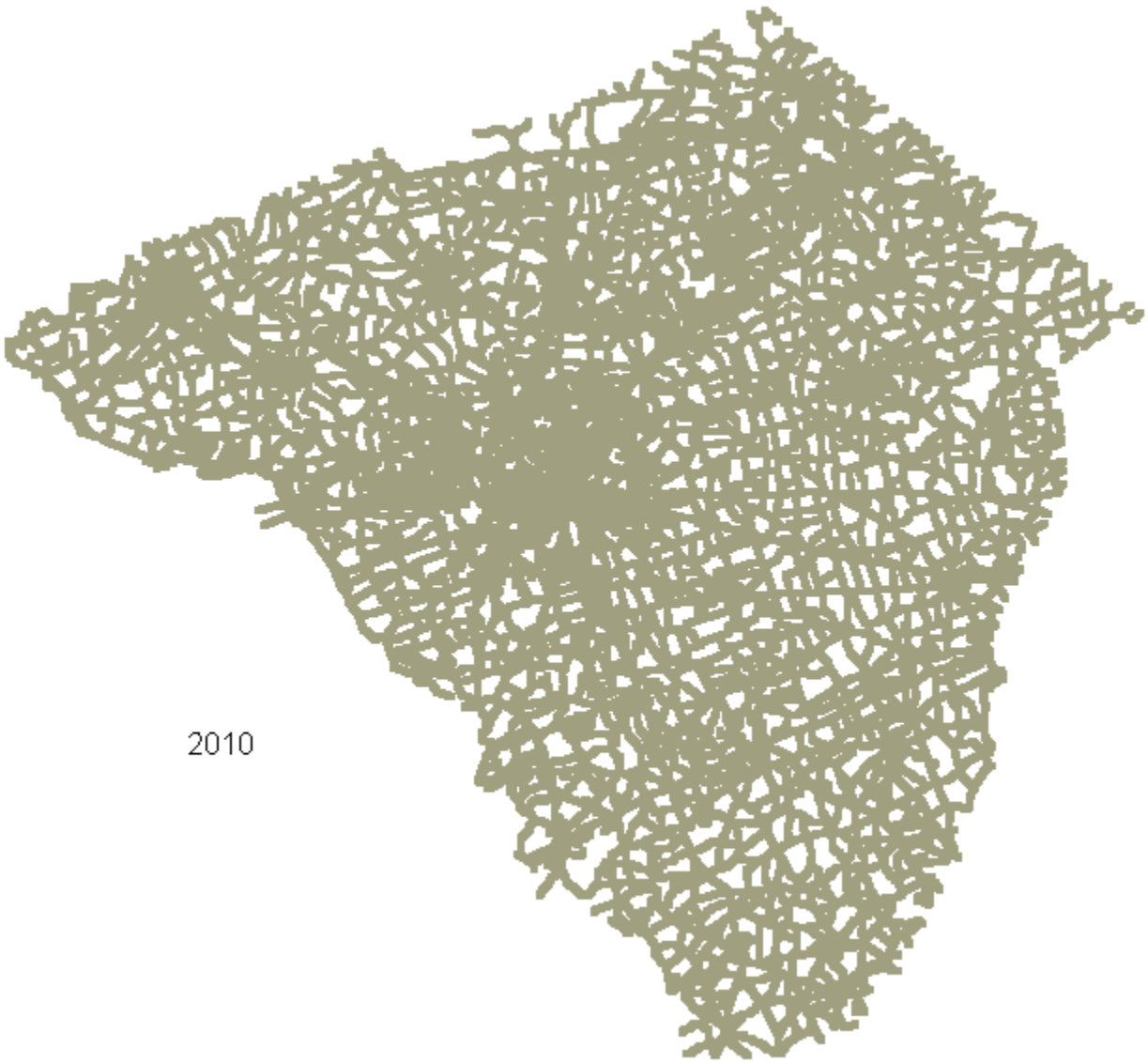
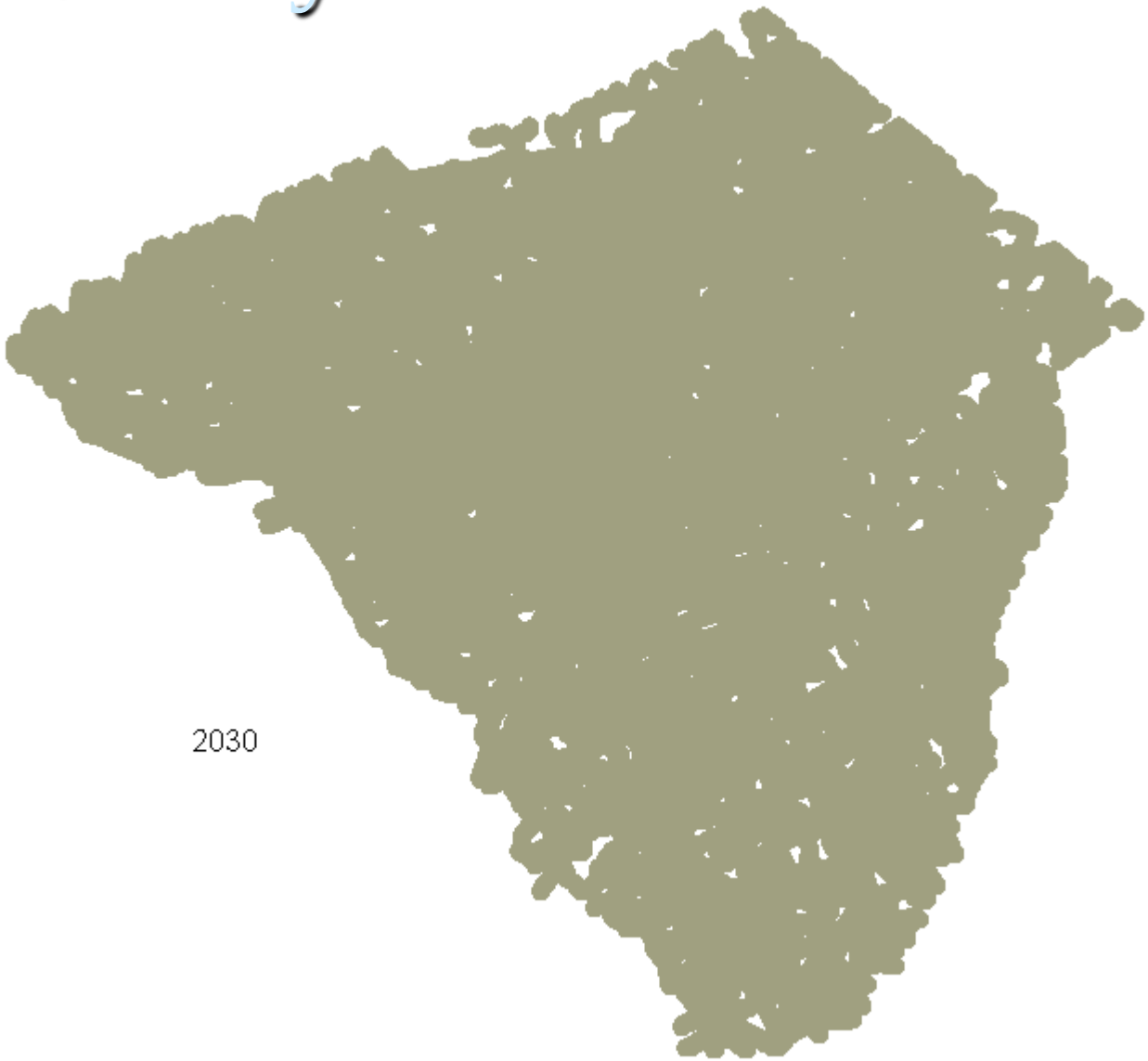




joe-ks.com

County Roads




2010

County Road