The following was presented at DMT'11
(May 22-25, 2011).

The contents are provisional and will be superseded by a paper in the DMT'11 Proceedings.

See also earlier Proceedings (1997-2010)
http://ngmdb.usgs.gov/info/dmt/

Inventory Mapping and Characterization of Landslides Using LiDAR: Kenton and Campbell Counties, Kentucky

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Introduction

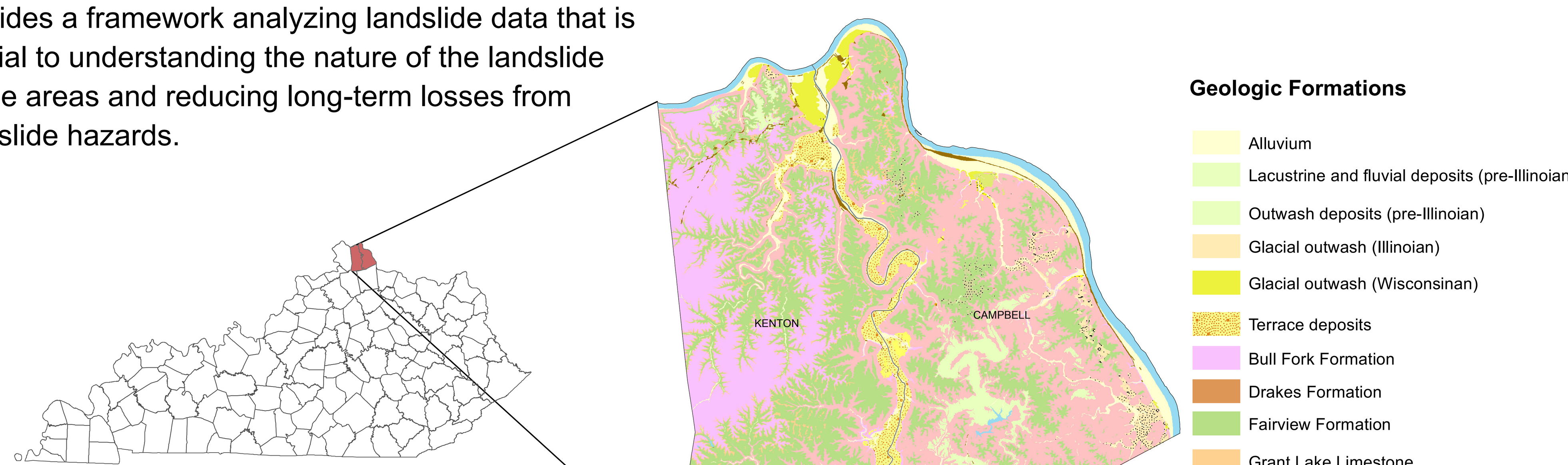
Landslide identification and hazard mapping using LiDAR has proven successful in other landslide prone areas of the U.S. The purpose of this project was to develop a methodology using LiDAR data optimal for the geologic setting of Kenton and Campbell Counties and document landslides as part of an existing inventory. To do this, potential landslides were mapped and digitized that were previously not visible on existing maps or coarse digital elevation models. Field verification of these locations, where possible, also followed. Developing a methodology for viewing high resolution LiDAR to identify potential landslides provides a framework analyzing landslide data that is crucial to understanding the nature of the landslide prone areas and reducing long-term losses from landslide hazards.

KY 177: Slide above and below road, note old retaining wall.

Licking Pike: Scarp and cracks in pavement, slide above and below road

KY 8: Leaning telephone poles on large slide above and below road

KY 1072: Old embankment failure

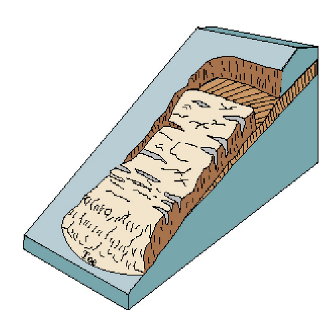


County map of Kentucky. Kenton and Campbell Counties highlighted in red.

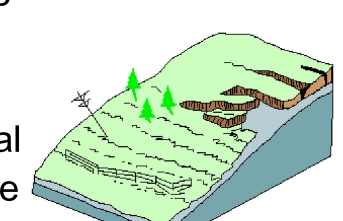
Geology & Common Landslide Types

Ordovician bedrock geology in Kenton and Campbell Counties consists of, in ascending order, the Kope Formation, Fairview Formation, Grant Lake Limestone, and Bull Fork Formation. Although landslides can occur in any of these units, the Kope Formation is especially problematic and is associated with many of the landslides in the area. The Kope shale weathers easily, slumping and producing colluvial soils of variable thickness Composition of the colluvium ranges from clayey (predominantly illi te) and silty to coarse with abundant limestone slabs. When clayey colluvium is mixed with large amounts of water, the soils pore-water pressure increases, which adds to the overall load on the slope.

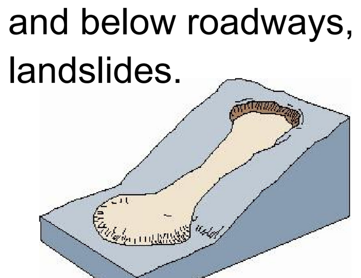
Thickness of colluvial soils ranges, but is typically thicker at the toe of the slope. Landslides typically occur on steep slopes in the colluvium or along the colluvial-bedrock contact. Other surficial deposits in the area are prone to landslides as well. Pleistocene glaciation in the region produced clayey lake deposits, outwash, glacial drift, and other fluvial deposits that fail. Artificial fill, particularly above and below roadways, is also susceptible to landslides.



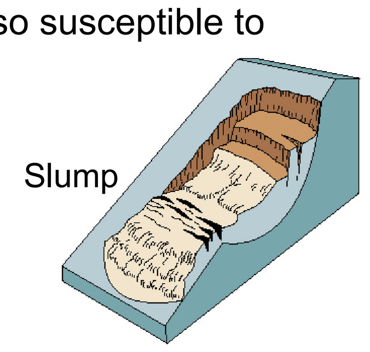
Translational slide



Creep



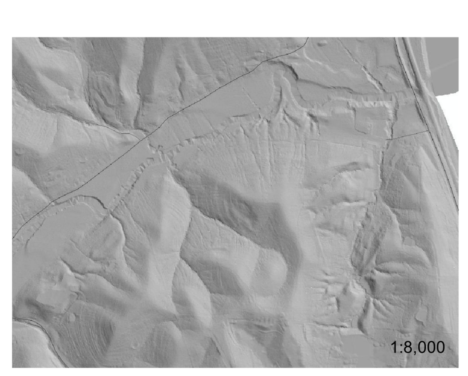
Earthflow



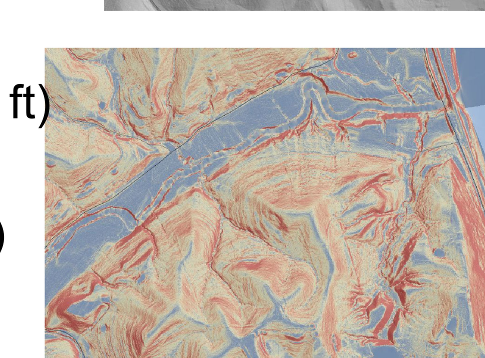
Slump

Data Sets

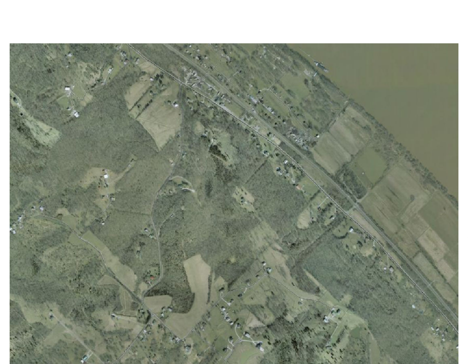
- Standard LiDAR LAS files (provided by the Northern Ky Area Planning Commission)
  - ✓ Digital Elevation Models (DEM's)
  - ✓ Slope maps
  - ✓ Hillshade DEM's (bare earth)
  - ✓ Topographic contours (2 and 4 ft)
- 1:24,000 scale geology
- 2-ft color aerial photography (leaf off)



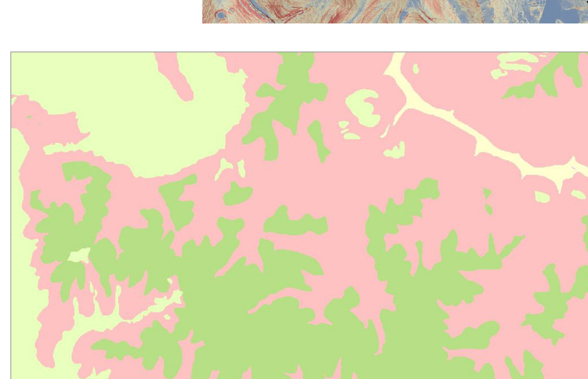
Bare earth LiDAR hillshade DEM
1 m resolution



Hillshade with slope



Aerial photo



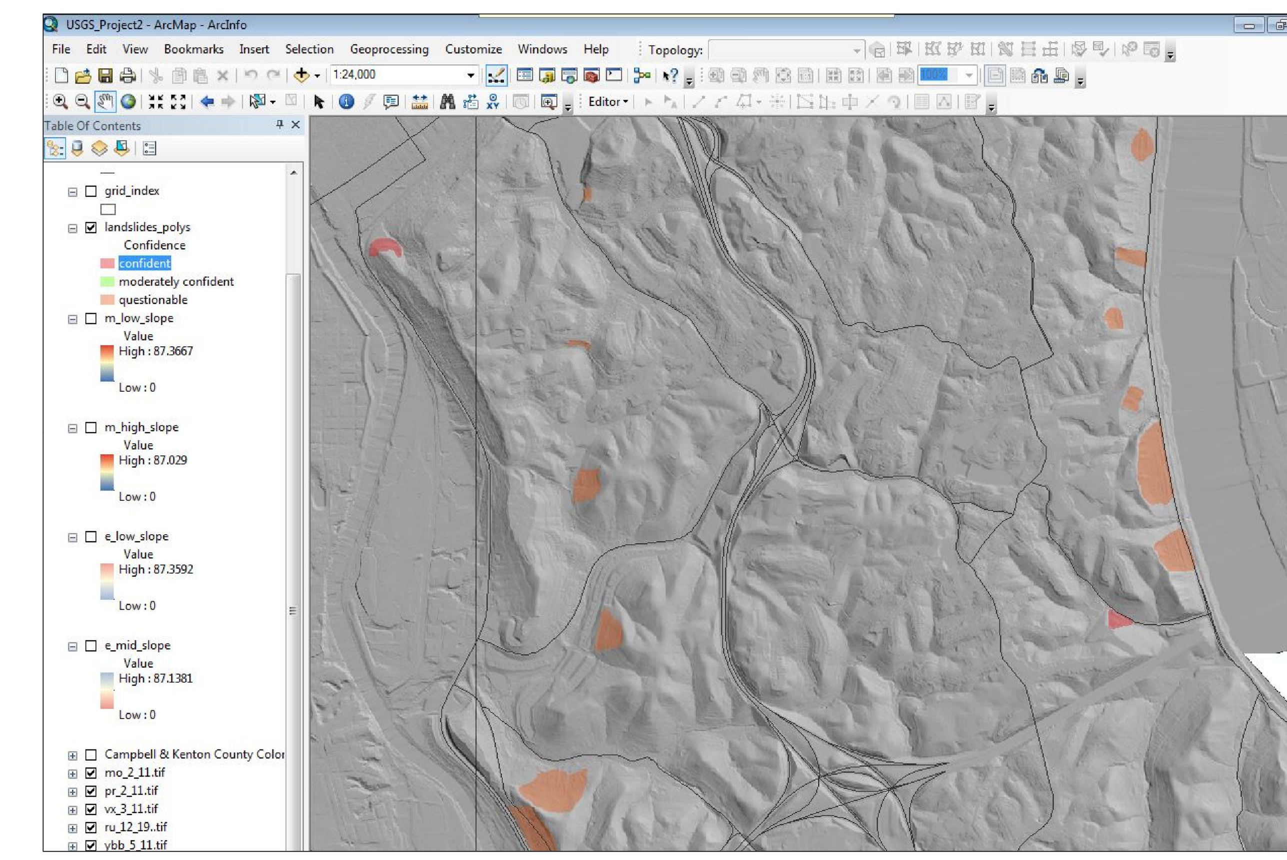
Geology

Acknowledgements

I would like to thank Paula Gori and Peter Lytle with the U.S. Geological Survey Landslide Hazards program, which provided funding for this project. I also thank Sarah Johnson with Northern Kentucky University, who provided assistance with field work and valuable discussion of landslide activity in the area. Finally, I would like to thank William Andrews, Jerry Weisenfluh, Jackie Silvers, and Meg Smath of the Kentucky Geological Survey, who helped with the proposal, deliverable report, and making this project possible.

Project Methodology

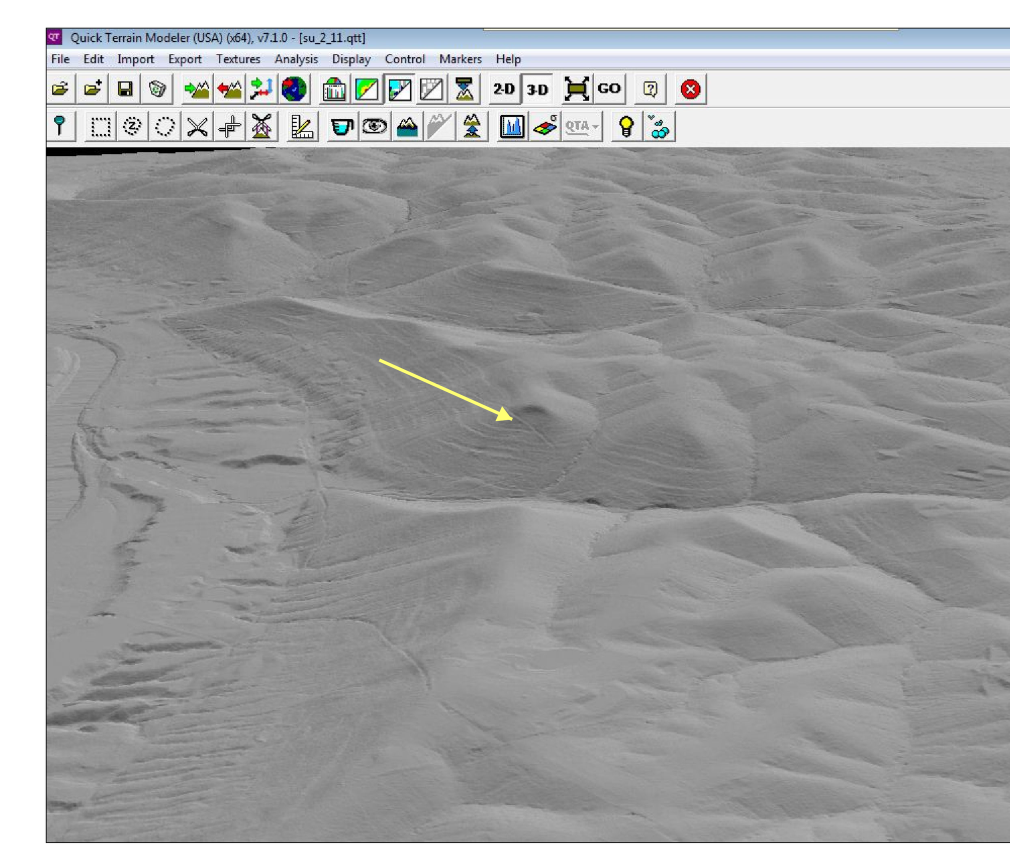
- Used Quick Terrain Modeler to create hillshade DEM's from the LAS files
- Imported DEM's to ESRI's ArcMap for visualization and spatial analysis
- Reexamined digitized landslides in Quick Terrain Modeler
- Performed field checking (example photos above)



ESRI's ArcMap software program was used to map potential landslides. ArcMap allows for other data sets (contours, aerial photography, and geology) to be used in conjunction with the LiDAR.

Visualization

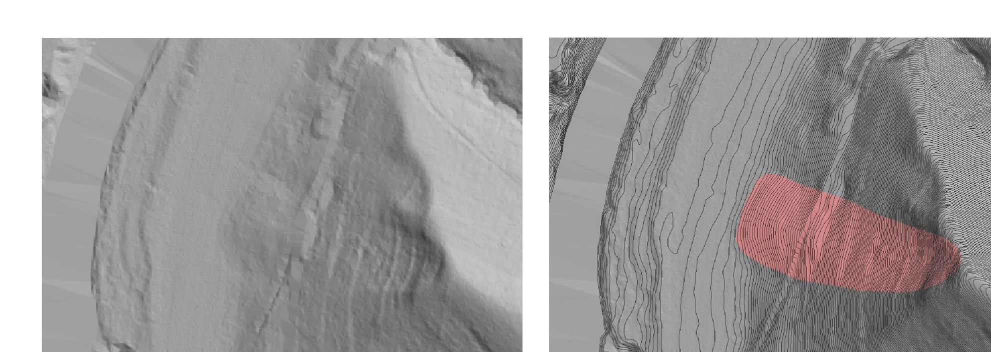
- Extents were digitized based on geomorphic signature: Scarp presence? Thick toeslope? Slope curvature? Hummocky?
- Systematic panning across the hillshade DEM's at various scales was used to identify and digitize the areal extent of potential landslides.
- A tiling scheme provided by the planning commission was used to help organize the visualization process
- Panning and zooming across the DEM's occurred: 1:10,000, 1:5,000, and 1:2,000
- Selected digitized features (25%) were reexamined in Quick Terrain Modeler with different azimuths, sun angles, and 3D
- For half of those, confidence was changed from questionable to moderately confident



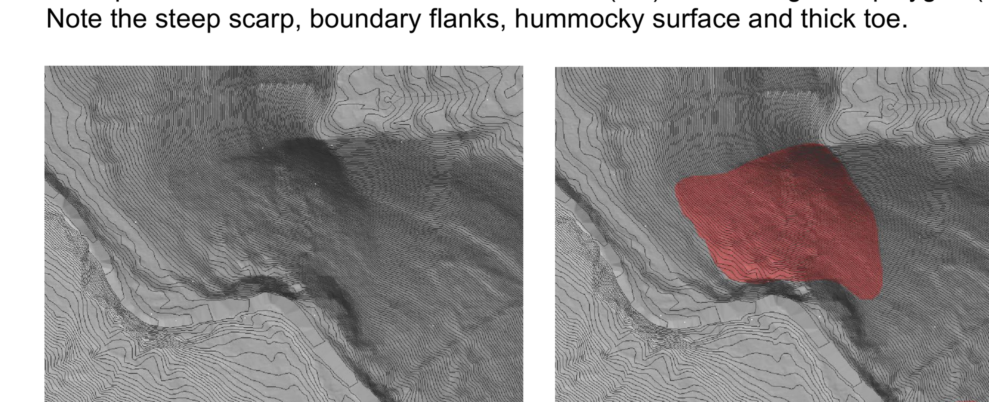
3D view in Quick Terrain Modeler. This software allows for creation of hillshade DEM's and rapid change of azimuths and sun angles.

Results

- 234 potential landslide extents digitized
- 10 % initially attributed as confident
- Other slides attributed as moderately confident or questionable
- 15% of slide extents digitized were field checked. Of these, 43% were confirmed, 40% were likely, and 17% were not accessible.
- Types of landslides were not determined.



Example of a landslide identified on the LiDAR (left) and the digitized polygon (right). Note the steep scarp, boundary flanks, hummocky surface and thick toe.



Example of a landslide identified on the LiDAR (left) and the digitized polygon (right). Note the steep scarp, boundary flanks, and hummocky surface. The steep scarp along the cutbank of the stream probably contributed to the larger slide above.