LiDAR for sinkhole detection and mapping in Knox County, TN

Clint Shannon, David Moore, Yingkui Li
UT Geography Department
Eureca Presentation 2017

Introduction

Sinkholes over the last 15 years have caused an average of over 300 million dollars worth of damage in the US (USGS, 2016). Sinkholes near or on roads are especially costly and occasionally deadly. Much of East Tennessee contains porous, soluble geology deeming it at risk for sinkholes (Dunigan, 2017). Currently, Knox County uses 4 ft resolution contour data to map potential sinkholes.

This project aims to develop a map layer from recently collected high-resolution LiDAR data to show the potential sinkholes located in the Dutchtown Road area of Knox County (Fig. 1-2). This project is pilot study for Knox County Stormwater Management to determine the feasibility of replicating this method for the entire Knox County area.

Objectives

- Derive a LiDAR-based GIS model to identify possible sinkhole locations and extent measurements.
- Analyze the sinkhole layer to determine the likely locations of actual sinkholes.
- Derive a LiDAR-based GIS model to identify possible sinkhole locations and extent measurements.

Data Sources

- Knox County Stormwater Management Database: Contour maps, feature data, and geologic maps.
- KGIS: aerial LiDAR data for Dutchtown Road area. LiDAR (Light Detection And Ranging) is a laser-based method of collecting imagery and elevation data.

Study Site

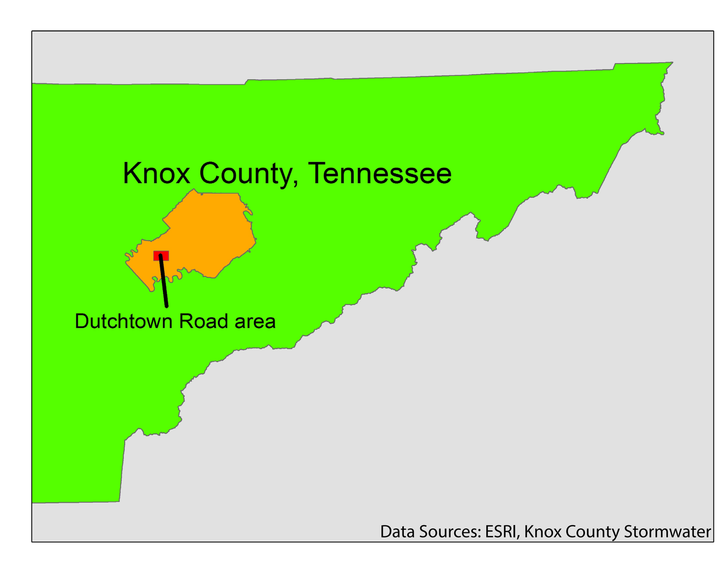

Figure 1

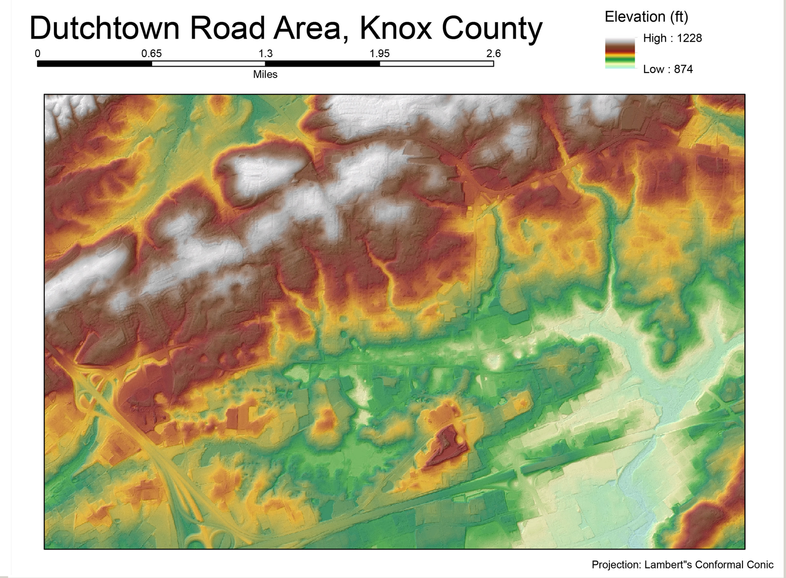

Figure 2

Methods

To identify sinkhole locations, LiDAR data was converted into a 1.3 ft resolution Digital Elevation Model (DEM) using Quick Terrain Modelor software. Then a model (Fig. 3) was created in ArcGIS Model Builder to extract surface depressions.

Area, perimeter, and a circularity index were then calculated from the depressions. Depressions that didn't meet specified criteria (area<50 ft2, circularity index<.85) were eliminated. Lastly, other features (streams, conduits, structures) were overlayed onto the map and used to eliminate depressions that are likely man-made. The final sinkholes are mapped in Fig. 8.

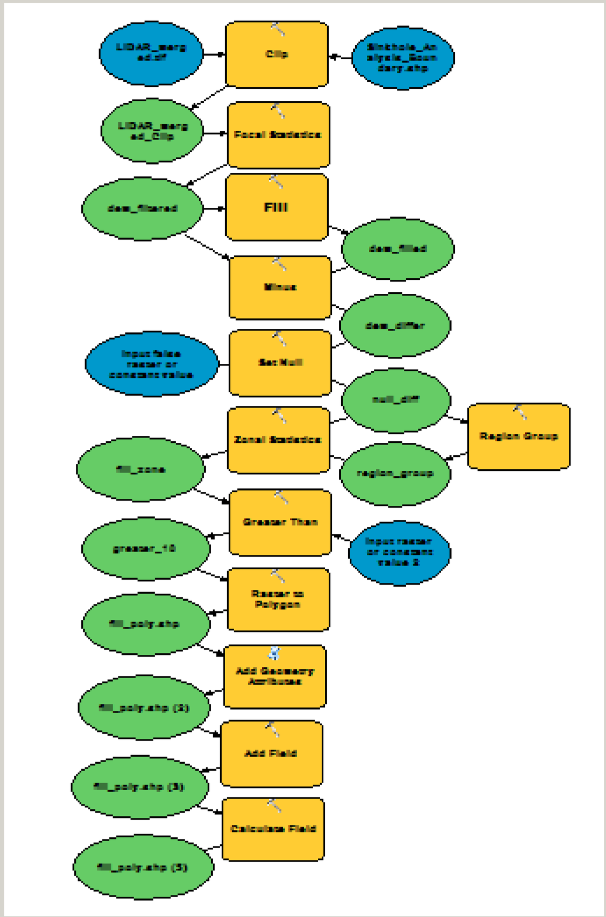

Figure 3. ArcGIS Model

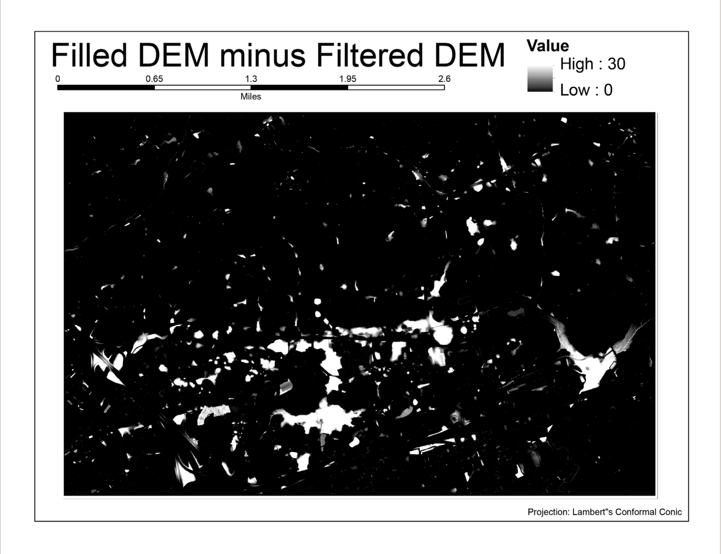

Figure 4. The orginal DEM is subracted from the DEM with filled depressions.

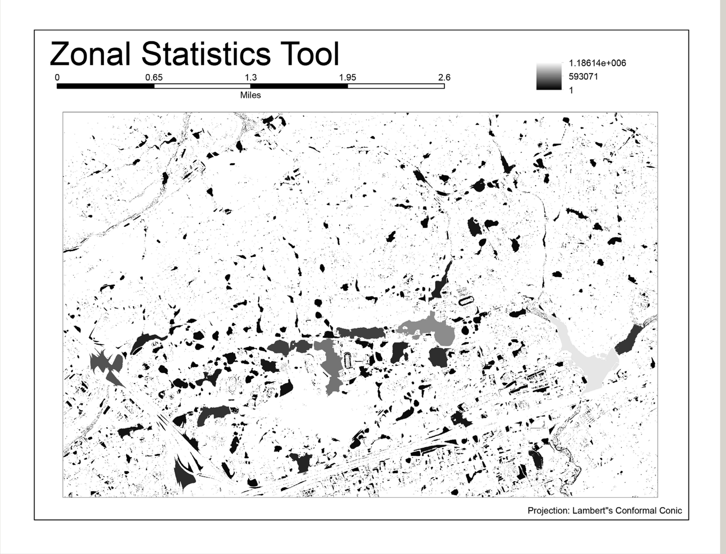

Figure 5. The "zonal statistics" tool calculates pixel statistics like area for the image.

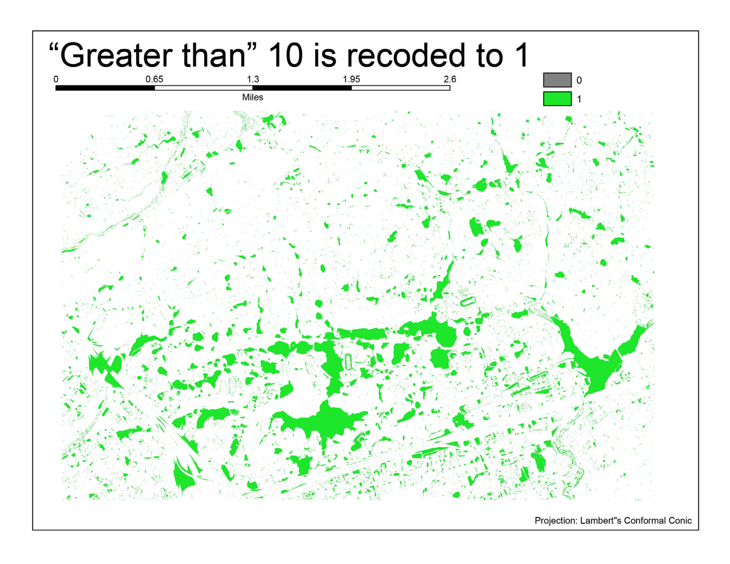

Figure 6. The "greater than" tool recodes data with pixel area greater than 10 to a value of 1 and all else to 0. This image is converted to a shapefile for further analysis.

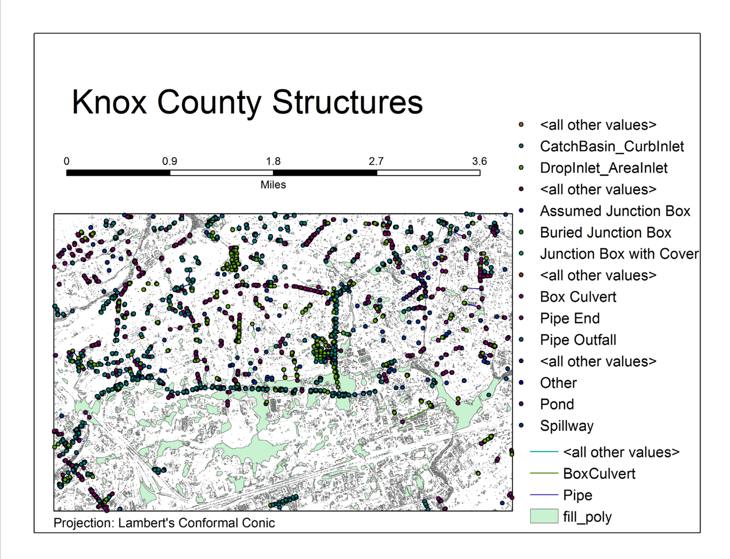

Figure 7. Structures are overlaid on the shapefile. Depressions that intersect the structures are considered man-made and are eliminated.

Results

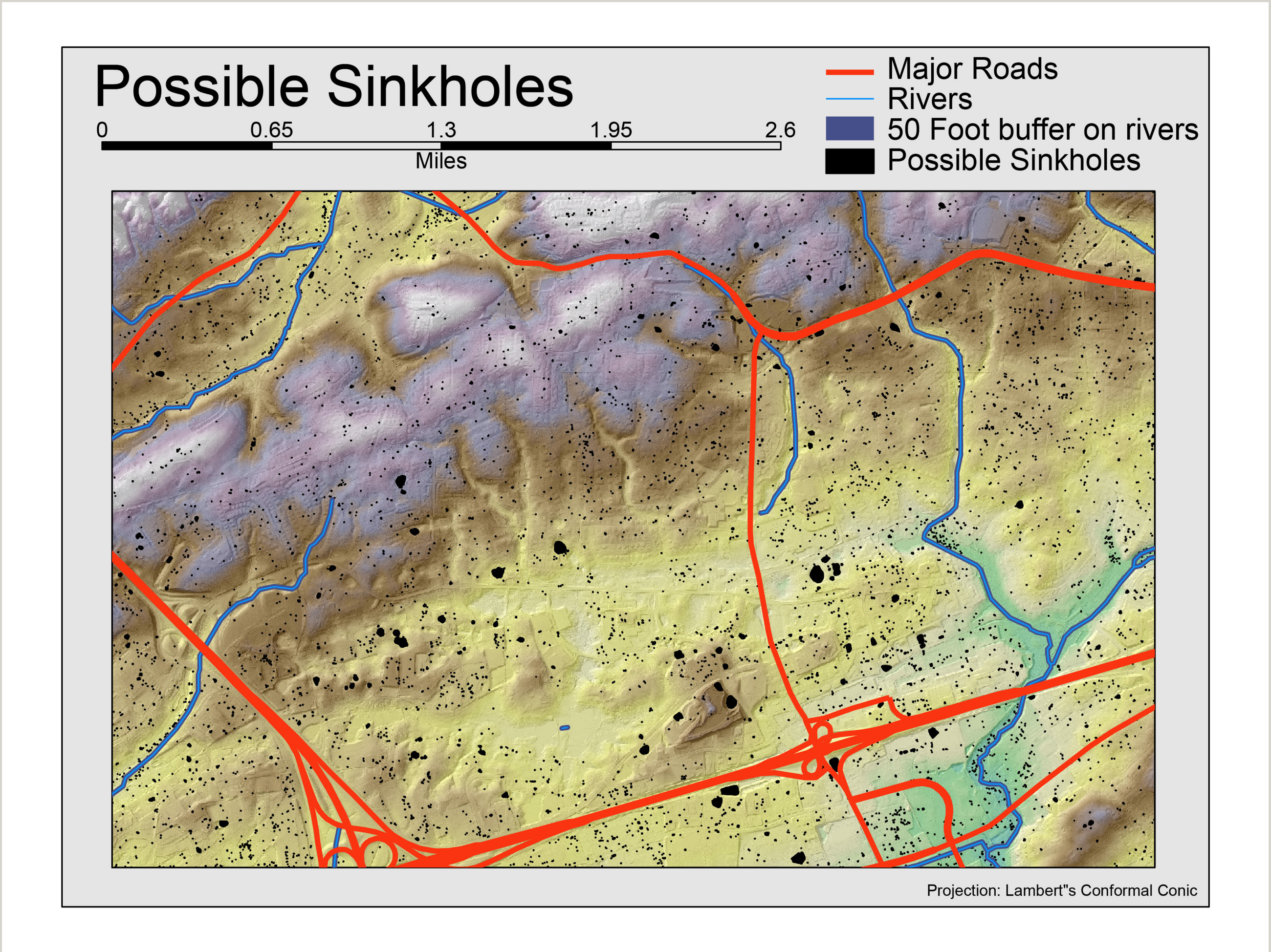

Figure 8.

Discussion and Conclusion

The main goal of this project was to develop a methodology for deriving possible sinkhole locations from LiDAR data and to map these areas. This was accomplished, and over 5000 possible sinkholes were identified. The primary challenge was data size. The immense ammount of data required the use of specific terrain modeling software for the creation of the initial DEM. The following steps for mapping sinkholes were completed with few setbacks.

Future work on this project should include a field-tested accuracy assessment of the derived map. Further methods of seperating sinkhole depressions from non-sinkhole depressions should also be explored.

References

Applied Imagery: Quick Terrain Modeler software. http://appliedimagery.com/
Dunigan, Tom. Tennessee Sinkholes. 23 February 2017. https://tnlandforms.us/landforms/sinks.php. 23 February 2017
ESRI: ArcGIS software. http://www.esri.com/
Ogden Environmental and Energy Services Co., I. (1999). Dutchtown Road Flood Study Report. Knoxville: Knox County.
USGS. USGS FAQs. 16 November 2016. https://www2.usgs.gov/faq/categories/11602/7921. 23 February 2017.
Zhu, Junfeng, et al. "Improved Karst Sinkhole Mapping in Kentucky Using LiDAR Techniques: A Pilot Study in Floyds Fork Watershed." Journal of Cave and Karst Studies (2014): 207-216. PDF document.

THE UNIVERSITY OF TENNESSEE KNOXVILLE

KNOX COUNTY TENNESSEE

KGIS