A Karst Feature Predictability Model within Barber County, Kansas

KELNER, G.M[1] gmkelner@mail.fhsu.edu , Gauvey, K.G[2] kgauvey@vols.utk.edu , Sumrall, J.B[1] jbsumrall@fhsu.edu

(1): Fort Hays State University, Department of Geosciences

(2): The University of Tennessee Knoxville, Department of Earth and Planetary Sciences

FORT HAYS STATE UNIVERSITY
WERTH COLLEGE OF SCIENCE, TECHNOLOGY AND MATHEMATICS
Department of Geosciences

Forward thinking. World ready.

Abstract:

The Gypsum Hills in Barber County, Kansas are known to have karst features such as caves and sinkholes. This study created a predictive model for karst features. Features that were previously identified were used to aid in the creation of a predictive model as well as Light Detection and Ranging (LiDAR) and WorldView-3 imagery. Two privately owned ranches in Barber County were used for this study due to ease of access. The predictive model for karst features will be useful for future exploration of karst features in Barber County. Understanding the distribution and occurrence of karst features will help landowners mitigate risk such as collapse leading to structural damage and aquifer contamination.

This karst feature predictability model encompasses the use of the ESRI ArcGIS software platform. The data for this model consists of slope and aspect, nearest neighbor elevation, Normalized Density Vegetation Index (NDVI), land cover/land use, distance to geomorphic features and subsurface geology. Other software platforms will be used in the creation of this model as needed such as MicroDEM, SAGA GIS and ENVI for imagery analysis. To test the relationship of geology to karst formation, rock samples were collected from various features to document the lithology and perform petrographic analyses. On these properties, the geologic contact between the Permian Medicine Lodge Gypsum and Flowerpot Shale appears to be a control on the formation of karst features and may play an important role in predicting the location of unknown features.

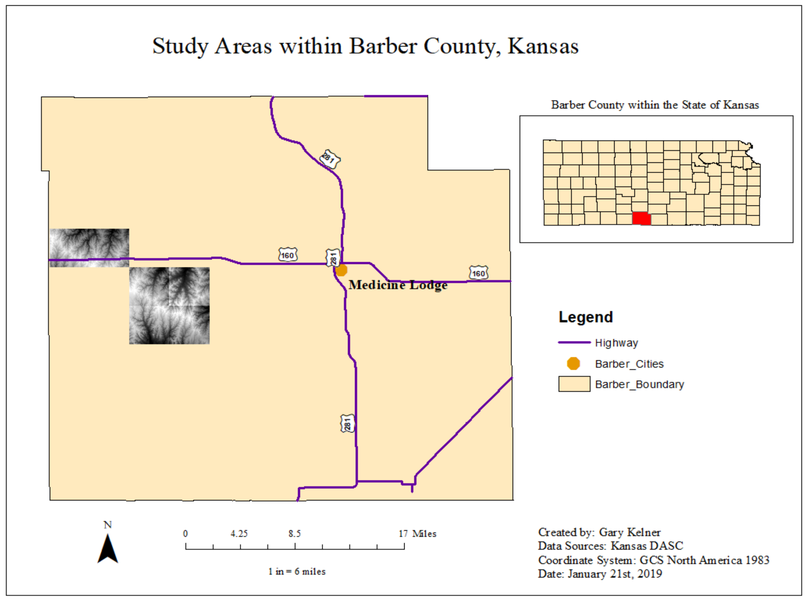

Figure 1: Map of Barber County showing the two study areas. Property One (southeastern property) is the primary property used for this portion of the project.

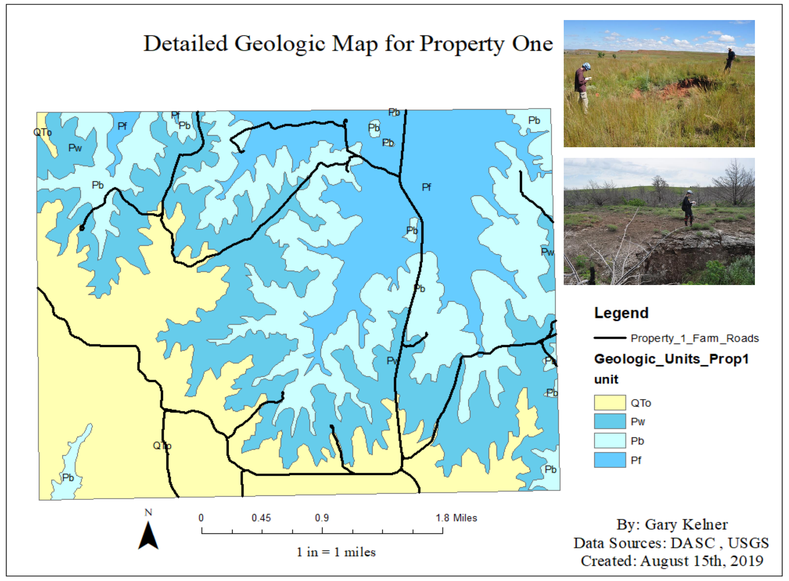

Figure 2: Map showing the detailed geology for Property One. The Permian Blaine Formation (Pb) is the dominant karst forming unit in the study area.

Preliminary Feature Identification:

The LiDAR has been used to aid in the detection of surface karst features such as sinkholes. Sinkhole complexes are visible in this format (Figure 3), and this method of identification was used to aid in field reconnaissance. Additionally, the LiDAR dataset has been incorporated into the karst prediction model for the study area.

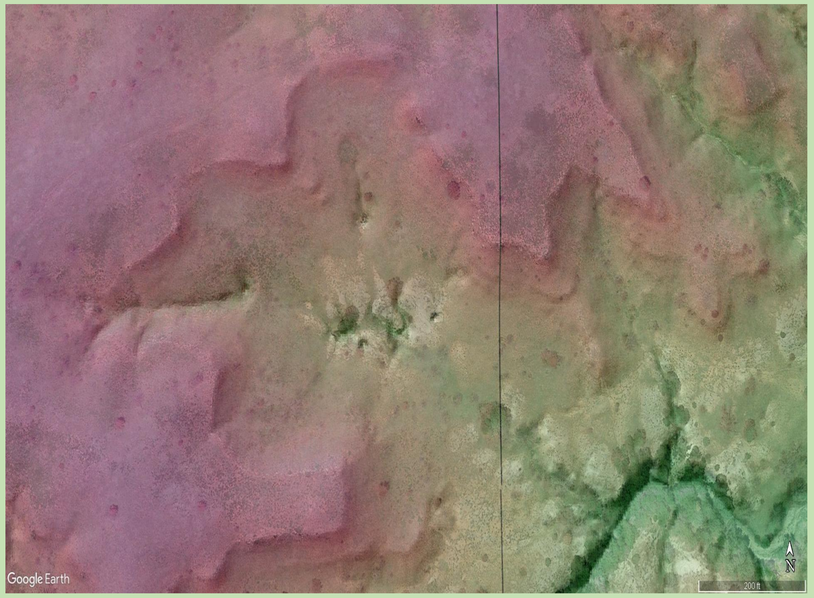

Figure 3: A sinkhole complex in the center of the image which is within Barber County, Kansas. This was taken from Google Earth with the LiDAR imagery draped over top from the MicroDEM software platform.

Other Parameters For Predictive Model:

The Normalized Difference Vegetation Index (NDVI) was used to identify stressed vegetation within the county and aided in the detection of surface karst features. Sinkholes act as fast routes for surface water to runoff, and vegetation stress is hypothesized to differ in sinkhole complexes compared to vegetation in other areas. It is hypothesized that vegetation in sinkhole complexes will be less stressed relative to vegetation in other areas.

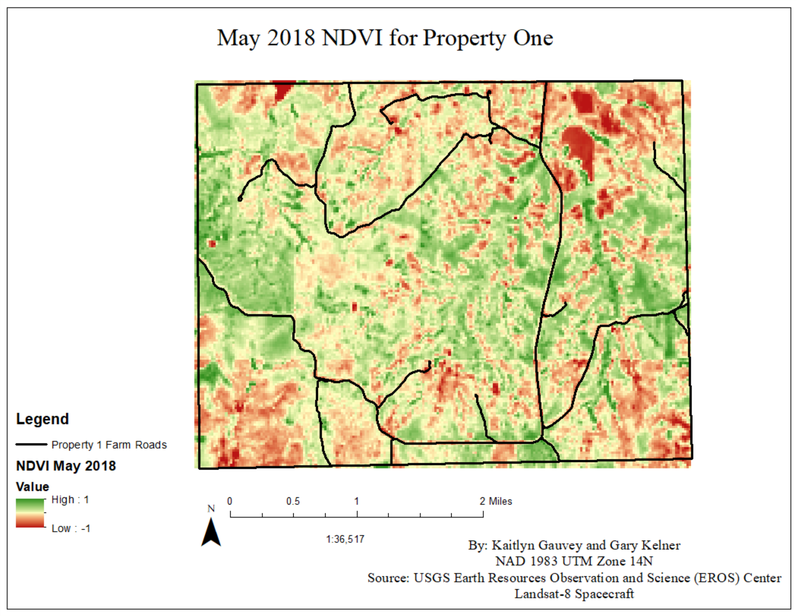

Figure 4: Normalized Difference Vegetation Index (NDVI) for May 2018 of Property One. May 2018 was chosen for the model due to coverage of other remotely sensed data layers. When observing the different months , the amount of vegetation changes based on the season of the year and how wet the soil is and if there was a drought during that particular month. Note: May 2018 was a relatively wet period of time following an intense period of drought conditions in the region.

Factors used for the preliminary karst predictability model:

- Local detailed geology
- Elevation (between the range of ~500 to 700 feet)
- Distance from farm roads and highways
- Normalized Difference Vegetation Index (NDVI) and Land Coverage Type
- Previously identified karst features in the area of study
- Hydrology features (springs, rivers and lakes)

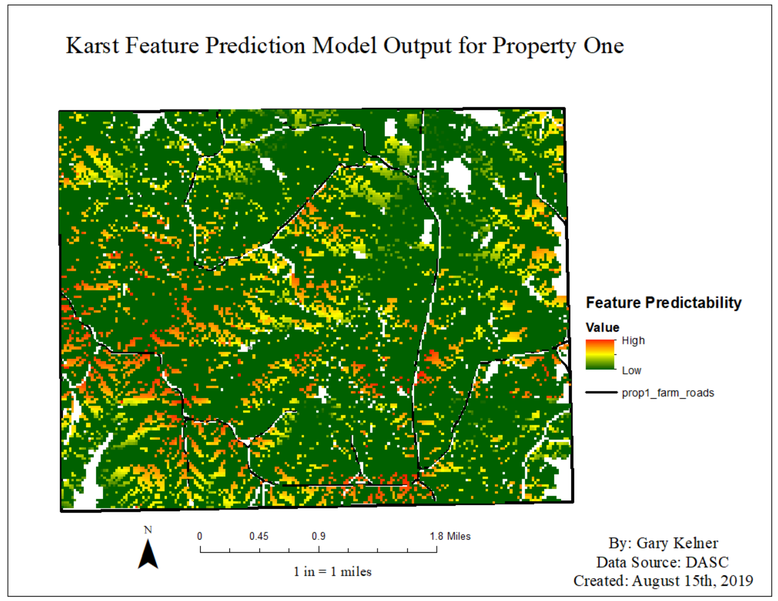

Figure 5: The results of the preliminary predictive model show the areas within Property One for surface karst features. This model is based on elevation, land coverage type, the distance from hydrological features, the local geology as well as the NDVI for May 2018. Future ground-truthing will determine the accuracy of this model for predicting karst features within the landscape of Barber County, Kansas.

Current and Future Work:

Preliminary work has been conducted using only LiDAR imagery which does appear to identify surface karst depressions (Figure 3). Approximately twenty features were identified using topography as well as field reconnaissance in a small section of Property One. These features have been incorporated into the larger karst inventory for the area and are going to be used to validate the model and check for model accuracy.

Additional predictive models for surface karst features will be created using several indices: NDVI, Wetness Index, slope and aspect, surface geology, and topography. These predictive models will be used for reconnaissance to find and identify new features. The models will be validated using known karst feature locations.

The model result in Figure 5 was constructed using the Raster Calculator tool in the ArcGIS toolbox. The model was created by converting the factors stated above to raster format and then inputting them into conditional statements within the Raster Calculator. The output of the first calculation was used as an input variable into the next calculation for the model to create the desired output. An example of the code is the following :

Feature Probability = Elevation Range + Land Use + Road/Hydrology Distance + Slope and Aspect Range + Geologic Layer + NDVI for May 2018

This work will provide meaningful information to property owners and land managers in the region, and it will be used to aid in the exploration and identification of other karst features in the area.

Acknowledgements:

The authors wish to thank Dr. Richard Lisichenko for his guidance with the project. A special thanks to Mr. Phil and Mary Lou Hinz and Brian Alexander for permission to access their land in Barber County. A portion of this research was supported by the Graduate Scholarly Experience Grant Program at Fort Hays State University.

References:

Chatterjee, S., Personal Communication, 2019.

Guth, P.L., 2009, Geomorphometry in MICRODEM, In Hengl, T., Reuter,H.I. (eds), Geomorphometry: concepts, software, applications. Developments in Soil Science Series, Elsevier, ISBN-13: 978-0-12-374345-9, p.351-366.

United States Geological Survey , 2005 , Selection of Colors and Patterns for Geologic Maps of the U.S. Geological Survey , Vol 1: https://pubs.usgs.gov/tm/2005/11B01/pdf/TM11-B1.pdf (accessed September 2019)