PREDICTING STRATIGRAPHIC OUTCROPS USING A LIDAR DIGITAL ELEVATION MODEL IN A KARST LANDSCAPE, FORT HOOD MILITARY INSTALLATION, TEXAS

By Keely Armstrong

Faculty Sponsors: Dr. Melinda Shaw Faulkner, Dr. Matthew Beauregard

ABSTRACT

The Fort Hood Military Installation is a karst landscape characterized by Cretaceous-age limestone plateaus and canyons in Bell and Coryell counties, Texas. The area is located in the Lampasas Cut Plain region of the Edwards Plateau and is stratigraphically defined by exposures of the Fredericksburg Group, namely the Comanche Peak and Edwards carbonates. The topography is dominated by plateaued draining divides capped by the resistant Edwards limestone and bordered by steep scarps exposing alternating layers of the Comanche Peak and Edwards units. This interfingering relationship has created a variable slope along the edges of the plateaus, defined by lithology.

The study area is located in the northeastern portion of the installation, and provides numerous outcrops of the Fredericksburg Group carbonates for terrain analyses. Traditional methods such as field surveying can yield accurate results; however, they are limited by time and physical constraints. Airborne Light Detection and Ranging (LiDAR) provides an alternative for high-density and high-accuracy three-dimensional terrain point data collection. For the purposes of this study, a 1 m Digital Elevation Model (DEM) derived from LiDAR captured in March of 2009 was used as a base map to determine the slope of selected outcrops, and slope analysis derived from the DEM was used to create a profile graph of these outcrops. These data were used to create a slope profile to predict outcrop patterns for the Comanche Peak and Edwards limestones. Field verification and refinement of this model was conducted in order to correct for anthropogenic modifications of slope by Army training activities and road building. Steeper slopes and recessed outcrops associated with the interfingering of the Comanche Peak and Edwards carbonates were not easily resolved by the digital elevation model with regard to slope and outcrop pattern, while gentler slopes were portrayed more accurately with regard to slope but the resolution associated with outcrop patterns were less clear.

Although the increasing capabilities of GIS (Geographic Information Systems) and accuracy of geographically referenced data has provided the basis for detailed terrain analysis and modeling, research on terrain-related surface features is highly dependent on terrain data collection and the generation of digital models. Although LiDAR analysis can be a powerful tool, filter mechanisms must be employed to remove major natural and anthropogenic terrain modifications resulting from military training exercises, road building and maintenance, and the natural influence of water bodies throughout the study area.

METHODODOLOGY

Using the 1-meter DEM of the study area derived from the LiDAR data, a slope analysis model was created. The slope model was used to predict outcrops of the Edward’s and Comanche Peak formations. From this model, topographic profiles were created using ArcGIS’s 3D Analyst tool. These profiles were used to predict outcrop pattern based on the changes in slope. These predictions were then compared to the actual outcrops in the study area.

RESULTS

Location 1

The outcrop at location 1 is in the northern section of the study area (A). Changes in slope were used to predict outcrop patterns on the graph (B). In the field, most of the breaks in slope were predictive of the outcrop pattern. The exception was the middle Edward’s unit, which did not show due to the uniform steepness of the slope (C). The bottom slope was covered with talus.

Location 2

The outcrop at location 2 is in the southern section of the study area (D). Changes in slope were used to predict outcrop patterns on the graph (E). The outcrop in (F) is a small uncovered section of a larger slope, most of which is covered by vegetation and modified by road building (G). Due to the steepness of the slope and the resolution of the DEM, the middle Edward’s in (F) was not seen in the profile model but was visible in the outcrop.

Location 3

Location 3 is a steep scarp along Cowhouse Creek, in the southern section of the study area (H). The slope is so steep that it was impossible to pick out the different formations in the profile (I). The scarp shows interfingering of the formations (J), it was only evident in outcrop. The Edward’s are the dark gray protruding ledges and the Comanche Peak are the lighter colored recessed slopes (K).

DISCUSSION AND CONCLUSIONS

Field verification and refinement of this model was conducted in order to correct for anthropogenic modifications of slope by Army training activities and road building. This slope is on the western section of the study area and was modified for road building (L). Because of the modification to this slope, no outcrop pattern could be determined.

There are many limitations to using spatially derived data to predict outcrop patterns. Dense vegetation and talus prohibited verification of formations. Steep scarps and cliffs could not be resolved well by the interpretive software. Figure (J) shows a steep but smooth drop in elevation, but in outcrop, the cliff face varies with the protruding Edward’s and the recessed Comanche Peak.

The LiDAR data and models derived from it was not well suited for the detailed scope of the project due to the interfingerring nature of these units, but could be applied on a more regional scale to predict major formation boundaries. Higher resolution data might be better suited for differentiating the interfingerring units.

STUDY AREA