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Determining Highly Erodible Land Utilizing LIDAR Data

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Abstract

Light Detection and Ranging collects a vast amount of data regarding the earth's surface. Utilizing this data to produce accurate field maps for a specific purpose was a goal for the Natural Resource Conservation Service. Field testing of the software tools designed to utilize LIDAR data was completed by the researchers. The results of the field test created land maps revealing the areas of Highly Erodible Land (HEL) and other classifications based upon erodibility. The utilization of LIDAR data created maps of extreme accuracy without the traditional on-site field data collection process. The researchers concluded that the software was a major time saving process that could replace in the field surveying and data collection. The most limiting factor in the software mapping process is the user's learning curve to learn the new software intricacies.

Keywords: LIDAR, erosion, Highly Erodible Land,

Introduction

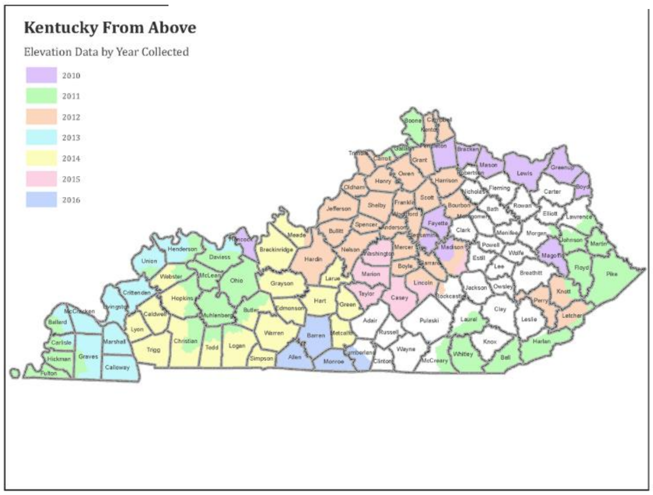
LIDAR stands for Light Detection and Ranging, (LIDAR). People not familiar with LIDAR may assume it is a new technology. LIDAR technology was developed over 40 years ago and was initially used for mapping particles in the atmosphere. During the 1980s, the further development and availability of GPS technology opened up the applications to moving sensors (airborne LIDAR). Bathymetric LIDAR was actually one of the first uses of airborne LIDAR. The surface of the water provided a "reference" that de-emphasized the absolute location of the airplane. . Some of the earlier non-bathymetric airborne applications were in the measurement of glaciers and how they were changing, (NOAA, 2012). The early 1990s saw the improvement of the inertial measurement unit, (IMU) and the ability to begin achieving decimeter accuracies. LIDAR can help determine where to apply costly fertilizer, (USDA 2010). It can create a topographical map of the fields and reveal slopes and sun exposure of the farm land. Researchers at the Agricultural Research Service used this topographical data with the farmland yield results from previous years, to categorize land into zones of high, medium, or low yield.LIDAR is an opportunity to take advantage of an extremely accurate and consistent base layer that will benefit agency business as well as the general public. Some applications include:

- Hydrologic modeling
- Engineering surveys and planning
- Floodplain delineations
- Terrain visualization
- Determination of slope gradient, aspect, and complexity
- Fast and accurate stream cross-section acquisition and geomorphology mapping
- Watershed evaluations
- Wildfire planning, fire behavior modeling, and rehab
- Oil and gas and mining rehab [1]

For the Commonwealth of Kentucky, elevation data are critical for agriculture and precision farming, natural resources conservation, flood risk management, infrastructure and construction management, forest resources management, geologic resource assessment and hazards mitigation, and other business uses. Today, high-density light detection and ranging (LIDAR) data are the primary sources for deriving elevation models and other datasets. Federal, State, Tribal, and local agencies work in partnership to (1) replace data that are older and of lower quality and (2) provide coverage where publicly accessible data do not exist.

A joint goal of State and Federal partners is to acquire consistent, statewide coverage to support existing and emerging applications enabled by LIDAR data. "Kentucky from Above," the Kentucky Aerial Photography and Elevation Data Program (http://kygeonet.ky.gov/kyfromabove/), provides statewide LIDAR coordination with local, Commonwealth, and national groups in support of 3DEP for the Commonwealth, (Carswell 2014). The state of Kentucky has been documented with the exception of the Appalachian region, (Figure 1). The Appalachian region of eastern Kentucky is covered by the Daniel Boone National Forest. Foliage from the trees provides interference between the beams and the ground. GIS specialists hope that all of Kentucky will have LIDAR coverage by January of 2019.

Figure 1LIDAR coverage of Kentucky



The mission of the Natural Resource Conservation Service (NRCS) is to provide national leadership in the conservation of soil, water, and related natural resources. The NRCS provides balanced technical assistance and cooperative conservation programs to landowners and land managers throughout the United States as part of the U.S. Department of Agriculture (USDA). [2]. The main way NRCS assists landowners is through the Environmental Quality Incentives Program. The program provides cost share on the implementation of conservation practices.

Many of the conservationist practices require in the field land surveying of the area to adequately evaluate the design elements of the conservation structure to be installed. The NRCS, like numerous other governmental agencies, has reduced the number of employees available to handle the increasing workload. Trends in federal employment suggest that the federal workforce may already be under strain from cost-cutting measures and that further reductions could impede the government's ability to fulfill parts of its mission.[3]NRCS field technicians and engineers are required to do more with less, the utilization of LIDAR technology is necessary to fill the reduced man-hours void. The NRCS had a staffed office in every county and during those times it was not very difficult to drive to the farm and survey/assess the land management issue. The technology tools developed for NRCS staff utilizing LIDAR data makes it possible to accurately deal with land management issues without several trips to the specific site and doing hours of "in the field" data collection.

The NRCS is tasked with evaluating land to determine its erodibility as shown in the following government regulations.

§ 12.20 - NRCS responsibilities regarding highly erodible land.

In implementing the provisions of this part, NRCS shall, to the extent practicable:
(a) Develop and maintain criteria for identifying highly erodible lands;
(b) Prepare and make available to the public lists of highly erodible soil map units;
(c) Make soil surveys for purposes of identifying highly erodible land; and
(d) Provide technical guidance to conservation districts which approve conservation plans and systems, in consultation with local county FSA committees, for the purposes of this part. (GOVREC 2016)

Soil scientists have broken all the soil classifications into the 3 groups Highly Erodible Land (HEL), Non-Highly Erodible Land (NHEL), and Potentially Highly Erodible Land (PHEL). If no classification has been determined for a parcel of land, then it is classified as Undetermined Highly Erodible Land (UHEL). Utilizing LIDAR data and appropriate NRCS software tools, PHEL soils can be determined without an in the field survey. The criteria for HEL determination is defined in the following regulation.
§ 12.22 - Highly erodible field determination criteria.

(a) *Predominance*. Highly erodible land shall be considered to be predominant on a field if either:
(1) 33.33 percent or more of the total field acreage is identified as soil map units which are highly erodible; or
(2) 50 or more acres in such field are identified as soil map units which are highly erodible. (GOVREG 2016)

Materials & Methods

This study conducted a field test of three of the NRCS developed LIDAR data based tools for erodibility determinations.“Determination Automated”, “PHE Tool” and “Representative Slope Tool”. For comparison purposes the site selected is shown in figure 2 as an unobstructed satellite view of the test site.

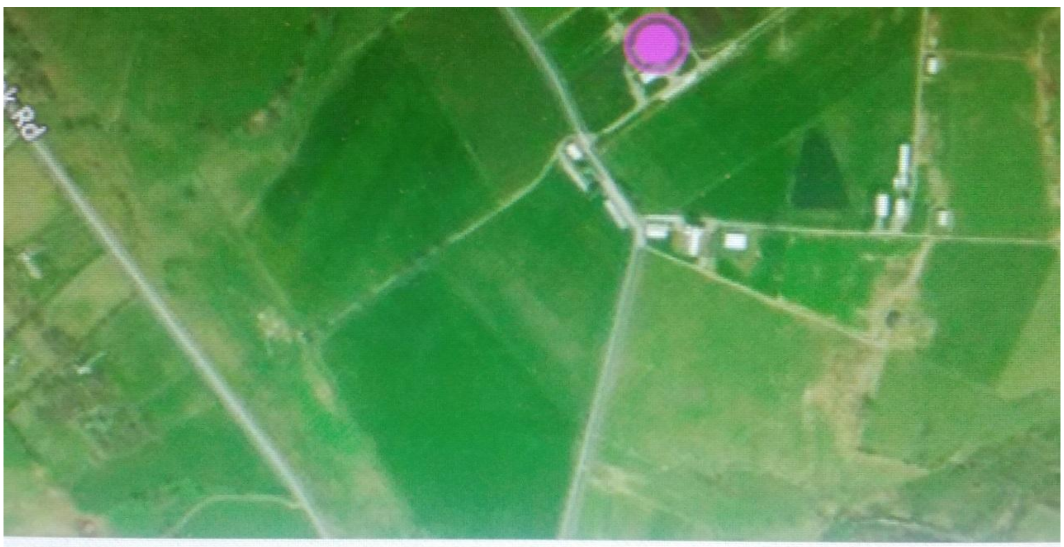


Figure 2.

The site is also shown in figure 3 as it appears in the soil survey book.

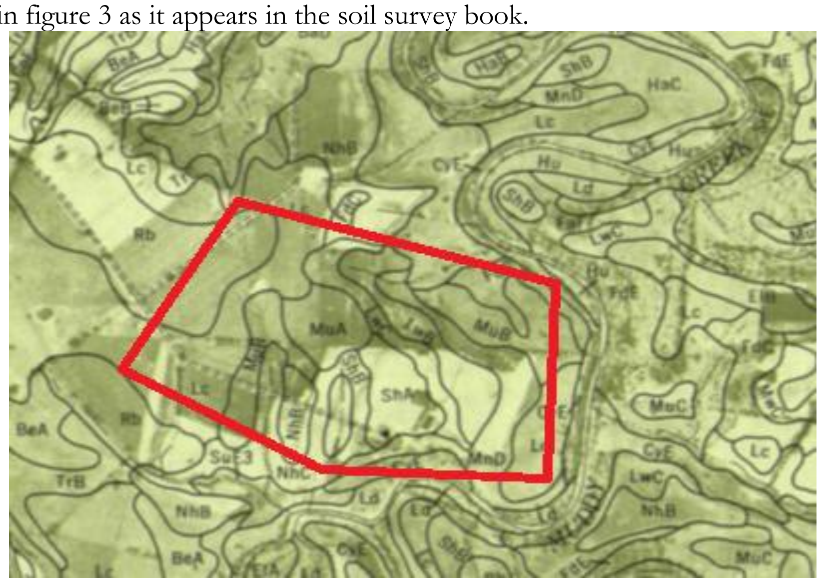
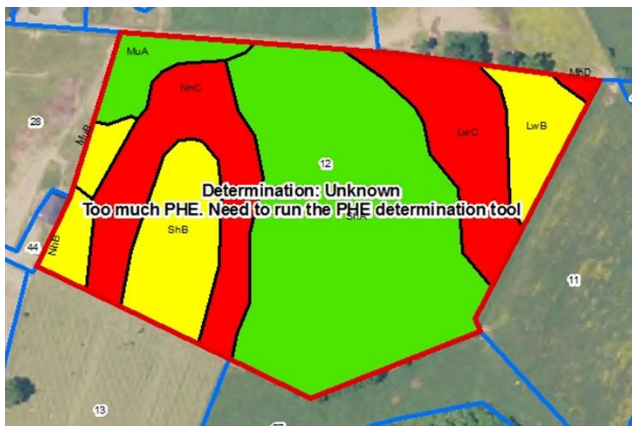


Figure 3

The "Determination Automated" tool processes the field data and extracts what part of the field is classified HEL. When the one or both of the following conditions are determined, there is over 33.3 percent HEL or 50 acres HEL, then the tool produces a user's map and soils description. If the above conditions are not determined, then the tool will generate a NHEL map and soils description. A PHEL determination will result in the land being classified as "Unknown" and the PHEL tool will be utilized to further analyze the field. NHEL is symbolized using green in the map, Red indicates HEL and Yellow indicates PHEL. Figure 4 demonstrates all three determinations of the test site.

The PHE Tool determines if PHEL areas should be classified HEL or NHEL. The first step in this procedure is to use the Contour tool. This tool maps the slope of the area in question. Input the required fields and draw a line perpendicular to the contours in the designated yellow PHEL area. The tool will calculate slope and based on the results the yellow land area will turn red (HEL) or green (NHEL). To complete the process the Determination Automated tool must analyze the landutilizing the layer of data generated from the PHE Tool step. A completed field determination will exist for the field.

Figure 4



Discussion Conclusions

The LIDAR data based software tools provided finished products that were accurate and descriptive of the test site. The LIDAR data based software tools allow the researchers to make a site determination with a significant reduction in man-hours to gather the same data provided by LIDAR. This is significant because of the reduction in NRCS staffing to complete such a task. The land erodibility tools utilize vast quantity of data to input into the form. Researchers determined it was a challenge to find the data and correctly import that data. The problem is further compounded by the fact that there is data for every county that is labeled unclear. Minimum inputs require a layer of data provided by Farm Services Agency, imagery for the county, the LIDAR data, and soils data for most tools. The agency recently converted from windows 7 to windows 10. This has created difficulty converting the programs to work on the new operating system. The LIDAR tools have had several issues and require technology skilled employees to correct them. There is a significant learning curve to utilize the LIDAR based tools. The learning curve is directly dependent upon the user's computer technology, prior experience, and skill level.

Acknowledgements

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