Possible Sections:

H063 - General Surface Hydrology and Catchment Science

H093 - Machine Learning in Hydrologic Modeling (if we implement a bona-fide ML technique)

**H149 - Water contamination and water quality improvement in rivers**

H151 - Water, land, environment and people

A Scalable Strategy for Quantifying Vegetative Cover in Riparian Buffers with LiDAR

Riparian vegetation is fundamental to the health of fluvial systems; it filters sediment and nutrients from runoff, stabilizes stream banks, controls sediment erosion, shades and cools water, and provides habitat for a diverse array of terrestrial organisms. Because of the outsized impact that riparian buffers have on water and ecosystem quality, quantifying its extent is of great interest to hydrologists, watershed planners, stream restorationists and many others. We propose a simple scheme that uses only LiDAR point cloud data to identify vegetation in riparian buffers, allowing rapid and scalable quantification of riparian vegetative coverage.

While manually identifying riparian vegetation using orthoimagery is feasible for small study areas, automated techniques become necessary as the size of the study area increases. Many automated approaches to quantifying riparian coverage work well but may require the acquisition of specialized imagery or have workflows obfuscated by the application of complicated machine learning techniques. Our strategy uses only LiDAR data to generate intermediate rasters that are combined to produce a final raster of vegetative coverage. The process is easy to understand, computationally efficient, can be implemented in a wide range of programming languages and GIS programs, and produces results that are on par with more complicated techniques.

We validated our model against a hand-delineated landuse dataset covering the XX watershed, a XX km2 catchment located in western Tennessee. LiDAR covering the study area was downloaded from the Tennessee Geospatial Portal. This LiDAR was collected in late 2012 by Laser Mapping Specialist, Inc for the US Army Corps of Engineers with a horizontal accuracy of 1.0m and vertical accuracy of 0.37m. Landcover predictions were made by applying various filters to raster datasets derived from the LiDAR, and filter parameter ranges were established by applying optimizing the filtering algorithm with a differential evolution algorithm.

Though many filter combinations are possible, it is necessary to find a combination that has good predictive power yet is also relatively simple. By using just two LiDAR-derived rasters, coverage was quantified with an accuracy of 85-87% in the riparian corridor depending on model parameters. The formal model can be written as follows:

where *ij* is the index of a cell in a raster, *p* is the truth value of the riparian coverage, *d* is the distance to the ground (sometimes referred to as canopy height), *n* is the average number of LiDAR pulse returns (*n* tends to increase as tree and shrub limbs fragment LIDAR pulses), *x* and *y* are positive real numbers and is the logical AND operator. The most effective arguments for this model in this study area were determined to be *x = 3 meters* and *y = 1.5*, though these are preliminary estimates. This model works best when riparian coverage is primarily arboreal; decreasing the canopy height threshold increases identification of shrub coverage but may gives false positives in agricultural fields. Canopy height and average pulse returns rasters are simple to derive from LiDAR using most GIS programs, and these same GIS programs can also perform efficient raster math.

Because of the increasing ubiquity of LiDAR data and the efficiency of raster/matrix operations, the proposed model can be used by anyone with access to basic GIS software to rapidly determine riparian vegetative coverage in large study areas, facilitating accurate assessments of ecological health, water quality and erosion susceptibility. This model is expected to generalize to other watersheds, and with further development it may be possible to differentiate coverage types within the riparian corridor by extending this raster filtering technique.