Quantifying the Role of Tree Throw in Hillslope Processes of the Western Appalachian Plateau

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Project Overview:

- **Time Frame:** Over a period of about eight weeks, we surveyed two 222 tree-throw events throughout the Denison University Biological Reserve (Bio Reserve).
- **Tree Throw?:** Tree throw is a dominant mechanism of bioturbation that generates and mixes soils on forested hillslopes. When trees topple and uproot - often as the result of high-wind events - root plates rip up soil and underlying bedrock and, depending on hillslope gradient as well as direction of fall, transport sediment downslope.
- **Study Area:** We worked within 140 hectares of deciduous and conifer forests. The land is second- and third-growth forest having been cleared as recently as the early 20th century. The underlying lithology is primarily siltstone and sandstone with some glacial till. The soils are mostly inceptisols and ultisols. The Bio Reserve is part of the broader physiographic region of the Appalachian Plateau.
- **Project Approach:** At each site, we recorded the length of the tree, diameter at breast height, a decay rating, root plate dimensions, direction of tree fall, and species, if possible. We also extracted a tree core to determine age at the time of topple if the tree was not too decayed.
- **Project Goals:** There is a need for more empirical data to inform process models for hillslope sediment transport. This project aims to quantifies the role of tree throw in the production and transport of soils in the western Appalachian Plateau of Central Ohio, USA.

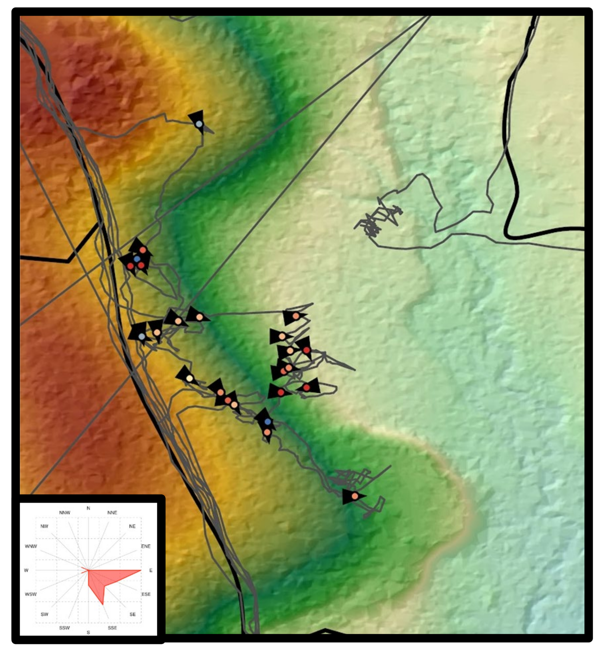
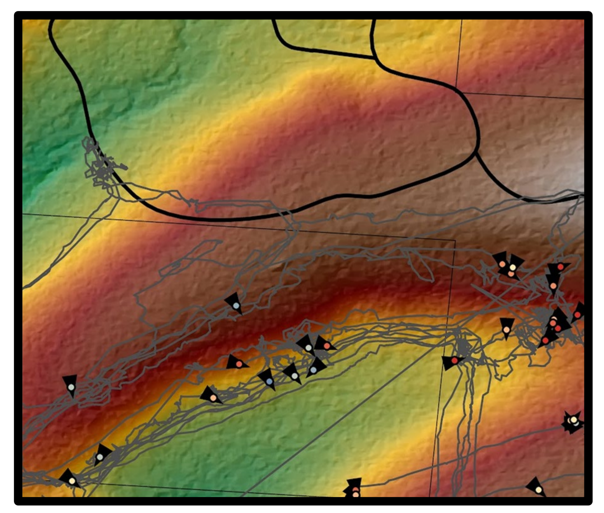


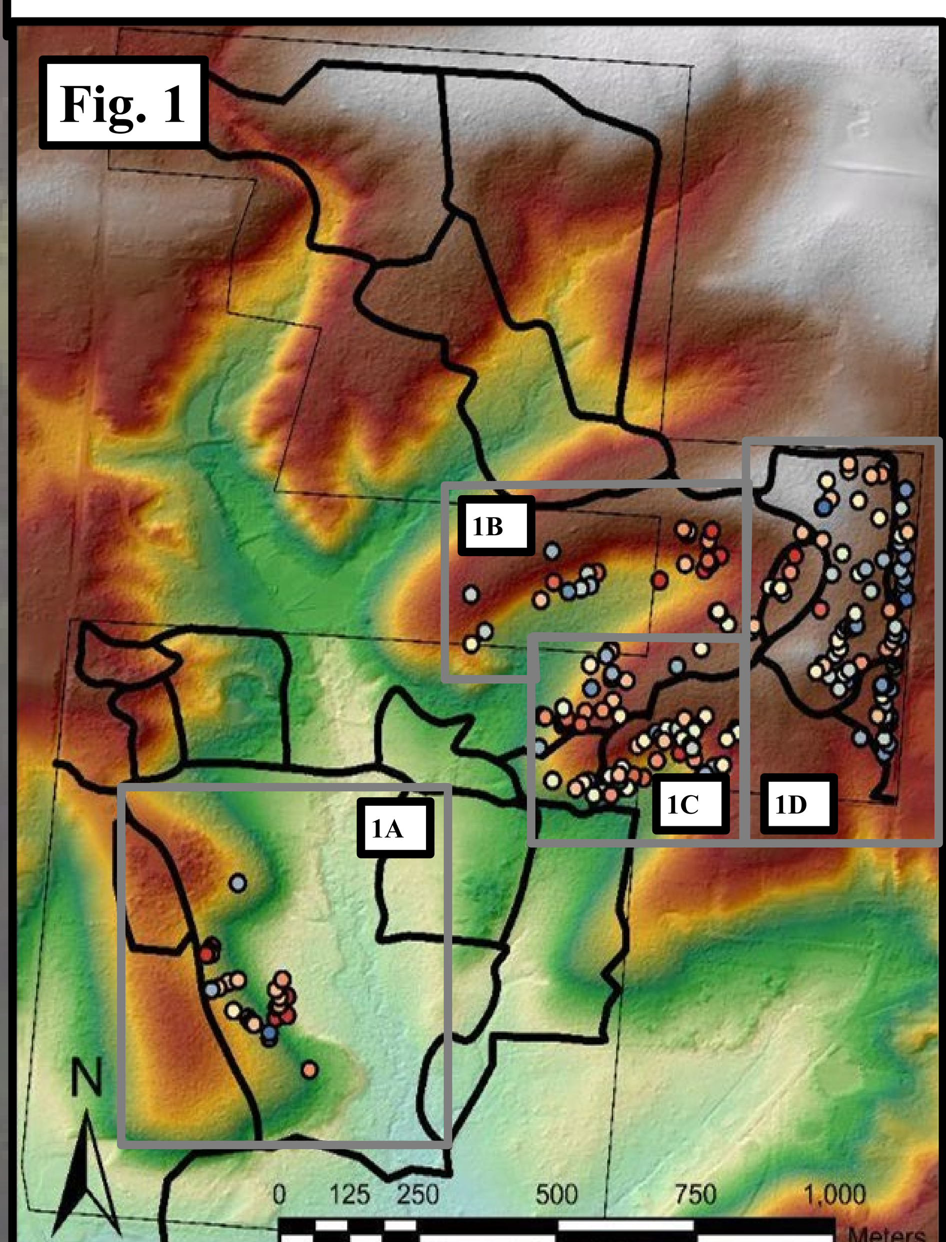
Figure 1A:

- The southernmost slope of the Bio Reserve.
- Tree fall azimuths support a dominant wind direction of NW to SE.
- Slope influenced by anthropogenic deforestation and dumping.

Figure 1B:

- The northernmost surveyed hillslope of the bio reserve.
- Fall direction are primarily to the SE and are concurrently downslope.
- Our extrapolated sediment flux rate (m^3 m^{-1} yr^{-1}) was anomalously high here. This was also reflected in. the relatively short time needed to mix the soil mantle We don't have a definite reason for this.
- Hillslope influenced by clear cutting in the past century.





Basemap:

- Includes 1 meter resolution LiDAR data that was collected by Licking County.
- Underlain by a hill shade to make the DEM seem three dimensional.
- DEM overlain by tree throw data and trail data.

DEM Key:

Elevation:

High: 1200 ft

Low: 950 ft

Tree Lengths:

- 0 meters
- 0 - 10.4 meters
- 10.4 - 14.6 meters
- 14.6 - 17.5 meters
- 17.4 - 19.9 meters
- 19.9 - 22.4 meters
- 22.4 - 25.3 meters
- 25.3 - 28.6 meters
- 28.6 - 32.0 meters
- 32.0 - 42.0 meters

Figure 1: A digital elevation model of the Denison University Biological Reserve. The dots denote individual survey sites. Four subsections have been denoted and expanded in subsequent figures to include azimuth of tree fall, survey lines as well as a clearer understanding of event dispersion and variety depending on the local geomorphic as well as wind regimes.

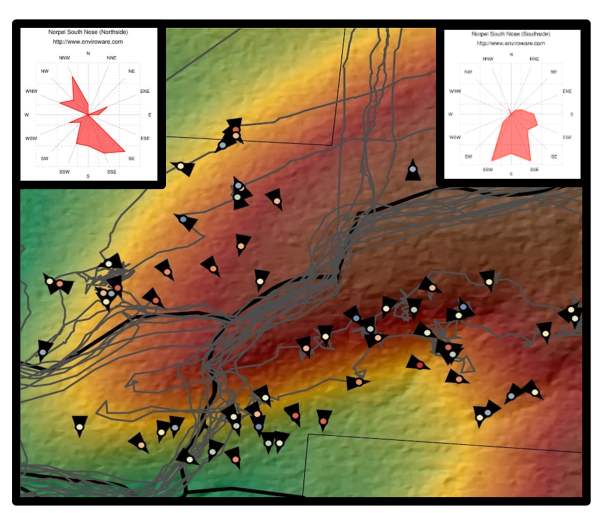


Figure 1C:

- Southern ridge east of Norpel Woods.
- Trees tended to fall in a (SE) direction even when upslope

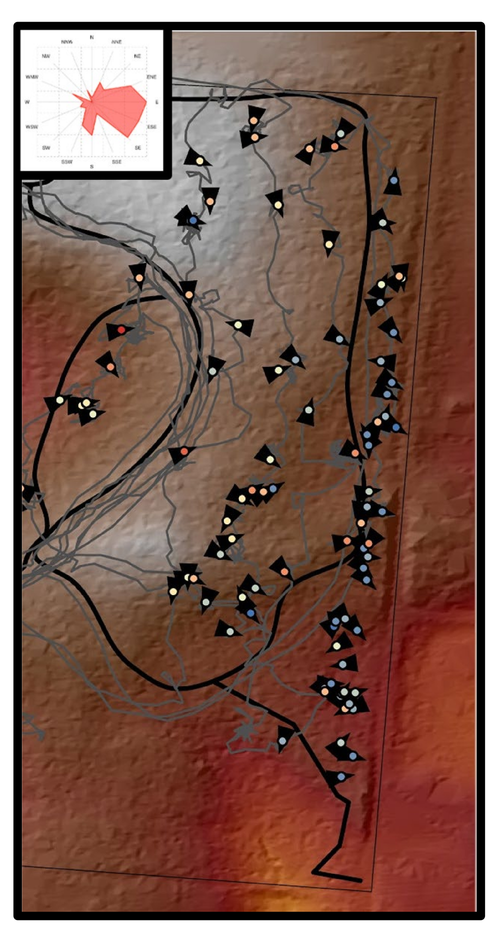
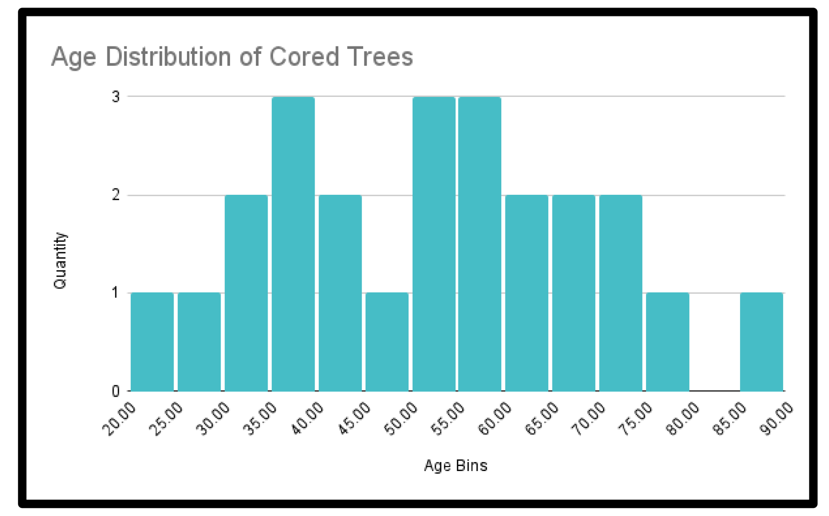


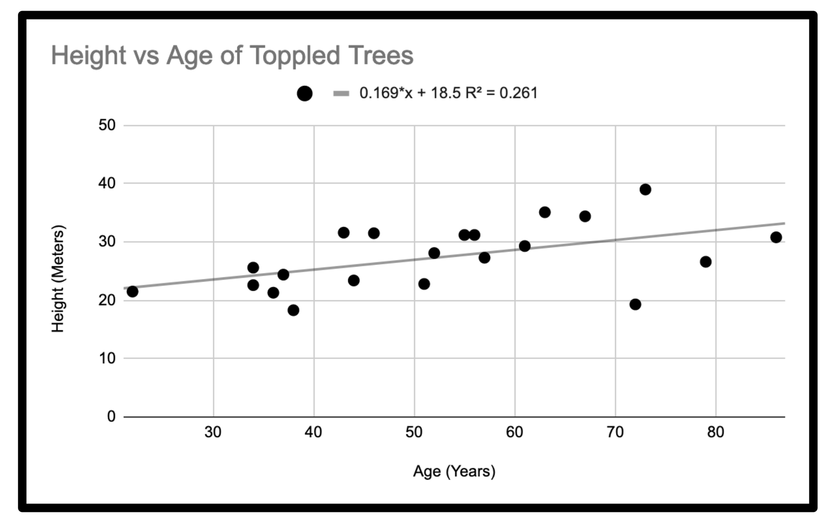
Figure 1D:

- This is the Norpel Woods section of the bio reserve.
- A large section is a confer plantation.
- The dominant fall direction is primarily(SSE).
- The gradually sloping landscape requires that wind is the more dominant factor in fall direction.
- The soil flux rate here is relatively low because of the compared to every other section of the bio reserve.

Tree Core Data:

Ages were calculated when possible by extracting a tree core and counting growth rings, shown to the left. Trees died at a mean age of 52 years. This varied by species. The only species-specific data we were able to gather was for sugar maple, which also had a mean age of 52 years. We were unable to collect a sufficient number of conifers to generate a good dataset.





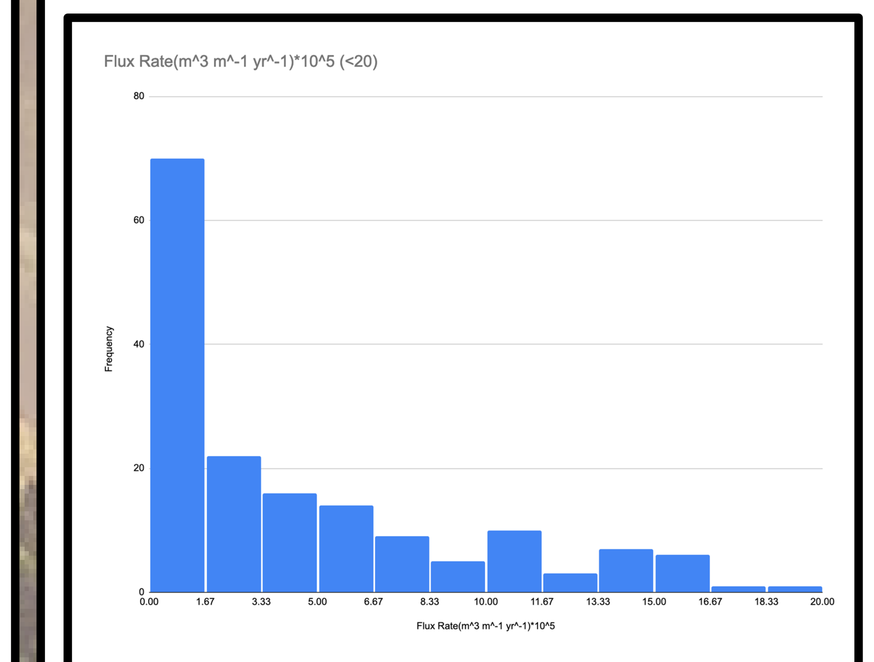
The correlation isn't strong, but there is a connection between age and height, as expected. We think this relationship would be stronger if we had more species data. While our R^2 value for Sugar Maple is lower, this is likely due to low sample size. Hopefully sampling a number of species would yield a stronger correlation

Soil Flux and Soil Mantle Turnover Rates:

The histogram below shows more than 95% of our calculated flux rates. Some outliers were up to $330*10^{-5}$ m^3 m^{-1} yr^{-1}. We calculated these flux rates following the approach of Gabet et al., 2003, where:

q_s= vol/event × distance/event × events/area × events/time.

The photo on the right is a piece of siltstone embedded in the root structure of a toppled tree. Root structures are extremely powerful and are able to uproot sizable clasts even larger than this one.



Turnover Rates: We also calculated an approximate duration for the amount of time it would take to turnover this landscape's soil mantle through the process of tree throw alone. Our results yielded a range from 7600 years in area 1B to 19,000 years. Our interpretation is that with limited high slope areas in the Norpel section, trees are less likely to topple in strong winds whereas in area 1B, the hillslope is quite steep, thus increasing the likelihood of topple.

Initial Conclusions:

The role of tree throw in the Denison bio reserve is clearly significant. Based on our calculated turnover and flux rates, wind and relief seem to be the primary controls on this geomorphic regime. This study should be expanded beyond the Denison Bio Reserve with the goal of capturing more species and age-based data of less decayed trees.

Plans For Future Work:

Beyond continued surveying, we will be collecting samples to analyze for fallout radionuclides. We will use those data – Cs-137 inventories, in particular – to calculate hillslope sediment flux rates via mass and isotope balances.

References Cited:

Gabet, Emmanuel & Reichman, OJ & Seabloom, Eric. (2003). The effects of bioturbation on soil processes and sediment transport. Annu. Rev. Earth Planet. Sci. 31. 249-73.

Acknowledgments:

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