Key Points

- Pit/Mound Profiles evolve through time
- Models of mounds require “Background” Transport Rates (“no flux” boundaries are not appropriate) on the hillslope, and hence provide estimates of soil flux at the lower boundary
- Mounds mix soil horizons, bury O/A horizons downslope

Study Area

- Piedmont of NW Delaware, USA
- Hardwood Forests, Soil-mantled Hillslopes

Methodology

- Survey pit/mound topographic profiles
- Utilize log decay as proxy for age of mounds
- Forward model young mounds and compare model results with older measured mounds
- Utilize boundary conditions in the model to get at “background” hillslope transport rates

Abstract

Pit and mound topography in hardwood forest in the Piedmont of northwest Delaware exhibit a range of forms based on age. This change in shape with age provides an opportunity to study constraints on the dominant transport processes acting on the hillslope at this local scale, as well as longer term hillslope transport rates.

Pit/mound topography depends strongly on the boundary conditions in the model. A “no flux” boundary yields a growing wedge at the base and receding slope at the top of the profile, both of which are inconsistent with old pit and mound profiles. A constant flux boundary must be estimated to replicate observed profiles. Specified flux boundaries from numerical modeling provide some estimate, then, of longer term transport rates along the hillslope.

Both the up and down slope effects (in the numerical model) are small, however, relative to the large changes of steep slopes on the mound itself. The slope-dependent transport model, yields a strong and fairly straightforward prediction: step-like smooths rapidly over time. Older mound profiles show spread out over the hillslope over time, suggesting a diffusive type of transport. However, slope dependent diffusive transport does not adequately describe all of the mounds we observe. Steep asperities present in many mounds long after the log has decayed and the mound has largely filled. Why? Pebbles mantle many of the older mounds, and rock-capped pedestals are common. Rock-covered pinnacles imply that rain splash and/or surface runoff are dominant sediment transporting agents on the mound. While splash is often thought to be fundamentally different, particularly in uniforms sandy substrates, in the presence of scattered patches or “non-diffusive” topography.

Are Tree Throws Common? Yes! The group of logs below were in an area of roughly 2 hectares, or ~50 tree falls per 10,000 m². Note that fewer than 50% of logs actually generate a pit and mound (lots of snags).

Topographic Profiles of tree throw pit-and-mound pairs

Potential tools to get at erosion rates

Exponential decay of relief, H = He^{-λt}, results in a rotation of a linear profile through time

Transport-based Profile Model

- Sediment transport rate, q, depends linearly on slope
- Randomly accesses nodes in a profile
- Updates elevation based on divergence of sediment transport

Hillslope transport rates. This is done via numerical modeling of pit and mound profiles. Applying a slope-dependent transport law to a young measured profile provides a forward model of pit and mound topography. Slope-dependent transport yields consistent predictions about mound and pit evolution. Namely, asperities on the mound are rapidly smoothed out. The pit fills with sediment. The uphill scarp reclines.

Modeling Time Evolution, Stage 1 Mound

The lower boundary condition is set as “constant flux”. No build up of sediment at the lower boundary, and mound material is transported away without showing much of an effect on the topographic surface.

Here we then, need to look closely at soils downslope from the mound.

The growing wedge at the base, and declining hillslope above the pit and mound suggest that “no flux” boundaries are not appropriate for this hillslope.

Quantify log decay

- Map soil horizons below mounds (better delineation of downslope transport and mixing of mound-derived material back into the soil horizons)
- Explore non-linear transport rules, and characterize time-dependent soil density in modeling efforts