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Tree Throw Pit/Mound Evolution and Soil Transport

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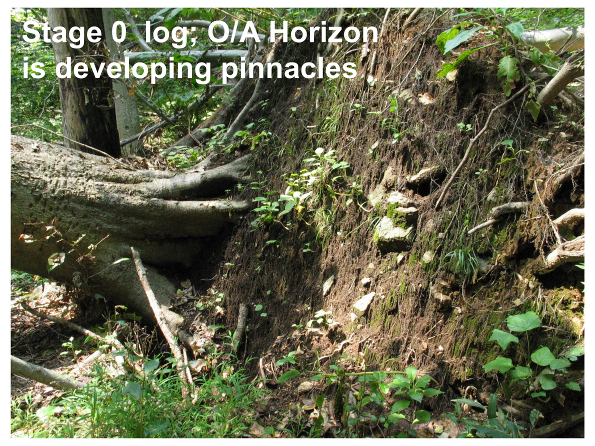
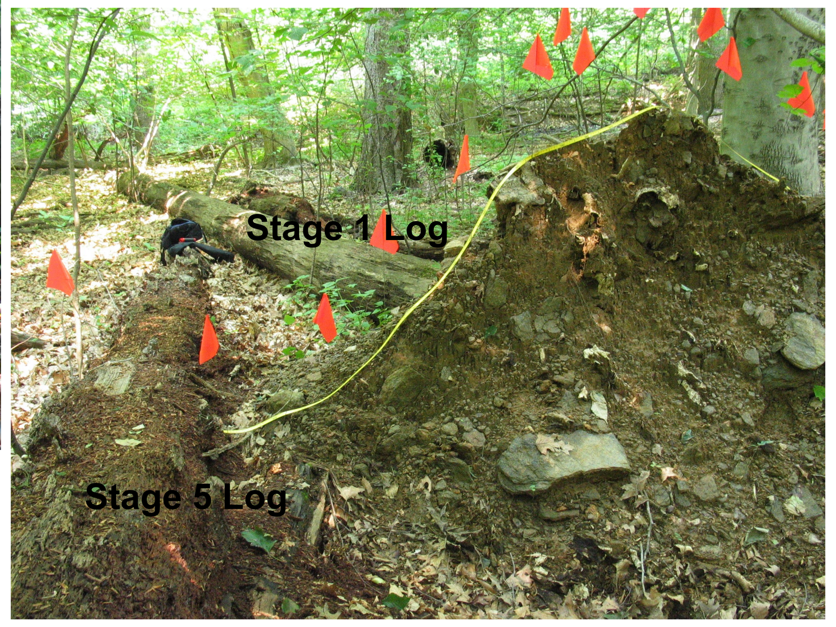
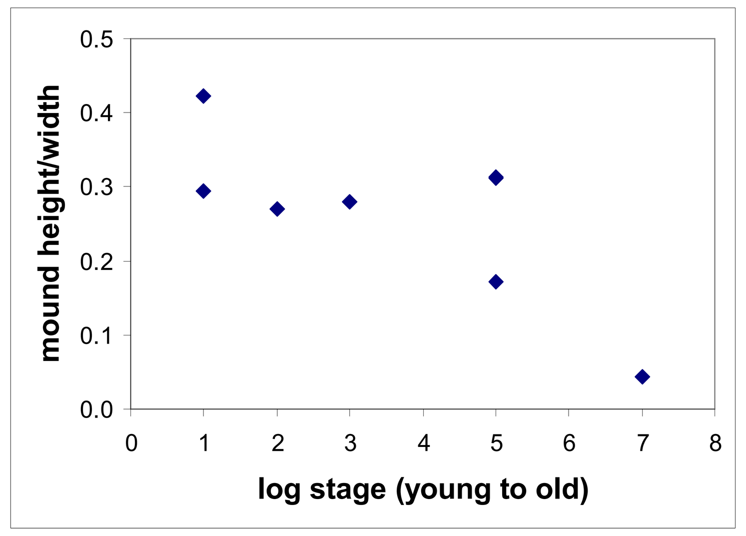




Log and mound decay



Stages
- 0—leaves present; tree fell in current season
- 1—Bark intact; small limbs and rootlets present
- 2—Bark gone; solid bleached wood exposed;
- 3—Log surface>50% solid, duff appearing
- 4—Log surface<50 solid; duff covers most of log
- 5—Log surface 100% duff covered; limb nodes protrude
- 6—Log is mound of reddish duff
- 7—All evidence of log is gone

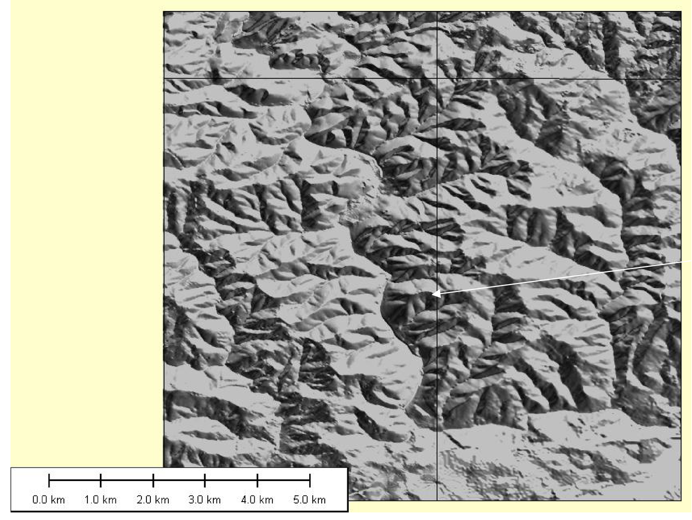
Mound height to cross slope width ratio declines in parallel with log stage; we need better age constraints here!!

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

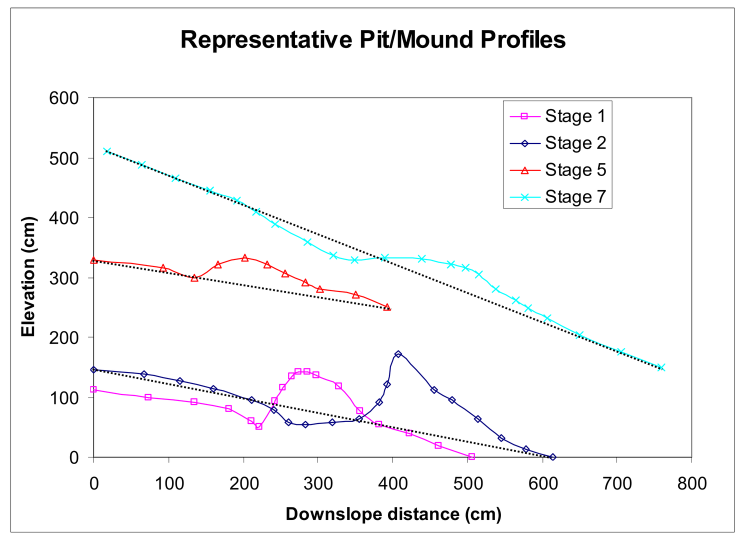
- *Piedmont of NW Delaware, USA*
- *Hardwood Forests, Soil-mantled Hillslopes*

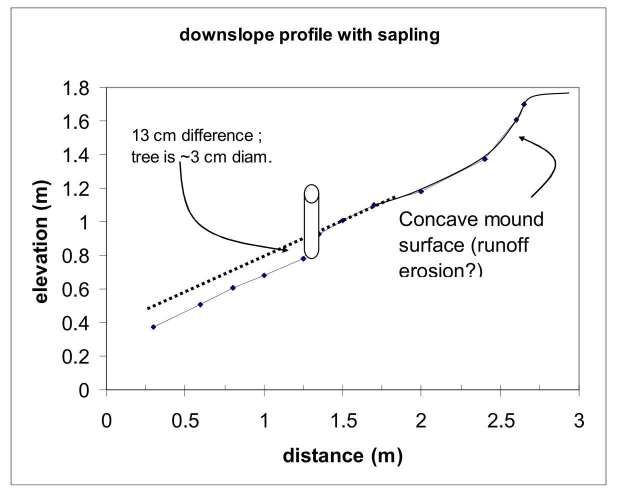


Methodology

- *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*

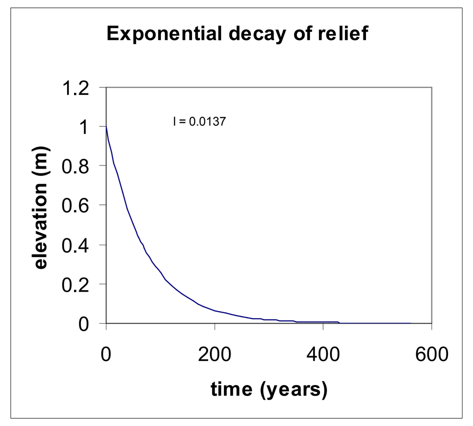
Topographic Profiles of tree throw pit-and-mound pairs

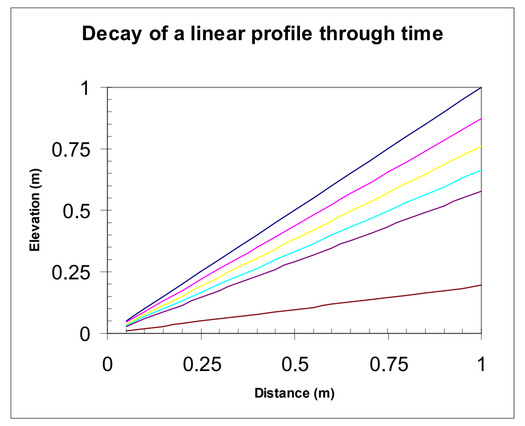




Potential tools to get at erosion rates

Exponential decay of relief, $H = H_o e^{-\lambda t}$, results in a rotation of a linear profile through time





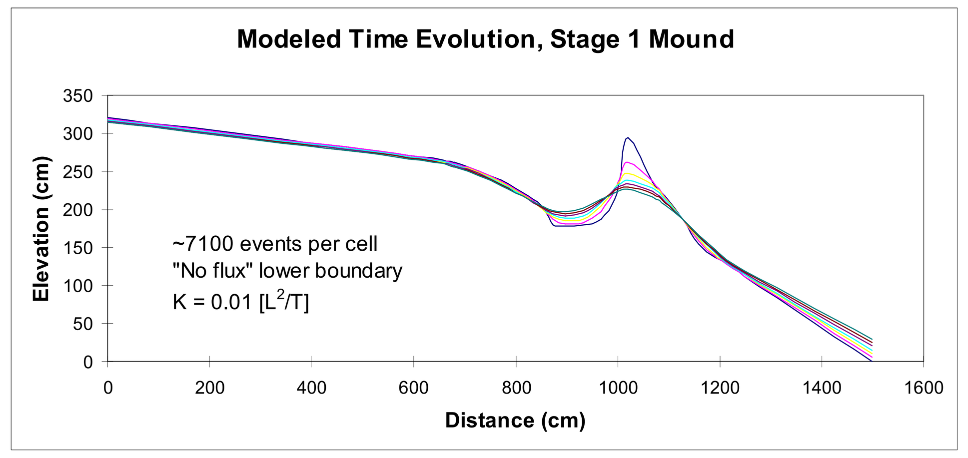
Decay constant λ = 0.0137 per year, from Zeide's work with tree throw mounds in NW Pennsylvania (Zeide, 1981)

As an erosion law, this model doesn't tell us much about transport—except that transport rates must increase downslope, and on a linear profile, this seems unlikely…

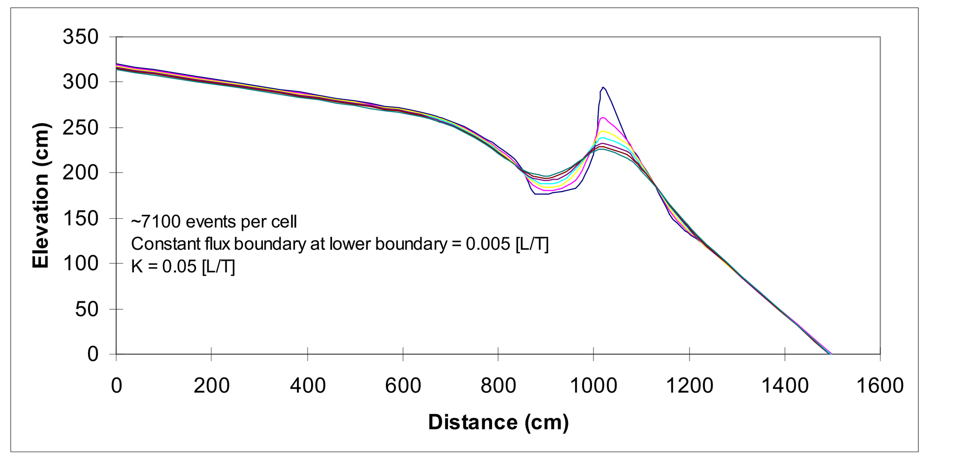
Transport-based Profile Model

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

$$\frac{\partial z}{\partial t} = -K\frac{\partial}{\partial x}q_s = -K\frac{\partial}{\partial x}f(S) = -K\frac{\partial}{\partial x}\frac{\partial z}{\partial x} = -K\frac{\partial^2 z}{\partial x^2}$$



The growing wedge at the toe, and declining hillslope above the pit and mound suggest that "no flux" boundaries are not appropriate for this hillslope



The lower boundary condition is set at "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.

Hence, this could be a tool to get at longer term hillslope scale transport rates!

We also then, need to look closely at soils downslope from the mound…

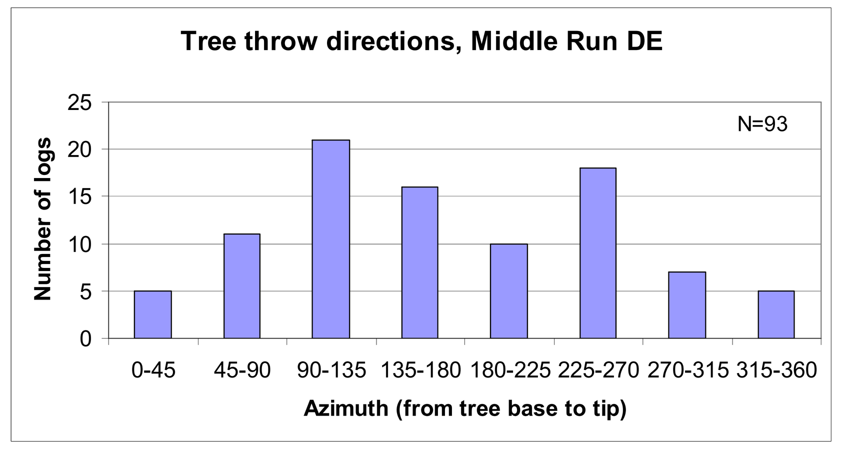
Abstract

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

Both upslope from the pit and downslope from the mound, the evolution of topography depends strongly on the boundary conditions in the model. A "no flux" boundary yields a growing wedge at the base and reclining 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 straight-forward prediction: asperities smooth rapidly over time. Older mound profiles do 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. Sharp asperities persist on many mounds long after the log has decayed and the pit has largely filled in. 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 mounds. While rainsplash is often thought to be fundamentally diffusive, particularly in uniform sandy substrates, in the presence of scattered pebbles, a "non-diffusive" form appears.

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



More work to do:

- ***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***