

DATA REPOSITORY ITEM**A PROCESS BASED MODEL LINKING POCKET GOPHER (*THOMOMYS BOTTAE*) ACTIVITY TO SEDIMENT TRANSPORT AND SOIL THICKNESS.**

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A BIOTURBATED SOIL MANTLE IN TRANSVERSE RANGE OF SOUTHERN CALIFORNIA

A soil-mantled hillslope in the Transverse Range of southern California, showing a thick, dark homogeneous A horizon (biomantle) overlying a distinct stone line. The homogeneity of the A horizon, the corresponding depths of gopher burrows, and the near absence of stones in the A horizons, are all consistent with previous interpretations in the region (Johnson, 1990)

Figure DR 1



DERIVATION OF EQUATION 5

1. $E = \nabla \cdot \tilde{q}_s$
2. $E = \frac{1}{g\mu^2\rho_s} \nabla \cdot \left[\frac{NP_i(-\nabla z)}{1-|\nabla z/\mu|^2} \right]$
3. $E = \frac{1}{g\mu^2\rho_s} \frac{1}{1-|\nabla z/\mu|^2} \left[NP_i(-\nabla^2 z) + \frac{2}{\mu^2} NP_i |\nabla z| \frac{(-\nabla z) \cdot (\nabla |\nabla z|)}{1-|\nabla z/\mu|^2} + (-\nabla z) \cdot \nabla (NP_i) \right]$
4. $E \approx \frac{1}{g\mu^2\rho_s} \frac{P_i}{1-|\nabla z/\mu|^2} [N(-\nabla^2 z) + (-\nabla z) \cdot \nabla N]$
5. $E \approx \frac{NP_i}{g\mu^2\rho_s} \frac{-\nabla^2 z}{1-|\nabla z/\mu|^2}$

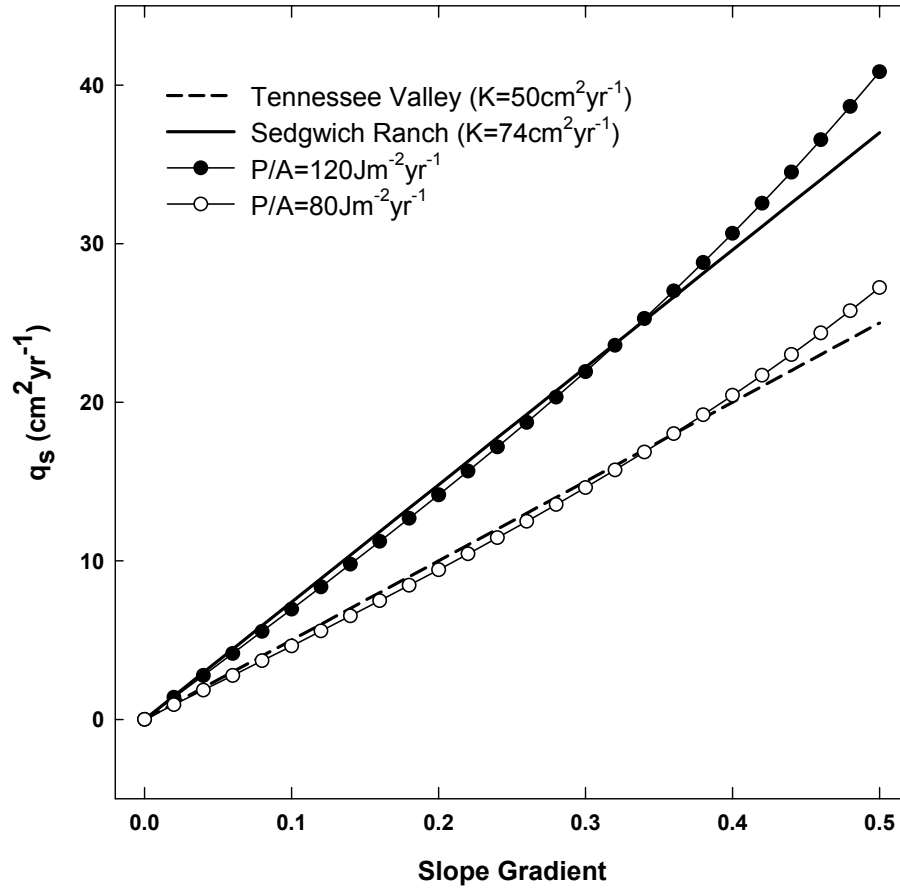
In the third equation, we ignored the second term in the parenthesis: for the 20 % slope used in this study, the omission of the second term leads to a 5 % underestimation of erosion rates. Secondly, ignoring $\nabla z \cdot \nabla N$ (in the fourth equation) does not imply a spatially constant N . This is an approximation in that the term $(\nabla z \cdot \nabla N)$ is smaller than $N(-\nabla^2 z)$. The term $-\nabla z \cdot \nabla N$ represents the rate that population density increases with distance in the steepest sloping direction. This term could be significant where convex slopes grade into footslopes with accompanying soil thickness increases, leading to population density increases. However, on convex slopes of the specific slope gradient and curvature we investigated, $\nabla z \cdot \nabla N$ is ignored due to (1) its small contribution to soil erosion relative to $N(-\nabla^2 z)$ and (2) the fact that our focus on a given point on the slope does not provide a boundary condition to calculate ∇N .

THE QUANTIFICATION OF BIOLOGICAL POWER INPUT

In the figure below, we plotted the linear approximation of the relationship between sediment fluxes and slope gradient for Tennessee Valley (Heimsath et al.,

1997) and Sedgewick Ranch (Gebert, 2000). Then, we choose power inputs (P/A) that allowed the sediment flux model (Eq. 4) to most closely replicate the empirical relationship between sediment fluxes and slope gradients.

Figure DR 2

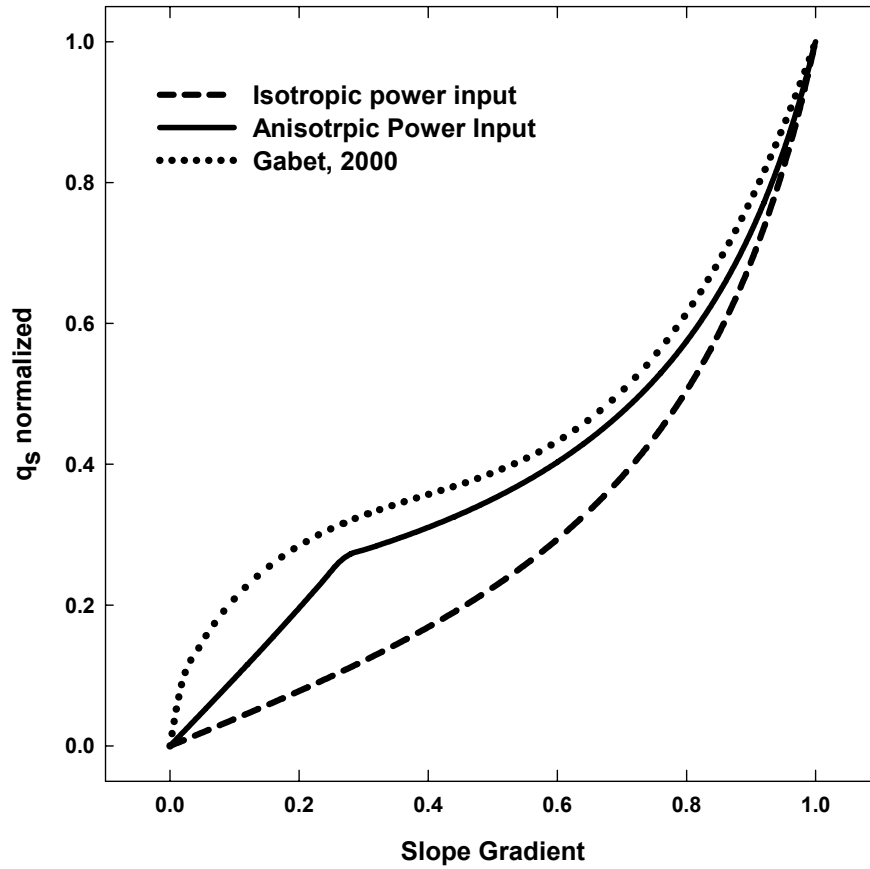


GOPHER'S POWER ORIENTATION

While we focused on the variation of gopher population density, our model can also address the gopher's preferential movement of sediments in certain directions by adjusting ψ in Eqs. 2 and 3. At Sedgwick Ranch, Seabloom et al., [2000] reported that gophers orient the lateral branches (used to push the excavated soils to ground surface)

exclusively in a downslope direction beyond a slope gradient of 0.27 to prevent tunnel back-filling. At the same site, Gabet [2000] observed that sediment flux abruptly increased on low gradient slopes due to gopher's preferential soil movement in a downslope direction. To simulate these cases, we calculated a sediment flux as a function of slope gradient with ψ increasing from 0.5 (isotropic power input at flat surface) to 1 (at gradient of 0.27). The calculated sediment fluxes were normalized relative to the sediment at the slope gradient of 1 in the figure below. This exercise shows an abrupt increase in sediment flux at low gradient slopes, which agrees with the observation by Gabet [2000].

Figure DR 3



THE APPLICATION OF SOIL THICKNESS DEPENDENT BIOLOGICAL ACTIVITY

While our paper focused on pocket gophers, biological soil thickness-dependent erosion may be a widespread but unrecognized phenomenon, though abiotic thickness-dependent creep has been suggested (e.g. Furbish and Fagherazzi, 2001). In Australia where soil transport occurs by burrowing wombats (*Vombatus ursinus*), ants, and termites (Heimsath et al., 2000), Braun et al. (2001) observed that soil thickness-curvature relationships disagreed with predictions based on a linear sediment transport model. They resolved the discrepancy using a thickness-dependent creep model (figure below). The inset in the figure is the biological power input that enables Eq. 8 to fit the observations. This suggests a nonlinear increase in biological mixing when soil thicknesses are $\geq \sim 50$ cm, consistent with observations that wombats habituate soils thicker than 30 cm (Heimsath et al., 2001). This proposed explanation for the observed soil thickness pattern is testable by field observations of biological activity.

Figure DR 4

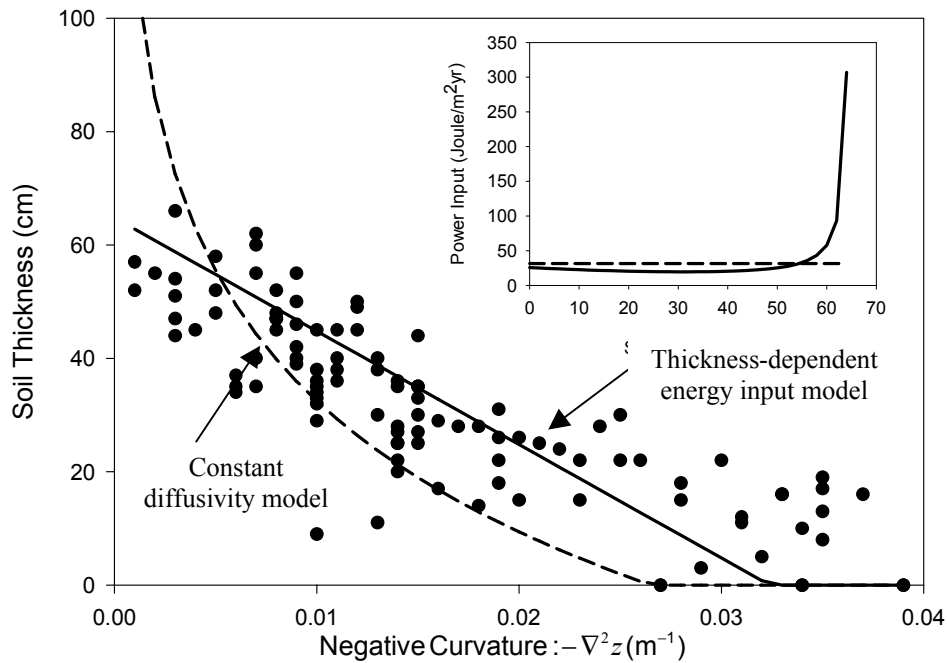


Figure. Measured soil thicknesses and curvatures on an Australian forested hillslope (Heimsath et al. 2000). The solid line is the calculated non-linear model steady state soil thickness derived using a soil thickness-dependent power input (solid line in inset figure). The broken line is the steady state soil thickness calculated using a spatially constant diffusivity ($49 \text{ cm}^2 \text{ yr}^{-1}$) or soil thickness-independent constant power input (the dashed line in inset figure) [Heimsath et al., 2000].

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