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A Biologically Informed, Mechanistic Model of Desert Shrub Population Dynamics Bearing on Arid Landscape Evolution

Stacey Worman (1), David Furbish (2), and Siobhan Fathel (2)

(1) Division of Earth and Ocean Sciences, Nicholas School of the Environment, Duke University, Durham North Carolina, USA, (2) Department of Earth and Environmental Sciences, Vanderbilt University, Nashville Tennessee, USA

In arid landscapes, desert shrubs individually and collectively modify how sediment is transported (e.g by wind, overland-flow, and rain-splash). Addressing how desert shrubs modify landscapes on geomorphic timescales therefore necessitates spanning multiple shrub lifetimes and accounting for how processes affecting shrub dynamics on these longer timescales (e.g. fire, grazing, drought, and climate change) may in turn impact sediment transport. To fulfill this need, we present a mechanistic model of the spatiotemporal dynamics of a desert-shrub population that uses a simple accounting framework and tracks individual shrubs as they enter, age, and exit the population (via recruitment, growth, and mortality). Our model is novel insomuch as it (1) features a strong biophysical foundation, (2) mimics well-documented aspects of how shrub populations respond to changes in precipitation, and (3) possesses the process granularity appropriate for use in geomorphic simulations. In a complimentary abstract (Fathel et al. 2014), we demonstrate the potential of this biological model by coupling it to a physical model of rain-splash sediment transport: We mechanistically reproduce the empirical observation that the erosion rate of a hillslope decreases as its vegetation coverage increases and we predict erosion rates under different climate-change scenarios.