Geomorphic thresholds

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Long-Term context: Arid and semiarid ecosystems are linked to geomorphic thresholds. Soils supply plants water and nutrient and are habitat for vertebrates, invertebrates, and billions of microorganisms (Bestelmeyer et al. 2003; 2015). Vegetation alters soil by secreting organic acids, mining mineral nutrients, breaking down rock by root expansion, and preventing erosion as ground cover while burrowing animals mix soil and microbes decompose organic matter and control oxidation-reduction reactions.

Approach: Our approach to understanding these linkages is to examine vegetative-soil-geomorphic patterns across multiple spatial and temporal scales. At the landscape scale, for example, topography affects micro-climate as a result of elevation, lateral redistribution of water, and slope orientation, which affects soil water and temperature impacts vegetation. Perturbations, like overgrazing, propagate through this system as a consequence of selective herbivory and seed dispersal that reduces ground-cover and promotes erosion and sedimentation (Fig. 1, Left).

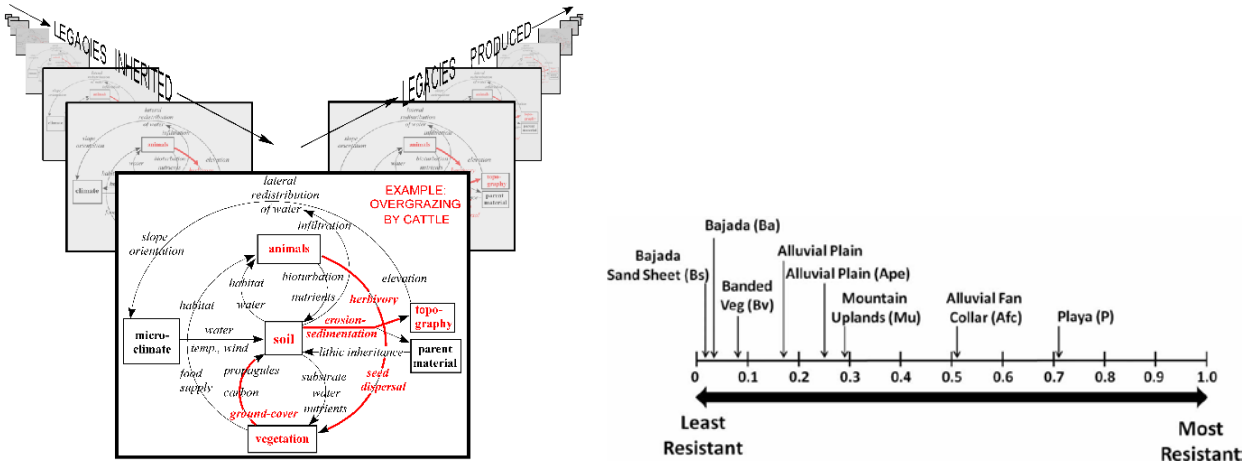

Fig 1. (Left) Conceptual framework showing linkages between ecological, soil, and geomorphic factors and processes, and their interactions with microclimate in dryland systems (Monger and Bestelmeyer 2006). (Right) A resistance index (RI) showing sensitivities of grassland to shrub invasion on Jornada landforms since 1858 (Rachal et al. 2012).

Specific objectives in the past 3 years were to continue mapping vegetative-soil-landforms patterns. These analyses have revealed that C4 grasslands on certain landscapes are more resistant to change than others when viewed in the context of 150+ years. The most resist C4 grasslands are on the heavy-textured depressions that receive run-on water from neighboring slopes (Figure 1, Right). The least resistant landforms (i.e., the most vulnerable to invasion by C3 shrublands) are on bajada landforms that lose water to runoff.

Our carbon isotope results support these conclusions. Comparison of $\delta^{13}C$ values were made along two transects of backhoe trenches that descended a bajada into an alluvial flat (Fig. 2). These trenches made it possible to trace carbon isotopes both laterally (giving a comparison across the landform boundary) and vertically (giving a comparison through time). Laterally, the modern soils have $\delta^{13}C$ values suggesting 32% C4 on the bajada vs. 52% C4 in the alluvial flat. The paleosols have 73% C4 on the bajada vs. 66% C4 in the alluvial flat (Fig. 5). Vertically, the bajada experienced a significant loss of C4 grasslands beginning in the mid-Holocene (73% vs. 32%), in contrast to the alluvial flat where there was a decline, but not a replacement of C4 vegetation (66% vs. 52%).

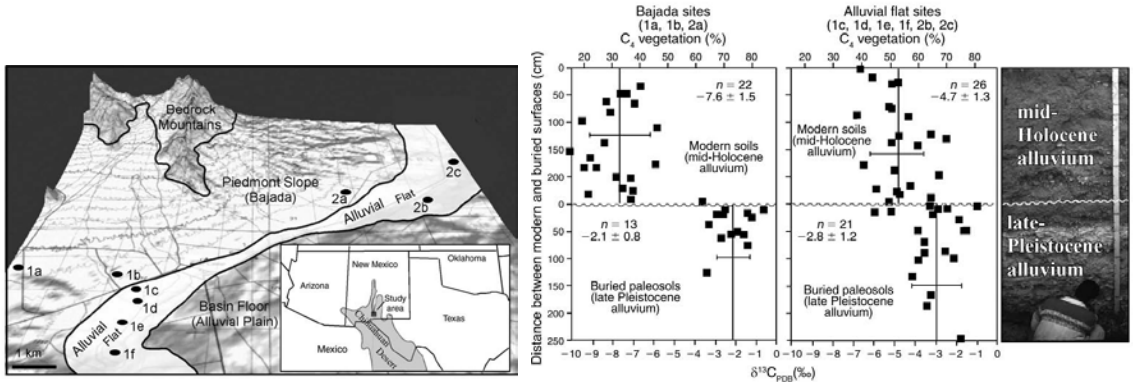

Fig 2. Comparison of $\delta^{13}C$ values of modern soils vs. underlying paleosols across a bajada–alluvial flat boundary (Monger et al., 2009). The wavy horizontal line in the picture and in the two graphs to the left corresponds to the depth of the buried land surface and marks the top of the paleosol.

Relationship with the LTER VI proposal: This objective falls under Obj. 5 (b) Patterns in soils and geomorphology.

Future analyses: We will continue to quantify the conceptual model linking Jornada ecosystems with geomorphic thresholds (Figure 1, Left). Soil moisture, for example, is being measured at multiple depths in 4-hour intervals at the Soil Climate Analysis Network site on the eastern bajada in neighboring grassland, dune, and bare sites. An array of other sites across the Jornada, such as the meteorological stations at the NPP sites, are also measuring soil moisture as well as soil temperature. We plan to investigate how soil climate regimes are migrating at the landscape and regional scales and how these lateral shifts will affect vegetative feedbacks to soils and geomorphic thresholds.

Literature Cited:

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