Transport vectors as drivers of dryland decomposition

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Decomposition of organic material is a fundamental driver of ecosystem processes. Research on decomposition has therefore been a component of the Jornada LTER program since its inception. While decay rates in mesic systems are generally quite successfully predicted by models driven by climatic variables, Whitford *et al.* {, 1981 #1646} pointed out a disconnect between measured and modeled decay rates in dryland ecosystems. This fundamental lack of understanding of the controls over decomposition in drylands remains today (reviewed in Throop and Archer 2009). However, recent research suggests two key drivers have been historically overlooked: UV photodegradation and soil transport processes, both a function of vegetation structure. Thus, cross-scale interactions are strongly at play in dryland decomposition, with patch structure influencing soil and plant material transport vectors and subsequent decomposition dynamics.

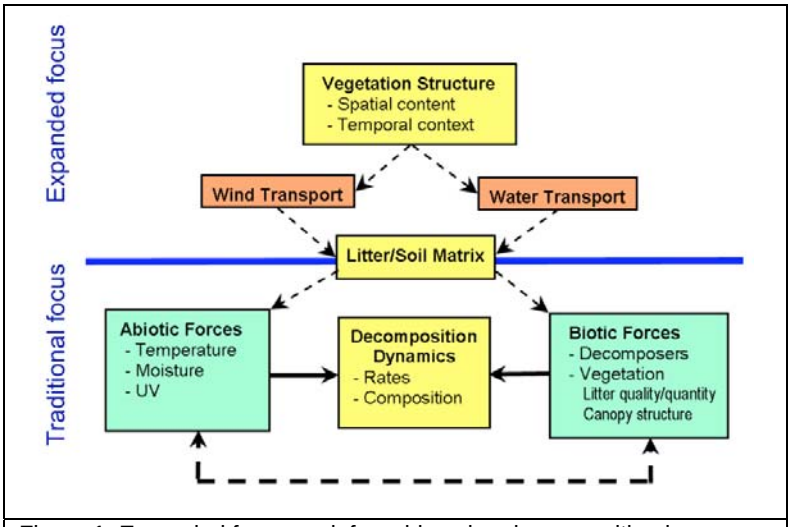

Figure 1. Expanded framework for addressing decomposition in drylands. We hypothesize that the litter/soil matrix is controlled by wind/water transport of soil which, in turn, is controlled by vegetation structure. We further hypothesize that as the litter/soil matrix develops, traditionally considered biotic (microbial activity) and abiotic forces (moisture, UV photodegradation) are strongly mediated. (From Throop & Archer 2009)

Our current work on decomposition at the Jornada LTER arose from work in the Sonoran Desert, where we found that vegetation structure was a fundamental driver of decomposition via its influence on aeolian and fluvial soil transport. Decreases in grass cover led to increased soil-litter mixing, which in turn enhanced rates of decomposition (Throop and Archer 2007). From this, we suggest that dryland decomposition dynamics must be explored within a conceptual framework that extends the traditionally-considered direct abiotic and biotic influences on decomposition to include an accounting of how vegetation structure influences transport vectors (wind and water) to determine the amount of litter-soil mixing (Figure 1).

We are currently quantifying 1) the links between vegetation structure/transport processes, UV photodegradation, and decomposition rates and 2) the mechanisms by which soil-litter mixing influences decomposition. We are testing the expanded framework in Figure 1 in the wind manipulation plots at the JRN. In the plots, established by Greg Okin and colleagues, grass cover has been reduced, thus reducing connectivity of herbaceous patches and promoting soil movement by wind transport processes (Li et al. 2007). Results following one year litterbag collections indicate that grass removal treatments and within-plot locations do not strongly affect decomposition rates. However, soil-litter mixing increases markedly with time on the plots with a strong effect on litter mass loss (Figure 2).

We are using litter incubations in controlled environment chambers to explore the mechanisms for observed field patterns. Preliminary data suggests that, while UV radiation can lead to significant mass loss through photodegradation, this effect is negated when thin layers of soil cover litter. Additional incubations suggest that soil-litter mixing most strongly influences decomposition under intermediate soil moisture treatments (Figure 3). Through a project with Los Alamos National Lab, we are using stable isotope analyses to tease apart biotic and abiotic drivers of decomposition.

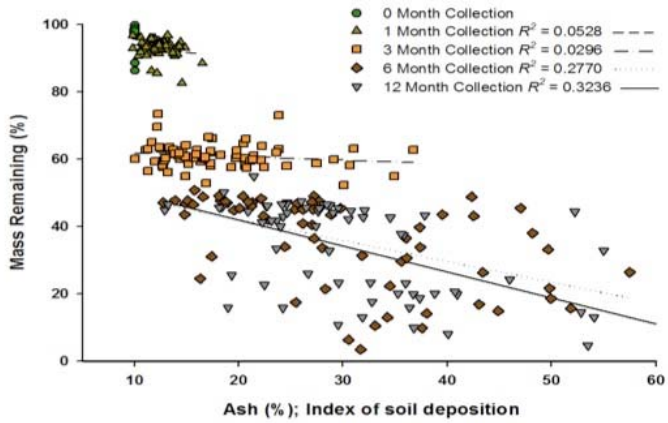

Figure 2. Relationship between soil-litter mixing and decomposition rates in litterbags deployed in the Okin et al. vegetation manipulation study.

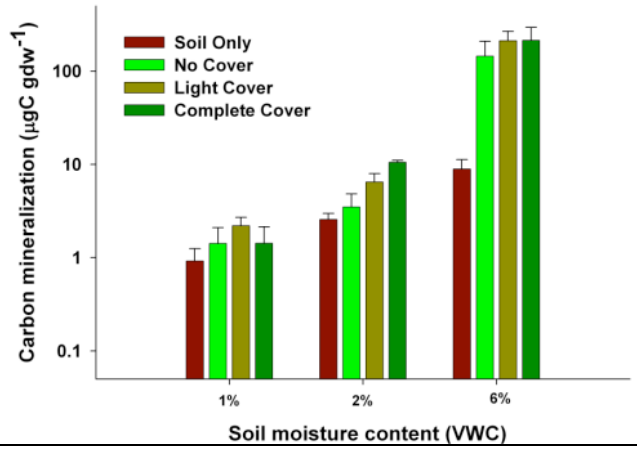

Figure 3. C mineralization following one week of lab incubation.

Several related projects also explore how transport vectors influence decomposition dynamics. NSF-REU student Jessica Fitzgerald is using laboratory incubations to explore interactions between soil-litter mixing and rainfall pulses on leaf litter decomposition. A project funded by the International Arid Lands Consortium explores the influence of fires on soil stability, soil-litter mixing, and subsequent litter decomposition rates in the San Andres mountains of the JRN.

This work links with fundamental questions asked in the Jornada V program. Patch-scale vegetation structure mediates transport vectors to influence the redistribution of soil, which in turn affect decomposition and subsequent nutrient availability.

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