Soil deposition and UV radiation influence litter decomposition in a shrub-invaded dryland ecosystem

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Introduction

- Decomposition of organic matter is a crucial component of global biogeochemical cycles that influences soil fertility, fate and residence time of soil C and N pools, and plant community composition and production.
- Predicting decomposition in drylands has proven problematic - models developed in more mesic systems typically under-predict rates in arid and semiarid systems.
- Lower vegetation cover in drylands means more soil movement and higher radiant energy loads on litter compared to mesic systems. We therefore propose that the performance of decomposition models could be improved by including soil-litter mixing and UV radiation components (Figure 1).
- Decomposition dynamics are also strongly influenced by land-cover changes that:
  - alter the quantity/quality of litter inputs via changes in plant life-form composition; and
  - alter the rate, extent and pattern of soil movement.
- The global phenomenon of shrub encroachment into grasslands (Figures 2, 3) redistributes C among herbaceous and woody vegetation reservoirs while simultaneously altering levels of soil-litter mixing and UV radiation to potentially influence decomposition.

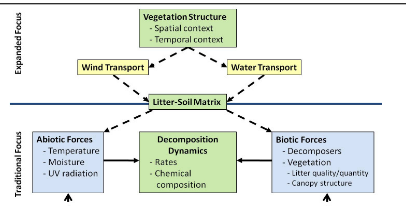


Figure 1. We test the proposition that changes in vegetation structure, coupled with subsequent changes in soil erosion, will significantly influence decomposition in drylands. If so, inclusion of these factors in models will improve our predictive capabilities (Throop and Archer 2009).

Objectives

- Quantify soil deposition and UV radiation effects on litter decomposition on litter from contrasting plant life-forms (grass vs. shrub).
- Determine the extent to which interactions between soil deposition and UV photodegradation drive decomposition.

Hypotheses

1. Soil deposition and UV radiation considered in isolation from each other will promote litter decomposition;
2. Soil deposition will shield litter and negate UV radiation effects. However,
3. Soil deposition x UV interactions will be such that soil deposition will have a net positive effect on decomposition rates.
4. Soil deposition, UV radiation and their interactions will have comparable effects on grass and shrub litter.

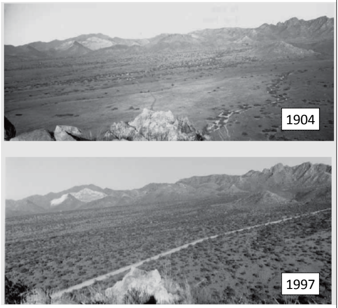


Figure 2. Changes in shrub cover on the Santa Rita Experimental Range, Arizona. We seek to understand how changes in grass and shrub abundance have altered the amount and quality of litter inputs to influence decomposition and hence, numerous soil properties.

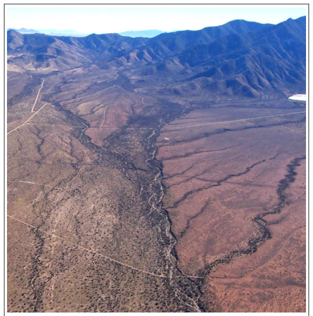
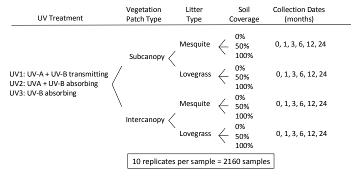


Figure 3. Aerial view of the Santa Rita Experimental Range illustrating contrast between shrub-invaded and grass-dominated soils. Photo: Bill Cable, 2003.

Methods

A factorial field experiment using open-topped litter boxes (Figure 4a, b) varied the following:

- Species
  - Mesquite (*Prosopis velutina*)
  - Lehmann lovegrass (*Eragrostis lehmanniana*)
- UV Radiation
  - Near ambient UV-A + UV-B
  - No UV-A or UV-B
  - No UV-B
- Total Radiant Energy (Canopy Cover)
  - Intercanopy – full sun in between canopies
  - Subcanopy – shaded under shrub canopy
- Soil Deposition
  - 0%, 50%, 100% of litter covered by soil



- Samples were collected at 0, 1, 3, 6, 12, and 24 months and analyzed for mass loss after ashing and litter chemistry. Ash content was used as an index of soil accumulation (Throop and Archer 2007).

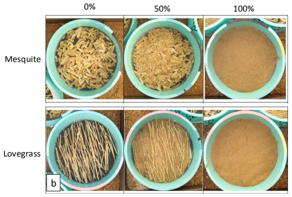


Figure 4. a) Experimental plots at University of Arizona Campus Ag Center. b) Soil deposition (% of litter covered by soil) treatment.

Results

Mixed Effects Model

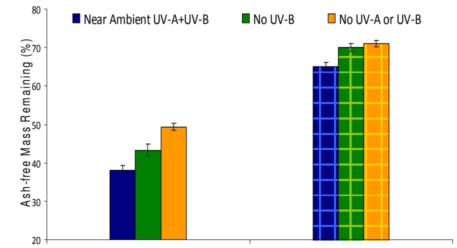
- Do treatments affect mass loss?

OVERALL	P-value
Species	< 0.0001
% Soil Cover	0.0183
UV	< 0.0001
Canopy	< 0.0001
% Soil Cover : Canopy	0.0136
% Soil Cover : Species	0.0573
Species : UV	0.0714
Species : Canopy	0.0851

MESQUITE	P-value
% Soil Cover	0.0167
UV	< 0.0001
Canopy	0.1291
LOVEGRASS	
% Soil Cover	0.0114
UV	0.0006
Canopy	0.4421
% Soil Cover : Canopy	0.0256

UV Radiation

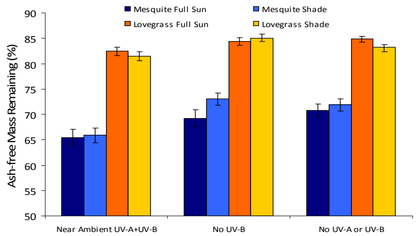
- At 12 months, a UV effect becomes apparent:
  - Greatest mass loss under ambient (full) UV; least mass loss when UV-A and UV-B blocked.
  - Mesquite lost more mass overall than lovegrass.



Results

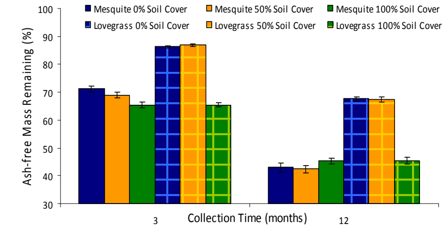
UV Radiation and Canopy

- Species responded similarly to UV treatments, but differently to overall radiant energy regime (full sun vs. shade).
- Both species lost more mass under ambient UV conditions compared to blocked UV treatments.
- Mesquite lost more mass in full sun treatments; lovegrass lost more mass in shade treatments.



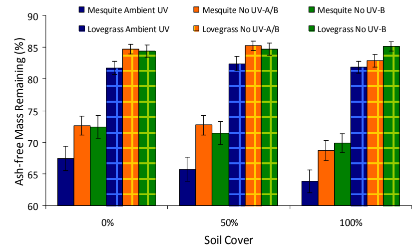
Soil Cover

- Soil cover generally promoted mass loss.
- Lovegrass was more responsive to high soil coverage than mesquite.



UV Radiation and Soil Cover

- Soil cover mediated the direct effects of UV on mesquite litter decomposition **but not lovegrass**.



Conclusions and Implications

- Soil-litter mixing and UV exposure were important drivers of decomposition. As such, their inclusion in models will improve our ability to predict changes in soil development in drylands.
  - Shrub and grass litter responded differently to UV and soil cover treatments.
    - Likely driven by litter quality (e.g., [N], lignin, cellulose).
- Results suggest land cover change in drylands will have substantial influences on litter decomposition dynamics.
  - Shifting from grassland to shrubland will change microsite and soil movement dynamics that will:
    - increase the amount of soil-litter mixing;
    - shield litter and decomposers from UV radiation.
  - Differences between shrub and grass litter decomposition will influence rates and dynamics of C input.
    - Decreased input of grass litter and increased input of highly labile mesquite litter will potentially increase the rate of C input.

Future Analyses

- Mass loss and litter chemistry – 24 mo. samples
- Mineralogy of soil films (x-ray diffraction)
- Microbial analyses (PLFA)

References

- Throop HL and SR Archer. 2007. Interrelationships among shrub encroachment, land management, and litter decomposition in a semidesert grassland. Ecological Applications 17: 1809-1823.
- Throop HL and SR Archer. 2009. Resolving the dryland decomposition conundrum: some new perspectives on potential drivers. Progress in Botany 70: 171-194.

Acknowledgements

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