Soil-litter Mixing Accelerates Decomposition and May Promote Soil Aggregate Formation in the Chihuahuan Desert

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Introduction

•Decomposition strongly regulates nutrient cycling and carbon storage
•Decomposition models under-predict rates of decomposition in drylands
•Recent studies have shown soil-litter mixing and UV radiation to be potentially important drivers of decomposition in drylands (Fig. 1)
•Drylands worldwide have seen a shift from grass dominance to shrub dominance during the past century
•Shrub encroachment may influence decomposition via changes in the abiotic environment (i.e. soil erosion & UV exposure)
•process in drylands.

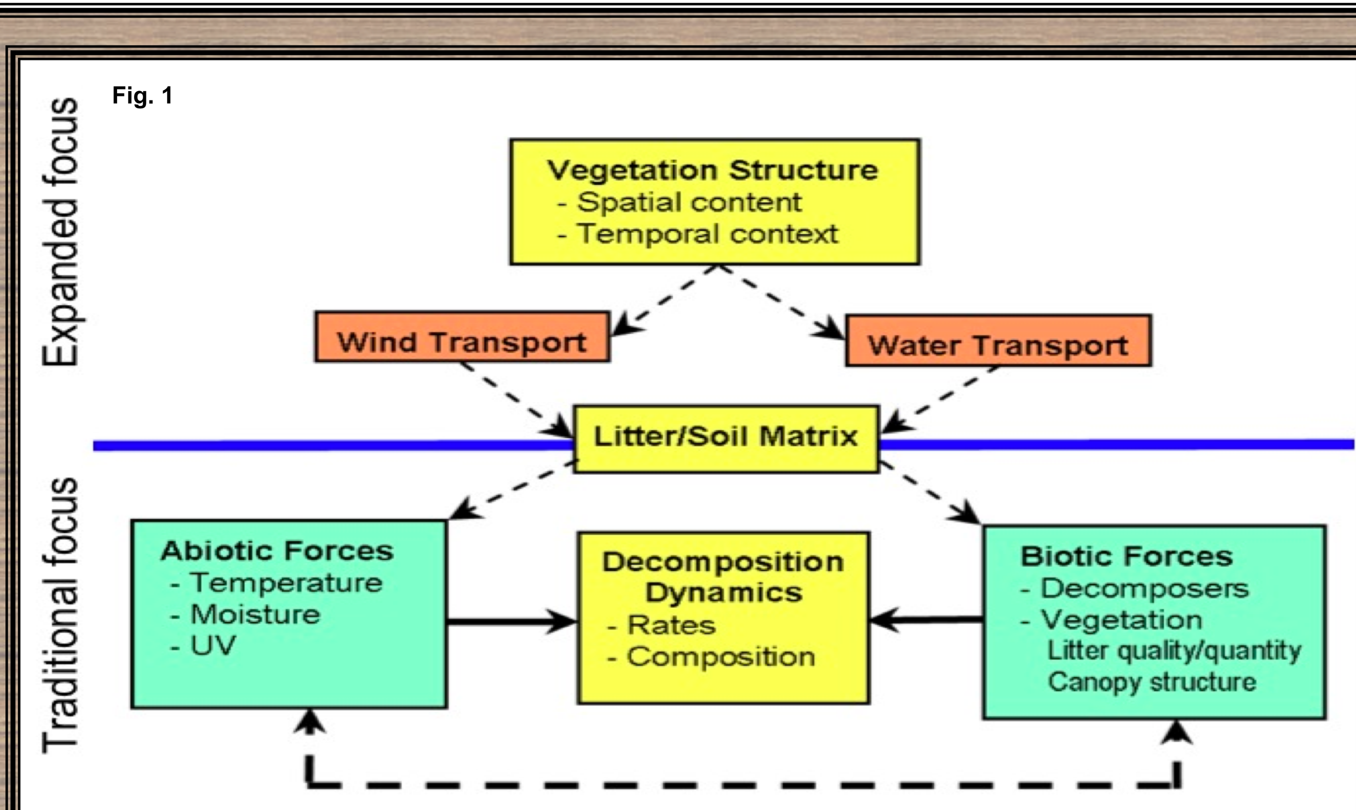


Figure 1 Recent work suggests that changes in vegetation structure, and subsequent changes in soil erosion, may influence decomposition in dryalnds (Throop & Archer 2009).

Study Objectives

1.Quantify the role of grass cover on soil-litter mixing as a driver of decomposition in drylands
2.Characterize cover and formation of soil-litter films and soil aggregates using microscopy based techniques

Methods

•Litterbag experiment in a mixed grassland at the Jornada Experimental Range, southern New Mexico, USA
•Grass removal treatments (Fig. 2) simulated the loss of native perennial grasses following shrub encroachment in the Chihuahuan Desert, which increases bare surface exposure to erosive winds and soil flux (Li et. al. 2007)

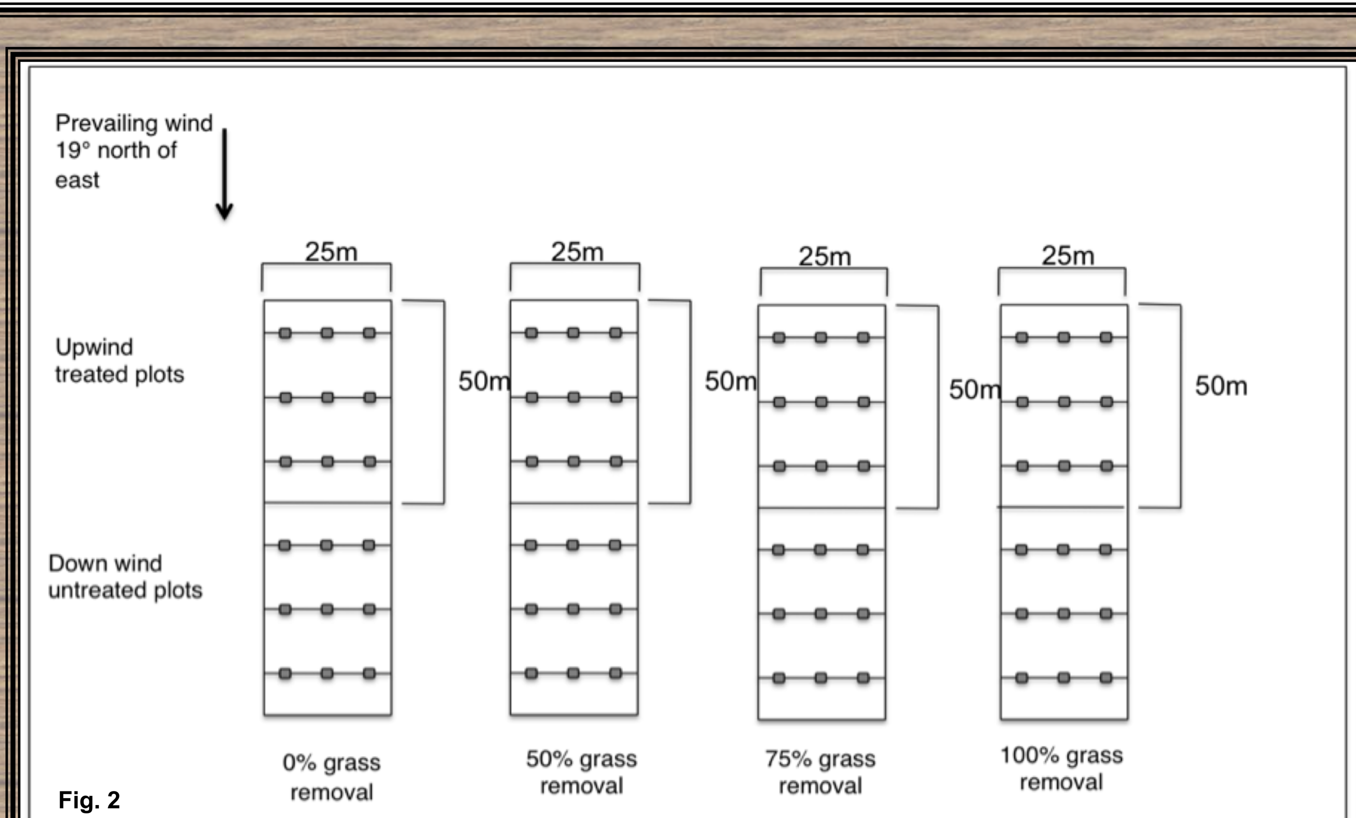
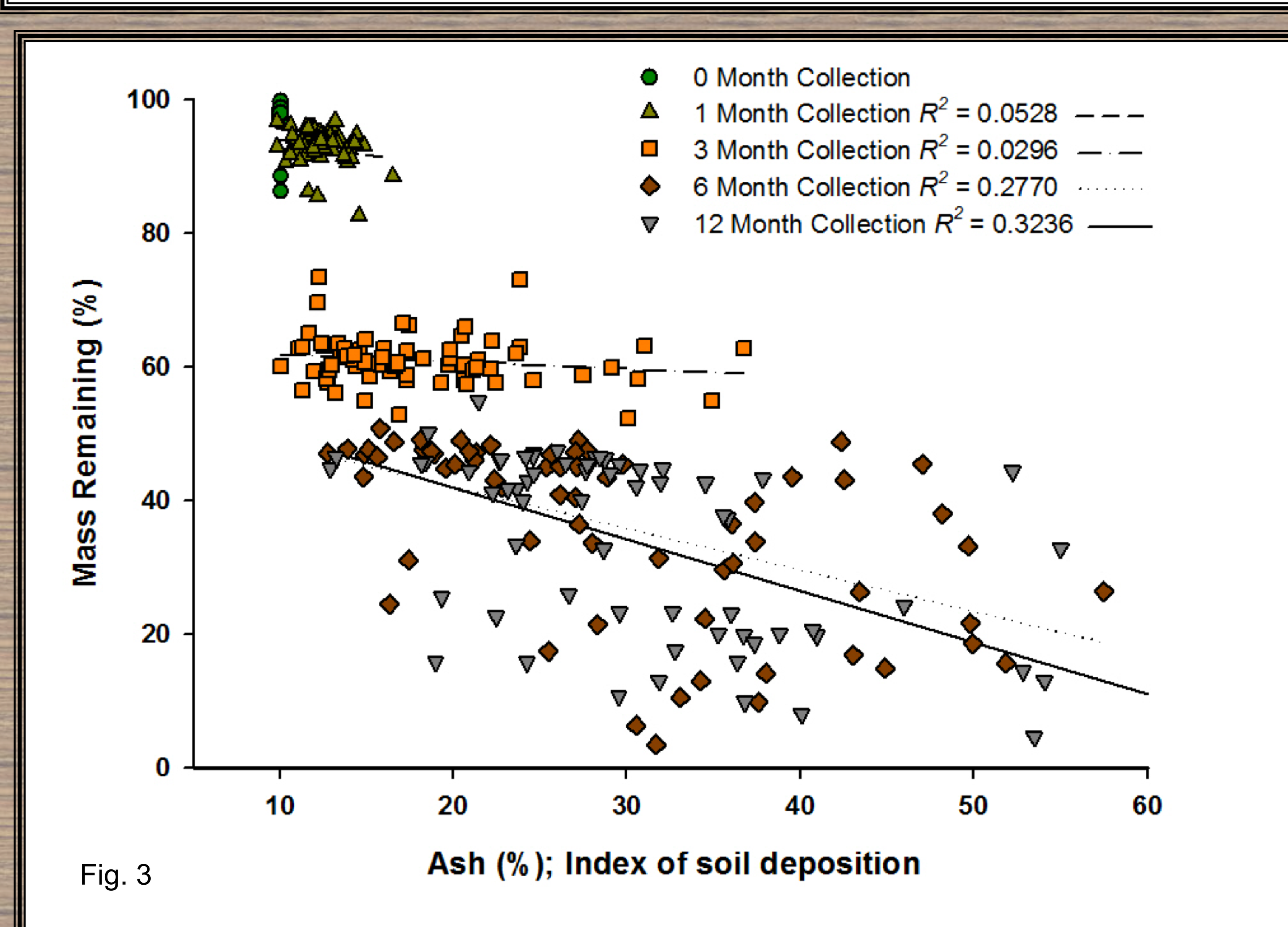
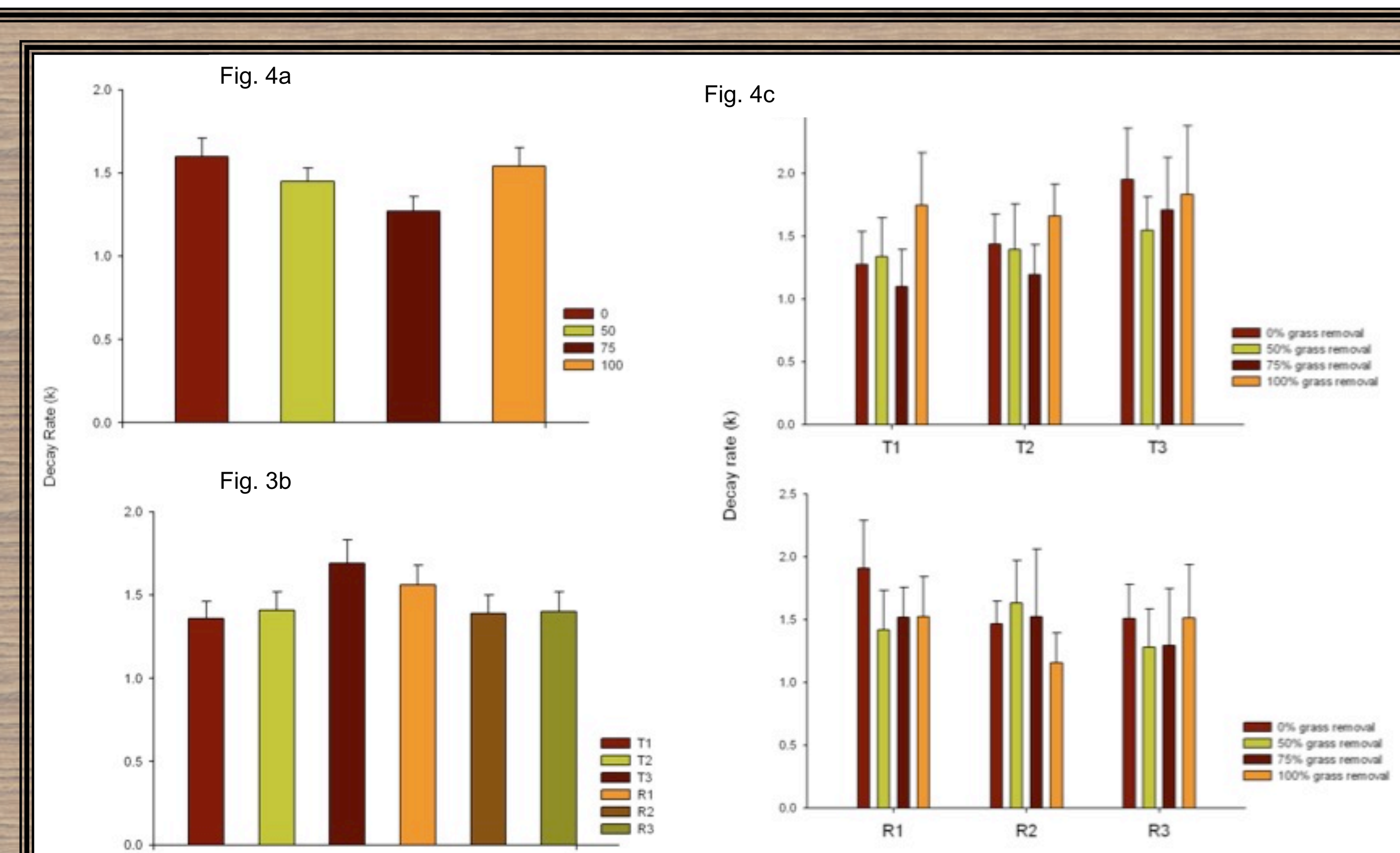


Figure 2 Litterbags containing a monolayer (2g) of dried *Prosopis glandulosa* leaflets were deployed on transects 5, 25, 45, 55, 75, 95m down wind of grass removal treatment in April 2008

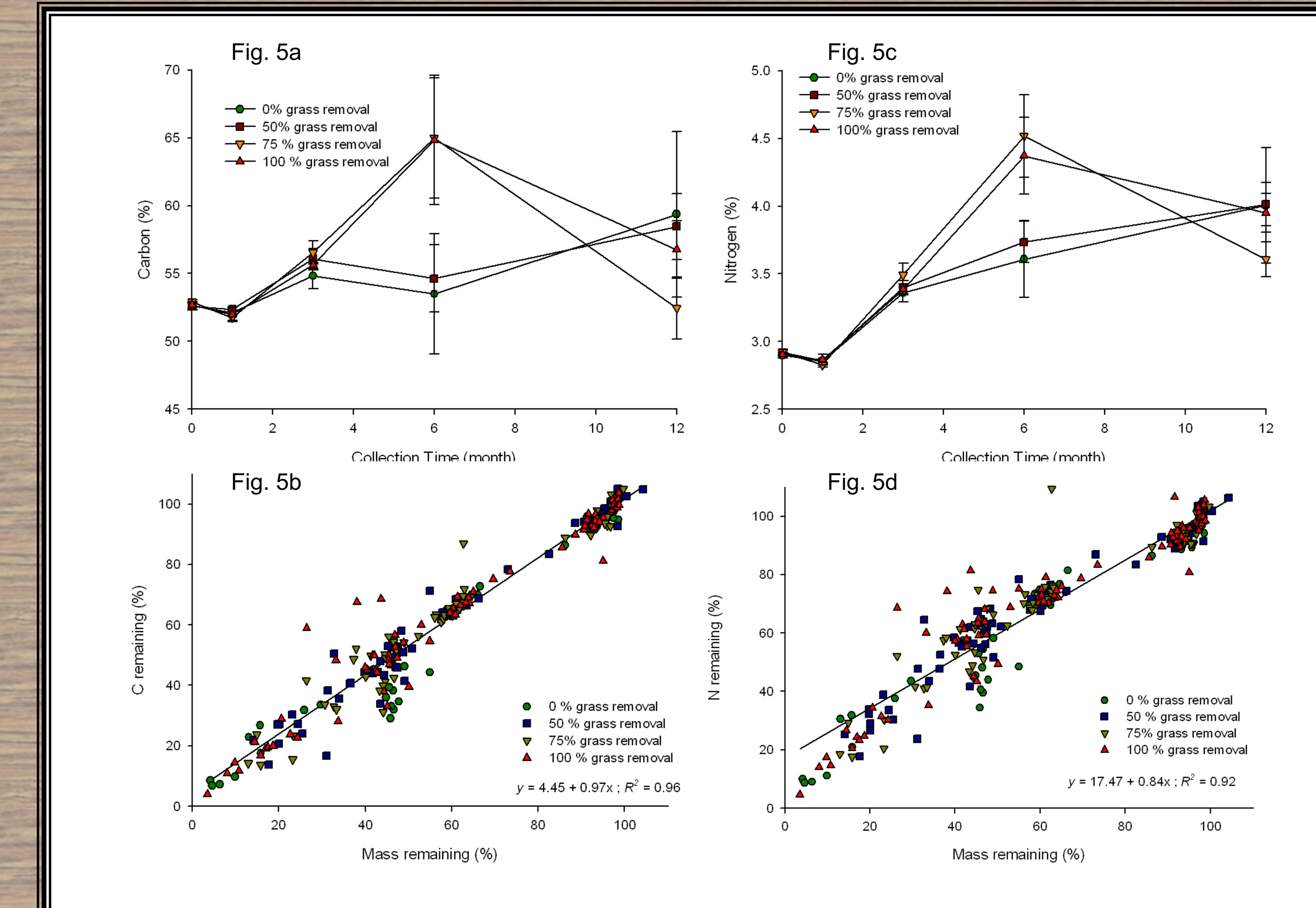
Results

Mass Loss: Backward stepwise regression was conducted on mass loss data (% mass remaining) to determine the contribution of grass removal, transect fetch length and soil deposition into litterbags (% ash). % Ash was determined to be the only significant variable and the best fitting model using Akaike Information Criterion for model selection. Regressions using this model at each collection time shows the relationship between % ash and mass loss increases with time (Fig. 3). Soil-litter mixing accelerates decomposition as soil infiltration increases.

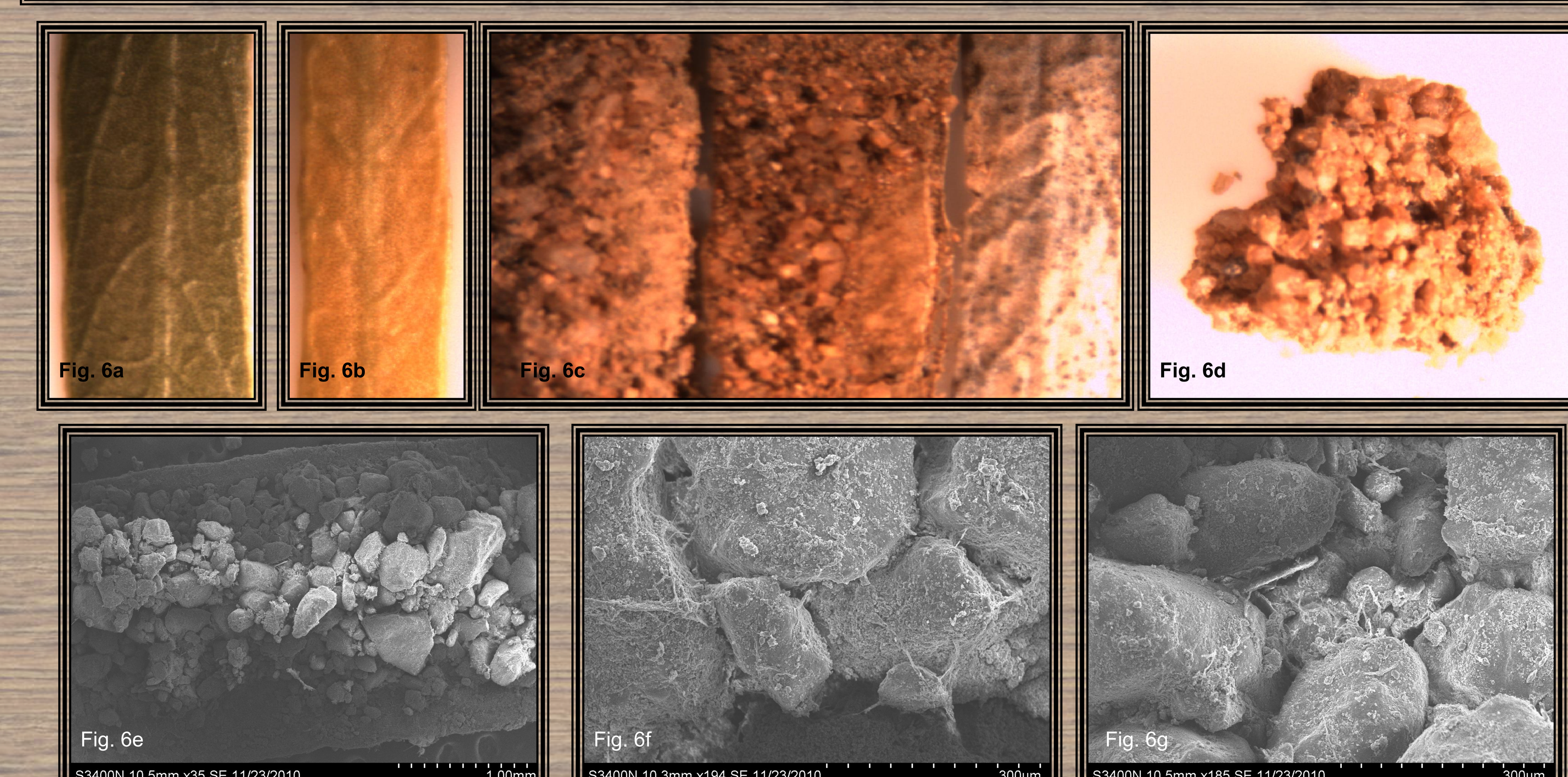




Decay: A single exponential decay model was used to generate decay constants (k) for grass removal treatment levels (Fig. 4a), downwind transects (Fig. 4b) and all combinations (Fig. 4c). Overall rates were similar to other dryland studies, but there were no significant treatment effects. Rates of decay seem to be indicative of the heterogeneous nature of soil erosion and deposition in drylands.



Litter Chemistry: Carbon (Fig. 5a) and nitrogen (Fig. 5c) contents of litter change during decomposition. The relationship between mass loss and % remaining C (Fig. 5b) and % remaining N (Fig. 5d). When C and N are limiting, microbes will acquire both via decomposition. Biotic activity may be facilitated by soil-litter mixing due to changes in litter microclimate and may account for changes in litter chemistry.



Soil-Litter Aggregates During the experiment we observed visible soil film develop on litter and the formation of soil aggregates in litterbags. Soil-litter mixing presumably alters microclimate and shields litter from UV allowing for increased biotic decomposition. Images taken using a dissecting microscope with a digital camera of leaflets exposed for 0, 1 & 6 months (Fig. 6a,b,c). At 1 month, degradation of the leaf tissue has begun (Fig. 6b). At 6 months leaflets have been coated by a soil-fungal film (Fig. 6c). Soil-fungal film development may be a function of dominant vegetation cover (Fig. 6c; bare soil, shrub, grass). Electron micrographs (Fig. 6e,f,g) showing a leaflet after 6 mo. of exposure and the aggregation of soil and litter with fungal networks. Soil aggregates >2mm have also been observed within litterbags after 6 months (Fig. 6d) field exposure. These aggregates also have visible fungal hyphae within their structure.

Conclusions

•Soil-litter mixing is a strong driver of decomposition in dryland systems.
•Soil-litter mixing, measured as % ash, is variable among grass removal treatments as indicated by results of our regression analysis
•Soil-litter mixing appears to facilitate soil-litter aggregation, which appears to be a result of fungal hyphae attaching to litter and soil and possibly while exuding adhesive biomineralized carbonates or extra cellular organic compounds.
•Aggregation may have implications for carbon storage in soils as (SOC) or carbonate

References: Li, J., G. Okin, L. Alvarez, and H. Epstein. 2007. Quantitative effects of vegetation cover on wind erosion and soil nutrient loss in a desert grassland of southern New Mexico, USA. Biogeochemistry 85:317-332.
Throop, H. L. and S. R. Archer. 2009. Resolving the dryland decomposition conundrum: some new perspectives on potential drivers. Pages 171-194 Progress in Botany.

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