Leslie Brandt
Name
University of Minnesota
University, City, State
Saint Paul, MN

Does photodegradation drive surface litter decomposition in grasslands?

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Overview of Research Project

Decomposition is the primary process by which carbon and nutrients are cycled from plants to the soil and atmosphere. Photodegradation, the break-down of chemical compounds by ultraviolet (UV) radiation, may contribute substantially to decomposition of surface litter, especially in areas with high penetration of solar radiation to the litter layer and relatively low microbial activity such as arid and semi-arid grasslands. The contribution of photodegradation to decomposition rates and the mechanisms by which photodegradation affects carbon and nutrient cycling are not well known.

Objectives:

1. Quantify the relative contribution of photodegradation to surface litter decomposition in grasslands across a gradient of UV radiation in the central United States.

2. Determine the mechanisms by which photodegradation affects carbon cycling through a series of laboratory experiments.

Background

Recent studies have found that exposure of surface litter to UV radiation during decomposition increases decomposition rates in arid and semiarid environments. In my previous work in Colorado shortgrass steppe, I found that surface litter exposed to UV radiation decomposed at a significantly faster rate under dry conditions in litter that had a high carbon to nitrogen ratio (Fig. 1).

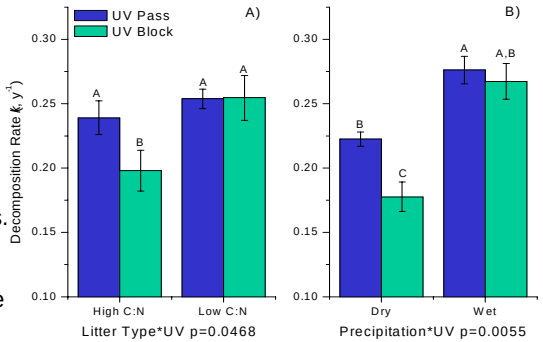

Fig. 1. Effect of UV on decomposition rates in Colorado for 3 years. Litter was screened from UV (Block) or exposed to UV (Pass). A) UV*Litter Type: Litter was grown under elevated or ambient CO_2 resulting in different carbon to nitrogen (C:N) ratios (elevated CO_2 increased C:N). B) UV* Precipitation: Precipitation scenarios were employed to simulate a wet or dry year.

Objective 1: Cross-site quantification

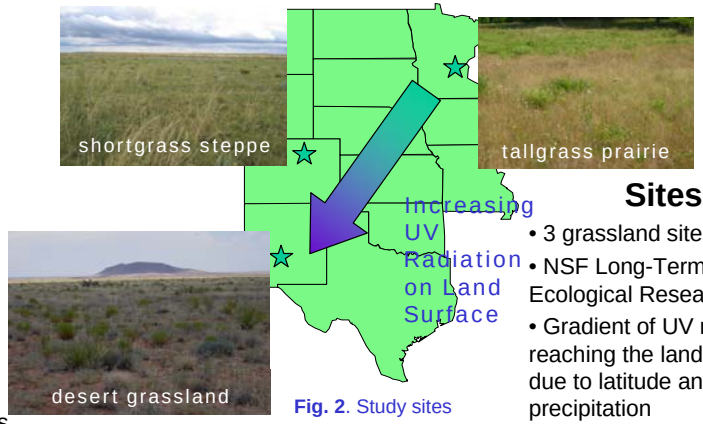

Fig. 2. Study sites

Sites

- 3 grassland sites (Fig. 2)
- NSF Long-Term Ecological Research Sites
- Gradient of UV radiation reaching the land surface due to latitude and precipitation

Approach

- Factorial design of UV and litter chemistry at each site
- Litter:
  - •2 grass species of contrasting chemistry
- •UV treatments:
  - Designed UV screens made of special clear plastic sheeting that either blocks 90% of UV-A and UV-B radiation or passes 90% of UV-A and UV-B radiation (Fig. 3).
  - Louvered design that faces south, allowing precipitation to reach the surface and minimizing temperature effects.
- Litter will be collected at four times during the 3-year field experiment.
- Litter will be analyzed for mass loss, changes in chemistry, and microbial activity and abundance.

Fig. 3. UV screen design and litterbags.

Objective 2: Mechanisms

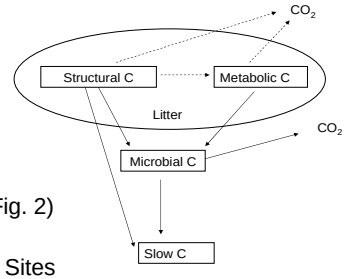

Fig. 4. Solid lines: known C fluxes. Dashed lines: proposed C fluxes from photodegradation

Photodegradation could increase the rate carbon cycling by 2 mechanisms (Fig. 4):

1. Direct oxidation of carbon compounds to gaseous forms (mainly CO_2).
2. Facilitation of microbial decomposition leading to higher respiratory fluxes of CO_2.

I will use a series of controlled laboratory experiments to separate these two mechanisms.

Significance

The results of this study will increase our understanding of patterns and mechanisms of the decomposition process in grasslands. In addition, study will improve the accuracy of biogeochemical models under current environmental conditions as well as increase our ability to predict future rates of decomposition due to changes in UV radiation at local, regional, and global scales.

Acknowledgments

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