Pathways and Patterns of Plant Litter Chemistry throughout Decomposition

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Introduction

- Decomposition is the breakdown of dead organic material into smaller particles, releasing nutrients for plant and microbial production. It is vital for carbon regulation and nutrient cycling, soil formation, and fundamental to energy flow in food webs.
- Plant litter chemistry can alter decomposition, yet few studies have examined the chemical composition of plant litter throughout decay. The majority of studies measure the initial plant litter chemistry, focusing on carbon and nitrogen, and presume that the initial measures will explain how litter will behave throughout decomposition.
- ***The main goal of this project is to test the assumption that initial chemistry predicts the route taken by plant litter during decomposition and examine the chemical pattern change in systems with different biotic and abiotic environments.***
- Figure 1 below demonstrates the three potential pathways by which litter chemistry can change during decomposition.

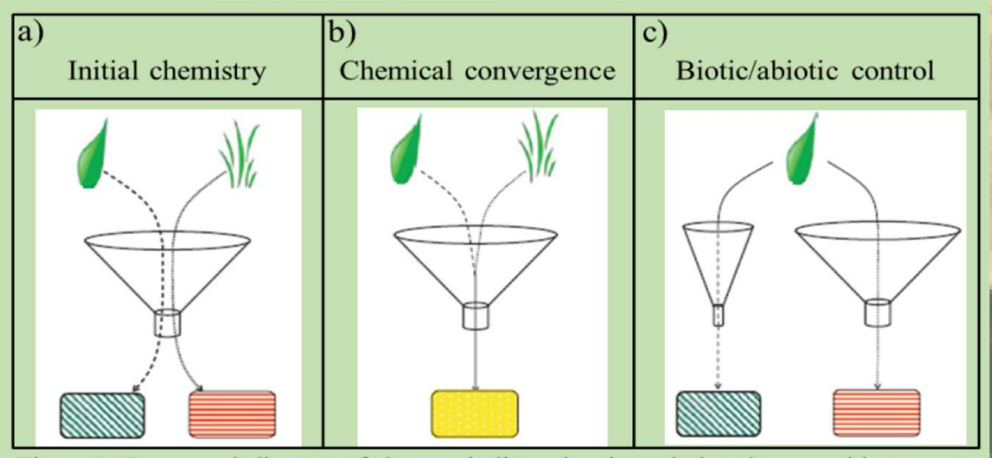


Figure 1. Conceptual diagram of changes in litter chemistry during decomposition (Wickings et al. 2012). The shape of litter represents different initial chemistry. The shape of funnel denotes different decomposer communities. Squares represent the chemistry of the decomposing litter.

Methods

- The litter samples were collected from archived Long-Term Ecological Research (LTER) study sites.
- The litter samples were single species, untreated, and from their native environment.
- The following analyses were conducted:
  1) Carbon to Nitrogen ratio measured using an elemental analyzer.
  2) Pyrolysis Gas Chromatography Mass Spectrometry (Py-GCMS) to measure major compounds detectable through mass spectrometry (lipids, lignin, proteins, phenols, etc.).
  3) Fiber analysis by conducting a sequential acid digestion.
  4) Phosphorous and micronutrients were measured by doing an elemental analysis on an inductively coupled plasma optical emission spectrometer (ICP-OES).

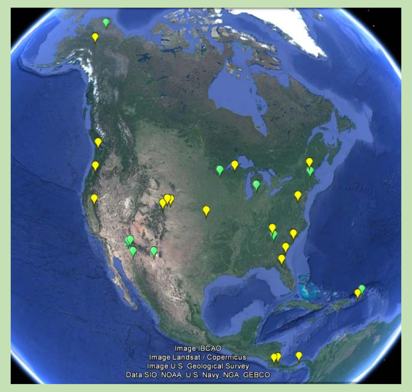
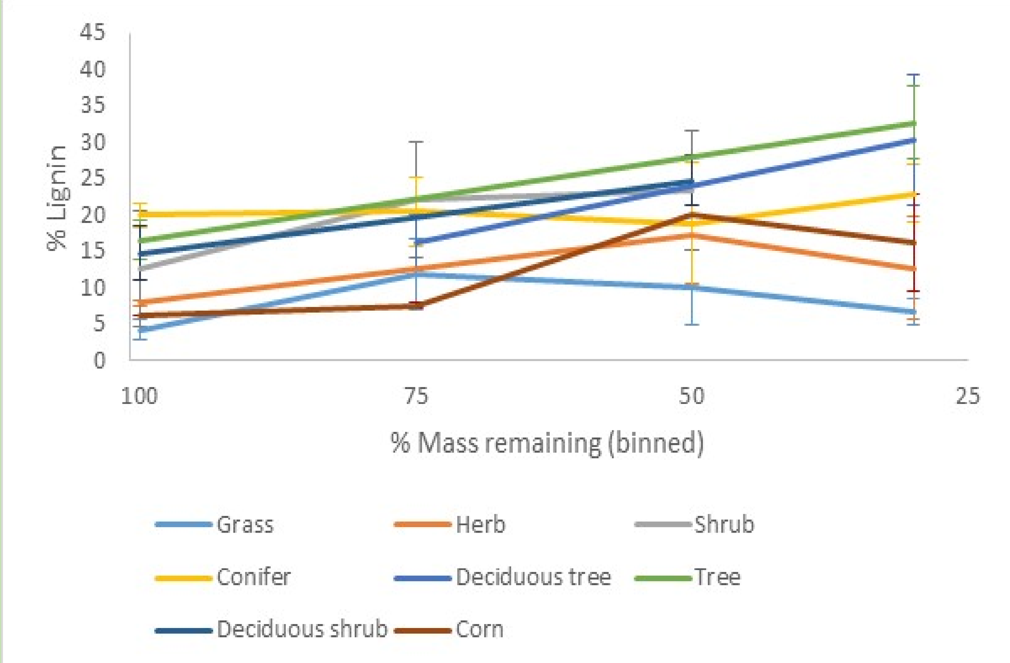


Image of the distribution of the origins of litter samples and data that were analyzed. Yellow placemarkers represent the locations of samples to be analyzed. Orange placemarkers represent additional sites from which archived data have been collected.

Photo of the sequential acid digestion method to measure hemicellulose, cellulose, lignin, and solubles.

Results



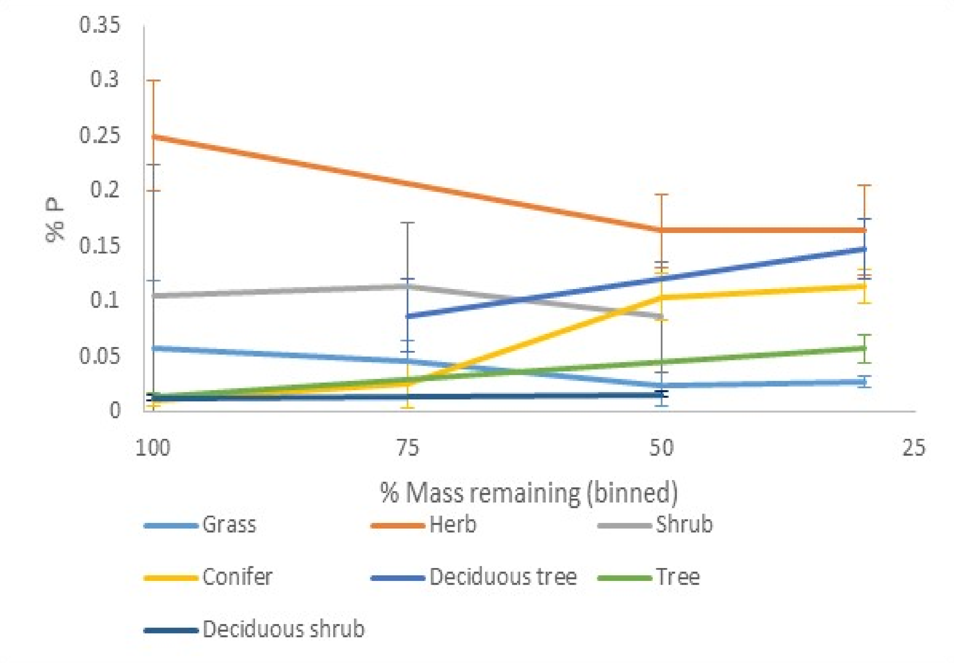


Figure 2 (left) and Figure 3 (right) above support all three hypotheses. Depending upon the parameter considered, chemically unique plants remained unique throughout decomposition, chemically unique plants converged throughout decomposition, and chemically similar plants diverged throughout decomposition.

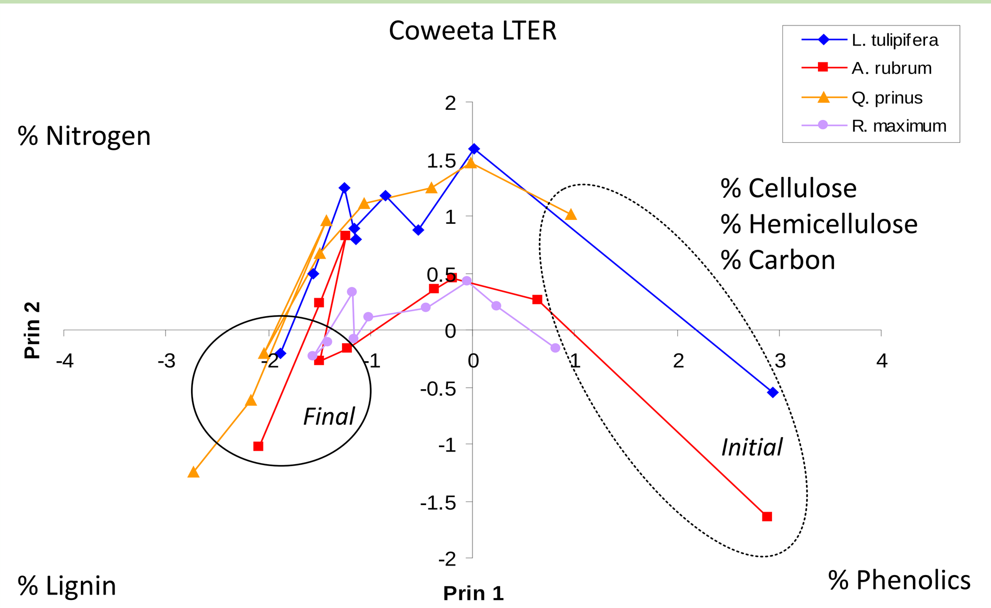
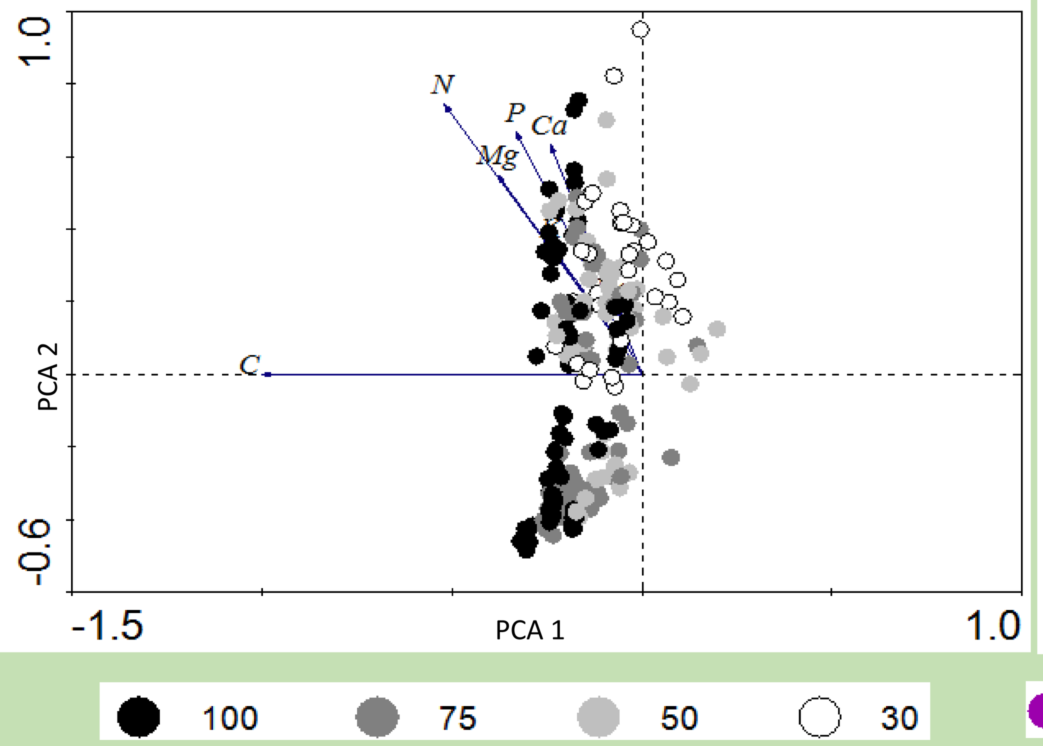
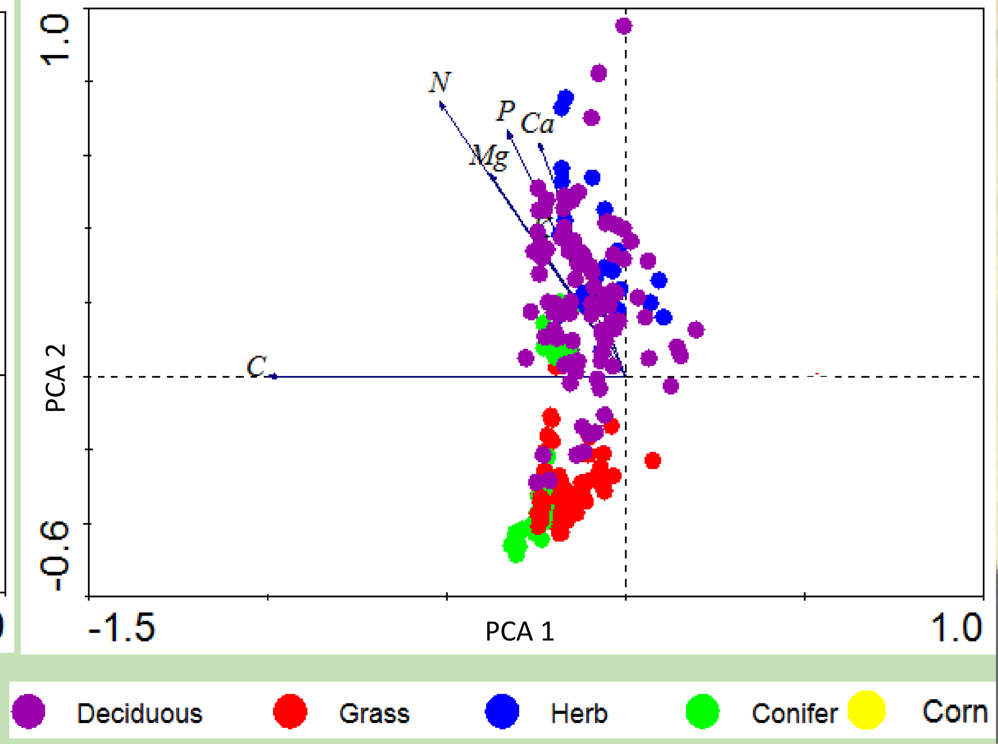


Figure 4 shows litter decomposition data from the Coweeta LTER. This supports our hypothesis in that it depicts convergence of compounds that were initially chemically different. As decomposition occurred, we see the different species converge chemically, thus showing that initial differences are not always maintained throughout decomposition.





The graphs above show an ordination of all the litter bag data, focusing on nutrient content. Figure 5 (left) shows the ordination according to mass loss. It does not show any patterns when color-coded by mass. Figure 6 (right) shows the ordination of litter by functional group. When color-coded this way, we begin to see a pattern of nutrients present in specific functional groups.

Images from left to right: *Q. prinus*, *R. maximum*, *A. rubrum*, and *I. tulipifera*. These are pictures of the species examined in Figure 4.

Acknowledgements: We would like to sincerely thank everyone involved in this project, the National Science Foundation Division of Environmental Biology (NFS DEB-1537920), the Long Term Ecological Research Network, Dr. Stuart Grandy, Scott Greenwood, Dr. Chelsea Prather, Paul Cattelino, Dr. Jennie DeMarco, Dr. Grizelle Gonzalez, Dr. D. Jean Lodge, Dr. Marshall McDaniel, and Gary Lovett.

Discussion

- The results support all three hypotheses portrayed in figure 1.
- There is evidence that follow the pattern where unique initial chemistry maintains through time.
  - This is supported by the parallel lines illustrated in figures 2-4.
- However, there is also evidence for convergence of litter chemistry.
  - Although there are parallel lines depicted in figures 2-3, there are lines that show chemically unique species becoming more similar through time.
- There is also evidence for divergence of litter chemistry.
  - For example, in figure 3 we see a deciduous shrub and tree that are initially chemically similar, but as time progresses, we see a divergence of chemistry.
- Figures 5 and 6 also show that functional groups portray a pattern in decomposition when grouped together versus mass loss.
  - This suggests that litter chemistry during decomposition differs according to plant functional groups more so than ecosystems.
- In summary, our preliminary data demonstrate that litter chemistry varies throughout decomposition, not strictly following one pattern. However, our analyses are ongoing, with continued litter contributions from across the country. More patterns are expected with a larger dataset.

Future (continuing) Research

- We will continue to collect archived litter samples from completed decomposition studies across the LTER network and analyze the complete set of litter chemistry parameters.
- We have an ongoing project at the Central Arizona- Phoenix LTER site located in the White Tank Mountains studying cactus decomposition of two different cacti species: *Opuntia chlorotica* (Pancake prickly pear) and *Cylindropuntia acanthocarpa* (Buckhorn cholla).
- We hope to get a detailed look at cactus decomposition, an important yet understudied functional group in the Sonoran Desert, studying nutrient cycling and water dynamics.
- Once the samples are collected, we will run a handful of tests including: C:N ratios and an elemental analysis to measure phosphorous and micronutrients.
- We will then compare the chemical composition of leaf versus cacti litter, as well as the two different cacti species.

The pictures above show the litter cages for the cactus decomposition project located at the CAP LTER. The far left picture shows the cholla species, the middle picture shows the prickly pear species and the right picture shows one of the plots with both species of cactus.