Despite more than a century of study, fundamental questions remain about plant litter decomposition, a key control on carbon (C) sequestration. Changing soil C storage in response to nitrogen (N) deposition, elevated CO_2, plant community composition shifts, and climate change, is a topic of growing interest because of the potential CO_2 feedback the atmosphere. These disturbances influence soil C by altering the interactions between microbial activity and plant litter chemistry during decomposition. However, we are unable to predict the magnitude or sometimes even direction of microbial response in specific instances, as the mechanisms controlling changes in plant litter decomposition are not well understood. **We propose an integrated field, laboratory, and modeling study of the biochemical mechanisms driving interactions between organic matter stabilization, litter chemistry, microbial community composition and enzyme activities during decomposition.** Our central hypothesis is that during decomposition there is a predictable and quantifiable microbial succession tied to litter chemistry, and that changes in decomposition rates and litter chemistry in response to nutrient availability reflect changes in the composition and function of the microbial community.

Many models are available for predicting relative mass loss rates of different plant litters, but these models lack resolution with regard to the late stages of decomposition. Most predictive models of decomposition are driven by initial litter quality and environmental conditions rather than microbial dynamics, and fail to capture impacts arising from “bottom up” changes in microbial community composition or function. Moorhead and Sinsabaugh (2006) have developed a new model that incorporates microbial succession into the decomposition process. With this model, the effects of exogenous N on organic matter stabilization can be simulated. This model, the Guild Decomposition Model (GDM), has generated a series of specific hypotheses about the mechanisms controlling the interactions between plant litter chemistry and microbial community composition and activity during decomposition. The proposed research will evaluate these hypotheses experimentally by monitoring changes in litter chemical composition, microbial community composition, and the activities of the exoenzymes that degrade plant litter throughout the decomposition of contrasting litter types, with and without added N. We will also label leaf litter subsamples with different ^{13}C compounds representative of the primary leaf litter chemical constituents to determine the community composition of active microorganisms capable of metabolizing specific products of decomposition. GDM simulations will be run using these experimental data, and these experiments have been designed to test the structure of, and predictions from the GDM, which in turn explicitly defines functional links between activities of decomposer microorganisms, litter chemistry and labile N.

Intellectual Merit: Because soil organic matter represents a large pool of C relative to the atmosphere, there is great interest in understanding the conditions under which soils will behave as a source or sink for atmospheric C. Disturbances such as N deposition and CO_2 enrichment affect SOM dynamics but the magnitude and direction of responses vary among systems. The work we propose will provide mechanistic insight into this variation, particularly the extent to which litter decomposition can be modified by changes in litter chemistry and N availability through “bottom up” effects on the composition and substrate use of microbial communities. A key area of scientific significance is the explicit integration of microbial community and chemical interactions during the long-term degradation and stabilization of plant litter. There has not yet been a working synthesis of this knowledge expressed in a comprehensive quantitative framework.

Broader impacts: We are proposing an integrated education and outreach program to complement the proposed research. To make this effort as effective as possible we are collaborating with the University of Toledo’s Center for Creative Instruction (CCI). For this project, the CCI will set up an online **i**nteractive **m**odel **o**f **l**eaf **d**ecomposition (iMold) to provide educational outreach about decomposition for grades 5-12. The iMold virtual environment will include a web site which will consist of two distinct experiences: public and members-only community. The Public community will consist of interactive animations of decomposing leaf litter, GDM simulations, and learning components available both on the website and by a version designed for the SMART Board™. The interactive animations will include the ability to select from different leaf liter types of varying chemistry and then select the environmental conditions they will decompose within, including global change scenarios. Visitors will be able to visualize the progress of the decomposition of litter as a whole, or different individual litter chemical constituents, along a time line to see how time, litter type, and environment relate to how quickly or slowly something decomposes. The members-only community will give teachers and students the ability to network between researchers and classrooms at other schools, enabling them to share data, ask questions, and collaborate on experiments. A communication center will be created so that the researchers and classrooms can share ideas and results, as well as ask questions in a blog-like environment. Regularly scheduled video conferences will be given by project researchers directly to the schools. Students and teachers can ask questions during the presentation or experiment, and each presentation will be archived for review on the web site.