Soil organic matter (SOM) represents the largest pool of actively cycling organic carbon (C) and nitrogen (N) in the terrestrial environment. However, an incomplete understanding of the complex interactions that exist between plants, soils, and microbes limits our ability to quantitatively account for the storage and dynamics of these elements in global budgets. Quantifying changes to SOM within the context of land cover/land use changes will help understand better the effects of human-induced perturbations and natural variability on ecosystem shifts and climate change. An ecosystem scenario that is important for documenting modern carbon budgets as well as paleoenvironmental interpretation is woody plant/grassland transitions as approximately 45 to 52% of the terrestrial surface is covered with grasslands, savannas, shrublands, and semiarid woodlands and these grass-dominated ecosystems store 30% of global soil organic carbon (SOC). This proposal seeks to document and quantify how various biological, chemical, and physical processes act as protective mechanisms for SOC following a major vegetation change from grassland to woodland. Specifically, a chronosequence (120 yrs) of woody plant invasion into a subtropical grassland will be utilized as a model system to investigate the storage or release (as respired CO2) of organic matter from specific soil physical and chemical fractions. The overall project goal is to relate microbial community structure and enzymatic activity, plant input chemistry, and soil microfabric to the specific chemical forms of organic C and N that are stabilized and released through the chronosequence. Four questions drive the research in this proposal: 1) How does soil physical structure determine the extent of C accrual over time following woody plant invasion? 2) What is the chemical composition and source of the plant and microbial carbon that is stabilized? 3) What is the role of shifting populations of soil microbes and enzyme activity in the respiration of litter and SOM fractions and how do they impact aggregation dynamics? 4) What is the relative accessibility of the "new" SOM derived from woody plants to microbial decay, and can we relate physically identifiable SOM fractions with calculated mean residence time to potential respiration in inoculation experiments?

These questions will be answered through application of novel molecular, isotopic, and microbiological methods to develop a fundamental understanding of the processes that control soil carbon storage and dynamics. **The intellectual merit** of this proposal rests on the potential for uncovering some of the most fundamental chemical and physical mechanisms that control one of the largest and most dynamic components of the global carbon cycle, Additionally, this work will contribute to the develop of a stronger scientific basis for modeling SOM dynamics, ecosystem processes, and the global carbon cycle. The multidisciplinary composition of the research team (ecology, biogeochemistry, microbiology) will contribute to the development of broad-based perspectives that will benefit a wide cross-section of the scientific community. **The broader impacts** of this work include the enhanced understanding of the role of soil processes in biogeochemical cycles and the earth system which will be of immediate significance to both scientists and policy-makers as mankind considers the potential for manipulating the carbon cycle in order to mitigate potential global climate change. Additionally, the project will generate educational opportunities for two Ph.D. students, with great promise to attract underrepresented students through Purdue's NSF Funded Alliance for Graduate Education and the Professoriate (AGEP) program. These students will receive training in state-of-the-art methodologies in biogeochemistry and global change research.