**"Scaling Up the Ecosystem Consequences of Forest Expansion in the Great Plains Region: A Renewal Proposal"**

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## Project Summary

Forest encroachment in the Great Plains is poorly known, difficult to quantify, but potentially important as a carbon (C) sink. Indeed, land use is becoming recognized as an equally important, if not more important, factor in controlling rates of C accumulation in biomass and soils, than growth enhancement due to climate change. Woody encroachment is occurring rapidly in the Great Plains. Juniper, in particular, is spreading over more than 7 million ha in five state area in the lower midwest.

Our current LCLUC project 'Land-Cover Change in the Great Plains: Predicting Impacts of Regional Forest Expansion on Biogeochemical Processes' is filling a critical gap in understanding the role of land cover change in the Great Plains. Our research group has quantified how woody encroachment in Kansas grasslands has resulted in fundamental changes in ecosystem function related to a life form shift from $C_4$ prairie grasses to a $C_3$ evergreen junipers. Our approach has been strongly multi-disciplinary: it has involved *in situ* biogeochemical measurement at the plot-level linked with multi-temporal Landsat images and historical aerial photographs and biogeochemical modeling. This research has been unique in that we have also quantified changes in C source/sink activity by using eddy flux towers in forest and grassland as a complement to direct measurements of C stocks in biomass and soils. From 1.5 years of net C exchange measurements, of particular note is how conversion to forest changes the phenology of net $CO_2$ exchange and source/sink activity; the forest site (with trees utilizing $C_3$ photosynthetic pathway) is a C sink in the cool parts of the growing season while the $C_4$ grassland site is a strong, but short duration, C sink in mid-summer. We aim to continue these measurements of net C exchange, water, and energy balance on an interannual basis to determine if the same phenological pattern continues and how strong year-to-year differences in temperature and precipitation affect source/sink activity in forest relative to grassland.

In this renewal proposal to our current LCLUC grant, our overall objective will be to 'scale up' our extensive plot-scale data to the regional level of the Great Plains and to continue to calibrate our biogeochemical model (GEM) to allow us to forecast the ecosystem consequences of woody encroachment. To assist in scaling and regionalization efforts, our renewal will also focus on the refinement and application of our preliminary linear spectral mixing models (LSMM) to characterize and quantify the grassland-forest continuum. Because the use of remote sensing is so integral to quantifying the rate and extent of forest encroachment, our research group has teamed up with Dr. Kevin Price of the Kansas Applied Remote Sensing Center. Price brings to the research over 19 years of experience using remote sensing to study land cover patterns. While our current biogeochemical studies have focused primarily on the 'endmembers'

of the grassland-forest continuum (grassland and closed canopy forest), we will now focus on quantifying rates of biomass and C accumulation and ecosystem change in the intermediate stages of the grassland-forest continuum. To accomplish our goals, we will:

- continue to develop the LSMM necessary to capture the fine-scale dynamics of woody encroachment across the Great Plains region. This will allow us to determine the regional extent of forest expansion and C storage. This will involve extensive use of Landsat and MODIS/AVHRR images to categorize sites into cover classes based on extent of woody vegetation,
- link our LSMM cover classes to plot-level changes in C and N stocks and fluxes to predict changes in rates of C and N accumulation in time and space,
- continue to parameterize and calibrate our biogeochemical model (GEM) to develop spatially explicit predictions of the ecosystem consequences of forest expansion,
- explore how interannual variation in temperature and moisture affect C source/sink activity, water, and energy balance in forest relative to grassland, and
- explore the ecological tradeoffs that may occur as forest encroachment drastically lowers biodiversity while providing a regionally important C sink.