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Carbon-Water Interactions of Longleaf Pine Ecosystems

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Carbon sequestration is an increasingly important consideration for forest and woodland management. There are still unresolved questions, however, regarding the dynamics of the terrestrial carbon cycle, particularly with respect water availability. In particular, there is no consensus in the literature on the allocation strategies of trees under water limitation. As ecosystems with a natural edaphic gradient and an identified potential for carbon sequestration and other ecosystem services, longleaf pine woodlands present an ideal opportunity to explore these relationships.

This research aims to investigate the carbon-water interactions of longleaf pine ecosystems using model-data fusion techniques, with particular reference to the presence of the three main functional groups in the system (oak, pine and understory). We present results for longleaf pine ecosystem productivity across an edaphic gradient using the process-based Soil-Plant-Atmosphere (SPA) model. Data from eddy-covariance towers on a wet and a dry site have been used to validate the model and assess productivity across the gradient. We also present the results of an ecophysiological field campaign including A-Ci curves at various canopy heights, belowground biomass across the gradient and diurnal measurements of leaf water potential/ambient photosynthesis from both sites. In conjunction with this data, energy and gas exchange data from the two eddy-covariance towers have been used to validate SPA.

SPA allows for exploration of allocation strategies and the identification of hydraulic system constraints. We hypothesise that oak and pine tree species at these sites are not directly limited by soil water availability, but by their hydraulic architecture which is itself a response to soil moisture. Previous work from the Joseph W. Jones Ecological Research Center has shown that the hydraulic architecture of pine is significantly different between wet and dry sites. Here we explore the hydraulic system constraints to identify at which point in the soil-plant-atmosphere continuum the principle resistor lies and whether or not this differs between the wet and dry sites. Results of the ecophysiological field campaign suggest that photosynthetic capacity is higher at the mesic site, but flux data shows overall productivity of the xeric and mesic sites is not significantly different for the summer months. During the winter, however, the wet site is more productive. We hypothesise this difference is largely due to the activity of the understory and related to the presence of fire in the system, but further assessment of the relative contributions of the main functional groups is necessary.

The ultimate aim of this research, through the use of SPA, eddy-covariance and leaf-level ecophysiological measurements is to develop a carbon budget for longleaf pine stands under a variety of moisture conditions. There is currently no published carbon budget for longleaf pine forests; a necessary step to further the understanding and conservation of longleaf pine and its unique ecosystem. In addition to this, this work provides an insight into the adaptability and ecological strategies of tree structure to drought conditions, which will be important if water availability becomes more limited with increasing anthropogenic pressures.