Opportunities for Research on Carbon Sequestration in Longleaf Pine Ecosystems

TALL TIMBERS

WORKING LANDS FOR WILDLIFE

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Recent research has made significant progress in identifying factors influencing carbon storage and dynamics in coniferous forests treated with periodic fire. Prescribed fire in longleaf pine ecosystems can result in carbon accumulation in soils (Greene 1935, McKee 1982, Godwin et al. 2017), where more than half of ecosystem carbon is stored (Schmidt et al. 2011). Recently identified mechanisms may include the slowing of soil microbial decomposition (Seminova-Nelson et al. 2019), alteration of litter inputs that make them less decomposable (Pellegrini et al. 2021), promotion of grasses with high fine root turnover rates which add soil organic matter (SOM) (Hart et al. 2005), pulses of nutrients that influence soil microbial activity (Coates et al. 2018), and soil chemistry of litter from plants promoted by fire (Dao et al. 2022). However, little is known about which factors are most important, how much they contribute, and how they interact. I identify this and other topics as having the greatest need for further research:

Photo courtesy of The Longleaf Alliance

1) Relative contributions of mechanisms of soil carbon accumulation - Carefully designed manipulative experiments can isolate and quantify specific ways that fire contributes to soil carbon accumulation. Experiments should include burned controls, manipulations of vegetation and litter to mimic fire effects without soil heating, and adding ash from burned areas to unburned areas, while monitoring SOM decomposition rates using recently developed technology. Experiments should be duplicated in native and old-field longleaf pine communities, closed-canopy pine plantations, and closed-canopy mixed forests to predict the effects of management regimes. Other experiments are needed to measure the contribution of fine root turnover and the rates of char addition attributable to fire in each of these management contexts.

2) Improved estimates of below-ground carbon - To date, soil carbon accounting has focused on the mineral soil and its mineral carbon SOM constituents but has largely ignored plant roots and their displacement of soil (Teixeira et al. 2022) as well as effects of small scale patterns of plants on soil carbon (West and Donovan 2004). Proper measurements are needed under various management regimes to correct this potentially large error and establish proper methods.

3) Whole-cycle carbon accounting - Most carbon accounting has focused on one point in the life cycle of forest stands, although SOM is dynamic and can rapidly change in response to current conditions. Soil microbial respiration needs to be measured at all stages of forest stand lifecycles, especially in response to growth, clearcutting, and planting of single-aged stands, in comparison to single-tree selection in mature stands, both used in longleaf pine forestry.

4) Long-term sequestration of longleaf products - It is currently not well known how privately-owned longleaf pine forests differ from lobolly pine plantations in the types of forest products produced and their durability determining long-term, post-harvest carbon sequestration.

5) How pine species influence soil carbon accumulation - It remains unknown why pine-dominated forest communities in particular show evidence of soil carbon accumulation in response to fire whereas broadleaf tree communities often do not. Experiments manipulating leaf litter inputs and examining leaf char in both contexts would shed light on this question.

Scientists at Tall Timbers Research Station are ready to administer such projects with appropriate funding. The Southeast Fire Map will be a crucial tool for extrapolating the benefits of prescribed fire associated with longleaf pine restoration to regional scales.

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