Effects of disturbance on carbon sequestration in the New Jersey Pine Barrens

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Disturbance affects tree and ecosystem functioning and has the potential to alter water use, carbon uptake and respiration rates. We studied both biogenic (insect defoliation) and anthropogenic (prescribed fire) disturbance effects on carbon and water cycling in forested stands (pine- and oak-dominated) within the New Jersey Pine Barrens. This research becomes particularly important as climate change may increase the occurrence of insect defoliation in northern forests and increasing suburbanization necessitates the prevention of widespread wildfires with prescribed burning. To determine the effects of prescribed fire, we measured sap flow rates and gas exchange to estimate leaf- and canopy-level stomatal conductance in three stands experiencing an early-spring burn and three nearby control sites. We found that effects of prescribed fire were transient, and were only evident during the growing season of the burn year. Likewise, effects of prescribed fire differed between pine- and oak-dominated forests. Trees in oak-dominated forests exhibited decreased stomatal conductance following prescribed fire, whereas trees in pine-dominated forests exhibited increased stomatal conductance. Prescribed fire in pine-dominated forests also led to short-term increases in rubisco-limited carboxylation rate (Vcmax) and intrinsic water use efficiency. In contrast to prescribed fire, gypsy moth defoliation caused longer lasting effects on forest carbon sequestration with a 25% loss in overstory oak basal area. In order to characterize the effects of this mortality, we made spot measurements of respiration rates of dead trees (snags and course woody debris) and modeled stand-level respiration rates from dead stems at a fine temporal scale using environmental parameters and forest inventory and analysis (FIA) datasets. We found that the mass of dead stems increased five-fold after defoliation and respiration rates increased more than three-fold. The contribution of dead stems to total ecosystem respiration more than tripled from 0.85% to almost 3% and respiration from dead stems alone was approximately equal to the net ecosystem exchange of carbon dioxide for the stand in 2011 (fourth year post-disturbance). In total, this research highlights the importance of forest type in determining disturbance effects as well as the length of time that a given disturbance will affect ecosystem function. Furthermore, forest response to disturbance varies from the leaf to the ecosystem level as well as between species and these differential responses interplay to determine the fate of forest structure and functioning. These results will aid in the parameterization of ecosystem models in light of disturbance regimes.