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Differential response by hardwood and deciduous stands in New England forests to climate change and insect-induced mortality

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Forests in the northeastern United States include large areas dominated by mosaics of oak/maple and hemlock stands. Often the hardwood dominated stands include a significant cohort of hemlock saplings. However, long-term survival of hemlock in this region is threatened by Hemlock Wooly Adelgid (HWA), an invasive insect that is fatal to eastern hemlock. The northern limit of HWA is affected in part by winter minimum temperature and warmer winters are enabling northward expansion of HWA infestation. At the Harvard Forest in central Massachusetts, two long-term eddy flux towers are measuring carbon exchange in a >100 year old hardwood stand since 1992 (EMS-Ha1) and in a 100-200 year old hemlock stand (Ha2) since 2004. The flux measurements are complemented by vegetation dynamics plots. Carbon exchange at the two sites has distinctly different seasonality. The hardwood site has a shorter carbon uptake period, but higher peak fluxes, while the hemlock stand has a long carbon uptake period extending from spring thaw until early winter freeze. Some contribution from the evergreen hemlock in the understory is evident before canopy greenup at the EMS tower and spring and fall carbon uptake rates have been increasing and contribute in part to a trend towards larger annual carbon uptake at this site. Carbon uptake by hemlock increases with warmer temperatures in the spring and fall transition.
Adelgids have reached the hemlock stand near Ha2 and have been widely distributed in the canopy since spring of 2012. The hemlock canopy in that stand is thinning and net carbon uptake and evapotranspiration have been decreasing since 2012. Adelgids have also been observed in scattered stands near the Ha1 tower, but as of 2015 the trees are still healthy. Because hemlocks stands have different seasonality and provide a distinct soil and sub-canopy light environment, their mortality and replacement by hardwood species will have significant impacts on forest dynamics, carbon balance, and hydrology. Ongoing flux and vegetation plot observations will document the changes in forest structure and function as this disturbance progresses.