ABSTRACT: Forests in northeastern U.S. are currently significant carbon sinks as they continue to regrow on land that were cleared for agriculture up until the early 1900’s. Understanding how long they will continue to sequester carbon is an important question for future carbon management. We have been analyzing the 20-year record of carbon fluxes and forest dynamics to better understand the interaction of climate and successional change to control the carbon balance of mixed deciduous forest. Red oak and red maple currently dominate the forest biomass at Harvard Forest. Red maples are an opportunistic, shade tolerant, relatively short-lived species, while red oaks are less shade tolerant, but long lived. Theory suggests that over time red maples should increase their dominance in mixed red oak-red maple stands. However, dendrochronology and growth increment data shows that maples are declining. To examine whether the maple decline is due to age-induced senescence or competition tree size and distance to nearest neighbors was analyzed on 3 stands; a control, a similarly aged logged site, and a younger stand. Historical patterns were examined by coring the same trees. Results show that the maples are capable of appreciable growth despite their age, but are suppressed by competition from nearby oaks. Disturbance events release red maples from this competition, resulting in increased growth. In spite of the decline in the canopy, the understory is overwhelmingly dominated by red maple, which suggests that although individual red maples are declining or dying, the current species distribution may remain stable; maples make up for short lifetime by having higher seedling survival. Retrospective analysis of carbon flux data for 1992-2010, seeks to determine the contributions of environmental factors to the observed trends and anomalies in Net Ecosystem Exchange. Annual NEE has nearly tripled over the time period, and the overall mean annual NEE (flux of CO2 from the atmosphere to the surface) is -3.07 Mg C ha-1 yr-1 with a range from -1.02 Mg C ha-1 yr-1 in 1998 to -6.44 Mg C ha-1 yr-1 in 2008. The environmental variables of air and soil temperature, precipitation, and light have large interannual variability but no significant trends. Anomalies in NEE influenced by disturbances such as late frosts and drought can persist through the remainder of growing season or longer. The increased annual CO2 uptake is due in part to increased growing season length; spring onset has been earlier and fall cessation has been later. Additionally the mean ecosystem response to temperature and PAR has changed over the 19 years, with the majority of the change happening during the growing season. Evaluation of this change points to changing physiology and ecosystem functioning driving the long-term trend in increased uptake. Neither the increased growing seasons nor the weather variations alone can account for the variation and trend in NEE. Increasing canopy efficiency suggests there has been an enhancement in foliar nitrogen or changing canopy composition, with possible small contributions from CO2 fertilization and water stress alleviation.