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Longer vegetative seasons and colder winters may be responsible for increased net ecosystem productivity in a deciduous forest in southern-central Indiana

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Changes in current climatic conditions are well documented at both local and global scales. While there is a general consensus on the causes and the expected trends for these changes, large uncertainties affect the predictions on the future roles of temperate forests in offsetting anthropogenic carbon emissions. This uncertainty mainly originates from the incomplete understanding of the mechanisms and controls that regulate the carbon cycle in forest, but also by a general lack of long-term measurements that could otherwise reveal trends in carbon, water and energy exchange between the ecosystem and the atmosphere. The AmeriFlux site in the Morgan Monroe State Forest in Indiana (MMSF) has been collecting observations on net ecosystem exchange (NEE) of carbon and its environmental drivers since 1998, and for this reason is one of the few sites in North America with the possibility of performing a decadal analysis on net ecosystem productivity (NEP) trends. Despite the large inter-annual variability in NEP, the observations show a significant increase in net forest productivity over the past 10 years (about 100 gC m^{-2}). This increase in productivity is hypothesized to be caused by changes in phenology and carbon cycle occurring as a result of climate changes. Different independent techniques were used to determine the start, the end, and the length of the vegetative season, including ground-, eddy-covariance-, and remote sensing-based approaches. Remarkably, the majority shows the same trends and they provide evidence for longer vegetative seasons that are caused by extension of the vegetative activity in the fall. Both phenological and flux observations indicate that the vegetative season extended later in the fall with an increase in length of about 3 days $year^{-1}$. However, these changes are responsible for only 50% of the total annual gain in forest productivity in the past decade. A negative trend in air and soil temperature during the winter months may explain an equivalent increase in net uptake through a decrease in ecosystem respiration.