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Multiple changes in atmospheric chemistry and responses of forest carbon dynamics in the US Mid-Atlantic region

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We use a process-based ecosystem model, PnET-CN, to examine how multiple atmospheric stresses – changing composition of CO2, O3 and N deposition – affect productivity, carbon storage, and carbon dynamics of Mid-Atlantic temperate forests. Our results suggest that the chronic changes in atmospheric chemistry in the past decades markedly affect carbon dynamics and sequestration in Mid-Atlantic temperate forests. Responses to the three major atmospheric chemical changes at the regional scale over the last 70 years are: net primary production increased by 28%; carbon sequestered in live forest biomass increased by 20%; and the carbon increase in soil organic matter was 18%. More fundamentally, changes in atmospheric chemistry components exert impacts on ecophysiological processes and ecosystem functioning. The modeling results suggest that N deposition is a stronger force than elevated CO2 for increasing primary production. In the Mid-Atlantic region, however, deciduous forests already show the phenomenon of N saturation under current deposition, while coniferous forests in infertile soils still have potential for uptake of additional N supply. The results reveal that N deposition mainly stimulates C allocation to short-lived tissues, foliage and fine roots. In contrast, elevated CO2 likely enhances more sustainable carbon storage in woody biomass. When elevated CO2 interacts with increased N supply from N deposition, a more favorable balance among plant resources breaks up the saturation thresholds either by CO2 or N, producing substantial increases in carbon sequestration. Finally, ozone pollution offsets about 22% of enhanced biochemical capacity for photosynthesis. The results from the process-based model PnET-CN are remarkably consistent with various experiments and observations and demonstrate a powerful approach to integrate and expand our knowledge of complex interactive effects of multiple environmental stresses on forest carbon dynamics.