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Leaf dynamics of a deciduous forest canopy: no response to elevated CO_2

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Abstract Leaf area index (LAI) and its seasonal dynamics are key determinants of terrestrial productivity and, therefore, of the response of ecosystems to a rising atmospheric CO_2 concentration. Despite the central importance of LAI, there is very little evidence from which to assess how forest LAI will respond to increasing [CO_2]. We assessed LAI and related leaf indices of a closed-canopy deciduous forest for 4 years in 25-m-diameter plots that were exposed to ambient or elevated CO_2 (542 ppm) in a free-air CO_2 enrichment (FACE) experiment. LAI of this *Liquidambar styraciflua* (sweetgum) stand was about 6 and was relatively constant year-to-year, including the 2 years prior to the onset of CO_2 treatment. LAI throughout the 1999–2002 growing seasons was assessed through a combination of data on photosynthetically active radiation (PAR) transmittance, mass of litter collected in traps, and leaf mass per unit area (LMA). There was no effect of [CO_2] on any expression of leaf area, including peak LAI, average LAI, or leaf area duration. Canopy mass and LMA, however, were significantly increased by CO_2 enrichment. The hypothesized connection between light compensation point (LCP) and LAI was rejected because LCP was reduced by [CO_2] enrichment only in leaves under full sun, but not in shaded leaves. Data on PAR interception also permitted calculation of absorbed PAR (APAR) and light use efficiency (LUE), which are key parameters connecting satellite assessments of terrestrial productivity with ecosystem models of future productivity. There was no effect of [CO_2] on APAR, and the observed increase in net primary productivity in elevated [CO_2] was ascribed to an increase in LUE, which ranged from 1.4 to 2.4 g MJ^{-1}. The current evidence seems convincing that LAI of non-expanding forest stands will not be different in a future CO_2-enriched atmosphere and that increases in LUE and productivity in elevated [CO_2] are driven primarily by functional responses rather than by structural changes. Ecosystem or regional models that incorporate feedbacks on resource use through LAI should not assume that LAI will increase with CO_2 enrichment of the atmosphere.

Keywords Absorbed PAR - Free-air CO_2 enrichment - Leaf area index - Light-use efficiency - *Liquidambar styraciflua*