Subalpine grassland carbon dioxide fluxes indicate substantial carbon losses under increased nitrogen deposition, but not at elevated ozone concentration

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Ozone (O$_3$) and nitrogen (N) deposition affect plant carbon (C) dynamics and may thus change ecosystem C-sink/source properties. We studied effects of increased background O$_3$ concentrations (up to ambient x 2) and increased N deposition (up to +50 kg ha$^{-1}$ a$^{-1}$) on mature, subalpine grassland during the third treatment year. During ten days and 13 nights, covering the vegetation period of 2006, we measured ecosystem-level CO$_2$ exchange using a steady state cuvette. Light dependency of gross primary production (GPP) and temperature dependency of ecosystem respiration rates (R$_{eco}$) were established. Soil temperature, soil water content, and solar radiation were monitored. Using R$_{eco}$ and GPP values, we calculated seasonal net ecosystem production (NEP), based on hourly averages of global radiation and soil temperature. Differences in NEP were compared to differences in soil organic C after five years of treatment.

Under high O$_3$ and with unchanged aboveground biomass, both mean R$_{eco}$ and GPP decreased throughout the season. Thus, NEP indicated an unaltered growing season CO$_2$-C balance. Under high N treatment, with a +31% increase in aboveground productivity, mean R$_{eco}$, but not GPP increased. Consequently, seasonal NEP yielded a 53.9 g C m$^{-2}$ ($\pm$ 22.05) C loss compared to control. Independent of treatment, we observed a negative NEP of 146.4 g C m$^{-2}$ ($\pm$15.3). This C loss was likely due to a transient management effect, equivalent to a shift from pasture to hay meadow and a drought effect, specific to the 2006 summer climate. We argue that this resulted from strongly intensified soil microbial respiration, following mitigation of nutrient limitation. There was no interaction between O$_3$ and N treatments.

Thus, during the 2006 growing season, the subalpine grassland lost $>2\%$ of total topsoil organic C as respired CO$_2$, with increased N deposition responsible for one-third of that loss.