MS60 Completion of scenario assessments of ecosystem responses to air pollution and climate change at experimental sites, based on final collated datasets

Note: This milestone is reported in detail under deliverable 13.4

A modelling study was carried out to assess the interacting effects of ozone and nitrogen (N) pollution and climate change. The MADOC model, originally developed to simulate effects of acid and N pollution, was extended early on in the ECLAIRE project by incorporating effects of ozone on plant productivity and on the translocation of N out of leaves before senescence. These effects were included as functions derived from empirical observations. Testing of the ozone-sensitive version of MADOC was described in a previous report (Deliverable 13.4). In the current report, the model was used to explore the effects of air pollution and climate change at two sites, Gårdsjön (Sweden) and Whim (UK). The model was first calibrated to key observations at the sites, such as mineral N flux, dissolved organic carbon flux, and soil total C/N ratio. Simple scenarios were then imposed from 2020, increasing mean annual temperature by +2 ^{o}C or +4 ^{o}C, and increasing and/or decreasing N and ozone pollution by +/- 20%.

The main effects of ozone and N pollution are broadly opposite. Nitrogen stimulates productivity in N-limited semi-natural ecosystems, whereas the major effect of ozone is to decrease productivity. These effects were well-illustrated by the model: for example, a 20% increase in N at Gårdsjön for ten years increased NPP by 5%, whereas a 20% increase in ozone at Gårdsjön for ten years decreased NPP by 2%. It is important to recognise that productivity is correlated with several ecosystem services (agricultural and forest production, and carbon sequestration) but is often inversely correlated with biodiversity, for example because species typical of infertile environments tend to be more scarce. Productivity changes are therefore likely to be valued differently by different societal actors.

Increased productivity is clearly not of universal benefit, and the effects of ozone beyond those on NPP also need to be considered. Although decreasing productivity is ostensibly beneficial for biodiversity, and ozone could be seen as mitigating the damage to biodiversity caused by N, this mitigation is likely to be partial. Sensitive plant and animal species may be affected directly by ozone as well as by N, and an environment chronically polluted by both of these atmospheric pollutants is likely to be impoverished. Effects of climate change (increase in mean annual temperate) were similar to the effects of N pollution, with direct impacts on NPP, and also through increased N mineralisation and availability. As with the other pollutants, broad effects simulated via impacts on NPP are unlikely to represent all likely changes, since many species will be unable to adapt to the changed climate at a particular site. Despite these limitations and subtleties, the modelling approach taken proved useful in illustrating the major effects of air pollution and climate change on ecosystems.