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ScienceDirect
Environmental Pollution 146 (2007) 736–743
ENVIRONMENTAL POLLUTION
www.elsevier.com/locate/envpol

Identifying ozone-sensitive communities of (semi-)natural vegetation suitable for mapping exceedance of critical levels

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Received 21 December 2005; accepted 4 April 2006

Grassland communities such as alpine and sub-alpine grasslands have the highest potential sensitivity ozone, based on the responses of their component species.

Abstract

Using published data on the responses of individual species to ozone, 54 EUNIS (European Nature Information System) level 4 communities with six or more ozone-sensitive species (%OS) and c. 20% or more species tested for ozone sensitivity, were identified as potentially ozone-sensitive. The largest number of these communities (23) was associated with Grasslands, with Heathland, scrub and tundra, and Mires, bogs and fens having the next highest representation at 11 and 8 level 4 communities each respectively. Within the grasslands classification, E4 (Alpine and sub-alpine grasslands), E5 (Woodland fringes and clearings) and E1 (Dry grasslands) were the most sensitive with 68.1, 51.6 and 48.6%OS respectively. It is feasible to map the land-cover for these and other communities at level 2, but it may not be currently possible to map the land-cover for all communities identified to be ozone-sensitive at levels 3 and 4.

Keywords: Ozone; Semi-natural vegetation; EUNIS; Communities; Relative sensitivity

1. Introduction

Numerous studies have indicated that many of Europe's natural and (semi-)natural vegetation species are potentially at risk from damage by ozone pollution. These studies have primarily involved exposure of plants to ozone pollution in solardomes (e.g. Hayes et al., in press-a) and open top chambers (e.g., Pleijel and Danielsson, 1997; Gimeno et al., 2004a) with one study using an open field exposure system (Volk et al., 2006). Regardless of exposure system used, the experiments have shown that a significant proportion of those species tested respond to ozone by developing one or more of the following: visible injury, premature and enhanced senescence, changes in biomass, resource allocation and/or seed production. Since each of these effects might impact on the vitality of plant communities, there has been a growing need to draw the published information together to identify which communities across Europe are potentially sensitive to ozone and to develop methods for mapping their location in relation to ozone exposure.

During the 1980s, the Convention on Long-range Transboundary Air Pollution (LRTAP Convention) adopted the critical loads/critical levels approach to defining sensitivity of receptors to pollutants (Bull, 1991). Much progress has been made since then in establishing critical levels of ozone for vegetation, above which adverse effects could be expected. Several workshops have been held in which the critical levels of ozone for crops and forest trees were developed to include concentration-based and more recently flux-based

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0269-7491/$ - see front matter
doi:10.1016/j.envpol.2006.04.005

methodology (LRTAP Convention, 2004). Because of the complexity of (semi-)natural communities, it is not possible yet to have a flux-based critical level for this vegetation type. The critical level is currently an AOT40[1] of 3 ppm h over three months and is applicable for growth reduction in perennial species and growth reduction and/or seed production in annual species when grown in a competitive environment (LRTAP Convention, 2004). Preliminary recommendations were suggested for mapping exceedance based on expert knowledge of those communities most likely to be sensitive to ozone. These were classified using the European Nature Information System, EUNIS (http://eunis.eea.eu.int/index.jsp) which has been adopted by the LRTAP Convention for mapping impacts of pollutants in Europe. This system provides a hierarchical approach to classification, with the broadest classes e.g. "Heathland, scrub and tundra" at level 1 denoted by a letter, in this case F, through to relatively specific descriptions of community types at level 4 denoted by the letter followed by "number. number number". As the full names are frequently long and wordy, these will be provided here at the first mention, and abbreviated names will be used thereafter. Using the EUNIS approach, ozone-sensitive communities were indicated in the Mapping Manual as Dry grasslands (EUNIS code E1), Mesic grasslands (E2), Seasonally-wet grasslands (E3) and Dehesa grasslands (E7.3) with Woodland fringes, clearings and tall forb habitats (E5, henceforth described as "Woodland fringes") also being considered likely to be sensitive. Such recommendations were based on peer review of available knowledge and were not based on any in depth analysis. Within this paper, we provide support for these choices as well as recommending other communities that are potentially at risk from ozone pollution.

Ideally, an analysis of which communities are at risk from ozone pollution would involve an assessment of the responses of many types of natural communities to several years of ozone exposure. However, there is only one long-term field-based study available – field exposure of sub-alpine pasture at Le Mouret, Switzerland (Volk et al., 2006). Similarly, very few studies have reported results from exposure of turves extracted from natural grassland and exposed to ozone (e.g. Nebel and Fuhrer, 1994). Because of the scarcity of field data, the critical level was based on results of four experiments in which one or more ozone-responsive species were grown in the presence of a competitor species (LRTAP Convention, 2004). Even with the more recently available data (see Fuhrer et al., in press), there remains insufficient information from experiments involving plants growing in a competitive environment on which to rank the ozone sensitivity of (semi-)natural vegetation communities for use in a Europe-wide risk assessment. Thus, we have based our analysis on results from exposure experiments involving single species exposed to ozone in ambient or near-ambient climatic conditions. The uncertainties associated with this approach are considered in the discussion.

The analysis presented uses data stored in OZOVEG (OZOne impacts on VEGetation), a database collated from over 60 papers describing the responses of natural vegetation to ozone (Hayes et al., in press-b). Data was selected for inclusion from field-release, open-top chamber or solardome experiments involving seasonal ozone exposure. Ozone-response functions were derived for the 83 species within OZOVEG that have three or more data points. The geographical coverage of the database reflects the sources of published data. Thus, it has a central and northern European bias since over 95% of the data OZOVEG contains is from experiments conducted in Sweden, Denmark, UK, Netherlands, Germany and Switzerland. Using the same database, Hayes et al. (in press-b) showed that species belonging to the *Fabaceae* had greater sensitivity to ozone than species of *Asteraceae*, *Carophyllacaeae*, and *Poaceae* and Jones et al. (in press) developed a model for predicting ozone sensitivity in communities based on the Ellenberg values of the component species. Here, we investigate simpler indices that can be applied across Europe in the absence of detailed information on species composition of communities.

The aim of this study was to identify ozone-sensitive communities that could be mapped using currently available European land-cover maps. Cinderby et al. (in press) recently reported on progress with harmonisation of two European land-cover datasets: the SEI land-cover dataset (Cinderby, 2002) and the European Environment Agency (EEA) Corine land-cover dataset (de Smet and Hettelingh, 2001). For (semi-)natural vegetation, additional data on climatic zone, moisture regime, soil pH and altitude were included with the combined dataset to aid differentiation between related vegetation classes within a EUNIS category to separate spatially communities such as EUNIS F4.1 (Wet heath) and EUNIS F4.2 (Dry heath). The feasibility of mapping those communities identified at EUNIS levels 2, 3 and 4 as ozone sensitive will be described here. Thus, this study shows how ozone sensitive communities of semi-natural vegetation can be identified based on the responses of individual species, confirms and adds to the choices identified in the Mapping Manual (LRTAP Convention, 2004) as potentially ozone sensitive and indicates factors to be taken into account in mapping the location of these communities within the framework of the EUNIS Hierarchy.

2. Methods

2.1. Identifying potential ozone-sensitive communities

In a previous paper (Hayes et al., in press-b), dose-response functions were derived for 82 species with more than three data points and used to determine the relative sensitivity (RS) as the ratio of the biomass at an AOT40 of 15 ppm h compared to that at 3 ppm h. Establishing which EUNIS communities these species are present in was difficult since such information is incomplete for the whole of Europe. Such data does exist, however, for the 69 species in the database that are found in the UK, in the form of the National Vegetation Classification, NVC (Rodwell, 1992). Using the UK National Biodiversity

[1] The sum of the differences between the hourly mean ozone concentration (in ppb) and X ppb when the concentration exceeds X ppb during daylight hours.