Urban Climate 14 (2015) 414–428

Contents lists available at ScienceDirect

Urban Climate

journal homepage: www.elsevier.com/locate/uclim

Pollen from alder (*Alnus* sp.), birch (*Betula* sp.) and oak (*Quercus* sp.) in the UK originate from small woodlands

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ARTICLE INFO

Article history:
Received 19 December 2013
Revised 28 August 2014
Accepted 16 September 2014

Keywords:
Pollen
Aeroallergens
Urban bioaerosols
Trajectory calculations
Source maps
Trees

ABSTRACT

We have analysed the pollen seasons in Worcester for the period 2005–12 for alder (*Alnus*), birch (*Betula*) and oak (*Quercus*) by using back trajectory calculations and produced the first detailed source maps for these three pollen types.

The study shows considerable variations in the source–receptor relationship of three of the most important tree pollen types in England with respect to allergy. Long Distance Transport is observed for *Quercus* and *Betula* but not for *Alnus*. The new source maps show a number of high emitting areas for *Betula* and *Quercus*, mainly near London, in the Midlands and in Wales. The production of source maps is sensitive to the used type of land cover data and how well they incorporate small woodlands. Two satellite products, Corine Land Cover and Globcover, are compared with the detailed national land cover product Land Cover Map 2007. The broad scale satellite products show either up to 50% less woody coverage or a direct misplacement of woodlands.

The Lagrangian back trajectory model, the pollen count observations and the source maps altogether suggest that small woodlands (below 25 ha) play a major role in the overall pollen load in urban areas in England.

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http://dx.doi.org/10.1016/j.uclim.2014.09.007
2212-0955/

1. Introduction

Birch (*Betula* sp. hereafter *Betula*) and alder (*Alnus* sp. hereafter *Alnus*) belong to the Betulaceae family and their pollen is highly allergenic (Ipsen and Lowenstein, 1997). Pollen from the Betulaceae family includes significant cross reaction between the species (Valenta et al., 1991). In general, *Betula* is the most important aeroallergen from the Betulaceae family (van Ree et al., 1999). However, hazel (*Corylus* sp.), hornbeam (*Carpinus* sp.) and *Alnus* are also important aeroallergens (Valenta et al., 1991; Gumowski et al., 2000), especially if they are present in large quantities when people spend considerable amounts of time outdoor (Hauser et al., 2011). Furthermore, there is considerable cross reactivity with pollen from the Betulaceae family with species from the Fagaceae family, especially oak (*Quercus* sp. hereafter *Quercus*), due to similarities of the allergens at the molecular level (Hauser et al., 2011). Pollen from *Alnus*, *Betula* and *Quercus* is among the most abundant and allergenic tree pollen in central and northern Europe (Skjøth et al., 2013). The spatial distribution and potential origin of these pollen is therefore important to understand, especially in densely populated countries like England.

The southern part of England has been identified as a region with large amounts of *Betula* trees in forests (Skjøth et al., 2008). This area is considered a cause of high loads of *Betula* pollen in London (Skjøth et al., 2009). Other regions in England may also affect the *Betula* pollen load in England. Central England or Wales could be a cause of high loads of *Betula* pollen previously observed in the West Midlands (Corden et al., 2000). If this should be explored, then it requires mapping of the sources (Pauling et al., 2012) and the application of an atmospheric transport model. This combination can be used for source-receptor studies. Source-receptor studies on *Betula* have been carried in a number of countries including Finland (Sofiev et al., 2006), Lithuania (Veriankaite et al., 2010), Denmark (Mahura et al., 2007; Skjøth et al., 2007, 2008) and England (Skjøth et al., 2009). In England, this type of study has only been carried out for London (Skjøth et al., 2009), even though that England is considerable larger than Denmark, Lithuania and Finland. Further studies on this topic are therefore highly relevant when considering the small knowledge base in England.

Alnus flowers about a month earlier than *Betula* (Linkosalo, 2000) and due to the cross-reactivity with *Betula* it will extend the hayfever season for sensitive individuals. Additionally, *Alnus* pollen is known to prime sensitive individuals before the birch pollen season (Emberlin et al., 2007). *Alnus* and *Betula* are found in nearly all of Europe with highest densities in Scandinavia and the Baltic countries (Skjøth et al., 2008). In southern England the load of both *Betula* and *Alnus* can be significant (Skjøth et al., 2009; Emberlin et al., 2007). The overall load of *Betula* pollen throughout England has previously been investigated for the years 1993–1997 (Corden et al., 2000). For *Alnus* there are no nation-wide studies. The only English study on *Alnus* covers the city of Worcester for the years 1996–2005 (Emberlin et al., 2007). Likewise, there are no published source-receptor studies on *Alnus* like those that have previously been published on *Betula* (Sofiev et al., 2006; Veriankaite et al., 2010; Mahura et al., 2007; Skjøth et al., 2007). Source-receptor studies on *Alnus* are therefore highly relevant.

Quercus begins flowering during or after the *Betula* season (Weryszko-Chmielewska et al., 2006) and due to cross reactivity with *Betula* (Hauser et al., 2011), *Quercus* will extend the hayfever season for sensitive individuals. To date, there is only one study on *Quercus* pollen in England covering Derby (Corden and Millington, 1999), which suggests pollen loads were increasing during the period 1970–1997. A recent European map suggests that *Quercus* pollen is present in similar quantities as *Betula* throughout central and southern England (Skjøth et al., 2013). Further studies on *Quercus* pollen in England are therefore highly relevant, especially in relation to potential spatial distribution.

High resolution maps or inventories on the abundance of tree species such as *Alnus*, *Betula* and *Quercus* can be highly useful in a number of disciplines within earth system sciences such as ecology (Hickler et al., 2012), meteorology and air quality (Oderbolz et al., 2013), and aerobiology. In aerobiology this includes the general recommendation for sensitive individuals, interpretation of observations, forecasting and the utilisation of atmospheric transport models. Use of atmospheric transport models is usually limited by the availability of source maps (Skjøth et al., 2010), as atmospheric transport models are well developed with respect to atmospheric physics and the transport of bioaerosols such as pollen (Pauling et al., 2012). This suggests that more detailed data sets are needed for regional scale assessments.