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Impact of land cover changes and climate on the main airborne pollen types in Southern Spain

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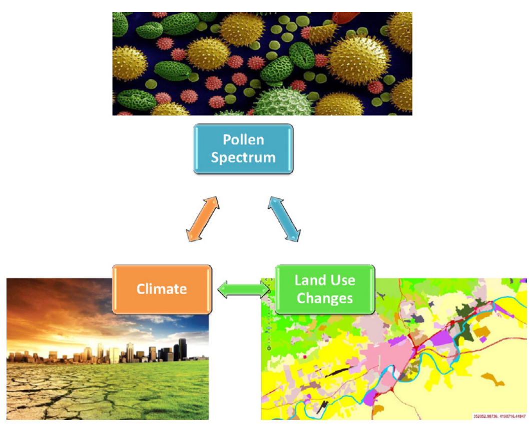
HIGHLIGHTS

- Usually airborne pollen changes are attributed only to climate and land cover changes are not taking into account.
- Pollen trends extracted by STL were compared with main changes on land use and climate.
- Changes in land uses and land cover may explain pollen spectrum variations through the years.
- Different increasing or decreasing trends depending on pollen taxa reflecting land cover and/or climate fluctuations

GRAPHICAL ABSTRACT



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ABSTRACT

Airborne pollen concentrations strongly correlate with flowering intensity of wind-pollinated species growing at and around monitoring sites. The pollen spectrum, and the variations in its composition and concentrations, is influenced by climatic features and by available nutritional resources but it is also determined by land use and its changes. The first factor influence is well known on aerobiological researches but the impact of land cover changes has been scarcely studied until now.

This paper reports on a study carried out in Southern Spain (Córdoba city) examining airborne pollen trends over a 15-year period and it explores the possible links both to changes in land use and to climate variations. The Seasonal-Trend Decomposition procedure based on Loess (STL) which decomposes long-term data series into smaller seasonal component patterns was applied. Trends were compared with recorded changes in land use at varying distances from the city in order to determine their possible influence on pollen-count variations. The influence of climate-related factors was determined by means of non-parametric correlation analysis.

The STL method proved highly effective for extracting trend components from pollen time series, because their features vary widely and can change quickly in a short term. Results revealed mixed trends depending on the taxa and reflecting fluctuations in land cover and/or climate. A significant rising trend in *Olea* pollen counts was observed, attributable both to the increasing olive-growing area but also to changes in temperature and rainfall. Poaceae pollen concentrations also increased, due largely to an expansion of heterogeneous agricultural areas

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and to an increase in pollen season length positively influenced by rainfall and temperature. By contrast, the significant declining trend observed for pollen from ruderal taxa, such as Amaranthaceae, *Rumex*, *Plantago* and Urticaceae, may be linked to changes in urban planning strategies with a higher building pressure.

1. Introduction

Changes in land use and land cover are major components of global dynamic, directly prompting alterations in habitat composition, biodiversity and the functioning of the ecosystem (Foley et al., 2005; Turner et al., 2007). The impacts and consequences of such changes directly affect processes such as land degradation and biodiversity loss that modify environmental conditions (Figueroa and Sánchez-Cordero, 2008; Sánchez-Cuervo et al., 2012). Since airborne pollen detected at a given location correlate directly with local land uses, one indirect consequence of changes in the landscape is the alteration of airborne pollen concentrations (Oteros et al., 2015). Moreover pollen grains preserved in soil sediment provide a record of past vegetation and they are an important source of information about climate and land cover during the Quaternary Period (Davis, 2000; Seppä and Bennett, 2003).

Most of airborne pollen is emitted by wind-pollinated plants, and it is strongly modulated by their phenology and flowering intensity. Both the timing and the intensity of the pollen season obviously vary among taxa and regions, due to differences in vegetation, climate, biogeography and land use (Scheifinger et al., 2013). Although some aerobiological studies include land use as a descriptive variable (e.g. Haberle et al., 2014; Rojo et al., 2015) there has been no specific analysis of the influence of land-use changes on variations in airborne pollen counts, which are usually attributed to weather-related factors.

The present study was carried out in Córdoba, a medium-sized city in Andalusia (southern Spain) belonging to the Mediterranean region, which has a lower degree of landscape persistence and a higher anthropization rate than the temperate region, and is therefore highly vulnerable to the impact of land cover changes on natural habitats and on the plant species growing in them (Martínez-Fernández et al., 2015). Plant physiology and phenology are also influenced by a number of biological factors, including pests, soil-related factors and age (Walther et al., 2002). Topography is responsible for micro-climate and micro-ecological conditions, and it is also a major factor driving phenology (Oteros et al., 2013a). However, the single factor most affecting phenology is the prevailing weather during the growing season, and more specifically temperature and water availability (Schwartz, 2013). Plant phenology is modulated by climate, and closely governed by air temperature for both herbaceous and arboreal species and water availability in the case of herbaceous plants, particularly in the Mediterranean Basin. Over recent years, southern Europe has witnessed an increase both in temperature and in rainfall intensity, especially in the Mediterranean climate area (IPCC, 2013). These changes are influencing the distribution areas of anemophilous species (Hamaoui-Laguel et al., 2015), and have a twofold effect on affecting pollen emission, influencing both pollen-season timing and pollination intensity (Ziello et al., 2012; Menzel et al., 2006; García-Mozo et al., 2010).

In wind-pollinated taxa airborne pollen concentrations are higher than in entomophilous ones and they are widely regarded as reliable indicators of flowering intensity and floral phenology (Menzel and Sparks, 2006). Although pollen production per flower is genetically determined in each species (Tormo et al., 1996; Prieto-Baena et al., 2003), atmospheric pollen concentration are obviously governed by the plant response to climate variables, but also by local land uses which determine the number of individuals of each species in a given area. Relatively few studies have focused on the impact of landscape management on airborne pollen, and these mainly address crop or ornamental species (Cariñanos and Casares-Porcel, 2011; Oteros et al., 2013b; Haberle et al., 2014).

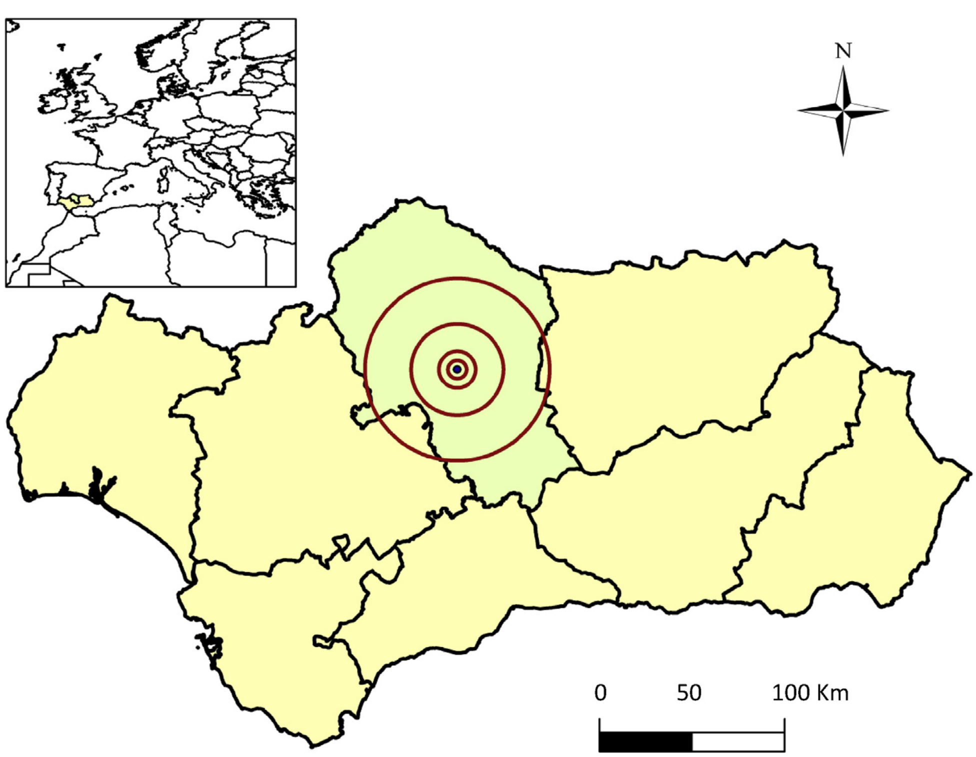

Fig. 1. Location of Córdoba city and range of land use analysis (outlined at 5 km, 10 km, 25 km and 50 km around pollen-trap location).