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Agricultural landscapes with prevailing grasslands can mitigate the population densities of a tree-damaging alien species

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ABSTRACT

Alien organisms can seriously damage plants that are important to humans. Because such pests are often managed at the site scale, our understanding of how factors on broader spatial scales affect their numbers remains poor.

To understand how factors relevant to larger spatial scales affect alien numbers, we used the horse-chestnut leaf miner (*Cameraria ohridella*) as a model organism. We studied how its site-based population density was related to six kinds of land use in independent landscapes (ranging from 2 to 64 km^2) that surrounded each study site in the Czech Republic. For each landscape, we quantified the area occupied by coniferous forests, deciduous forests, crop fields, grasslands, parks and urban areas, and linear vegetation. Data were collected from 30 sites in 2002 and from 35 different sites in 2014.

The abundance of alien pest was most closely associated with the landscape occupied by grassland. This relationship was negative, and its strength increased with spatial scale in 2002 but decreased in 2014. Grassland area was negatively correlated with crop field area, and we infer that grasslands help to control alien pest abundance while crop fields should have the opposite effect.

We suggest that increasing the percentage of the landscape patches planted with grassland is one of the possibilities that could help control alien and perhaps other pests of trees. Furthermore, increasing the area of grasslands might hinder the spread of invasive organisms and facilitate pest management. Moreover, landscape-based management might be directly or indirectly influenced by agricultural subsidies.

1. Introduction

Native fauna and flora are threatened by alien organisms that have the potential to fill the ecological niches of the natives. Furthermore, by seriously damaging plants, alien herbivores could threaten the survival of local human populations (Joshi, 2007). Some invasive pests, on the other hand, do not cause serious economic losses but might be highly conspicuous and distasteful to humans. For example, an alien might damage an economically unimportant ornamental plant. Nevertheless, the latter kind of alien might be a useful model organism for studying the mechanisms of spread and possible pest management and amendments (Rigot et al., 2014).

Pest management approaches include those that are used at the place (i.e. site) of the problem (e.g., cutting a tree attacked by bark beetles or spraying pesticides in a corn field) and those that are based on a broader spatial scale. The scale that is relevant to management could depend on pest distribution. Pearson and Dawson (2003) divided the spatial range of factors that influence the distribution of a species into the following scales: local (1–10 km), landscape (10–200 km), regional (200–2000 km), continental (2000–10,000 km), and global. Among these, the local scale could be quite important for pest management because the local scale can be readily influenced by local managers or authorities and can also be influenced by readily measured environmental factors (e.g., Agri-Envi subsidies; Stenseke, 2006).

Large-scale studies, which are still uncommon compared to site based (Zhou et al., 2014), can indicate patterns of pest distribution that cannot be easily observed and dealt with by local managers. Even local spatial scales are less frequently studied than site- or

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micro-scales of less than 10 m (Pearson and Dawson, 2003). Factors that affect the spread of tree-damaging alien insect pests at larger spatial scales are poorly understood. Models operating at larger spatial scales can predict areas at risk of invasion (Jones et al., 2010) and local scale models are known to be useful to experts (Brummer et al., 2013).

The abundance and spread of tree-damaging alien pests are likely to be affected by forest characteristics such as total forest cover or volume of host trees. Not all tree species and their associated fauna, however, are typical for forest biomes (Ives and Wong, 1988), and not all forests in the past were so closed as those that prevail in the present landscapes (Vera, 2000). For example, the abundance of the forest tent caterpillar, which is a pest of trembling aspen, was negatively affected by the forest cover in the surroundings (Rothman and Roland, 1998). Thus, it seems likely that tree-damaging species could be influenced by open landscapes including the kinds of open landscapes generated by agriculture.

The main aim of this study was to determine the relationships between the population density of an alien organism at a site and land use and area of the surrounding landscape. The alien organism was the horse-chestnut leaf miner (*Cameraria ohridella* Deschka & Dimic, 1986). Landscape area surrounding each site ranged from 2 to 64 km^2, and land uses included coniferous forests, deciduous forests, crop fields, grasslands, parks and urban areas, and tree rows.

2. Materials and methods

2.1. Study area, species, and sampling

We used the horse-chestnut leaf miner, *C. ohridella*, as a model alien organism (Blackburn et al., 2014). As its common name indicates, it is a leaf miner of the horse-chestnut (*Aesculus hippocastanum* L.), which is an exotic deciduous tree in areas other than southeastern Europe. Horse-chestnut is often planted as an ornamental tree along avenues and in gardens, parks, and open

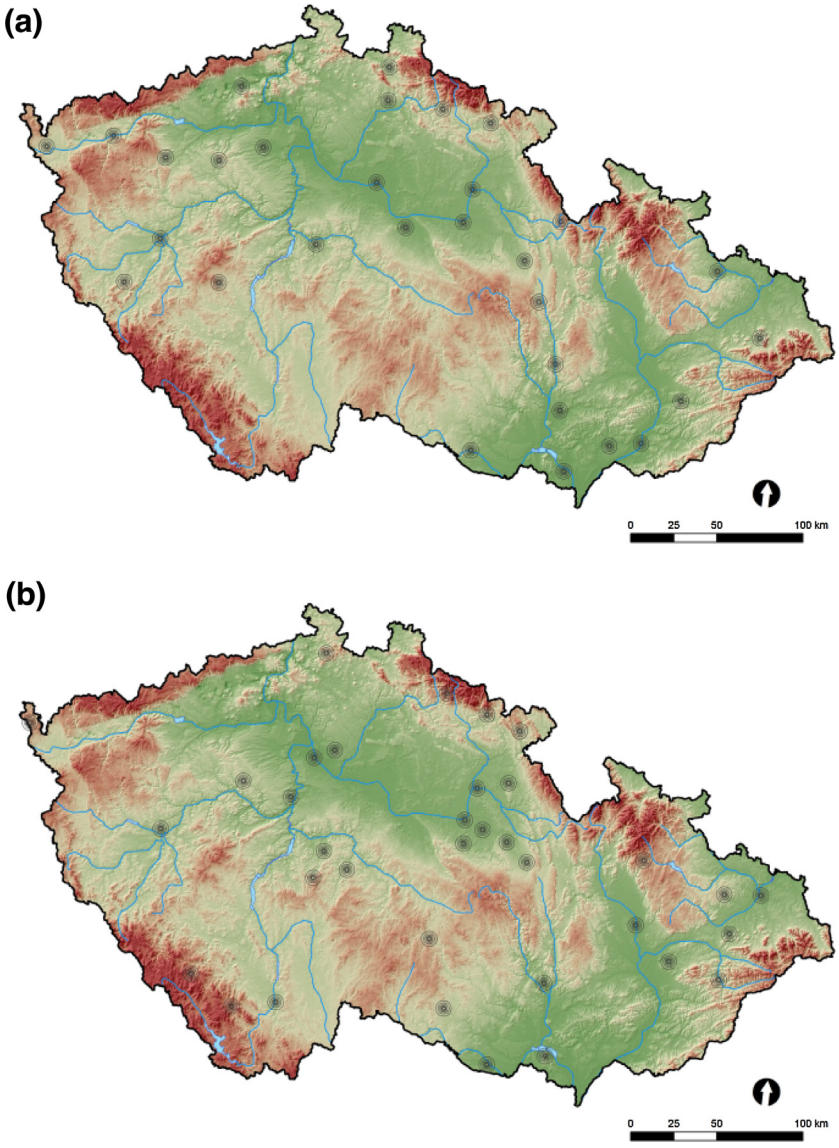

Fig. 1. Distribution of the 30 study sites in 2002 (a) and of the 35 study sites in 2014 (b) in the Czech Republic. The dark zone in the center of each circle indicates the site where population density of alien pest was assessed, and the larger circle indicates the landscape surrounding each site, a landscape that included six kinds of land uses. Green indicates lowlands and brown indicates mountains; main rivers are indicated by blue lines. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)