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Five major invasive alien tree species in European Union forest habitat types of the Alpine and Continental biogeographical regions

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ABSTRACT

Invasive alien species are a threat to protected areas, species, and habitats worldwide. At the European level, the control of invasive alien species is a major goal of the EU Biodiversity Strategy, and a cornerstone, in this sense, is the Regulation (EU) no.1143/2014 on invasive alien species. In this study, we focus on the Alpine and Continental biogeographical regions of Europe (defined in art. 1 of the Habitats Directive; 92/43/EEC), and aim to give an overview of the main protected forest habitat types threatened by invasive alien species, and focus on five major invasive alien tree species (*Acer negundo*, *Ailanthus altissima*, *Prunus serotina*, *Quercus rubra*, and *Robinia pseudoacacia*). We considered the assessment reports under Article 17 of the Habitats Directive for the period 2007–2012, and six documents on the interpretation of habitats, to identify those most threatened by invasive alien species and in particular by the five invasive alien trees. We also assessed selected examples of impacts by these alien tree species on different species groups within Natura 2000 sites to highlight potential effects on biodiversity. Riparian forest habitats and oak dominated woodlands are among the most prone to invasion within the two biogeographical regions. *A. altissima* and *R. pseudoacacia* are the most reported invasive alien trees in these protected forest habitat types. Furthermore, examples of the impacts of these tree species have indicated potential detrimental effects on forest habitats structure and functions, and on single species listed in the Habitats and Birds Directives. In conclusion, we emphasise the need for effective management and systematic monitoring of these five invasive alien tree species within Natura 2000 sites.

1. Introduction

Invasive alien species are a threat to protected areas, habitats, and species worldwide, due to their negative impacts on both biodiversity and ecosystem processes (Foxcroft, Richardson, Pyšek, & Genovesi 2013). Despite this, compared to other pressures on protected areas (e.g. land use change), the impacts of invasive alien species are frequently less well understood (Hulme et al., 2014). Therefore, additional research efforts on the prevalence of invasive alien species in protected areas would assist in the development and implementation of management plans.

Protected areas in Europe are among the most threatened worldwide by invasive alien species, and this threat is predicted to persist throughout the 21st century (Early et al., 2016; Seebens et al., 2017). Between 1992 and 2009, over 132 million EUR were spent through European Commission funding programmes to tackle biological invasions (Scalera, 2010). Indeed, combating invasive alien species is still a major target as underlined by the EU Biodiversity Strategy (European Commission, 2011). Another cornerstone in these control efforts is the EU Regulation No 1143/2014 on invasive alien species, which entered in force on the 1st of January 2015 (Genovesi, Carboneras, Vilà, & Walton 2015). This Regulation "set out rules to prevent, minimise and mitigate the adverse impact on biodiversity" brought on by invasive alien species. Sound scientific research should be used to support coordinated actions and to adopt measures aimed to achieve effective conservation management against invasive alien species (Beninde, Fischer, Hochkirch, & Zink 2015; Tollington et al., 2017). Therefore, this legislation calls for dedicated efforts from several disciplines to achieve a better understanding of the impacts of invasive species, and to improve management options for those responsible for protected natural areas, such as forest managers and authorities (Sitzia, 2014; Sitzia, Campagnaro, Kowarik, & Trentanovi, 2016a). The first list of invasive alien species of European concern was published

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in 2016 (Commission Implementing Regulation (EU) 2016/1141), however it is considered by many to be too short, and requires the inclusion of additional species to be effective to address biological invasions in Europe (Pergl, Genovesi, & Pysek 2016). For example, no alien tree species were included in the first list, in spite of the many ongoing control programmes for invasive alien trees species throughout the European Union (Silva, Sopeña, & Sliva 2014), and numerous efforts at the local scale for the eradication of these species from protected areas, such as the efforts to combat *Ailanthus altissima* in the Mediterranean basin (Brunel, Brundu, & Fried 2013; Vagniluca, Quilghini, & Giunti 2014).

Many European protected areas were established in landscapes where alien species were introduced long before their establishment, and no legal restrictions regarding their introduction were in place (Braun, Schindler, & Essl 2016). More than 50% of the Natura 2000 European protected areas consist of forests, and these include important habitat types and habitats for a huge number of species, many of which are of conservation concern. Of particular concern are natural and semi-natural forest habitats, where native tree species can be outcompeted and replaced by invasive alien tree species (e.g., Cierjacks et al., 2013). Invasive alien tree species tend to be strongly competitive in natural vegetation succession processes occurring throughout many parts of Europe (e.g., Sitzia, Campagnaro, Dainese, & Cierjacks 2012). In many European countries, managers of Natura 2000 sites are aware of the threats posed by invasive aliens trees, however there is typically less awareness among decision makers and the general public (Scalera & Zaghi 2004). Although temperate forests are often viewed as being less susceptible to invasive alien plants than other habitats, forest invasibility can be influenced by several factors (Essl, Mang, & Moser 2012). Indeed, forest and landscape characteristics may mask woodland invasibility and invasive species propagule pressure. For example, the density and type of forest roads (Mortensen, Rauschert, Nord, & Jones 2009), forest edges (Cadenasso & Pickett 2001), and artificial landscape matrix (Essl et al., 2012), are among the various factors that can influence forest invasion processes.

Monaco and Genovesi (2014) identified ten top plant invaders among a set of protected areas in Europe, two of which are tree species: *Robinia pseudoacacia* (black locust) and *A. altissima* (tree of heaven). Furthermore, a recent study on invasive alien species in central European protected areas has highlighted *R. pseudoacacia*, *Acer negundo*, *Prunus serotina*, and *Quercus rubra* among the most widely managed species (Braun, Schindler, & Essl 2016). Invasive alien tree species are of particular interest due to their potential detrimental effects on the properties and functions of European natural and semi-natural forest habitats. Indeed, invasive alien tree species may have a substantial negative effect on native communities and ecosystem processes, and they may act as ecosystem engineers, i.e. causing changes in the physical nature (abiotic or biotic) of ecosystems (Crooks 2002; Lamarque, Delzon, & Lortie 2011). However, the spread (Lamarque et al., 2011) and impacts (Pyšek et al., 2012) of invasive alien species are context-dependent, which highlights the need for better understanding their spatial and temporal variability, particularly within sensitive ecosystems. Furthermore, research and information sharing on the impacts, and how to measure and compare them across habitats and regions, is still much needed (Dick et al., 2017; Hawkins et al., 2015; Jeschke et al., 2014; Rabitsch et al., 2016).

This study examines the currently available knowledge on biological invasions within forest habitat types in Europe under the framework of the Habitats Directive (Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora). We focus on protected forest habitat types threatened by invasive alien species with an emphasis on invasive alien trees. The main aim is to give (i) an overview of the forest types most commonly threatened by invasive alien species with (ii) a focus on five major invasive tree species and (iii) their effects on biodiversity within Natura 2000 sites. Our paper draws mainly on the raw data and reports related to the Habitats Directive within the Alpine and Continental biogeographical regions. We considered these sources of information to be very useful for highlighting which forest habitat types listed in Annex I of the Habitats Directive (hereafter called forest habitat types) are invaded by alien species. Furthermore, we listed case studies dealing with impacts on biodiversity caused by invasive alien tree species, and highlighting those occurring within protected areas. Finally, we discuss information on the control of the most invasive alien tree species within the context of forest management.

2. Methods

2.1. Study area and data collection

This study focuses on the Alpine and Continental biogeographical regions of Europe (see Article 1 of the Habitats Directive). The Alpine region stretches across 13 EU Member States, whereas the Continental region is present in 14 EU Member States (Fig. 1). To evaluate which forest habitat types among those listed in the Habitats Directive are mostly affected by invasive alien species, we considered (a) the assessment reports under Article 17 of the Habitats Directive for the period 2007–2012, and (b) six documents on the interpretation of habitats.

We obtained information on invasive alien species in the two biogeographical regions from the Member States assessments under Article 17 of the Habitats Directive (EEA, 2015). Information on the pressures currently acting upon forest habitat types was extracted from this database.

We gathered the EU-28 interpretation manual (European Commission, 2013) and five national manuals for Austria (Ellmauer, 2005), Czech Republic (Chytrý et al., 2010), France (Bensettiti, Rameau, & Chevallier 2001), Italy (Biondi et al., 2009), and Poland (Herbich, 2004), occurring within both of the investigated biogeographical regions. We selected the most common alien tree species occurring within the two biogeographical regions based on information from the main databases on invasive alien species in Europe (Fig. 1) and expert opinion. This resulted in the selection of the following five alien tree species (listed in alphabetical order): *A. negundo*, *A. altissima*, *P. serotina*, *Q. rubra*, and *R. pseudoacacia*. We systematically analysed the six interpretation manuals to record those forest habitat types reported as threatened by the most common invasive alien tree species.

To assess which impact types occurred in the Natura 2000 sites in the two biogeographical regions we reviewed and summarized case studies by preparing a dedicated database. We focused on the impacts to biodiversity caused by the five selected invasive alien tree species. The studies were selected to illustrate the variety of taxa and impacts that can be observed in the literature.

2.2. Data analysis

Data reported in the Member State assessments were collected and analysed considering only the information under the category I01, as this code refers to the pressure or threat posed by biological invasions. We analysed only data on the current pressures, as they refer to pressures occurring during the period under consideration (2007–2012). The number of assessments for one habitat type corresponds to the number of countries reporting such pressure for that habitat type. To quantify the intensity of such pressure, a score ranging from 1 to 3 was given based on the available evaluations originally provided in the reports according to a qualitative scale (low, medium, high). These values take into consideration

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