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Plant invasions in temperate forests: Resistance or ephemeral phenomenon?

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Abstract

Invasion patterns in Europe are uneven across habitats. In particular, temperate zonal forests are relatively little affected by invasions. However, long generation periods of forest species and the rarity of disturbance events may lead to long time lags, and so, invasion resistance of temperate forests may have been overestimated.

Based on the inventory of the alien vascular flora of 15 study sites in East Austrian lowland forest patches adjacent to villages, we analysed diversity and temporal trends of their alien flora and the influence of within-habitat diversity, occurrence of forest areas dominated by alien tree species and adjacent land use diversity on the level of invasion.

In total, we recorded 119 alien (neophyte) species. Species introduced by horticulture are of overriding importance (86% of all aliens). Using the year of first record in Austria as a proxy for local residence time, numbers of aliens have increased linearly by five species per decade since 1800. A GLM including the study site size and ratio of forest areas dominated by alien vs. native tree species explains 64% of the variance of the number of alien species. Size was more important, but the ratio of forest areas dominated by alien trees (*Ailanthus altissima*, *Robinia pseudacacia*) significantly increased alien species number.

Our results show, that invasion of alien trees with strong impacts on ecosystem properties facilitates invasion in Central European forests, leading to "invasional meltdown". Further, high levels of propagule pressure, created by adjacent settlements and gardens, may foster invasions. Currently observed low levels of invasion in Central European forests situated in greater distance to settlements may turn out to be an ephemeral phenomenon. Spread of alien forest plants on the landscape level may ultimately, although possibly only over long time periods, lead to increased levels of invasion.

Zusammenfassung

Neophyten besiedeln unterschiedliche Lebensräume Europas in unterschiedlichem Ausmaß. Im Besonderen gelten temperate zonale Wälder als nur wenig von biologischen Invasionen betroffen. Allerdings können die lange Generationszeit von Waldarten und die Seltenheit von Störungserereignissen zu besonders langen Verzögerungen von Invasionen führen, sodass die Invasionsresistenz temperater Wälder möglicherweise überschätzt wird.

Auf Basis eines Inventars der Neophytenflora von 15 an Siedlungen angrenzenden Waldflächen im östlichen Tiefland Österreichs untersuchten wir Diversität und zeitliche Trends der Neophytenflora sowie die Bedeutung der Habitatvielfalt, des Vorkommens von durch nichtheimische Baumarten dominierten Waldflächen und angrenzender Landnutzung.

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Insgesamt fanden wir 119 Neophytentaxa. Aus Gartenkultur verwilderte Arten dominierten (86% aller Neophyten). Auf Basis des Erstnachweises der Arten in Österreich als Maßzahl für lokale Anwesenheitszeit wuchs die Neophytenflora mit einer linearen Zunahme von 5 Arten pro Dekade seit 1800 an. In den letzten Jahrzehnten haben Sträucher, aus Asien stammende Arten, in Gartenkultur entstandene Sippen (Anökophyten) und als Gartenpflanzen eingeführte Arten überproportional zugenommen.

Ein GLM mit Flächengröße und dem Anteil von durch nichtheimische Baumarten dominierten Waldflächen erklärt 64% der Varianz der Neophytenzahl. Flächengröße war wichtiger, aber der Anteil von durch nichtheimische Baumarten (*Ailanthus altissima*, *Robinia pseudacacia*) dominierten Waldflächen erhöhte ebenfalls die Neophytenzahl signifikant.

Unsere Ergebnisse zeigen, dass das Eindringen nichtheimischer Baumarten mit starken ökosystemaren Auswirkungen die Ausbreitung anderer Neophyten in mitteleuropäischen Wäldern begünstigt und zu einem "invasional meltdown" führt. Angrenzende Siedlungen und Gärten scheinen wegen des hohen Samendrucks Invasionen zu begünstigen. Die derzeit beobachtete geringe Ausbreitung von Neophyten in mitteleuropäischen Wäldern in größerem Abstand zu Siedlungen mag sich daher zukünftig als ein temporäres Phänomen herausstellen. Die Ausbreitung von Neophyten auf der Landschaftsebene mag letztlich, wenngleich vermutlich über längere Zeiträume, zu einem höheren Invasionsniveau führen.

Keywords: Central Europe; Habitat diversity; Horticulture; Invasional meltdown; Life form; Pathway; Propagule pressure; Residence time; Temporal change; Vascular plants

Introduction

The rate of biological invasions is rapidly increasing worldwide (Lambdon et al. 2008; Hulme, Pyšek, Nentwig, & Vilá 2009). Invasive species (transformer species sensu Richardson et al. 2000) are causing large detrimental effects on both biodiversity and human well-being (Vilà et al. 2009). Recent research has demonstrated that, besides climate matching, human activities are an important determinant of the biogeography of invasions (Taylor & Irwin 2004; Hulme 2009). In particular, human population size and various indicators of socio-economic behaviour have been shown to be linked to patterns of invasion (McKinney 2001; Pyšek, Kucera, & Jarošik 2002; Taylor & Irwin 2004; Hulme 2009), because they are surrogates of propagule pressure and changed disturbance regimes of natural systems (McKinney 2001; Lockwood, Cassey, & Blackburn 2005; Colautti, Grigorovich, & MacIsaac 2006; Krivánek, Pyšek, & Jarošik 2006).

Biological invasions are often characterized by time lags between first introduction of a species in a new territory and the start of invasive spread (Kowarik 1995; Richardson et al. 2000). The duration of such time lag phenomena largely depends on species traits (e.g. life cycle), introduction history (e.g. amount of propagules or individuals introduced) and matching of the alien species autecology with the habitat conditions in the new territory (Pyšek & Richardson 2007; Bucharova & van Kleunen 2009; Pyšek, Krivánek, & Jarošik 2009) or the time necessary for phenological or genetic adaptations to new abiotic and biotic environments. For long-lived species like shrubs or trees such time lags may be substantial, reaching decades or centuries (Kowarik 1992, 1995; Pyšek et al. 2009, but see Daehler 2009).

Invasion patterns in Europe are inconsistent across habitats (Chytrý et al. 2008). So far, temperate zonal forests are relatively little affected by invasions (Chytrý, Pyšek, Tichy, Knollova, & Danihelka 2005; Chytrý et al. 2008; Walter, Essl, Englisch, & Kiehn 2005). However, taking into account that forests are dominated by woody species with long generation periods and invasion into forests predominantly occurs when disturbances create gaps or clearings (Chytrý et al. 2005, 2008) leading to temporarily increased resource availability, which can foster plant invasions (Davis, Grime, & Thompson 2000), invasions in temperate forests may exhibit particularly long time lags. Hence, invasion resistance of temperate forests might have been overestimated.

Based on the inventory of the alien vascular flora of 15 study sites in East Austrian lowland forest patches, we ask the following questions: (1) What is the diversity, structure and composition of the alien flora? (2) What are the temporal trends (time elapsed since the invasion of the species in Austria) in alien species composition and is there a change over time in the importance of pathways, regions of origin and life forms? (3) What are the effects of within-habitat diversity, occurrence of forest areas dominated by alien tree species and adjacent land use type diversity on the level of invasion?

Data

Study area

The study area is situated in the Marchfeld region in the lowlands of Eastern Austria, 30 km east of Vienna (48°17′–48°20′N, 16°35′–16°43′E, Fig. 1). The flat area is part of the glacial Danube valley (165 m a.s.l.). The bedrock consists of gravel deposited by the Danube during the Ice Ages, which is covered by sandy alluvial soils. The climate is temperate pannonic, with cool winters and warm summers, average annual temperature being 10 °C and annual precipitation 550–600 mm (1961–1990, Wiesbauer & Mazucco 1997). The Marchfeld is dominated by agriculture, so only few significant forests remain. However, in the central part of the