

Rapid Communication**Introduction, spread and distribution of *Abies cephalonica* in Austria**

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OPEN ACCESS**Abstract**

I report on the introduction, spread and current distribution of the Greek Fir (*Abies cephalonica*) (Pinaceae) in Austria. The species was introduced in Austria in the second half of the 19th century as an ornamental tree. Very locally, it has already been planted in forests for the first time likely in the late 19th century, while some more trial forestry plantations have only been established in the 1970s. Currently, 14 escaped occurrences of *A. cephalonica* are known, occurring in parks, gardens and forests. All escaped populations are found on the eastern rim of the Northern Calcareous Alps south of Vienna. Some of these escaped populations are large (up to at least 1000 young trees) and spreading. Inferring from the size of escaped plants and from the literature, spread at some sites must already have started in the mid-1970s at latest. Based on the data presented here, I conclude that *A. cephalonica* should be considered as locally established in Austria.

Key words: alien flora, biological invasions, conifers; ornamental tree, Pinaceae, spread, vascular plants

Introduction

The number of alien species is increasing rapidly in most parts of the world (Seebens et al. 2017) and is predicted to further do so (Seebens et al. 2021). While horticulture is known to be the most important pathway for plant invasions in general (Hulme et al. 2018; van Kleunen et al. 2018), for trees it is rivalled by introduction for forestry purposes (Krivánek et al. 2006; Essl et al. 2010).

Conifers are widely introduced and often planted on a large scale particularly in temperate to Mediterranean regions of the Southern Hemisphere (Richardson and Rejmánek 2004; Essl et al. 2010, 2011). However, also in Central Europe, a substantial number of alien conifers are currently spreading (Essl 2005; Krivánek et al. 2006; Essl et al. 2010). In Austria, the most widespread alien conifer species is *Pseudotsuga menziesii* (Essl 2005), but also several other conifers (e.g. *Pinus strobus*, *Thuja occidentalis*, *T. orientalis*) are locally established (Essl and Rabitsch 2002; Essl 2007). Given the increasing detrimental impact of climate change on native conifers in recent years, it is likely that foresters will increase the portfolio of alien conifers that are

resistant to drought- and heat-stress in the future (Krumm and Vítková 2016; Pötzelsberger et al. 2020). In this context, *Abies cephalonica* might potentially become a species of some forestry interest due to its resistance to dry soils and warm climatic conditions.

Here, I summarize the introduction and historical spread of *A. cephalonica* in Austria and extend the knowledge of the current distribution of escaped occurrences, population size and habitat affiliation. This synthesis is based on an exhaustive assessment of the relevant literature and on own fieldwork from 2008 onwards.

Materials and methods

Since the early 2000s, the spread of alien conifers in Austria has received substantial attention (e.g. Essl 2005, 2007). In total, five conifer species have been recorded as established, and several other species have been recorded as casuals (Essl et al. 2010). Further, an update of the Alien Flora of Austria (Essl and Rabitsch 2002) is currently underway (Essl et al. *in prep.*). In this context, all known historical records of escaped populations of *A. cephalonica* as well as additional sites that were reported by local botanists and foresters have been surveyed twice (in 2008 and 2022). For all recorded populations of *A. cephalonica*, data on population size, accompanying vegetation and invaded vegetation types were collected during the visits. Species taxonomy and nomenclature follow Fischer et al. (2008).

Results

Species native range and ecology

Greek Fir (*Abies cephalonica* Loudon, Pinaceae) is an endemic conifer of the Greek mainland mountains and of some adjacent islands (e.g. Euboea). The species is closely related to King Boris fir (*Abies borisii-regis* Mattf.) which occurs in northern Greece, southern Albania, North Macedonia and western Bulgaria; this species is assumed to be of hybrid origin of the *A. alba* and *A. cephalonica* (e.g. Bella et al. 2015). In its native range, *A. cephalonica* grows in a wide variety of Mediterranean mountain forests, mostly on calcareous soils, at altitudes between 400 and 1800 m asl. It is a pyramidal tree that grows up to 30 m tall, with long horizontal branches. Needles are spirally arranged, with a sharp pointed apex (Conifers.org 2021) – which makes the needles more spiny than those of *Abies alba* and which is likely the most conspicuous feature for determining the species in the field.

Introduction history in Austria

The introduction of alien tree species for forestry purposes in Austria started with trial plantations that were organized by the public forestry research institute in the 1880s (Rannert 1979). By 1901, on the territory of the Austrian part of the former Austro-Hungarian Empire, a total of 17 conifer

species was used in forestry plantations, but *A. cephalonica* was not included then, as seemingly, its importance was marginal (Rannert 1979). Similarly, in a more recent synopsis of alien tree species planted in forests in the federal state of Lower Austria, *A. cephalonica* was not listed (Minelli 1967). However, *A. cephalonica* was already used for ornamental plantations in parks and private gardens south of Vienna (e.g. cities of Baden and Bad Vöslau) and elsewhere (e.g. park of castle Grafenegg in Lower Austria) in the second half of the 19th century – for instance, a large tree that was felled in 2009 in the park of the castle Gainfarn near Bad Vöslau was c. 130 years old (Stadtgemeinde Bad Vöslau 2009). Similarly, small plantations for forestry purposes were established in Niederschlatten near Bad Vöslau around that time as can be inferred from several large trees still standing there (R. Stingl *pers. comm.* and *own observation*).

In the late 1970s, a small forestry trial plantation (size: c. 3000 m²) of *A. cephalonica* was established at the Harzberg near Waldandacht northwest of Bad Vöslau (Stadtgemeinde Bad Vöslau 2010). In the 1980s, several forestry trial plantations of *A. cephalonica* have been established in eastern Austria, mostly on the eastern rim of the Northern Calcareous Alps (Liesebach et al. 2007). However, in general, the use of *A. cephalonica* in forestry remains marginal up to date, and in recent overviews on introduced forestry tree species it was not even considered (Kristöfel 2003).

Spread and distribution in Austria

While occurrences of escaped populations of *A. cephalonica* have already been reported previously (Fischer et al. 2008; Stadtgemeinde Bad Vöslau 2010) for Austria, no comprehensive overview on its spread and current distribution is available. A first overview on escaped populations was published by Essl (2008) reporting four occurrences. Based on additional fieldwork in 2022 at known sites of plantation and at sites with planted old trees in parks and gardens, currently 14 escaped occurrences of *A. cephalonica* are known (Figure 1). All sites are located at the eastern rim of the Northern Calcareous Alps in Lower Austria south of Vienna.

Several populations are large, consisting of several hundreds young trees, and a few populations have spread considerable distances away from planted old trees and have spread over several hectares. Some older escaped trees are already reproducing (Figure 2B). Escaped occurrences of *A. cephalonica* in Austria occur mostly in deciduous and mixed forests and in old parks and hedgerows (Supplementary material Table S1). Based on the age of the oldest escaped trees (as derived from cut trees or visually assessed), and on additional information provided by a local expert (R. Stingl *pers. comm.*), the approximate onset of spread occurred at latest in the mid-1970s at some sites (Table S1).

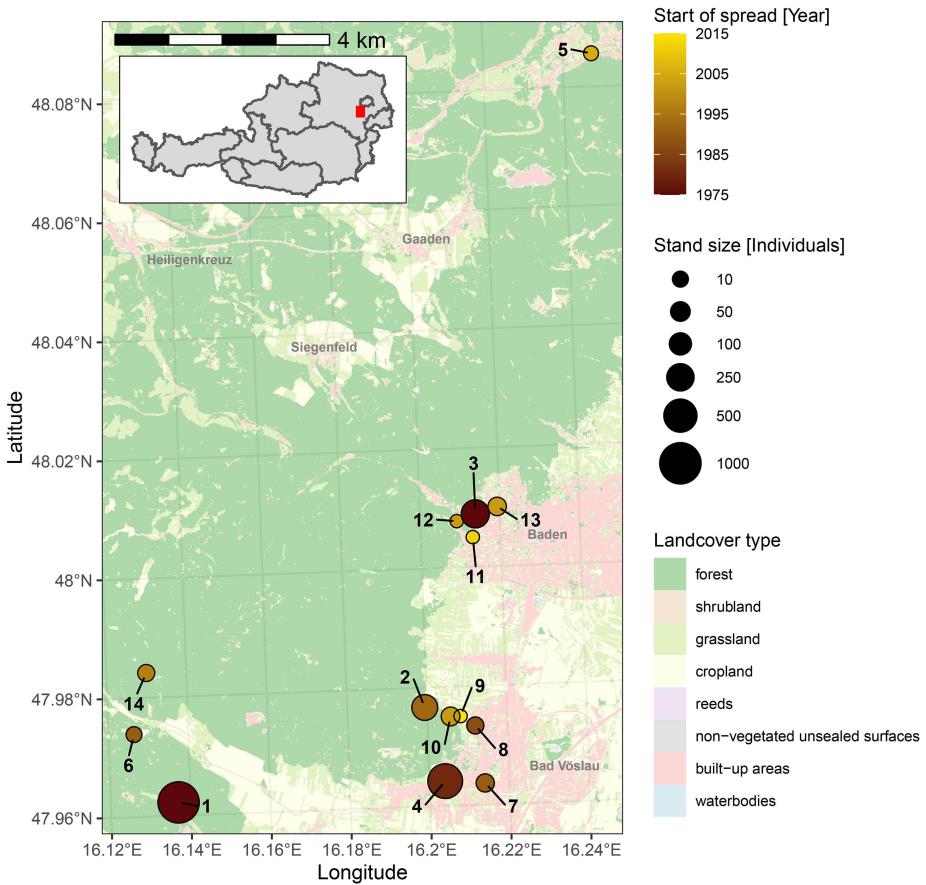


Figure 1. Locations of the 14 escaped occurrences of *Abies cephalonica* in Lower Austria. Different colours indicate the approximate year when escaped trees presumably first occurred (i.e. minimum residence time), different sizes of circles indicate population sizes (i.e. approximate number of escaped trees) based on counts in January 2022. For details see Supplementary material Table S1.

Discussion

Abies cephalonica was initially introduced in the 19th century as an ornamental tree mostly in private and public parks, however it was popular only in small parts of Austria, where edaphic and climatic conditions are favourable. The hot spot of introduction then were green spaces in cities at the eastern rim of the Northern Calcareous Alps south of Vienna (i.e. Baden, Bad Vöslau), where dry calcareous soils and the Pannonic climate with moderate annual precipitation of c. 600–700 mm and annual mean temperatures of c. 9–10 °C (1971–2000) (Seger 2019) provide suitable conditions. Under mesic conditions, *A. cephalonica* grows substantially slower than the native congeneric *A. alba*, but the former is less browsed by ungulates due to its spiny needles. *Abies alba* and *A. cephalonica* co-occur at several sites, particularly so at Niederschlatten (*pers. obs.*).

To my knowledge, the Austrian occurrences reported here represent one of the first escaped occurrences of *A. cephalonica* in Central Europe. For instance, the species is missing from the alien vascular plant checklists of the Czech Republic (Pyšek et al. 2012), Slovakia (Medvecká et al. 2012), and Switzerland (Infoflora 2022). However, in westernmost Hungary an



Figure 2. A group of escaped trees of *Abies cephalonica* at the site Niederschlatten (A); forestry trial plantation at Schöpfbeben at the Harzberg west of Bad Vöslau, 07.03.2010, R. Stingl; cone (B); young escaped tree in the understorey of site Tremlhofspark (C); twig with the characteristic sharp pointed needles; 20th January 2020 (D).

escaped occurrence of *A. cephalonica* in the Sopron hills has been recorded (Kiraly 2004), and there are also occurrences in Slovenia near the village of Komen (Heberle 2021). In Western and Northern Europe, few records of *A. cephalonica* are known. In the British Isles, seedlings have been reported from a few sites (Clement and Foster 1994). No records of the species are known from Norway (Gederaas et al. 2012) and Belgium (Verloove 2006).

In Austria, *A. cephalonica* invades dry lowland forests on calcareous bedrock as well as old parks and hedgerows in neglected gardens. Escaped occurrences are found nearby planted old trees, although escaped trees may occur at distances of up to a few hundred meters at most from the next old standing tree. Given its tolerance to drought- and heat-stress, and its moderate growth under mesic conditions, it is likely that suitable regions

for potential spread of *A. cephalonica* are currently limited in Central Europe. However, in these regions, spread can occur rather easily—as shown by the considerable number of sites reported here—when reproducing old trees are present. I conclude that given the ongoing—but still localized—spread of *A. cephalonica* in Austria it should be considered locally established in this country.

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Supplementary material

The following supplementary material is available for this article:

Table S1. Geographic coordinates, number of escaped trees, estimated age of oldest escaped trees, and invaded habitats of *Abies cephalonica* in Austria.

This material is available as part of online article from:

http://www.reabic.net/journals/bir/2022/Supplements/BIR_2022_Essl_SupplementaryMaterial.xlsx