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Review and synthesis

Black locust (*Robinia pseudoacacia*) beloved and despised: A story of an invasive tree in Central Europe

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ABSTRACT

Robinia pseudoacacia, invaded many countries a long time ago and is now a common part of the Central European landscape. Positive economic but negative environmental impacts of *Robinia* result in conflicts of interest between nature conservation, forestry, urban landscaping, beekeepers and the public when defining management priorities. Because current legislation will determine the future distribution of *Robinia* in the landscape, a comprehensive view of this species is necessary. Although this species is well studied, most of the scientific papers deal with the economic aspects. Other information is published in local journals or reports. Therefore we reviewed the ecological and socio-economic impact of *Robinia* placing particular emphasis on the species' history, vegetation ecology, invasiveness and management. In Central Europe, *Robinia* is limited climatically by late spring frost combined with a short vegetation period, soil hypoxia, shade and frequent major disturbances. The long historical tradition of using *Robinia* for afforestation has resulted in its popularity as a widespread forest tree and it being an important part of the economy in some countries. The main reasons are its fast growth, valuable and resistant wood, suitability for amelioration, reclamation of disturbed sites and erosion control, honey-making and recently dendromass production. On the other hand, a side-effect of planting this nitrogen-fixing pioneer tree, very tolerant of the nature of the substrate, is its propagation and spread, which pose a problem for nature conservation. *Robinia* is considered invasive, threatening especially dry and semi-dry grasslands, some of the most species-rich and endangered types of habitat in the region, causing extinction of many endangered light-demanding plants and invertebrates due to changes in light regime, microclimate and soil conditions. Other often invaded habitats include open dry forests and shrubland, alluvial habitats, agrarian landscapes, urban and industrial environments and disturbed sites, e.g. post-fire sites, forest clearings or degraded forestry plantations. Without forestry, black locust abundance would decrease during succession in forests with highly competitive and shade tolerant trees and in mature forests it occurs only as admixture of climax trees. The limited pool of native woody species, lack of serious natural enemies and a dense cover of grasses and sedges can suppress forest succession and favour the development of *Robinia* monodominant stands over 70 years old. A stratified approach, which combines both tolerance in some areas and strict eradication at valuable sites, provides the best option for achieving a sustainable coexistence of *Robinia* with people and nature.

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1. Introduction

Robinia pseudoacacia L. (black locust) was one of the first North American trees to be introduced into Europe at the beginning of the 17th century (e.g. Ernyey, 1927; Kolbek et al., 2004; Vadas, 1914). It is one of the most widely planted woody species in the world (Keresztesi, 1988), but also very invasive. It is listed amongst the 40 most invasive woody angiosperms globally (Richardson and Rejmánek, 2011) and is reported as naturalized in 154 regions out of a total of 843 in the world (GloNAF database, unpublished; Pyšek et al., unpublished data; van Kleunen et al., 2015). In several European databases *Robinia* is classified as highly invasive (CABI, 2015; DAISIE, 2006; EPPO, 2002) and is included in national Black Lists and checklists of alien species across Europe (e.g. Norway – Gederaas et al., 2012; Czech Republic – Pergl et al., 2016b; Pyšek et al., 2012b; Germany – Seitz and Nehring, 2013; Switzerland – FOEN, 2010; info Flora, 2014; Italy – Celesti-Grapow et al., 2009; Central Russia – Vinogradova et al., 2010). Due to unavailability of a comprehensive risk assessment as well as the pressure from some EU Member States it is not included in the list of invasive alien species (IAS) of Union concern (Commission Implementing Regulation (EU) 2016/1141 of 13 July 2016 adopting a list of invasive alien species of Union concern pursuant to Regulation (EU) No 1143/2014 of the European Parliament and of the Council). Despite *Robinia pseudoacacia* meeting the criteria listed in Article 4 of the Regulation for being included among the IAS of Union concern, its general ban for silvicultural use across the entire EU would be problematic (Sitzia, 2014; Sitzia et al., 2016a). According to Article 12, black locust can be included in the national lists of IAS in the Member State concern category and appropriate measures (mentioned in Articles 7, 8, 13 to 17, 19 and 20) can be taken. Among Central European countries, black locust is not a subject to legislation for example in Slovakia and Poland (Table 1).

In Central Europe, *Robinia* has been studied for a long time (e.g. Cierjacks et al., 2013; Göhre, 1952; Keresztesi, 1988; Kowarik, 1992; Vadas, 1914), but mainly in terms of its economic value (Lukasiewicz et al., 2015; Mantovani et al., 2014; Quinkenstein and Jochheim, 2016; Yang et al., 2004) rather than its ecology. There is currently no summary of the ecological and socio-economic impact of *Robinia* with respect to the species' history, vegetation ecology, invasiveness and management. Such information is rather rare and scattered, and often published in local journals or reports. The only existing review by Cierjacks et al. (2013) for the British Isles focuses mainly on ecophysiology, reproductive biology, mycorrhiza, parasites and diseases, here we review the Central European literature and our unpublished results of a long-term study on the above mentioned aspects of the black locust invasion in this region.

The objectives of this paper are to (1) summarize and evaluate existing knowledge on *Robinia* in Central Europe, (2) explain its regional distribution in a historical context; (3) assess the causes and consequences of its invasion, including those in threatened habitats; (4) categorize black locust plantations growing under various environmental conditions, and (5) outline management strategies for the region. For a definition of Central Europe we follow the common concept (e.g. Encyclopædia Britannica) and include Austria, Czech Republic, Germany, Hungary, Lichtenstein, Poland, Slovakia, Slovenia and Switzerland (Fig. 1).

Table 1
Invasiveness of *Robinia pseudoacacia* according to national legislation.

	Invasiveness	References
Austria	Yes	Essl and Rabitsch (2002, 2016)
Czech Republic	Yes	Pergl et al. (2016b)
Germany	Yes	Seitz and Nehring (2013)
Hungary	Yes	Botta-Dukát and Balogh (2008)
Poland	No	Dz.U. 2011 nr 210 poz. 1260
Slovakia	No	Act No. 543/2002 Coll. on Nature and Landscape Protection and Decree no. 158/2014 Coll.
Slovenia	Yes	Jogan et al. (2012)
Switzerland	Yes	FOEN (2010); info Flora (2014)

2. History of introduction, planting and invasion

Invasion history of *Robinia pseudoacacia* follows that typical of cultivated aliens; following introduction, date of which is rather unclear, there was a long lag phase and then rapid invasion supported by frequent planting in the wild. Although it was first described in honour of Jean Robin by Cornutus in 1635 as *Acacia Americana Robini*, Ernyey (1927) explains that both Robins (Jean and his son Vespasian) did not introduce this plant to Paris and therefore dismisses the often cited first year of introduction to Paris as of 1601. There were probably several independent introductions from North and South America (Ernyey, 1927), which has resulted nowadays in widespread plantations. Following introduction, it was quickly distributed as a rare ornamental exotic to botanical gardens all over Europe, with Paris the most important distribution centre (Wein, 1930). In Central Europe, it was first introduced into Germany (1672 in Berlin; Wein, 1930) where it soon became fashionable, to plant it (Böhmer et al., 2001) and according to Flora Norimbergensis (Volckameri, 1700) it was already very common in southern Germany at the beginning of the 18th century. It also quickly spread to Hungary and the Czech Republic with the first record of introduction into both countries in 1710 (Nožička, 1957; Vadas, 1914). The very latest introduction in Central Europe was in Slovenia at the beginning of the 19th century, probably from northern Italy (Friuli plain; Rudolf and Brus, 2006). For a summary of the history of introduction across Central Europe see Table 2.

The invasion of black locust in Central Europe was encouraged by extensive planting. *Robinia* was first recommended for large-scale afforestation by Johann Georg Kramer for Hungarian lowlands in 1735 but these plans were never put into practice due