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Plant Biosystems: 153 (2019): 900-904

Prunus serotina in Italy: a challenging candidate for the national list of Priority Invasive Alien Species

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Abstract

In accordance with the European regulation on Invasive Alien Species (IAS), the black cherry tree (*Prunus serotina* Ehrh.) has recently been indicated as one of the 96 species proposed for the development of the national list of priority alien species in Italy. The species, native to North America, is recognised as one of the most harmful IAS in Europe, given its high spread potential and the associated ecological and economic impacts reported in its alien range. Although *P. serotina* is recognised as a pest within the EU, plants are still available on the market, confirming intentional introduction as a current potential pathway for this species arrival into new areas. Since a comprehensive overview of the main features characterizing the invasive potential of this species is still lacking, we aim to underpin the high priority status of *P. serotina* as a IAS of main concern in Italy by outlining the main biological features, pathways and impacts of the black cherry in its secondary range. Management measures to be potentially included in specific action plans are also summarised.

Keywords: black cherry; ecosystem transformer; EU regulation on IAS; impacts; Invasive tree

Introduction

The Regulation (EU) No 1143/2014 (European Commission 2014) on the prevention of the introduction and management of Invasive Alien Species (IAS) has become a top priority for conservation policy at both European and national levels. The Regulation is strengthened by a list of IAS of Union concern. Invasive alien species of Union concern shall not be intentionally traded, introduced, planted, breed, kept in the territory of the Union. Member States are required to take action on pathways of unintentional introduction, to take measures for the early detection and rapid eradication of these species, and to manage those that are already widely diffused in their territory (Genovesi et al. 2014). The most recent update of the Union list, i.e. the Commission Implementing Regulation (EU) 2019/1262 of 25 July 2019 (European Commission 2019) brought the total number of listed species to 66.

Although the Regulation is considered "a pioneering attempt to standardize policy across taxa and sectors on a regional scale, which has never been attempted in combating IAS" (Tollington et al. 2017), several issues have already arisen. In particular, only three alien tree species are included in the Union list so far, despite the fact that a significantly larger number of invasive alien tree species are of main concern due to their current and potential invasiveness in European natural and semi-natural forest habitats (Campagnaro et al. 2018). Although temperate forests are often viewed as being less susceptible to invasive alien plants than other habitats (Rejmánek 2015), European forests are prone to alien plant invasions (Krumm and Vítková 2016) especially when exposed to disturbance, fragmentation, alien propagule pressure or high soil nutrient levels (Wagner et al. 2017). Invasive alien trees, in particular, tend to be strongly competitive in such conditions (Sitzia et al. 2012; Wagner et al. 2017) and show a substantial negative effect on native communities and ecosystem processes (Richardson and Rejmánek 2011).

In the light of these considerations and in an attempt to take on board the EU Regulation on IAS, Lazzaro et al. (2019) have proposed 14 alien tree species to be included in the future Italian list of invasive alien species. The list of candidate species will undergo further prioritization procedure (*sensu* Branquart et al. 2016) to finalize the national list of invasive alien species (European

Commission 2014). Species were selected based on the knowledge of IAS in Italy gathered since the early 2000s, when the Italian Botanical Society (SBI) implemented a series of research projects funded by the Ministry of the Environment, Land and Sea (MATTM), with the aim of providing a comprehensive picture of the non-native vascular flora at the national level (Celesti-Grapow et al. 2009; 2010). Subsequent to the IAS Regulation, information on IAS was further improved by an increase in studies aimed at highlighting impacts (e.g. Lastrucci et al. 2018), mapping distribution of widespread established IAS (e.g. Gentili et al. 2017) together with emerging alien species (e.g. Brundu et al. 2015) in Italy. Among the 14 tree species identified as a high priority IAS in Italy, *Prunus serotina* Ehrh. (black cherry), is considered a species of major concern for the conservation of forests (Hulme 2009; Campagnaro et al. 2018). Introduced from North America to Europe in 1623 (Marquis 1990), the black cherry was intentionally introduced in Italy for experimental reasons in the early 20th century and has then rapidly expanded, colonising the northern part of the country and soon becoming an invasive species at a local level. Despite being recognised as a 'wood pest', 'invasive engineer', 'strong invader', 'aggressively spreading species' or even a 'transformer' (Aerts et al. 2017), new provenances and genotypes of *P. serotina* are still at risk of further intentional introduction in Italy, a risk which adds up to the threat of the species spreading from already established populations. In fact, it is still cultivated in many nurseries in Europe, in countries such as Belgium and Italy and, in some cases, is still sold on the market (Seitz and Nehring 2013).

In order to carry out a comprehensive evaluation of the potential and effective threat represented by the black cherry in its alien range, in particular in Italy, a Pest Risk Analysis (PRA), in conformity with the EPPO Express PRA decision scheme (EPPO 2012), was performed on *P. serotina* within the framework of the "Scientific support service for the implementation of the National Biodiversity Strategy" commissioned by the MATTM and carried out by the SBI.

In the light of the ecological and economic impacts resulting from the invasion of the black cherry in its secondary range, this study intends to raise public awareness and inform relevant stakeholders

77 on the need of adopting rapid and rigorous control measures, including eradication where possible,
78 by focusing on the current knowledge of *P. serotina* in Italy: reproductive and dispersal traits,
79 history of introduction, distribution, impacts and management measures.

80 **Reproductive and dispersal traits**

81 *Prunus serotina* Ehrh. (black cherry) is a broadleaved, deciduous tree of the Rosaceae family,
82 which can grow up to 40 m tall in its native region, but barely reaches 20 m in the alien range,
83 where it often grows as a small, contorted shrub in the understorey of woodlands (Starfinger 2010).
84 Trees in the alien range have a shorter life span (about 25 years) compared to those thriving in the
85 native area (up to 250 years). Reproduction takes place mainly by seed dispersal, but also through
86 stump and root suckers (Closset-Kopp et al. 2007), which start flowering earlier than trees in the
87 native range, between the age of 5 to 10 years (Hough 1960; Deckers et al. 2005). Seeds remain
88 viable for up to 5 years (Vanhellemont et al 2009 and references therein), with each tree producing
89 a large number of fruit/seeds (an average of 6011 per tree per year, Closset-Kopp et al. 2007; up to
90 8940 berries per tree per year, Pairon et al. 2006), which are then dispersed by gravity or by
91 animals. Once established, provided ecological conditions are favourable (light and nutrients, such
92 as those found in an agricultural landscape), the age-size correlation is positive. In most cases,
93 however, seedlings manage to survive as ageing juveniles under dense forest understorey shade
94 conditions. While Closset-Kopp et al. (2007) reported 6-year-old individuals with a height of 20 cm
95 and a stem diameter of 0.2 cm, Vanhellemont et al. (2010) found 60-year-old black cherry
96 individuals less than 10 m tall. *Prunus serotina* is, therefore, able to build a shade-tolerant, self-
97 sustaining population which dominates the forest understory, with individuals able to engage in
98 rapid growth, reproducing as soon as an opening occurs and light conditions improve (Auclair and
99 Cottam 1971; Godefroid et al. 2005; Vanhellemont et al. 2010; Terwei et al. 2013).

100

101 **Introduction pathways, distribution and spread**

In the native range there are four varieties of *P. serotina*, which are characterised by distinct distributions: *P. serotina* var. *eximia*, *P. serotina* var. *rufula*, *P. serotina* var. *serotina* and *P. serotina* var. *virens* (USDA-NRCS 2015). The variety most commonly introduced is *P. serotina* var. *serotina*, which comes from the Allegheny Plateau in Pennsylvania, one of the best-known black cherry growing sites in its native range (Pairon et al. 2010).

The introduction history of the black cherry in its whole alien range, including Italy and the rest of Europe, confirms that plant trade has been the main pathway of entry for this species.

In Europe the black cherry first arrived in the 17th century, where it was introduced initially as an ornamental tree in parks and gardens in France between 1623-1629 (two decades after the introduction of the black locust, *Robinia pseudacacia* L.), in Britain in 1629 and in Germany in 1685. In the following years, the black cherry was planted in many European countries for various purposes: ornamental, horticultural, soil improvement, fire prevention, restoration of mining land and timber production (Terwei 2014). Control measures were adopted as soon as the species began to spread rapidly outside plantations or confined areas, but most of these measures proved to be unsuccessful. Currently, the species is widespread and can be found growing extensively in Europe (Pairon et al. 2010) and is continuously expanding its range (Klotz 2009).

In Italy, early reports state that the black cherry was already cultivated in Turin Botanical Garden and in other Gardens in the Piedmont region at the beginning of the 18th century (Bouvet 2013). In 1922 it was introduced for forest provenance trials in an extended zone in the province of Varese (Sartori 1985). This site is considered to be the original nucleus from which this alien tree naturally spread to the northern part of the country (Caronni 2008), soon becoming a locally invasive species. At present, the black cherry is regulated as an invasive species in the Piedmont and Lombardy regional black lists, where it is spreading in the few remnants of alluvial forests in the Po Plain. As for other areas in Italy, *P. serotina* is reported as a casual or locally invasive species in three regions (Trentino-Alto Adige, Emilia Romagna, Friuli-Venezia Giulia) located in the northern sector of the country (Celesti-Grapow et al. 2009; Galasso et al. 2018).

128 The analysis of the current distribution in Europe reveals that the species is considered invasive in
129 those countries where the most intensive forestry intervention with *P. serotina* occurred in the past
130 (Vanhellemont 2009). Nevertheless, dispersal by natural means accounts for further range
131 expansion of the black cherry. An analysis of the current distribution and rate of colonisation shows
132 that the invasion process is increasing in forests as well as in open habitats (Deckers et al. 2005;
133 Vanhellemont 2009; Skowronek et al. 2014). *P. serotina* undoubtedly benefits from a high spread
134 potential through natural pathways due to its reproductive biology and behavioural strategies
135 employed during its life cycle (Closset-Kopp 2007; Terwei et al. 2013). The species' natural spread
136 is mainly mediated by fruit/seeds, which are dispersed by gravity and animals (Marquis 1990;
137 Closset-Kopp et al. 2007). Barochory accounts for the larger part of seed dispersal (up to 95 % in
138 Pairon et al. 2006). Zoochory is mediated by generalist frugivorous birds and mammals, which
139 account for the long-distance dispersal and spread of the species, both in agricultural landscapes and
140 in woodlands (Deckers et al. 2005; Closset-Kopp et al. 2007). Various estimates of the average seed
141 dispersal distance from the source plant can be found in the literature, ranging from 257 m (Pairon
142 et al. 2010) up to a kilometre (Starfinger et al. 2003), and longer distances are expected to be
143 covered in open habitats rather than in woodlands.
144 The resprouting capacity of *P. serotina* promotes the colonization at the local scale, while its
145 contribution to range expansion is negligible (Sebert-Cuvillier et al. 2007).
146 After a lag phase between the initial introduction and the first record of establishment, which ranges
147 from 29 years in Germany to 89 years in Sweden (Vanhellemont 2009 and references therein), the
148 species has spread at different rates: less than 1 km in 40 years in Germany (Starfinger et al. 2003),
149 whereas in Italy the prediction of 5 km every 10 years, calculated in the 1980s, in some cases
150 proved to be correct 20 years later (Caronni 2008).
151 The overall likelihood of spread in Italy is high. The species is particularly invasive in the woods
152 along the river Ticino and is currently expanding its range, with its abundance predicted to
153 substantially increase in the next 30 years if no control measures are undertaken (Caronni 2008;

154 Annighöfer et al. 2015). Ticino area represents the largest continuous woodland area in the Po Plain
155 and is an important ecological corridor connecting the Alps with the Apennine mountains. It could,
156 therefore, facilitate the natural spread of the species to new Italian regions and consolidate its
157 invasive status in those regions where its status is still reported as casual.

158 **Negative economic and environmental impacts**

159 In its alien range *P. serotina* has significant ecological and economic impacts, with an overall
160 negative effect on ecosystem services. It forms mono-specific stands or highly competitive, dense
161 thickets, which alter the light conditions and modify the topsoil, threatening the natural regeneration
162 of indigenous forest tree species (Starfinger 2003; Verheyen et al. 2007; Chabrerie et al. 2010). *P.*
163 *serotina* has proved to be responsible for numerous changes in the ecosystem: in particular, it alters
164 soil composition and releases allelopathic substances (Starfinger et al. 2003; Vanderhoeven et al.
165 2005; Halarewicz and Pruchniewicz 2015). Black cherry leaf litter is characterised by a higher N
166 and P content when compared to native deciduous trees (Aerts et al. 2017), thus it has a faster
167 decomposition rate. The species is also a strong competitor for water and nutrients, reducing the
168 fitness of other plants by negatively affecting the supply of resources. It exhibits a higher rate of
169 above and belowground biomass production than native trees, also affecting their biomass
170 allocation towards roots as a reaction to competitive stress (Godefroid et al. 2005; Kawaletz et al.
171 2013; 2014). In many cases, the black cherry reduces plant species richness and/or modifies the
172 composition of plant communities, representing a major threat to biodiversity and, in general, to
173 ecosystem functioning (Aerts et al. 2017). The above-mentioned ecological effects have already
174 been reported in Italy (Sartori 1985; Caronni 2008; Skowronek et al. 2014) where *P. serotina* has
175 invaded mainly remnants of oak-hornbeam forests in the Po Plain, which correspond to the habitat
176 9160 “Sub-Atlantic and medio-European oak or oak-hornbeam forests” of the 92/43/EEC Habitats
177 Directive. The black cherry could also invade other ecosystems, including grasslands and other

178 open habitats where rare species occur more frequently, thus causing serious conservation problems
179 (Starfinger 2010).
180 With regard to the economic impact of the species, in Europe *P. serotina* represents an important
181 issue in forestry, causing severe management problems (Reinhardt et al. 2003; Vanhellemont et al.
182 2009 and references therein; Annighöfer et al. 2012). The removal of the species is made difficult
183 by the density of the thickets, which impedes forest management, together with its high resprouting
184 capacity and large number of seeds on the forest floor. Forest management of natural stands and
185 plantations is, therefore, very expensive (Terwei 2014).
186 In Italy, the control of the black cherry is both difficult and costly. In the Parco del Ticino in
187 northern Italy, for instance, black cherry trees successfully invaded 514 ha (Meloni et al. 2016).
188 Caronni (2008) estimated a management cost for the Ticino forest of around € 1,000- 2,000 ha^{-1} and
189 reported that the sum of € 830,000 was spent during a 10-year period for forestry practises on 514
190 ha. In addition, potential problems may derive from the fact that the species is a host plant for
191 agriculture and forestry pests (Terwei 2014), including the European quarantine fruit pest
192 *Rhagoletis cingulata* and the fruit fly *Drosophyla suzukii* (Lampe et al. 2005; Poyet et al. 2014).
193 The diffusion of *P. serotina* in Italy could therefore have indirect economic repercussions by
194 facilitating the spread of these pests, which, in the case of *D. suzukii*, attack grapes and other soft
195 fruits.

196 **Management measures**

197 *Prunus serotina* has mainly invaded remnants of woodlands in the Po Plain, representing habitats of
198 high conservational value and thus included in protected areas, such as regional parks, Sites of
199 Community Importance (SCI) or biosphere reserves. Since the goal of these protected areas is to
200 develop near-natural forests in the future, consisting of native species, silvicultural measures should
201 be limited as much as possible.

202 Two factors contribute to the difficulty of controlling *P. serotina*: first, its capacity to resprout from
203 stumps and roots after cutting and fire events and second, the density of seeds and juveniles in the
204 invaded stands. In managed forest, disturbance events which create sudden increases of light, such
205 as clear cuts and thinning, promote the invasiveness of the species, and should be therefore avoided.
206 In forest ecosystems many authors propose a "sit-and-wait" strategy, allowing natural succession
207 (Terwei et al. 2013; Skowronek et al. 2014). This strategy is considered to be effective since *P.*
208 *serotina* is recognised as a pioneer species of secondary succession and an opportunistic gap-
209 species (Closset-Kopp et al. 2007; Vanhellemont et al. 2010; Annighöfer et al. 2015), so that
210 persistent shade will, theoretically, be able to negatively affect the reproductive capacity of the
211 black cherry over a long period (Closset-Kopp et al. 2007). Various silvicultural methods are,
212 therefore, suggested in the literature in order to control the spread of the species by supporting
213 natural dynamics (Meloni et al. 2016 and references therein): avoiding clearcutting and openings,
214 mowing suckers and girdling of fruit-bearing adults, conversion of coppice to high forest and under-
215 planting with shade-tolerant native species (e.g. *Carpinus betulus*, *Acer* spp., *Corylus avellana*) that
216 will be able to outcompete black cherry in the long run and, finally, allowing ageing without
217 intervention or further treatments.

218 **Conclusions**

219 The present review of the current knowledge on the invasive alien tree *Prunus serotina* reveals that
220 the species poses a major threat to biodiversity, ecosystem services and functioning in Italy. All the
221 areas included in the Continental Region, which are more climatically similar to the other invaded
222 countries in Europe, are likely to be colonised by the black cherry in future. The risk of spread and
223 further establishment in northern regions, including areas at lower altitudes in the Alps and
224 Apennines, is likely to increase as a result of human intervention, due to the use of the black cherry
225 in forestry and for ornamental purposes.

Currently, the invaded range of *Prunus serotina* in Italy is limited to a few regions. This still allows to implement prevention, local eradication or control measures, continuous monitoring, and awareness-raising campaigns to limit further spread. These measures are needed to avoid the transition from a local to a widespread invasion, the control of which would be very costly or even unfeasible. Therefore, the inclusion of *Prunus serotina* in the Italian national list of Priority Invasive Alien Species is highly recommended as this would allow to enforce the same restrictions as in the case of the invasive alien species of Union concern, promoting the effectiveness of control before it is too late.

Authors' contributions

TF and EB conceived the idea and contributed equally to the writing of the manuscript. All the authors contributed to the Research project and to the manuscript revision and gave final approval for publication. EB coordinated the study as project leader for the Alpine and Continental Region, with an assignment from the Italian Botanical Society (SBI).

Acknowledgements

This work was carried out under the framework of the project "Scientific support service for the implementation of the National Biodiversity Strategy" funded by the Ministry of the Environment, Land and Sea (MATTM) and coordinated by the Italian Botanical Society (SBI).

Disclosure statement

No potential conflict of interest was reported by the authors.

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