RISK ASSESSMENT SUMMARY SHEET

Updated: 2021

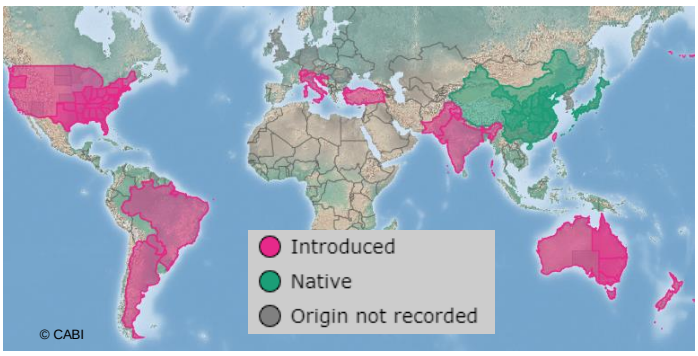
# Foxglove Tree (*Paulownia tomentosa*)


- A fast-growing, deciduous tree with bright purple flowers capable of growing to 15m.
- Popular ornamental species in GB, also used elsewhere as a forestry species for timber and bio-energy.
- Despite long presence in GB as an ornamental, self-sustaining populations have established only recently.
- Currently limited by climate and ecology to warmer, urban areas.
- Known to be invasive in eastern United States where it forms monocultures and can be a nuisance weed. Also on watch / action lists in Czech Republic, Germany and Switzerland. Risk assessment has identified it as potentially invasive in South Africa and Australia.

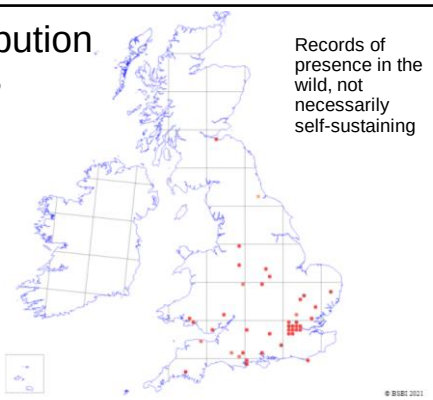
## History in GB

Native to China. First introduced to GB as an ornamental species in 1838. The first self-sustaining records from the wild date from the 1990s. Capable of seeding profusely and re-sprouting from roots and stumps. Grows particularly in disturbed and urban areas.

## Global Distribution




## Distribution In GB



Records of presence in the wild, not necessarily self-sustaining

## Impacts

Environmental (moderate, low confidence)

- Primarily likely to be found in urban areas and disturbed ground, making environmental impacts less likely.
- Can form monocultures in woodlands; however, not shade tolerate and so likely to be outcompeted by native trees in the long term.
- Most likely impact is to open rocky or riparian habitats, displacing species and altering ecosystem function.

Economic (minor, low confidence)

- Can be a nuisance weed requiring management, for example in urban areas and railway lines.

## Introduction pathway

Ornamental (very likely): the original introduction pathway and still a popular plant in parks and gardens.

Agro-forestry (moderately likely): used as a timber species elsewhere and while not currently used for this purpose in GB this is possible in the future.

## Spread pathway

Natural (moderate): produces large numbers of seeds that spread up to 3km, also spreads through root and stem shoots

Human (moderate): ornamental use has and continues to spread this species widely in GB

## Summary

| | Response | Confidence |
|---|---|---|
| Entry | V LIKELY | V HIGH |
| Establishment | V LIKELY | V HIGH |
| Spread | MODERATE | MEDIUM |
| Impact | MODERATE | MEDIUM |
| Overall risk | MEDIUM | MEDIUM |

# RISK ASSESSMENT COVERING PAGE - ABOUT THE PROCESS

**It is important that policy decisions and action within Great Britain are underpinned by evidence. At the same time it is not always possible to have complete scientific certainty before taking action. To determine the evidence base and manage uncertainty a process of risk analysis is used.**

Risk analysis comprises three component parts: risk assessment (determining the severity and likelihood of a hazard occurring); risk management (the practicalities of reducing the risk); and risk communication (interpreting the results of the analysis and explaining them clearly). This tool relates to risk assessment only. The Non-native Species Secretariat manages the risk analysis process on behalf of the Programme Board for Non-native Species. During this process risk assessments are:

- Commissioned using a consistent template to ensure the full range of issues is addressed and maintain comparable quality of risk and confidence scoring supported by appropriate evidence.
- Drafted by an independent expert in the species and peer reviewed by a different expert.
- Approved by the NNRAF (an independent risk analysis panel) only when they are satisfied the assessment is fit-for-purpose.
- Approved by the Programme Board for Non-native Species.
- Placed on the GB Non-native Species Secretariat (NNSS) website for a three-month period of public comment.
- Finalised by the risk assessor to the satisfaction of the NNRAF and Programme Board if necessary.

**Common misconceptions about risk assessments**

The risk assessments:

- Consider only the risks (i.e. the chance and severity of a hazard occurring) posed by a species. They do not consider the practicalities, impacts or other issues relating to the management of the species. They also only consider only the negative impacts of the species, they do not consider any positive effects. They therefore cannot on their own be used to determine what, if any, management response should be undertaken.
- Are advisory and therefore part of the suite of information on which policy decisions are based.
- Are not final and absolute. They are an assessment based on the evidence available at that time. Substantive new scientific evidence may prompt a re-evaluation of the risks and/or a change of policy.

**Period for comment**

Once placed on the NNSS website, risk assessments are open for stakeholders to provide comment on the scientific evidence which underpins them for three months. Relevant comments are collated by the NNSS and sent to the risk assessor for them to consider and, if necessary, amend the risk assessment. Where significant comments are received the NNRAF will determine whether the final risk assessment suitably takes into account the comments provided.

**To find out more:** published risk assessments and more information can be found at http://www.nonnativespecies.org/index.cfm?pageid=143

# GB NON-NATIVE ORGANISM RISK ASSESSMENT SCHEME

**Name of organism:** *Paulownia tomentosa*, foxglove tree
**Author:** Katharina Dehnen-Schmutz, Coventry University
**Risk Assessment Area:** Great Britain
**Version:** Draft 1 (Jan 2021), Peer review (Jan 2021), NNRAP 1 (Mar 2021), Draft 2 (Jul 2021), NNRAF 2 (Jul 2021), Draft 3 (Sep 2021)
**Signed off by NNRAF:** July 2021
**Approved by Programme Board:** January 2023
**Placed on NNSS website**: January 2024

**What is the principal reason for performing the Risk Assessment?**

Officials in GB are interested to better understand the risk posed by this species, in part because it is known to be planted in GB, but also because a proposal to establish plantations of *Paulownia* hybrids is currently being considered. It is important to note that the plantation proposal is for Paulownia hybrids, not *P. tomentosa*.

This risk assessment is about the risk posed specifically by the species *P. tomentosa* to GB. However, the risk assessor is encouraged to comment on the risk posed by potential hybrids if it is possible to do so.

| **SECTION A – Organism Information** | |
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| **Stage 1. Organism Information** | **RESPONSE AND COMMENT** |
| 1. Identify the organism. Is it clearly a single taxonomic entity and can it be adequately distinguished from other entities of the same rank? | *Paulownia tomentosa* (Thunb.) Steud. (Paulowniaceae) foxglove tree, princess tree, royal paulownia.<br><br>*P. tomentosa* is a deciduous tree of up to 21 m height. It is characterised by its purple/blueish large flowers appearing in spring before the large leaves (up to 40 x 20 cm) fully emerge. The tree is a pioneer species able to colonise disturbed and open habitats very quickly, due to its fast growth (1 m/year from seeds and 5 m/year from root sprouts) (Stimm et al., 2015). There are six accepted species within the Paulownia genus, plus one accepted hybrid (*P. catalpifolia, P. elongata, P.fargesii, P. fortunei, P. kawakamii, P. x taiwaniana*), (http://powo.science.kew.org/taxon/urn:lsid:ipni.org:names:30013788-2) *P. tomentosa* can be clearly distinguished by an experienced botanist, however, there are also a number of cultivars and hybrids available in GB, both for ornamental and agroforestry purposes, which could make identification more difficult, particular when flowering parts of the plant are not present. |
| 2. If not a single taxonomic entity, can it be redefined? (if necessary use the response box to re-define the organism and carry on) | NA |
| 3. Does a relevant earlier risk assessment exist? (give details of any previous risk assessment) | No relevant earlier risk assessment for the risk assessment area exists, however, risk assessments have been conducted for the species in areas outside the risk assessment area.<br><br>Risk assessments for P. tomentosa have been undertaken for example for:<br>Australia = reject this species for import (http://www.hear.org/pier/wra/australia/patom-wra.htm)<br>Hawaii = high risk (http://www.hear.org/pier/wra/pacific/paulownia_tomentosa_htmlwra.htm)<br>Florida = high invasion risk (https://assessment.ifas.ufl.edu/assessments/paulownia-tomentosa/) |

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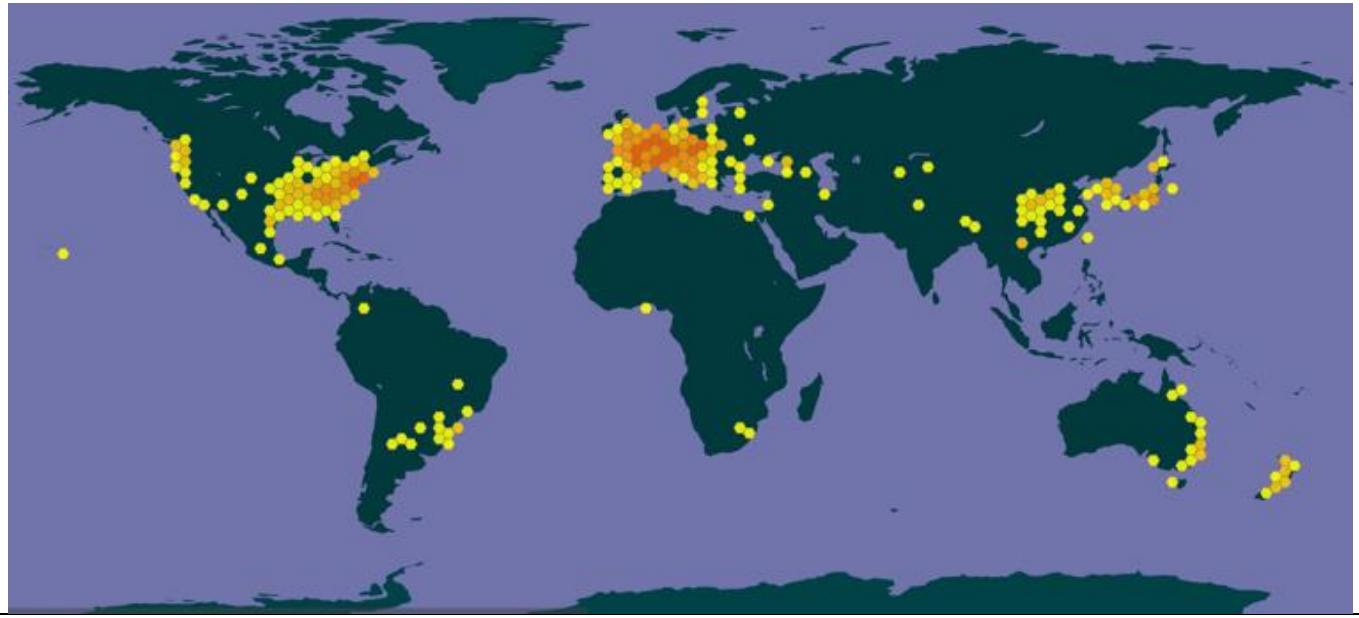
| | For Canada, a risk assessment is pending (https://inspection.canada.ca/plant-health/plant-pests-invasive-species/invasive-plants/weed-risk-analysis-documents/eng/1427387489015/1427397156216#listp, accessed 10/6/21 ) |
| 4. If there is an earlier risk assessment is it still entirely valid, or only partly valid? | NA |
| 5. Where is the organism native? | Southeast Asia (China North-Central, China South-Central, China Southeast, Korea, Manchuria) (Plants of the World Online, accessed 4/7/2021 http://www.plantsoftheworldonline.org/taxon/urn:lsid:ipni.org:names:185784-2) |
| 6. What is the global distribution of the organism (excluding the risk assessment area)? | *P. tomentosa* has been introduced to other parts of Asia (Japan, Bangladesh, Turkmenistan, Uzbekistan), North and South America, Africa, Australia, New Zealand and Europe.  |

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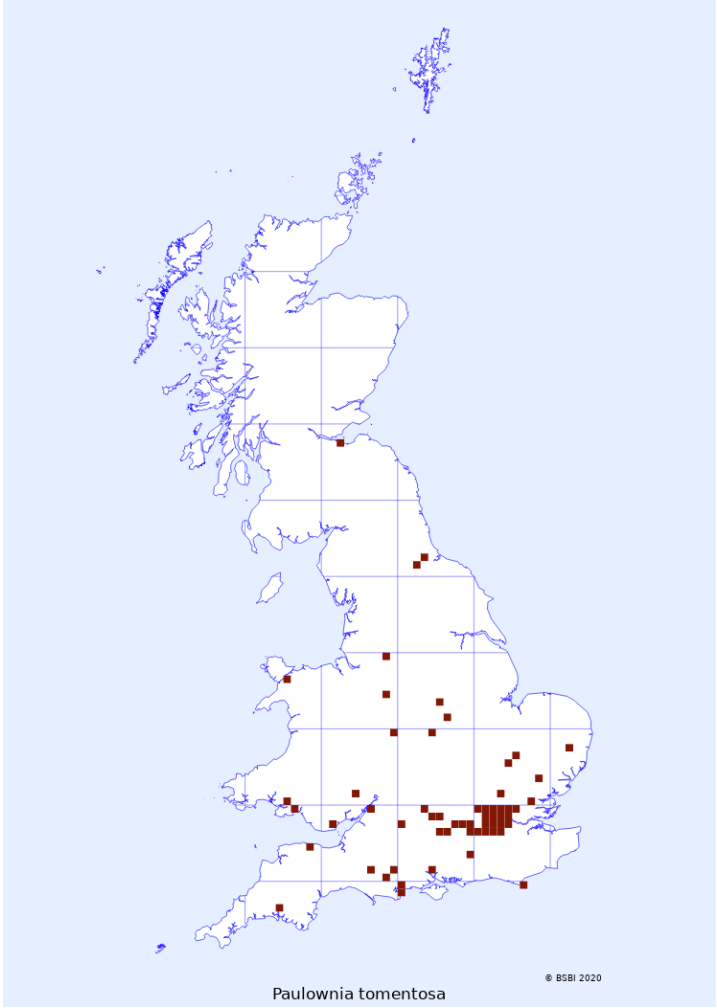
| | Fig 1: Global distribution of *Paulownia tomentosa*. Map taken from GBIF (accessed 12/12/2020, https://www.gbif.org/species/3170823 ). |
| 7. What is the distribution of the organism in the risk assessment area? | *P. tomentosa* was introduced to Britain in 1838 (Bean, 1987) and is considered naturalised in the risk assessment area since at least the 1990s with first self-sown records of the species reported from Middlesex (Stace, 2019). The BSBI distribution database (accessed 10/6/2021) has currently 105 records of the species including 32 which are marked as planted, three are classified as "established in wild for at least five years and spreading" and 17 as "alien, excluding casual". There is a risk, particular for earlier records of" unknown" status, that planted records may not have been distinguished from self-sown occurrences, although these records still provide information on where the species can grow (Figure 2).<br><br>Fig 2: Distribution of *Paulownia tomentosa* in the risk assessment area at a 10 sqkm grid scale. Data from the BSBI Distribution Database<br><br>  <br>(https://database.bsbi.org/maps/?taxonid=2cd4p9h.3r9, accessed 12/12/2020) |

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| 8. Is the organism known to be invasive (i.e. to threaten organisms, habitats or ecosystems) anywhere in the world? | Yes. The species is classified as invasive in the United States from Pennsylvania south to Georgia and west to Missouri (Langdon, 2009), New Zealand and Hawaii (CABI 2020). However, the species has also been listed in several countries on precautionary watch or action lists. For example in Europe, *P. tomentosa* is listed in the Czech Republic (Watch List, Pergl et al, 2016), Germany (Grey list, i.e. watch list, Nehring et al. 2013), and Switzerland (Watch List, Infoflora, 2014, https://www.infoflora.ch/de/assets/content/documents/neophyten/neophyten_diverses/Schwarze%20Liste_Watch%20List_2014_v2020_05_18.pdf, accessed 4/7/2021) . In South Africa, *P. tomentosa* has been categorised as '1a' species ('immediate compulsory control. This has been interpreted that nation-wide eradication is feasible and has been set as the management goal', https://www.environment.co.za/weeds-invaders-alien-vegetation/alien-invasive-plants-list-for-south-africa.html, accessed 4/7/2021).<br>These listings are the results of rapid risk classification schemes and are not usually based on full risk assessments. |
| 9. Describe any known socio-economic benefits of the organism in the risk assessment area. | The species is mainly used as an ornamental tree; however, it is also used in agroforestry projects and of interest for biomass production. |

## SECTION B – Detailed assessment

# PROBABILITY OF ENTRY

Important instructions:

- Entry is the introduction of an organism into the risk assessment area. Not to be confused with spread, the movement of an organism within the risk assessment area.
- For organisms which are already present in the risk assessment area, only complete the entry section for current active pathways of entry or if relevant potential future pathways. The entry section need not be completed for organisms which have entered in the past and have no current pathways of entry.

| QUESTION | RESPONSE [chose one entry, delete all others] | CONFIDENCE [chose one entry, delete all others] | COMMENT |
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| 1.1. How many active pathways are relevant to the potential entry of this organism?<br><br>(If there are no active pathways or potential future pathways respond N/A and move to the Establishment section) | few | very high | The main pathway for entry for *P. tomentosa* is the use of the tree as an ornamental species. A second pathway is the use as fast growing tree for timber or biomass production in plantations and agroforestry systems, which could become more important in the future. |
| 1.2. List relevant pathways through which the organism could enter. Where possible give detail about the specific origins and end points of the pathways.<br><br>For each pathway answer questions 1.3 to 1.10 (copy and paste | i. Ornamental horticulture<br>ii. Agroforestry and biomass production | | |

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| additional rows at the end of this section as necessary). | | | |
| Pathway name: | i. Ornamental horticulture | | |
| i.1.3. Is entry along this pathway intentional (e.g. the organism is imported for trade) or accidental (the organism is a contaminant of imported goods)?<br><br>(If intentional, only answer questions 1.4, 1.9, 1.10, 1.11) | intentional | very high | *P. tomentosa* was introduced in the risk assessment area in the 1830s and has since been used for ornamental purposes. The species is planted to grow as a tree and for its attractive flowers but also to be coppiced annually for a multi-stemmed display of foliage. |
| i.1.4. How likely is it that large numbers of the organism will travel along this pathway from the point(s) of origin over the course of one year?<br><br>Subnote: In your comment discuss how likely the organism is to get onto the pathway in the first place. | very likely | very high | *P. tomentosa* is a popular ornamental plant and it is likely that high number of plants or seeds are travelling along this pathway to garden and plants in the risk assessment area. The RHS Plant Finder lists 63 nurseries selling the species (RHS Plant Finder online edition, accessed 8/12/2020). All other *P. tomentosa* species are also available with the next popular species being *P. kawakami* (10 nurseries) and *P. fortunei* (4). It has not been possible to determine if these plants on offer have been propagated in the risk assessment area or been imported by nurseries. Seeds of *P, tomentosa* are also frequently offered on several online trading platforms including by sellers labelling the seeds with British origin. |
| i.1.9. How likely is the organism to be able to transfer from the pathway to a suitable habitat or host? | very likely | high | Seeds from *P. tomentosa* trees planted in gardens, parks and as street trees are likely to be the main source of self-sown plants of the species in the risk assessment area as currently little evidence of self-established or forestry plantations exist that could also serve as seed sources. *P.tomentosa* also |

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| | | | spreads vegetatively, although evidence for this has not been observed in the risk assessment area. |
| i.1.10. Estimate the overall likelihood of entry into the risk assessment area based on this pathway? | very likely | very high | The ornamental use of the species is considered to be the initial pathway of introduction of *P. tomentosa* in the risk assessment area (Stace and Crawley, 2015) and the fact that it is still popular in the horticultural trade is evidence that this pathway is still important. Other *Paulownia* spp and hybrids are also increasingly being planted. |
| Pathway name: | ii. Agroforestry and biomass production | | |
| ii.1.3. Is entry along this pathway intentional (e.g. the organism is imported for trade) or accidental (the organism is a contaminant of imported goods)?<br><br>(If intentional, only answer questions 1.4, 1.9, 1.10, 1.11) | intentional | very high | The use of *Paulownia spp* and especially their hybrids for biomass production and in agroforestry systems is a more recent use of the species resulting in a further potential pathway of introduction. One characteristic of this pathway is that several species of *Paulownia* as well as hybrids are used and sources are often just referring to 'Paulownia' which makes it difficult to assess the importance of this pathway. *P. tomentosa* appears to be less commonly used for this purpose. |
| ii.1.4. How likely is it that large numbers of the organism will travel along this pathway from the point(s) of origin over the course of one year?<br><br>Subnote: In your comment discuss how likely the organism is to get onto the pathway in the first place. | moderately likely | medium | *Paulownia ssp* for biomass and agroforestry production are sold by large globally trading nurseries (e.g. Biotree (https://paulowniatrees.eu/ , Bulgaria), Paulownia professional (https://paulownia.pro/en/ ,Spain), iPaulownia (https://www.ipaulownia.com/, Spain/UK), or more specific for agroforestry in the UK https://www.agroforestry.co.uk/product/paulownia-tomentosa/ ). Paulownia species marketed for biomass and agroforestry are often hybrids involving *P. elongata*, *P. fortunei* and *P. kawakamii*, some of which include *P. tomentosa* in the parentage; however, some companies also offer *P. tomentosa* itself. The hybrid, P. 'Cotevisa 2' is specifically described as 'sterile', however, its parentage does |

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| | | | not include *P. tomentosa* (https://www.ipaulownia.com/en/shop/hybrid-paulownia-tree-cotevisa-2/).<br>Furthermore, seeds of *P. tomentosa* sold in large quantities (in units of up to 50,000) on online trading platforms (e.g ebay.co.uk) may also be targeted more to biomass/agroforestry farmers than gardeners. |
| ii.1.9. How likely is the organism to be able to transfer from the pathway to a suitable habitat or host? | likely | high | If *P. tomentosa* is be used in biomass plantations or in agroforestry systems and plants would grow to flower and produce seeds, *P. tomentosa* could establish and spread outside of these plantations. Plantations growing for biomass production and coppiced in a 2-3 year rotational system would not flower and produce seeds, however, plantations aiming to produce timber are likely to do so. |
| ii.1.10. Estimate the overall likelihood of entry into the risk assessment area based on this pathway? | moderately likely | medium | Currently, there is little evidence of the use of *P. tomentosa* in agroforestry systems or for biomass plantations in the risk assessment area. Indeed, other species or hybrids seem to be preferred, but the use of *P. tomentosa* cannot be excluded. An investigation into the use of Paulownia in agroforestry systems also found that agroforestry farmers and advisers were aware of the potential invasiveness of the species (Jensen, 2016). Should *Paulownia ssp* cultivation for these purposes become more popular in coming years, this pathway is likely to become more important. |
| *End of pathway assessment, repeat as necessary.* | | | |
| ii.1.11. Estimate the overall likelihood of entry into the risk assessment area based on all pathways (comment on the key issues that lead to this conclusion). | very likely | very high | *P. tomentosa* is already grown as an ornamental tree throughout the risk assessment area and this seems to be the most important current entry pathway. The use of the species in agroforestry and biomass plantations could become more important in the future. |

# PROBABILITY OF ESTABLISHMENT

Important instructions:

- For organisms which are already well established in the risk assessment area, only complete questions 1.15, 1.21 and 1.28 then move onto the spread section. If uncertain, check with the Non-native Species Secretariat.

| QUESTION | RESPONSE | CONFIDENCE | COMMENT |
|---|---|---|---|
| 1.12. How likely is it that the organism will be able to establish in the risk assessment area based on the similarity between climatic conditions in the risk assessment area and the organism's current distribution? | very likely | very high | Climatic conditions in most parts of the risk assessment area are suitable for *P. tomentosa* to grow, although for establishment only parts with warmer winters may be suitable. Conditions in the native range in South East Asia are characterised by warmer summers than in Britain, however, the species' non-native range in Europe and North America includes climate conditions similar to the risk assessment area (Koeppen-Geiger zone Cfb, warm temperate, fully humid, warm summer). As an ornamental species *P. tomentosa* has a hardiness rating of H5 (= hardy in most places throughout the UK even in severe winters (-15 to -10°C)), (RHS 2020). However, the overwintering flower buds are vulnerable both to winter cold and late spring frosts (Johnson, 2004) limiting seed production in colder areas. Observations from central Europe show that adult *P. tomentosa* trees can survive winter temperatures down to -25°C, but seedlings and young plants are damaged at -10°C (Essl, 2007). This vulnerability of seedlings has also been observed in London, where the majority of seedlings are found in warm and sunny areas and years with cold spring weather can result in reduced seedling abundance (M. Spencer, pers. comm.). |
| 1.13. How likely is it that the organism will be able to establish in the risk assessment area based on the similarity between other abiotic conditions in the risk | very likely | very high | *P. tomentosa* tolerates diverse environmental conditions. It grows best in moist, uncompacted, well drained soils, but tolerates a variety of soil types and conditions including low fertility, high acidity, and drought (Innes, 2009). These conditions are widely available in the risk assessment area. |

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| assessment area and the organism's current distribution? | | | |
| 1.14. How likely is it that the organism will become established in protected conditions (in which the environment is artificially maintained, such as wildlife parks, glasshouses, aquaculture facilities, terraria, zoological gardens) in the risk assessment area?<br><br>Subnote: gardens are not considered protected conditions | unlikely | medium | While theoretically possible, it seems unlikely *P. tomentosa* would establish in protected conditions due to the high level of maintenance which would prevent the undeliberate establishment of the plant. |
| 1.15. How widespread are habitats or species necessary for the survival, development and multiplication of the organism in the risk assessment area? | widespread | high | *P. tomentosa* grows well in wide range of conditions in open habitats. In continental Europe, the species has been recorded in particular along railway lines, wall crevices and in urban-industrial habitats, but has also been reported from riverbanks (Essl, 2007). In Switzerland, the species is spreading in open clearings in woodlands (Wunder et al., 2018), as well as in forests in the Western Caucasus (Pshegusov & Chadaeva, 2021). In eastern North America, *P. tomentosa* is known to grow in disturbed forests, forest edges, roadsides and rocky habitats (Innes, 2009). In Greater London, regenerating seedlings of P. tomentosa have been observed in ancient woodland, parkland woods, canal side ruderal habitats, railways, pavements and walls (M. Spencer, pers. comm.).<br><br>These habitats are widespread in the risk assessment area. |

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| 1.16. If the organism requires another species for critical stages in its life cycle then how likely is the organism to become associated with such species in the risk assessment area? | NA | | |
| 1.17. How likely is it that establishment will occur despite competition from existing species in the risk assessment area? | very likely | high | Preferred habitats for the establishment are ruderal habitats and disturbed habitats in urban areas where competition from existing species is low. *P. tomentosa* is not considered to be a very competitive species, particular during the establishment phase where it needs light for germination and seedlings do not grow well in shaded conditions (Stimm et al., 2015). This could prevent the invasion in more natural habitats, in particular natural undisturbed forests, and has been used has a potential explanation why *P. tomentosa* is currently rarely reported from natural habitats in Europe (Essl, 2007). |
| 1.18. How likely is it that establishment will occur despite predators, parasites or pathogens already present in the risk assessment area? | very likely | high | A number of pests and pathogens have been described to affect *P. tomentosa* in its native range, as well as in India, Pakistan and North America (CABI 2020), however, there are no reports of the presence of these pests in Britain. *Paulownia ssp.* are listed as "sometimes affected" host species of honey fungus (*Armillaria ssp*.) in the UK in the RHS's honey fungus plant list (RHS 2021), but these impacts, or any other impacts from pests or pathogens present in the risk assessment area, are unlikely to be severe enough to prevent establishment (see also question 2.24). |
| 1.19. How likely is the organism to establish despite existing management practices in the risk assessment area? | likely | high | Weed management practices in urban habitats and on railway lines designed to prevent plant establishment could prevent establishment of *P. tomentosa* to some extent. However, these management practices are not preventing the continued (re-)establishment of other invasive species, most notably *Buddleja davidii* and *Ailanthus altissima*, in |

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| | | | similar habitats, and it seems therefore unlikely they would successfully prevent *P. tomentosa* to establish at all. |
| 1.20. How likely are management practices in the risk assessment area to facilitate establishment? | likely | medium | Management practices involving habitat disturbance could facilitate *P. tomentosa* establishment. Soil disturbances or forest fires are known to have favoured *P. tomentosa* establishment in North America (Innes, 2009). However, these practices are less likely to be applied in the mostly urban habitats where the species is currently most likely to establish more widely. In woodlands, the practice of coppicing generates more open and lighter spaces which could favour *P. tomentosa* establishment, and young self-sown *P. tomentosa* trees have been observed in a coppiced woodland in London (M. Spencer, pers. comm.). |
| 1.21. How likely is it that biological properties of the organism would allow it to survive eradication campaigns in the risk assessment area? | likely | high | Eradication of *P. tomentosa* appears difficult mainly due to the existence of many planted occurrences of the tree in parks and gardens that would be a continued seed source for new establishment. The existence of a seed bank and the ability to re-sprout from its root system after cutting or herbicide treatment (Innes, 2009) would further hinder eradication. |
| 1.22. How likely are the biological characteristics of the organism to facilitate its establishment? | very likely | very high | Establishment of *P. tomentosa* is likely to be favoured by the high number of seeds the tree produces and the short time period to flower and seed production.<br><br>*P. tomentosa* produces very high numbers of seeds, estimated at 2000 per seed capsule adding up to up to 20 million for a large tree (CABI 2020). The light winged seeds are distributed by wind up to 4km (Innes, 2009). Reproduction starts early in trees from age 4-5 (Stimm et al., 2015) or 8-10 years ((CABI 2020), depending on locations. Seeds can survive in the soil seedbank for more than a year, although |

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| | | | seed-banking is not considered part of the species reproductive strategy (Hyatt and Casper, 2000).<br><br>Successful seed germination requires high light levels (Stimm et al., 2015). |
| 1.23. How likely is the capacity to spread of the organism to facilitate its establishment? | very likely | very high | The high number of small wind-dispersed seeds produced by the tree (see 1.22. above) is very likely to facilitate the establishment of *P. tomentosa*, as the species is more likely to reach suitable habitats. |
| 1.24. How likely is the adaptability of the organism to facilitate its establishment? | likely | high | *P. tomentosa* grows in a wide range of habitats with different conditions indicating its high adaptability (see 1.13). |
| 1.25. How likely is it that the organism could establish despite low genetic diversity in the founder population? | likely | medium | There is little information available on the genetic variation of invasive *P. tomentosa* populations. However, a study of post fire multiple large-scale invasions in North America revealed very little genetic variation between the populations suggesting they may have originated from a single introduction (Lovenshimer and Madritch, 2017).<br><br>Reports of the initial introduction of *P. tomentosa* to Europe suggest that a tree introduced from Japan to Paris in 1832 was the source of between 20,000 and 30,000 plants raised from this single individual by seeds and vegetative propagation and was also the source of first introduction to England, although a further introduction also from Japan to England occurred (Bean, 1987). |
| 1.26. Based on the history of invasion by this organism elsewhere in the world, how likely is it to establish in the risk assessment area? (If possible, | very likely | very high | The species is already considered established in the risk assessment area since at least the 1990s (Stace and Crawley, 2015), when self-sown occurrences were first reported. Similar to the invasion history in Europe (Essl, 2007) these first records of establishment are from urban areas and climatically warmer parts in the risk assessment area. In the |

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| specify the instances in the comments box.) | | | city of Stuttgart (Germany) Richter (2003) reported a 25-year-old spontaneous tree that was also likely to have generated further offspring. Seedlings most likely originating from self-sown trees have also been observed in London (M. Spencer, pers. comm.). |
| 1.27. If the organism does not establish, then how likely is it that transient populations will continue to occur?<br><br>Subnote: Red-eared Terrapin, a species which cannot re-produce in the risk assessment area but is established because of continual release, is an example of a transient species. | very likely | very high | As the species is present in gardens and parks a continued supply of seeds from these trees is likely to be the source for transient populations. |
| 1.28. Estimate the overall likelihood of establishment (mention any key issues in the comment box). | very likely | very high | *P. tomentosa* is considered established in the risk assessment area with self-sown plants documented since the 1990s (Stace and Crawley, 2015, Stace, 2019). Most of these self-sown plants seem to originate from planted parent plants in nearby locations. There is no published evidence of self-sustained populations, however, it seems very likely that if seedlings manage to grow in the right habitat and location they will go on and flower and produce seeds. This has already been observed in London. |

# PROBABILITY OF SPREAD

Important notes:

- Spread is defined as the expansion of the geographical distribution of a pest within an area.

| QUESTION | RESPONSE | CONFIDENCE | COMMENT |
|---|---|---|---|
| 2.1. How important is the expected spread of this organism in the risk assessment area by natural means? (Please list and comment on the mechanisms for natural spread.) | moderate | very high | Spread by natural means is important at the local scale. The tree produces high numbers of small, light and winged seeds, that are distributed by wind up to 4 km from the parent plant (Langdon and Johnson, 1994, Innes, 2009). A study in the city of Stuttgart (Germany) found 80% of self-sown records of the species within a distance of 700m from any potential parent plants and only very few records in more than 1600m distance (Richter, 2000). According to Carpenter et al. (1983) trees start to produce seeds from 8 years and full-grown trees in favourable conditions are estimated to produce up to 20 million seeds. *P. tomentosa* also spreads vegetatively through root and stem sprouts (Innes, 2009), mostly after coppicing, but this is not considered an important mechanism of spread. |
| 2.2. How important is the expected spread of this organism in the risk assessment area by human assistance? (Please list and comment on the mechanisms for human-assisted spread.) | moderate | very high | The use of *P. tomentosa* as an ornamental plant in parks and gardens and for other purposes is likely to facilitate the long distance spread of *P. tomentosa* as the plant can spread from these planted occurrences in areas suitable for establishment.<br>Seeds attached to machinery or with soil movement could also assist the spread of *P. tomentosa*. |
| 2.3. Within the risk assessment area, how difficult would it be to contain the organism? | difficult | high | It would be difficult to contain the organism as planted occurrences in parks, gardens or as urban street trees would continue to function as seed sources. Similar, continued planting for the same purpose or for biomass production could also impact on efforts to contain establishment. |

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| 2.4. Based on the answers to questions on the potential for establishment and spread in the risk assessment area, define the area endangered by the organism. | see comments | medium | Urban areas throughout the risk assessment area, particularly in the South and Midlands of England and southern Wales. Where seed sources are present, establishment could also occur in open and coppiced woodlands, along riverbanks and other open habitats in the warmer areas of these parts of the risk assessment area.<br><br>Based on current records it seems likely that *P. tomentosa* will be able to establish mainly in urban areas throughout the risk assessment area. The main limitations in northern and higher areas will be from temperature: young seedlings are vulnerable to frosts below -10 C and late frosts can affect flowering and seed production. However, as suggested for continental Europe, where the species has started to spread exponentially (Essl, 2007) also mainly in urban areas, *P. tomentosa* has the ability to spread into near-natural habitats outside cities (Essl, 2007). In the risk assessment area, *P. tomentosa* has already been observed in near-natural habitats, for example on the banks of the River Teff in Cardiff, and in an ancient woodland in the Greater London area (M. Spencer, pers. comm.). Further habitats outside urban areas which could be affected are open roadsides, railways, rocky habitats, forest edges and clearings, which are known to be invaded by *P. tomentosa* in Europe and in its North American range (Innes, 2009). |
| 2.5. What proportion (%) of the area/habitat suitable for establishment (i.e. those parts of the risk assessment area were the species could establish), if any, has already been colonised by the organism? | 0-10 | medium | The BSBI distribution database (BSBI 2020) has 105 records of *P. tomentosa* in 46 hectads in the risk assessment area in 2021, which is an increase from the nine hectads where it was recorded before the year 2000. These records are mainly in urban areas, and earlier records may be of planted trees. In particular, records from Edinburgh shown in the BSBI distribution map (Figure 1) are of planted trees recorded in 2019 (BSBI 2020). |

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| 2.6. What proportion (%) of the area/habitat suitable for establishment, if any, do you expect to have been invaded by the organism five years from now (including any current presence)? | 0-10 | medium | Given the current low number of records it is not expected that *P. tomentosa* would spread beyond 10% of the area of suitable habitats in the next five years. |
| 2.7. What other timeframe (in years) would be appropriate to estimate any significant further spread of the organism in the risk assessment area? (Please comment on why this timeframe is chosen.) | 20 | medium | *P. tomentosa* records are only recently increasing in the risk assessment area. The situation could be compared to central Europe where many first records of self-seeded plants were recorded in the 1980s and became more frequent at the beginning of this century over a 20 year period (Essl, 2007). In Austria *P. tomentosa* was first recorded in the 1960 and started spreading more rapidly since the 1980s increasing to being found in 1% of the grid cells of the Austrian floristic mapping system (with 27 out of a total of 2612 grid cells). In the Great Smoky Mountains National Park, USA, eight trees were recorded along a 430 km road in 1975 and despite control actions, the number increased to several thousands in the early 1990s (Langdon & Johnson, 1994). |
| 2.8. In this timeframe what proportion (%) of the endangered area/habitat (including any currently occupied areas/habitats) is likely to have been invaded by this organism? | 0-10 | low | It has been argued that *P. tomentosa* follows a similar invasion process as *Ailanthus altissima* (Essl, 2007) which until the 1980s was only found in urban areas in parts of central Europe with the warmest summers, but has since expanded its distribution into cities in colder regions, and is spreading out from inner city centres where it was initially recorded coinciding with a period of milder climate facilitating seedling establishment (Kowarik & Säumel, 2007). In Austria (Essl, 2007) and Germany (Adolphi, 2001) the two species are frequently found in the same habitats. Comparing the records of *P. tomentosa* in the risk assessment area in 2020 to early records of *A. altissima* before the year 2000 confirms a similar pattern and expectation of comparable spread for |

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| | | | *P. tomentosa* in the next 20 years. The number of A. altissima records nearly trebled from around 200 to nearly 600 records (BSBI database). The uncertainty is high because the extent of planted occurrences functioning as seed sources for further establishment is not known. |
| 2.9. Estimate the overall potential for future spread within the next five years for this organism in the risk assessment area (using the comment box to indicate any key issues). | very slow | medium | The natural and human mediated spread of this species is of moderate importance, because seed dispersal facilitates local spread, while people move it longer distances by planting it in gardens, parks, etc. It has been present in the risk assessment area for many years (since 1838) but its range has increased considerably in recent decades (from being present in 9 hectads in 2000 to 46 hectads in 2021). In this respect its spread in GB may be similar to *Ailanthus altissima*. Despite this, it is not anticipated that *P. tomentosa* will have occupied more than 10% of its habitable range in GB within the next 5 years. In fact, it is not considered likely that this would happen in the next 20 years. As a result, overall spread is considered very slow with medium confidence. Nevertheless, it is emphasised that this species appears to be spreading more rapidly in recent decades than in the past and could be at the early stages of considerable expansion. |

# PROBABILITY OF IMPACT

Important instructions:

- When assessing potential future impacts, climate change should not be taken into account. This is done in later questions at the end of the assessment.
- Where one type of impact may affect another (e.g. disease may also cause economic impact) the assessor should try to separate the effects (e.g. in this case note the economic impact of disease in the response and comments of the disease question, but do not include them in the economic section).
- Note questions 2.10-2.14 relate to economic impact and 2.15-2.21 to environmental impact. Each set of questions starts with the impact elsewhere in the world, then considers impacts in the risk assessment area separating known impacts to date (i.e. past and current impacts) from potential future impacts. Key words are in bold for emphasis.

| QUESTION | RESPONSE | CONFIDENCE | COMMENTS |
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| 2.10. How great is the economic loss caused by the organism within its existing geographic range **excluding the risk assessment area**, including the cost of any current management? | moderate | medium | There is no documented evidence of negative economic impacts of *P. tomentosa*. Nevertheless, the species is managed as an invasive species in parts of the USA and it is likely that this is causing management costs. For example, in the Great Smoky Mountains National Park in the south-eastern USA, management aims to eradicate the tree especially in rare plant habitats and includes surveys of burned sites after natural occurring forest fires and in disturbed areas (Langdon and Johnson, 1994). Recommended techniques include repeated cutting, herbicide applications and hand-pulling of seedlings, with increased efforts up to 600 hours in years following forest wildfires (Webster et al., 2006). |
| 2.11. How great is the economic cost of the organism **currently** in the risk assessment area **excluding management** costs (include any past costs in your response)? | minimal | high | There is currently no evidence of any economic costs caused by *P. tomentosa* in the risk assessment area. |

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| 2.12. How great is the economic cost of the organism likely to be **in the future** in the risk assessment area **excluding management** costs? | minor | low | Economic costs could be caused by damages to buildings and infrastructure by the establishment of *P. tomentosa* in wall crevices, one of the main habitats it was observed in in Austria (Essl, 2007). |
| 2.13. How great are the economic costs **associated with managing** this organism **currently** in the risk assessment area (include any past costs in your response)? | minimal | high | There is currently no evidence of any management of *P. tomentosa* in the risk assessment area. |
| 2.14. How great are the economic costs **associated with managing** this organism likely to be **in the future** in the risk assessment area? | moderate | medium | The establishment and spread of *P. tomentosa* in urban areas could cause management costs due to the need to remove the species from railway infrastructure, wall crevices and crevices in pavements, which were among habitats where the species was most frequently recorded in Austria (Essl, 2007). There could be further management costs if the species would establish in semi-natural and natural habitats. |
| 2.15. How important is environmental harm caused by the organism within its existing geographic range **excluding the risk assessment area**? | moderate | high | There are few records of environmental harm caused by *P. tomentosa*. In central Europe, the species is currently mainly recorded in urban areas and impacts of environmental harm in these habitats have not been reported. In Switzerland, observations of occurrences of the species in forest ecosystems concluded that *P. tomentosa* would not be able to compete with native species in the long term in such ecosystems due to its low tolerance to shade (Wunder et al., 2018). Observed impacts included higher browsing pressure by deer on native vegetation in the same area, because the deer did not browse on *P. tomentosa* (Wunder et al., 2018). |

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| | | | In Italy (Piedmont), the species has reportedly been included in a management list of invasive plants due to it its adverse impacts on biodiversity and buildings. (Badalamenti, 2019).<br><br>A study of *P. tomentosa* colonising areas of the southern Appalachian Mountains in North America following fires found that the species was not able to persist against native tree species competition after several years in the succession, however, was likely to establish in xeric and exposed cliff habitats of high conservation value with potential risks to endangered native plants (Kuppinger et al., 2010). Many south-eastern states in the USA have listed *P. tomentosa* as an invasive species posing a substantial or severe threat to native communities (Innes, 2009). |
| 2.16. How important is the impact of the organism on biodiversity (e.g. decline in native species, changes in native species communities, hybridisation) **currently** in the risk assessment area (include any past impact in your response)? | minimal | medium | There is currently no evidence or any anecdotal reports of observations of impacts of *P. tomentosa* on biodiversity in the risk assessment area. |
| 2.17. How important is the impact of the organism on biodiversity likely to be in the **future** in the risk assessment area? | moderate | low | Impacts on biodiversity are likely to be moderate, particular if *P. tomentosa* would establish in habitats of high conservation value. This could occur in urban as well as in non-urban habitats. In urban brownfield sites which can offer conditions similar to more natural habitats and support rare and endangered species (Harrison & Davies, 2001, Eyre et al., 2003, Angold et al., 2006), *P. tomentosa* could become dominant, outcompete non-woody vegetation and change light and structural conditions in these habitats. In Austria for example, 20% of urban habitats in which *P. tomentosa* was found were xerophytic ruderal |

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| | | | habitats (Essl, 2007), which are important invertebrate habitats (Venn et al., 2013).<br><br>Outside urban areas, establishment in rocky habitats, open woodlands or in riparian habitats is likely to have impacts on native biodiversity. Currently, the presence of this species in rocky habitats has only been observed in North America, where habitats with endangered plants were affected (Kuppinger et al., 2010), whereas in Switzerland, establishment in woodlands has not resulted in documented substantial negative impacts (Wunder et al. 2018). Observation in the Greater London Area of *P. tomentosa* in a coppiced ancient woodland (M. Spencer, pers. comm), however, indicate potential impacts of the species in open woodland habitats as well. Similar, occurrences in riparian habitats in the risk assessment area, which have also been reported from Austria (Essl, 2007), and Switzerland (Haag et al. 2013) could indicate the ability of the species to establish in these habitats with negative impacts on native riparian ecosystems. Uncertainty with regard to these impacts is high, as very little investigation into and published evidence of biodiversity impacts is available, partly due to the fact that the invasion process in other parts of Europe has not advanced to a stage where these impacts could be assessed. |
| 2.18. How important is alteration of ecosystem function (e.g. habitat change, nutrient cycling, trophic interactions), including losses to ecosystem services, caused by the organism **currently** in the risk assessment area (include any past impact in your response)? | minimal | high | There is currently no evidence of impacts of *P. tomentosa* on ecosystem function in the risk assessment area. |

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| 2.19. How important is alteration of ecosystem function (e.g. habitat change, nutrient cycling, trophic interactions), including losses to ecosystem services, caused by the organism likely to be in the risk assessment area in the **future**? | moderate | low | Impacts on ecosystem function are more likely to be expected if the species would spread into natural and semi-natural habitats, i.e. woodlands, rocky habitats or riverbanks. These impacts may be only temporarily for example in woodlands, but could be more persistent in naturally tree less habitats. where *P. tomentosa* as a drought adapted species could compete with native species. *P. tomentosa* flowers are attractive to pollinators and could reduce pollinator visitation rates in native plants. Litter from the large leaves (up to 40 x 20 cm) can prevent undergrowth and change nutrient cycling (Stimm et al., 2015). |
| 2.20. How important is decline in conservation status (e.g. sites of nature conservation value, WFD classification) caused by the organism **currently** in the risk assessment area? | minimal | high | *P. tomentosa* has been recorded in a designated SSSI, designated LNR and from canal sides classified as SINC (Sites of Importance for Nature Conservation) in Greater London (M. Spencer, pers. comm.), however, declines in conservation status have not been documented. |
| 2.21. How important is decline in conservation status (e.g. sites of nature conservation value, WFD classification) caused by the organism likely to be in the **future** in the risk assessment area? | moderate | low | A decline in conservation status could occur if *P. tomentosa* would further establish and spread in urban habitats of conservation value (see 2.17 and 2.20) as well as into natural and semi-natural habitats outside urban areas, in particular exposed rocky habitats of high conservation value, ancient woodlands and riparian habitats with designated conservation status. |
| 2.22. How important is it that genetic traits of the organism could be carried to other species, modifying their genetic nature and making their economic, environmental or social effects more serious? | minimal | medium | *P. tomentosa* is known to hybridise with some of the other seven species in the genus (CABI 2020). No *Paulownia* species are native in the risk assessment area, although several of the other species as well as hybrids are available in the horticultural trade. There is no evidence of any of the other Paulownia species or hybrids being invasive and having negative impacts. However, if they would become more popular for biomass |

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| | | | production and more widely planted, hybridisation cannot be excluded which could result in an increase in potential risks of impacts. |
| 2.23. How important is social, human health or other harm (not directly included in economic and environmental categories) caused by the organism within its existing geographic range? | minimal | high | No evidence of social, human health or other harm was found. |
| 2.24. How important is the impact of the organism as food, a host, a symbiont or a vector for other damaging organisms (e.g. diseases)? | minimal | high | *P. tomentosa* is a host species for *Halyomorpha halys* (brown marmorated stink bug). *H. halys* is not considered established in the risk assessment area, but casual records have been observed since 2010, most recently in 2020 (NIAB/EMR 2020), *H. halys* is a pest causing damage to vegetables and fruit as well as through invading and congregating in houses for overwintering (Defra 2015). As *H. halys* is a polyphagous insect with several of its host species already widespread in the risk assessment area, the additional impact of *P. tomentosa* to sustain its possible establishment and expansion is considered minimal. *P. tomentosa* is also a host species for two South Asian longhorn beetles (*Apriona germari, Massicus raddei*), which are both not present in Europe but are also pests of native trees and trees of economic importance in the risk assessment area (EPPO 2020). Reports from Serbia in 2016 of severe damage in a *P. tomentosa* plantation were confirmed to be caused by the wood decaying fungus *Trametes hirsuta* (Milenković et al., 2018), which is native and widespread in Britain but usually found on dead wood (NBN 2020). Furthermore, *P. tomentosa* is a wild host for *Pseudomonas syringae pv. actinidiae,* an emerging plant disease in Kiwi fruit production in several European countries, but not present in the UK (EPPO 2020). *Paulownia* spp. are also affected by Paulownia witches-broom phytoplasma; which is not present in the risk |

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| | | | assessment area or other parts of Europe (CABI 2021), but may be a potential biocontrol agent. |
| 2.25. How important might other impacts not already covered by previous questions be resulting from introduction of the organism? (specify in the comment box) | NA | | |
| 2.26. How important are the expected impacts of the organism despite any natural control by other organisms, such as predators, parasites or pathogens that may already be present in the risk assessment area? | moderate | medium | There is no evidence of natural control of *P. tomentosa* in the risk assessment area currently and is seems unlikely, given evidence from other European countries, that any natural control would prevent impacts. |
| 2.27. Indicate any parts of the risk assessment area where economic, environmental and social impacts are particularly likely to occur (provide as much detail as possible). | see comment | medium | Urban areas throughout the risk assessment area, particular in the South and Midlands of England and southern Wales. Open habitats like rocks and cliffs, open woodlands, riparian areas in southern England and southern Wales.<br><br>Based on current records it seems likely that *P. tomentosa* will be able to establish mainly in urban areas throughout the risk assessment area. The main limitations in northern and higher areas will be from temperature: young seedlings are vulnerable to frosts below -10 C and late frosts can affect flowering and seed production. However, as suggested for continental Europe, where the species has started to spread exponentially (Essl, 2007) also mainly in urban areas, *P. tomentosa* potentially has the ability to spread into near-natural habitats outside cities (Essl, 2007) and this could also apply in the risk assessment area. Habitats affected in this |

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| | | | case could be open roadsides, river banks, rocky habitats, forest edges and clearings, which are known to be invaded by *P. tomentosa* in its North American range (Innes, 2009). As these habitats are also more likely to be subject to frosts, they may be less suitable for seedling establishment of *P. tomentosa* in the northern parts of the risk assessment area. |
| 2.28. Estimate the overall impact of this organism in the risk assessment area (using the comment box to indicate any key issues). | moderate | medium | Impacts of *P. tomentosa* are most likely to occur in urban areas affecting biodiversity in habitats of conservation value, infrastructure and buildings as well as costs from management. If the species would establish in habitats of high conservation value, particular open rocky habitats, woodlands and riparian areas, impacts on biodiversity could occur more widely outside urban areas. |

# RISK SUMMARIES

| | RESPONSE | CONFIDENCE | COMMENT |
|---|---|---|---|
| **Summarise Entry** | very likely | very high | *P. tomentosa* is already grown as an ornamental tree throughout the risk assessment area and this seems to be the most important entry pathway. The use of the species in agroforestry and biomass plantations seems to be of less importance, but could become more active in the future. |
| **Summarise Establishment** | very likely | very high | *P. tomentosa* is considered established in the risk assessment area with self-sown plants documented since the 1990s (Stace and Crawley, 2015), although self-sustained populations are only suspected and have not been documented so far. Nevertheless, as plants raised from seeds are known to come to flower and produce viable seeds, it seems likely that self-seeded plants will have the capacity to reproduce. Climatic conditions in most parts of the risk assessment area are suitable for *P. tomentosa* to grow, although for establishment areas with cold winter temperatures may not be suitable as flowers and seedlings are prone to frost damage. |
| **Summarise Spread** | very slow | medium | The natural and human mediated spread of this species is of moderate importance, because seed dispersal facilitates local spread, while people move it longer distances by planting it in gardens, parks, etc. It has been present in the risk assessment area for many years (since 1838) but its range has increased considerably in recent decades (from being present in 9 hectads in 2000 to 46 hectads in 2021). In this respect its spread in GB may be similar to *Ailanthus altissima*. Despite this, it is not anticipated that *P. tomentosa* will have occupied more than 10% of its habitable range in GB within the next 5 years. In fact, it is not considered likely that this would happen in the next 20 years. As a result, overall spread is considered very slow with medium confidence. Nevertheless, it is emphasised that this species appears to be spreading more rapidly in recent decades than in the past and could be at the early stages of considerable expansion. |

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| **Summarise Impact** | moderate | medium | Impacts of *P. tomentosa* are most likely to occur in urban areas affecting biodiversity in habitats of conservation value, infrastructure and buildings as well as costs from management. If the species would establish in habitats of high conservation value, particular open rocky habitats, woodlands and riparian areas, impacts on biodiversity could occur more widely outside urban areas. |
| **Conclusion of the risk assessment** | moderate | medium | The overall risk of *P. tomentosa* is considered as moderate as it seems likely the species will continue to establish and spread. However, the confidence score is not high, as there is uncertainty with regard to the possible impacts on semi-natural and natural habitat areas which depend on the ability of the species to spread outside urban areas. |

Additional questions are on the following page ...

| ADDITIONAL QUESTIONS - CLIMATE CHANGE | | | |
|---|---|---|---|
| 3.1. What aspects of climate change, if any, are most likely to affect the risk assessment for this organism? | Increase in temperature | high | Given the origin of *P. tomentosa* in a warmer climate, the history of establishment and spread in central Europe, and the species invasiveness in eastern North America, it seems very likely that the invasion process of *P. tomentosa* will be facilitated by warmer temperatures. The trees adaptability, in particular to endure longer periods of drought, will also be an advantage. |
| 3.2. What is the likely timeframe for such changes? | 10 | medium | Recent increases of *P. tomentosa* in Central Europe have already been attributed to increased temperatures (Essl, 2007; Sukopp and Wurzel, 2003) and may have contributed to the increase in records in the risk assessment area in the past ten years already. |
| 3.3. What aspects of the risk assessment are most likely to change as a result of climate change? | All | high | Increased temperatures are likely to affect all stages of the invasion process of *P. tomentosa*. The tree could become more popular due to response and mitigation measures to climate change, in particular afforestation and carbon sequestration programmes, while at the same time it is more likely to establish and spread resulting in increased impacts. |

| ADDITIONAL QUESTIONS - RESEARCH | | | |
|---|---|---|---|
| 4.1. If there is any research that would significantly strengthen confidence in the risk assessment please summarise this here. | Research on impacts | high | There is little evidence of impacts, however, this could also be the result of less research and publication activity on this species. |

Please provide a reference list on the following page ...

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