



Department
for Environment
Food & Rural Affairs

Rapid Pest Risk Analysis (PRA) for: *Sirococcus tsugae*

December 2016

Summary and conclusions of the rapid PRA

This rapid PRA shows that *Sirococcus tsugae*, the causal agent of Sirococcus shoot blight on cedars and hemlocks, is a damaging fungal pathogen on *Cedrus* spp., with light to moderate damage seen on *Tsuga* spp. Native to the Pacific Northwest of North America, it has been introduced to the United Kingdom and present for at least a decade, with impacts beginning to emerge in 2013. *Sirococcus tsugae* has been found at an increasing number of sites, and has potential to cause significant impacts to *Cedrus* spp. planted in parks and gardens across the UK.

Risk of entry

The pathway of introduction to the UK is unknown. Plants for planting and cut branches of *Cedrus* and *Tsuga* can act as a pathway of entry. Although this pathway is prohibited from North America, entry to the UK may have occurred before this prohibition. Plants can be imported from Germany, from where the pest was reported for the first time in 2014. Further entry on plants is rated as unlikely with medium confidence. Seed transmission for *S. tsugae* has not been confirmed on *Tsuga* or *Cedrus* seeds, but the closely related *Sirococcus conigenus* can be transmitted by seed. Further entry on seed is rated as unlikely with low confidence.

Risk of establishment

Sirococcus tsugae is already established outdoors in the UK and establishment is rated as very likely with high confidence. There is evidence the pest is spreading both naturally and in the trade of planting material.

Economic, environmental and social impact

Impacts in the current range of the pest (excluding the UK) are rated as small, with medium confidence. Very few impacts are reported from the native range of the pest in the Pacific North-West of North America. Where it has been introduced to the East Coast of the USA no significant impacts have been reported, though, due to the recent nature of the introduction event full impacts may yet to have emerged. The pest is reported as damaging on *Cedrus* in Germany, but it still has a limited distribution.

Potential economic impacts in the UK are rated as small, with medium confidence. Economic impacts will largely occur in nursery environments due to symptoms of the disease making plants unmarketable. *Cedrus* and *Tsuga* are non-native species and neither is currently widely planted for forestry use, environmental impacts are therefore rated as very small with high confidence. *Cedrus* species are very widely planted in the UK in public parks and gardens, and also feature prominently in the gardens of stately homes. The disease is very damaging to cedar, causing cankers that can lead to considerable dieback and death of the tree, or cause trees to become safety hazards so that they must be removed. *Cedrus libani* has been planted in the UK as part of a conservation project for this Lebanese native, but the success of this project is endangered by *S. tsugae*. Social impacts are rated as large, with medium confidence.

Endangered area

The whole of the UK is endangered by the pest.

Risk management options

The pest is established in Great Britain and eradication is very unlikely to be feasible. The pest was confirmed in Northern Ireland in November 2016, on mature trees, and is likely to also be established there. The pest was present in the UK for at least a decade before being first identified. Given the fact the pest is becoming increasingly widespread in the UK, further statutory measures are very unlikely to inhibit the spread of the pest.

Good hygiene measures, such as removing sources of inoculum and not planting hosts within the vicinity of nurseries, can help reduce the impacts of the pest.

Key uncertainties and topics that would benefit from further investigation

- Though seed transmission of *S. tsugae* has not been demonstrated in published literature, it remains a potential pathway of introduction. Studies which confirm the seed transmission capability of *S. tsugae* would be very beneficial for the technical justification of measures to prevent further spread of the pest.
- There remains uncertainty over the full distribution of the pest in the UK and more widely. Reports of trees with suspicious symptoms can be submitted via Tree Alert: <http://www.forestry.gov.uk/treealert>
- The pest has entered three different locations on an unknown pathway(s): the East Coast of the USA, Germany and the UK. Identifying the pathway in any of these cases is very unlikely, but it is a key source of uncertainty in this PRA.
- Due to only limited damage being reported in the USA, it appears that the pathogen is more damaging in the UK than in its native range. The reason for the more aggressive symptoms seen on *Cedrus* in the UK is not known, as climatic conditions are similar to the Pacific North-West of the USA.
- There is very little information on management options for *S. tsugae*, and most relate to basic hygiene practices. Further research could be carried out to identify potential protectant or curative treatments for *S. tsugae*.
- The spore dispersal capacity of *S. tsugae* is unknown, including potential long distance spread via strong winds during storm conditions.

Images of the pest



Sirococcus tsugae on *Cedrus atlantica* in the UK. Image courtesy of Forest Research.



A canker extending into the phloem on *C. atlantica*. Image courtesy of Forest Research.

Is there a need for a detailed PRA or for a more detailed analysis of particular sections of the PRA? If yes, select the PRA area (UK or EU) and the PRA scheme (UK or EPPO) to be used.

No			
Yes		PRA area: UK or EU	PRA scheme: UK or EPPO

Given the information assembled within the time scale required, is statutory action considered appropriate / justified?

Survey work indicates *S. tsugae* is becoming increasingly widespread in the UK and is now reported from all territories. The pest is known to spread locally via rain splash, but it is also possible that long distance dispersal during storms may occur, although no research on long distance spore dispersal for this pathogen has been carried out. Based on the fact that trees may be initially asymptomatic and thus inadvertently moved in trade, and the number of findings in the wider environment, it is very unlikely that statutory action will limit the spread of the pest further. Instead industry should pursue best practice to limit the impacts of the disease.

Yes
Statutory action

No
Statutory action

Stage 1: Initiation

1. What is the name of the pest?

Sirococcus tsugae Rossman, Castlebury, D.F. Farr & Stanosz (Fungi: Ascomycota)

Causal agent of Sirococcus shoot blight on cedars and hemlocks.

Special notes on taxonomy

Sirococcus tsugae was formally described in 2008, and had previously been part of *Sirococcus conigenus sensu lato* (Rossman et al., 2008). An earlier publication had demonstrated host related variation within *S. conigenus s.l.* (Smith et al., 2003). As a consequence, publications that refer to *S. conigenus* before 2008 may be referring to *S. tsugae*, or could be referring to another member of *S. conigenus s.l.* There is an overlap in the host range of *S. tsugae* and *S. conigenus sensu stricto* as both are recorded on *Cedrus deodara* (Rossman et al., 2008). There is also overlap in the spore dimensions of *S. conigenus*, *S. piceicola* and *S. tsugae*, which adds to the uncertainty of the identity of historical records of *S. conigenus s.l.* (Aoife Smith, DAERA, personal communication 02/12/2016).

This PRA concentrates on literature that refers to *S. tsugae* or reports of *S. conigenus s.l.* on hosts now known to be restricted to *S. tsugae*.

2. What initiated this rapid PRA?

An increase in the UK cases of *S. tsugae* reported in 2016 triggered this PRA, in order to see if continued action against findings in nursery stock was technically justified and identify additional risk management options for the UK.

3. What is the PRA area?

The PRA area is the United Kingdom of Great Britain and Northern Ireland.

Stage 2: Risk Assessment

4. What is the pest's status in the EC Plant Health Directive (Council Directive 2000/29/EC¹) and in the lists of EPPO²?

The pest is not listed in the EC Plant Health Directive. It was added to the EPPO Alert list in April 2015 after an outbreak was reported in Germany (EPPO, 2015).

5. What is the pest's current geographical distribution?

The native distribution of *S. tsugae* has been described as “Western North America from Oregon to Alaska”, this includes British Columbia and Haida Gwaii (islands off the coast of British Columbia) within Canada, and Oregon, Washington and Alaska within the USA (Rossman *et al.*, 2008).

From 2006, symptoms were noted on *Tsuga canadensis* (eastern hemlock) in Southern Maine, on the East Coast of the USA, which were confirmed as being caused by *S. tsugae* in 2010 (USDA, 2010). The pest was later reported from Georgia, in the South-East of the USA (Stanosz *et al.*, 2015). EPPO also lists it as present in the state of Vermont (EPPO, 2015).

In 2014 *S. tsugae* was reported in Germany for the first time, in Niedersachsen (EPPO, 2015). It was described as occurring at “several sites in private gardens and public green spaces in the vicinity of Oldenburg, Lower Saxony”. Since it was occurring on mature trees it is assumed to have been present for some time (Butin *et al.*, 2015).

Distribution in the UK is discussed more in section 6 below.

Because of the change in taxonomy, that has separated *S. tsugae* from *S. conigenus s.l.*, there is considerable uncertainty about the distribution of this pest especially since *S. conigenus s.s* is known from across the Northern Hemisphere (Rossman *et al.*, 2008). Thus, other cases of *S. tsugae*, especially in North America and Europe, may be present but overlooked, a point also made in the paper which first described *S. tsugae* (Rossman *et al.*, 2008).

¹ <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CONSLEG:2000L0029:20100113:EN:PDF>

² <https://www.eppo.int/QUARANTINE/quarantine.htm>

Table : Distribution of <i>Sirococcus tsugae</i>	
North America:	Canada (British Columbia), USA (Alaska, Georgia, Maine, Oregon, Vermont, Washington).
Central America:	No records
South America:	No records
Europe:	Germany, United Kingdom
Africa:	No records
Asia:	No records
Oceania:	No records

6. Is the pest established or transient, or suspected to be established/transient in the UK/PRA Area?

Sirococcus tsugae is now established in Great Britain, with cases reported from England, Scotland and Wales. Figure 1 shows the distribution of confirmed cases in the UK, as of November 2016.

Reports of symptoms which would later be attributed to *S. tsugae* were first recorded in autumn 2013 (Pérez-Sierra *et al.*, 2015), and the pest was recorded from a range of locations in Great Britain during 2014 and 2015 (see Figure 1). The number of cases detected in Great Britain in 2016 increased significantly. There had been 33 cases in 2015, and in 2016 as of November 24th there have been 103 cases. Total cases per species to this date in Great Britain are: *C. atlantica* 53, *C. atlantica* 'glauca' 64, *C. libani* 13, *Cedrus* sp. 20, *T. heterophylla* 3 and *T. metensiana* 2.

A survey for the pest was undertaken in Northern Ireland, and, in November 2016, 5 cases were confirmed in Belfast and the surrounding areas (see Figure 2). These cases were on mature trees and not associated with recently planted material, suggesting the pest is also established in Northern Ireland. Historical records of *S. conigenus* in both Northern Ireland and the Republic of Ireland were checked, all were on hosts other than *Cedrus* and *Tsuga* and are thus unlikely to be *S. tsugae* (DAERA, unpublished data).

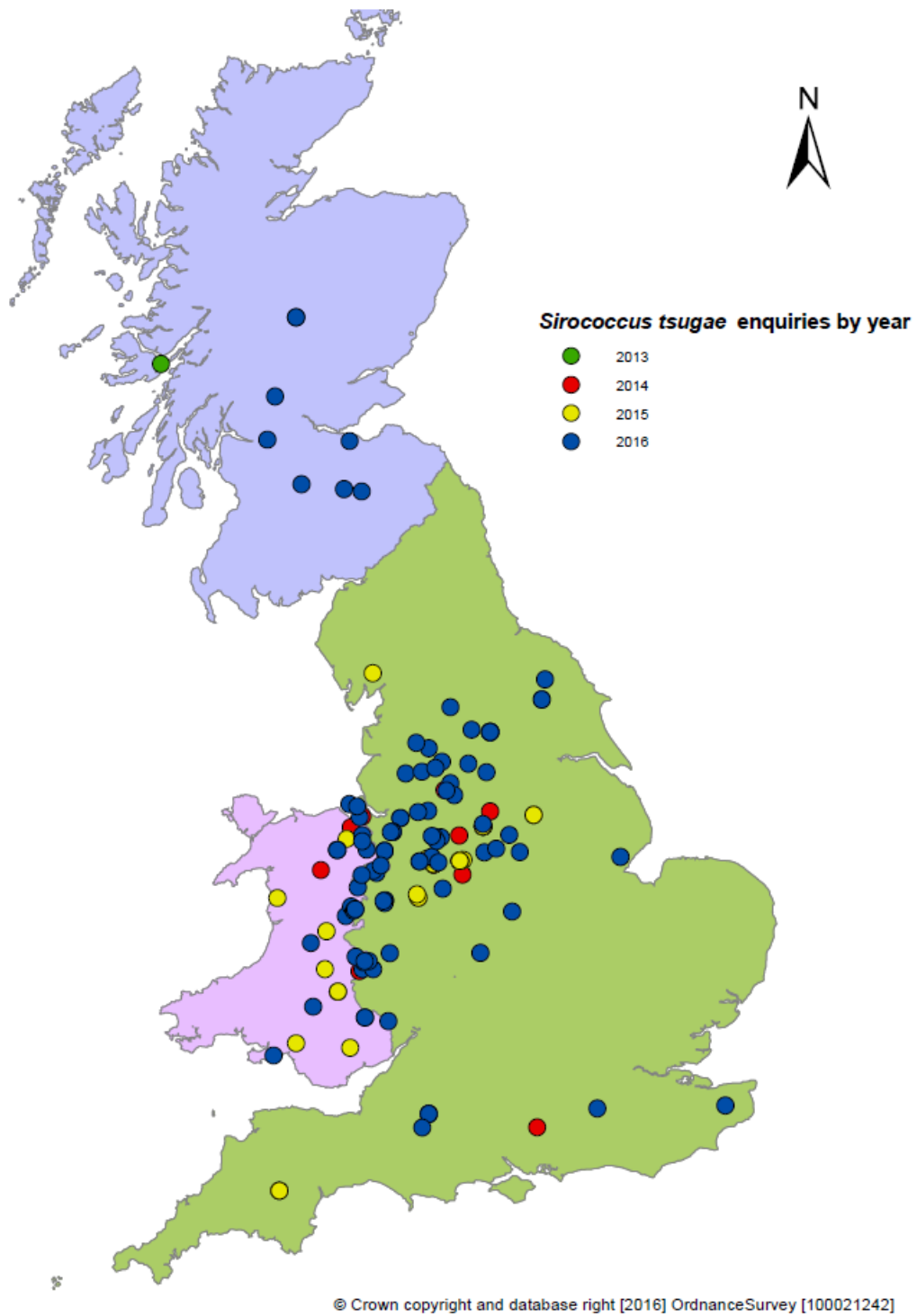


Figure 1: Cases of *Sirococcus tsugae* in Great Britain by year, as of November 24th 2016 (Image courtesy of Forest Research).

Sirococcus tsugae Situation for Northern Ireland as of 30.11.16

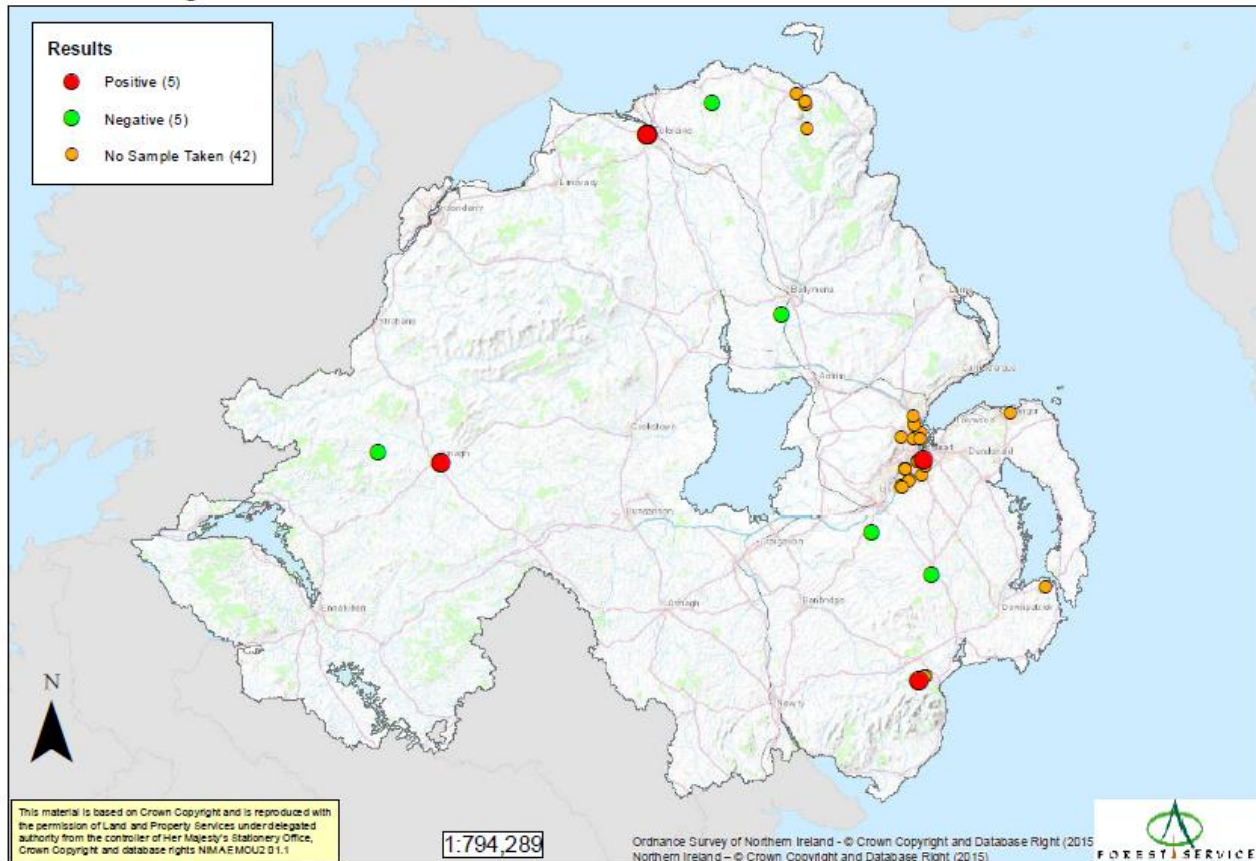


Figure 2: Cases of *Sirococcus tsugae* in Northern Ireland as of November 30th 2016 – 5 confirmed cases (Image courtesy of DAERA). Survey work is ongoing to establish how widely it is found there.

The precise date and pathway of introduction to the UK is unknown. A herbarium record indicates the pest has been present since at least 2004. This specimen was collected from *T. mertensiana* in Scotland. As well as on ornamental trees, the pest has also been found on natural regeneration of *T. heterophylla* in south-west England (Forest Research, 2016b).

7. What are the pest's natural and experimental host plants; of these, which are of economic and/or environmental importance in the UK/PRA area?

The published hosts of *S. tsugae* are: *Cedrus atlantica* (Atlas cedar), *C. deodara* (deodara), *Tsuga canadensis* (eastern hemlock), *T. heterophylla* (western hemlock) and *T. mertensiana* (mountain hemlock) (Forest Research, 2016b).

None of the known hosts are native, but all are grown in the UK. *Cedrus atlantica* is not currently used for forestry plantations in the UK, though it is a species that has potential use in some climate change scenarios (Forest Research, 2016a). Both *C. atlantica* and *C. deodara* are planted as ornamental species in the UK, and are often included as plants in

public parks and large gardens of stately homes, in particular *C. atlantica* which was first introduced to the UK in 1841 (Savill & Wilson, 2015). *Cedrus libani* (cedar-of-Lebanon) is also grown as an ornamental in the UK and it was planted in many stately homes from the 1740s onwards (Woodland Trust, 2016). *Cedrus libani* is not recorded as a host in North America, but it is not widely planted there. Cases of infection on this host have been reported in the UK (Ana Perez-Sierra, Forest Research, personal communication), though it should be noted that *C. libani* and *C. atlantica* are very closely related and may be misidentified in the field (Pijut, 2000), but it is now considered that *C. libani* is a host of *S. tsugae*.

Tsuga heterophylla is a relatively minor forestry species in the UK, though it shows high natural regeneration and so can persist at sites where previously planted (Forest Research, 2016c), and there are approximately 1500 ha of *T. heterophylla* in Scotland (Anna Brown, Forestry Commission Scotland, *personal communication*). It is considered to have potential as a forestry species for Wales (Tom Jenkins, Forest Research, *personal communication*). Like the other *Tsuga* hosts of *S. tsugae*, it is also planted as an occasional ornamental species.

Since *Cedrus* is not native to North America, it is likely that *Tsuga* is the natural host of *S. tsugae* which has then spread on to ornamental plantings of *Cedrus*. Since the majority of coniferous genera grown in the UK are also found in the Pacific North-West (e.g. *Pinus*, *Picea*, *Pseudotsuga*, *Juniperus*), it is unlikely *S. tsugae* will spread to hosts in other genera but may be able to infest additional species of *Cedrus* or *Tsuga* not already recorded as hosts. No other species of *Cedrus* or *Tsuga* are of significant importance to the UK.

8. What pathways provide opportunities for the pest to enter and transfer to a suitable host and what is the likelihood of entering the UK/PRA area?

Plants (excluding seeds)

This pathway covers both plants for planting, cut branches of hosts or any material with roots attached. However, the main risk being presented is by plants for planting, as, although fruiting bodies of *S. tsugae*, which spread locally by rain splash, can form on the dead needles or cankers of stems/branches, the risk of transfer from cut branches to living hosts has a lower likelihood.

Import of *Cedrus* spp. and *Tsuga* spp. plants from Non-European countries is prohibited under current plant health legislation. The pest has been present in the UK since at least 2004, and may have been introduced earlier. Since prohibition of plants came into effect in 2000, the pest may have originally entered on plants before the current prohibition, but further introductions on North American plant material is very unlikely, with high confidence, though some prohibited imports may occur.

The pest is also present in Germany, from which host plants can be imported. Though symptoms are highly noticeable, and would make plants unmarketable, they can initially be confused with frost damage (Butin *et al.*, 2015) and very recent infections would not be symptomatic. The fungus overwinters in dead shoots that may be left attached to some plants before they are transported, or plant debris from infected plants may be inadvertently transported with other plants from the nursery. To date, there are no records of *S. tsugae* in nurseries in Germany (Butin *et al.*, 2015), but there has been a finding in UK nurseries (Defra, unpublished data) on trees of UK origin, showing the pest can move on this pathway. The volumes of cedar imported from the EU are not known, though larger specimen trees (8-12 ft.) are likely to be imported rather than produced in the UK. Such trees are difficult to inspect due to their size and subtle early symptoms may go unnoticed.

The prohibition on imports of host plants from North America, combined with the reported limited distribution in Germany and the lack of observations within nursery stock, make new introductions on plants unlikely, with medium confidence. The entry is not rated lower, due to the uncertainty surrounding the global distribution of the pest, which is also why confidence is only rated as medium.

Cones or Seeds

There are no published studies that demonstrate that *S. tsugae* can be transmitted by seed. This does not rule out seeds as a source of inoculum, as no studies have been published that demonstrate it cannot be transmitted by seed. In addition, the very closely related *Sirococcus conigenus* is seed borne, having been recorded as being transmitted by seed in *Picea* (spruce) species (Sutherland *et al.*, 1981). It has also been isolated from *Abies* seeds, though it was not demonstrated that these seeds were capable of going on to produce infected seedlings (Talgø *et al.*, 2010).

The prohibition on the plants of *Cedrus* and *Tsuga* from outside of Europe does not apply to fruit (e.g. cones) or seeds, whose import is unregulated. Forestry Commission did not source seed material of *Cedrus* or *Tsuga* from the range of the pest between 2003 and 2013 (Forestry Commission, unpublished data), but it may have been imported by nurseries or private individuals. Such seed is available to buy from several internet trading sites.

Cones could also be imported either for decorative use or individuals may bring them back in passenger baggage as souvenirs, which are later disposed of. Fruiting bodies of *S. tsugae* are known to occur on the cones of *Tsuga* and *Cedrus* and so cones are a source of inoculum, however to reach potential host trees such cones would need to be either kept or disposed of outdoors in reasonable proximity to a host species, to allow dispersal of spores by wind/rain splash. Such a scenario is not impossible, but is very unlikely.

Overall the likelihood of entry on seeds or cones is rated as unlikely, with low confidence. Contributing factors to the low confidence are the absence of data concerning the ability or inability of *S. tsugae* to be transmitted by seed and that it is unknown what volume of seeds/cones are imported into the UK from the range of the pest.

Wood for timber

The fungus overwinters in dead shoots, which are unlikely to be imported with wood for timber. Imported coniferous wood must either be bark free, or have undergone specified treatments. These mitigations are designed to limit the likelihood of pests and pathogens being associated with this product, therefore this pathway is assessed as very unlikely with high confidence.

Plants (excluding seeds) Very unlikely Unlikely Moderately likely Likely Very likely

Confidence High Confidence Medium Confidence Low Confidence

Seeds Very unlikely Unlikely Moderately likely Likely Very likely

Confidence High Confidence Medium Confidence Low Confidence

Wood for timber Very unlikely Unlikely Moderately likely Likely Very likely

Confidence High Confidence Medium Confidence Low Confidence

9. If the pest needs a vector, is it present in the UK/PRA area?

Sirococcus tsugae does not require a vector.

10. How likely is the pest to establish outdoors or under protection in the UK/PRA area?

As detailed in section 6, the pest is already established outdoors in the UK and spreading. Establishment outdoors is thus very likely, with high confidence.

The hosts are not usually grown under protection, and so establishment in protected environments is very unlikely with high confidence.

<i>Outdoors</i>	Very unlikely	<input type="checkbox"/>	Unlikely	<input type="checkbox"/>	Moderately likely	<input type="checkbox"/>	Likely	<input type="checkbox"/>	Very likely	<input checked="" type="checkbox"/>
<i>Confidence</i>	High Confidence	<input checked="" type="checkbox"/>	Medium Confidence	<input type="checkbox"/>	Low Confidence	<input type="checkbox"/>				
<i>Under Protection</i>	Very unlikely	<input checked="" type="checkbox"/>	Unlikely	<input type="checkbox"/>	Moderately likely	<input type="checkbox"/>	Likely	<input type="checkbox"/>	Very likely	<input type="checkbox"/>
<i>Confidence</i>	High Confidence	<input checked="" type="checkbox"/>	Medium Confidence	<input type="checkbox"/>	Low Confidence	<input type="checkbox"/>				

11. How quickly could the pest spread in the UK/PRA area?

Natural spread

Natural spread is via spores, which are produced on dead needles, stems and cones on diseased trees and debris on the ground. These spores can then be dispersed by rain/water splash (Stanosz, 2012). Such spread is likely to be largely local but strong winds may be capable of spreading them further (Forest Research, 2016b). Spores are produced all year round, though initial infection usually occurs in the spring and early summer (Stanosz, 2012). No published studies on the spore dispersal capacity of *S. tsugae* could be found.

It is not known if the majority of cases seen in the UK in 2016 were caused by local spread, or movement in trade. To date, there has only been one finding within a nursery. The concentration of findings in the west of the UK, many on mature trees, indicates that natural spread is occurring. Younger trees in a stately home in Great Britain were found to be infected, but these trees had been produced on site, suggesting they had been infected by a source of inoculum in the wider environment. It is difficult to determine if the increase in findings indicates that the pest is spreading faster naturally, or is related to the increased publicity the pest has received leading to the public reporting sick trees. If spores can be spread longer distances by strong winds, then the increase in cases could be related to the winter storm season of 2015/2016.

Natural spread is rated as at a moderate pace, with low confidence, caused by the lack of data on spore dispersal capacity and the fact it is not possible to tell if the increase in UK cases is due to increased reporting of the pest in response to publicity campaigns, or natural spread of the pest.

Spread with trade

Symptoms on traded plants are likely to make them unmarketable, and thus reduce the ability of the pest to travel on this pathway, though early infection would be difficult to detect and nurseries may use fungicide to suppress the symptoms. In addition, though diseased plants may be rogued out, if all associated debris e.g. needles is not removed these could be inadvertently moved with other nearby plants. If *S. tsugae* is capable of seed transmission, then the pest could move via this traded pathway and would be cryptic. **Spread in trade is rated as at a moderate pace, with medium confidence.** Spread may be faster with trade if *S. tsugae* is transmitted efficiently via seeds.

<i>Natural Spread</i>	Very slowly <input type="checkbox"/>	Slowly <input type="checkbox"/>	Moderate pace <input checked="" type="checkbox"/>	Quickly <input type="checkbox"/>	Very quickly <input type="checkbox"/>
<i>Confidence</i>	High Confidence <input type="checkbox"/>	Medium Confidence <input type="checkbox"/>	Low Confidence <input checked="" type="checkbox"/>		
<i>With trade</i>	Very slowly <input type="checkbox"/>	Slowly <input type="checkbox"/>	Moderate pace <input checked="" type="checkbox"/>	Quickly <input type="checkbox"/>	Very quickly <input type="checkbox"/>
<i>Confidence</i>	High Confidence <input type="checkbox"/>	Medium Confidence <input checked="" type="checkbox"/>	Low Confidence <input type="checkbox"/>		

12. What is the pest's economic, environmental and social impact within its existing distribution?

Sirococcus tsugae is described as being able to damage seedlings of all ages; saplings, larger ornamental trees and those within forestry stands; with seedling infection leading to blighting symptoms which may make them unmarketable or that may kill the seedlings outright (Stanosz, 2012). In Alaska, *S. tsugae* is reported to kill young growth of western hemlocks at moderate levels in some years, but there are also reports that the disease is of "minimum ecological consequence" as trees are rarely killed and stands are usually densely stocked (USDA, 2004).

When *S. tsugae* was introduced to the East Coast of the USA, it demonstrated an ability to be able to infect eastern hemlocks, though the pathogen is described as less aggressive on *T. canadensis* than on *T. heterophylla*, with tree damage in most stands described as "light" (USDA, 2010). A later outbreak in Georgia reported blighted shoot tips on *T. canadensis*, with incidence on some trees as high as 70%, but varying greatly (Stanosz *et al.*, 2015). Since this is a relatively recent introduction, confidence about impacts on eastern hemlock is relatively low.

Though *Cedrus* is recorded as a host in North America, there are no reports of significant impacts on this host. In Oregon, *S. tsugae* is considered to be a minor twig dieback pathogen on cedar, and cankers on nursery or landscape trees of *Cedrus* have not been observed. Impacts are usually seen every 5 – 7 years and measures are not usually required to control the disease (Melodie Putnam, Oregon State University, *personal communication*). In Germany, *Cedrus* showed discolouration of needles leading to dieback

of the affected shoots. Authors stated infection could progress to the point of tree death but it is not clear if any trees have been killed to date in Germany (Butin *et al.*, 2015).

Given that *S. tsugae* rarely causes significant economic impacts in its native range, and distribution is still limited in Germany, impacts in the current range are rated as small with medium confidence. Taxonomic confusion contributes to the medium confidence rating, as there may be impacts of *S. tsugae* that are reported under the species name *S. conigenus* and introduction to the East Coast and Germany is relatively recent, so impacts there may still be emerging.

Impacts Very small Small Medium Large Very large
 Confidence High Confidence Medium Confidence Low Confidence

13. What is the pest’s potential to cause economic, environmental and social impacts in the UK/PRA area?

Economic impacts

Since *T. heterophylla* is only a minor forestry species in the UK, and this host is rarely killed by the disease in the native range of the pest and deaths are usually of seedlings, potential economic impacts on forestry are very small, although this extrapolation is with some uncertainty as the UK impacts on cedars have been much greater than on cedars in the USA. The spread of *S. tsugae* could impact on any future forestry use of *Cedrus* spp., which has been considered as a potential species in climate change scenarios.

Disease symptoms in the UK appear to be significantly worse on *Cedrus* than *Tsuga*. In the UK, symptoms begin as the discolouration and death of needles. Shoots die and may show cankers. Branches can also develop cankers, which may girdle the branch, killing it. Lesions can extend further, into the main stem, where they spread longitudinally (Forest Research, 2016b). Disease symptoms are very distinctive, needles turn purplish in colour and the aesthetic of the tree is drastically reduced even if the pathogen does not cause crown dieback or tree death.

The main economic impacts are likely to be related to the presence of the disease in nursery stock. Symptoms of disease are likely to make these trees unmarketable. *Cedrus* are popular ornamentals, more so than *Tsuga*. Since spread usually occurs locally, good hygiene measures could prevent major losses within nurseries, and to date there has only been one confirmed finding on nursery stock. However, the pathogen could cause significant losses in beds of *Cedrus* being grown in nurseries where overhead irrigation is used, as this can spread the disease quickly. However overhead irrigation is not common in tree nurseries, and good hygiene practices could limit the spread of the disease. It is used for containerised stock production, so impacts may occur for these producers.

Overall economic impacts are rated as small, with medium confidence.

Environmental impacts

Neither *Cedrus* nor *Tsuga* are native species to the UK, and nor are they widely planted in forestry stands, though western hemlock may be used more in the future. Individual trees may still provide benefits to local wildlife, but overall **environmental impacts are rated to be very small with high confidence.**

Social impacts

As previously mentioned, *Cedrus* is widely planted ornamental in public parks and spaces, as well as being found within many landscaped gardens at stately homes. Capability Brown, the famous English landscape architect, was noted for his use of *C. libani* in his designs, though many of these do not survive today (Doughty, 2016). In some stately homes these trees will be replaced by one of the same species. For example, an English Heritage project helped to replace the well-known avenue of trees at Chiswick House and Gardens (Anon, 2015). Cases of *S. tsugae* have already been detected in stately homes in England, both on younger and mature trees, and in some instances trees have had to be removed. *Cedrus* is also planted in private gardens. *Tsuga* is planted as an ornamental to a lesser extent.

Cedrus libani is now considered vulnerable in its native range due to forest destruction (International Conifer Conservation Programme, 2016). As a consequence, a conservation programme has been undertaken by the Royal Botanic Gardens Edinburgh and seed collected in Lebanon was grown up into young trees, which were then planted at “safe sites” across the United Kingdom, largely at stately homes where the trees traditionally feature in the landscape (RBGE, 2016). *Sirococcus tsugae* poses a serious risk to the success of this conservation project. Trees may be killed by the pest, and, if the disease becomes widespread in the UK, then material could not be transported back to Lebanon without the risk of introducing the disease to the native range of *C. libani*.

As the disease progresses in mature trees, some trees may become safety hazards and have to be removed, particularly if branches are girdled by the infection. There will be cost associated with the removal of such trees, and their replacement.

Social impacts in the UK are rated as large, with medium confidence.

<i>Economic Impacts</i>	Very small <input type="checkbox"/>	Small <input checked="" type="checkbox"/>	Medium <input type="checkbox"/>	Large <input type="checkbox"/>	Very large <input type="checkbox"/>
<i>Confidence</i>	High Confidence <input type="checkbox"/>	Medium Confidence <input checked="" type="checkbox"/>	Low Confidence <input type="checkbox"/>		
<i>Environmental Impacts</i>	Very small <input checked="" type="checkbox"/>	Small <input type="checkbox"/>	Medium <input type="checkbox"/>	Large <input type="checkbox"/>	Very large <input type="checkbox"/>
<i>Confidence</i>	High Confidence <input checked="" type="checkbox"/>	Medium Confidence <input type="checkbox"/>	Low Confidence <input type="checkbox"/>		

<i>Social Impacts</i>	Very small <input type="checkbox"/>	Small <input type="checkbox"/>	Medium <input type="checkbox"/>	Large <input checked="" type="checkbox"/>	Very large <input type="checkbox"/>
<i>Confidence</i>	High Confidence <input type="checkbox"/>	Medium Confidence <input checked="" type="checkbox"/>	Low Confidence <input type="checkbox"/>		

14. What is the pest’s potential as a vector of plant pathogens?

Sirococcus tsugae is not a vector of plant pathogens.

15. What is the area endangered by the pest?

The climatic requirements of *S. tsugae* are not known. It is native to the cool, wet Pacific northwest of North America, but has also been found to be damaging to *Tsuga* in Georgia which has a humid, sub-tropical climate. As a consequence, any sites where *Cedrus* or *Tsuga* are grown are considered endangered by the pest.

Stage 3: Pest Risk Management

16. What are the risk management options for the UK/PRA area?

Exclusions and Eradication

Given the number of sites *S. tsugae* has now been found at, with many trees being on private properties and the likelihood that other trees are diseased but unreported, eradication of the pest from Great Britain is not considered feasible. Investigations into the distribution of the pest in Northern Ireland are ongoing, but findings on mature trees indicate eradication there is also very unlikely to be feasible.

Isolated outbreaks in the UK, related to recently planted trees, could be eradicated by removal and destruction of the trees by burning or deep burial. Care would need to be taken that all plant debris e.g. cones, dead needles are removed from the site, as the pathogen can survive and produce fruiting bodies on such debris.

Containment

Spread of *S. tsugae* is thought to occur on a local scale via rain splash. It is uncertain if spores may be disseminated longer distances by storms or strong winds. Long distance dispersal could also occur on infected planting material, and current UK policy is to take statutory action against findings in commercially traded plants. Several factors indicate that

continued statutory action against traded material is very unlikely to reduce the spread of the pest:

- The pest has been present in Great Britain for at least 10 years before it was first detected, during which time it was able to spread both naturally and potentially in traded planting material.
- The number of reported cases in the UK has increased dramatically in the last 3 years indicating considerable natural spread.
- Recently infected plants will not be symptomatic, and early symptoms may be confused with frost damage.

Non-Statutory Controls

In North America, there are cultural practices which can reduce the impacts of *S. tsugae*. Documents providing written advice are relatively scarce, perhaps because the pest usually has small impacts in its North American range. In order to reduce impacts on nurseries, it is suggested that non-hosts are grown in the vicinity of the nursery. When disease is detected, sources of inoculum should be removed, and host material (e.g. needles, cones etc.) should not be used as mulch (Stanosz, 2012). Infected branches can be pruned off, and overhead watering (which could increase spread) avoided in the summer. In the USA, chemical control options can also be used to protect against infection if applied during spring, just after bud break (Oregon State University, 2016, USDA, 2004), but it should be noted that these fungicides may not be available or registered for use on nursery trees in the UK.

For private individuals whose *Cedrus* or *Tsuga* are affected, hygiene measures could aid in preventing spread of the disease to other nearby hosts. Pruning off affected branches and removing plant debris and other sources of inoculum may aid tree survival.

In the USA, measures in forestry stands are not usually required, but thinning can be beneficial in reducing disease incidence (USDA, 2004). No fungicides are known for use in forestry situations (Forest Research, 2016b).

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