Department
for Environment
Food & Rural Affairs

Rapid Pest Risk Analysis (PRA) for:

Heterobasidion parviporum

May 2016

Summary and conclusions of the rapid PRA

This rapid PRA shows that *Heterobasidion parviporum* is a significant fungal pathogen of Norway spruce across much of Europe, and that could have large economic impacts on this species in the unlikely event it is introduced to the UK. Impacts could also be experienced in Sitka spruce plantations, though the magnitude of these impacts is very uncertain.

Risk of entry

There is no evidence that *H. parviporum* is currently moving in association with traded material that could harbour the fungus, despite the UK importing large volumes of timber, wood packaging material, utility poles and wooden stakes from the range of the pest. Untreated wood packaging materials, and wooden stakes of host material intended to stake coniferous trees, were considered the riskiest pathways, but entry on these pathways is still unlikely.

Risk of establishment

Norway spruce (*Picea abies*), the main host of *H. parviporum,* is a commercially produced forestry species in the UK, and the climate is also expected to be suitable for establishment. Norway spruce is grown both for timber and Christmas tree production throughout the UK. Sitka spruce, (*Picea sitchensis*) is also a known host and grown on a very large scale across the UK. *Heterobasidion parviporum* is persistent once present at a site, and found in countries in the EU with similar climates to the UK. For these reasons, establishment in the UK is very likely with high confidence.

Economic, environmental and social impact

Heterobasidion parviporum causes economic impacts by reducing timber volume through decay and general reduced growth rate, and some trees are killed particularly saplings/young trees planted on infested sites. It causes large economic impacts on *P. abies* in much of Scandinavia. Potential economic impacts in the UK have been rated as large, with low confidence. This is because, although Sitka Spruce (*P. sitchensis*) which is a very important forestry species to the UK is a known host, it is rarely grown in most of Europe and so there are no records of impacts on this species.

Like most *Heterobasidion* species, the impacts of *H. parviporum* will be greatest in managed monocultures and forestry plantations. *Picea abies* and *P. sitchensis* are not native species to the UK, however plantations of these species do provide ecosystem services, including supporting iconic species. Since mature trees tend to survive the disease, though may suffer reduction in growth, they can still be utilised by wildlife and environmental impacts are rated as very small with medium confidence.

Stands containing Sitka and other spruces are utilised for recreational purposes, particularly in Scotland and Northern Ireland. Social impacts are rated as small, with low confidence, social impacts could occur due to trees in recreational areas becoming structurally unstable, and suffering wind throw that damages manmade structures or limits access to paths. Confidence is low as *H. parviporum* would need to be a more aggressive pathogen on *P. sitchensis* than the native *H. annosum s.s* butt rot for social impacts to occur, as this and other species will already be affecting Sitka spruce and may make trees structurally unsafe.

Endangered area

Forestry stands of *Picea* across the UK. Since the disease spreads through root to root contacts with infected stumps, individual ornamental trees are not likely to be at risk.

Risk management options

Though the risk of introduction is low, regulation through a protected zone at EU level could further mitigate the risk. Eradication may be possible if outbreaks are detected early, by the removal of all stumps after harvest and planting non-host trees for the next rotation.

However, the likelihood of early detection is very low, and stump removal is an expensive process that may also cause environmental damage. The disease impacts could also be managed via urea stump treatments.

Key uncertainties and topics that would benefit from further investigation

In order to more accurately assess the potential impacts in the UK, the following points could benefit from additional research:

- The potential impacts on *Picea sitchensis* (Sitka spruce). This species is a much more significant forestry species for the UK compared to *P. abies*. It is known to be susceptible to *H. parviporum*, but since it is not a forestry species in most of the range of the pest, impacts are highly uncertain.
- The current rate of infection of *Picea* by *H. annosum s.s.*in the UK. In Scandinavia, only about 10% of infection of *P. abies* are caused by *H. annosum s.s.*, however, since this is the only *Heterobasidion* pathogen in the UK, the rates of infection in *Picea* may be higher in the UK. This in turn may mean stump treatment is already being carried out in some stands, which would reduce the impacts of *H. parviporum* if it should be introduced, but the rate of stump treatment across the UK can be highly variable.
- Site type of *Picea* plantations in the UK. Impacts of *H. parviporum* will be considerably higher on certain site types, such as those with mineral soils. Forestry Commission data could be further analysed to provide some of this information.

Images of the pest

	
The basidiocarps of *H. parviporum* on a *P. abies* stump. Taken from CABI, 2016. Image copyright Kari Korhonen.	Root rot symptoms on a freshly felled Norway spruce. Taken from CABI, 2016. Image copyright Kari Korhonen.

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?

If viable *H. parviporum* is detected on imports of plants, timber or other wooden commodities, statutory action would be appropriate. Statutory action may also be appropriate on findings in forestry settings if the disease has a limited distribution that can be contained, though early detection to make such a scenario possible is very unlikely.

Yes Statutory action	✓	No Statutory action	

Stage 1: Initiation

1. What is the name of the pest?

Heterobasidion parviporum Niemelä & Korhonen 1998 (Basidiomycetes, Russulales)

Heterobasidion parviporum is one of several fungi that causes root and butt rot of conifers.

Special notes of taxonomy

Heterobasidion parviporum belongs to the *Heterobasidion annosum sensu lato* group that was initially referred to as the "Eur-S group", until it was formally described as a distinct species from *H. annosum sensu stricto* in Europe. After its classification as a separate species, several Asian countries reclassified some *H. annosum* (*sensu lato*) records as *H. parviporum*. References to the North American "S group" do not refer to *H. parviporum*, but a separate species, *H. occidentale* (Otrosina & Garbelotto, 2010). No hybridisation between *H. parviporum* and other *Heterobasidion* species has been recorded.

Both earlier and current records of *H. annosum* in the literature may actually be referring to *H. parviporum*. This PRA concentrates on literature which specifically refers to *H. parviporum* or the Eur-S group.

Though still considered the same species, there are slight morphological differences between European and East Asian populations of *H. parviporum* (Tokuda *et al.*, 2009). In addition, whereas *H. parviporum* in Europe is largely restricted to attacking *Picea abies* (Norway spruce) with occasional records on other conifers, the East Asian population is found more frequently on a wider range of conifers, as detailed in section 7. Tokuda *et al.* (2009) and Dai *et al.* (2006) also concluded that the East Asian populations appear to be less aggressive on native conifers than European populations, and mostly occur on dead trees and stumps. Both populations are considered together in this PRA, though greater emphasis is placed on the risk of introduction from European populations as this is considered to be the greater risk.

2. What initiated this rapid PRA?

Currently, only *H. annosum sensu stricto* is known to occur in the UK. The risk from the introduction of other members of the *H. annosum sensu lato* group of conifer pathogens was assessed via the UK Plant Health Risk Register in November 2015. *Heterobasidion parviporum* was identified as a potential threat and given a priority for PRA.

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/EC[1]) and in the lists of EPPO[2]?

Heterobasidion parviporum is not listed in the EC Plant Health Directive and is not recommended for regulation as a quarantine pest by EPPO, nor is it on the EPPO Alert List

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

Heterobasidion parviporum is a Eurasian species and its distribution is summarised in Table 1 based on CABI (2016). There is some uncertainty over its distribution, particularly outside of Europe, since some countries may still refer to the species as *H. annosum*. References to *H. parviporum* in North America are incorrect and refer to the species *H. occidentale* (Otrosina & Garbelotto, 2010), and thus, although CABI (2016) lists *H. parviporum* as present in the USA and Canada, this is not included in Table 1.

Heterobasidion parviporum has a limited distribution in East Asia, being found in the island of Hokkaido and subalpine areas of Honshu island, Japan and northern China to the eastern Himalayas (Tokuda *et al.*, 2009) including Tibet (Dai *et al.*, 2006).

A study into the viruses of *Heterobasidion* reported isolates of *H. parviporum* from Bhutan, Kyrgyzstan and India (Vainio *et al.*, 2011). CABI, 2016 lists *H. parviporum* as present in Kyrgyzstan, however the reference cited was checked and no reference to *H. parviporum* populations from Kyrgyzstan was mentioned within it (Dai *et al.*, 2003). No other references to *H. parviporum* in Bhutan or India could be found, so these are also not included in Table 1.

Table 1: Distribution of *Heterobasidion parviporum* (CABI, 2016)	
North America:	No records
Central America:	No records

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

[2]https://www.eppo.int/QUARANTINE/quarantine.htm

South America:	No records
Europe:	Austria, Belarus, Bulgaria, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Italy, Latvia, Lithuania, Norway, Poland, Russia, Slovakia, Slovenia, Sweden, Switzerland, Ukraine
Africa:	No records
Asia:	China, Japan
Oceania:	No records

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

There are no records of *H. parviporum* in the UK – only *H. annosum s.s.*is known to be present. It should be noted that the fruiting bodies between *H. annosum s.s.* and *H. parviporum* cannot be differentiated in the field, and the last major survey work in the UK was over a decade ago.

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?

In Europe, the majority of reports of *H. parviporum* are on *Picea abies* (Norway spruce) and it is described as having a "relatively strict specialisation" for Norway spruce (Asiegbu *et al.*, 2005). *Pinus sylvestris* (Scots pine) is also a host. *H. parviporum* will infest stumps of *P. sylvestris,* but spread to standing *P. sylvestris* trees is a much less frequent occurrence (Rönnberg *et al.*, 2006), and *P. sylvestris* is considered "fairly resistant" and can be used on already infested sites (Piri, 2003). When other conifer species are planted on sites with previous *P. abies* infestations, they may be infested by *H. parviporum,* as has been seen in hybrid larch (*Larix* x *eurolepsis*) stands (Wang *et al.*, 2012), lodgepole pine (*Pinus contorta*) (Rönnberg & Svensson, 2011) in Sweden and *P. sylvestris* saplings and a *Juniperus communis* plant in Finland (Piri, 2003).

The UK grows large amounts of *Picea sitchensis* (Sitka spruce) for forestry purposes. This species is native to North America and is not widely grown in the rest of Europe. There are limited references to *P. sitchensis* being a host of *H. parviporum* in Denmark, one of the European nations that have some *P. sitchensis* plantations.

Populations of *H. parviporum* in Asia tend to be found on a more diverse range of conifer hosts. Dai *et al.* 2006 listed the following coniferous hosts of *H. parviporum* in China: *Abies*

delavayi (Delavay's fir), *A. fabri* (Faber's fir), *A. fargesii* (Farges' fir), *A. forrestii* var. *georgei* (George's fir), *A. nephrolepis* (Manchurian fir), *Larix griffithii* (Sikkim larch), *Picea jezoensis* (Jezo spruce), *P. likiangensis* (Likiang spruce), *P. schrenkiana* (Asian spruce), *Pinus koraiensis* (Korean pine), *Tsuga chinensis* (Chinese hemlock) and *T. dumosa* (Himalayan hemlock). Additional host species recorded in Japan are *Abies sachalinensis* (Sakhalin fir), *A. veitchii* (Veitch's fir) and *Picea glehnii* (Sakhalin spruce).

Both Sitka and Norway spruce are grown for forestry purposes in the UK. Sitka spruce is by far the widest grown species in the UK – accounting for around one half of all conifer plantations – approximately 665 000 hectares, compared to 27 000 of Norway Spruce (FC, 2015).

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?

Some knowledge of the lifecycle of the pest is useful to understand the risk of entry on different pathways. The lifecycles of the *Heterobasidion annosum s.l.* species are all very similar (except for their host preferences) and has been summarised by Asiegbu *et al.* (2005). Briefly, fruiting bodies produced mainly in the summer release spores that are airborne and will land on exposed stumps of felled trees, or sometimes wounds on the root or stem of a tree. The spores germinate and grow, producing mycelia, which colonise the whole of the stump including the roots left in the ground. It is then able to spread to new, standing tree hosts via root to root contacts. It will then cause a rot of the heartwood and sometimes sapwood, and eventually produces new fruiting bodies.

Pathways of entry considered for this PRA are plants for planting, timber, wooden stakes, utility poles and wood packaging material. Though *P. abies* is a traditional Christmas tree species, little evidence of *H. parviporum* being a problem in Christmas tree plantations in Europe could be found. Traditionally Norway donates a few (around 6) large Christmas trees to the UK cities each year, which are likely to originate from forests rather than Christmas tree plantations, however these trees pose little risk of transferring *H. parviporum* to commercial conifer plantations as it is usual practice to dispose of them via chipping and composting. For this reason, the pathway for Christmas trees is not considered further. Natural spread of spores from the continent is also not considered further, as *H. parviporum* is a widespread and native species on the Continent and thus if natural spread was possible the pest would likely have already arrived in the UK, where it has never been recorded.

No evidence of *H. parviporum* moving in the trade of any of the commodities considered in this PRA could be found.

Plants for Planting

The import of plants of the genus *Abies, Cedrus, Chamaecyparis, Juniperus, Larix, Picea, Pinus, Pseudotsuga* and *Tsuga* (other than fruit or seeds) is prohibited from non-European countries. Because infection of other conifers is rare in Europe, and tends to only occur in forestry stands previously used for *P. abies* timber production, the risk from import of other conifer species for planting is not considered further.

Trade data indicate that there is only a very small import of *P. abies* plants from the EU into the UK for forestry purposes, with only one import of plants from France between 2003-2013 (Forestry Commission 2014, *unpublished data*). Trees for ornamental purposes are also imported from Europe, but there is no evidence than any *Heterobasidion* species are found in ornamental nurseries, though systematic surveys may not have occurred.

The lifecycle of *H. parviporum* also makes it very unlikely to enter on planting material. It is very unlikely that plants in a nursery situation will have been placed close to infected stumps to allow for spread by root to root contacts. Trees are also most likely to be moved at an age when their root systems are reasonably small and have yet to make root to root contacts with trees around them.

Thus entry on plants for planting is **very unlikely with high confidence.**

Timber

Timber in this instance refers to any wood being brought into the UK for processing, which may be non-squared (e.g. with the bark intact) or roughly squared (with some residual bark). Saw logs, which tend to come from the base of the tree where *Heterobasidion* infection is most likely to be present, are likely to present the greatest risk of transfer.

Timber may be imported with fruiting bodies, or they may form during storage of the timber in the UK. If any cut stumps or trees with wounds are in the vicinity of where the wood is stored, spores may land on these stumps and infect them. There is no evidence that this has ever occurred. Storage conditions may not always be conducive to the survival of the fungus and, if fruiting bodies do form, there may be no suitable stumps close by for the pathogen to infest.

Studies have been carried out on piles of stored stumps, which are removed from the ground after tree felling in Finland and stored for several years before being used for biofuels. Stump piles were found to contain fruiting bodies, 80% were on the layer that had partial contact with the ground and the rest in the layer above this (Piri & Hamberg, 2015).

If saw logs are stored in similar conditions to the stumps for several years, it is theoretically possible that fruiting bodies may form - though no published records of this occurring could be found. The amount of time required for fruiting body formation is likely to depend on the level of colonisation of the wood and thus it may occur sooner than several years. It seems

more likely that the majority of timber will be processed relatively soon after import into the UK, reducing the risk of fruiting bodies forming.

Since the main host in Europe is Norway spruce, the import of timber of this commodity was investigated. There are two relevant commodity codes on Eurostat that were used to obtain trade data:

- Spruce of the species *Picea abies* Karst. or silver fir *Abies alba* Mill., in the rough, whether or not stripped of bark or sapwood, or roughly squared.
- Saw logs of spruce of the species *Picea abies* Karst. or silver fir *Abies alba* Mill., whether or not stripped of bark or sapwood, or roughly squared.

Due to the means of recording imports, it is not possible to distinguish how much trade may be spruce, and how much is fir – a very infrequent host of *H. parviporum*. Trade in this commodity from the current range of the pest is significant with over 15,000 tonnes of spruce and fir timber being imported into the UK from the range of the pest in 2015. A large proportion of the trade originated from Estonia, Latvia, Lithuania and Sweden where *H. parviporum* is widespread (CABI, 2016).

Timber of conifers imported into the UK needs to meet one of three criteria that are designed to reduce the risk of introduction of certain spruce infesting *Ips* species. Two of the criteria would be ineffective against *H. parviporum*, but the third involves kiln drying and would be likely to kill any *H. parviporum* in the timber. It is not known what proportion of spruce timber entering the UK has been kiln dried.

Though the volume of trade is large, entry of *H. parviporum* on timber is rated as **very unlikely with medium confidence**, as there is no evidence that fruiting bodies of this species form on cut timber and the transfer of spores to suitable host stumps is also very unlikely.

Wooden Stakes

Wooden stakes, of coniferous wood, are rated separately from timber because they pose a greater risk of transfer. If fungal mycelia are present in the stakes, and the stakes are used on young conifer trees, the fungus may then come into direct contact with the roots of a host tree and infect it. *Heterobasidion parviporum* could then spread to other hosts via root to root contact as in its normal lifecycle. In addition, as described above for timber, if stored in suitable conditions some fruiting bodies may also be produced on wooden stakes.

Coniferous poles will have to meet the same requirements regarding the Ips protected zone as timber, and any that have been kiln dried will not pose a risk of introducing *H. parviporum*, and some stakes may have undergone other preservative treatments that have a detrimental effect on the survival of *H. parviporum*.

There are two commodity codes under which such stakes may be imported:

- Posts and beams of wood. Just over 5000 tonnes of material was imported under this commodity code into the UK in 2015.
- Hoopwood; split poles; piles, pickets and stakes of wood, pointed but not sawn lengthwise; wooden sticks, roughly trimmed by not turned, bent or otherwise worked, suitable for the manufacture of walking sticks, umbrella, tool handles or the like, of coniferous wood. Over 27,000 tonnes of material was imported into the UK under this commodity code in 2015.

Imports brought into the UK under both of these commodity codes will include a significant amount of non-host material, such as those made from non-coniferous wood, and material that is not destined to be used for the staking of coniferous hosts. As such, though trade is large, only a fraction of it presents a risk of direct transfer to host trees in the UK allowing for the entry of the pathogen.

In the EPPO PRA for the related pest *H. irregulare*, wooden stakes and poles were also considered a risk because they may be made of lower quality wood (possibly caused by the infection) and refers to research (not available in English) that such poles have transferred *H. annosum s.l.* in experiments in the past (EPPO, 2015).

Entry on wooden stakes is rated as unlikely, with low confidence. This is because only a very small amount of the trade is expected to meet all of the criteria that would be necessary for entry on this pathway, that is: a) infected with viable *H. parviporum* mycelia and b) destined for use as a wooden stake with a host species. Though there is also a risk of fruiting body formation, as for timber this is considered very unlikely, and the main risk would be direct contact of living *H. parviporum* with the roots of a host tree. Confidence is low, because details of the trade such as species composition of the stake wood, intended use and treatments are unknown.

Telegraph (Utility) Poles

Telegraph (or utility) poles may be made from a range of coniferous woods, including various *Picea* species. If such poles are imported into the UK from countries where *H. parviporum* is known to occur then there is a risk they may be associated with the pest. Such poles are usually debarked and left to reduce moisture content in a forest or at saw mills for several months (Joan Webber, Forest Research, *personal communication,* March 2016). It is documented that such poles can have active decomposition organisms before they are put into service including *Heterobasidion* species (Brown & Webber, 2009, Eslyn, 1979, Shigo & Shigo, 1974).

Though telegraph poles are usually treated with preservatives such as creosote, this treatment does not penetrate all the way through and the fungus could remain alive within the heartwood. Fruiting bodies could be formed via cracks or splits that may occur in the poles over time, for example bracket fungi in the genus *Gloeophyllum* infest material such as telegraph poles, and produce fruiting bodies via cracks in the wood (Pegler, 1990, Wolman, 2016). No publications relating to findings of fruiting bodies of *H. parviporum*, or any other *Heterobasidion* species, on telegraph poles could be found. If formation of

fruiting bodies does occur on telegraph poles within the vicinity of coniferous woodland, spores could be released that land on exposed stumps, allowing the pest to enter.

Entry on this pathway is rated as **very unlikely with medium confidence**, since, although rotting of utility poles is associated with *Heterobasidion* species, the formation of fruiting bodies has not been recorded. This suggests that if fruiting body formation occurs on such poles, it is a rare event.

Wood Packaging Material

Wood packaging material (WPM) could contain viable mycelia or fruiting bodies. This pathway is suspected to have introduced *H. irregulare* into Italy from North America (EPPO, 2015). WPM from outside of the EU must be compliant with ISPM15, which involves heat or methyl bromide treatment, which should be effective at killing *H. parviporum*. Such treatments do not have to be applied to WPM manufactured and moving within the EU, though a large proportion may have been treated. Not all WPM will be made of coniferous wood, though that which is may be made of lower quality timber which is more likely to be infested.

To transfer to a suitable host, infested WPM would need to be left outside close to cut stumps or wounded trees, in conditions conducive for the production of fruiting bodies. Wooden pallets may be discarded or kept outside for long periods, but there is only one suspected case of a *Heterobasidion* moving along this pathway despite the massive trade in WPM globally.

Entry on WPM is rated as unlikely, with medium confidence.

Plants for Planting	Very unlikely	☑	Unlikely	☐	Moderately likely	☐	Likely	☐	Very likely ☐
Confidence	High Confidence	☑	Medium Confidence	☐	Low Confidence	☐		☐	☐
Timber	Very unlikely	☑	Unlikely	☐	Moderately likely	☐	Likely	☐	Very likely ☐
Confidence	High Confidence	☐	Medium Confidence	☑	Low Confidence	☐			
Wooden stakes	Very unlikely	☐	Unlikely	☑	Moderately likely	☐	Likely	☐	Very likely ☐
Confidence	High Confidence	☐	Medium Confidence	☐	Low Confidence	☑			
Telegraph (utility) poles	Very unlikely	☑	Unlikely	☐	Moderately likely	☐	Likely	☐	Very likely ☐

Confidence	High Confidence	☐	Medium Confidence	☑	Low Confidence	☐		
Wood packaging material	Very unlikely	☐	Unlikely	☑	Moderately likely	☐	Likely	☐
Confidence	High Confidence	☐	Medium Confidence	☑	Low Confidence	☐		

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

Heterobasidion parviporum does not require a vector.

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

Heterobasidion parviporum is widespread in northern Europe and the main host is a commercial forestry species in the UK. It can persist for decades (up to 50 years) in stumps even if suitable standing trees are not close by (Asiegbu *et al.*, 2005, Piri & Korhonen, 2007). **Establishment outdoors is very likely with high confidence.**

Hosts are not usually grown under protection and *H. parviporum* has not been recorded from commercial protected production systems. **Establishment under protection is very unlikely with high confidence.**

Outdoors	Very unlikely	☐	Unlikely	☐	Moderately likely	☐	Likely	☐	Very likely	☑
Confidence	High Confidence	☑	Medium Confidence	☐	Low Confidence	☐				
Under Protection	Very unlikely	☑	Unlikely	☐	Moderately likely	☐	Likely	☐	Very likely	☐
Confidence	High Confidence	☑	Medium Confidence	☐	Low Confidence	☐				

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

H. parviporum is considered to have **slow natural spread, with high confidence**. *Heterobasidion parviporum* shows both primary and secondary spread. Primary spread is through airborne spores that land on and infect cut stumps or sometimes via wounds on

trees, and secondary spread is through root to root contacts once a stump has become fully infested, with the fungus reaching the roots from where it entered on the above ground parts of the stump.

The majority of *Heterobasidion* spores are reported to land within 100 m of the fruiting body (Gonthier *et al.*, 2012), so primary spread is slow. Some spores may be carried further distances. Root to root contact may then spread the disease up to 50 cm a year (Asiegbu *et al.*, 2005). The introduction of *H. irregulare* to Italy has seen the pathogen spread 79 km in one direction since World War II (approximately 70 years) (EPPO, 2015), a rate of approximately 1 km per year. It should be noted that *H. parviporum* can infect successive generations of *P. abies* planted at a diseased site, either through infected stumps or by infected root fragments left in the soil (Piri, 2003, Piri & Hamberg, 2015, Piri & Korhonen, 2001).

As discussed in entry, there is little evidence that *H. parviporum* is moving in traded commodities. **Spread with trade is rated as very slowly, with high confidence.**

Natural Spread	Very slowly	☐	Slowly	☑	Moderate pace	☐	Quickly	☐	Very quickly ☐
Confidence	High Confidence	☑	Medium Confidence	☐	Low Confidence	☐			
With trade	Very slowly	☑	Slowly	☐	Moderate pace	☐	Quickly	☐	Very quickly ☐
Confidence	High Confidence	☑	Medium Confidence	☐	Low Confidence	☐			

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

Heterobasidion parviporum is a major and economically important pathogen of *P. abies*, particularly in Baltic and Scandinavian countries where disease incidence levels are high. *Heterobasidion annosum s.l.* is reported to damage approximately every 6th mature *P. abies* in Finland, with *H. parviporum* making up 90% of those infections (Piri & Korhonen, 2001). Like other white rot fungi, *H. parviporum* colonises the heartwood of the tree, in some instances the fungal growth can expand into the sapwood (which carries the vessels transporting water and nutrients) – considerable decay of the sapwood leads to death of the tree (Hietala *et al.*, 2009).

Many trees will not be killed outright by *H. parviporum*, but economic impacts will still be caused by reduction in growth which adds up over time leading to "considerable losses" (Hellgren & Stenlid, 1995). Reports of growth loss vary. Hellgren and Stenlid (1995) reported losses of 8 – 10%, lower than earlier reports. Based on a volume gross loss of 9%, and a disease frequency of 14.5%, they estimated that in Sweden this led to 620 000

m^3 of Norway spruce timber not produced due to infection annually, which would have been worth 155 million SEK (very approximately £26.7 million in today's money). Decay of heartwood also means that the timber is unsuitable for processing, leading to losses. The decay column can extend up to 10 metres up the stem of the tree (Hietala *et al.*, 2011).

Infected trees are also thought to be more pre-disposed to wind throw, and uprooting tests have indicated that infected trees are easier to uproot (Giordano *et al.*, 2011).

Impacts in the current range are rated as large, with high confidence.

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

Many factors could influence the potential economic impacts of *H. parviporum* in the UK. The key uncertainty regarding potential economic impacts is the susceptibility of *P. sitchensis.* Commercial stands of this forestry species are known to be affected by *H. annosum s.s.,* and Sitka spruce has been described as "very susceptible to decay by *Heterobasidion annosum*" (Woodward *et al.*, 2007).

It is possible that *H. parviporum* could be an even more aggressive pathogen on *P. sitchensis,* since this pathogen is adapted to attack another species of *Picea,* but there is no evidence to support this assertion. In artificial inoculation experiments on *P. sitchensis* under greenhouse conditions in Sweden, there was no difference between infection rates of seedlings inoculated with *H. annosum s.s* compared with *H. parviporum,* and the rate of growth in sapwood was also very similar. A single tree (out of 25) was killed by *H. parviporum* whilst none of the 25 *H. annosum s.s* inoculated trees died, however this is not a statistically significant difference (Swedjemark & Stenlid, 1995). It is uncertain whether these experimental results would be relevant under field conditions. A survey of *Heterobasidion* on various conifers in 1992 in Denmark included some Sitka spruce. This survey only found fruiting bodies of *H. annosum s.s.* associated with Sitka stumps, however isolation of fungi from wood of Sitka spruce trees removed during thinning were only *H. parviporum* (Iben M. Thomsen, Department of Geosciences and Natural Resource Management, University of Copenhagen, *unpublished data).* Only a small number of Sitka spruce were in this survey (11 of the samples of fruiting bodies or mycelium from logs were from Sitka) and so it is difficult to draw conclusions about the impacts on this species.

Impacts would be expected on Norway spruce. In the UK this species is known to be susceptible to *H. annosum s.s.*, but the incidence of the disease is unclear. Some growers may also be treating stumps to prevent *H. annosum s.s.* infection, and such treatments

would be equally effective against *H. parviporum*, but there are no data on the percentage of *Picea abies* plantations already treated. It is possible that very few private plantations are treated. The timing of any thinning activities (which creates stumps that can become infected and then lead to secondary spread of the disease) will also influence impacts. Thinning at peak spore release could increase infection rates. In Scandinavia peak spore release is in the summer and autumn, but it is not known when the spore release period would be in the UK. Finally, impacts of *H. parviporum* can be affected by the physical and chemical characteristics of the stand site. Damage by *Heterobasidion annosum s.l* tends to be higher on sites with sandy soils, fertile soils or high calcium or pH levels (or a combination of these factors) (Garbelotto & Gonthier, 2013). It is not known what proportion of *Picea* is grown on such high risk sites, though the recommended sites for best growth of *P. abies* are "moist, sufficiently aerated soils of poor to medium fertility such as sandy loams" (FR, 2016).

Economic impacts in the UK are rated as large, with low confidence. It is assumed similar impacts will be seen in the UK as is recorded in Southern Scandinavia, though due to the very slow spread of the pathogen it would take many years post introduction before the same level of damage is seen. The rating of large economic impacts also depend on *P. sitchensis* being more susceptible to infection by *H. parviporum* than the native *H. annosum s.s* – because there is very little information on this, confidence in the rating is low.

Environmental Impacts

The impacts of *Heterobasidion* species are usually greatest in managed monocultures and plantation forestry (Garbelotto & Gonthier, 2013). In natural ecosystems *H. parviporum*, like other *H. annosum s.l* species, will play a role as a saprophyte breaking down dead wood. Tree mortality caused by *H. parviporum* will create gaps in the canopy and affect species composition, increasing biodiversity (Garbelotto & Gonthier, 2013). No reports of environmental impacts by *H. parviporum* could be found.

Norway spruce is not a native species to the UK but it is a common non-native. It is also known to be a preferred species of the red squirrel, which is not as well supported by Sitka spruce monocultures (Bryce *et al.*, 2005). Widespread death of Norway spruce would likely impact on red squirrels in the UK, though there are other species they can utilise. However such widespread death is not predicted, mature trees suffer from internal decay that slows growth but remain standing, allowing them to still be utilised by wildlife.

Early practise at growing Sitka Spruce in the UK largely involved monocultures of even-aged stands, with little thinning, and replanting after felling (Mason, 2015). Death of Sitka spruce in such stands from *H. parviporum* could help improve biodiversity and have beneficial environmental impacts. There are now moves to manage Sitka spruce stands differently, such as through continuous cover forestry, and promote more biodiversity (Deal *et al.*, 2014, Mason, 2015). In Scotland, there has been significant restructuring of some mature Sitka spruce stands in both age class and species diversity, and these 50-60%

Sitka stands support a number of species of conservation importance such as red squirrels and pine martins (Hugh Clayden, Forestry Commission Scotland, *personal communication*). In Northern Ireland, some stands have "special protect area" status due to the presence of priority species such as merlin and hen harriers (see http://jncc.defra.gov.uk/page-1400 for a full list of sites). Where Sitka spruce is part of such sites, then death of these trees could have an environmental impact. However, as for *Picea abies*, the main impacts of *H. parviporum* are not from the death of trees but rather the reduction in growth and heartwood rot that make timber unmarketable and standing trees can still be utilised by wildlife. No widespread mortality of Sitka spruce would be expected in more diverse forestry plantations from *H. parviporum*, and when death of trees did occur the dead wood would provide an important habitat for some species.

Though the two hosts of concern for the UK are non-native species, they can provide some environmental benefits. *Heterobasidion* species are not generally associated with environmental impacts and the loss of growth caused by the disease is unlikely to significantly impact on the species they support. **Environmental impacts are rated as very small, with medium confidence.**

Social Impacts

Because of the nature of the spread of the disease *H. parviporum* would be very unlikely to affect trees planted as single ornamentals. The main social impacts would be related to the affect *H. parviporum* may have on spruce stands used for recreational purposes. In Scotland and Northern Ireland, Sitka spruce does form a significant component of important sites used for recreation, such as the Queen Elizabeth Forest Park and Argyll Forest Park. In such situations, infection by *H. parviporum* could cause spruce to become structurally unstable, presenting a safety hazard for visitors to the forest. Infected trees have been theorised to be more susceptible to wind throw (Giordano *et al.*, 2011). It is not clear from the literature how often infected trees may present such safety hazards, perhaps because the conditions conducive to wind throw are not when recreational users tend to be present in forests e.g. stormy weather. Fallen trees could still interfere with activities such as by blocking paths or causing damage to manmade structures, but there are a number of other pests already present in the UK that could also pose the same risk.

The severity of disease on Sitka spruce would also affect the overall level of social impacts. If *H. parviporum* is not a more aggressive pathogen on Sitka spruce than the native *H. annosum s.s,* then social impacts may not occur as a significant increase in trees made structurally unstable by disease would not be expected.

Social impacts are rated as small, with low confidence. The low confidence is related to the lack of data on the potential of *H. parviporum* to cause safety hazards particularly in relation to infection of Sitka spruce.

Economic Impacts	Very small	☐	Small	☐	Medium	☐	Large	☑	Very large ☐

Confidence	High Confidence	☐	Medium Confidence	☐	Low Confidence	☑			
Environ - mental Impacts	Very small	☑	Small	☐	Medium	☐	Large	☐	Very large ☐
Confidence	High Confidence	☐	Medium Confidence	☑	Low Confidence	☐			
Social Impacts	Very small	☐	Small	☑	Medium	☐	Large	☐	Very large ☐
Confidence	High Confidence	☐	Medium Confidence	☐	Low Confidence	☑			

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

Heterobasidion parviporum does not act as a vector of plant pathogens.

15. What is the area endangered by the pest?

Forestry stands of *Picea* across the UK. Since the disease spreads through root to root contacts with infected stumps, individual ornamental trees are not likely to be at risk.

Stage 3: Pest Risk Management

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

Exclusion

This PRA considers *H. parviporum* to be unlikely to enter the UK. The pathogen is widespread in the EU, and if measures were desired to reduce the risk of entry through legislation then a Protected Zone would need to be obtained. Ideally this would include requirements on commodities that pose a risk of introducing *H. parviporum*. Many of the recommended requirements for *H. irregulare* made by the 2015 EPPO PRA would be suitable for *H. parviporum*.

Briefly, requirements on the following commodities originating from countries where *H. parviporum* is known to occur could be:

- Wood of all conifers (including that in the form of stakes and poles) is either from an officially recognised pest free area or subject to heat treatment (for at least 56°C for at least 30 minutes).
- WPM of host material should meet the ISPM15 requirements.
- Plants for planting of conifers should originate from a pest free area or have been grown under complete physical protection throughout their life or are grown in pots in sterilized substrate at least 20 km from the nearest infestation.

Eradication and Containment

Eradication may be possible if outbreaks are detected early. As *Picea* in the UK is already susceptible to *H. annosum s.s.,* and the species cannot be distinguished in the field, early detection of an outbreak is very unlikely. *Heterobasidion parviporum* may only be detected if unusual death of *Picea* during stand establishment leads to further investigations into the cause.

Eradication may be achieved at a site if, after harvest, all stumps are removed and disposed of by burning or deep burial. Such stump removal can, however, have environmental impacts (Walmsley & Godbold, 2010). Root fragments in the soil may pose a risk of infection to the next generation. These can be removed by soil sieving but such action may be impractical. An alternative would be to place a notice on the site to ensure that the next crop in the rotation is of a low susceptibility host species – preferably a broadleaved tree, but firs or pines could also be considered. Any natural regeneration of *Picea* should also be removed.

Containment would be difficult to achieve but stump treatment may help slow the spread of the disease to a certain extent. Urea is commonly used on conifer species in the UK, and this has been effective in reducing butt rot of *P. abies* in Scandinavia (Oliva *et al.*, 2008), where most cases are caused by *H. parviporum*. Stump treatments would need to take place for at least a kilometre around the infected site due to the potential movement of airborne spores. Research into efficacy testing would be useful before this is recommended.

Cultural Controls

The main cultural controls would be stump treatment, thinning of trees outside of the spore release time and removal of stumps. At the moment, only urea is available as a treatment for *P. abies* stumps. The biological control agent *Phlebiopsis gigantean* does reduce disease incidence of *H. parviporum* (Berglund & Rönnberg, 2004), but the commercial product (PG Suspension) is currently only registered for use on pines in the UK.

17. References

Asiegbu FO, Adomas A & Stenlid J (2005): Conifer root and butt rot caused by Heterobasidion annosum (Fr.) Bref. sl. *Molecular plant pathology* **6**, 395-409.

Berglund M & Rönnberg J (2004): Effectiveness of treatment of Norway spruce stumps with Phlebiopsis gigantea at different rates of coverage for the control of Heterobasidion. *Forest Pathology* **34**, 233-243.

Brown A & Webber J (2009): Biocontrol of decay in seasoning utility poles. I. Growth rate and colonizing ability of bluestain and decay fungi in vivo and in vitro. *Forest Pathology* **39**, 145-156.

Bryce J, Cartmel S & Quine C (2005) Habitat Use by Red and Grey Squirrels: Results of Two Recent Studies and Implications for Management. Forestry Commission, Edinburgh, UK. Available at: http://www.forestry.gov.uk/pdf/fcin076.pdf/$FILE/fcin076.pdf (accessed 13.04.2016.

CABI (2016) Heterobasidion parviporum. CABI, Wallingford, UK. Available at: http://www.cabi.org/cpc/datasheet/27048 (accessed 28.01.2016.

Dai Y, Yuan H, Wei Y & Korhonen K (2006): New records of Heterobasidion parviporum in China. *Forest Pathology* **36**, 287-293.

Dai YC, Vainio E, Hantula J, Niemelä T & Korhonen K (2003): Investigations on Heterobasidion annosum s. lat. in central and eastern Asia with the aid of mating tests and DNA fingerprinting. *Forest Pathology* **33**, 269-286.

Deal RL, Hennon P, O'Hanlon R & D'Amore D (2014): Lessons from native spruce forests in Alaska: managing Sitka spruce plantations worldwide to benefit biodiversity and ecosystem services. *Forestry* **87**, 193-208.

EPPO (2015) Pest risk analysis for Heterobasidion irregulare. EPPO, Paris. Available at: http://www.eppo.int/QUARANTINE/Pest_Risk_Analysis/PRAdocs_fungi/15-21059_PRA_Heterobasidion.pdf (accessed 29/01/2016.

Eslyn W (1979): Utility pole decay. *Wood Science and Technology* **13**, 117-126.

FC (2015) Forestry Statistics 2015, United Kingdom.

FR (2016) Norway Spruce (NS). Forest Research, UK. Available at: http://www.forestry.gov.uk/fr/infd-8cyjmx (accessed 1.2.2016.

Garbelotto M & Gonthier P (2013): Biology, epidemiology, and control of Heterobasidion species worldwide. *Annual review of phytopathology* **51**, 39-59.

Giordano L, Lione G, Nicolotti G & Gonthier P (2011) Effect of Heterobasidion annosum sl root and butt rots on the stability of Norway spruce: an uprooting test. In *Proc. 13th Int. Conf. Root and Butt Rots, Firenze and S. Martino di Castrozza, Italy*, pp. 247-250.

Gonthier P, Lione G, Giordano L & Garbelotto M (2012): The American forest pathogen Heterobasidion irregulare colonizes unexpected habitats after its introduction in Italy. *Ecological Applications* **22**, 2135-2143.

Hellgren MB & Stenlid J (1995): Long-term reduction in the diameter growth of butt rot affected Norway spruce, Picea abies. *Forest ecology and management* **74**, 239-243.

Hietala A, Nagy N, Yakovlev I, Fossdal C & Solheim H (2011) Interaction of Norway spruce and Heterobasidion parviporum in xylem. In *XIII Conference" Root and Butt Rot of Forest Trees" IUFRO Working Party 7.02. 01*, p. 147.

Hietala AM, Nagy NE, Steffenrem A, Kvaalen H, Fossdal CG & Solheim H (2009): Spatial patterns in hyphal growth and substrate exploitation within Norway spruce stems colonized by the pathogenic white-rot fungus Heterobasidion parviporum. *Applied and environmental microbiology* **75**, 4069-4078.

Mason WL (2015): Implementing continuous cover forestry in planted forests: Experience with sitka spruce (Picea sitchensis) in the British Isles. *Forests* **6**, 879-902.

Oliva J, Samils N, Johansson U, Bendz-Hellgren M & Stenlid J (2008): Urea treatment reduced Heterobasidion annosum sl root rot in Picea abies after 15 years. *Forest ecology and management* **255**, 2876-2882.

Otrosina WJ & Garbelotto M (2010): Heterobasidion occidentale sp. nov. and Heterobasidion irregulare nom. nov.: a disposition of North American Heterobasidion biological species. *Fungal Biology* **114**, 16-25.

Pegler D (1990) *Mushrooms and Toadstools of Britain and Europe*. Kingfisher.

Piri T (2003): Early development of root rot in young Norway spruce planted on sites infected by Heterobasidion in southern Finland. *Canadian journal of forest research* **33**, 604-611.

Piri T & Hamberg L (2015): Persistence and infectivity of Heterobasidion parviporum in Norway spruce root residuals following stump harvesting. *Forest ecology and management*.

Piri T & Korhonen K (2001): Infection of advance regeneration of Norway spruce by Heterobasidion parviporum. *Canadian journal of forest research* **31**, 937-942.

Piri T & Korhonen K (2007): Spatial distribution and persistence of Heterobasidion parviporum genets on a Norway spruce site. *Forest Pathology* **37**, 1-8.

Rönnberg J, Petrylaite E, Nilsson G & Pratt J (2006): Two studies to assess the risk to Pinus sylvestris from Heterobasidion spp. in southern Sweden. *Scandinavian journal of forest research* **21**, 405-413.

Rönnberg J & Svensson S (2011) Susceptibility of lodgepole pine to Heterobasidion annosum and H. parviporum in central Sweden. In *XIII Conference" Root and Butt Rot of Forest Trees" IUFRO Working Party 7.02. 01*, p. 151.

Shigo AL & Shigo A (1974) Detection of discoloration and decay in living trees and utility poles. Northeastern Forest Experiment Station, Upper Darby, PA, p. 15.

Swedjemark G & Stenlid J (1995): Susceptibility of conifer and broadleaf seedlings to Swedish S and P strains of Heterobasidion annosum. *Plant Pathology* **44**, 73-79.

Tokuda S, Hattori T, Dai Y-C, Ota Y & Buchanan PK (2009): Three species of Heterobasidion (Basidiomycota, Hericiales), H. parviporum, H. orientale sp. nov. and H. ecrustosum sp. nov. from East Asia. *Mycoscience* **50**, 190-202.

Vainio EJ, Hakanpää J, Dai Y-C, Hansen E, Korhonen K & Hantula J (2011): Species of Heterobasidion host a diverse pool of partitiviruses with global distribution and interspecies transmission. *Fungal Biology* **115**, 1234-1243.

Walmsley J & Godbold D (2010): Stump harvesting for bioenergy–a review of the environmental impacts. *Forestry* **83**, 17-38.

Wang L, Pålsson H, Ek E & Rönnberg J (2012): The effect of Phlebiopsis gigantea and urea stump treatment against spore infection of Heterobasidion spp. on hybrid larch (Larix× eurolepis) in southern Sweden. *Forest Pathology* **42**, 420-428.

Wolman (2016) Bracket fungi (Gloeophyllum spp.). BASF. Available at: https://www.wolman.biz/en/infocenter_wood/about_wood_pests/wood_destroying_fungi/blaettlinge/index.php (accessed 13.04.2016.

Woodward S, Bianchi S, Bodles WJ, Beckett L & Michelozzi M (2007): Physical and chemical responses of Sitka spruce (Picea sitchensis) clones to colonization by Heterobasidion annosum as potential markers for relative host susceptibility. *Tree physiology* **27**, 1701-1710.

Name of Pest Risk Analyst(s):

Melanie Tuffen

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Any enquiries regarding this publication should be sent to us at

The Chief Plant Health Officer

Department for Environment, Food and Rural Affairs

Room 11G32

Sand Hutton

York

YO41 1LZ

Email: plantpestsrisks@defra.gsi.gov.uk