Department for Environment Food & Rural Affairs

Rapid Pest Risk Analysis (PRA) for:

Heterobasidion occidentale

July 2016

Summary and conclusions of the rapid PRA

This rapid PRA shows that *Heterobasidion occidentale* is an economically important fungal pathogen of conifers (excluding pines (*Pinus*)) native to western North America. Though very unlikely to enter the UK, it could have significant impacts should introduction occur. Like other *Heterobasidion* species, *H. occidentale* colonises stumps of trees, before spreading to new standing trees through root to root contacts where it can cause rot of the sapwood and in some cases death of the tree.

Risk of entry

Pathways of entry identified for the UK are plants (including plants for planting and Christmas trees), timber, wood stakes, wood packaging material and utility poles. Due to current plant health measures (largely for other pests) and a lack of trade, all pathways are considered **very unlikely** with **high** or **medium confidence**, depending on the pathway. No evidence of *H. occidentale* moving in trade could be found.

Risk of establishment

Heterobasidion occidentale is established in a range of climates across the west coast of North America, from south-eastern Alaska to Mexico. Some regions include areas with similar climates to the UK, and since it is able to colonise a range of coniferous hosts grown in the UK, establishment outdoors is **very likely** with **high confidence**.

Economic, environmental and social impact

The impacts of *H. occidentale* vary considerably depending on the host and location. Impacts are caused by a loss of vigour due to root rot and sometimes rot of the sapwood, in particular in *Abies* (fir) species. In addition, younger trees may be killed by infection. Some species, such as *Picea sitchensis* (Sitka spruce), are reported to suffer only very minor impacts in Alaska and Oregon but can be highly susceptible to the disease in other parts of the USA. Another example is Douglas-fir, which is seldom damaged but whose susceptibility is said to increase with latitude. Fir species are generally the hosts that suffer the greatest impacts. Both forestry plantations and Christmas tree plantations are impacted by *H. occidentale.* Infection with *H. occidentale* can cause trees to become hazardous due to their increased risk of wind fall or stem breakage, and thus measures are often required on trees infected near recreational areas or other areas utilised by people. Overall, impacts in the current range of the pest are rated as **large**, with **high confidence**.

Potential impacts in the UK may vary depending on location. Those areas with cool, wet climates may only suffer minor damage, as observations indicate that *H. occidentale* (like the native *H. annosum sensu stricto*) does not thrive in regions with high rainfall. Economic impacts in other parts of the UK are rated as **medium**, with **low confidence**. Though no native conifer species are hosts, mixed conifer plantations containing non-native species such as spruce and firs can provide important wildlife habitats. Death of trees could have small impacts on biodiversity and potential environmental impacts in the UK have been rated as **small**, with **medium confidence**. Due to trees becoming hazardous due to infection, social impacts have been rated as **medium**, with **medium confidence**.

Endangered area

The endangered area is coniferous plantations, excluding monocultures of pine, warm, dry areas of the UK. Based on the distribution of the pest in North America, and where it is damaging, those parts of the UK with a cool, wet climate such as parts of Northern Ireland, Wales and Scotland are unlikely to suffer significant impacts from *H. occidentale*, though the pest may be able to establish there. It is uncertain if impacts will occur in cool, moist climates and warm, moist climates.

Risk management options

Though the pest is considered very unlikely to enter, further protection could be sought by regulation of the pest which has the potential to cause impacts in both the UK and Europe. Suitable measures could be placed on pathways including wood and plants for planting. Eradication of outbreaks in the wider environment is very unlikely, due to the number of hosts and the fact the pest can survive in stumps for up to four decades. The main cultural control method would be appropriate stump treatments, since this is the main route through which *H. occidentale* colonises standing trees. In some situations, such as infested stumps near recreational areas or smaller stumps in Christmas tree plantations,

stump removal may be an economically viable option to control the pest. Stump removal is unlikely to be feasible in most forestry settings though.

Key uncertainties and topics that would benefit from further investigation

The following points could benefit from further research:

- Based on observations of where the pest is considered damaging in North America, it is assumed that areas of the UK with a cool, wet climate will only suffer minor, if any, impacts from *H. occidentale*. It is then uncertain what damage may be in areas with cool, moist climates or warm, moist climates as it is not known if temperature or rainfall – or a combination of both – is limiting impacts of *H. occidentale* in these regions. Further climate analyses, comparing the climate of the UK to regions where the pest is and isn't damaging, could increase confidence in this assertion. In the very unlikely event of an outbreak, these data could also be used to help with management decisions regarding where stump treatment would be appropriate.
- *Sequoiadendron giganteum* is a host of *H. occidentale* whose plants (unlike other hosts) can be imported into Europe. It is assumed that trade in this species from the current range of the pest is low, but if plants are being traded data on this could help more accurately assess the risk.
- It is not known how effective the current stump treatments (urea and the biological control agent *Phlebiopsis gigantea*) used in the UK against *H. annosum s.s.* are when used to prevent *H. occidentale* from colonising stumps.

Images of the pest

Fruiting bodies of *H. occidentale* at the base of a tree. Image copyright: Natural Resources Canada

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 pest is detected on imports, than statutory action would be appropriate. Statutory action may also be appropriate in outbreak situations where containment of the pest may be possible.

Yes Statutory action	✓	No Statutory action	

Stage 1: Initiation

1. What is the name of the pest?

Heterobasidion occidentale Otrosina & Garbelotto MB

Heterobasidion occidentale is one of several species that causes root and butt rot of conifers.

Special notes on taxonomy

Previously, *H. occidentale* was included within *H. annosum sensu lato,* which had different 'inter-sterility groups' (ISGs) which varied based on host range, distribution and ability to hybridise. *Heterobasidion occidentale* was described as a distinct species in 2010 (Otrosina & Garbelotto, 2010), having previously been referred to as the North American S ISG (Inter-Sterility Group) – this should not be confused with the European S ISG (or Eur-S) which refers to a separate species, *H. parviporum*.

The other member of *H. annosum s.l.* in North America is *H. irregulare* (the North American P ISG). The range of these two species overlaps, and for this reason when North American publications refer only to *H. annosum* it cannot be said with certainty to which pest they refer, though the host range of the two species differs considerably so it can sometimes be inferred. This PRA concentrates on publications that refer to *H. occidentale* or the North American S ISG.

A hybrid between *H. occidentale* and *H. irregulare* has been observed in nature, within a pine stand (Garbelotto *et al.*, 1996), and has been shown to be genetically stable (Garbelotto *et al.*, 2004). A second incident of a *H. irregulare* and *H. occidentale* hybrid was reported from a decayed root ball of *Larix lyalli* (subalpine larch) in 2013 (Lockmanl *et al.*, 2013). Formation of such hybrids in nature does appear to be a very rare event, but there is an additional risk that introduction of *H. occidentale* to the UK could lead to hybridisation with the native *H. annosum s.s.*, producing a hybrid with characteristics derived from both species.

2. What initiated this rapid PRA?

Currently, only *H. annosum s.s.* is known to occur in the UK. The risk from the introduction of other members of the *H. annosum s.l.* group of conifer pathogens was assessed via the UK Plant Health Risk Register in November 2015. *Heterobasidion occidentale* was identified as a potential threat and given a priority for PRA. *Heterobasidion parviporum* was also identified at this time and given a priority for a 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 occidentale 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 occidentale is limited to western North America from Alaska to southern Mexico (Garbelotto & Gonthier, 2013). Natural Resources Canada only list the pest as present in British Columbia (Natural Resources Canada, 2015). States of the contiguous USA the pest is reported from are: Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington and Wyoming (Lockman *et al.*, 2016).

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

Heterobasidion occidentale has never been detected in the UK, and nor has it ever been intercepted. The only *Heterobasidion* species known to occur in the UK is *H. annosum s.s*. However it should be noted that members of *H. annosum s.l.* cannot be distinguished in the field, and the last large scale survey was over a decade ago.

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

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

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?

North American natural and experimental hosts

In North America, *H. irregulare* generally attacks species of *Pinus* (pine) – and attacks by *H. occidentale* occur on other species of conifer (Lockman *et al.*, 2016). The host range of *H. occidentale* has been described as "broad but limited to conifers", notably of the genera *Abies* (firs)*, Picea* (spruce)*, Pseudotsuga* (Douglas fir)*, Sequoiadendron* (sequoia) and *Tsuga* (hemlock) (Otrosina & Garbelotto, 2010). The genus *Sequoiadendron* only contains a single species, *S. giganteum* (giant sequoia or giant redwood) (Otrosina *et al.*, 2010).

Published records of *Abies* affected by *H. occidentale* include *Abies concolor*, or white fir, which is also the species on which fruiting bodies are most typically found (Otrosina & Garbelotto, 2010). *Abies amabilis* (Pacific silver fir)*, A. lasiocarpa* (subalpine fir) and Shasta red fir (*Abies x shastensis* [*magnifica x procera])* are also susceptible to root rot caused by *H. occidentale* (Devine *et al*., 2012). A study investigating *Heterobasidion* root rot in Christmas tree plantations in the Pacific Northwest isolated *H. occidentale* from the following additional species of *Abies: A. fraseri* (Fraser fir), *A. grandis* (grand fir), *A. nordmanniana* (Nordmann fir), and *A. procera* (noble fir) (Dart *et al.*, 2007). In Mexico it has been reported from *A. hickeli* (Garbelotto & Chapela, 2000). Also in Mexico, *A. religiosa* (sacred fir) has been reported as a host of *H. annosum s.l.* (Rodríguez & Pinzón-Picaseño, 2006), and given the host it is very likely this is *H. occidentale*.

Species of *Picea* that can be infested by *H. occidentale* include *Picea sitchensis* (Sitka spruce) (Reeb & Shaw, 2015), which is a native species in this region. Other reported *Picea* hosts are *P. breweriana* (Brewer spruce) and *P. engelmannii* (Engelmann spruce) (Devine *et al.*, 2012). It is not known if European species of spruce, such as *P. abies* (Norway spruce) may also be hosts.

Western hemlock, *Tsuga heterophylla* and mountain hemlock, *T. mertensiana* are both reported as susceptible to *H. occidentale* (Devine *et al.*, 2012). *Pseudotsuga menziesii* (Douglas fir) was the only species of *Pseudotsuga* for which published reports of *H. occidentale* infection could be found (Dart *et al.*, 2007).

Heterobasidion occidentale was included in a list of decay fungi of unknown importance in western red cedar, *Thuja plicata* (Sturrock *et al.*, 2010). There are very few other references to this species as a host of *H. occidentale*. In Montana, USA, western red cedar is described as "moderately resistant", though some sites have been found to be considerably damaged, though with low mortality rates (Hagle, 2007).

Some host records are less certain. Natural Resources Canada (2015) list the following species as secondary hosts: alders (*Alnus*), apples (*Malus*), bigleaf maple (*Acer macrophyllum*), grand fir (*Abies grandis*), lodgepole pine (*Pinus contorta* var. *latifolia*), ponderosa pine (*Pinus ponderosa*), western redcedar (*Thuja plicata*) and white spruce

(*Picea glauca*). It is not clear what is meant by secondary hosts in this context. It has been noted that *H. occidentale* can infest *Pinus* stumps (USDA Forest Service, 2010) – though there is no evidence of spread to standing trees. A single incense cedar (no species name given, but this common name usually refers to *Calocedrus decurrens*) was recorded as infected close to a mortality centre of white firs (Garbelotto *et al.*, 1999).

Hosts of importance to the UK

Many *H. occidentale* hosts are of commercial importance to the UK. Sitka spruce is by far the widest grown coniferous timber species in the UK – accounting for around one half of all conifer plantations – approximately 665 000 hectares (FC, 2015). Many *Abies* species are grown for Christmas tree production in the UK – with Nordmann fir estimated to be around 80% of the trees grown in the UK (British Christmas Tree Growers Association, 2016). Other hosts such as Western hemlock are more minor forestry species. It should be noted that alternative forestry species, including hosts of *H. occidentale*, may come into use in the UK in response to factors such as climate change. No records of *H. occidentale* attacking conifers native to the UK could be found.

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 wounds on the root or stem of a tree. For *H. occidentale*, fresh wounds of species other than *Abies* are rarely colonised (USDA Forest Service, 2010). 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.

No evidence of *H. occidentale* moving on any of the pathways assessed could be found.

Plants (including plants for planting and Christmas trees)

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. In the EU legislation, ‘plants’ covers any commodity with foliage or roots, and thus will encompass cut Christmas trees or cut branches.

Sequoiadendron can be imported from the range of the pest. Though precise figures on trade are not known, it is likely to be very low. Association with plants that have been propagated in nurseries is also very unlikely, as *H. occidentale* is a disease of site; usually

infecting trees planted for forestry purposes, and is not usually associated with tree nurseries. In addition, infections of *S. giganteum* are theorised to be usually caused by proximity to diseased *Abies,* which encroach on redwood sites due to fire suppression activities (Otrosina & Garbelotto, 1997, Otrosina *et al.*, 2010). Proximity of *Sequoiadendron* to such diseased *Abies* in a nursery environment is very unlikely.

Since the majority of host plants are prohibited, and there is only limited trade in *Sequoiadendron*, entry on plants is **very unlikely with high confidence**.

Timber

Sawlogs, which are taken from the base of the tree and intended for processing at sawmills, pose the biggest risk of being infested with *H. occidentale*.

There are measures on wood of conifers (excluding *Thuja*, which is not considered to be a significant host of *H. occidentale*) that originate from the range of *H. occidentale* in the USA and Canada; these are related to pinewood nematode, *Bursaphelenchus xylophilus*. Wood must either be subjected to heat treatment (56°C for 30 minutes), or fumigated with an appropriate product or undergone chemical impregnation with an appropriate product. If the heat treatment option is chosen, this should be effective against *H. occidentale*, but other options would not be effective.

There are also measures on wood of conifers that relates to the exclusion of non-European species of *Monochamus, Pissodes* and members of the Scolytinae subfamily (bark and ambrosia beetles). However of the six options for these pests, only one would be effective against *H. occidentale*, which is the heat treatment of the wood.

It is not known what proportion of conifer wood entering from the range of *H. occidentale* has been subjected to heat treatment, as opposed to the other options available to exporters.

The import of coniferous saw logs from Canada, Mexico and USA was investigated. A search of Eurostat (data extracted 24/05/2016) using the following commodity codes was performed:

- Coniferous wood in the rough, whether or not stripped of bark or sapwood, or roughly squared
- Sawlogs of coniferous wood, whether or not stripped of bark or sapwood, or roughly squared (excluding wood of the species *Picea abies, Abies alba* and *Pinus sylvestris*)
- Sawlogs 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

Only import of sawlogs of *Picea abies* or *Abies alba* was recorded, from the USA, and only 500kg.

If sawlogs were imported into the UK and kept in suitable conditions, it is theoretically possible that fruiting bodies could form on the sawlogs, and if stored in the vicinity of coniferous stumps or trees with wounds, spores may be released and transfer to a suitable host. However there are no published observations of this ever occurring.

Timber is also imported as sawn planks of wood from North America, which are more economical for exporters to heat treat (Ian Brownlee, Forestry Commission, *personal communication*). If heat treated, these sawn planks do not pose a risk. Even if the planks are untreated, by sawing lengthwise, each individual plank will have a reduced level of inoculum compared to sawlogs. Such planks are also unlikely to be stored in the moist conditions that would promote fruiting body formation.

Due to the very limited amount of trade, and the fact that formation of fruiting bodies on sawlogs has never been observed, entry on this pathway is rated as **very unlikely with medium confidence.** If trade patterns change in the future, this risk may need to be reviewed.

Wooden Stakes

Wooden stakes are rated separately from timber, because, depending on the intended use of the stake, there could be a greater risk of transfer to a coniferous host. Wooden stakes are often made of lower quality wood, and may harbour live *H. occidentale* mycelium. If such infested stakes were used in the staking of young coniferous trees, then these trees could become infected if roots make contact with the fungi in the stakes. Such stakes would still have to meet the requirements as described for timber, and may have also undergone other treatments (such as creosote or Copper Chrome Arsenate) that would also be disadvantageous to the survival of *H. occidentale.*

The import of wooden stakes from the range of *H. occidentale* was investigated. Import data are only available on a country level, and the origin of commodities within Canada, USA or Mexico is not known. There are two commodity codes under which such stakes may be imported:

- Posts and beams of wood.
- Hoopwood; split poles; piles, pickets and stakes of wood, pointed but not sawn lengthwise; wooden sticks, roughly trimmed but not turned, bent or otherwise worked, suitable for the manufacture of walking sticks, umbrella, tool handles or the like, of coniferous wood.

Between 2011-2015, only imports under the commodity code “posts and beams of wood” were recorded and only from the USA and Canada. Trade was small, totalling 62 tonnes in 5 years. The commodity code “posts and beams of wood” will include those made of non-host material (e.g. non-coniferous wood), as well as posts and beams originating from outside of the range of *H. occidentale*. Some will have been heat treated, eliminating the risk of *H. occidentale.* Only a fraction, if any, of the posts and beams imported will be used for staking coniferous trees, which presents the biggest risk of transfer to host trees. However stakes stored in suitable conditions could also theoretically allow the formation of

H. occidentale fruiting bodies, and if storage is in the vicinity of cut stumps these could become infested, though this is considered very unlikely and has never been observed.

Because of the small trade from the current range of the pest, with much of the imported material unlikely to be destined for staking of host trees, entry on this pathway is **very unlikely with medium confidence.**

Utility Poles

Utility poles, also referred to as telegraph poles, may also act as a pathway of entry for *H. occidentale*, though it is not known if such poles are imported from the range of the pest.

Utility poles are usually treated with preservatives such as creosote, however this treatment does not penetrate all the way through and the fungus could remain alive within the heartwood. 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). 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. occidentale*, or any other *Heterobasidion* species, on utility poles could be found.

If formation of fruiting bodies occurred on utility 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 very rare event.

Wood Packaging Material (WPM)

All WPM that originates from outside of the EU must meet the requirements of ISPM15. This requires that wood packaging material be heat treated to 56°C for at least 30 minutes, throughout the profile of the wood (Forestry Commission, 2012). This treatment should be effective against *H. occidentale*. There are cases of non-compliance with ISPM15. Since WPM and dunnage tend to be made of lower quality wood, which may be lower in quality due to fungal infection by pests such as *H. occidentale*, if untreated WPM were to be stored outside, it is theoretically possible that fruiting bodies could form and spores transfer to cut stumps/wounds on trees if any were in the vicinity. This is how it is thought *H. irregulare* was introduced to Italy from the USA around World War II (before ISPM15 requirements were mandatory) (EPPO, 2015).

Entry on WPM is rated as **very unlikely with high confidence.** The majority of WPM from the range of *H. occidentale* will be ISPM15 compliant, and thus pose no risk. Where WPM

is non-compliant and infested with *H. occidentale*, it would still need to be stored in suitable conditions close to hosts to allow for formation of fruiting bodies and spore dispersal, and these events are also considered very unlikely with high confidence.

Plants	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					
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		Very likely	
Confidence	High Confidence	✓	Medium Confidence		Low Confidence					

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

Heterobasidion occidentale does not require a vector.

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

Hosts of *H. occidentale* are abundant and widespread in the UK. The fungus is found in several US states and one Canadian province. Large parts of Washington State (USA)

and British Colombia (Canada) have a similar climate to the UK. There appear to be no factors that would prevent the establishment of *H. occidentale* outdoors in the UK, and **establishment outdoors is therefore rated as very likely with high confidence.**

Hosts are not usually grown under protection, and so **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?

Natural spread occurs initially through spore release. Most spores of *Heterobasidion* species are reported to land within 100m (Garbelotto & Gonthier, 2013), though this does not preclude some spores travelling longer distances, as wind may carry the spores for "many kilometres" (Natural Resources Canada, 2015). In addition, *H. occidentale* is considered to be a "prolific spore producer" (Reeb & Shaw, 2015), producing spores all year round (Natural Resources Canada, 2015), and this may aid its natural spread. Once the fungus has colonised the stump, it will then spread very slowly through root to root contacts. Estimates of spread by root to root contacts are 0.2 to 1 m/year, in a study of white firs the largest genet (trees infected by the same individual) was 10 metres, the average 5.5 metres. High tree density was also noted to favour secondary spread (Garbelotto *et al.*, 1999). **Natural spread is rated as slowly, with medium confidence.**

As detailed in the entry section, *H. occidentale* does not seem to be associated with commodities that are moved in trade. **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 occidentale is recorded as an economic pest in forestry plantations and Christmas tree plantations.

Abies, in particular white fir (*A. concolor*), is one of the most frequently infected hosts of *H. occidentale.* In this species *H. occidentale* will commonly colonise the sapwood, which reduces growth of the tree and can lead to mortality (Garbelotto *et al.*, 1994). Unlike other species of *Heterobasidion*, where infection via wounds seems to be a rare occurrence, the genus *Abies* appears to be susceptible to primary infection by spores via wounds. This means that standing trees of *Abies* do not have to be in close proximity to infested stumps to become infected and it is not uncommon to find single infected *Abies* trees which were probably infected via wounds (Garbelotto *et al.*, 1999). Such trees can even be infected with more than one *H. occidentale* genotype (Garbelotto *et al.*, 1994) e.g. more than one spore germinates and infects the tree.

Impacts of *Heterobasidion* species tend to be greatest in intensely managed forestry plantations (Garbelotto & Gonthier, 2013), as felling activities (include thinning and commercial harvesting) creates stumps and wounds which can be infested and spread the disease (Natural Resources Canada, 2015, Stambaugh, 1989). High tree densities, which may be found in plantations, can also favour the spread of the disease (Garbelotto *et al.*, 1999, Lockman *et al.*, 2016). Management by fire exclusion is also thought to contribute to the infection of *S. giganteum* by *H. occidentale*, as it leads to encroachment of easily infected *Abies* species which then act as sources of infestation for nearby *Sequoiadendron* (Otrosina, 1997).

In the northern region of the USA, an estimated 1.6 million ha are affected by *H. occidentale*, with an estimated 311, 600 ha predicted to suffer greater than 25% mortality of trees due to the disease (Lockman *et al.*, 2016). Grand fir and white fir in Oregon and Washington are described as being "frequently infected and often killed", and substantial decay in older hemlocks (*Tsuga*) is associated with stem breakage (Goheen & Willhite, 2006).

Despite the presence of *H. occidentale* in the native range of Sitka spruce, knowledge of impacts on this species are somewhat limited. In Oregon, lack of knowledge has been reported to be because only low levels of management in plantations of this species (Reeb & Shaw, 2015). It is uncertain if this refers to a lack of monitoring, or whether there is an absence of commercial activities (such as thinning) that encourage disease development. In Alaska only low level impacts are reported on young stands of Sitka spruce (Holsten & Region, 2001, Lockman *et al.*, 2016), causing internal wood decay but mortality is rare. However guidance for Washington State describes Sitka as being "highly susceptible to infection and can be severely damaged" (Kohler *et al.*, 2013). It is possible these regional differences may be due to environmental factors that influence the severity of the disease, and it has been stated that impacts vary depending on host and region (Lockman *et al.*, 2016). Another example is that in Washington and Oregon Douglas-fir species are

described as “seldom damaged” but that “susceptibility appears to increase with latitude” (Filip *et al*., 2015).

In Alaska, it has been suggested the “cool, excessively wet climate” (more than 1600mm of rainfall a year) in the South-East (the only region where *H. occidentale* is known to occur) may not be conducive to spread and growth of *H. occidentale,* with findings of fruiting bodies being rare (Graham & Heutte, 2013, Shaw III, 1989). The theory that *H. occidentale* does poorly in areas of high rainfall is based on field observations, rather than scientific analysis. However, other publications do note that *H. occidentale* is most important in drier habitats (Reeb & Shaw, 2015).

Damage in Christmas tree plantations has been detailed in Dart *et al.* 2007 and references therein. Fir species are becoming an increasingly popular Christmas tree species in the Pacific North West (the range of *H. occidentale*), and with expansion of *Abies* plantations have come increases in *H. occidentale* disease incidence. In Oregon infection rates were reported to have risen from 4% in 1980 to 25% in the year 2000. Death of trees from *H. occidentale* infection is common, with rates of 15% in noble fir and 40% in Fraser fir reported. Disease incidence occurs in aggregates, or mortality pockets, which often contain multiple genotypes of *H. occidentale* and are thought to be the result of harvesting of nearby trees during peak spore release times. The practice of removing stumps after harvest is reported to have reduced disease incidence in Christmas tree plantations.

Trees infested with *Heterobasidion* in the USA (species not specified) are also reported to be more susceptible to attack by secondary pests such as bark beetles (Lockman *et al.* 2016 and references therein). Infection with *H. occidentale* is also associated with increased incidences of wind throw (trees uprooted or broken by wind) and stem breakage of trees, including species such as western hemlock and Sitka spruce (Holsten & Region, 2001, Natural Resources Canada, 2015, Reeb & Shaw, 2015, USDA Forest Service, 2010). Because *H. occidentale* can affect the structural integrity of the tree, infected trees are considered to be hazardous when in the vicinity of people or manmade structures in case they fall, and removal of these trees (and in some instances even the costly removal of the stump to prevent spread) is recommended (Reeb & Shaw, 2015, USDA Forest Service, 2010). In 2009, a campground had to be closed in the Shasta-Trinity National Forrest, California due to the presence of such hazardous trees. *Heterobasidion occidentale* infected large white fir trees, weakening them and leading to attack by the bark beetle *Scolytus ventralis* (fir engraver beetle) which led to the death of the trees (Angwin *et al.*, 2016). The same reference details other incidents of *H. occidentale* and bark beetle attacks at several other recreational areas in California, which led to management action being necessary.

Impacts of *H. occidentale* in its 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?

In some regions of the UK the impacts of *H. occidentale* may be affected by climate. This is similar to *H. annosum s.s.*, which also does not do well in cool, wet climates meaning management is not usually required (Pratt, 2003). Assuming *H. occidentale* behaves in a similar way in the UK as it does in North America, only very minor impacts would be expected in cool, wet areas of the UK such as parts of Scotland and Wales and the north of England, as shown in Figure 2. This figure does not show Northern Ireland, but areas of Northern Ireland with high rainfall (around 1600 mm per year) would also only expect to incur minor impacts. However, this conclusion is based on field observations of the severity of the disease in Alaska and a rough comparison of the climates of those areas to the UK, and, as a consequence, there is low confidence in the assertion. More detailed climate analyses comparing the climate of the UK to regions where the pest is damaging and where no impacts occur would be needed to help increase confidence in these conclusions.

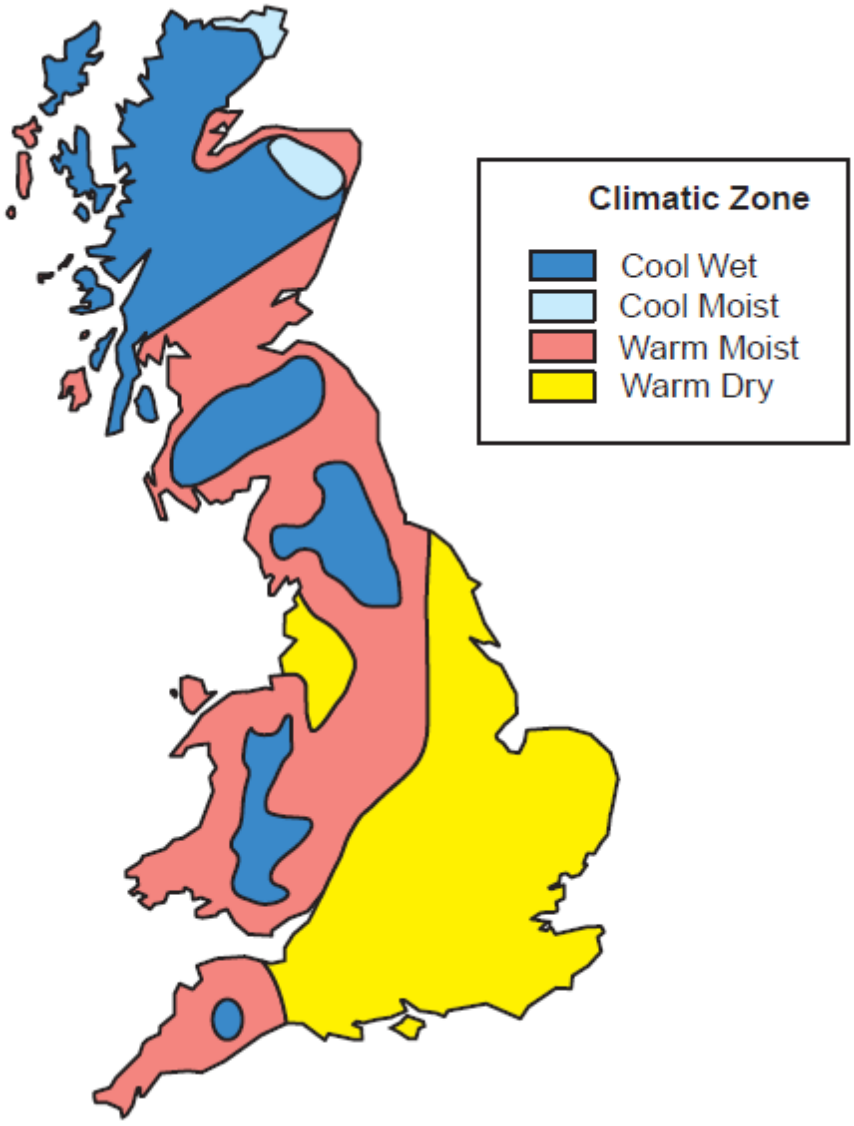

Figure 2: Climate zones of Great Britain based on accumulated temperature (day degrees above 5°C) and annual soil moisture deficit (mm). Taken from (Pratt, 2003).

In other regions of the UK, especially those with warm, dry climates, economic impacts of *H. occidentale* may be medium. It should be noted that the warmer drier climates of the UK tend to utilise *Pinus* species for forestry plantations, as *Pinus* is more drought tolerant than spruce and other species (Joan Webber, Forest Research, *personal communication* 17/06/2016). Since *Pinus* is not a host, this will also limit impacts. Economic impacts may occur in both forestry plantations of mixed conifers species, especially those that contain high densities of *Abies* and *Picea*, as well as in Christmas tree plantations. Economic impacts will be due to the death of trees (largely younger trees) and also reduced growth due to root and sapwood infection leading to losses in timber volume.

Potential economic impacts in the UK are rated as medium, with low confidence. *Heterobasidion occidentale* spreads slowly, and, if introduced, may take decades before impacts are measurable, and, given further decades, the pest may reach its maximum extent at which point economic impacts may become larger. Confidence is low, because of the considerable variation in disease impacts reported on various species of forestry importance to the UK in the USA. In particular Sitka spruce, the most widely grown conifer species in the UK, only suffers minor impacts in most of its range though some reports indicate it is highly susceptible. This species is described as thriving in "*the North and West of the country on damper and elevated sites"* (Forestry Commission, 2016). A map showing the distribution of Sitka spruce in the UK (and Ireland) is shown in figure 3, and reflects the fact the species is concentrated in the north and west of the UK, where in some parts wet and often cool conditions prevail, and where significant economic impacts would not be expected to occur.

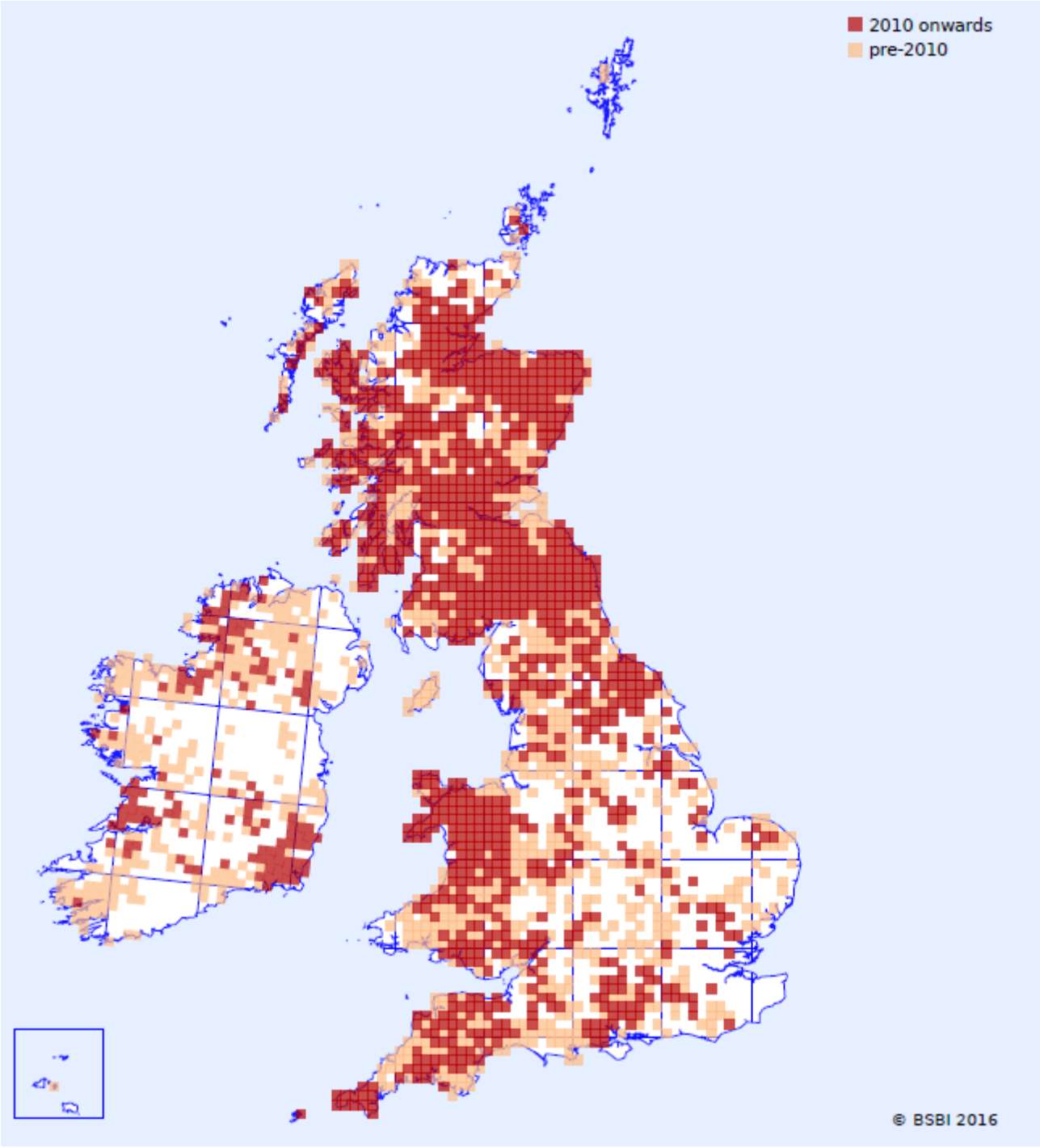

Figure 3: Distribution of Sitka spruce (*Picea sitchensis*) from the UK by 10 km grid squares. Map taken from the Botanical Society of Britain and Ireland (BSBI) distribution maps: http://bsbi.org/maps. Downloaded 13/06/2016.

No records of *H. occidentale* attacking conifers native to the UK could be found. However, coniferous plantations of non-native species can still provide important habitats for key UK species. Other members of the *Heterobasidion annosum* complex tend to infect trees which remain standing and can therefore still be utilised by wildlife (such as detailed in the UK pest risk analysis for *Heterobasidion parviporum*). With *H. occidentale,* larger infected trees may not remain standing, suffering from stem breakage or wind throw meaning they can no longer provide habitats for species such as red squirrel. However, the dead wood

would provide an important habitat for other species. **Environmental impacts are rated as small, with medium confidence.**

The main social impacts are due to the fact that *H. occidentale* creates hazardous trees, that may break and fall on people or man-made structures. Trees may have to be removed as soon as signs of infection are detected, to prevent them reaching the stage where they pose a hazard, and this could interfere with the use of recreational areas. In addition, severe outbreaks in Christmas tree plantations may reduce consumer choice, in particular as firs are currently a favoured Christmas tree. There is also a small risk to ornamental or landscape host trees, in particular those relatively close to coniferous plantations, since *H. occidentale* can infect trees via wounds. **Social impacts are rated as medium, with medium confidence.**

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 occidentale is not a vector of plant pathogens.

15. What is the area endangered by the pest?

The endangered area is coniferous plantations, excluding monocultures of pine (*Pinus*), excluding those in cool, wet climate. Based on the distribution of the pest in North America, and where it is damaging, those parts of the UK with a cool, wet climate such as Northern Ireland and Scotland are unlikely to suffer impacts from *H. occidentale*, though the pest may be able to establish there. There is more certainty over endangerment to those areas of the UK with warm, dry climates than those with cool moist or warm moist climates.

Stage 3: Pest Risk Management

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

Exclusion

This PRA considers *H. occidentale* to be very unlikely to enter the UK, but should introduction occur there is a potential for impacts in both the UK and Europe, and it would therefore be beneficial to prevent introduction of the pest to Europe. Further protection against introduction could be achieved through regulation. Many of the recommended requirements for *H. irregulare* made by the 2015 EPPO PRA would be suitable for *H. occidentale*.

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

- Wood of all conifers (including timber, wooden stakes and utility poles) is either from an officially recognised pest free area or subject to heat treatment (at least 56°C for at least 30 minutes).
- 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. Though many hosts of *H. occidentale* are currently prohibited, having measures on other conifers which can occasionally become infected is prudent.

Eradication and Containment

If the pest becomes established in the wider environment, eradication is very unlikely. The USDA management guidelines for *Heterobasidion* spp. state that the fungus can survive in stumps for two to four decades (USDA Forest Service, 2010). Options for eradication from a site would either be:

- Removal of stumps and soil sifting to remove any root fragments, which *Heterobasidion* can also survive in (Stenlid, 1987). However such action is expensive and may be impractical, in addition stump removal can have environmental impacts (Walmsley & Godbold, 2010).
- Place a notice on the site so that no hosts are grown for at least 40 years. This may also be impractical, as natural regrowth of conifer species would need to be suppressed. It may be ineffective for *H. occidentale* as well because it is a prolific, year round sporulator, and the airborne spores may be able to reach other conifer plantations in the vicinity.

Containment would also be difficult. Appropriate stump treatments, as detailed in the cultural control section, may help slow the spread, as would the planting of species less susceptible to infection by *H. occidentale* such as pines.

Cultural Controls

The main cultural controls would be stump treatment, to prevent the fungus from colonising stumps. These stump treatments are unlikely to be required in all areas of the UK, as those with cool and wet climates are unlikely to suffer significant impacts from *H. occidentale.* In the USA, borax fungicides are recommended to be applied to stumps, and these can be at least 90% effective at preventing stump colonisation (USDA Forest Service, 2010). Trials on Sitka spruce seem to indicate borax is effective at preventing *H. annosum s.s.* colonisation in this species (Seaby & Schaible, 2000). It is recommended that treatment is applied 4 to 24 hours after a tree is felled. Urea treatments are commonly used against *H. annosum s.l.* in Europe, but no data on the effectiveness of this option against *H. occidentale* could be found.

The biological control agent *Phlebiopsis gigantean* is used against *H. annosum s.s.* in the UK, however, the effectiveness of this against *H. occidentale* is unknown. Currently, the commercial product (PG Suspension) is only registered for use on pines in the UK, which are not endangered by *H. occidentale*.

In *Abies,* which are a common Christmas tree species in the UK, *H. occidentale* can additionally enter through wounds that may occur during harvest. Because of the mortality caused by *H. occidentale* in this genus, practicing stump removal in Christmas tree plantations may be economically viable, especially in those plantations where trees are harvested as they reach the desirable height, creating stumps in-between still growing trees that can be infested.

Removal of stumps may also be necessary in areas that are close to those utilised by people, and is recommended by the USDA in recreational grounds because infected trees can quickly become hazardous (USDA Forest Service, 2010).

In both forestry plantations and Christmas tree plantations, the wounding of adjacent trees during felling activities or clearing of windblown trees should be avoided as much as is practical, to help prevent infection of *H. occidentale* via wounds.

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This publication is available at https://secure.fera.defra.gov.uk/phiw/riskRegister/plant-health/pest-risk-analysis-consultations.cfm

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