Department for Environment Food & Rural Affairs

Rapid Pest Risk Analysis (PRA) for:

Xylosandrus crassiusculus

April 2015

Stage 1: Initiation

1. What is the name of the pest?

Xylosandrus crassiusculus (Motschulsky) (Coleoptera, Curculionidae: Scolytinae). Common names include Asian ambrosia beetle and granulate ambrosia beetle.

Synonyms

Xylosandrus crassiusculus has eleven synonyms, though only *Xylosandrus semiopacus* is found commonly in the literature.

Special notes on taxonomy

Xylosandrus crassiusculus is an ambrosia beetle and a member of the subfamily Scolytinae, previously considered to be a distinctive taxonomic family, the Scolytidae, but now treated as a specialised sub-family within the Curculionidae (weevils).

Ambrosia beetles generally have a symbiotic relationship with a primary species of fungus, which is inoculated into host plants by the females where it grows and acts as the food source for both adults and larvae. The symbiotic fungus of *X. crassiusculus* has recently been described as *Ambrosiella roeperi* (Harrington *et al.* 2014).

2. What initiated this rapid PRA?

Xylosandrus crassiusculus was included in phase I of the UK Plant Health Risk Register due to its addition to the EPPO Alert List after its spread from its native range in Asia both to the USA and Italy. It was identified as a priority for PRA for the UK, with particular focus on its potential for establishment and likelihood of impacts (Defra 2014).

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]?

Xylosandrus crassiusculus is not listed in the annexes of the EC plant health directive. Non-European species of Scolytidae spp are regulated on wood and plants of conifers, but since *X. crassiusculus* does not attack conifers, and is now present in Europe, this legislation does not apply.

Xylosandrus crassiusculus is currently on the EPPO Alert list; it was added in March 2009 after the pest was detected in Italy (EPPO 2009).

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

The distribution of *X. crassiusculus* is summarised in Table 1 and taken from EPPO (2009), with modifications. It is generally considered that *X. crassiusculus* is native to Asia, but was introduced to Africa hundreds of years ago (EPPO 2009). It is likely to be invasive in much of its current range outside East and South East Asia. In addition to the countries in Africa and Asia listed by EPPO, it has also been recorded in Gabon (Beaver 2005) and Israel (Buse *et al.* 2013).

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

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

It was first noted in the continental USA in 1974, with two adults being identified from sweet gum logs (Anderson 1974), though it had been reported 19 years earlier from Hawai'i (Van Zwaluenberg 1955). It has since spread across much of the south-eastern United States and has been reported as far north as Michigan (Cognato *et al.* 2009). The first report from Canada was in Ontario in 2013 (Douglas *et al.* 2013, Fraser 2014). The first report of *X. crassiusculus* in the western United States (LaBonte *et al.* 2005) was from Wasco County, Oregon in 2005 in traps placed to detect exotic wood boring insects near a mill site. The site in question was importing raw railroad sleepers from the southern states of the USA. The large numbers of *X. crassiusculus* captured indicated a local population was likely to have established and an eradication campaign was undertaken in 2005 and 2006, and post treatment surveillance has not detected any further instances of the pest (LaBonte 2011). In Central America, adults were first collected in 1996 in Costa Rica and 2004 in Panama. Kirkendall & Ødegaard (2007) considered that collection data indicates that *X. crassiusculus* may be distributed along the whole Caribbean coast of lower Central America.

Italy

The first report of *X. crassiusculus* in Europe was from Italy in 2003, with specimens collected from a forested area in Tuscany (Pennacchio *et al.* 2003) and further findings in that region indicate the pest is likely to be established (EPPO 2013). *Xylosandrus crassiusculus* was also reported infesting carob trees (*Ceratonia siliqua*) in private gardens in Liguria in 2007 and 2008, and is very likely to be established here also (EPPO 2013). A single adult was caught in a trap in Veneto in 2009. However this trap was placed at a port of entry to detect exotic pests (Rassati *et al.* 2014) so this finding is not necessarily from a locally established population.

France

In summer 2014 *X. crassiusculus* was reported for the first time in France in Nice, also infesting *C. siluqua* within a forest in an urban area. Four trees were found to be infested, and eradication measures are being undertaken at the outbreak site (EPPO 2014). The pest was later detected on the island of Sainte Marguerite, near Cannes, meaning the pest may be more widespread than the original trapping indicated and may have been present already for a few years (Alain Roques, *pers comm* 15.03.2015). The region of Liguria in Italy, where the pest is present, borders with the French region of Alpes Maritimes where the outbreak has occurred. It is unclear if this outbreak may represent natural spread of the pest from Liguria, or if it is a new introduction event.

Table 1: Distribution of *Xylosandrus crassiusculus*. Taken from EPPO (2009) and amended.	
North America:	USA (Alabama, Arkansas, Delaware, Florida, Georgia, Hawaii, Indiana, Louisiana, Maryland, Michigan, Mississippi, New Jersey, New York, North Carolina, Ohio, Oklahoma, South Carolina, Tennessee, Texas, Virginia), Canada (Ontario)
Central America:	Costa Rica, Panama
South America:	No records
Europe:	France (under eradication), Italy
Africa:	Cameroon, Congo Democratic Republic, Côte d'Ivoire, Equatorial Guinea, Gabon, Ghana, Kenya, Madagascar, Mauritania, Mauritius, Nigeria, Seychelles, Sierra Leone, Tanzania.
Asia:	Bhutan, China (Fujian, Hong Kong, Hunan, Sichuan, Xizhang, Yunnan), India (Andaman and Nicobar Islands, Assam, Himachal Pradesh, Karnataka, Madhya Pradesh, Maharashtra, Tamil Nadu, Uttar Pradesh, West Bengal), Indonesia (Irian Jaya, Java, Kalimantan, Maluku, Nusa Tenggara, Sulawesi, Sumatra), Israel, Japan (Hokkaido, Honshu (including Ogasawara Islands**)**, Kyushu, Shikoku), Korea Democratic Peoples' Republic, Korea Republic, Malaysia (Sabah, Sarawak, West Malaysia), Myanmar, Nepal, Pakistan, Philippines, Sri Lanka, Taiwan, Thailand, Vietnam
Oceania:	New Caledonia, Palau, Papua New Guinea, Samoa

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

Xylosandrus crassiusculus is not known to be established in the PRA area, nor has it been intercepted.

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?

Xylosandrus crassiusculus is highly polyphagous on woody hosts, though it apparently does not attack conifers (EPPO 2009). However, juniper (*Juniperus* spp.) is listed as a breeding host by Horn & Horn (2006) and other *Xylosandrus* species can attack conifers, so the host status of this group of plants is uncertain. Most authors estimate the number of hosts to be greater than 100 species in over 40 plant families (Horn & Horn 2006, Mani *et al.* 2013). Examples of hosts of importance to the UK include: *Acer* (maples), *Alnus* (alder), *Betula* (birch), *Cornus* (dogwoods), *Eucalyptus, Fraxinus* (ash), *Magnolia, Malus* (apples), *Platanus* (plane), *Populus* (poplar), *Prunus* (stone fruits), *Quercus* (oaks), *Salix* (willow), *Ulmus* (elms) and *Vitis* (grape).

As well as broadleaved trees, *X. crassiusculus* was able to breed successfully in the rachis of large fallen leaves of the palm *Deckenia nobilis* (Beaver 1988).

The only observed host in Europe to date is carob, *Ceratonia siliqua* (EPPO 2013, 2014), which is not widely grown in the UK. Evidence of attacks on other hosts was not found in surveys in the Liguria outbreak (Andrea Minuto *pers. comm.* 17.03.2015) and only infested Carob was observed in France (EPPO 2014). It is unknown why *X. crassiusculus* is showing a preference for *C. siliqua* in Europe. Infestation of this host has not been recorded in other parts of the known range of the pest, but as a largely Mediterranean species with a limited distribution in North America (Janick and Paull 2008), there is little previous crossover between the two species. The only host record of *X. crassiusculus* that could be found for Israel, where carob is found widely, was on *Quercus calliprinos* (Buse *et al.* 2013).

As the trapped specimens in Tuscany were from a forested area that mainly contained *Pinus pinaster* and *Quercus cerris*, with “dense shrubby undergrowth” (Pennacchio *et al.* 2003), it is likely that *X. crassiusculus* is infesting other hosts in Europe.

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?

Xylosandrus crassiusculus reproduces by sibling mating and only mated females leave the larval galleries. As a consequence, a viable population can be formed by the successful introduction of a single adult female. Adult females are capable of flight (males are flightless), aiding movement on to suitable hosts. Adult females are small (2-3 mm) and reddish brown (Cranshaw 2004) and thus may be difficult to spot in isolation, though *X. crassiusculus* is larger than other *Xylosandrus* species which may make it easier to identify. Since adult females stay with their brood until maturity, and overwinter in the larval galleries (Cote 2008), all life stages are likely to be present in infested material.

Plants for Planting

Xylosandrus crassiusculus is a well-documented pest of nursery trees, particularly in the United States (Atkinson *et al.* 2014, Cote 2008, Gill 2010). Attacks can occur on branches as thin as 1.5 cm (Browne 1963) and trunks approximately 2.5 to 6 cm in diameter (Hopkins and Robbins 2015) Outbreaks in tree nurseries have not been reported in Europe to date and are not widely reported elsewhere in the pest's range, though recently transplanted trees have been attacked in Ghana and the pest has a preference for small branches and stems (Browne 1963).

Despite its attacks on nursery and young trees, there is little evidence of the pest moving on this pathway. This may be because once one tree has been attacked, it then becomes a more attractive target for other *X. crassiusculus,* possibly because an infested tree releases more stress related volatiles, which are attractive to *X. crassiusculus* (Gorzlancyk *et al.* 2013). Studies have also shown that the pest is attracted to the scent of its symbiotic fungi (Hulcr *et al.* 2011). Typically, nursery trees are killed by pest infestations or are otherwise unmarketable (Frank & Bambara 2009, Layton 2012, Mizell & Riddle 2004). This reduces the likelihood of trees being moved with pests in trade.

Current phytosanitary measures will also reduce the likelihood of entry on plants for planting. Though many of the recorded hosts can be imported from the current range of the pest, those entering from outside of the EU will need to be accompanied by a Phytosanitary Certificate and are likely also to be subject to inspection upon arrival. Infestations lead to the production of toothpick like strands of frass. These would likely be knocked off during transport, but the presence of frass around the base of infested trees could still act as a diagnostic feature and small tunnels (described as 'pencil lead' sized) will remain which may be packed with frass (Hopkins & Robbins 2015). Galleries can also cause branches and stems to split (Browne 1963), which would be easily detected on inspection but could be put down to other causes. There will be fewer controls on the movement of planting material from the range of *X. crassiusculus* in Europe, however to date it has not been recorded as a pest of nursery trees in Europe. In addition only carob has been recorded as a host. Carob is a Mediterranean species and is rarely grown in the UK and so is unlikely to be imported from Italy. If the host range in Europe expands, or *X.* crassiusculus does begin to infest nursery trees, then the risk of entry on this pathway will increase.

Planting material originating from areas with low prevalence of *X. crassiusculus* may become infested at low levels and symptoms of the infestation would be harder to spot. Because of the current lack of evidence that the pest moves in nursery trees, its tendency to kill young trees or make them unmarketable and the current phytosanitary measures, *X. crassiusculus* is rated as unlikely to enter on plants for planting with low confidence, as low numbers of the pest may be moving unnoticed on planting material.

Plants for planting	Very unlikely	☐	Unlikely	☑	Moderately likely	☐	Likely	☐	Very likely	☐
Confidence	High Confidence	☐	Medium Confidence	☐	Low Confidence	☑				

Cut Foliage

Ambrosia beetles may be associated with cut foliage or cut flowers where woody material is present. *Xylosandrus crassiusculus* has been recorded as attacking branches as thin as 1.5 cm (Browne 1963), so thicker branches for ornamental purposes are a potential pathway of entry. In California *X. crassiusculus* (life stage not reported) was intercepted on cut flowers originating from Hawai'i in 2001(Gill *et al.* 2001), and twice in 2004 on cut foliage in Los Angeles County – though in this latter instance the origin of the material was not stated (Los Angeles County 2004). These interceptions show the pest can move along this pathway.

It is uncertain how much cut foliage is imported from the pest's current range. Though common in nurseries where it is found in the USA, there appear to be no reports in the literature of the pest being a problem at sites where cut foliage production occurs. Because of the intended use of the commodity, cut foliage is a pathway that provides little opportunity of transfer to a new host, though material disposed of outside (including ornamental bouquets that may be left in cemeteries) near suitable hosts could provide a transfer opportunity. Galleries on branches would be harder to spot when included in large bouquets.

Entry on cut foliage is rated as unlikely, with low confidence. Though there is limited evidence of the pest moving on this pathway, there are no reports of it in cut foliage production systems. Confidence is also low due to the lack of trade data on cut foliage from the pest's current distribution.

Cut foliage	Very unlikely	☐	Unlikely	☑	Moderately likely	☐	Likely	☐	Very likely	☐
Confidence	High Confidence	☐	Medium Confidence	☐	Low Confidence	☑				

Timber and Other Raw Wood Products

In addition to a preference for attacking thin branches on living trees, attacks on cut timber, in particular freshly cut logs, are well documented from across its current range (Atkinson *et al.* 2014, Beaver 1988, Browne 1963, Khen & Intachat 2000, Kirkendall & Ødegaard 2007).The pest has also been recorded from logs used as bait specifically to catch *X. crassiusculus* (Ito & Kajimura 2009) or as part of studies looking at bark beetle diversity (Mayfield *et al.* 2013, Ulyshen *et al.* 2012). There are also records of *X. crassiusculus* moving in trade of timber and other raw wood products. It is very likely that it was introduced to Oregon on raw wood railway ties (sleepers) originating from the South-Eastern USA which were left outside to dry (LaBonte 2011). It has also been intercepted by New Zealand on unspecified casewood (for furniture production) originating from Hong Kong (Brockerhoff *et al.* 2003) and on 10 occasions by the USA in association with wood material (including wood packaging) between 1984 to 2008 (Haack and Rabaglia 2013). Thus *X. crassiusculus* is clearly associated with the raw wood pathway.

There are various requirements in the EU Directive regarding wood of some host species of *X. crassiusculus* originating from some parts of its range such as the removal of bark or appropriate heat treatment of *Quercus* wood from the USA. Because *X. crassiusculus* excavates galleries into the wood, debarking alone would not be an effective treatment to mitigate the association of the pest with the commodity. Wood (including raw wood products such as railway sleepers) of certain species can only enter with a Phytosanitary Certificate stating that it is free from quarantine pests and diseases and substantially free from other harmful organisms (*X. crassiusculus* falls into the latter category).

However, for some countries and species, there will be no controls in place for the import of wood. Restrictions are even fewer within the EU, and *X. crassiusculus* is established in Italy. One of the interceptions on wood products of *X. crassiusculus* in the USA was on unspecified wooden material of Italian origin (Haack and Rabaglia, 2013). The ability of *X. crassiusculus* to transfer to a suitable host from raw wood will depend on the final destination and use of the product. Since *X. crassiusculus* is highly polyphagous, those untreated products stored outdoors at timber yards, mills or elsewhere are likely to provide ample opportunities for transfer both to other timber products and living hosts.

Due to the lack of phytosanitary requirements on many of the raw wood products, evidence that *X. crassiusculus* has travelled along this pathway and the common practice of storing raw wood and logs outside providing transfer opportunities, *X. crassiusculus* is rated as likely to enter on raw wood products, with medium confidence.

Raw wood	Very unlikely ☐	Unlikely ☐	Moderately likely ☐	Likely ✓	Very likely ☐
Confidence	High Confidence ☐	Medium Confidence ✓	Low Confidence ☐		

Wood Packaging Material

All Wood Packing Material (WPM) that originates from outside the EU should be compliant with ISPM 15. This standard requires that all WPM should be debarked. However, bark less than 3cm in width or greater than 3 cm in width, with the total surface area of an individual piece of bark less than 50 cm^2, is permitted. WPM must then undergo heat treatment that achieves a minimum temperature of 56°C for 30 minutes throughout the entire profile of the wood, or be treated with methyl bromide. Correct application of these measures should be effective in ensuring that there is no risk of *X. crassiusculus* entering on this pathway. However, WPM could still provide a pathway of entry for *X. crassiusculus*. Surveys of WPM following the implementation of ISPM 15 showed interceptions of pests of quarantine concern were found on 0.5% of inspected ISPM 15 marked WPM in Australia, 0.3% in the EU and 0.1% in the USA (Haack & Brockerhoff 2011). Though these percentages are small, it is important to consider them in the context of the very large quantities of WPM that are imported into the UK. Members of the Scolytinae are commonly intercepted on non-compliant WPM - 73% of Scolytinae interceptions in the USA were on WPM and new introductions of Scolytinae are strongly associated with WPM (Marini *et al.* 2011). Furthermore, ISPM 15 does not apply to material that originates within the EU, such as Italy, where *X. crassiusculus* is established. A search of Europhyt notifications made between January and November 2014 gave 62 notifications by EU countries of instances of ISPM 15 non-compliance with treatment specifications, 20 of these interceptions were reported by the UK (Europhyt data retrieved 03.02.2015).

Large volumes of WPM enter the UK from the current range of *X. crassiusculus*. Some material may be disposed of outdoors allowing the transfer of *X. crassiusculus* on to living hosts. Entry on this pathway is rated as moderately likely, with medium confidence.

Wood Packaging Material	Very unlikely	☐	Unlikely	☐	Moderately likely	☑	Likely	☐	Very likely	☐
Confidence	High Confidence	☐	Medium Confidence	☑	Low Confidence	☐				

Natural Spread

The distribution of the pest in the south of Europe means that arrival by natural spread to the UK in the near future is very unlikely. However, given the fact females are capable of flight and the pest has a vast host range, continued natural spread within the EU to other Member States, similar to the spread observed in North

America, is very likely. If the pest spreads into northern Europe, then entry via natural dispersal into the UK would need to be re-assessed.

Natural Spread	Very unlikely	✓	Unlikely	☐	Moderately likely	☐	Likely	☐	Very likely	☐
Confidence	High Confidence	✓	Medium Confidence	☐	Low Confidence	☐				

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

X. crassiusculus has established in areas with a wide range of climates, some of which are comparable to the UK. Adult females overwinter inside larval galleries (Reding *et al.* 2010) and all life stages have been reported as overwintering inside hosts in Northern Florida, where the pest survived low temperatures of 19°F (approximately -7°C) (Mizell & Riddle 2004). Winter temperatures in the more northern locations of *X. crassiusculus* are significantly lower than the average winter conditions in the UK, indicating that winter temperatures in the PRA area are unlikely to prevent establishment.

However, the relatively cool summers of the UK may limit the establishment potential of the pest. Nevertheless, adult beetles have been recorded in Sapporo, Hokkaido, Japan (Ito & Kajimura 2009) and Elgin County, Ontario (Douglas *et al.* 2013). In order to compare the coolness of the summers at these locations, a global degree day map has been utilised. Figures 1a and 1b superimpose these locations on a map of temperature accumulations (Degree Days) based on a threshold of 10°C using 1961-90 monthly average maximum and minimum temperatures taken from the 10 minute latitude and longitude Climatic Research Unit database (New et al 2002). This shows that Sapporo is marginally and Elgin wholly in the 1000-1200 annual degree day bands. Figure 1c, which provides the degree day base 10°C map for the UK, shows that only small parts of south and south-east England lie in the 750-1000 band. This suggests that the summer temperatures in the UK are cooler than found at the northernmost extent of its distribution in Japan and Canada and are thus marginal for *X. crassiusculus*. However, there is considerable uncertainty because: (a) we do not know the minimum threshold for development for this species and 10°C has just been used as an indicator of coolness, (b) the species may still be spreading in Canada and this location may not represent the coolest summers it can survive and (c) Sapporo may not be representative of the northernmost limit to its distribution in Japan and d) climate change could lead to warmer summers in the UK more conducive for the pest. Temperature accumulation maps for the whole of Europe are included in Appendix 1.

Several references state that high humidity is required for successful reproduction (Atkinson *et al.* 2014, Frank & Bambara 2009, Weyer); however, the region where *X. crassiusculus* established in Oregon was described as “arid” (LaBonte 2011). In the USA, two generations or more a year are common in the southern states (Fulcher & Bowers 2013), but only rarely seen in Maryland (Gill 2014) and more northern states. The recorded generation time is 55.2 days in Tennessee where at least two generations occur (Oliver & Mannion 2001), and it is stated as between 55-60 days in Maryland where damage is usually only recorded from one generation (Gill 2014), but there are no data for generation times further north. If establishment occurred in the UK it would likely to be with a single generation per year.

Though attacks can be recorded throughout spring and summer and into autumn, there is often a peak emergence of females and the time of year varies across the pest’s distribution. The emergence time may relate to the number of generations that can be achieved – with earlier emergence leading to more generations. In north Florida attacks on trees were noted every month except November and December in 2003 (Mizell & Riddle 2004), though peaks in activity were between February and April (Atkinson *et al.* 2014). In Arkansas activity starts in March and peaks in late April (Hopkins & Robbins), similar to Georgia (Weyer) and in North Carolina flying adults peak in early April (Frank & Bambara 2009) whereas in Maryland peak flight time is in May (Gill 2014) and monitoring in Oregon during the outbreak there showed the peak occurring in mid-June (LaBonte 2011). Peak emergence is very likely to be related to temperature – in Maryland years where damage is highest is when there is a warm period in the spring of more than 80°F (approximately 26°C) (Gill 2014), but there are no published studies related to temperature and emergence time for *X. crassiusculus*.

The related pest *Xylosandrus germanus* has a range that overlaps in some regions with *X. crassiusculus,* and since being introduced to Europe has become widespread, including recently becoming established in the UK. The two species had similar emergence times and peak activity times when studied in Virginia and Tennessee (Reding *et al.* 2010) and first reports of attacks were also similar in Maryland (Gill 2010). A study in Ohio showed a strong relationship between infestation by *X. germanus* and maximum daytime temperatures of ≥20°C and it is not known if *X. crassiusculus* attacks would have a similar relationship - *X. crassiusculus* is much more widely spread in tropical and sub-tropical regions compared to *X. germanus,* and thus appears to be less well adapted to more northern climates.

Based on its continued expansion in its distribution northwards in North America and into regions with climates similar to the UK, *X. crassiusculus* is rated as moderately likely to establish outdoors in the UK, with low confidence. This is due to the lack of data concerning its specific temperature development requirements and its lifecycle in more northerly parts of its range and a poor knowledge of its northernmost distribution in Hokkaido, Japan and other Asian countries.

Ambrosia beetles are not considered to be pests of protected cultivation, and their hosts are not usually grown under protection in the UK, so establishment under protection is rated as 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 ☐		

Figures 1a and 1b respectively show the most northerly records of *Xylosandrus crassiuculus* in Japan (Sapporo), Canada (Elgin County, Ontario) superimposed on a map of temperature accumulations (Degree Days) based on a threshold of 10°C using 1961-90 monthly average maximum and minimum temperatures taken from the 10 minute latitude and longitude Climatic Research Unit database (New *et al*., 2002). Fig 1c provides the degree day base 10°C map for the UK.

Figure 1a

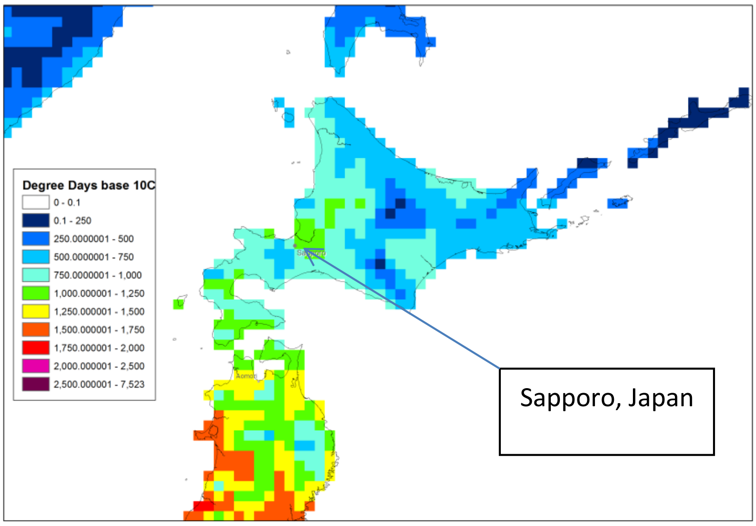


Figure 1b

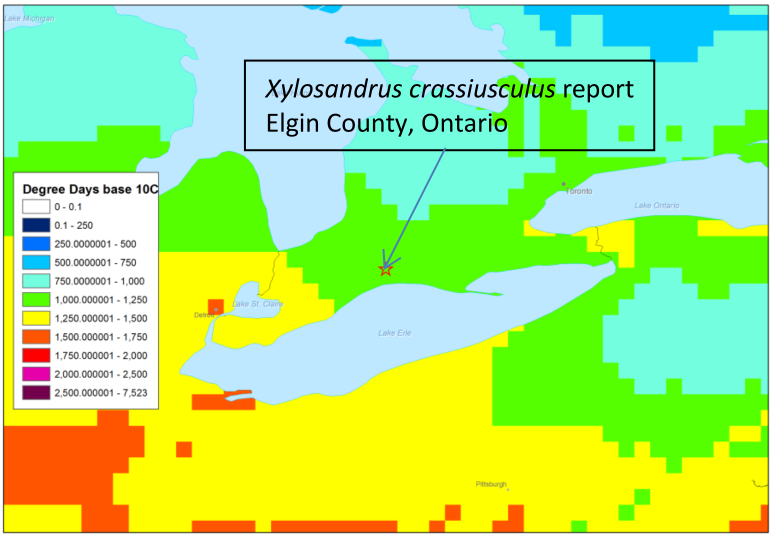
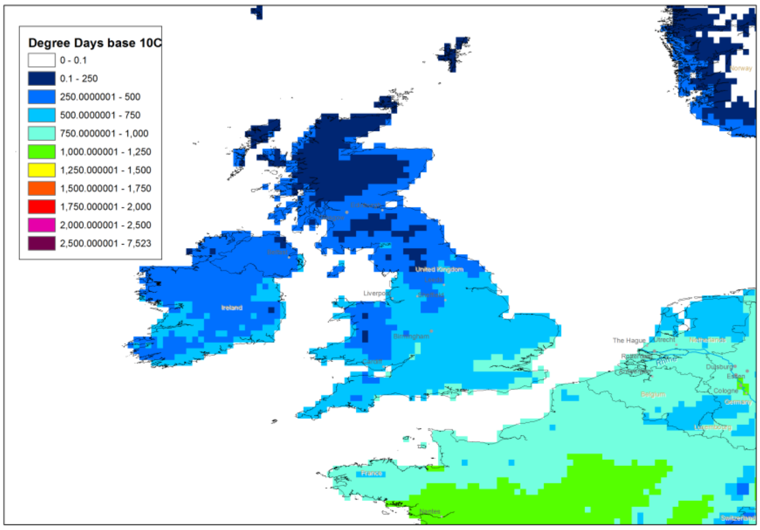


Figure 1c



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

Xylosandrus crassiusculus is a free living organism and no vector is required.

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

There are very little data on the natural spread capabilities of *Xylosandrus crassiusculus.* Females are capable of flight, but the distances that can be achieved are not recorded. It is difficult to judge how many new records of *Xylosandrus crassiusculus* outside its native range are due to the natural spread of the pest or due to a new introduction event on infested material. Spread of the related *X. germanus* has been described as tens of kilometres per year (Henin & Versteirt 2004), but this may include movement in infested timber. Natural spread in the UK is rated as moderate based on the spread of the related *X. germanus*, with low confidence due to a lack of data on the natural dispersal potential of the pest.

In trade, *X. crassiusculus* is most likely to move in infested timber/raw wood products. *Xylosandrus crassiusculus* could spread via this pathway quickly, with medium confidence as there are only a few examples of known long distance spread via trade.

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?

In its current range, *Xylosandrus crassiusculus* causes impacts on both nursery trees and recently felled trees and logs – with the latter being the behaviour usually seen in its native range, whereas attacks on nursery trees are common where it is invasive in the USA (Ito & Kajimura 2009). Female beetles bore into trees creating tunnels which they seed with the ambrosia fungus, which acts as a food source for both adults and larvae. As the fungus grows it breaks down wood, and may block the vascular system causing wilting and dieback and in some instances death of the tree (Frank & Bambara 2009). Attacks on young plants are reported to be usually near ground level, and on more established trees near already existing bark wounds (Weyer 2015).

In Ghana, the infestation of young plantations of *Khaya ivorensis* and *Aucoumea klaineana* led to near complete destruction of the plantations (Browne 1963). In Florida, attacks by *X. crassisculus* on logs of sweet gum (*Liquidambar styraciflua*) being stored at a mill before processing rendered the logs unfit for purpose leading to economic losses (Atkinson *et al.* 2014). In the Seychelles it is particularly noted as a pest of recently cut cinnamon logs, though is not considered as damaging as other species of *Xylosandrus* (Beaver 1988). Of the 109 pests ranked in order of seriousness to Malaysian *Acacia* plantations, *X. crassiusculus* was considered the third most serious pest, and is reported as attacking both live and freshly felled trees leading to timber staining due to the growth of the ambrosia fungus (Khen & Intachat 2000). Attacks on *Acacia* logs in the Philippines have also been reported (Braza 1995).

Attacks on nursery trees within the North American range of *X. crassiusculus'* are a common occurrence each year. Most infestations occur before leaves are fully expanded. It is these attacks that are usually the most serious and can lead to the death of the tree (Gill 2010, Hopkins & Robbins , Layton 2012). Some authors report that trees are less attractive to *X. crassiusculus* once the leaves are fully expanded (Layton 2012, Weyer). For example in Tennessee, 74% of attacks on sweet chestnut were before the trees began to break dormancy (Oliver & Mannion 2001). Once an attack begins on a tree, it becomes more attractive to other *X. crassiusculus* (Layton 2012). Studies in Florida have shown that an attack of between 5 – 10 beetles will kill the majority of young trees (Mizell & Riddle 2004), which fits with the widespread reporting of mortality of nursery stock in the USA (Atkinson *et al.* 2014, Frank & Bambara 2009, Hopkins & Robbins, Layton 2012).

Many sites could also suffer from concurrent attacks of *X. germanus*, which has recently become established in the UK. In Maryland in 2008, attacks by both *Xylosandrus* species led to a single nursery suffering severe damage to over 100 trees of the London plane (*Platanus* x *acerfolia*), river birch (*Betula nigra*) and *Zelkova*. In 2014 an attack on one nursery caused an estimated $320,000 of damage when a large number of trees were destroyed after suffering extensive damage. Excessive loss of azalea plants in a private arboretum has also been reported every year since 2008, in this instance attacks were reported to be solely *X. crassiusculus.* Damage appears to be worse in Maryland in years when temperatures are high enough for the pest to complete a second generation (Gill 2014). Layton (2012) describes *X. crassiusculus* as “one of the most damaging insect pests of young trees in Mississippi” – with typical damage described as significant loss of two to three year old peach trees and 10-15% mortality in some species of container grown trees in nurseries. It has been described as causing damage in excess of $5000 per nursery in the south eastern USA and Texas (Gorzlancyk *et al.* 2013).

In India *X. crassiusculus* is reported as a sporadic pest of grapevine (*Vitis vinifera*) – though attacks on this host in other parts of its range are largely absent. The beetle attacks the main trunk and can cause mortality in 15 – 20 months (Mani *et al.* 2013).

Though it has been found in the wider environment in many parts of its range, there are not currently any reported environmental impacts from this pest. Social impacts can occur in instances where landscape trees are attacked, however in the USA such trees are usually reported to survive (Frank & Bambara 2009, Hopkins & Robbins).

Damage in Liguria, Italy has, to date, only been reported on carob. Infested trees show a general weakening, with leaf yellowing and withering, early leaf fall and occasional wilting of branches. No tree deaths due to *X. crassusculus* have been reported in Italy (Andrea Minuto, *pers. comm.* 18.03.2015).

Impacts in the current range are rated as large, with high confidence, due to the pest's extensive record of causing mortality of young trees and economic impacts on timber production.

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?

Climate is likely to limit the impacts of *X. crassiusculus* in the UK should it be introduced. As discussed in section 9, cooler spring temperatures mean the pest would be expected to become active later in the year, and in all but perhaps exceptionally warm years only a single generation would occur.

It is unclear if *X. crassiusculus* has the potential to become a serious pest of nursery trees in the UK. No attacks on nursery trees have been reported in Europe, but these introductions are relatively recent. There are fewer reports of *X. crassiusculus* as a nursery pest in the more northern parts of its range in the USA. It is relatively common in nurseries as far north as Long Island, (Mike Reding, *pers. comm.*

05.01.2015) and in 2010 a concurrent attack of *X. crassiusculus* and *X. germanus* was damaging to European beech in East Hampton, and two trees were killed by this attack (Gilrein 2010) – thus it can be damaging to living trees in the northern parts of its range. In Ohio, though, it has not yet been recorded in nurseries – the pest is present at relatively low numbers in this state (Mike Reding, *pers.* comm) but it is not clear if this is due to climate or not.

As discussed in section 12, the more serious attacks tend to occur before or during leafing out stage, implying nursery trees are either more tolerant to attack once leaves are fully expanded or that the trees are less attractive to *X. crassiusculus*. Since climate means that the peak flight time of *X. crassiusculus* is expected to be later in the year the majority of trees will then already be in leaf. In springs with exceptionally high temperatures attacks on nursery trees may occur.

Economically damaging attacks may be expected to occur on freshly cut wood and stored logs. The ambrosia fungus can cause staining, leading to the timber being unsuitable for use. Economic impact is rated as small, as the cooler UK climate is expected to limit the impacts of the pest – to date most reports of significant damage have been from regions with hotter summers than the UK., There is medium confidence due to uncertainty over the ability of *X. crassiusculus* to adapt to the UK climate and the lack of data on its temperature development requirements and its flight threshold requirements. The temperature at which females begin to actively fly has a significant effect on the ability of the pest to spread and cause impacts.

There are no apparent environmental impacts in the pest's current range – and so environmental impact is rated as small, with high confidence. Ambrosia beetles are known to attack stressed trees – and *Xylosandrus crassiusculus* may have environmental impacts as a secondary pest in areas of broadleaved woodland where trees are affected by other abiotic and biotic stresses such as disease or drought. In these instances attacks may hasten the death of the tree.

Social impacts may occur when trees in private gardens and public spaces are infested – these are rated as small, with high confidence, as only attacks of younger trees are likely to result in the death of the tree.

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?

As described in section 1, *X. crassiusculus* has a symbiotic relationship with the ambrosia fungus *Ambrosiella roeperi*, which is carried in the mycangia of the beetle and deliberately introduced to its breeding galleries to act as a food source for both adults and larvae. DNA extraction studies on the contents of the mycangia of *X. crassiusculus* indicated that a range of other fungi may be present including known plant pathogens. For example, *Diplodia corticola* was frequently isolated from *X. crassiusculus* and other ambrosia beetles (Kostovcik *et al.* 2014). *Diplodia corticola*, which is not recorded in the UK, is associated with dieback of oak (*Quercus*) in the USA (Dreaden *et al.* 2011) and in Europe (Franceschini *et al.* 2005). Transmission of plant pathogenic fungi by *X. crassiusculus* has not been shown, but this pest and other ambrosia beetles may play a role in the dissemination of fungal plant pathogens and could introduce other non-native fungal species into areas where they become invasive.

15. What is the area endangered by the pest?

The southern parts of the UK are more likely to have a climate that allows for damaging populations to occur. Several consecutive years of hot summers would be needed to allow damaging populations to build up and in these conditions nursery trees may be attacked. Saw mills, timber yards and other places where logs are stored are at particular risk of damaging populations occurring.

Stage 3: Pest Risk Management

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

Exclusion

Exclusion of the pest represents the best risk management option for the UK, as any established populations are likely to be difficult to detect early and eradicate.

Evidence indicates that *X. crassiusculus* is established in Italy, where measures are not apparently being taken against the pest. Eradication measures are being taken in France. Since the pest has potential to continue to spread and be damaging in Europe, it would be prudent to put measures in place to contain its further spread. One option would be appropriate listing in the annexes of the current EU plant health legislation, Council Directive 2000/29/EC. Since the pest only has a limited distribution in Europe, listing in Annex IAII (harmful organisms known to occur in the community and relevant for the entire community) could be considered. Appropriate measures could then be included in Annex IV of the directive to control movement on material including plants and timber – such as requirements that they originate from a pest free area, or timber is treated in a manner that reduces the likelihood of the pest being associated with the commodity, such as by removal of the sapwood. Distinctive toothpick strands of frass should help with detection of the pest in new areas. Alternatively, the UK could seek protected zone status for the pest.

Continued monitoring for WPM that is non-compliant with ISPM15 will reduce the likelihood of entry on this pathway – however material originating from the EU is not subject to ISPM 15 requirements, and the USA has intercepted the pest on wooden material of Italian origin, though it is not clear if this was WPM or another wood product. Thus increased monitoring of both WPM and raw wood products that originate from areas of Italy where the pest is known to be established could be considered.

Eradication and Containment

If populations of the pest establish, eradication will be complicated by the broad host range of the pest, and the fact that chemical insecticides are only effective during the flight period – females and developing stages are protected once they are inside the galleries.

In both Italy and Oregon, *X. crassiusculus* was first detected because of the use of traps set up to detect exotic ambrosia beetles (LaBonte 2011, Pennacchio *et al.* 2003, Rassati *et al.* 2014). The use of baited Lindgren funnel traps or similar at sites with a high risk of entry could help to detect populations of *X. crassiusculus* early, aiding in any eradication efforts. In addition they would have the added benefit of detecting other exotic Scolytinae.

Increased publicity could also help to detect populations of *X. crassiusculus* early. The distinctive toothpick strands of frass, as shown in the image in section 19, should be easy to identify by both stakeholders and members of the general public.

Eradication of an established population of *X. crassiusculus,* with a very local distribution (most catches within 160 hectares and all catches within 350 hectares), has been achieved in Oregon. The eradication protocol included ground sprays of all trees and shrubs within a defined area with a pesticide containing permethrin as the active ingredient across the 860 acres (approximately 3.5 km^2) twice, with a third application occurring within the higher risk zone of 394 acres (approximately 1.6 km^2) (LaBonte 2011). This is believed to be the first instance of the successful eradication of an exotic ambrosia beetle in North America – which demonstrates how difficult eradication of this pest could be if introduced, especially if it is not detected early.

Spread of the pest could be reduced by placing measures on the movement of planting material and timber from a delimited area around known infestations. Movement of raw wood could be limited to winter months, and processed before spring when emergence would occur. It is not clear how effective such measures would be, since not much is known about the natural spread rate of the pest and it may be difficult to contain through official measures. It may also be present in areas at low levels for several years before it is detected.

Non-Statutory Controls

There are several measures that could be taken by the industry to limit the impacts of the pest should it be introduced. Since freshly felled wood is attractive to *X. crassiusculus*, it has been recommended that timber is not stored in the forest where populations of the pest may be present – and any infested wood is quickly destroyed (Pennacchio *et al.* 2003). Raw wood products should be treated or processed as quickly as possible. In Oregon heat treatment or creosoting of railway sleepers at risk of infestation was required and, currently, movement of raw wood products from the south-eastern United States is only allowed in the winter months when *X. crassiusculus* is at low risk of emergence (LaBonte 2011).

Both nurseries and businesses dealing with timber could reduce impacts via the careful application of pyrethroid treatments to wood and trees during the main flight season. This would require monitoring for the emergence of *X. crassiusculus* using appropriate traps baited with ethanol and applying the treatments when adult females are detected. This is the main method of control recommended for use in nurseries in the USA (Frank & Bambara 2009, Hopkins & Robbins , Layton 2012, Reding *et al.* 2010). In some countries wood protection nets which are impregnated with pesticides are used to cover timber and protect it from insect infestation (TTJ online, 2014).

In the USA when nursery trees are attacked, they become more attractive to other *X. crassiusculus* and it is often recommended that attacked trees are placed at the edge of the lot to attract further beetles and protect other trees, and once the peak flight period is completed infested trees should be removed and burned to prevent the pest completing its lifecycle (Fulcher & Bowers 2013, Hopkins & Robbins , Layton 2012).

17. Summary and conclusions of the rapid PRA

This rapid PRA shows that *X. crassiusculus* is a highly damaging pest in much of its current range with the potential to continue to spread and become introduced to new areas in Europe.

Risk of entry

Entry is likely on raw wood products, including timber and other unprocessed woods products, moderately likely on wooden packaging material and unlikely on planting material and cut branches. Though entry very natural spread to the UK is very unlikely, risk of continued natural spread in the EU is high.

Risk of establishment

Establishment outdoors is moderately likely, though with low confidence due to a lack of data on the specific temperature development requirements and flight threshold temperature of the pest.

Economic, environmental and social impact

Xylosandrus crassiusculus has large economic impacts some parts of its current range as a pest of both cut timber and nursery trees. Climate is expected to limit impact if introduction occurs, in particular on nursery trees, and economic impacts are rated as small with medium confidence. There are few recorded environmental or social impacts of the pest, and these are rated as small with high confidence.

Endangered area

Saw mills, timber yards and other areas where freshly cut wood is stored in the south of the UK where climate will be more suitable for the pest.

Risk management options

Exclusion is the best risk management option. Since the pest could pose a risk to many European countries, regulation at a European level could be considered. Eradication would be difficult to achieve in the event of establishment. Increased publicity and monitoring would improve chances of early detection of the pests. Careful monitoring for the pest combined with the use of preventative chemical treatments could reduce impacts in nursery and timber businesses.

Key uncertainties and topics that would benefit from further investigation

A major uncertainty relates to the temperature development requirements for this pest and the minimum temperature at which flight occurs, and thus the extent to which the cooler summers of the UK would prevent establishment, or reduce the likely impact. In addition, there is a lack of data on the flight of adult females – without knowing the average and maximum flight of female *X. crassiusculus* it would be difficult to put into place measures for containment or pest free areas. Understanding the thermal requirements of the pest, in particular the temperature flight threshold is key to understanding the risk this pest poses and further research into this area could lower uncertainties.

18. 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	

19. Images of the pest

 Toothpick strands of frass typical of a *X.*	 An adult female. Image credit: J.R. Baker &

crassiusculus infestation. Image Credit: Sabrina Tirpak, Rutgers PDL.	S.B. Bambara, North Carolina State University, Bugwood.org.

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

Yes Statutory action	✓	No Statutory action	

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Appendix 1

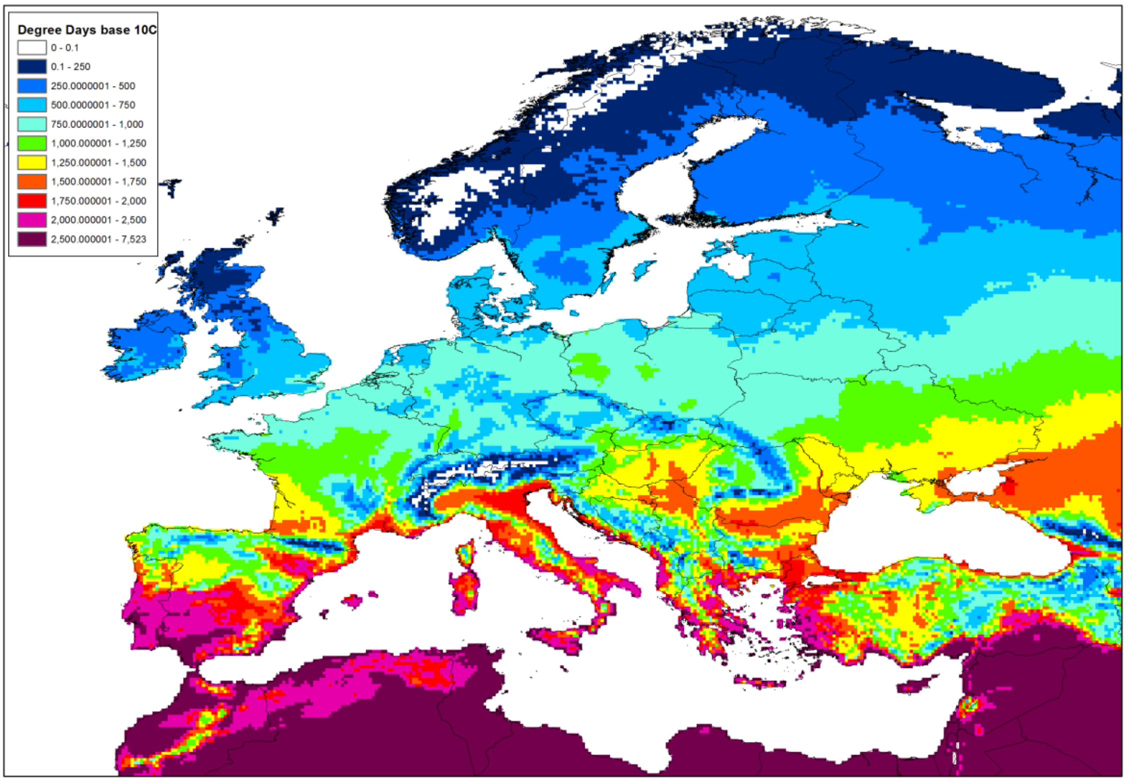

Figure 2. Temperature accumulations (Degree Days) based on a threshold of 10°C using 1961-90 monthly average maximum and minimum temperatures taken from the 10 minute latitude and longitude Climatic Research Unit database (New *et al*., 2002) for Europe. The most northerly records of *X. crassiusculus* in Sapporo, Japan and Elgin, Ontario lie in the 1000-1200 annual degree day band. Much of southern and central Europe lie in this or greater degree day bands, indicating that *X. crassiusculus* may be able to establish.Climate in the north of Europe would be more marginal for establishment, and probably unlikely in much of Scandanavia.

This publication is available at:
https://secure.fera.defra.gov.uk/phiw/riskRegister/index.cfm

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