Rapid Pest Risk Analysis for *Xylosandrus germanus* (Coleoptera: Scolytinae)

Disclaimer: This document provides a rapid assessment of the risks posed by the pest to the UK in order to assist Risk Managers decide on a response to a new or revised pest threat. It does not constitute a detailed Pest Risk Analysis (PRA) but includes advice on whether it would be helpful to develop such a PRA and, if so, whether the PRA area should be the UK or the EU and whether to use the UK or the EPPO PRA scheme.

STAGE 1: INITIATION

1.What is the name of the pest?

Xylosandrus germanus (Blandford)

Synonyms:
Xyleborus orbatus (Blandford): This was recognised as the male of the species by Nobuchi (1981); (the males are smaller and flightless).

Common names of the pest:
Black timber bark beetle
Black stem borer
Small alder bark beetle

Taxonomic position:
Order – Coleoptera
Family – Curculionidae
Subfamily - Scolytinae
Genus – *Xylosandrus*

Special notes on nomenclature or taxonomy:
Xylosandrus germanus was originally placed in the genus *Xyleborus* (Blandford 1894), and has been previously referred to in the literature as *Xyleborus germanus.*

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

The species is not listed in the EU Annexes and is not on the EPPO Alert or Action lists, due to its now wide distribution in continental Europe.

3. What is the reason for the rapid assessment?

The pest was not known to occur in the UK, but specimens of *Xylosandrus germanus* were collected in a mixed pine forest in north Hampshire (Bramshill and Warren Heath; N 51.331°, W 0.892°) in 2012 and 2013, as part of a larger entomological trapping study (D. Inward unpublished). The identity of the species was confirmed using the collections of the Natural History Museum, London. This is the first record of the species in Britain. Further collections made in 2014 have now also identified the species to be present in the New Forest, Hampshire.

Xylosandrus germanus is originally native to eastern Asia, but was introduced to both North America and continental Europe in the mid-20th century, where it has since become widespread (CABI 2014). As an ambrosia beetle, it carries a symbiotic fungus which is introduced to the host plant, on which the larvae and adults feed. This allows it to utilise and attack a very wide variety of hosts. It reproduces by sibling mating, so that dispersing adult females are already fertilised. These traits appear to have helped it become both widely established and to attain large population sizes (e.g. Grégoire *et al.* 2001, Gandhi *et al*. 2010), potentially to the detriment of native competitors. It tends to attack weakened or stressed host plants (Hoffman 1941) and both coniferous and broadleaf stored timber (Maksymov 1987, Graf and Manser 2000), which may additionally be stained by the ambrosia fungus. However, it has also been recorded attacking apparently healthy trees (Weber and McPherson 1984a, Oliver and Mannion 2001). These combined factors have led to it being widely considered as a potentially damaging pest species of a range of host trees and timber.

This rapid PRA has been undertaken to assess the likelihood of establishment and spread in the UK, and the levels of damage that might be expected as a result of the introduction of this beetle.

STAGE 2: RISK ASSESSMENT

4. What is the pest's present geographical distribution?

Xylosandrus germanus is native to eastern Asia (Japan, Korea, China), but was introduced to both Europe (Groschke 1952) and North America (Felt 1932). It subsequently spread to much of the eastern half of the US and south-eastern Canada (Wood and Bright 1992), and has more recently been recorded on the west coast in British Columbia (Humble 2001) and Oregon (La Bonte *et al*. 2005). Since the first European record in Germany (Groschke 1952), *X. germanus* has spread across much of central and western Europe (CABI 2014). A separate introduction into southern Russia has also been identified (Mandelshtam 2000).

Table 1. Geographic distribution of *Xylosandrus germanus*

Region	Country	Locality
Europe		
	Austria	
	Belgium	
	Croatia	
	France	
	Germany	
	Hungary	
	Italy	
	Netherlands	
	Slovenia	
	Spain	
	Switzerland	
	UK	
North America		
	Canada	British Columbia
		Nova Scotia
		Ontario
		Québec
	USA	Connecticut
		Delaware
		Florida
		Georgia
		Hawaii
		Illinois
		Indiana
		Kentucky
		Louisiana
		Maine
		Maryland
		Massachusetts
		Michigan
		Missouri
	USA	New Jersey
		New York
		North Carolina
		Ohio
		Oregon
		Pennsylvania
		Rhode Island
		South Carolina
		Tennessee
		Virginia
		West Virginia
Asia		
	China	Anhui
		Fujian
		Shanxi
		Sichuan
		Xinjiang
		Xizhang
		Yunnan
	Japan	Hokkaido
		Honshu
		Kyushu
		Ryukyu Archipelago
		Shikoku
	Korea, Republic	
	Taiwan	
	Vietnam	
	Russia	Far East
		Southern Russia

Distributional data obtained from PQR database (EPPO 2014) and CABI invasive species compendium (CABI 2014), and references therein.

5. Is the pest established or transient, or suspected to be established/transient in the UK?

Specimens of *X. germanus* were collected in 2012 and 2013 in a mixed coniferous forest in north Hampshire, in moderate numbers (25+ individual females each year; males are flightless), indicating an established population. No businesses importing timber are known locally.

Since detection requires the use of bark beetle traps, and specialist identification skills, additional trapping across England and Scotland has been conducted by Forest Research to better understand its present distribution. Collections in seven other pine forests in 2013 did not yield any more records of *X. germanus*, however in 2014 it was collected in both pine and oak woodland in the New Forest, southern Hampshire (collection sites: N 50.932°, W -1.689° and N 50.917°, W -1.632°). The presence of *X. germanus* in oak as well as pine forest was expected, as it is regularly recorded in deciduous forests; these are apparently more optimal habitats than conifer forest (e.g. Grégoire *et al*. 2001, Bouget and Noblecourt 2005). Full results from the 2014 trapping are not yet available, but since *X. germanus* is highly polyphagous and is capable of relatively rapid spread (Henin and Versteirt 2004), it is likely to be even more widespread (at least within south-east England) than presently recorded.

Therefore *X. germanus* is considered to be established in the UK, with a Hampshire-wide distribution known at present.

Xylosandrus germanus adults and larvae feed upon a symbiotic 'ambrosia' fungus (*Ambrosiella hartigii*) which is carried by the females in specialised structures (mycangia) and introduced to the plant host at the time of gallery formation (Weber and McPherson 1984b). *Ambrosiella hartigii* is known to be shared with the ambrosia beetle *Xyleborus dispar* (French and Roeper 1972), which is native and widespread throughout the UK. This does not therefore represent a new introduction of the ambrosia fungus to the UK. Because of the adaptation to transport *A. hartigii* in mycangia, this is not a resource that will be a limiting factor in the establishment or spread of X*. germanus*.

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

The association with *Ambrosiella hartigii* has enabled the pest to attack a wide range of woody plant species wherever it has been introduced, primarily as a secondary agent upon stressed, unhealthy or recently dead hosts. Serious economic or environmental damage caused by *X. germanus* has been relatively limited, but damage has been recorded in Europe on oak and beech logs (Maksymov 1987), and spruce and pine logs (Graf and Manser 2000). In North America the pest has attacked apparently healthy black walnut (Weber and McPherson 1984a) and chestnut trees (Oliver and Mannion 2001). Over 200 species from 51 families have been identified as host plants, and a preference for deciduous over coniferous hosts is apparent (Weber and McPherson 1983). Listed below are some of the more 'important' hosts.

Abies
Acer
Alnus
Betula
Camellia sinensis (tea)
Carpinus
Carya
Castanea
Cornus
Fagus sylvatica

Fraxinus
Juglans nigra
Juglans regia
Magnolia
Picea
Picea abies
Pinus
Pinus sylvestris
Populus
Prunus
Pseudotsuga menziesii
Quercus
Salix
Ulmus glabra
Vitis vinifera (grapevine)

7. If the pest needs a vector, is it present in the UK?

No vector needed.

8. What are the pathways on which the pest is likely to move and how likely is the pest to enter the UK?

The introduction of *X. germanus* into Europe (Germany) and eastern North America, and the subsequent spread of the species to the west coast of North America, is likely to have been via movement of infested wood (Bruge 1995, La Bonte *et al*. 2005), such as untreated solid wood packaging material or raw timber. This is also the most likely pathway by which the pest entered the UK. Since the beetle constructs galleries in the wood itself (albeit usually shallowly), de-barked timber and even squared wood may harbour individuals if not treated. This has important implications for assessing the risk of introducing other exotic ambrosia beetles via the same pathway.

Other potential pathways include cut branches and woody plants for planting, the latter particularly if the plant is in poor health. Once established, natural dispersal has apparently been the primary manner of spread within Europe and North America.

	Very unlikely	Unlikely	Moderately likely	Likely	Very likely
Infested timber				x	x	
Infested packaging				x		
Plants for planting		x				

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

Xylosandrus germanus is considered to be established in the UK. However, the likely source and the full extent of its UK range are unknown at this time.

Regarding its climatic range, *X. germanus* is widespread across western Europe, but appears to be limited by lower temperatures encountered at higher altitude. Very few individuals have been recorded above 350m in the Ardenne, Belgium (Henin and Versteirt 2004), although moderate abundance was recorded up to 575m in Bavaria (Blashke and Bussler 2012). Given the relatively low altitude of most of the UK's forests, the temperate climate, and the polyphagous nature of the insect, its eventual widespread establishment in the UK would appear very likely.

Hosts of *X. germanus* are not usually grown under protection, and ambrosia beetles are not considered pests of protected cultivation, so establishment under protection is very unlikely.

Establishment outdoors	Very unlikely		Unlikely		Moderately likely		Likely		Very likely	x
Establishment under protection	Very unlikely	x	Unlikely		Moderately likely		Likely		Very likely	

10. How quickly could the pest spread in the UK?

Trapping studies suggest that *X. germanus* has good mobility over distances of up to 2km (Grégoire *et al*. 2001), but longer distances may be achieved by some individuals, particularly if assisted by air currents (CABI 2014). However, initial rates of spread in the US and Europe suggest movements of several tens of km/year (Henin and Versteirt 2004), presumably assisted by the movement of infested timber, and it has become very widespread in both of these regions. Additionally, since reproduction occurs by sibling mating within the brood gallery, dispersing females are already fertilised, meaning that the initial spread of the species is not limited by difficulties of mate location in a small population (Kirkendall and Faccoli 2010). Rate of spread may be expected to reduce in the cooler parts of the UK (with lower mean spring to autumn temperatures), where development rate would be reduced, generation time increased, and the flight threshold temperature of approximately 21°C (Zhang 2008, Reding *et al*. 2013) achieved later in the year.

Natural spread:	Very slowly		Slowly	x	Moderate pace	x	Quickly		Very quickly		
In trade:	Very slowly		Slowly		Moderate pace	x	Quickly	x	Very quickly		

11. What is the area endangered by the pest?

The highly polyphagous nature of *X. germanus* means that it is capable of colonising a wide range of deciduous and coniferous woodlands and nurseries throughout the UK. It may reach its climatic limits in the far north of the country, particularly at higher altitude, but there appear to be no restrictions limiting the spread of this pest species right across the UK. A widespread distribution would then enable the pest to respond locally anywhere within its UK range to trees made susceptible by factors such as drought, disease, or attack by other insects. This makes it difficult to predict where such attacks may occur, but woodlands impacted by disease (e.g. ash dieback, or Acute Oak Decline) might be subject to larger and more damaging populations of *X. germanus* and other ambrosia beetles.

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

Damaging attacks have been observed on stored logs, including spruce and pine (Graf and Manser 2000) and oak and beech (Maksymov 1987). The beetle's galleries rarely extend deep into the wood, but the inoculated ambrosia fungus stains the timber around them. In association with other ambrosia beetles *X. germanus* has damaged grapevine in Europe (Boll *et al*. 2005), and the roots of tea plants in Japan (Kaneko 1967), whilst attacks on apparently healthy nursery trees have been documented on chestnut (*Castanea mollissima*) (Oliver and Mannion 2001) and black walnut (*Juglans nigra*) (Weber and McPherson 1984a). The insect shows a preference for attacking younger black walnut trees up to 8 years old, causing top dieback, profuse basal epicormic sprouting and a reduction in tree growth (Weber and McPherson 1984a, Katovich 2004). Direct mortality of such hosts is relatively rare, but attacks may additionally introduce pathogenic *Fusarium* fungi causing cankers and wilting (Kessler 1974, Katovich 2004). Reported attacks on other apparently healthy tree species include oak (Heidenreich 1964), elm and maple (Weber and McPherson 1983).

Xylosandrus germanus however appears to be primarily a secondary pest, attacking physiologically stressed hosts, often in association with other ambrosia beetles including *Trypodendron* spp., *Xyleborinus saxesenii*, *Xylosandrus crassiusculus*, and *Xyleborus dispar* (e.g. Kaneko 1967, Grégoire *et al*. 2001, Oliver and Mannion 2001, Bouget and Noblecourt 2005). Ethanol is a key stress-related volatile emitted by physiologically stressed hosts, and has been demonstrated to be a primary host-selection cue for *X. germanus* (Ranger *et al.* 2010). Hosts which may appear healthy but are in fact subject to environmental stress such as drought or flooding may emit ethanol signifying their suitability for attack (Ranger *et al*. 2013).

Xylosandrus germanus has been reported to become highly abundant once it has established in broadleaf forest, apparently becoming one of the most numerically dominant bark beetles in a range of forest types (e.g. Grégoire *et al.* 2001, Oliver and Mannion 2001, Bouget and Noblecourt 2005). In its native range, it is also an abundant species (Ito *et al*. 2009), but as an invasive its abundance may be detrimental to native scolytine species, which may be outcompeted.

	Very small		Small		Medium		Large		Very large	
Economic:						x				
Environmental:				x		x				
Social:				x		x				

13. What is the pest's potential to cause economic, environmental or social impacts in the UK?

A wide range of potential host plant species are available in the UK to *X. germanus*, and the majority of Britain is likely to be climatically suitable to establishment. Its damage potential is therefore likely to be similar to that in northern Europe, where the pest primarily attacks stressed, dying, or recently dead trees, and recently felled timber.
Unlike in the USA, where attacks on nursery trees by *X. germanus* are reported (and sometimes concurrent with the related *X. crassiusculus*), there is no evidence of damage to nursery trees in Europe attributed to *X. germanus*. However *X. germanus* was present in Ohio for over fifty years

before it became a problem in nursery tree production (Mike Reding, *pers. Comm.* 06.01.2015), and it is possible that damage from Ambrosia beetles in European nurseries has been reported without being linked to this species – leading to uncertainty over potential future impacts on this sector.

However, levels of damage may increase and become more frequent as forests are influenced by the predicted effects of climate change, such as increased mean temperatures, changes in rainfall pattern (leading to flooding and drought events), and increased frequency of storms and other extreme weather events. Forest damage from storms, severe frost, and flooding have all been shown to benefit ambrosia beetles (Bouget and Noblecourt 2005, La Spina *et al*. 2013, Ranger *et al.* 2013), and precipitate large scale attacks in deciduous forest (e.g. Grégoire *et al.* 2001, Henin *et al*. 2003) in which *X. germanus* becomes active and very abundant. The potential for interactions with plant pathogens is also quite high given the range of host plants suitable for *X. germanus.* For example, diseases as diverse as *Dothistroma* needle blight on pine, Acute Oak Decline on oak and *Chalara fraxinea* on ash may all increase the availability of suitable host trees.

	Very small		Small		Medium		Large		Very large	
Economic:						x				
Environmental:				x		x				
Social:				x		x				

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

As an ambrosia beetle, *X. germanus* carries the mutualistic fungus *Ambrosiella hartigii* in specialised structures (mycangia). This is usually non-pathogenic to plants, although it does cause staining of timber around the galleries created. *X. germanus* has been experimentally shown to be capable of vectoring the Dutch elm disease pathogen *Ophiostoma ulmi* (Buchanan 1940), but is not considered to be an important vector. Of more concern is its frequent association with fungi of the genus *Fusarium*, which have been isolated from galleries in attacked black walnut and oaks (Heidenreich 1964, Kessler 1974, Weber and McPherson 1984b, Katovich 2004), where they caused cankers, wilting and dieback. Vectoring of *Fusarium* is probably accidental, since it does not appear to be transported in the mycangia (Weber and McPherson 1984b), but any association with this genus raises concerns due to the many plant pathogenic species it includes (Booth 1971).

STAGE 3: PEST RISK MANAGEMENT

15. What are the risk management options for the UK?

Detection of endemic-level populations and determining the current distribution of *X. germanus* with greater certainty requires additional targeted trapping in the field. This has been carried out in 2013 and 2014 by Forest Research. Inspection of potentially infested material may be made visually, but adults are small (approx. 2 mm long), and tunnel into wood where brood galleries are constructed. The galleries may not be readily observed in timber or host plants (entrance approx. 1mm diameter), although a slender cylinder of frass pushed out of the entrance may be apparent (up to 50mm length). Adults tend to remain within the galleries, except during dispersal. Bark beetle identification requires specialist knowledge, although it is quite a distinctive species. For monitoring purposes, ethanol is highly attractive to *X. germanus* (Ranger *et al.* 2010), and can be employed as a lure to attract dispersing female adults to traps, during their flight period (peak May-

June in the UK and Europe). Full results from the targeted surveys carried out in 2014 across the UK should be available soon.

Given the dispersal abilities of the adult females, and expected wider distribution in southern England, no containment measures are presently being considered. The cryptic nature of the life cycle within the host also makes it difficult to control an attack effectively. Tests of insecticide control have met little success (Kaneko 1967). Pesticide use must be carefully timed with the attack period, applied repeatedly, or have a long residual effect (Oliver and Mannion 2001), and is likely to be effective only on a small scale, for example for high value or amenity trees. Destruction of infested material may reduce the local population size and reduce the risk of attack upon other susceptible trees nearby. No natural enemies appear to have been recorded from the species (CABI 2014).

Attacks upon nursery trees tend to concentrate on those weakened by poor growing conditions or with stem injuries (Katovich 2004). Good silvicultural practice should be applied to prevent this, including the selection of optimal planting sites for the tree species. To avoid infestation of harvested timber, logs should be removed from the forest as soon as possible, particularly during the beetle's flight period. Where an otherwise healthy-looking tree has been temporarily weakened (e.g. by drought) and attacked by *X. germanus*, evidence suggests that the tree may well recover with the timely return of more favourable conditions (e.g. Weber and McPherson 1984a), unless subject to a sustained attack from other pests or pathogens.

16. Summary and conclusion of rapid assessment.
This rapid assessment shows:

Likelihood of entry: HIGH.
The potential for entry via a wide range of host plants, and along numerous pathways, is available to *X. germanus,* whilst its small size and cryptic lifestyle makes it difficult to detect in host material. It has entered the UK and is currently known from two locations in Hampshire, 70 km apart.

Likelihood of establishment: HIGH, with moderate to rapid spread.
The beetle is highly polyphagous and the majority of the UK is climatically suitable for its establishment and spread. Multiple individuals have been collected on three successive years in northern and recently southern Hampshire, and it is considered to be established here.

Economic, environmental and social impact is expected to be: SMALL to MEDIUM
The beetle tends to attack stressed or dying hosts and recently felled timber. To date it has caused limited mortality in its established range, but has been involved in damaging attacks on deciduous trees, often in association with other ambrosia beetles. It is also occasionally associated with *Fusarium* species of fungi on some hosts. Increased host availability is likely to be influenced by severe climatic events and disease.

Endangered area:
All of the UK, except perhaps at higher altitudes and in the far north. A very wide range of woody plant species are available as hosts.

Risk management:
Better understanding of its current distribution (by targeted trapping) is being addressed. Options for control/management of an outbreak are limited, for example containment by restricting movement of wood would be unsuccessful due to its good dispersal abilities and polyphagous nature. Risk of damaging attack may however be reduced by good silvicultural management.

17. Is there a need for a detailed PRA?

Although this is a 'rapid' PRA, a thorough review of the literature was undertaken. At this time, there is little additional information available for *X. germanus*, and a better understanding of its current status in the UK would be desirable before a detailed PRA is performed.

Yes ☐ No ☒

If yes, select the PRA area (UK or EU) and the PRA scheme (UK or EPPO) to be used.
PRA area: UK or EU? ☐ PRA scheme: UK or EPPO? ☐

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