Plant biosecurity and Perennial Green Manure (PGM) systems – considering pest threats and management measures to minimise the risk of introducing and spreading notifiable pests.

Date: September 2023

Details of Contract

This report was a short (3.5 days) desk-based study aimed at providing an insight into the potential pest threats that may be associated with PGM systems and the biosecurity measures that could be implemented to minimise pest risks. The report was commissioned by Perennial Green Manures Project, part of Ecodyfi (www.ecodyfi.wales).

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Summary

The damage from new or exotic plant pests (including diseases) to cultivated and natural plant life in Great Britain (GB) is a problem that is causing considerable concern. In recent decades the rising rate of new plant pest occurrences has been attributed mainly to an increase in international trade. This includes the supply of live plant material from international sources that can potentially be infested (or infected) by exotic plant pests and moved into new regions if effective regulatory and industry-led (voluntary) biosecurity measures are not implemented.

Over twenty such plant pests have been introduced into GB since the turn of the millennium, these include (year of introduction): oak processionary moth (2008), ash dieback (2011), and chestnut blight (2011). Some of these plant pests have a narrow host range, meaning that they only infest a small number of plant species. Other plant pests are polyphagous meaning that they have wide host ranges. Ramorum disease (2002) is an example of a polyphagous plant pest and it can infest over 150 plant species. Once a new pest is introduced into a country and it is not eradicated, it can spread further via a number of pest movement pathways such as: the movement of plant material via national supply chains, on machinery and even on footwear.

To help prevent further pest introductions and spread, a Plant biosecurity strategy for Great Britain (2023 to 2028)[1] was published as it is recognised that plants are a crucially important part of our economy, from agricultural and horticultural production to timber, medicines and wider co-benefits including for public wellbeing.

Many land management practices that involve the cultivation, management and movement of live plant material present a potential risk of inadvertently moving new and damaging plant pests. However, these threats have been reduced by enhanced regulations and the development of voluntary standards to support the application of effective biosecurity measures by professionals who cultivate, manage and trade live plants and plant products. These measures and actions help protect GB's plant life.

The potential benefits of PGM crops to support sustainable horticulture and agriculture production systems is currently being explored by researchers in the Dyfi Biosphere (Wales). As part of their research they have sought proactively to examine the potential exotic or notifiable pest threats to PGM production systems. The method for conducting this research into potential pest threats was to use the publicly available UK Plant Health Risk Register to identify the highest risk pest threats that could infest a selection of PGM crops should pests either be introduced to, or spread further if they are already present in Wales.

This information is key to understanding the measures can be put in place to ensure that the cultivation of PGM crops is carried out in a biosecure manner. This report identifies the highest risk pests, provides information on the pathways for the potential spread of these pests and proposes a non-exhaustive list of measures that could be applied to PGM crops to support effective pest risk management systems. As PGM cultivation, harvesting and processing systems develop further, additionally measures can be identified that may also help minimise the pest threat to an Acceptable Level of Protection, as detailed in the GB's Plant Health Management Standard, which is referred to in this report.

Four recommendations for further research or next steps are proposed. These are: (i) explore and identify pest control options for the Integrated Pest Management regimes for the pests identified;

[1] Plant biosecurity strategy for Great Britain (2023 to 2028)

(ii) Work with Natural Resources Wales to classify PGM products and determine the regulations that cover proposed systems of production and application of PGM products; (iii) Explore the effectiveness of heat treatments and pasteurisation processes as a means of minimising pest risks in PGM systems;(iv) Develop a set of PGM case studies to demonstrate how effective plant biosecurity measures can be integrated into PGM production systems.

Plant biosecurity and Integrated Pest Management (IPM)

Biosecurity refers to a set of precautions that aim to prevent the introduction and spread of harmful organisms. These include non-native tree [and plant] pests, such as insects, and disease-causing organisms, called pathogens, such as some bacteria and fungi.[2]

Integrated Pest Management (IPM) is an approach that involves the management of a pest instead of controlling or eradicating a pest. It requires a greater knowledge of the pest, crop and the environment. Therefore, its strategy focuses on harnessing inherent strengths within ecosystems and directing the pest populations into acceptable bounds rather than toward eliminating them.[3]

IPM implies that the target pest or pests are present and require a pest control strategy for the plants that are being cultivated and/or protected. Plant biosecurity relates closely to IPM systems in that biosecurity aims to prevent the need for controlling new pest species by preventing their introduction and spread into or within a new area.

Plant biosecurity in Great Britain (GB)

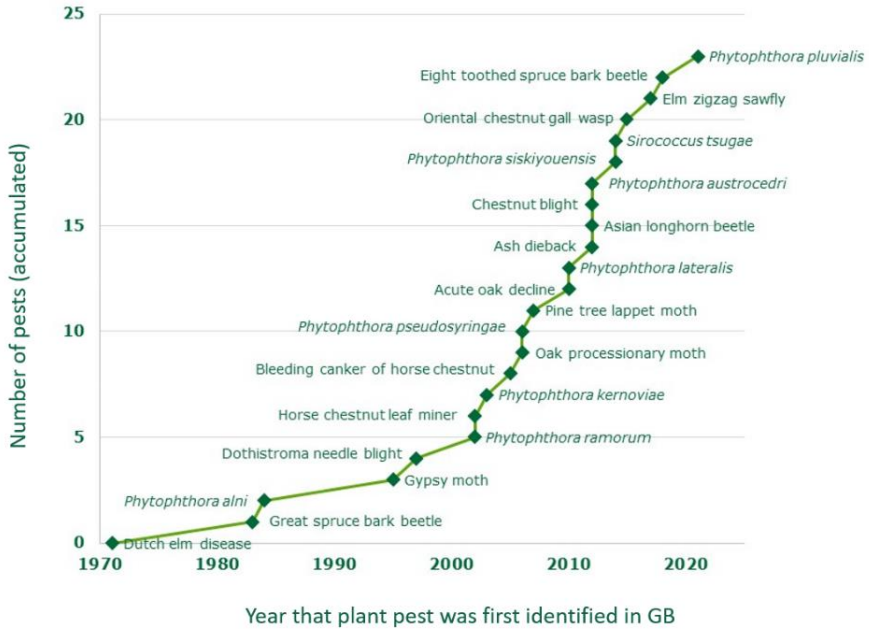
The risks to plant health from new or exotic plant pests (and pathogens)[4] as a result of the movement of live plant material and associated products is a threat that has caused increasing concern in recent decades. This is the case in Great Britain (GB) with over twenty such plant pests being introduced since the turn of the millennium. The graph below, sourced from the Forestry Commission, shows some (not all) of the tree plant pests that have arrived recently into GB. The reason for the increase in the rate of pest introductions has been ascribed to globalisation, i.e. global trade, passenger movements and trading in plants and plant products have increased dramatically over the last 10 to 15 years, resulting in increased risk of importing pests and diseases. In 2017, for example, over 300 different pests and diseases were intercepted at our [GB] borders.[5]

[2] https://www.gov.uk/guidance/prevent-the-introduction-and-spread-of-tree-pests-and-diseases

[3] Integrated Pest Management. C.O. Ehi-Eromosele, O.C. Nwinyi and O.O. Ajani (2013)

[4] In this paper and in line with the International Plant Protection Convention's (IPPC) definitions, the term pest includes pathogens (i.e. plant diseases) and the term infest includes infect.

[5] European Union Committee - Brexit: plant and animal biosecurity. 21st Report of Session 2017-19 - published 24 October 2018 - HL Paper 191



Graph showing some (not all) of the tree plant pests that have arrived into GB and the dates that they were identified. Source: Forestry Commission.

The spread of new plant pests is not only an international issue. Notifiable plant pests can spread within GB. The *Phyto-threats* project (Forest Research) was established to address the risk of Phytophthora spread through nursery practices. Over a three-year period approximately 4000 water and root samples were collected from plant nurseries located across Britain. These included fifteen partner nurseries intensively sampled in a 'finescale' survey and a further 118 nurseries sampled as part of a 'broad-scale' survey. Samples were tested for the presence of Phytophthora DNA using a state-of-the-art metabarcoding approach. Approximately 50% of all samples were positive for Phytophthora, with over 50 *Phytophthora* species identified across all samples including quarantine regulated pathogens and species not previously reported in the UK. Some of the most diverse Phytophthora assemblages were found in river water used to irrigate plants and in open reservoir irrigation sources, as well as in puddles which formed around plant stock, confirming that effective water treatment and good drainage are essential components of *Phytophthora* management.[6]

It is useful to draw a distinction between native plant pests, which have evolved as component parts of ecosystem function and 'exotic' or 'alien' organisms that have been recently introduced or have been identified as a threat to a region's cultivated and native flora if this type of pest were to arrive in a new area and establish. Generally speaking the pests that plant biosecurity is concerned with halting the spread of is the latter group, that is pests which are non-native and can infest host plant species which have not evolved effective physiological mechanisms to repel or tolerate the presence of novel and injurious organisms. Plant biosecurity measures are aimed at halting the spread of non-native or alien plant pest species along the pathways in which they can potentially move. Plant biosecurity measures also confer a degree of protection against plant pest species that are considered widespread or established within in a region. Some of these established pests may cause economically unacceptable damage and therefore are also regulated with a view to minimising their impact.

[6] https://www.forestresearch.gov.uk/research/global-threats-from-phytophthora-spp-phyto-threats/

Plant pests - key definitions

Plant pests which did not naturally evolve in a region can be described using several terms, for example: non-native, exotic, alien, quarantine or notifiable pests.

A pragmatic definition is the use of the International Plant Protection Convention (IPPC) terms[7]: quarantine pests and regulated non-quarantine pests as these terms are used for the authorisation to issue Plant Passports in the UK:

Quarantine pest (QP)

A pest of potential economic importance to the area endangered thereby and not yet present there, or present but not widely distributed and being officially controlled [FAO, 1990; revised FAO, 1995; IPPC 1997]

Regulated non-quarantine pest (RNQP)

A non-quarantine pest whose presence in plants for planting affects the intended use of those plants with an economically unacceptable impact and which is therefore regulated within the territory of the importing contracting party [IPPC, 1997]

Both QPs and RNQPs are notifiable, meaning that they must be reported to the National Plant Protection Organisation (NPPO) or an agency delegated by NPPO if such an organism is identified or suspected. Plant Passports need to be issued by professional operators, e.g. plant nurseries, when supplying plants to other professional operators. The criteria to be fulfilled by professional operators authorised to issue plant passports can be found in Article 89 of Regulation (EU) 2016/2031[8] which has been retained by the UK after leaving the European Union.

If a Quarantine pest or Regulated non-quarantine pest is suspected on plants growing in a nursery, on a farm or in the wider environment then it should be reported to the appropriate authorities for the region (see Defra Plant Health Portal[9]) or by submitting a report to Forest Research via the Tree Alert[10] web portal.

The UK Plant Health Risk Register (UKPHRR)

As a result of the independent Task Force on Tree Health and Plant Biosecurity the UK Plant Health Risk Register (UKPHRR) was established and is a publicly available. The UK Plant Health Risk Register is part of GB's approach to plant health risk and is a tool for government, industry and stakeholders to prioritise action against pests and diseases which threaten our crops, trees, gardens and countryside. The UK Plant Health Risk Register does not represent a comprehensive record of all pests of plant health concern, it is an evolving document to which more pests are being added every month.[11]

Biosecurity risks associated with land management practices

There are plant biosecurity risks associated with many land management practices. This is reflected in the inclusion of plant biosecurity measures in the United Kingdom Forestry Standard[12] and with Government stating that Defra will reward and incentivise good biosecurity practices through the Environmental Land Management and other Future Farming schemes.[13] The international

[7] https://assets.ippc.int/static/media/files/publication/en/2023/07/ISPM_05_2023_En_Glossary_PostCPM-17_2023-07-12_Fixed.pdf
[8] https://www.legislation.gov.uk/eur/2016/2031/article/89
[9] https://planthealthportal.defra.gov.uk/pests-and-diseases/reporting-a-pestdisease/
[10] www.treealert.forestresearch.gov.uk
[11] https://planthealthportal.defra.gov.uk/pests-and-diseases/uk-plant-health-risk-register/index.cfm
[12] The UK Forestry Standard The governments' approach to sustainable forestry (2017)
[13] Plant biosecurity strategy for Great Britain (2023 to 2028)

movement of fresh produce and live plants via ornamental horticultural supply chains are also considered pathways of concern for the movement of notifiable plant pests. The polyphagous bacterial plant pathogen *Xylella fastidiosa* has caused particular concern in the horticultural sector as over 600 plant hosts, which include many plant species used for forestry, farming and ornamental purposes. The European Food Safety Authority describes *Xylella fastidiosa* one of the most dangerous plant bacteria in the world. It causes a wide range of diseases, with huge economic impact on agriculture, gardens and the environment.[14]

PGMs and legislation concerning the movement of plant material.

PGM or Perennial Mobile Green Manure (PMGMs) systems involve the cultivation of plant material that is then transferred as an input into another agricultural system on a separate site for soil improvement, i.e. as an organic fertiliser. PGMs are a novel cropping system which can potentially use several plant species.

PGM / PMGM systems are under development with researchers looking at practical aspects of the technique, for example how best to harvest, store and apply PMGMs[15]. The cropland, where the PGM is applied, may be fertilised with fresh, dried or pelleted leaf material.[16] Therefore the way that a PGM is processed provides an opportunity for minimising the risk of pest movement and spread.

If a PGM crop becomes infested with a notifiable plant pest then a Statutory Plant Health Notice (SPHN) may be applied, depending on the pest species. Forestry, environmental and waste legislation are devolved issues and in Wales, where the PGM initiative is being developed, the authority that overseas SPHNs and associated plant health legislation is Natural Resources Wales (NRW). For details of SPHNs in relation to Scotland contact Forestry Land Scotland[17] and in England contact Forestry England[18].

Waste legislation is also covered by NRW. PGM material may have similar qualities to materials that are classified as waste, however PGMs are the primary product of a cropping system, rather than a co-product, by-product or waste material. It is recommended that NRW are contacted to assess and classify what type of material a PGM is designated in terms of how PGMs relate to all relevant legislative requirements.

[14] https://www.efsa.europa.eu/en/press/news/190515-0
[15] Climate-wise agriculture – how best to fertilise our crops? Clean Slate
[16] https://www.dyfibiosphere.wales/perennial-green-manures
[17] https://forestryandland.gov.scot/
[18] https://www.forestryengland.uk/

Methodology – assessing the potential biosecurity risks associated with PGMs

The aim of this report is to understand and manage proactively the plant biosecurity risks associated with PGMs in GB. To do this the UKPHRR was used to identify the plant pests associated with the following host species that have been identified for potential use in PGM systems:

- *Alnus* genus (alder)
- *Corylus avellana* (hazel)
- *Cytisus scoparius* (common broom)
- *Laburnum anagyroides* (common laburnum)
- *Salix* genus (willow)
- *Symphytum officinale* (comfrey)
- *Ulex europeaus* (common gorse)

Once the plant pests had been identified for each of the above species a variation of the Plant Health Management Standard's Site and Operations Pest Risk Assessment (SOPRA)[19] was adapted and used to indicate how the general threat from notifiable pests can be mitigated and minimised by applying plant biosecurity measures within PGM systems.

The UKPHRR mitigated risk-ratings were used as the initial risk level for PGM systems as this is the assessed risk to the UK with legislation or industry certification schemes in place.[20] One of the following five risk levels, based on the mitigated risk rating were assigned to each pest: Low (blue), Low/Medium (green), Medium (yellow), Medium/High (orange), High (red). These levels are based on table below which is taken from the guidance document for the UKPHRR:

Rating	**Colour & score**				
	Blue	**Green**	**Yellow**	**Orange**	**Red**
Likelihood, spread, impact, value at risk, etc.	**1**	**2**	**3**	**4**	**5**
Likelihood x impact	**1-4**	**5-9**	**10-14**	**15-19**	**20-25**
Overall UK risk rating	**1-14**	**15-29**	**30-44**	**45-59**	**60-125**

In Appendix 1 a set of risk sheets can be found for each of the proposed PGM plant taxa. The search was conducted using the genus level rather than the species level as some entries in the UKPHRR although entered as an individual species also relate to other species within a given genus.

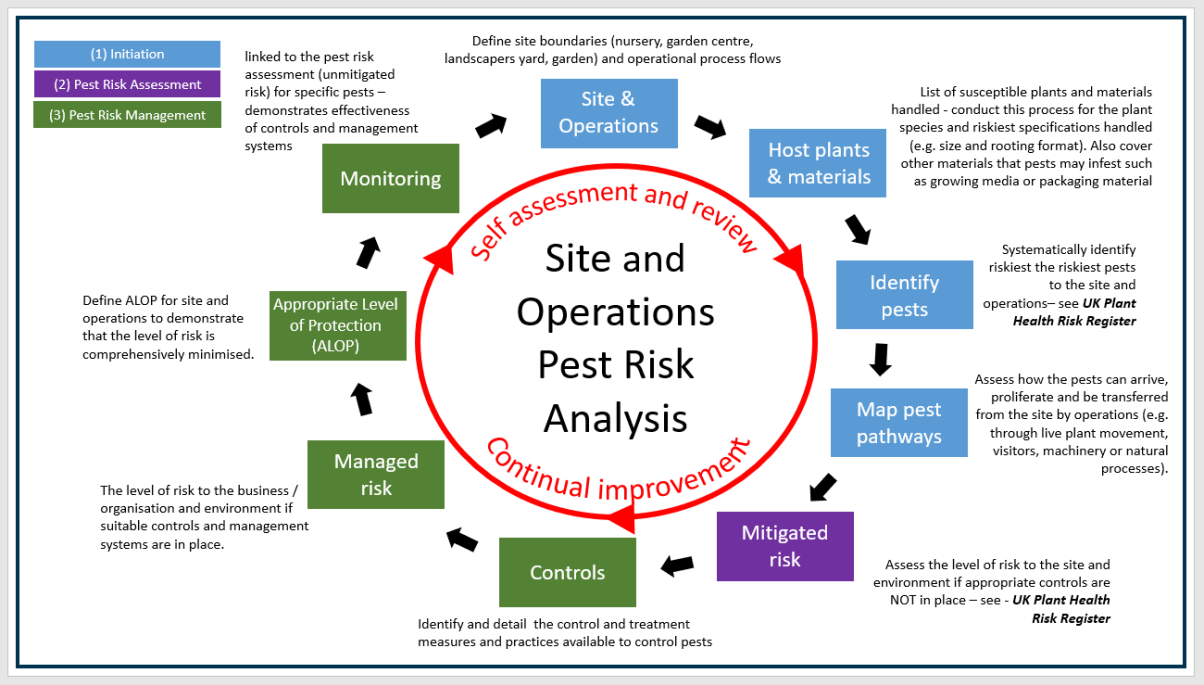
The pest risk sheets are simplified versions of the UKPHRR in that only selected fields from the UKPHRR database were used. These fields cover the common name (if available) and scientific name of the pest, type of organism, mitigated risk rating (if available), pathways, assessed risk for PGMs.

Two key concepts are integral to the SOPRA: World Trade Organisation's Appropriate Level of Protection; and International Plant Protection Convention's Pest Risk Analysis. These concepts have been adapted to be applicable to individual horticultural sites. The SOPRA process aims to match the notifiable pests that can potentially infest host plants that are grown or managed as part of a

[19] Plant Health Management Standard – Version 1.2. July 2022
[20] Guidance document for the UK plant health pest risk register. Summer 2021

horticultural site. The same principal is applied to PGM systems however rather than applying the process to an individual site this report applies the principles of the SOPRA generically to the concept of PGMs. In practice, each PGM system will be unique, for example in terms of the location, the plant species used, cultivation systems, harvesting and processing methods. This initial framework can be developed and therefore support the pest risk management approach for an individual farm's PGM systems.

Below is a schematic of the steps covered in the PHMS's Site and Operations Pest Risk Analysis.



Site and Operations Pest Risk Analysis schematic from the Plant Health Management Standard V1.2.

Rationale for determining risk in the context of a PGM system

For the seven PGM plant species assessed, 116 pest species were identified from the UKPHRR. For the purposes of this exercise the High, Medium / High and Medium mitigated risk-rated pest species that have a presence in the UK were prioritised. The approach assumes that plants for PGM systems can be readily sourced from UK nurseries where the live plant material does not come from international sources. There is a threat that plants or plant material may be sourced from GB nurseries that import plants that are not used for PGM systems and there is a risk of cross contamination between GB grown plants and internationally sourced plants. To minimise this threat, it is recommended that plants are sourced from nurseries that have pest risk management plans in place based on the Plant Health Management Standard.

Addressing the highest risk pests prior to systematically considering lower risk pest species is in line with the SOPRA guidance. This approach aims to avoid the highest impact pest threats first. The biosecurity measures implemented for these pests should also confer a degree of protection against lower risk plant pests as several of the mitigation measures will minimise the risk of pests moving along pathways common to several types of plant pest.

Appendix 2 presents a table of nine pest species that have a mitigated risk rating of 30 or above and are classified as present in the UK as either widespread, limited or unknown in their distribution. Out of the seven plant taxa considered in this report the UKPHRR indicates that three genera have associated plant pest species that are present in the UK and have a mitigated risk rating of 30 or

above. Two of the pest species are common to more than one of the plant taxa - *Phytophthora ramorum* and *Xylosandrus germanus* are hosts of both *Corylus spp.* and *Salix spp.*

Both appendices provide information on the main pathways for each pest to spread. The information on pathways is provided by the UKPHRR. There are limitations to the information on the UKPHRR which are detailed on the website. It should also be noted that the pathways described are the pathways that a pest is most likely to spread. It should be assumed that it may be the case that the pest can spread via other pathways that are not listed. Specialist advice should be sought for the main pest and diseases for the plant taxa considered in this report.

A description of each pest (from the UKPHRR) and potential mitigation measures from various sources are as follows:

- ***Phytophthora alni* – host *Alnus spp*.**

UKPHRR – general comments: Damaging pathogen of alder; first detected in the UK in 1993; which has subsequently spread to most areas of the UK. Alders are important in the context of watercourse management. No prospect of eradication or containment but possible co-ordinated action to mitigate impacts to be considered with stakeholders.

Management and control – Forest Research advise the following measures.[21]

- Evaluate nursery stock for infection before buying alder plants.
- Ensure good biosecurity practice in nurseries to prevent infection.
- Be aware that planting alder on river banks that are liable to flooding and where the disease already occurs presents a high risk.
- Coppice diseased trees, which can often regenerate them.

- ***Melampsoridium hiratsukanum* (alder rust) – host *Alnus spp*.**

UKPHRR – general comments: Fungal pathogen of alder; established in the UK and elsewhere.

This pathogen is present in the UK and was confirmed for the first time in Wales on samples collected in 2000 (N. Stringer, pers comm.) from the native alder *Alnus glutinosa* and *A. cordata* and *A. incana*, which are introduced species.[22]

Management and control – no advice found

- ***Phytophthora siskiyouensis* – host *Alnus spp*.**

UKPHRR – general comments: Pathogen causing disease of alder and other tree species in the USA and Australia; now detected in the UK. Could possibly be mistaken for *Phytophthora alni*. A Pest Risk Analysis (PRA) will help to better assess the risk to the UK.

In late summer 2013, stem cankers and sparse foliage were reported on European grey alder (*Alnus incana*) growing on a 500-hectare site recently-planted with broadleaf and coniferous trees in south-west England.[23]

[21] https://www.forestresearch.gov.uk/tools-and-resources/fthr/pest-and-disease-resources/phytophthora-disease-of-alder-phytophthora-alni/
[22] https://planthealthportal.defra.gov.uk/data/pests/27245/data
[23] https://www.ndrs.org.uk/article.php?id=031017

Management and control – no advice found

- ***Phytophthora ramorum* – host *Corylus and Salix spp*.**

UKPHRR – general comments: Pathogen of larch and other hosts subject to a containment strategy in the UK; reflecting its presence in wider environment/forestry settings in some areas.

Management and control – Forest Research details best practice[24] as follows:

The following are the minimum measures which will help to minimise the spread of phytophthora diseases – or any other plant diseases – from infected woods and forests.

- Ensure staff are aware of guidance.
- Carry recommended biosecurity equipment when visiting infected woodland.
- Ensure that footwear, tools, equipment, plant and machinery are free from any soil and plant debris before leaving the site by brushing off as much soil and plant debris as is reasonably practicable. This is already common practice when moving machinery from site to site via main roads, and we suggest it be extended to all movements of plant, machinery, tools and equipment within the forest.
- In areas where either *P. ramorum* or *P. kernovii** infection is detected, a Statutory Plant Health Notice (SPHN) will impose measures including, in addition to the above, disinfection with an appropriate fungicide. (See below.)

* Please note that the plant pathogen *P. kernovii* [*P. kernoviae*[25]] is included in Forest Research's general guidance for Phytophthora species. *P. kernoviae* is not currently listed as a pest of the PGM hosts that have been considered in this report.

- ***Xylosandrus germanus* – host *Corylus and Salix spp*.**

UKPHRR – general comments: Ambrosia beetle affecting a wide range of trees and woody hosts. Widespread in Europe and elsewhere and now present in the south of England. Impacts can be reduced by good silvicultural practices.

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 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.

Management and control – 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. Pesticide use must be carefully timed with the attack period, applied repeatedly, or have a long residual effect, 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.

[24] https://www.forestresearch.gov.uk/tools-and-resources/fthr/pest-and-disease-resources/ramorum-disease-phytophthora-ramorum/phytophthora-manual-3-biosecurity-measures/
[25] https://www.forestresearch.gov.uk/tools-and-resources/fthr/pest-and-disease-resources/phytophthora-kernoviae/

Attacks upon nursery trees tend to concentrate on those weakened by poor growing conditions or with stem injuries. 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, unless subject to a sustained attack from other pests or pathogens. [26]

- ***Colletotrichum acutatum* - host *Corylus spp*.**

UKPHRR – general comments: Fungal pest of strawberry and other hosts.
Colletotrichum acutatum is a common fungal pathogen of a wide range of crops and wild plant species, having been recorded on more than 40 hosts worldwide since it was first described by Simmonds in 1965. It is now recognized as a cosmopolitan pathogen causing anthracnose diseases on a number of economically important crops. In strawberries, *C. acutatum* causes extensive losses in fruit production, and is considered the world's second most important pathogen after *Botrytis cinerea* in terms of economic impact.[27]

- ***Takahashia japonica* - host *Salix spp*.**

UKPHRR – general comments: Scale insect present in East Asia and invasive in Italy; polyphagous on deciduous; woody trees. Unlikely to pose a significant threat to UK plant health.

Takahashia japonia is a scale insect (Hemiptera: Coccidae) native to East Asia, that was first detected in Europe in Italy in 2017. It is polyphagous, feeding on a wide range of deciduous trees including many that are commonly found in the UK. It was first recorded in the UK in December 2018 infesting a Magnolia that had been planted three years previously in a private garden. The insect was reported to the Royal Horticultural Society (RHS) who informed the Animal and Plant Health Agency (APHA) and a sample submitted to Fera Science Ltd for confirmation.

Takahashia japonica was added to the UK plant health risk register shortly after it was first reported from Europe. At that time, a decision was made that statutory action be taken against interceptions on recently imported plants, but not against finds on established plants. This approach would reduce the risk of the pest being introduced to the UK and being spread rapidly through trade, but also reflected the relatively low threat the pest is thought to pose. It remains uncertain how well T. japonica may establish in the UK. To date, it has largely been recorded from geographical regions with hotter summers than in the UK and the climate here may prove to be marginal for the species, despite it apparently surviving for three years in the UK. [28]

Management and control – no information found for this pathogen on *Salix spp.*

[26] https://planthealthportal.defra.gov.uk/data/pests/22313/data
[27] https://bsppjournals.onlinelibrary.wiley.com/doi/10.1111/j.1365-3059.2012.02647.x
[28] https://planthealthportal.defra.gov.uk/data/pests/27909/data

Approaches to mitigating pest threats for PGMs – a systems approach

The section above provides some pest management guidance for some of the higher risk pest species. In both of the appendices there are columns that indicate potential movement pathways for all of the plant pests of the selected PGM taxa. Below a list of measures is set out that can be implemented in a PGM system with the aim of helping minimise the pest risk. The list is not exhaustive and is presented with a view to be adapted and enlarged as PGM systems evolve and the threat from plant pests is increasingly understood.

Some of the measures will address individual pathways and others will generally improve plant biosecurity and plant health through sensible agronomic measures such as site assessments and crop hygiene practices.

Critical control points should be identified as part of the design process of a PGM system. A critical control point (CCP) is a point, step, or procedure at which control can be applied and a hazard can be prevented, eliminated, or reduced to acceptable levels. Multiple measures can then be implemented throughout the PGM system which together will minimise pest threats further. This design process is called a 'systems approach' and aims to manage pest threats proactively. The systems approach to plant biosecurity is an area of development by researchers and regulators and should augment traditional phytosanitary systems. Traditional approaches are essentially reactive; they rely on endpoint inspections to detect infested plants and do not address unknown pathogens or pests. In contrast, systems approaches are proactive; they aim to reduce the risk of infestation by correcting unsafe nursery practices for all pathogens and pests.[29] Although much of the focus of a systems approach to plant biosecurity has been focussed on nursery systems and the movement of ornamental or amenity plants, the principle can also be applied to any forestry, farming or landscape plant cultivation and management system.

Measures for improving plant biosecurity (and plant health) in PGM systems

- **Plant Biosecurity Policy**

A policy document for a land-based business or operation that uses plants and plant material is a good basis for taking a proactive approach to plant biosecurity. The document enables land managers (e.g. managers of PGM systems) to set out a statement of intent to identify potential pest threats specific to their site and operations and to mitigate these threats by implementing effective plant biosecurity measures. A good example of a policy template can be found in the Application of Biosecurity in Arboriculture – Guidance Note 2.[30]

- **Site assessment – right plant in the right place (buffer zones)**

Matching the right PGM species to a suitable site for growing is a fundamental agronomic consideration. Marginal sites may lower the vigour of a crop and predispose the plants to primary and secondary pest infestations. A useful tool for matching tree species to an area is Forest Research's Ecological Site Classification Tool.[31] The physical features of each planting site should be identified and direct the design of a planting plan, e.g. an extended non-intervention buffer zone may be put in place near or along water courses.

[29] Parke, J., & Grunwald, N. (2012). A systems approach for management of pests and pathogens of nursery crops. PLANT DISEASE, 96(9), 1236-1244. doi: 10.1094/PDIS-11-11-0986-FE

[30] https://www.trees.org.uk/Help-Advice/Biosecurity-Guidance

[31] http://www.forestdss.org.uk/geoforestdss/

- **Knowledge of the pests that infest the host plants**

As per the Site and Operations Pest Risk Analysis, identifying which hosts present a threat at the planning stage is a key factor to consider when planning and assessing the productivity of a PGM crop. Identifying if any tolerant or resistant cultivars are available to key plant pests is worth considering.

- **Presence of pest species**

If a plant pest is or is likely to be present or prevalent in an area then this should be considered in terms of what controls can be implemented to manage the impact of the pest on the PGM crop and what measures can be integrated into the production process to ensure that the cultivation and application of PGMs does not assist the spread of a pest within the environment.

- **Site preparation – hygiene measures**

Ensure that all equipment and machinery has been risked assessed for contamination and appropriate hygiene measures are taken to ensure a pest is not introduced onto the planting site.

- **Sourcing of plants – regulations**

Check that the regulatory requirements have been adhered to on the UK Plant Health Portal.[32]

This will help minimise the risk of pests being transferred via the plants for planting pathway.

- **Sourcing of live plant material and seeds – certified or assured nurseries**

Sourcing of live plant material and seeds from certified nurseries. There is the Plant Heathy Certification Scheme and the Woodland Trust's UK and Ireland Sourced and Grown assurance scheme.

This will help minimise the risk of pests being transferred via the plants for planting pathway.

- **Growing media and soil improvement**

If growing media or soil improver is being used in the production process check that the supplier has a biosecurity policy in place that ensure that any pest risks have been identified and minimised. See the guidance note on Biosecurity best practice for safe disposal of plant waste and spent growing media.[33]

This will help minimise the risk of pests being transferred via the soil and growing media pathway

- **Monitoring and reporting**

Once the PGM crop or crops are planted monitor the crops and the surrounding area for the presence of pests. If a notifiable pest is present then this must be reported to the relevant authorities

- **Pasteurisation**

[32] https://planthealthportal.defra.gov.uk/
[33] https://planthealthy.org.uk/assets/images/PHC2021_02-Plant-Waste-Guidance.pdf

Arboricultural arisings, such as woodchip, brash, stump grindings, bark and timber, are a concern in relation to transmission of plant pests (which can remain undetected within or on the arisings) as they are easily transported and stored.

A process for woodchip pasteurisation has been documented by Forestry Commission England[34]. The pasteurisation process reduces, and in some cases eliminates, pathogens using the heat generated by woodchip breaking down naturally when it is piled, just like a compost heap. This differs from sterilisation which works at high temperatures that cannot be generated by natural breakdown alone and results in the elimination of all pests and pathogens. An example of a custom-built and managed woodchip pasteurisation plant is at the Forestry Commission's Westonbirt Arboretum. This was designed and built after an outbreak of *Phytophthora ramorum*.[35]

- **Composting to PAS 100 standards**

PGM crops are currently not composted. However, if in the future composting is considered to be a useful control measure then PAS 100, Publicly Available Specification for Composted Materials, is a widely recognised standard within the organics recycling sector. It contributes to the concept of the circular economy as the base document for the end of waste criteria for compost. Independent certification against the end of waste criteria (including PAS 100 requirements) means that the material is no longer subject to waste regulatory controls and has achieved product status.[36]

As noted in a previous section, PGMs are a primary product and thus are not a 'waste' product. However, some PGMs potentially share qualities that are similar to material that is subject to waste legislation and this is an area that should be explored with NRW.

[34] Forestry England – Case Study – Heating it up. Woodchip treatment facility at Westonbirt National Arboretum.

[35] APPLICATION OF BIOSECURITY IN ARBORICULTURE. Arboricultural Association.

[36] https://www.qualitycompost.org.uk/standards/pas100

Conclusion

Plants for planting or other forms of live plant material are moved to meet society's food and fibre needs. Plants also serve many other purposes (e.g. cultural) and thousands of plant species are moved through ornamental plant supply chains for landscaping purposes. So, it should be noted that other land uses, e.g. the ornamental horticultural sector use a far wider range of plant taxa suggesting that these sectors will have to manage the threat from more pest species.

Another factor in the movement of plant pests is the way in which live plant material is cultivated, harvested, moved and used, as some aspects of plant or plant product production systems may act as pathways for pest spread. For example, a live plant that is propagated and grown in one region and then moved to another region where the plant is planted and grown in the landscape may present a greater threat than cultivated plant material that is harvested and processed locally. The processing of the plant material may inherently minimise or remove the threat, for example if the plant material is desiccated or heat treated in the production process of a product. Heat and desiccation processes are part of some PGM systems and should be assessed as a potential pest control measure.

This paper has considered seven taxa that can be used in PGM systems and, using the available information on the UK Plant Health Risk Register, identified medium, medium-high- and high-risk pests that may present a risk to plant health if cultivated in the UK.

By identifying and understanding the life-cycle of potential plant pests and the stages of PGM cropping and production, systems can be designed to manage and minimise pest threats. This proactive or systems approach should improve help land managers improve the plant biosecurity of PGM systems.

Further research and next steps

This report was a short (3.5 days) desk-based study that looked at the pest risks associated with PGM systems. Two key sources of information were relied upon to conduct the assessment and provide a framework that could be developed to minimise the pest risk for PGM systems – The UK's Plant Health Management Standard and the UK Plant Health Risk Register.

Three areas of further research or next steps were identified:

(i) **Integrated Pest Management (IPM)** - The focus on this report was to consider PGM systems from a plant biosecurity perspective. The report has highlighted some plant pests that may be a risk now or in the future to PGM systems. Research on these pests and how they can be controlled should be conducted in case they become an established pest of the plant species used in PGM systems. This information will support the design of current and future IPM strategies for PGM production systems.

(ii) **PGMs and legislation** – this report has highlighted the need to consult with Natural Resources Wales (or equivalent UK authority) on the regulations that PGM systems may be subject to. From a biosecurity point of view, it is anticipated that PGM systems will be subject to SPHNs as per any other plant or tree cropping/forestry system. Waste material legislation may need to be considered, although it is noted that PGMs are not a waste product, however PGM products may share some qualities that are similar to materials that may be considered as waste products, e.g. arboriculture arisings.

(iii) Explore the use of heat treatments and pasteurisation processes as a potential means of minimising certain plant pests and diseases in PGM systems.

(iv) **Plant Biosecurity case studies for PGMs** – As with most land management systems that involve the movement or management of plant material, biosecurity is becoming an increasingly important issue. There are guidance and standards available which are designed to support the responsible movement of plants and plant material. A useful next step would be to consider applying existing plant biosecurity guidance and systems to a range of PGM or PMGM systems through the development of case studies.

Appendix 1 – Plant pests associated with the seven selected PGM plant host taxa

Pest Risk Assessment and mitigation measures: *Alnus*

information source - UK Plant Health Risk Register - 03 July 2023

						Pathways (4)															
	Common Name	**Pest Name**	**Type of pest**	**UK Relative Risk Rating (mitigated)**	**UK**	Plants for planting (except seeds bulbs and tubers)	insect vectors	Soil / growing medium	Natural spread	Wood and wood products	Non-squared wood	Squared wood	Woodchip	Bark	Wood packaging material	Cut flowers or branches	Firewood	Hitchhiking	Fruits or vegetables	Manufactured plant products	Seeds	Risk Likelihood x Impact (5)
1	Alder bleeding canker; Alder Phytophthora root disease	*Phytophthora alni*	Oomycete	48	Present (Widespread)	Yes		Yes	Yes													Medium / High
2	Namangan longhorn beetle; willow longhorn beetle	*Xylotrechus (Turanoclytus) namanganensis*	Insect	40	Absent	Yes					Yes				Yes							Medium
3		*Melampsoridium hiratsukanum*	Fungus	36	Present (Limited)	Yes																Medium
4		*Phytophthora siskiyouensis*	Oomycete	36	Present (Unknown Distribution)	Yes		Yes			Yes					Yes						Medium
5	Kuroshio Shot Hole Borer	*Euwallacea kuroshio*	Insect	30	Absent	Yes					Yes				Yes		Yes	Yes				Medium
6	Ussuri oystershell scale; Ussurian comma scale	*Lepidosaphes ussuriensis*	Insect	30	Absent	Yes										Yes		Yes				Low / Medium
7		*Acleris senescens*	Insect	20	Absent	Yes										Yes			Yes			Low / Medium
8		*Agrilus hastulifer*	Insect	20	Absent	Yes					Yes			Yes		Yes						Low / Medium
9		*Phytophthora polonica*	Oomycete	20	Absent	Yes		Yes														Low / Medium
10		*Oxycarenus modestus*	Insect	9	Present (Unknown Distribution)	Yes										Yes		Yes			Yes	Low
11	canker of beech; dieback of beech; European canker of apple; Eye rot of apple; Eye rot of pear; Postharvest rot of apple	*Neonectria ditissima*	Fungus		Present (Widespread)																	Low

Pest Risk Assessment and mitigation measures: *Corylus*

information source - UK Plant Health Risk Register - 03 July 2023

						Pathways (4)																
	Common Name	**Pest Name**	**Type of pest**	**UK Relative Risk Rating (mitigated)**	**UK**	Plants for planting (except seeds bulbs and tubers)	insect vectors	Soil / growing medium	Natural spread	Wood and wood products	Non-squared wood	Squared wood	Woodchip	Bark	Wood packaging material	Cut flowers or branches	Firewood	Hitchhiking	Fruits or vegetables	Manufactured plant products	Seeds	Risk Likelihood x Impact (5)
1	Ramorum leaf blight; Ramorum shoot dieback; Rhododendron twig blight; Sudden oak death	*Phytophthora ramorum*	Oomycete	80	Present (Limited)	Yes		Yes			Yes			Yes								High
2	Black timber bark beetle; Smaller alnus bark beetle; tea root borer	*Xylosandrus germanus*	Insect	60	Present (Limited)	Yes			Yes		Yes			Yes	Yes	Yes						High
3	Apple stem borer; city longhorn beetle; Sart longhorn beetle; The Quetta Borer; town longhorn beetle; Uzbek longhorn beetle	*Aeolesthes sarta*	Insect	45	Absent						Yes				Yes			Yes				Medium / High
4	Apple tree; borer; Pacific flatheaded; Pacific flatheaded borer;; Plum and prune-Pacific flatheaded borer	*Chrysobothris mali*	Insect	45	Absent	Yes					Yes	Yes			Yes	Yes	Yes					Medium / High
5	Asian longhorn beetle; Starry sky beetle	*Anoplophora glabripennis*	Insect	40	Absent	Yes				Yes					Yes							Medium
6	Anthracnose of strawberry; Black spot of strawberry; Crown rot of anemone; Leaf curl of anemone; Leaf curl of celery; Terminal crook disease of pine	*Colletotrichum acutatum*	Fungus	40	Present (Widespread)	Yes																Medium
7	Stem dieback of hazel nut	*Pseudomonas avellanae*	Bacterium	36	Absent	Yes																Medium
8	Brown winged cicada	*Pochazia shantungensis*	Insect	32	Absent (see general comments as this entry was missing)	Yes																Medium
9		*Anisandrus maiche*	Insect	30	Absent	Yes											Yes					Medium

10	Blight of hazel; Eastern blight of filbert; Eastern filbert blight	*Anisogramma anomala*	Fungus	30	Absent	Yes																Medium
11	Black and white longhorn; Citrus longhorn; Citrus longhorn beetle; Citrus root cerambycid	*Anoplophora chinensis*	Insect	30	Absent	Yes										Yes						Medium
12	Forest tent caterpillar; Forest tent caterpillar moth	*Malacosoma disstria*	Insect	30	Absent	Yes								Yes		Yes						Medium
13	Lemon tree borer	*Oemona hirta*	Insect	30	Absent	Yes					Yes	Yes										Medium
14	verticillium wilt	*Verticillium albo-atrum (sensu stricto)*	Fungus	30	Present (Widespread)	Yes																Medium
15	Verticillium wilt; Verticillium wilt of cotton	*Verticillium dahliae*	Fungus	30	Present (Widespread)	Yes																Medium
16	Oblique-banded leafroller; rosaceous leaf roller	*Choristoneura rosaceana*	Insect	24	Absent	Yes										Yes			Yes			Low / Medium
17		*Spilostethus pandurus*	Insect	24	Absent	Yes													Yes			Low / Medium
18		*Megaplatypus mutatus*	Insect	20	Absent	Yes			Yes		Yes			Yes	Yes							Low / Medium
19	Canker of almond; Twig canker of peach	*Diaporthe amygdali*	Fungus	18	Absent	Yes																Low / Medium
20	Bacterial blight of hazel nut	*Xanthomonas arboricola pv. corylina*	Bacterium	18	Present (Limited)	Yes																Low / Medium
21		*Eccopisa effractella*	Insect	16	Absent	Yes			Yes							Yes						Low / Medium
22	Verticillium wilt; Verticillium wilt of tomato; Wilt of potato	*Verticillium albo-atrum*	Fungus	16	Present (Widespread)	Yes																Low / Medium
23	Strawberry yellows; StrawY	*'Candidatus Phytoplasma fragariae'*	Phytoplasma	12	Present (Limited)	Yes																Low
24		*Pseudaonidia trilobitiformis*	Insect	12	Absent	Yes																Low
25		*Monochamus guttulatus*	Insect	10	Absent	Yes					Yes				Yes							Low
26		*Elsinoe coryli*	Fungus	8	Absent	Yes			Yes													Low
27	Kulsi teak borer	*Stromatium barbatum*	Insect	5	Absent						Yes	Yes		Yes						Yes		Low
28	A root knot; Bacterial gall; burr knot; Crown gall; hairy root of apple	*Agrobacterium tumefaciens*	Bacterium		Present (Widespread)																	Low

29	Apple infectious variegation; Apple mosaic; Chestnut mosaic; European plum line pattern; Horsechestnut yellow mosaic; Mountain ash ringspot mosaic; Peach line pattern; Plum European line pattern; Plum line pattern; Rose infectious chlorosis; Rose mosaic; Variegation of mountain ash	*Apple mosaic virus*	Virus or Viroid		Present (Widespread)																	Low
30	honey fungus; Root rot	*Armillaria mellea*	Fungus		Present (Widespread)																	Low
31	Filbert bud mite; Hazelnut gall mite; Nut gall mite	*Phytoptus avellanae*	Mite		Present (Widespread)																	Low

Pest Risk Assessment and mitigation measures: *Cytisus*

information source - UK Plant Health Risk Register - 03 July 2023

						Pathways (4)															
	Common Name	**Pest Name**	**Type of pest**	**UK Relative Risk Rating (mitigated)**	**UK**	Plants for planting (except seeds bulbs and tubers)	insect vectors	Soil / growing medium	Natural spread	Wood and wood products	Non-squared wood	Squared wood	Woodchip	Bark	Wood packaging material	Cut flowers or branches	Firewood	Hitchhiking	Fruits or vegetables	Manufactured plant products	Seeds	Risk Likelihood x Impact (5)
1	Alfalfa dwarf; Anaheim disease; California vine disease; Dwarf disease of alfalfa; Dwarf disease of lucerne; Leaf scald of oleander; Leaf scald of plum; Leaf scorch; Phony disease of peach; Pierce's disease of grapevine; Variegated chlorosis of citrus	*Xylella fastidiosa*	Bacterium	30	Absent		Yes															Medium
2	Japanese long scale; Japanese maple scale; Long scale; Japanese; Pear white scale	*Lopholeucaspis japonica*	Insect	8	Absent	Yes																Low

Pest Risk Assessment and mitigation measures: *Laburnum*

information source - UK Plant Health Risk Register - 03 July 2023

						Pathways (4)																
	Common Name	**Pest Name**	**Type of pest**	**UK Relative Risk Rating (mitigated)**	**UK**	Plants for planting (except seeds bulbs and tubers)	insect vectors	Soil / growing medium	Natural spread	Wood and wood products	Non-squared wood	Squared wood	Woodchip	Bark	Wood packaging material	Cut flowers or branches	Firewood	Hitchhiking	Fruits or vegetables	Manufactured plant products	Seeds	Risk Likelihood x Impact (5)
1	honey fungus; Root rot	Armillaria mellea	Fungus		Present (Widespread)																	Low

Pest Risk Assessment and mitigation measures: *Salix*

information source - UK Plant Health Risk Register - 03 July 2023

						Pathways (4)															
	Common Name	**Pest Name**	**Type of pest**	**UK Relative Risk Rating (mitigated)**	**UK**	Plants for planting (except seeds bulbs and tubers)	insect vectors	Soil / growing medium	Natural spread	Wood and wood products	Non-squared wood	Squared wood	Woodchip	Bark	Wood packaging material	Cut flowers or branches	Firewood	Hitchhiking	Fruits or vegetables	Manufactured plant products	Seeds	Risk Likelihood x Impact (5)
1	Ramorum leaf blight; Ramorum shoot dieback; Rhododendron twig blight; Sudden oak death	Phytophthora ramorum	Oomycete	80	Present (Limited)	Yes		Yes			Yes			Yes								High
2		Lonsdalea populi	Bacterium	64	Absent	Yes					Yes											High
3	Black timber bark beetle; Smaller alnus bark beetle; tea root borer	Xylosandrus germanus	Insect	60	Present (Limited)	Yes			Yes		Yes	Yes		Yes	Yes	Yes						High
4		Agrilus fleischeri	Insect	48	Absent	Yes					Yes		Yes	Yes	Yes							Medium / High
5	Apple stem borer; city longhorn beetle; Sart longhorn beetle; The Quetta Borer; town longhorn beetle; Uzbek longhorn beetle	Aeolesthes sarta	Insect	45	Absent						Yes				Yes			Yes				Medium / High
6	Apple tree; borer; Pacific flatheaded; Pacific flatheaded borer;; Plum and prune-Pacific flatheaded borer	Chrysobothris mali	Insect	45	Absent	Yes					Yes	Yes			Yes	Yes	Yes					Medium / High
7	flat-headed apple tree borer	Chrysobothris femorata	Insect	45	Absent	Yes					Yes	Yes		Yes	Yes		Yes	Yes				Medium / High
8	Elm spanworm; Ennomid; white; Linden moth; snow-white	Ennomos subsignaria	Insect	45	Absent						Yes			Yes		Yes	Yes	Yes				Medium / High
9		Orgyia thyellina	Insect	45	Absent	Yes												Yes				Medium / High
10	White-marked Tussock Moth	Orygia leucostigma	Insect	45		Yes							Yes	Yes	Yes	Yes	Yes	Yes				Medium / High
11		Trichoferus campestris	Insect	45	Absent	Yes					Yes	Yes			Yes			Yes		Yes		Medium / High
12	Namangan longhorn beetle; willow longhorn beetle	Xylotrechus (Turanoclytus) namanganensis	Insect	40	Absent	Yes					Yes				Yes							Medium
13	Asian longhorn beetle; Starry sky beetle	Anoplophora glabripennis	Insect	40	Absent	Yes				Yes					Yes							Medium

14		Cathaica fasciola	Other	40	Absent	Yes												Yes				Medium
15	Japanese swift moth	Endoclita excrescens	Insect	40	Absent	Yes																Medium
16	Yellow-spotted stink bug	Erthesina fullo	Insect	40	Absent										Yes			Yes				Medium
17	brown marmorated stink bug; Yellow-Brown stink bug	Halyomorpha halys	Insect	40	Absent	Yes												Yes				Medium
18	Tufted apple bud moth	Platynota idaeusalis	Insect	40	Absent	Yes										Yes			Yes			Medium
19	Japanese beetle	Popillia japonica	Insect	40	Absent	Yes	Yes											Yes				Medium
20	String cottony scale	Takahashia japonica	Insect	40	Present (Limited)	Yes																Medium
21	Parallel-banded Leafroller Moth; Spotted Fireworm Moth	Choristoneura parallela	Insect	36	Absent	Yes										Yes			Yes			Medium
22	Plum; borer; American	Euzophera semifuneralis	Insect	36	Absent	Yes					Yes			Yes								Medium
23	New Zealand pinhole boring beetle	Platypus apicalis	Insect	36	Absent	Yes					Yes	Yes		Yes								Medium
24	Brown winged cicada	Pochazia shantungensis	Insect	32	Absent (see general comments as this entry was missing)	Yes																Medium
25	Fruit; pyralid; quince moth	Euzophera bigella	Insect	32	Absent	Yes										Yes			Yes			Medium
26	Mulberry longhorn beetle	Apriona germarii	Insect	30	Absent	Yes					Yes	Yes			Yes					Yes		Medium
27	Japanese mulberry longhorn beetle; Mulberry; borer	Apriona rugicollis	Insect	30	Absent	Yes					Yes	Yes			Yes					Yes		Medium
28	Black and white longhorn; Citrus longhorn; Citrus longhorn beetle; Citrus root cerambycid	Anoplophora chinensis	Insect	30	Absent	Yes										Yes						Medium
29	Polyphagous Shot Hole Borer	Euwallacea fornicatus	Insect	30	Absent	Yes					Yes				Yes		Yes	Yes				Medium
30		Hylesia nigricans	Insect	30	Absent	Yes												Yes				Medium
31	Gypsy moth	Lymantria dispar	Insect	30	Present (Limited)				Yes									Yes				Medium
32	Rosy gypsy moth	Lymantria mathura	Insect	30	Absent	Yes					Yes					Yes		Yes				Medium
33	Kuroshio Shot Hole Borer	Euwallacea kuroshio	Insect	30	Absent	Yes					Yes				Yes		Yes	Yes				Medium
34	Ussuri oystershell scale; Ussurian comma scale	Lepidosaphes ussuriensis	Insect	30	Absent	Yes										Yes		Yes				Medium
35	Rusty brown tortricid; Variegated leafroller	Platynota flavedana	Insect	30	Absent	Yes										Yes			Yes			Medium
36	Carpenter; worm	Prionoxystus robiniae	Insect	30	Absent	Yes					Yes				Yes							Medium
37		Rusticoclytus rusticus	Insect	30	Absent						Yes	Yes			Yes					Yes		Medium
38		Scirtothrips inermis	Insect	30	Present (Limited)	Yes										Yes						Medium

39	; Apple bark beetle; Asian ambrosia beetle; Granulate ambrosia beetle	Xylosandrus crassiusculus	Insect	30	Absent	Yes					Yes	Yes			Yes	Yes						Medium
40	lesser apple leaf-folder; yellow-headed fireworm	Acleris minuta	Insect	24	Absent	Yes										Yes			Yes			Low / Medium
41		Agrilus ater	Insect	24	Present (Limited)	Yes					Yes			Yes	Yes							Low / Medium
42	Oblique-banded leafroller; rosaceous leaf roller	Choristoneura rosaceana	Insect	24	Absent	Yes										Yes			Yes			Low / Medium
43	Japanese bayberry whitefly	Parabemisia myricae	Insect	24	Absent	Yes													Yes			Low / Medium
44	Indian wax scale; Indian white wax scale	Ceroplastes ceriferus	Insect	20	Absent	Yes																Low / Medium
45	Tortoise wax scale	Ceroplastes japonicus	Insect	20	Absent	Yes																Low / Medium
46	Mountain ring silk moth	Malacosoma parallela	Insect	20	Absent	Yes								Yes		Yes						Low / Medium
47		Megaplatypus mutatus	Insect	20	Absent	Yes			Yes		Yes	Yes			Yes							Low / Medium
48		Neopulvinaria innumerabilis	Insect	20	Absent	Yes																Low / Medium
49		Acleris senescens	Insect	20	Absent	Yes										Yes			Yes			Low / Medium
50		Tremex fuscicornis	Insect	20	Absent	Yes					Yes	Yes			Yes		Yes					Low / Medium
51		Xiphinema californicum	Nematode	18	Absent	Yes		Yes														Low / Medium
52	Orange; leafroller; Raspberry snout; moth	Platynota rostrana	Insect	15	Absent	Yes										Yes			Yes			Low / Medium
53		Acleris issikii	Insect	12	Absent	Yes										Yes						Low
54	Fig wax scale	Ceroplastes rusci	Insect	12	Absent	Yes													Yes			Low
55		Monochamus guttulatus	Insect	10	Absent	Yes					Yes				Yes							Low
56	Royal Midget	Phyllonorycter pastorella	Insect	9	Present (Limited)	Yes																Low
57	Oriental scale; Oriental yellow scale	Aonidiella orientalis	Insect	8	Absent	Yes			Yes							Yes			Yes			Low
58	watermark disease of willow; willow vascular wilt; willow watermark disease; willow wilt	Brenneria salicis	Bacterium	8	Present (Limited)	Yes			Yes													Low
59	Kulsi teak borer	Stromatium barbatum	Insect	5	Absent						Yes	Yes			Yes					Yes		Low
60		Aleuroclava psidii	Insect	4	Absent	Yes										Yes			Yes			Low
61		Aphrophora angulata	Insect		Absent																	Low
62		Eurhizococcus brasiliensis	Insect		Absent																	Low

63	Fusarium dieback spread by Polyphagous Shot Hole Borer	Fusarium euwallaceae (Neocosmospora euwallaceae)	Fungus		Absent																	Low
64		Graphocephala hieroglyphica	Insect		Absent																	Low
65		Graphocephala versuta	Insect		Absent																	Low
66	Broad-headed sharpshooter	Oncometopia (Oncometopia) orbona	Insect		Absent																	Low
67	A root knot; Bacterial gall; burr knot; Crown gall; hairy root of apple	Agrobacterium tumefaciens	Bacterium		Present (Widespread)																	Low
68	honey fungus; Root rot	Armillaria mellea	Fungus		Present (Widespread)																	Low
69	canker of beech; dieback of beech; European canker of apple; Eye rot of apple; Eye rot of pear; Postharvest rot of apple	Neonectria ditissima	Fungus		Present (Widespread)																	Low

Pest Risk Assessment and mitigation measures: *Symphytum*

information source - UK Plant Health Risk Register - 03 July 2023

							Pathways (4)																
	Common Name	**Pest Name**	**Type of pest**	**UK Relative Risk Rating (mitigated)**	**UK**	**Pathway to convert into individual cells - (H-W)**	Plants for planting (except seeds bulbs and tubers)	insect vectors	Soil / growing medium	Natural spread	Wood and wood products	Non-squared wood	Squared wood	Woodchip	Bark	Wood packaging material	Cut flowers or branches	Firewood	Hitchhiking	Fruits or vegetables	Manufactured plant products	Seeds	Risk Likelihood x Impact (5)
1		*Ralstonia pseudosolanacearum*	Bacterium	24	Absent		Yes										Yes			Yes			Low / Medium
2	Eelworm; Tomato black ring; Needle nematode	*Longidorus elongatus*	Nematode		Present (Widespread)																		Low / Medium

Pest Risk Assessment and mitigation measures: *Ulex*

information source - UK Plant Health Risk Register - 03 July 2023

							Pathways (4)																
	Common Name	**Pest Name**	**Type of pest**	**UK Relative Risk Rating (mitigated)**	**UK**	**Pathway to convert into individual cells - (H-W)**	Plants for planting (except seeds bulbs and tubers)	insect vectors	Soil / growing medium	Natural spread	Wood and wood products	Non-squared wood	Squared wood	Woodchip	Bark	Wood packaging material	Cut flowers or branches	Firewood	Hitchhiking	Fruits or vegetables	Manufactured plant products	Seeds	Risk Likelihood x Impact (5)
1	No pests identified																						

Appendix 2 - Potential medium to high risk pests of selected PGM taxa and present in the UK

PGM systems - table of pests and diseases that are present in the UK with a mitigated risk-rating of 30 or higher - information source - UK Plant Health Risk Register - 03 July 2023

						Pathways (4)																
Host plant - Genus	**Common Name**	**Pest Name**	**Type of pest**	**UK Relative Risk Rating (mitigated)**	**UK**	Plants for planting (except seeds bulbs and tubers)	insect vectors	Soil / growing medium	Natural spread	Wood and wood products	Non-squared wood	Squared wood	Woodchip	Bark	Wood packaging material	Cut flowers or branches	Firewood	Hitchhiking	Fruits or vegetables	Manufactured plant products	Seeds	Risk Likelihood x Impact (5)
Alnus	Alder bleeding canker; Alder Phytophthora root disease	*Phytophthora alni*	Oomycete	48	Present (Widespread)	Yes		Yes	Yes													Medium / High
Alnus	Alder rust (taken from separate PRA)	*Melampsoridium hiratsukanum*	Fungus	36	Present (Limited)	Yes																Medium
Alnus		*Phytophthora siskiyouensis*	Oomycete	36	Present (Unknown Distribution)	Yes		Yes			Yes					Yes						Medium
Corylus	Ramorum leaf blight; Ramorum shoot dieback; Rhododendron twig blight; Sudden oak death	*Phytophthora ramorum*	Oomycete	80	Present (Limited)	Yes		Yes			Yes			Yes								High
Corylus	Black timber bark beetle; Smaller alnus bark beetle; tea root borer	*Xylosandrus germanus*	Insect	60	Present (Limited)	Yes			Yes		Yes			Yes	Yes	Yes						High
Corylus	Anthracnose of strawberry; Black spot of strawberry; Crown rot of anemone; Leaf curl of anemone; Leaf curl of celery; Terminal crook disease of pine	*Colletotrichum acutatum*	Fungus	40	Present (Widespread)	Yes																Medium
Salix	Ramorum leaf blight; Ramorum shoot dieback; Rhododendron twig blight; Sudden oak death	Phytophthora ramorum	Oomycete	80	Present (Limited)	Yes		Yes			Yes			Yes								High
Salix	Black timber bark beetle; Smaller alnus bark beetle; tea root borer	Xylosandrus germanus	Insect	60	Present (Limited)	Yes			Yes		Yes	Yes		Yes	Yes	Yes						High
Salix	String cottony scale	Takahashia japonica	Insect	40	Present (Limited)	Yes																Medium