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Biosecurity practices to support plant health: a review of knowledge and practice

Project Final Report

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Content

1 Executive summary

This research represents an initial investigation of plant biosecurity risks from site visitors, tools & equipment, and large machinery. We engaged with businesses and organisations within the UK to explore how these aspects of biosecurity are understood and what procedures may be in place to address them. By better understanding the issues faced by individuals attempting to protect their businesses and organisations from these risks, more appropriate guidance can be produced to help them.

The project considered published guidance and used questionnaires and interviews to identify biosecurity practices. Data were collected on respondents' awareness of previous biosecurity campaigns, biosecurity responsibility within organisations, how risk is assessed, what procedures are already in place to manage visitor biosecurity, the type of machinery sharing activities, and what barriers may exist to behaviour change.

Some stakeholders are already carrying out several biosecurity actions including briefing contractors and volunteers on biosecurity when they arrive on site, specific cleaning measures for equipment and machinery, biosecurity policies, checking and quarantining of new planting stock as it arrives, and limiting access to public and contractors where appropriate.

Research also examined what activity may be underway internationally to address these biosecurity risks. Data were gathered from the available literature as well as discussions with international plant health practitioners.

In addition, other sectors were explored (e.g., health & safety, human health, and animal health) to investigate whether there may be lessons that could be learned and applied to biosecurity procedures and awareness raising for plant health.

Overall conclusions and recommendations derived from the study:

- This review suggests that there is some awareness of current biosecurity messaging but that it is a) not getting through to all practitioners, and b), does not necessarily result in change when it does.
- Some businesses and organisations are taking a proactive approach to biosecurity by undertaking staff training, ensuring policies are in place and available to all relevant staff, undertaking tool and footwear cleaning, restricting access of visitors to certain areas and checking that contractor's machinery arrives on site cleaned.
- Biosecurity guidance on visitors, tools and machinery is fragmented and not widely integrated within and between sectors in Scotland. For example, the "Keep it Clean" campaign is largely viewed as a forestry initiative, but the messaging is relevant to all sectors.
- This suggests the need for clear, evidence led, sector-relevant, biosecurity guidance for businesses and organisations involved in managing the biosecurity risks associated with visitors, tool hygiene and machinery movement.
- To reduce the siloed nature of current guidance, new advice not only needs to be relevant to a particular sector, but also applicable to others so it can be referred to where appropriate. For example, the "Keep it Clean" forestry guidance could be used in countryside codes of relevance to all sectors.
- Potential visitors to the countryside and gardens must specifically look for biosecurity information rather than being presented with it when planning a trip. More consistent cross-sectoral messaging would encourage broader awareness and adoption as standard practice wherever visits are made.
- Biosecurity success is likely to depend on coordination across sectors through a shared understanding of the issues and aligned activity to address them. Regulation has a role to

play in behaviour change as does industry through initiatives such as the Plant Healthy Standard.

- Assessing risk is very difficult for organisations. A much simpler resource is required showing the highest risk and notifiable pests for each sector, updated regularly. This would help organisations trying to understand risk, for example, when issuing plant passports. The Pest Risk Index, based on the UK Plant Health Risk Register is a useful first step.
- There are lessons to be learned from other sectors and international initiatives. Further, in depth research is required into several areas described in this review, particularly international approaches to improving biosecurity compliance, and behaviour change science in human health.

2 Introduction

The last 20 years has seen the introduction and spread of several new plant pests and diseases across the UK (Brasier, 2008; Spence, 2020). Some of these species have gone on to have a significant impact on landowners and businesses across all sectors. For example, ash dieback disease, caused by the fungus *Hymenoscyphus fraxineus*, has caused the widespread decline and death of ash (*Fraxinus excelsior*) in the UK. This not only has a profound ecological impact on woodlands and hedgerows, but it also has economic ramifications for many land managers faced with managing the failing trees (Hill, et al., 2019).

The fungus that causes ash dieback is spread in the wind (Bakys, et al., 2009) so once infected plants are introduced into a new region/country it is often too late to stop the spread. Another example of this is potato blight, caused by the fungal-like pathogen *Phytophthora infestans*, which is responsible for significant losses annually in global potato and tomato production (Birch and Whisson, 2001). *P. infestans* reproduces asexually, abundantly producing short-lived structures called sporangia which are transported by wind to other potato plants and new locations (Sunseri, et al., 2002).

These fast-spreading pathogens have had an immediate impact but there are other species which are having a more subtle impact as they spread slowly, due in part to their proclivity to inhabit the soil (Reeleder, 2003). These pathogens may be unwittingly moved by people. An example of such a pathogen is *Phytophthora austrocedri*, an aggressive soil borne pathogen which has infected and killed juniper across northern England and Scotland in recent years (Green, et al., 2015). Pathogens like this can easily be moved from one site to another on muddy footwear, bicycle wheels, machinery wheels and livestock (FC & APHA, 2021).

These biosecurity risks provide land managers with a range of problems. For example, how can a population of juniper be managed in such a way that the risk of inadvertent introduction of *P. austrocedri* can be minimised? Advice on this, and other pests and diseases, has been published (DEFRA, 2017; Forest Research, 2022) but are they practicable and are they being followed?

Awareness of the risks posed by new introductions of plant pests and diseases has increased significantly in recent years. This has led to a greater understanding of many aspects of biosecurity, such as the risk of moving plants across borders and the need for more information on new pest and pathogens to be made available, e.g., the UK Plant Health Risk Register (DEFRA, 2022d).

However, there are several aspects of biosecurity where evidence is still lacking. In particular:

- How can important plant species in botanic collections and historic gardens be protected from inadvertent pathogen introduction on the footwear, bicycle wheels, etc. of unwitting visitors?
- What is the risk of further inadvertent spread from gardens into the wider natural environment?
- What risk does the movement of forestry workers, contractors and machinery pose (within sites and from one site to another)?
- What risk does recreational use of forestry pose from walking to mountain biking?
- What is the risk from the movement of staff, contractors and agricultural machinery with soil attached? For example, contractors visiting several farms across a growing season.
- How can gardens, nurseries, farms and the natural environment be protected from pest and pathogen spread through the movement of large machinery with soil attached?

In addition to this, biosecurity has not traditionally been a cross-sector activity. It is conceivable that new insights could be obtained from other sectors that have not previously been explored, e.g., human health.

This project therefore sought to:

1. Determine what official cross sector biosecurity advice (agriculture, forestry, public gardens and natural environment) already exists in Scotland for the specific risks outlined above.
2. Establish what procedures are already being used at various locations across Scotland and the UK.
3. Explore other sectors to learn if they could provide additional insights and novel approaches to plant biosecurity.
4. Carry out a thorough assessment of what procedures are in place, or being considered and developed, in different countries/regions to address these specific biosecurity risks.

3 Methods

A mix of methodologies was used to gain an understanding of current practices and to explore potential new approaches to biosecurity.

3.1 Survey

An online survey was built in Google Docs (https://docs.google.com/document/u/0/) and opened on 28th February 2022 and ran for 10 weeks. People were invited to respond to 34 structured questions (see Appendix A).

The survey comprised a range of question types:

- Multiple choice.
- Single choice array.
- Likert scale.
- Free-text comment.

The survey was presented in English and was available for completion on desktop computers as well as mobile devices such as phones and tablets.

The survey was widely promoted through the Plant Health Centre for Scotland networks which included trade organisations, government agencies and third sector organisations that own or manage land. Considerations when analysing the data:

1. The survey only captures the views of those who participated, we recognise that there are always people who do not or cannot engage.
2. The survey was only available to those willing to respond online.
3. Although the survey took around 20 minutes to complete, it is clear from some of the responses that people spent considerably longer on it. It is conceivable that some people started the survey but did not complete it. The software used for this survey did not capture survey attempts which were not completed.
4. The results analysed are those received from respondents; with minor exceptions where there were obvious discrepancies (e.g., spelling mistakes), no attempt was made to verify data reported.

3.2 Structured interviews

The questions in the online survey were used as a guide for the structured interviews. Participants were selected who had experience within the sectors under investigation (e.g., animal health) and were initially contacted via email. The interviews were carried out over Teams or by telephone.

3.3 Literature review

To gather evidence on the elements of biosecurity under investigation in this study, a comprehensive literature review took place. This analysed existing scientific papers, regulatory publications (e.g., Health & Safety) and the websites of relevant organisations (e.g., Plant Health Australia), to gain a thorough understanding of the current biosecurity landscape and potential initiatives to improve it.

3.4 Case studies

During both the literature review and structured interviews, a number of approaches were identified that were suited for presenting as case studies. Where relevant, further investigation of the specific details relating to each case study was conducted via email and telephone conversations.

4 Results

4.1 Current relevant UK biosecurity awareness raising initiatives

Early research on *Phytophthora ramorum* spread showed that this pathogen can be spread locally by visitors moving through infected sites (e.g., on footwear) (Cushman & Meentemeyer, 2008). As a result, the "Keep it Clean" campaign (figure 1) was launched in 2015 by Forestry Commission Scotland (Farming UK, 2015) to raise awareness of this issue among those involved in land or forest management, after the widespread infection of plantation Japanese larch (*Larix kaempferi*). Signs ask visitors to clean footwear, bicycle tyres and dog paws after visiting a forest, this ensures that at the next visit, visitors arrive clean.

Figure 1: Keep it Clean campaign logo. Forestry & Land Scotland.

The Plant Health Accord is a new initiative which aims to improve public engagement with plant health and biosecurity by bringing together organisations to raise public awareness of plant health and biosecurity (DEFRA, 2022a). There are currently twenty-nine signatories to the Accord, including DEFRA, the Royal Horticultural Society, National Farmers Union, National Trust, Tree Council and Horticultural Trades Association – amounting to a total membership of over seven million people across the country.

Plant Health Action (PHA) is an initiative coordinated by the UK's Chief Plant Health Officer, Nicola Spence (PHA, 2022). It has many partner organisations including UK Plant Health Authorities, membership organisations and charities. Its main aim is to organise plant health and biosecurity awareness raising activities throughout the new annual National Plant Health Weeks.

The "Don't risk it!" campaign was initiated across Europe by the European and Mediterranean Plant Protection Organisation (EPPO). It urges visitors to countries not to bring plants home after holidays abroad. Awareness raising signs for this initiative are displayed at UK points of entry.

4.2 Currently available UK biosecurity advice

4.2.1 Forestry

There are a number of biosecurity resources available to forestry and woodland management (FC & APHA, 2021), possibly due to the significant impact on this sector by a number of serious pests and pathogens. For example, Scottish Forestry have a biosecurity webpage on their website which covers what visitors should do as well as what procedures professional foresters should follow (SF, 2022).

However, advice is not integrated across information platforms. Biosecurity webpages often exist in isolation and biosecurity messaging does not appear where it is relevant. Many organisations have a webpage where visits to sites can be planned, but biosecurity advice frequently does not appear within these pages.

For example, Forestry and Land Scotland (FLS) have a biosecurity webpage (FLS, 2022a) which explains about cleaning footwear and bicycles after a visit, but the walking webpage (FLS, 2022b) and the forest cycling code (FLS, 2022c) do not mention biosecurity. Visitors to the website must specifically look for biosecurity information to find it.

4.2.2 Farming

Biosecurity advice available to farmers often combines animal and plant health. In terms of the biosecurity issues associated with visitors, tools and machinery, this is not necessarily a bad thing. If all farm visitors are already cleaning their boots to prevent the spread of zoonotic diseases, then plant pathogens will also be washed off footwear, equipment and machinery. For example, the "Disease? Not On My Farm!" campaign (MSD Animal Health, 2022) recommends:

- Make certain every visitor disinfects their footwear when entering and exiting your farm
- Check visitors' clothing, footwear and tools are free of soil or organic waste before entering and leaving the farm
- Train staff in biosecurity and farm hygiene practices (e.g. management, personal, equipment and vehicles)

However, this only benefits plant health on farms that have livestock and are following good animal health procedures, advice for arable farms appears to be much more limited in terms of detailed guidance. For example, the Agriculture and Horticulture Development Board (AHDB) (AHDB, 2022) do mention plant health, but their suggested biosecurity actions are a mix of animal and plant health advice:

- Don't buy in problems in stock or seeds
- Don't let disease spread across your farm boundaries
- Don't bring disease into your farm on boots, vehicles, equipment or other supplies

Although farm biosecurity is concentrated on animal health, there is general advice for managing visitors, tools and machinery which could apply to farms should the farmer be engaged enough to go and look for it, but the pathway to this information is not clear. For example, the "Keep it Clean" forestry advice would improve biosecurity on an arable farm if followed (e.g., visitors cleaning boots), particularly if they manage a woodland on their farm, but information is often not viewed as cross-sector. Evidence gathered from structured interviews suggests that farmers do not feel that the "Keep it Clean" advice relates to them.

4.2.3 Ornamental and amenity plant production

One sector where there has been a significant increase in biosecurity awareness and activity is the plant production sector (horticultural and forestry). This is in part due to the discovery of a particularly damaging bacterium, *Xylella fastidiosa,* causing extensive damage to ancient olive groves in southern Italy in 2010 (Loconsole, et al., 2014). This pathogen has a very wide host range which includes many frequently traded ornamental garden plants and herbs. As a result, the EU plant health authorities introduced emergency measures to control the spread of this pathogen which included the destruction of stock and plant movement bans which would result in a significant disruption to trade if there was an interception (European Commission, 2022).

There is information available to the sector on the UK Plant Health Information Portal which is managed by DEFRA (DEFRA, 2022b). For example, there is a "Biosecurity Best Practice: Top Ten Tips" document which includes advice on cleaning tools and equipment (DEFRA, 2022c).

The emergence of the threat from polyphagous pests such as *Xylella fastidiosa* has resulted in some businesses and organisations in the UK horticultural sector voluntarily improving their plant biosecurity systems.

In the UK, the Plant Healthy Certification Scheme is a voluntary plant biosecurity quality assurance system, launched in 2020. The Scheme - based on the requirements of the Plant Health Management Standard - enables nurseries, retailers, landscapers, arborists and gardens to be independently audited. This process requires the systematic examination of the range of plant production processes and live plant management practices, to identify and establish controls to minimise plant pest risks. This is a significant step forward as it recognises the role of the horticultural sector in improving biosecurity and enables stakeholders to proactively adopt voluntary requirements and operate under a recognised certification mark.

4.2.4 Natural environment

Some limited, pathogen specific, advice exists for managers of land in the wider environment. For example, in 2017 DEFRA produced management guidance for juniper in light of the discovery of the aggressive pathogen *Phytophthora austrocedri* (DEFRA, 2017).

Chapter 7 of the Scottish Code for Conservation Translocations (Hollingsworth, et al., 2014) recommends using the advice which was designed for SEARS (Scotland's Environmental and Rural Services) staff for conservation translocations in Scotland. It covers personal, vehicle and equipment biosecurity as well as other aspects of biosecurity and health and safety (e.g. use of disinfectants) (SEARS, 2013).

The Scottish Outdoor Access Code mentions biosecurity, but it is related to animal health (Scottish Outdoor Access Code, 2018). There does not appear to be any link to other sectors, for example the code does not mention the biosecurity advice which is recommended by Forestry authorities for visitors to forests (e.g., Keep it Clean). Including such biosecurity messaging in countryside codes would be a simple way to reach a very wide audience that may already be, or planning to be, engaged in outdoor activities.

4.3 Biosecurity processes and procedures currently in use

A survey was used to gain an understanding of the current biosecurity landscape across sectors and organisations. There were 36 respondents across sectors in Scotland, England and internationally including stakeholders from agriculture, forestry, horticulture and the natural environment. Detailed responses can be found in Appendix A.

4.3.1 General biosecurity awareness

We found that there was some awareness of previous biosecurity public campaigns, those mentioned included "Keep it Clean", "SASA and DEFRA campaigns" (no specifics given), "Plant Healthy", "Forestry Commission" and "posters at airports warning of the dangers and legality of importing plants". However, the majority of respondents to the survey (19 of 33 responses) were unaware of previous campaigns. 5 of these were from the agricultural sector with an additional response of "not applicable".

In order to gauge behaviour change, we asked if respondents had noticed any changes in the behaviour of people visiting their sites which could be a result of the campaigns mentioned above. The majority relied "no" or "unsure" (50% and 20% respectively).

4.3.2 Biosecurity responsibility and risk assessment

Having clear plant health roles and responsibilities is important for a business. For example, who does a member of staff report potentially diseased plants to if they find something concerning?

When asked "do you have a member or members of staff with specific responsibility for plant biosecurity" 66% responded "yes", 31% "no" and 3% "it is the responsibility of several staff". This shows that the majority have a person (or people) that can be approached by a member of staff if a biosecurity issue is identified. In addition, we found that 60% of businesses surveyed undertake or offer employees some form of plant health or biosecurity training.

Respondents were asked to rank their vulnerability to pests and diseases from 1 (not vulnerable at all) to 10 (very vulnerable). More than half of the respondents (n=18) ranked their vulnerability between 6 and 8, the mean average for all responses was 6 out of 10.

In order to further understand how risk was being assessed, we asked respondents to describe their assessment method against a number of options. The majority (39%) have assessed their sites for the pests and diseases they have heard of, 35% have risk assessed for known and exotic pests and 26% have not done a risk assessment.

4.3.3 Impact of pests and diseases

We asked respondents to list the pest and diseases on their sites in descending order of impact. The most impactful and commonly reported diseases were *Phytophthora* species (16 mentions) followed by ash dieback (14 mentions). The *Phytophthora* species mentioned were *P. ramorum*, *P. pluvialis*, *P. kernoviae* and *P. infestans*.

There were many other pests and diseases named as impactful (Appendix A, table 1), many of which unsurprisingly corresponded closely to the sectors involved. For example, *Dendroctonus micans* (the great spruce bark beetle) in forestry, Oak Processionary Moth in parks and gardens and Potato Cyst Nematode in agriculture. The impacts were not only operational but also financial, reputational and ecological.

It is conceivable that these data are dependent on which pest is being considered in each sector. For example, forestry and woodland management respondents rated impact as high in all areas, possibly because of a number of particularly impactful diseases such as *P. ramorum* and ash dieback. Conversely, ornamental gardens (e.g., botanic gardens) rated the impacts as low to medium.

4.3.4 Managing risk

4.3.4.1 Visitor biosecurity

We asked respondents what they consider to be the greatest risk from people introducing plant pests and diseases onto their sites. By far the most common response was contractors, particularly those working on numerous similar sites and not cleaning boots, equipment and machinery between jobs. In addition, non-horticultural contractors were identified as high risk because they will not have come across biosecurity before, e.g., plumbers. Also mentioned was the risk from contractors that have recently been overseas.

The next riskiest was thought to be the general public (visiting sites) and new plants being brought onto site (equally rated) and then soil transfer between sites, e.g., on machinery that has not been cleaned.

44% of respondents had a plant health policy which included details on managing the biosecurity risks associated with visitors, 56% did not.

Other specific responses included:

- "Hitchhikers (insects which move around undetected on people, machinery, etc.)".
- "Increasingly warmer and more humid climate".
- "Neighbouring crops that have lower pest thresholds than ours".
- "Growers using potato seed originating from Holland".
- "Anglers introducing *Gyrodactylus* from overseas (salmon fluke)".

4.3.4.2 Moving material between sites

One of the major pathways for pest and pathogen movement is on other materials, for example wood products or live plants which are intended to be planted.

Respondents were asked to indicate which materials were moved between sites (more than one option could be ticked). Of the 31 responses, 54% moved live plants for planting, 55% moved seed, 42% timber or other woodland products, 35% soil, 26% food crops, 23% growing media, 23% green waste, 3% seed potatoes and 6% "other" (where one response was "checking all crops of plants of concern in trade" and one was "processed seashells").

4.3.4.3 Tools, equipment and machinery

Just over half of the businesses surveyed (53%) have a written policy which includes a section on managing the risks associated with tools, equipment and machinery.

When asked which specific measures are in place to manage this risk, responses fell within a few actions:

- Regular cleaning / sterilising of tools, particularly when working in areas known to be infected by a specific disease.
- Follow the measures set out in a Statutory Plant Health Notice (these may be general or specific to a particular pathogen/context).
- Wash down areas for machinery.
- Washing machinery between sites.
- All soil engaging machinery is owned and operated in house.

In order to carry out this work, 44% regularly use chemical agents to clean tools, 41% when absolutely necessary and 15% never.

We also wanted to gauge the risk posed by run-off from cleaning areas which may pose a biosecurity hazard because it may contain pathogens. Respondents were therefore asked how they manage their run-off, 48% did not manage run-off at all.

To understand how machinery sharing is viewed and to what extent it takes place, we asked respondents if they share machinery with other site owners. Only 12% replied that they "regularly share machinery", a further 29% "occasionally share machinery", but the vast majority (59%) replied that they "never share machinery".

However, when asked how often they use external contactors' machinery on site, 31% replied "often", 14% "very often", 51% "occasionally" and only 4% "never". In terms of mitigating the biosecurity risk posed by this activity, we asked if respondents requested that machinery arrives on site visibly clean, 64% replied that they did, 27% replied that they did not (9% replied N/A).

In addition to this, we asked if businesses / organisations allowed staff, volunteers and contractors to use their own tools on site, 61.8% indicated that they did allow this, 35% did not (3% replied N/A).

4.3.5 Risk mitigation

Respondents were asked what measures they put in place to manage the risks identified above. There were many different responses, but they all largely fell into several activities:

- Specific cleaning measures in place (e.g., footbaths, vehicle cleaning, etc.) (6 respondents)
- Biosecurity policy in place for staff and/or biosecurity specified in contracts (5 respondents)
- None for visitors (4 respondents)
- Contractors and volunteers briefed on biosecurity when they arrive on site (4 respondents)
- Checking new planting stock for pests as it arrives (3 respondents)
- Limiting access to public and contractors where appropriate (2 respondents)
- Quarantining new stock as it arrives (2 respondents)

4.3.6 Biosecurity adoption and non-adoption

To enable us to understand how to improve the uptake of biosecurity measures we asked what would encourage respondents to adopt tighter biosecurity measures by selecting a number of options. The three most selected options (as selected by 20 or more people) were:

- "More scientific evidence of the effectiveness of different approaches".
- "A cooperative approach with other likeminded businesses/organisations".
- "More definitive information/guidance".

In addition, we asked if respondents thought that there might be any other measures that they could take / are aware of but have opted not to. There were 7 responses:

- "Foot disinfection for visitors".
- "Boot washing; tool inspection; restrictive signage".
- "Installing a biosecure area for bought in plants".
- "Fine contractors who transport contaminated machines".
- "Yes, full clean down of machinery when moving between fields. But not practical and economically sustainable".
- "More publicity".
- "Not as such, however I am amazed that all farmers do not have properly configured pressure washer - washdown facilities with appropriate silt traps which could also assist with nematode monitoring".

To further understand this, we asked what barriers exist to the adoption of the measures listed in the previous question (against several options where more than one could be selected). The most cited barriers were "practicality" (23%), "lack of knowledge" (18%), "cost" (16%) and "time constraints" (15%). 7% replied "I do not think that there are any barriers".

A number of other answers were also provided:

- "Perceived futility at the effectiveness over such a large and complex site".
- "Public and contractor perception and willingness to cooperate".
- "Staff knowledge - now that we've undergone a round of recruitment & have appointed to posts developing a phytosanitary policy is a priority for this year".
- "A little of all of the above, difficult to pinpoint how best to move forward".

4.4 Case studies showing specific biosecurity procedures currently in place

4.4.1 Protecting an NNR from a tree pathogen

A boot washing station was installed at the Upper Teesdale National Nature Reserve by Natural England in 2015 after an outbreak of *Phytophthora austrocedri* on the local juniper (*Juniperus communis*) population. This Juniper woodland is on the Pennine Way and therefore is subjected to significant footfall throughout the year. There are two stations, one at either end of the juniper woodlands.

Figure 2: Boot cleaning station at Upper Teesdale NNR. Martin Furness

The station is built on a hardcore path and consists of three fixed brushes in a trough which is fed with clean water from a tank (figure 2). The trough is commercially available from Muddybootz, County Down, Northern Ireland. A hand brush is also provided. Up until 2019, there was also disinfectant present, but this has been temporarily removed due to Covid.

There are small information signs in place to explain why the footbaths are there and to explain how to effectively clean boots.

The Stations are maintained by staff once a week, checking water levels and clearing out the trays of gravel and mud. The brushes are replaced when required.

It has been noted by Natural England staff that most people stop to clean their boots, unless there is a queue, in which case people tend to move on.

The intention of this facility is to stop the spread of *P. austrocedri* from this heavily infected juniper woodland to wider juniper populations across the NNR. This appears to have been successful because there have not been any confirmed positive cases in the wider reserve. Of course, this could be due to a number of factors but at the very least this approach has increased biosecurity awareness of people who use this path.

This case study demonstrates the applicability of such an approach to protect an important plant collection from disease spread. In addition, it presents an opportunity for awareness raising with countryside users.

4.4.2 Protecting a plant collection at a botanic garden

The Royal Botanic Garden Edinburgh has been using disinfecting mats across its four sites (Edinburgh, Dawyck, Logan and Benmore) for more than 10 years (figure 3). To make sure visitors use them, the mats are placed at the entrances and exits in a way that avoiding them is difficult. Disinfectant (Virkon) is regularly topped up in the mats as they dry out, or in some cases waterlogged.

The feedback from visitors is positive and the presence of the mats frequently prompts questions from the public which enables conversations on biosecurity to take place. Interpretation boards are present so that visitors understand why the mats are there and why they are important for protecting the plant collection (figure 4).

This relatively cheap approach is applicable for any garden with a small number of entrances.

Figure 3. Footwear and wheel cleaning mats at RBGE Edinburgh. Author

Figure 4. Interpretation for the mats at RBGE. Author

4.4.3 Protecting an industry from high visitor numbers due to tourism

One of our international respondents highlighted the risk to vineyards in Australia due to high visitor numbers. This is particularly concerning because grape vines (*Vitis* spp.) are at high risk of infection from *Xylella fastidiosa*, common name, Pierce's disease of grapevine.

Vineyards are often part of organised wine tours where large numbers of tourists move between vineyards throughout the day. It is therefore conceivable that a disease in one vineyard could be spread very quickly to others during these tours. This is particularly concerning as tourists often go into the fields to take selfies within the vines.

This has led some in the industry to build viewing platforms where pictures can still be taken but visitors are not in direct contact with the grapevines or soil. This is potentially something that British vineyards could consider for visitors to lower the risk of *Xylella* introduction and spread.

4.4.4 Protecting a threatened tree species from a dieback disease

A specific reaction to a biosecurity threat in NZ is protecting areas of native Kauri Forest from an aggressive pathogen *Phytophthora agathidicida*. This work is led by the Kauri Dieback Recreation Project team (from the Department of Conservation), who coordinate with the wider Kauri Dieback Programme led by Biosecurity NZ (Ministry for Primary Industries) (NZ Department of Conservation, 2022).

The project's work plan includes:

- Upgrading tracks to eliminate muddy sections and protect kauri roots
- Re-routing tracks to avoid kauri

- Changing the allowable recreational use of tracks and, in some locations, closing the tracks
- Improving signage
- Installing footwear hygiene stations at track entrances
- Education and behaviour change.

To achieve the first three points above, 735km of track through Kauri Forests were surveyed, with all Kauri trees within 1.5m of a track being mapped. 186 tracks were identified for possible upgrade or closure; so far over 70 tracks have been upgraded, and over 40 closed. This process is ongoing in consultation with local communities.

Covered boot cleaning stations have been installed at entrances to Kauri Forests to help stop the spread of this disease (figure 5). Stations are designed to be easy to install and maintain and hard to ignore. They have a brush fixed to the base, so people can clean their shoes while holding onto a rail, rather than balancing on one foot holding a scrubbing brush. They also feature a pedal pump to spray disinfectant on to the bottom of footwear. Instructions for use are simple:

1. Brush all soil from your shoes.
2. Inspect thoroughly and if not clean brush again.
3. Disinfect by stepping on the foot pump.
4. After you're done, remember to stay on the track.

These measures are designed to ensure people arrive at the trees clean and leave the area with clean footwear to prevent further spread. The stations are subject to ongoing monitoring and feedback which inform further refinements.

Figure 5. Boot cleaning facility at the entrance to a Kauri Forest. Author.

4.4.5 Raising awareness with biosecurity trails in botanic gardens

Auckland Botanic Garden launched a Biosecurity Trail in April 2019 in partnership with Better Border Biosecurity (B3), funded by Plant and Food Research (Teulon, 2019). The trail has twelve checkpoints over 1.8km where people can learn about different pests and invasive

species and the damage they can cause. Issues that are currently being highlighted by the trail are the brown marmorated stink bug, myrtle rust and kauri dieback.

A map is available in the form of a pamphlet for people to follow the trail. The interpretation boards are located beside selected plant species, with information on critical invasive pests or pathogens threatening them. Images are displayed at each station, along with information about other susceptible host plant species (figure 6). There is also multimedia provision through the STQRY platform (https://stqry.com/) so visitors can scan the interpretation boards to explore and discover more as they walk the trail.

Figure 6: Examples of the interpretation boards at Auckland Botanic Garden. Sandanayaka, et al., 2021

Sandanayaka, et al. (2021) looked at the effectiveness of the trail at Auckland Botanic Garden and found that:

- Awareness increased after taking the Trail. In addition, the data collected illustrated that the Biosecurity Trail offered the opportunity to clarify confusion about biosecurity threats and leave visitors with clearer idea of what to do if they find a threat (e.g., calling the NZ Biosecurity Hotline).
- The Trails have become a valuable teaching resource for local school students.

Since the success of the trail in Auckland, further trails were set up in 2021 at Wellington Botanic Garden and Christchurch Botanic Garden. This approach could be taken at gardens in the UK with a relatively small investment (e.g., arboreta, historic gardens, botanic gardens).

4.5 Other sectors which may provide insights into improving biosecurity adoption

4.5.1 Health and Safety

When discussing improved biosecurity awareness and compliance, health and safety is often mentioned as a good example of an area where significant improvements have been made over time. For example, a comparison of fatal injury numbers between 1974 (when the Health and Safety at Work Act was introduced) and 2020/21, adjusting to allow for the difference in industry coverage of the reporting requirements between these years, suggests that fatal injury numbers to employees have fallen by around 90% over this period, although more recently numbers have been broadly level (HSE, 2021).

A 2008 study investigated what activity has led to improved health and safety outcomes (Cox, et al., 2008), key findings included:

- Inspection and awareness-raising face-to-face:
    - Events play an important role in large scale multi-method campaign activities.
    - Partners and intermediaries can play an important role.
    - Print-based messages alone have some effectiveness in raising awareness of risks but are weak in converting awareness to behavioural change.
    - Multi-method campaigns appear to be more effective as there is evidence of behaviour change in a small proportion of employers.

- Regulation provokes improved health and safety practice.
- Tools and Safety and Health Awareness Days (SHADs) are helpful for willing and committed employers.
- Worker involvement techniques such as worker health and safety representatives can be effective in disseminating health and safety messages and generating behavioural change.
- Targeted initiatives can be helpful in enabling setting objectives and encouraging progress towards sectoral health and safety improvements by building commitment among organisations.

This study also suggested that a scale of 5 levels could be used to judge intervention effectiveness:

- Level 1: Raising awareness of hazards.
- Level 2: Self-reported action as a result of heightened awareness.
- Level 3: Independently verified action as a result of awareness.
- Level 4: Measurable impact on health and safety outcomes such as accident and sickness statistics.
- Level 5: Cost-benefit effectiveness of the intervention to HSE.

It is important to recognise that health and safety is law due to the Health & Safety Act 1974 whereas, generally speaking, biosecurity is not. Therefore, an increase in health and safety compliance should be seen in this context. Non-compliance can result in serious legal consequences and substantial fines which is bound to be a significant motivation for improved compliance. With no Biosecurity Act in the UK, the immediate consequences for noncompliance will be less significant than those seen in health and safety, although organisational reputation may still be seen as risk.

4.5.2 Food safety

A system for ensuring that food was not contaminated during production was created by NASA during the 1960s Space Program to ensure that the food provided for astronauts was safe. This system became known as HACCP (Hazard Analysis Critical Control Point) and has since been adopted for food safety legislation across the world.

In brief, the HACCP approach consists of a prescribed series of logical steps to identify, evaluate, and correct sources of hazards. For example, for food safety, the US Food and Drug Administration (US FDA, 2022) state that the following steps are required:

1. Conduct a hazard analysis
2. Identify the critical control points
3. Establish critical limits
4. Establish monitoring procedures
5. Establish corrective actions
6. Establish record-keeping procedures

7. Establish verification procedures

This systems approach has obvious comparisons to biosecurity and over the last 20 years HACCP has been both proposed and adopted in various locations around the world. For example, the Nursery and Garden Industry of Australia (NIASA) have adopted a HACCP systems approach for plant production and management organisations (Prince, 2008).

This is relevant to this study because, in this context, visitors, tools and machinery are Critical Control Points (CCPs) within a systems approach. If, for example, a botanic garden developed a HACCP approach for biosecurity they would identify visitors as a CCP and bring in measures to reduce biosecurity risk (e.g., footbaths).

The UK Plant Health Management Standard takes a systems approach to plant biosecurity and is similar to HACCP as it sets out a basis for practitioners to conduct a full Site and Operations Pest Risk Analysis. Based on the principles of ISPM 14 - *The use of integrated measures in a systems approach for pest risk management* - The Standard aims to augment regulatory requirements by integrating additional voluntary requirements with official phytosanitary measures.

Parke and Grünwald (2012) suggested a systems approach based on HACCP for managing pests and pathogens of nursery crops after the significant impact of *Phytophthora ramorum* in the West Coast states of the US. This study concluded that HACCP based systems showed promise in improving biosecurity and that it should be possible to replace the current approach of end-point inspections within a few years through analysing hazards, identifying critical control points, obtaining data on best management practices that are effective in mitigating CCPs, and gathering data on effectiveness and costs.

In addition, this study highlighted that a systems approach is a process that is always subject to improvement by continued learning and reassessment of CCPs followed by implementation of new control strategies.

4.5.3 Human health related behaviour change

Public health behaviour change has been successful in some areas, such as smoking cessation, but not others such as diet, alcohol consumption and physical inactivity (Marteau, et al., 2015). Kelly & Barker (2016) argue that the reasons for the failure to tackle the current epidemics of non-communicable disease are based on a number of incorrect assumptions about human behaviour including:

- Assuming that it is just common sense, i.e., it is obvious what needs to be done, so let us just get on and do it.
- Changing health behaviour is simply a matter of getting the packaging of messages right.
- Information from expert sources will act as a driver of behaviour change.
- People act rationally and that they do what they know to be sensible and logical after critical and rational appraisal of the evidence.
- It is possible to predict accurately. However, whilst great strides in identifying key factors which shape behaviour and what works in changing behaviour, it is still difficult to say with any certainty how individual people will behave in many situations.

In relation to biosecurity, there are also strong social and economic forces which a business owner may consider. Even if they understand the risks to their business, in the same way a smoker understands the health risk, they may still not change their biosecurity activity especially if actions are perceived to be costly.

By way of a solution to the above, it has been suggested that instead of working on public health messaging in the conventional campaign-by-campaign approach, a regressive form of

inference, working in the opposite direction, can be more effective (Kelly & Barker, 2016). This approach is based upon unravelling the cause of an issue in order to understand how to change the behaviour that caused it.

In biosecurity terms, this could start with an event (B) which could be the finding of a notifiable pest in an imported tree. Ordinarily, this would lead to increased surveillance, awareness raising and statutory action in a reactive fashion. A more proactive response, taking inspiration from public health behaviour change research, would be to seek to understand and articulate the preceding conditions which led to B, along with the network of other things the behaviour is linked to. For example, these particular trees are not currently available in the UK so have to be imported; why are they not available, because they are too expensive to grow; why are they too expensive to grow; etc.

This regressive inference approach is premised on the notion that things do not happen in a random or chance way; social relations and social practices are patterned, and they happen because of preceding events (Blue, et al., 2016). Those considering initiatives to encourage behaviour change in biosecurity can certainly learn from the lessons of public health successes and failures.

4.5.4 Animal Health

Respondents suggested that animal health is more emotive than plant health and that people relate more empathetically to sick animals than they do sick plants. This has perhaps been reinforced by the images of the management of animals infected with Foot and Mouth disease during the 2001 UK outbreak.

This devastating outbreak also reinforced the need for a rethink of livestock biosecurity for farming. For example, delivery vehicles were implicated in the spread of disease from farm to farm so this risk needed to be addressed by farmers.

More recently, new controls were introduced on the movement of pork and pork products into Great Britain. The regulations, which came into force on 1st September 2022, aim to help safeguard Britain's pigs from the threat of African swine fever. It will no longer be legal to bring pork or pork products weighing over two kilograms into Great Britain, unless they are produced to the EU's commercial standards (Defra, 2022e).

Specific animal health biosecurity measures that were identified during our study included:

- Vets and other farm visitors (e.g., Gov officials, AI company, etc.) are expected to suit & boot up before entering the farm. This is a point of professional integrity.
- Visitor flow in farms is often managed (e.g., deliveries go to a store near the entrance to a farm as opposed to delivery vehicles and people moving through the farm).
- Contact with livestock is minimised.
- "Closed herd" concept where animals are not exchanged between farms once a herd is established (e.g., AI used instead of introducing a bull to the herd).
- Certain livestock are considered more high risk than others (e.g., pigs and chickens) and are subjected to extra biosecurity procedures.
- Open farms very aware of public safety due to zoonotic diseases.
- Farm quality assurance schemes are helping.
- Slurry and silage machinery are increasingly seen as concerning (for human diseases).

There are certainly measures mentioned above which are applicable to plant health, particularly the idea of visitors arriving clean, contact with stock is minimised and visitor flow is managed.

4.6 International approaches to biosecurity

For clarity, it is important to note that in some countries biosecurity also relates to "weeds", i.e., non-native invasive species. This can mean that there are associated benefits to plant health due to biosecurity management and awareness of invasive species.

4.6.1 Australia

In Australia, access to farms in some states are restricted to stop the spread of invasive plant species, this has obvious benefits for restricting the spread of plant pests and diseases. In these areas farmers are provided with gate signs which asks all visitors to phone the landowner for access so that there is some oversight of visitor management and that all visitors can be informed of any specific biosecurity protocols that are currently in place (figure 7).

Figure 7. Farm biosecurity sign. Australia Dept of Agriculture & Food.

"Farm Biosecurity" is a joint initiative of Animal Health Australia (AHA) and Plant Health Australia (PHA) which aims to help producers reduce the risks posed by diseases, pests and weeds to their crops and livestock. It has produced a biosecurity toolkit which can be used by any business to help implement biosecurity measures on their land (Farm Biosecurity, 2022a). The user creates a profile, including the livestock and crops that are specific to their business, which enables a profiler to gather all of the relevant information and create their tailor-made biosecurity toolkit.

Specific advice on visitors, tools and machinery is also available (Farm Biosecurity, 2022b). For example, for vehicles and machinery:

- Vehicle access:
    - Limit the number of entry and exit points (one is preferable).
    - Examine each vehicle entry and exit point for the risk they pose, particularly in relation to the distance from livestock and crops.
    - Display biosecurity signs, with clear instructions and contact details, at all vehicle access points.
    - Clearly sign and lock restricted access areas.
    - Keep a visitor register.

- Vehicle hygiene:
    - Ensure visitor vehicles are clean and are parked in a designated area away from livestock or crops.
    - Establish a vehicle high pressure wash down facility well away from livestock and crops to clean vehicles and equipment which need to enter the property.
    - The wash down area should have a sump to collect any waste water.
    - Ensure any runoff is directed away from livestock pens, paddocks, crops and waterways.
    - Regularly check areas around the wash down facility for new pests or weeds.
    - Keep an up-to-date equipment and vehicle cleaning record.
    - Clean machinery from the top down and dismantle it as far as possible to gain access to internal spaces.

- Clean and disinfect all borrowed or second-hand machinery before using it on your property.
- Follow any wash down with a broad-spectrum disinfectant. This will further reduce the risk of introducing less visible threats like bacteria, viruses, and spores onto your property.

Mountain bikers have also been the subject of awareness raising campaigns in Australia. For example, "Ride Clean" is a campaign by Natural Resource Management (NRM) South in Tasmania which asks bikers to clean their bike every time they ride (figure 8) (NRM South, 2015).

Figure 8: A "Ride Clean" poster from Tasmania. NRM South

In 2021, the Australian Government produced the *Exotic pest identification & surveillance guide for tropical horticulture* (Australian Government, 2021) which details the key exotic pests that horticultural growers need to be aware of, and the specific biosecurity processes that should be undertaken for prevention, such as:

- Entering and leaving the farm: key points to remember
- Cleaning and disinfecting
- What type of disinfectant should be used?
- Surveillance techniques
- Reporting

This guide gives businesses clarity on the most significant pests, how to prevent their business being impacted by them, and what to do if they have a plant health concern.
One of the most impactful plant diseases to be introduced into Australia's wider environment is caused by *Phytophthora cinnamomi*. As a result, the Australian Government produced

guidelines in 2015 to help stop the spread of *P. cinnamomi* and other pests and diseases, these guidelines are called "Arrive Clean, Leave Clean" (Australian Government, 2015).

4.6.2 New Zealand

New Zealand (NZ) is often seen as having a very strict biosecurity regime, both within country and at its border. This is due to the implementation of the Biosecurity Act (1993) which aims to reduce the impact of "all unwanted organisms". This act gives the government power to act in the interests of the country to protect businesses and the wider landscape with prosecutions for noncompliance (NZ Government, 2022).

For industries such as horticulture and agriculture there is the Government Industry Agreement (GIA) for biosecurity readiness and response (GIA, 2022). The GIA operates as a legally binding partnership between primary industry and government to manage pests and diseases that could impact primary industries, economy, and environment. Signatories to the GIA (e.g., horticulture sector) share the decision-making, responsibilities, and costs of preparing for and responding to biosecurity incursions. By working in partnership, industry is much more engaged in the process and so better biosecurity outcomes can be achieved.

However, the NZ approach is not only reliant on legislation, but there is also a philosophy of joint responsibility where every citizen has a responsibility for biosecurity, and it is not just down to government or industry. One of the key strategic directions of the NZ Government's biosecurity strategy, Biosecurity 2025, is a collective effort across the country where "every New Zealander becomes a biosecurity risk manager and every business manages their own biosecurity risk", summarised as "A biosecurity team of 4.7 million" (Ministry for Primary Industries, 2022).

5 Discussion

This review found that many businesses and organisations have introduced biosecurity practices to protect their plant collections and the wider environment. This is clearly demonstrated in the case studies, for example using footwear cleaning facilities in a National Nature Reserve and a botanic garden. Businesses also reported that they carried out activities such as cleaning tools between jobs, restricting visitor access to high-risk areas and ensuring machinery arrives on site clean. Some also provided biosecurity training to staff. This clearly demonstrates that some biosecurity awareness exists across sectors in Scotland, however there would be considerable merit in further research to establish the efficacy of biosecurity measures which have so far been implemented.

5.1 Protecting plant collections in parks and public gardens

Biosecurity has become an increasingly important issue for parks and public gardens and as a result many now have a biosecurity policy. We found some have dedicated work clothing and tools which remain on-site, tool cleaning procedures, and staff training on plant health and biosecurity. As shown in the case studies, some have footwear-cleaning mats at entrances to both raise awareness and prevent disease introduction.

All of these activities will help protect plant collections as long as staff training takes place, and the biosecurity policies are followed. Respondents also indicated that they were concerned with the biosecurity related to the movement of plants, hitchhiking insects and soil transfer. This project does not directly look at these risks so, given the level of concern, future projects could focus on these pathways.

Gardens open to visitors have an important role to play in biosecurity awareness-raising given the potentially high numbers of visitors they attract. Once again, the case studies presented here show how a biosecurity trail within a botanic garden in New Zealand presents a good opportunity to explain the issues to visitors. This is a relatively cheap and simple initiative which could be used in any garden in Scotland to highlight the plant health threats.

5.2 Biosecurity in forestry

Biosecurity awareness is high in forestry in Scotland. This is due to the long running “Keep it Clean” campaign as well as the need to respond to the introduction of several novel tree pests and diseases in the last few decades. Compared to agriculture, crop rotations in forestry are considerably longer and the trees are exposed to potential pest and disease threats for many years. Any new pest or pathogen introduced within this period could potentially impact the benefits which accrue – whether as a commercial crop or through other ecosystem services. Therefore, biosecurity knowledge relating to workers, machinery movement and tools is widespread in forestry and information is widely available.

However, biosecurity actions need to be followed. It is important that complacency does not set in over time, and this study found that there can be a perception of futility given the enormity of the issues. Managers therefore need to keep staff engaged with the process.
As forests become more popular with visitors for recreation, the biosecurity risk may increase. Some forests have become destinations for activities such as walking and mountain biking which makes them more vulnerable to the inadvertent introduction of pests and pathogens. Once again, the “Keep it Clean” messaging is prominent in these forests and some destination sites (e.g., Glentress) offer bike cleaning facilities for mountain bikers to help stop the spread of pathogens.

In a study examining visitor attitudes to biosecurity in forests in Rowardennan in Loch Lomond and the Trossachs National Park, Hall et al. (2020) found that people already clean their walking boots to prolong their usefulness and therefore biosecurity messaging could be

linked to this activity. In addition, forest users wanted to see biosecurity information and have access to boot cleaning facilities at the start of their walk, i.e., in the car park or trail entrance. However, even if this information and equipment was available, there is no guarantee that people would use it.

In forests, signage is restricted to a small number of high-visitor sites. More general biosecurity advice should be made available for cyclists such as the "Ride Clean" example in Australia. This could be incorporated in the FLS forest cycling code which currently does not mention biosecurity.

5.3 The movement of agricultural machinery

There are a number of significant agricultural pests and diseases that can be spread on soil attached to machinery, for example PCN and clubroot. Farmers and contractors working with the crops associated with these issues (e.g., potatoes and brassicas) are very aware of biosecurity when moving machinery between sites. The majority of farmers (58.8%) reported that they never share machinery and only 11.8% replied that they regularly share machinery. However, a potentially higher risk issue is the use of external contactors' machinery on sites which was far more common with only 4% replying that they never have external machinery on site. 63.6% of respondents that do allow machinery on site, request that it arrives visibly clean, but 27.3% do not.

Significant lessons on farm biosecurity can be learned from international examples. In Australia for example, the spread of invasive weed species has accelerated biosecurity activities across agriculture. Initiatives such as "Farm Biosecurity" can provide inspiration for increased biosecurity take-up in Scottish farming.

5.4 Biosecurity in plant production nurseries

Biosecurity awareness has increased in horticulture in recent years. There are a number of significant threats to the industry, such as *Xylella fastidiosa*, which would have a significant impact if they arrived.

As a result, nurseries reported that they restricted access to visitors, not allowing them to freely move around the site. Other measures reported included tool cleaning, boot cleaning facilities at entrances, vehicle cleaning areas, and hard-standing area for deliveries. Several also reported that they have biosecurity policies and staff training.

We found that nurseries and other businesses were concerned about the biosecurity risk associated with contractors (e.g., electricians, plumbers, etc.). In particular, contractors that visited several similar businesses within a day without necessarily considering biosecurity. As a result, some nurseries brief contractors as they arrive and ask them to clean their footwear to reduce this risk.

5.5 Risk assessment

We found that respondents struggled to assess risk, with 26% not doing any risk assessment at all, 39% risk assessing pests they have heard of and 35% assessing for known and exotic pests (i.e., horizon scanning). There is a myriad of information available, for example on the UK Plant Health Risk Register (DEFRA, 2022d) contains information on 1,335 pests (28th June 2022), but how does an individual use this information within their organisation to assess risk without feeling overwhelmed? A much simpler version showing the highest risk hosts and notifiable pests for each sector, updated regularly, would be beneficial for organisations trying to understand risk when, for example, issuing plant passports. This process has started with the development of the Pest and Disease Index (DEFRA, 2021).

5.6 Biosecurity information availability and dissemination

This review suggests that there is some awareness of current biosecurity messaging, but it is a) not getting through to all practitioners, and b), does not necessarily result in change when it does. We suggest that lessons on awareness raising could be learned from the behaviour change successes of human health (e.g., smoking cessation) and health & safety adoption.
We found that biosecurity guidance is siloed and not widely integrated within and between sectors. For example, "Keep it Clean" is largely viewed as a forestry initiative and therefore farmers do not necessarily think that it applies to them. In addition, biosecurity messaging often exists in isolation and does not appear in potentially relevant places. For example, the mountain biking and walking webpages of various organisations could mention "Keep it Clean" but they currently do not. A countryside user is frequently required to go looking for biosecurity guidance rather than being presented with it.

Similarly, the Scottish Outdoor Access Code, and the more recently reviewed Countryside Code, do not mention biosecurity. This is a missed opportunity to raise awareness of biosecurity issues and measures to visitors to the countryside who may be visiting various different sites within a day (e.g., forests, parks, gardens and the natural environment). Fortunately, a more joined-up approach to biosecurity awareness raising seems to be underway with initiatives such as the recent Public Engagement in Plant Health Accord which aims to improve the understanding of plant biosecurity in wider society.

There are precedents that can be followed for improving wider biosecurity awareness. New Zealand has fostered a philosophy of shared responsibility where every citizen has a role to play to protect business and the natural environment. Some of the comments we received from respondents apportioned blame for biosecurity failures to particular sectors or the government. This may be the case for certain plant pest introductions. However, a wider recognition of the threat should be encouraged, as many pests and diseases are threats to multiple plant species and everybody potentially has a role to play in raising awareness of plant health issues and improving plant biosecurity.

Our study highlighted a difference in perception of the relevance of biosecurity in different sectors. Initially, respondents to the survey from the agricultural sector indicated that the survey was not relevant to them. This may suggest that the biosecurity language used in the survey was more familiar to ornamental growers and foresters and that more targeted information using different terminology may be required for the agricultural sector.
For those organisations willing to adopt biosecurity measures, advice is often unspecific and vague. Respondents were engaged in the process with 66% having a member of staff responsible for biosecurity and 60% offer staff training. However, without clear guidance, an ad hoc approach within sectors has developed with organisations doing the best they can with the information they have. This is where the Plant Health Management Standard is beneficial, as it aims to ensure that each organisation involved knows exactly what they to do to reduce their site and operations plant pest risk to an acceptable level. The HACCP approach has been shown to drive standards up over time in other sectors (e.g., food safety), and in international examples of plant production, there is no reason to doubt that it will do the same in the UK for plant health.

Therefore, to improve biosecurity adoption, organisations and businesses require a) more scientific evidence of the effectiveness of different approaches, b) a cooperative approach with other likeminded businesses/organisations, and c) more definitive information/guidance. These requests should be met by governmental plant health authorities through working with industry (e.g., horticulture, forestry) to understand the issues they are facing and gathering the evidence required to create clear guidance.

Reasons given for organisations not adopting biosecurity measures were related to practicality and cost as well as a lack of knowledge. There were comments that there are no particular

barriers but that businesses just do not know where to start. Once again, this points to the need for clear guidance for organisations wanting to improve their biosecurity standards.

It is difficult to assess the effectiveness of specific biosecurity measures such as disinfecting mats or boot washing facilities, but these approaches do offer an opportunity to engage visitors to a site and raise awareness of plant health issues and how to prevent disease spread.

There are significant lessons to be learned from other sectors when it comes to behaviour change. The raised standards of food safety and workplace health and safety over the last few decades offer an insight into how to achieve widespread change. In some cases, this has been achieved internationally through biosecurity acts (e.g., New Zealand Biosecurity Act (1993)) which bring biosecurity up to a level legal footing to environmental protection and health and safety. Further international biosecurity initiatives can provide tried and tested examples of where biosecurity behaviour change has been achieved and where it has not, helping to produce effective messaging.

Human health research shows that it is important to realise that behaviour takes place within social environments and that there are political and economic forces which act directly on people regardless of any individual choices that they may make about their own conduct (Glasgow & Schrecker, 2016). For this reason, behaviour change is complex and likely to take time.

6 Conclusions

This review has gained a good understanding of current biosecurity practices across sectors in Scotland, highlighting the need for clear, evidence led, sector-relevant, biosecurity guidance for businesses and organisations managing the biosecurity risks associated with visitors, tool hygiene and machinery movement.

To reduce the siloed nature of current guidance, new advice not only needs to be relevant to a particular sector, but also applicable to others so it can be referred to where appropriate. For example, “Keep it Clean” guidance from forestry could be used in countryside codes which potentially touches all sectors. In addition, specific advice can be incorporated in publications which are aimed at particular users, for example mountain biking biosecurity should be mentioned in forest cycling codes.

Unfortunately, countryside users must specifically look for biosecurity information to find it, rather than being presented with it when planning a trip. If biosecurity is to be more widely adopted and awareness increased, then this needs to be addressed. All land managers have a role to play in this process.

It is important that organisations not only have a biosecurity policy but that this translates into daily processes and that staff training takes place so that everyone understands their obligations. In order to be effective, biosecurity actions need to be followed. It is important that complacency does not set in over time. Managers have an important role to ensure that staff take biosecurity seriously so that a perception of futility does not set in.

There is much to be learned from approaches taken by other sectors when trying to achieve behaviour change but more in-depth research is required to understand how this can be achieved in plant biosecurity. International examples certainly provide lessons in which biosecurity initiatives promote behaviour change and which do not.

International examples also show that regulation has a role to play in behaviour change but industry must also play its part through initiatives such as the Plant Healthy Standard. Public gardens in particular have an important role to play in biosecurity awareness-raising given the potentially high numbers of visitors they attract.

Assessing risk is problematic for organisations and businesses. There is a significant amount of pest and disease information available, but a lack of clarity on how to translate risk assessment into specific organisational actions. More help should be provided by the Plant Health Authorities on risk assessment.

Biosecurity success is likely to depend on coordination across sectors through a shared understanding of the issues and aligned activity to address them. A proactive, long-term, coordinated, biosecurity awareness raising plan with a clear objective and realistic metrics is required. The GB Plant Biosecurity Strategy was a recognition of this and has resulted in wider awareness of biosecurity across sectors, the 2022 version aims to go further by strengthening engagement with the public.

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8 Appendix A – Plant biosecurity practices: people, tools, equipment and machinery survey questions.

Plant biosecurity practices: people, tools, equipment and machinery

The Royal Botanic Garden Edinburgh is conducting research on awareness and adoption of plant biosecurity practices. The main aim of the work is to understand how businesses and landowners manage the biosecurity risks posed specifically by:

(1) People (visitors and staff) moving onto and from an area

(2) Use of and movement of tools, equipment and machinery

The results (including your answers) will be used to produce a report on the current situation and provide recommendations on the next steps required to improve biosecurity guidance.

This survey is designed to be filled out by a person with management responsibility - i.e. a person who is responsible for making the decisions of how a site or sites are managed and run (e.g. writing policies and ensuring procedures are implemented).

All information gathered will be treated in the strictest confidence and any information used in a final report will be anonymised. There are 32 questions that should take approximately 15 minutes to complete.

All answers are optional and any information that you are able to provide by the 13th May 2022 will be greatly appreciated.

Context - site characteristics

1. What is the name of your organisation?

2. What sector(s) describe your organisation? Check all that apply.
- production of live plants (nursery stock)
- retailing of live plants
- garden management / landscaping
- farming
- forestry / arboriculture
- habitat conservation / improvement
- charity / volunteering
- Other:

3. Do the site(s) you have management responsibility for include any of the following features? Check all that apply.
- nursery for propagating and / or growing on plants
- plant sales area (open to public)
- garden open to the public
- food crops (allotment areas or cropped land)
- tree or wooded areas (arboreta, parkland trees or forested areas)
- open green space such as meadows / playing fields / lawns
- habitat / conservation areas
- recreation facilities - e.g. mountain bike tracks or water sports
- shooting
- fishing

4. Do you move any of the following materials between sites? These can be between sites within your organisation or to and from other sites that you do not own or manage. Check all that apply.
   - live plants for planting [e.g. ornamental or amenity plants and trees]
   - seed (e.g. wild flower mixes)
   - food crops
   - soil
   - timber or other woodland products (e.g. coppice products or firewood)
   - wood packaging material
   - growing media
   - green waste
   - Other:

General Plant biosecurity

5. Do you have a member or members of staff with specific responsibility for plant biosecurity? This could be you in your capacity of site manager or a colleague. Mark only one oval.
   - Yes
   - No
   - Not sure
   - Other:

6. Do you undertake or offer employees any form of plant health or biosecurity training? Mark only one oval.
   - Yes
   - No
   - Not sure

7. How vulnerable do you assess your site to be to the threat of new plant pests and diseases?

Mark only one oval.

	1	2	3	4	5	6	7	8	9	10	
not at all	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	highly vulnerable

8. With reference to the previous question, what best describes your assessment method? Mark only one oval.
   - I have not conducted a plant pest and disease assessment for my site(s)
   - I have assessed my site(s) for the plant pests and diseases I have heard about
   - I have conducted an assessment of the existing and exotic (i.e. not currently in your area) pests that could impact my site(s)
   - Other:

9. Please list the pest and diseases on your site in descending order of impact and how they arrived - with an [indication] of certainty.

E.g.: first most damaging - Phytophthora ramorum, which we [suspect] arrived on planting material; second most damaging - ash dieback, which we [know] was blown in on the wind; third most damaging - OPM, which we [know] was introduced on planting material; etc.

10. How significant was the impact on your organisation/site? Ecological, operational, reputational and financial.

Mark only one oval per row.

	High	Medium	Low
Operational	◯	◯	◯
Financial	◯	◯	◯
Reputational	◯	◯	◯
Ecological	◯	◯	◯

11. Do you consider that there are immediate plant pest and disease threats to your site(s)? Please specify.

People who work or visit your site

Part of this project is understanding the how people understand and assess the risk of people who visit their site(s). It is not a well understood area and we are looking to gain insights into how people manage the threat of people inadvertently introducing plant pests and diseases to a new area, i.e. your site(s)

12. Do you have a written plant health policy for your site that includes a section on managing the risk of people who work or visit your site? Mark only one oval.

- Yes
- No

13. Is biosecurity considered when writing RAMs (risk assessment and method statements)? Mark only one oval.

- Yes
- No
- Not sure

14. Please estimate how many people visit or work on your site each year. Mark only one oval.

- Over 1000
- Between 500 - 1000
- Between 100 - 499
- Between 50 - 99
- Between 10 - 49
- Below 10

15. Does your site have volunteers and/or contractors working on it? Mark only one oval.

- Yes
- No
- N/A

16. What do you consider to be the greatest risk from people introducing plant pests and diseases on your site(s)?

e.g. contract workers who have come from high risk sites OR members of the public who have allotments?

17. What measures have you put in place to manage these risks?

18. Are you aware of any public campaigns to raise awareness of the need for good plant biosecurity practices either aimed at professionals and/or public - If yes please list the names of the campaigns.

19. As a result of these campaigns, did you notice any changes in the behaviour of people visiting you site?

- Mark only one oval.
- Yes
- No
- unsure
- As per previous question I was unaware of any campaigns

Tools, equipment and machinery

Part of this project is understanding how people understand and assess the potential risks from tools, equipment and machinery in the spread of new plant pests and diseases. This too is not a well understood area and we are looking to gain insights into how people manage this threat.

20. Do you have a written plant health policy for your site that includes a section on identifying and managing the risk of tools, equipment and machinery in the role of spreading plant pests? Mark only one oval.

- Yes
- No

21. What measures have you put in place to manage the risks associated with tools, equipment and machinery?

22. Do you use chemical agents to clean tools, equipment and machinery? Mark only one oval.

- Regularly
- Only when absolutely necessary
- Never

23. How do you manage the run off from cleaning tools, equipment and machinery?

24. What are your views on the use of chemicals in terms of unintended consequences (e.g. damage to beneficial organisms in the vicinity, build-up of resistance)

25. Do you share machinery with other site owners? Mark only one oval.

- Regularly
- Occasionally
- Never

26. How often do you use external contactors' machinery on site? Mark only one oval.

- Very Often
- Often
- Occasionally
- Never

27. Do you request that any machinery arrives visibly clean and free from any organic debris and soil? Mark only one oval.

- Yes
- No
- N/A

28. Do you allow staff, volunteers or contractors to use their own tools on your site? Mark only one oval.

- Yes
- No
- N/A

Biosecurity adoption

29. What would encourage you to adopt tighter biosecurity measures? Check all that apply.

- A cooperative approach with other likeminded businesses/organisations?
- More definitive information/guidance?
- More scientific evidence of the effectiveness of different approaches?
- Further regulations?
- Voluntary certification schemes for plant biosecurity?
- An award to recognise best practice for for plant biosecurity
- To avoid statutory action (e.g. plants being destroyed due to a finding of a disease)?
- A specific and/or immediate threat?
- Other:

30. Are there other measures which you could take/are aware of but have opted not to? Please list:

31. What barriers exist to the adoption of the measures listed in the previous question? Check all that apply.

- cost - too expensive
- practicality
- perceived futility "why should I do this if no one else is?
- information
- time constraints
- lack of knowledge / understanding of the risk
- Lack of suitable equipment
- I do not think there are any barriers
- Other:

Please add any general views that relate to safeguarding your site from the threat of notifiable pests and diseases

32. Is there anything else you'd like to say that relates to the general theme of plant biosecurity or specifically to the movement of people, tools, equipment and machinery?
Thank you for your participation

Thank you for taking this survey - your participation is very much valued.

This work is being funded by the Scottish Plant Health Centre and we value your input wherever you are located in the world. Our goal is to help improve our collective understanding of how we can improve plant biosecurity and protect our valued plants and landscapes from further damage from destructive plants pests and diseases.

If you have put your email in section 1 then we will send you a copy of the final report.

33. Would you be prepared to be contacted about any of your answers in this survey? Mark only one oval.

- Yes (please provide your email below)
- No

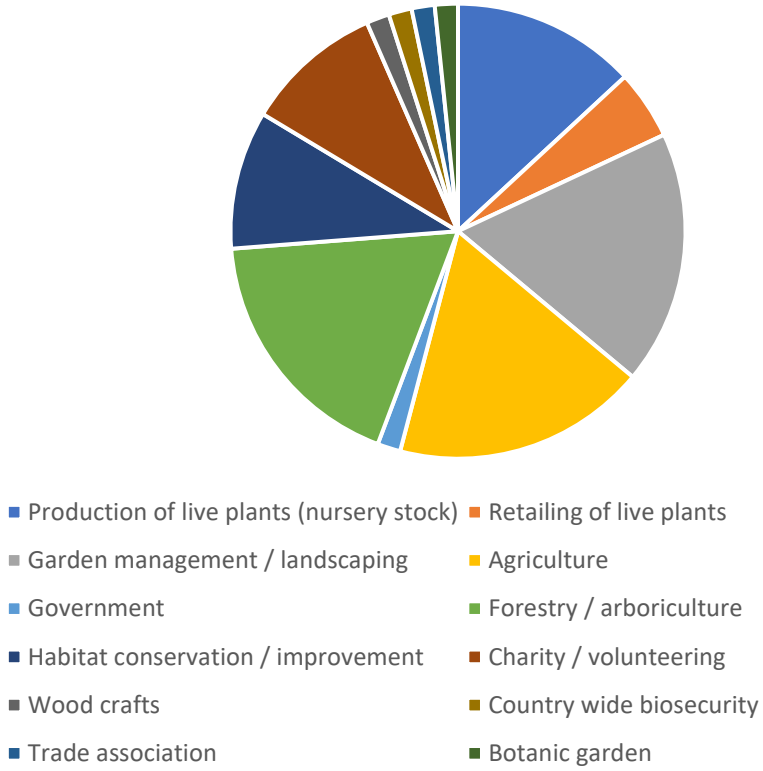
34. If you wish to receive a copy of the final report please provide your email address.

9 Appendix B – Detailed responses to the plant health survey

1 Cross sector biosecurity procedures currently in use

A survey was used to gain an understanding of the current biosecurity landscape across sectors and organisations (see method section). There were 36 respondents across sectors in Scotland, England and internationally. Figure 1 shows the sectoral breakdown of respondents (where more than one option could be selected, e.g., a botanic garden may also contain nurseries, retail, and areas of woodland so all could be selected).

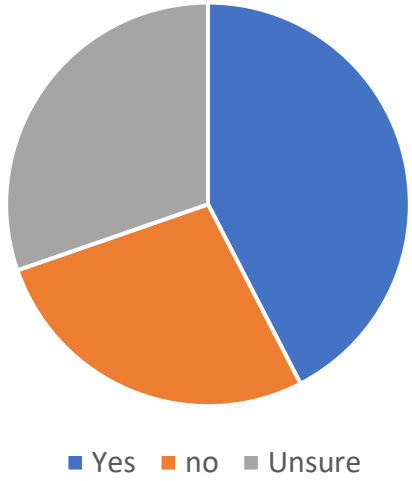
Figure 1: Sectoral breakdown of respondents to survey



2 Awareness of previous public campaigns

When asked "Are you aware of any public campaigns to raise awareness of the need for good plant biosecurity practices either aimed at professionals and/or public", 14 respondents were aware, 9 were not and 10 were unsure (or did not answer this question) (figure 2).

Figure 2: Are you aware of any public campaigns to raise biosecurity awareness?

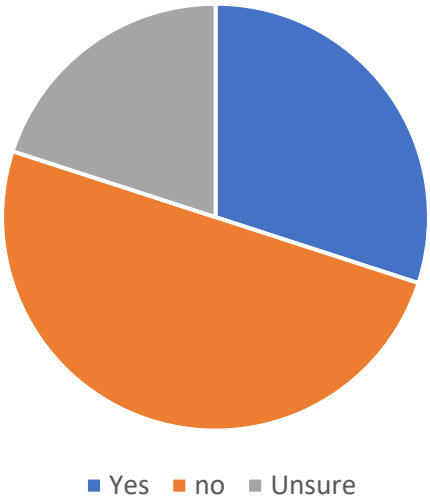


Awareness raising measures mentioned by respondents included “Keep it Clean”, “SASA and DEFRA campaigns” (no specifics given), “Plant Healthy”, “Forestry Commission” and “posters at airports warning of the dangers and legality of importing plants”.

5 of the 9 “no” responses were from the agricultural sector with an additional response of “not applicable”.

In order to gauge behaviour change, we asked if respondents had noticed any changes in the behaviour of people visiting their sites which could be a result of the campaigns mentioned above. The majority relied “no” or “unsure” (50% and 20% respectively) (figure 3).

Figure 3: As a result of these campaigns, did you notice any changes in the behaviour of people visiting your site?



3 Plant health responsibility

Having clear plant health roles and responsibilities is important for a business. For example, who does a member of staff report potentially diseased plants to if they find something concerning?

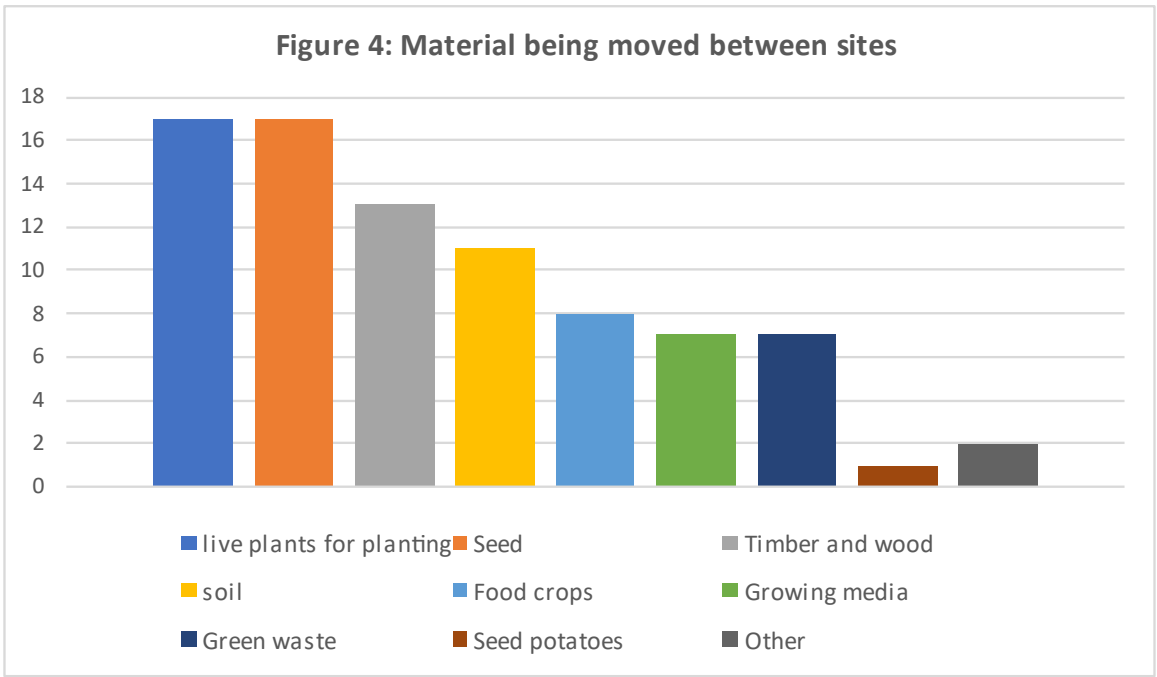
When asked "do you have a member or members of staff with specific responsibility for plant biosecurity" 65.7% responded "yes", 31.4% "no" and 2.9% "it is the responsibility of several staff". This shows that the majority have a person (or people) that can be approached by a member of staff if a biosecurity issue is identified.

When asked if biosecurity is considered when writing RAMs (risk assessment and method statements), 66.7% replied "yes", 15.2% "no" and 18.2% "not sure".

In addition, we found that 60% of businesses surveyed undertake or offer employees some form of plant health or biosecurity training.

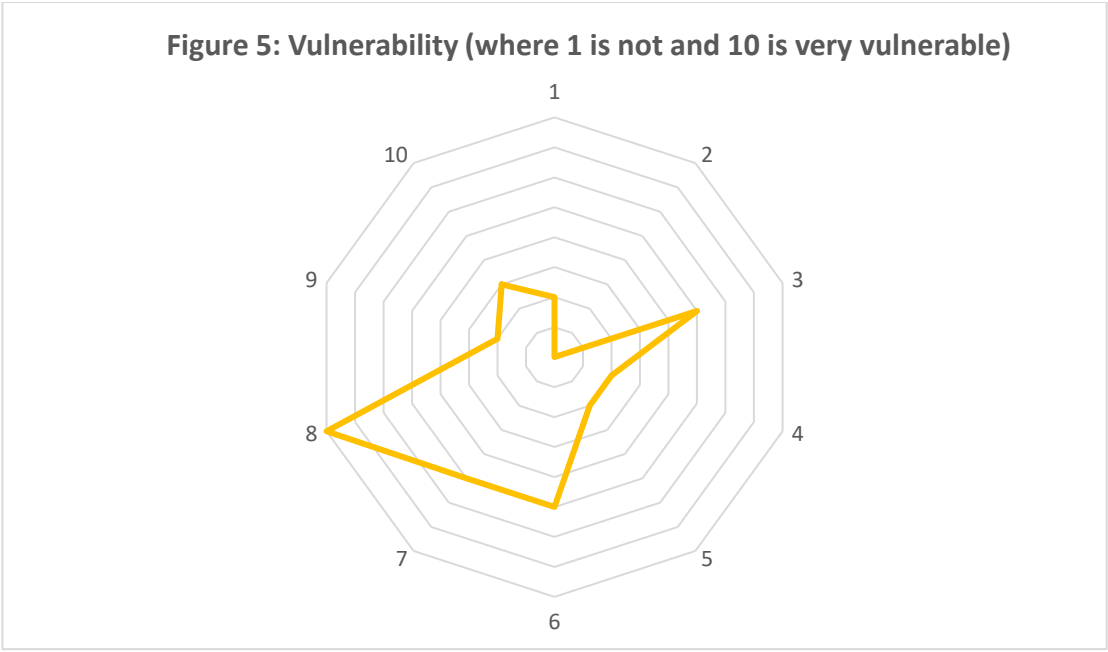
4 Moving material between sites

Respondents were asked to indicate which materials were moved between sites (more than one option could be ticked) (figure 4). Of the 31 responses, 54.8% moved live plants for planting, 54.8% moved seed, 41.9% timber or other woodland products, 35.5% soil, 25.8% food crops, 22.6% growing media, 22.6% green waste, 3.2% seed potatoes and 6.4% "other" (where one response was "checking all crops of plants of concern in trade" and one was "processed seashells").

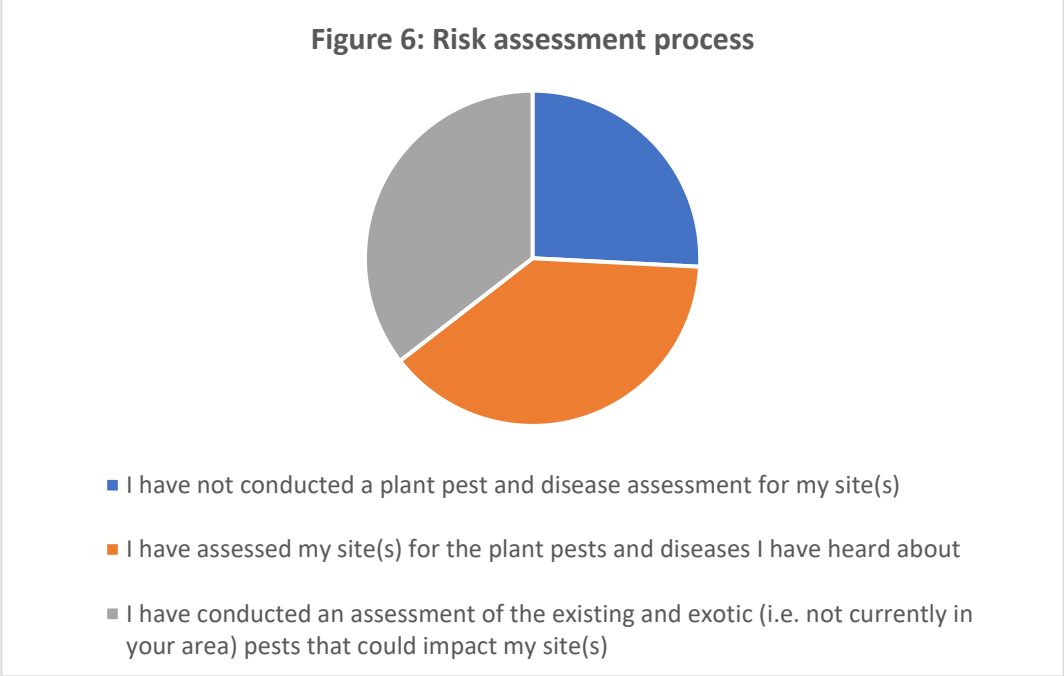


5 How businesses assess risk and vulnerability

Respondents were asked to rank their vulnerability to pests and diseases from 1 (not vulnerable at all) to 10 (very vulnerable). More than half of the respondents (n=18) ranked their vulnerability between 6 and 8 (figure 5), the mean average for all responses was 6 out of 10.



In order to further understand how risk was being assessed, we asked respondents to describe their assessment method against a number of options. The majority (39%) have assessed their sites for the pests and diseases they have heard of, 35% have risk assessed for known and exotic pests and 26% have not done a risk assessment (figure 6).



In addition to these responses, there were also two specific answers:

- "We are part of a pest sentinel network with other botanic gardens and monitor plants which could harbour a number of potential pests not currently in Australia but at risk of arriving"
- "We fumigate our potato stores annually to prophylactically treat against known plant pests"

6 Impact of pests and diseases

We asked respondents to list the pest and diseases on their sites in descending order of impact. The most impactful and commonly reported diseases were *Phytophthora* species (16 mentions) followed by ash dieback (14 mentions). *Phytophthora* species mentioned were *P. ramorum*, *P. pluvialis*, *P. kernoviae* and *P. infestans*.

There were many other pests and diseases mentioned (table 1), many of which unsurprisingly corresponded closely to the sectors involved:

Sector	**Pests and pathogens**
Forestry	*Dendroctinus micans*, deer, squirrel, *Dothistroma septosporum,* aphids*, Ips typographus, Neonectria neomacrospora, , Sirococcus tsugae*, chestnut blight, Dutch elm disease, honey fungus, *Ganoderma*, *Meripilus*, pine weevil, scarid fly, rabbit.
Parks and gardens	Box blight, Oak Processionary Moth, Fire blight, and box caterpillar.
Ornamental growers	Thrips, Mildew, white fly, Tortrix moth, red spider mite, Sciarid fly, *Pythium, Fusarium*, cockroach, mealybugs, orchid viruses, vine weevil.
Agriculture	PCN (Globodera ssp.), potato viruses, *Fusarium*, Powdery scab, potato spindle tuber viroid, *Meloidogyne fallax*, *Pectobacterium* ssp, cavity spot, clubroot, gangrene, skinspot, Blackleg, *Rhizoctonia.*
International responses	*Phytophthora cinnamonii*, *Armillaria*, elm leaf beetle (Tasmania). Rhino beetle, Palm weevil, *Chilades pandava*, Mango stem borer (Thailand).

Table 1: Pests and diseases mentioned by respondents in descending order of impact (in addition to Phytophthora ssp. and ash dieback). Species in blue were only mentioned once.

In terms of the level and nature of the impact on a business, respondents were asked how significant the impact was operationally (figure 7), financially (figure 8), reputationally (figure 9) and ecologically (figure 10):

Figure 7: Operational impact

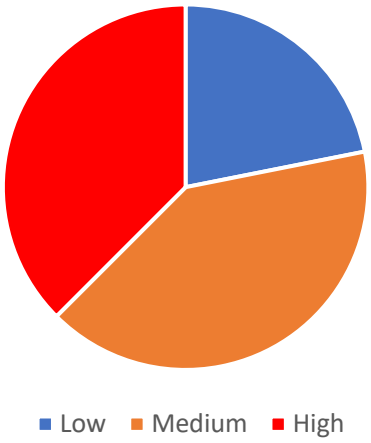


Figure 8: Financial impact

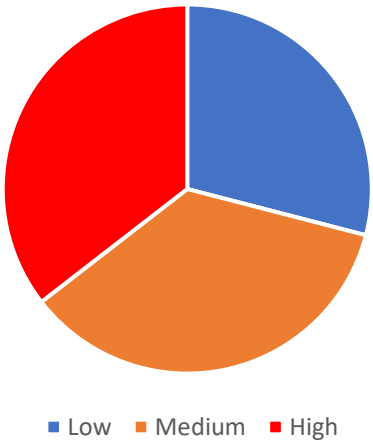


Figure 9: Reputational impact

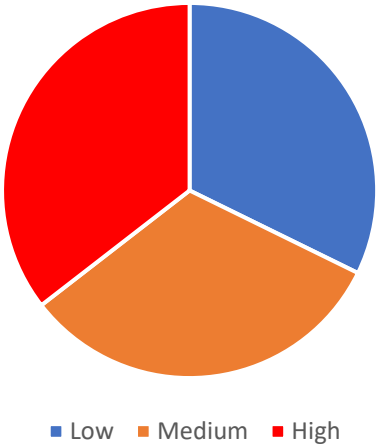
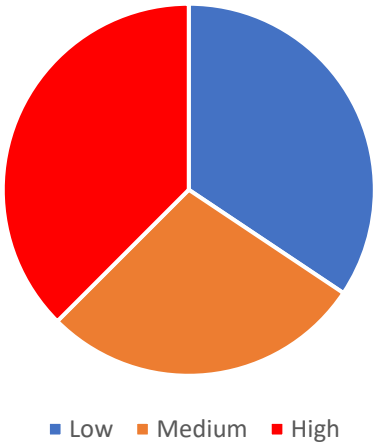


Figure 10: Ecological impact



It is conceivable that these data are dependent on which pest is being considered in each sector. For example, forestry and woodland management respondents rated impact as high in all areas, possibly because of a number of particularly impactful diseases such as *Phytophthora ramorum* and ash dieback. Conversely, ornamental gardens (e.g., botanic gardens) rated the impacts as low to medium.

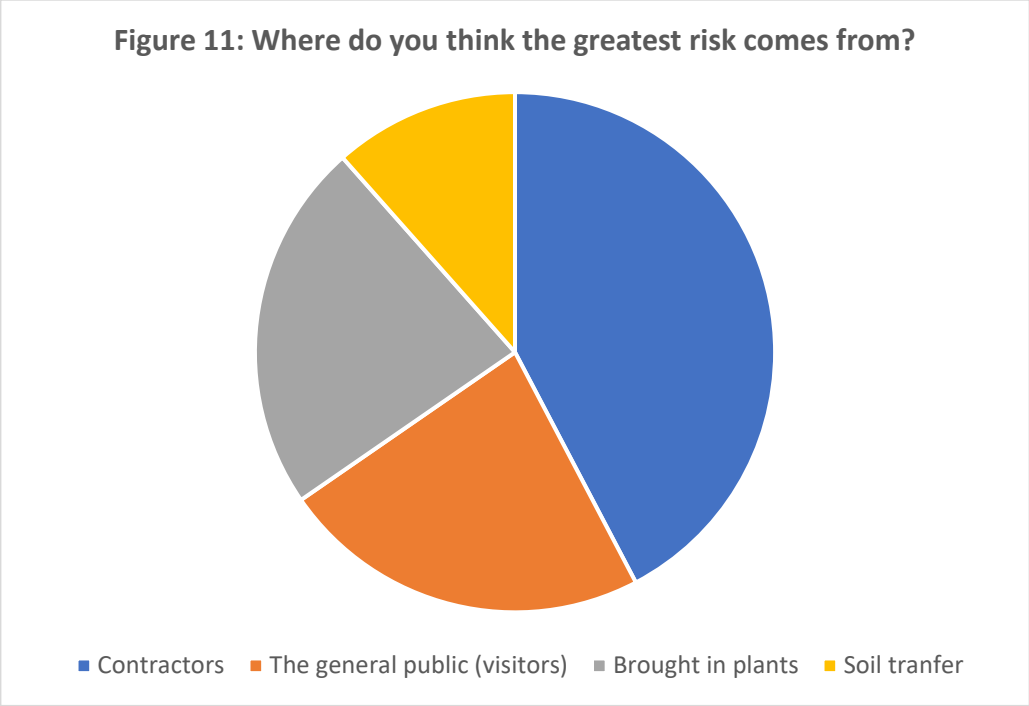
7 Visitor biosecurity

The majority of organisations surveyed had more than 1000 visitors (47.1%). In addition, 91.2% had volunteers or contractors regularly working on their sites.

44.1% of respondents had a plant health policy which included details on managing the biosecurity risks associated with visitors, 55.9% did not.

We asked respondents what they consider to be the greatest risk from people introducing plant pests and diseases onto their sites. By far the most common response was contractors (figure 11), particularly those working on numerous similar sites and not cleaning boots, equipment and machinery between jobs. In addition, non-horticultural contractors were identified as high risk because they will not have come across biosecurity before, e.g., plumbers. Also mentioned was the risk from contractors that have recently been overseas.

The next riskiest was thought to be the general public (visiting sites) and new plants being brought onto site (equally rated) and then soil transfer between sites, e.g., on machinery that has not been cleaned.



Other specific responses included:

- "Hitchhikers (insects which move around undetected on people, machinery, etc.)".
- "Increasingly warmer and more humid climate".
- "Neighbouring crops that have lower pest thresholds than ours".
- "Growers using potato seed originating from Holland".
- "Anglers introducing *Gyrodactylus* from overseas (salmon fluke)".

8 Risk mitigation

Respondents were asked what measures they put in place to manage the risks identified above. There were many different responses, but they all largely fell into several activities:

- Specific cleaning measures in place (e.g., footbaths, vehicle cleaning, etc.) (6 respondents)
- Biosecurity policy in place for staff and/or biosecurity specified in contracts (5 respondents)
- None for visitors (4 respondents)
- Contractors and volunteers briefed on biosecurity when they arrive on site (4 respondents)
- Checking new planting stock for pests as it arrives (3 respondents)
- Limiting access to public and contractors where appropriate (2 respondents)
- Quarantining new stock as it arrives (2 respondents)

9 Tools, equipment and machinery

Just over half of the businesses surveyed (52.9%) have a written policy which includes a section on managing the risks associated with tools, equipment and machinery.
When asked which specific measures are in place to manage this risk, responses fell within a few actions:

- Regular cleaning / sterilising of tools, particularly when working in areas known to be infected by a specific disease.
- Follow the measures set out in a Statutory Plant Health Notice (these may be general or specific to a particular pathogen/context).
- Wash down areas for machinery.
- Washing machinery between sites.
- All soil engaging machinery is owned and operated in house.
-

In order to carry out this work, 44.1% regularly use chemical agents to clean tools, 41.2% when absolutely necessary and 14.7% never.

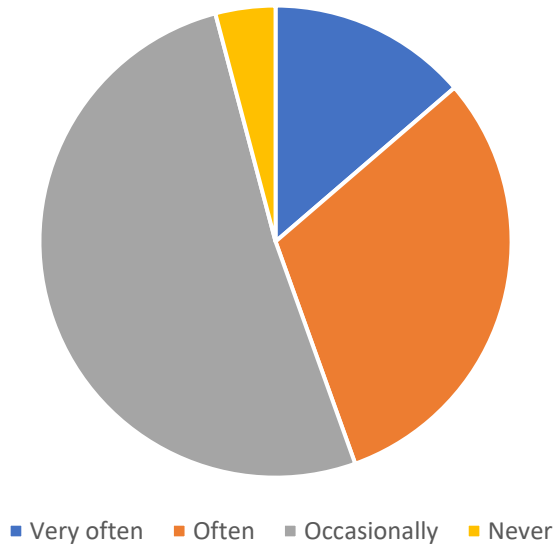
We also wanted to gauge the risk posed by run-off from cleaning areas which may pose a biosecurity hazard because it may contain pathogens. Respondents were therefore asked how they manage their run-off, 48% did not manage run-off at all.

10 Machinery sharing

To understand how machinery sharing is viewed and to what extent it takes place, we asked respondents if they share machinery with other site owners. Only 11.8% replied that they "regularly share machinery", a further 29.4% "occasionally share machinery", but the vast majority (58.8%) replied that they "never share machinery".

However, when asked how often they use external contactors' machinery on site, 31% replied "often", 14% "very often", 51% "occasionally" and only 4% "never" (figure 12).

Figure 12: How often do you use external contactors' machinery on site?



In terms of mitigating the biosecurity risk posed by the movement of contractors' machinery with soil attached, we asked if respondents requested that machinery arrives on site visibly clean, 63.6% replied that they did, 27.3% replied that they did not (9.1% replied N/A).
In addition to this, we asked if businesses / organisations allowed staff, volunteers and contractors to use their own tools on site, 61.8% indicated that they did allow this, 35.3% did not (2.9% replied N/A).

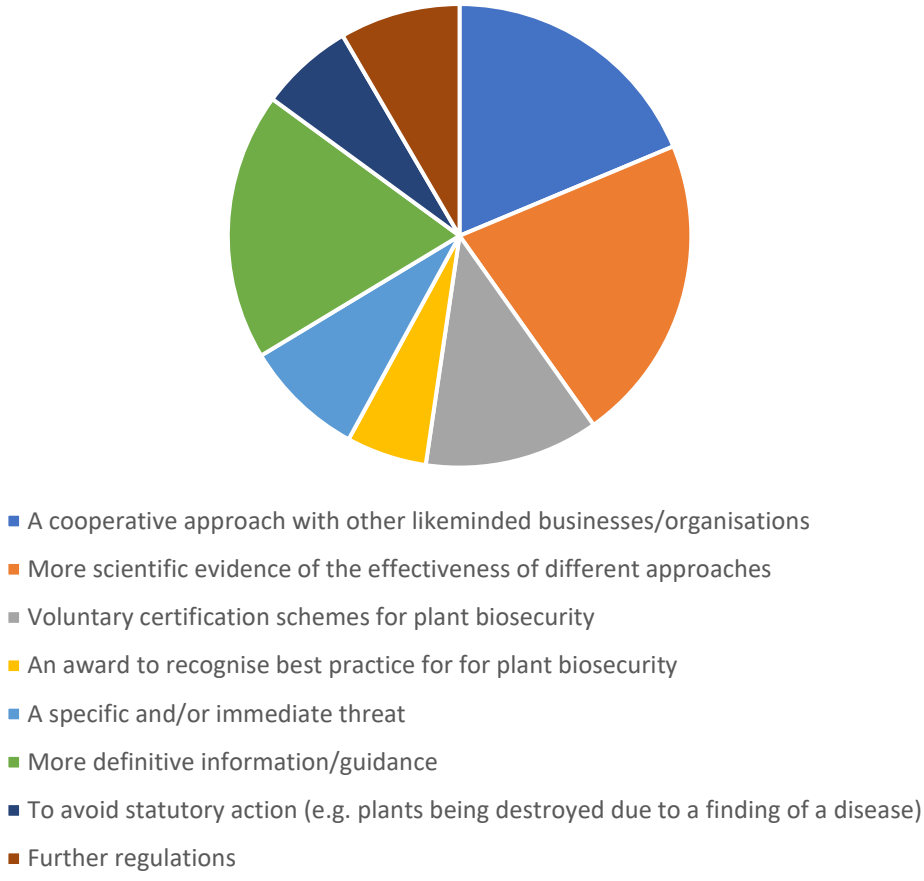
11 Biosecurity adoption

To enable us to understand how to improve the uptake of biosecurity measures we asked what would encourage respondents to adopt tighter biosecurity measures by selecting a number of options (figure 13).

The three most selected options (as selected by 20 or more people) were:

- "More scientific evidence of the effectiveness of different approaches".
- "A cooperative approach with other likeminded businesses/organisations".
- "More definitive information/guidance".

Figure 13: What would encourage you to adopt tighter biosecurity measures?



A number of other answers were also provided:

- "Government policy driven so comply".
- "Training".
- "Raise public awareness, if not you are wasting your time".
- "We already adopt measures".
- "We already have a voluntary biosecurity scheme (Safe Haven) of which we are members".
- "I am currently the lead promoting a project to build a "Quality Center" for root crops (primarily for certified seed potatoes and ware). This project will feed into biosecurity practices and has the potential to assist with tracking disease and pests".

12 Non adoption of measures

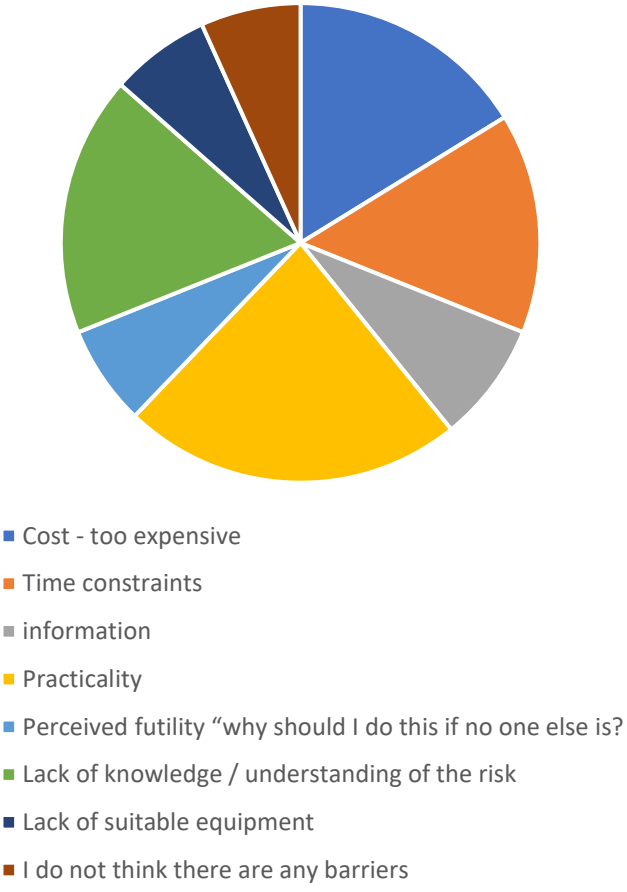
In addition, we asked if respondents thought that there might be any other measures that they could take / are aware of but have opted not to. There were 7 responses:

- "Foot disinfection for visitors".
- "Boot washing; tool inspection; restrictive signage".
- "Installing a biosecure area for bought in plants".
- "Fine contractors who transport contaminated machines".
- "Yes, full clean down of machinery when moving between fields. But not practical and economically sustainable".
- "More publicity".
- "Not as such, however I am amazed that all farmers do not have properly configured pressure washer - washdown facilities with appropriate silt traps which could also assist with nematode monitoring".

13 Barriers to adoption

To further understand this, we asked what barriers exist to the adoption of the measures listed in the previous question (against a number of options where more than one could be selected). The most cited barriers were "practicality" (23%), "lack of knowledge" (18%), "cost" (16%) and "time constraints" (15%) (figure 14). 7% replied "I do not think that there are any barriers".

Figure 14: What barriers exist to the adoption of the measures listed in the previous question?



Once again, a number of other answers were also provided:

- “Perceived futility at the effectiveness over such a large and complex site”.
- “Public and contractor perception and willingness to cooperate”.
- “Staff knowledge - now that we've undergone a round of recruitment & have appointed to posts developing a phytosanitary policy is a priority for this year”.
- “A little of all of the above, difficult to pinpoint how best to move forward”.

14 Further information

To conclude the survey, we asked respondents if there was anything they would like to say that relates to the general theme of plant biosecurity or specifically to the movement of people, tools, equipment and machinery. The 11 responses were:

- “I think we could all improve in this area”.
- “No, interested to hear the outcome”.
- “Helpful if UK government was provided with greater resource to facilitate more plant health awareness events with the trade and public”.
- “Fly tipping of contaminated materials is becoming more common and unpredictable. More practical solutions to improve bio security for large machines and lorries travelling in and out of sites will convince others to take it seriously. Currently the attitude is, why clean my boots when a lorry can drive away covered in potentially contaminated material”.
- “Not really, except that Brexit (of which I was not a supporter on balance) has given us an opportunity to reinforce the power of our island status as a protection. More could be done to prevent pathogens entering the UK by Government if it had a will to do so”.
- “The threat of PCN is ever increasing to the growing of potatoes in Scotland. The amount of PCN infesting land is a huge worry to the potato sector, especially seed growing areas this problem can be easily exacerbated by movement of contaminated soil by people, machinery, tools etc”.
- “I feel we are at constant risk of foreign organisms adversely affecting ecosystems in Scotland. Evidence continues to prove actions of well-intentioned people introducing plants and animals into the UK can have catastrophic unintended consequences”.
- “If you can’t see it, it isn’t a problem”.
- “Since I represent a trade association some members of which do grow food crops most of the questions I cannot answer. However, in my 40 years experience of travelling around farms I've noted that biosecurity, in respect to people, tools and machinery, is a fairly low priority with the noted exception of growers of high grade seed potatoes. The spread of Potato Cyst Nematode over the past 100+ years is a good example of what can happen due to a lack of adequate biosecurity practises. However, more recently the increase in the prevalence of Blackgrass within cereal crops over the past 10 years has encouraged more biosecurity measures to be implemented to reduce the inadvertent spread of Blackgrass seed on machinery traveling between fields. This area could be better managed through the implementation of the plant health regulations surrounding 'Professional Operators' within The Plant Health (Amendment etc.) (EU Exit) Regulations 2020”.
- “Integrated Pest management best practice is sold short if on farm storage and hygiene standards are sub optimal. Government needs to recognise that they can influence and support Food security and profitability if Biosecurity is taken more seriously”.
- “I blame gardeners”.

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