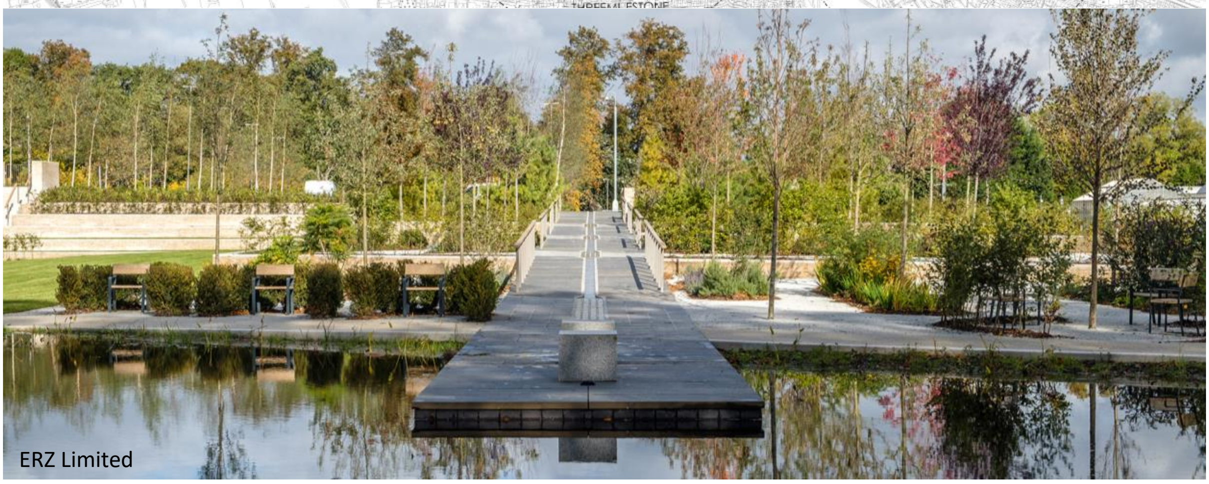
Assessment of plant biosecurity risks to Scotland from large-scale plantings for landscaping and infrastructure projects

PHC2019/05: Project Final Report

AHR Architects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Content

1 Executive Summary

This report focuses on the assessment of tree and plant biosecurity risks to Scotland from large scale planting for landscaping and infrastructure projects. There were 325 major planning applications across Scotland in 2018/19, 1.2% of all planning applications. Large-scale projects of this type can typically involve tens of thousands of individual plants, which can provide multiple ecosystem services, but also potentially pose threats to plant health in Scotland due to the biosecurity risks of import, trade and widespread planting of infested or diseased plants.

The project aimed to understand the extent and means of mitigating against such plant biosecurity risks with a focus on mapping the pathways from plant specification through to planting and establishment and highlighting different actors' biosecurity awareness, decision-making and procurement processes.

Using the publicly accessible planning portal we carried out a tracing exercise on 11 existing largescale projects in Scotland, covering four typical build project types: residential, campus (e.g. business or retail park, or university campus), urban open space (e.g. public town square), and infrastructure (e.g. along a road). The research then took a two-pronged approach for each project; recruitment and semi-structured interviews where possible with key actors involved in the landscaping; and inspecting sites to ground truth planting against the original plans available from the planning portal. A further set of six semi-structured interviews were conducted with actors related to two specific case examples: planting along trunk roads, and an exploration of an historical outbreak.

Structured interviews were sought with key pathway actors (landscape architects, local authorities, clients, developers, landscape contractors and landscape managers). The structured interviews followed a questionnaire covering specification, hiring of contractors, plant sourcing and supplier choice, planting, establishment and maintenance, and biosecurity awareness. We interviewed 15 landscape architects, one client, no developers, one landscape contractor, three local authorities, and two landscape managers. We used the planning portal, snowballing (i.e. asking participants to identify other participants), and internet searches to find contact details for pathway actors. We also conducted four interviews with landscape architects and two with landscape managers for the two additional case studies.

Despite intensive efforts, the response rate was very low for certain groups. A number of these actors are considered hard to reach and recruitment was made more difficult through COVID 19 and subsequent lock-downs. Thus, we are missing the knowledge and experiences of a number of key actors (clients, developers, contractors and landscape managers) along the planning to planting chain and inevitably we may not have captured all the complexities and relationships involved. Future research on this topic should aim to improve understanding of the roles of these groups in the plans to planting pathway and specifically in relation to biosecurity practices.

For the characterisation of the green infrastructure, the planting specifications for 81 sites (across Scotland and England) were transcribed. Twenty sites in Scotland and 14 in England were then visited to undertake the ground truthing exercise. The planting of six 2x2m quadrats for each site was evaluated against the original plans and recorded in a dataframe.

The interview respondents were generally engaged in the conversations, often felt a sense of pride towards their projects, and expressed an interest in learning more about biosecurity.

Respondents were also unaware of any significant plant pest or disease issues in the planted stock. However, we found a number of missed opportunities for practices that could lead to greater biosecurity based on a general lack of awareness and communication. We report on key issues identified in the plans to planting pathways and reflect on opportunities for improvement. The key issues and reflections are highlighted below:

<u>Key issues</u>

Despite the small sample size, the study highlighted a number of potential blind spots in the planting pathways, namely; variable inclusion of biosecurity measures and lack of species diversity in plant specifications; low consideration of biosecurity in procurement processes; changes to plants for planting or lack of completed planting and lack of awareness and authorisation of substitutions.

Biosecurity inclusion at the beginning of the pathway

- Biosecurity is included in landscape specifications and the National Building Specification Building Information Modelling Object Standard is used by some landscape architects for this process. However, while it does mention biosecurity, it is more broad and generic. Methods could be developed to enable landscape architects to explore biosecurity at a site level.
- A narrow range of plant species was specified leading to low resilience towards potential plant and diseases outbreaks.

Lack of biosecurity visibility and ownership

- Along the pathways from planning to planting we found little evidence of connectivity between actors in relation to biosecurity. Often, some actors were unaware of who other actors were within the pathway, and where responsibilities for plant biosecurity lay.
- Plant biosecurity is generally not a high priority. None of the participants currently have a biosecurity policy, and levels of awareness were generally low. Participants often expected biosecurity expertise to come from elsewhere, mainly the landscape contractor or the supplier (expecting them to source responsibly).

Biosecurity inclusion at the end of the pathway

- Information about processes later in a project's lifespan (contracting, sourcing, replacement and management) often does not flow back to individuals involved in the planning and specification stages of a project (i.e. landscape architects and local authorities). This was highlighted by a number of inconsistencies or contradictions in responses from different actors within individual projects.
- Perceptions of the accuracy of planting carried out compared to the original plans, and actual planting accuracy identified by the fieldwork was significantly different. Whereas 67% of the survey respondents reported that projects matched the plans, our fieldwork found that this figure is nearer a quarter of all projects. This indicates that decisions may be taken outside of the contractual agreement or without the client's agent (i.e. the landscape architect) knowing about it. The client and landscape architect therefore have no way of understanding what the biosecurity risks for the projects are. These issues were common, indicating a systemic challenge to biosecurity.

<u>Key reflections</u>

Reflection 1: There is scope to improve biosecurity industry-specific information and guidance for non-biosecurity specialist roles in construction such as clients, contractors, landscape architects and local authorities. From our sample there appeared to be limited existing awareness but a willingness to learn about key biosecurity risks. Information and training could be usefully targeted through key communication channels. Identification of key personnel who can have the greatest influence on promoting biosecurity behaviours along the pathway could also help address this. Information should clearly outline what biosecurity means and identify where the risks lie.

Reflection 2: It would be beneficial if responsibility for biosecurity was clearly allocated in contractually binding documents. This will prevent a 'someone else deals with that' mindset and make sure actors such as landscape architects, landscape contractors and nurseries are aware of their roles and responsibilities in relation to biosecurity. There is an opportunity to consider what support trusted organisations such as the Landscape Institute need to raise the profile of biosecurity amongst their members.

Reflection 3: Opportunities may exist to encourage biosecurity considerations in specifications, such as through improved integration into the National Building Specification (NBS) Building Information Modelling (BIM) Object Standard and other tools used during the specification process.

Reflection 4: Requesting relevant biosecurity documentation in specifications can help improve transparency of practices for all involved actors, as well as support accountability and enforcement. Improved enforcement, ensuring that planting is carried out according to plans, is important in closing the gap between specification and practice. However, there may be capacity limitations here.

Reflection 5: As a narrow range of species is specified for these projects, it is also important to promote the use of diverse species in landscaping projects and clarify the importance of diversity for resilience to pests and diseases.

Reflection 6: Special focus may be needed on large trees as these appeared to be the most difficult to source nationally, and therefore potentially pose increased threats to tree health.

Reflection 7: A biosecurity risk assessment process that is monitored throughout the planning to planting process could strengthen oversight of biosecurity issues.

2 Introduction

Threats to the UK green infrastructure are on the rise. Climate change, the increasing pressures of development, and pests and diseases all impact on plants in urban and rural settings. Between 1970 and 2004, 234 novel plant pathogens were recorded in the UK, the majority of which were introduced on ornamental plants (Jones and Baker 2007). Tree pest and disease introductions into the UK have also increased from near zero reported in the early 1900s to just over 40 in 2015 (Spence et al. 2019). Introductions are driven by global trade with pests and diseases often accidentally imported from overseas and climate change altering the habitat conditions which can increase the chances of pests and diseases establishing (Marzano et al. 2020; Linnakoski et al. 2019; Spence et al. 2019; Urquhart et al. 2018; Potter et al. 2017; Ramsfield et al. 2016; Brasier, 2008).

The impacts of a new pest or disease can be enormous. For example, it was estimated that the financial cost of ash dieback in Britain could amount to £15bn over 100 years, including the loss of biodiversity benefits provided by ash trees (Hill et al. 2019). Similarly, *Phytophthora ramorum*, originally imported via the plant trade has caused large landscape scale changes with the removal of larch forests. In Scotland, plant pests and diseases threaten a £1.8 billion rural economy including agriculture, horticulture, parks and gardens, forestry and the natural environment (the Scottish Government 2016). Biosecurity is therefore key to achieving the Scottish Government's National Outcomes for the environment.

In 2018/19, 27,373 planning applications were submitted across Scotland, of which 325 were considered major (for example, developments of 50 houses or more, or sites exceeding 2 hectares; the Scottish Government, 2019). Almost all large infrastructure or building projects such as hospitals, roads and motorways, residential developments, schools, and business parks include a landscaping component. The planting associated with such projects is often a key feature of the long-term visual impact of the project and provides an essential range of ecosystem services. However, large-scale landscaping projects often require significant volumes of plants, posing potential risks of pest and disease introductions through the import, propagation, and distribution of live planting materials as well as the movement of soil, equipment and people. These risks are potentially increased by the lack of available plant and tree stock within Scotland, the lead-in times needed for delivering large volumes of stock, and the at times competitive advantages of internationally sourced stock. Although significant, there is little publicly accessible hard data on the actual volumes of plant and tree stock imported to Scotland, the routes through which they enter the country or the procurement processes underpinning these practices.

For the future of our treescapes, it is pivotal that biosecurity measures are considered and implemented throughout the process from procurement to planting for development. Further investigation is needed to identify whether current biosecurity practices and procurement routes are fit for purpose. Planting pathways are currently poorly understood, and the actors involved (e.g. landscape architects, local authorities, clients, developers, landscape contractors and landscape managers) are understudied in the field of tree health.

The aim of this research was to identify the key processes and potential biosecurity risks in large-scale developments. A detailed description of the planning to planting process has been outlined in Box 1. However, we followed a simplified process outline with a focus on key points of biosecurity risks along the following steps: plant specification, planning approval, contracting, sourcing, planting and maintenance and surveillance of planted stock (Figure 1, Table 1). By taking the following approach we sought to understand the risks and challenges associated with large-scale and complex supply chains highlighted by the following research questions:

1) What are the flows of plants into or within Scotland for large infrastructure and landscaping projects?
2) What are stakeholders' awareness of
   a) plant pests and diseases?
   b) inclusion and visibility of biosecurity in specification and procurement processes?
   c) important factors influencing sourcing of plants (e.g. range, volumes, availability, cost, reputation of supplier) for construction and planting operations?
3) What are the roles and responsibilities of key players in promoting better biosecurity?
4) For soft landscape specifications that have received planning permission, how are these implemented in reality?

In order to identify potential bottlenecks to biosecurity we undertook a tracing exercise of planting schemes in four key areas: campus-style developments (such as business parks, hospitals or universities); urban open space, suburban residential, and infrastructure. The tracing exercises aimed to identify the different actors along the planting pathway and their personal involvement with biosecurity as well as communication between actors. We also conducted several interviews with key stakeholders related to specific case examples such as planting along trunk roads and an historical outbreak in a country park.

We present our findings based on interviews with actors recruited as part of the tracing exercise projects and an evaluation of the specified and planted green infrastructure (for a review of this term see Matsler et al. 2021). The latter combines data from Scotland with data for a similar project in England to demonstrate synergies and contradictions. Opportunities for and barriers to better plant biosecurity within the pathways can then be highlighted to identify key intervention points and other reflections on opportunities for reducing the risks associated with large-scale planting.

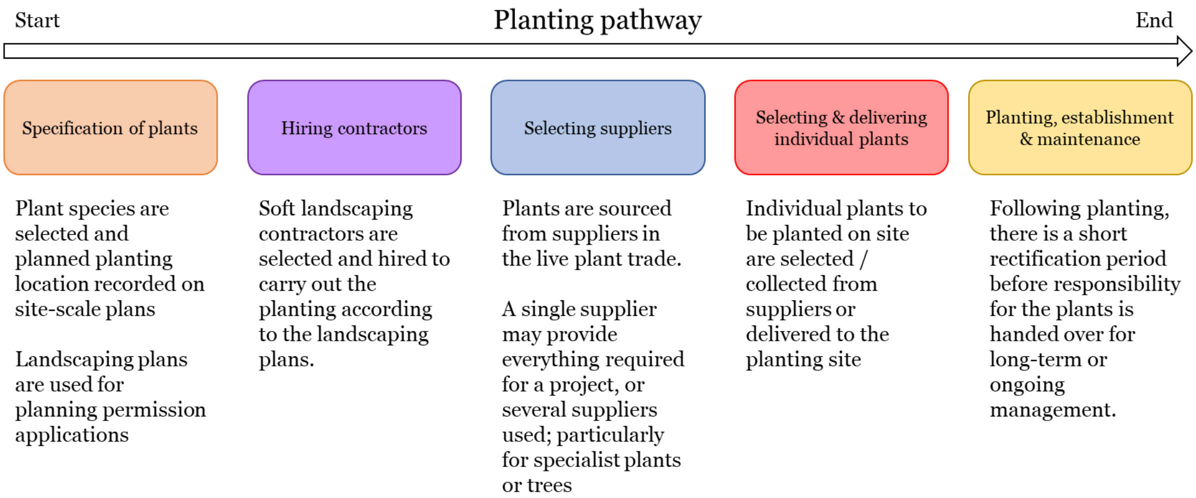

Figure 1 - Simplified planting pathway for large-scale landscaping projects. In reality, projects are more complicated and less linear than shown here

Table 1 - Actions along the planting pathway and associated examples of good biosecurity practice

Actions along the planting pathway	Biosecurity risks	Examples of good biosecurity practice
Specification of plants	(a) Lack of genetic/species diversity increases risk of large-scale outbreaks (b) specification of a known high-risk species or one with movement bans/restrictions (c) specification of plants that are not fit for site, leading to low resistance to pests or diseases	Avoiding invasive species and minimising monoculture. Specifying a diversity of species and genetic stock but maximising local sourcing Selecting species or populations of species primarily as a result of fitness for site rather than aesthetic or ecosystem service delivery.
Hiring contractors	Poor biosecurity practices from contractors increase risk of pests and diseases not being recognised, movement of soil and plant material between sites	Hiring contractors with understanding of and commitment to plant health issues generally and with reference to the specific project
Selecting suppliers	Poor biosecurity practices increase potential for infested or diseased plants to enter and move through the pathway or for pests and diseases to spread to healthy plants	Using plant suppliers with up-to-date plant movement records, well trained staff, clean and tidy sites and excellent plant hygiene practices. Plant accreditation schemes such as the Plant Healthy Certification Scheme can help identify suppliers who follow best practice standards.
Selecting & delivering individual plants	Unhealthy, infested or diseased plants are selected for planting, and transported to the site, introducing P&D	Checking plants for signs of pest or disease
Planting establishment/ maintenance	Pests and diseases are not caught early risking larger outbreaks. Plants are not maintained correctly, leaving them more susceptible to pest and disease	Recording reasons for plants needing replacement communicating replacements to other relevant stakeholders, identifying and acting on instances of pest or disease, maintaining healthy plants to resist pest and disease, reducing plant stress for other reasons

Box 1 - Detailed plan to planting pathway process

- *Outline specification* – plant species are selected by a designer and set out in a General Arrangement drawing and Landscape Specification document. This step will typically draw on arboricultural, ecological and landscape assessments and incorporate any steps required for accreditation schemes.
- *Planning* – Drawings and Specifications are submitted to the Local Planning Authority for planning permission where appropriate.
- *Detailed specification* – Once permission has been granted, detailed drawings will be produced addressing any conditions that are required by the Local Planning Authority for Planning Permission. This will be carried out by a consultant on behalf of the Developer- usually this is the Landscape Architect who drew up the original plans but in Design and Build contracts this becomes the responsibility of the Contractor. At this stage, value engineering is often carried out to achieve efficiencies in cost or supply time.
- *Procurement* – A Contractor is engaged to carry out the soft landscaping, who will sometimes in turn engage a Sub-contractor for specialist components of the contract (e.g. if there are hard to obtain plants). The Contractor will be responsible for procuring the plants that are specified in the design from nurseries and planting them as required. Selection of a Contractor is a competitive process, requiring Contractors to find the most cost-effective ways of delivering the brief.
- *Contract period* – During the planting and construction, the Client's Agent monitors the planting. In some cases, the Client's Agent is a Landscape Architect but often this could be a Quantity Surveyor or Project Manager. The Contractor is responsible for delivering the plans and the plants specified, although the knowledge base of the Client's Agent and level of value place by the Client on the work often combine with commercial pressures to result in variations to contract being accepted by the Client. At the end of the Contract, the site is inspected by the Client's Agent to ensure that all works have been carried out and variations agreed upon between the Client and the Contractor.
- *Maintenance* – For soft landscape projects, the Contractor typically undertakes to manage the plants for the first 12 months after planting, replacing any plants that fail at their own cost. After this period, a new maintenance contract is competitively tendered, sometimes resulting in a different team being appointed.

3 Methods

The research process initially involved a stakeholder mapping exercise and review of existing datasets followed by a tracing exercise which included three components: 1) characterisation of the green infrastructure specified in landscaping plans, 2) structured interviews with actors involved in the projects, and 3) ground truthing fieldwork to compare actual planting with plants specified in the landscaping plans. A data review was undertaken to identify gaps in existing information about planting for large scale infrastructure projects, and to avoid duplication of research effort. Data and reports for relevant research projects were identified in collaboration with the research team and steering group. We then conducted keyword searches using the terms “biosecurity” and “planting” within the webpages of organisations of relevance to the synthesis (Scotland specific and UK-wide landscaping, horticulture and construction organisations). Key results are presented in Section 4. A stakeholder map was also produced to identify key actors and other stakeholders in relation to large scale planting.

3.1 Project selection

A tracing exercise was conducted by Harry Watkins, Abel McLinden, Sally O’Halloran and Lucia Hudson to identify suitable projects and key contacts. Publicly available local authority Planning Portals were searched and a longlist of 81 landscape projects across England and Scotland was created for characterisation of green infrastructure, combining this study with a similar study in England. The sites on the longlist were categorised within four types of development: Infrastructure, Urban Public Realm, Residential Development and Commercial and Campus projects. Subsets of the longlist were then created (with 20 sites selected in the Central Belt in Scotland, and 14 sites in Birmingham and Sheffield) and used for detailed analysis and ground truthing in later stages. Results presented on green infrastructure specification and ground truthing represent a combination of datasets.

From the longlist we chose a subset of 14 projects in Scotland for the interview tracing exercises based on the date of their completion (completed within the past five years) and of a suitably large scale. Two of these projects were later found not to have been granted planning permission and were subsequently excluded from the sample. We were unable to recruit any actors for a third project for the interviews, and therefore we have interview data for 11 projects.

3.2 Recruitment

Each of the landscaping plans identified in Scotland provided information on the landscape architect, and in some cases, the planning officer approving the drawings, the developer and/or the client. The landscape architect for each project was then contacted for an interview. An introduction to the project was emailed by the Chair of the Landscape Institute Scotland to project landscape architects where possible. If no response was received, phone calls were made where the phone number was available, and/or follow-up emails were sent. Participants were asked during the interview whether they would be able to provide contacts for other actors throughout the specification-planting process, and if they would be willing to make an introduction. We specifically sought landscape architects, project clients, developers, landscape contractors, landscape managers and council planning departments involved in the projects. If the landscape architect for a project did not respond, searches were conducted in the landscape plans and other documents in the Planning Portal and finally Google to identify relevant actors for that project. We aimed to locate the relevant individual within an organisation before sending out an invitation email, but when this was not possible, emails were sent to organisation email addresses. A further set of interviews was conducted in relation to the trunk roads and historical outbreak case examples and recruitment were conducted via known contacts.

3.3 Structured interviews

For the tracing exercise, if a respondent agreed to participate in an interview, they were sent a consent form. If the form was not completed before the interview, oral consent was sought before recording. We conducted structured interviews following a questionnaire which was built in Smart Survey (see Supporting Information 1). The interviews were conducted over Microsoft Teams and lasted approximately 60 minutes. The questionnaire contained "skip-logic", navigating the interviewee to the sections of the questionnaire relevant to the different participating actors (Figure 2). The questionnaire had nine sections, four of which were completed by all interviewees: consent for participation; description of interviewee's role in the project; biosecurity awareness; and final reflections. Four sections asked brief general questions about the interviewee's level of involvement and responsibility for a key action in the project process: specification of plants; hiring contractors; selecting suppliers; and selecting individual plants. Where the interviewee was involved in each action, additional questions on this action were asked. Otherwise the interviewee was moved onto the next section. In the remaining section, planting establishment and maintenance, interviewees were asked if they were involved in the action, but also if plants required replacement after planting had taken place. Where plants did require replacement, additional questions were asked (Figure 2).

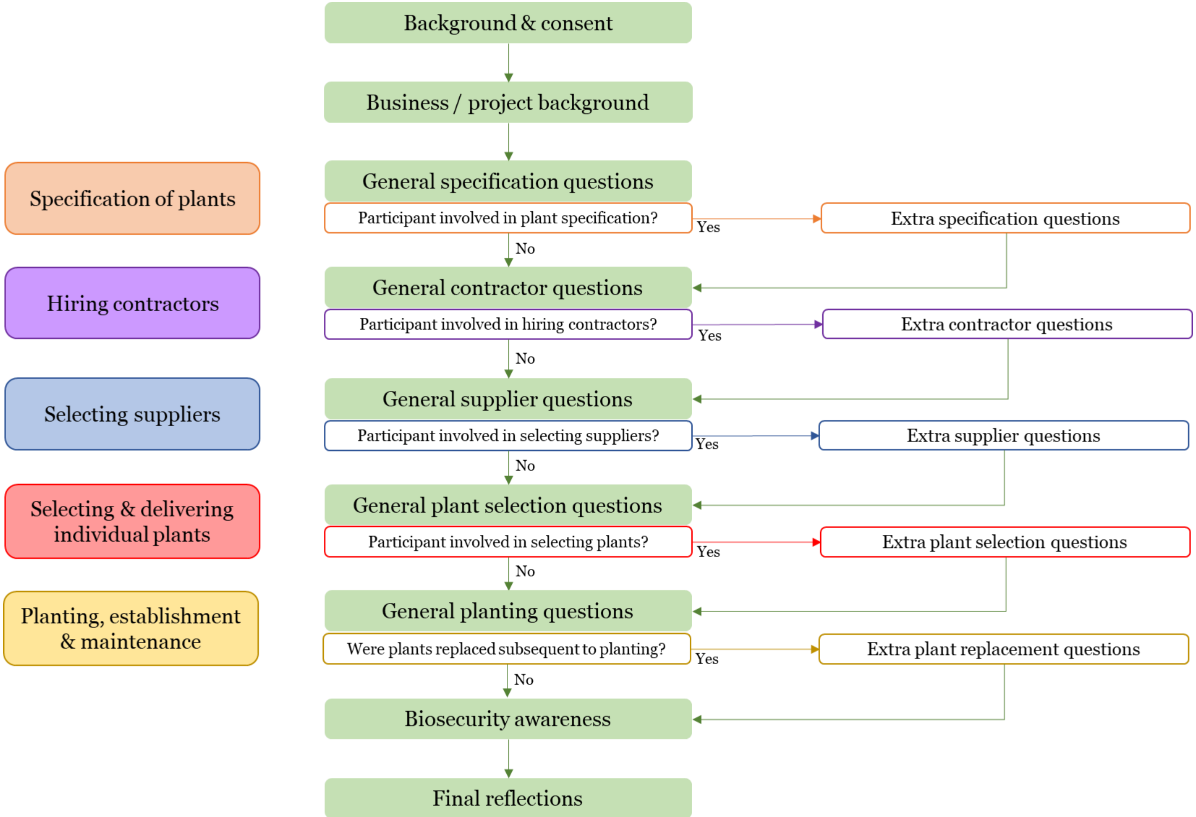

Figure 2 - Questionnaire structure incorporating skip logic. All participants answered general questions on each section (green boxes). Where participants indicated they had greater involvement in key actions, further questions were asked (orange, purple, blue, red, and yellow boxes, respectively).

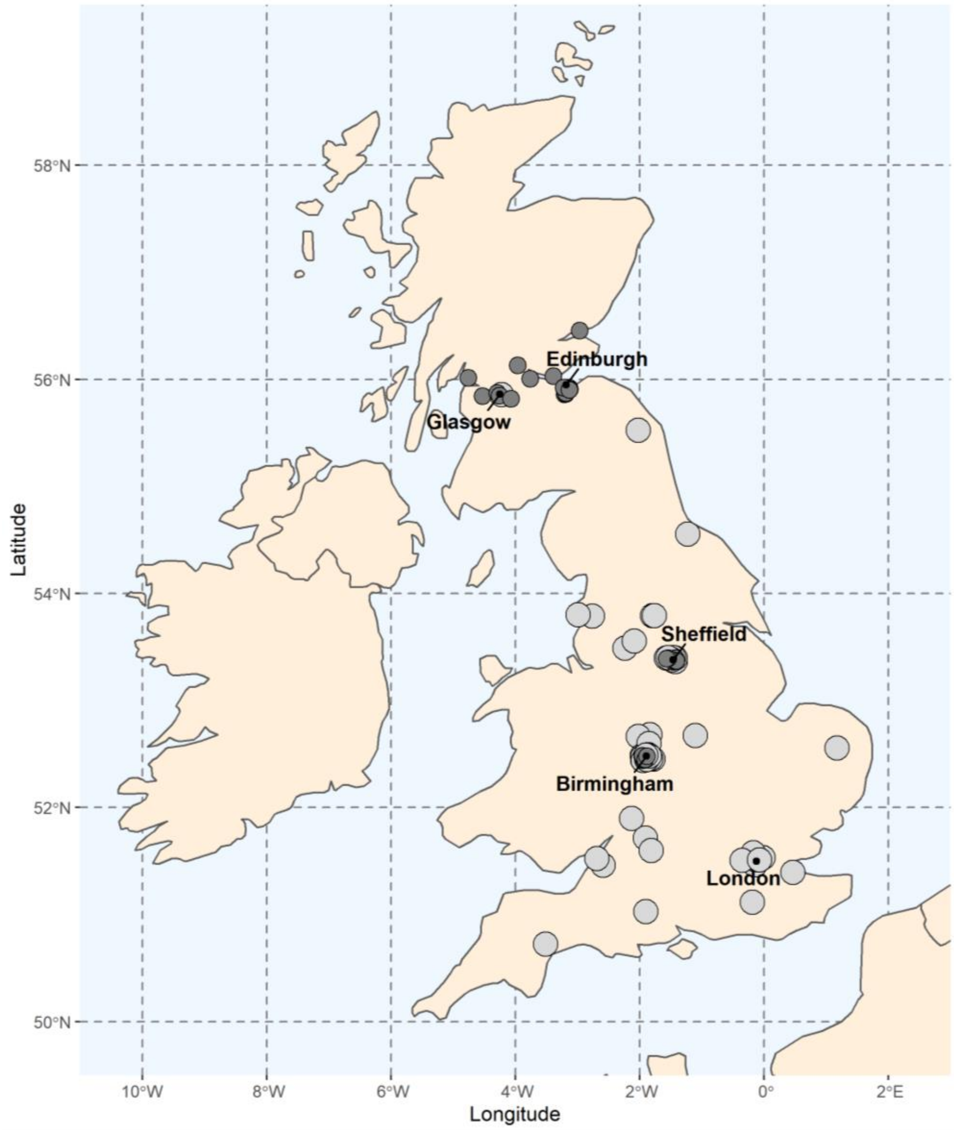

Figure 3. 81 sites in England and Scotland identified through a search of local authority planning portals (sites for which desktop evaluation and fieldwork were carried out are shown in dark grey; sites for which a desktop study was carried out are shown in pale grey).

A separate interview protocol was developed for semi-structured interview with actors discussing their experiences with planting along trunk roads and a historical outbreak in a country park.

3.4 Analysis of interview data

The interview questionnaire data was exported into Microsoft Excel and summarised. Because respondents were only asked questions within sections of the questionnaire that were relevant to them, the sample of responses invited for each question differs. Therefore, we report on responses in total numbers. One organisation played a role in five of the projects with one individual representing this organisation interviewed and completing a questionnaire for each of the five projects. In summary statistics this has been treated as five separate interviews. The recordings were maintained and used for reference where questionnaire data was not sufficiently detailed.

3.5 Characterisation of green infrastructure

For all 81 projects, the most detailed planting plans approved by the local authority were downloaded and the specifications transcribed (data available in: Watkins et al. In review), recording the species, quantities, site name, habitat type and plant form for each species included in the project. This provided further detailed understanding of the types of plants selected for projects of this scale and their potential impacts at a landscape scale, such as inclusion of invasive plants or known hosts of pests or diseases. Functional trait data for each species were downloaded from TRY database (Kattge et al 2020) and species ordinated in CSR using the StrateFy tool developed by Pierce et al (2017) to evaluate the functional diversity of habitats. We then calculated diversity of species selected conducting a Simpson's Index of Diversity for each type of planting to assess the ecological resilience of the green infrastructure. Finally, to assess whether the green infrastructure was likely to be stable in terms of species composition, the species were cross referenced against Schedule 9 of the Wildlife and Countryside Act (1981, as amended) and two horizon scans of invasive species (Roy et al 2014, Roy et al 2019) to identify the frequency with which species with known or likely invasive behaviour are specified or planted.

The 20 sites in Scotland (as part of the PHC project, including the tracing exercise projects) and 14 sites in England (see Figure 3 below) were visited to compare perceptions of planting accuracy based on planning plans with the actual species planted and maintained on the sites. At each site, six 2x2m quadrats were randomly selected and four questions were evaluated for each quadrat:

- Was the planting area created?
- Was the planting area the same size as shown in the approved drawing?
- What proportion of plants were the same form (e.g. tree, shrub, herbaceous perennial) as specified in the approved drawing?
- What proportion of plants were the same species as specified in the approved drawing?

Results were recorded in a dataframe (Watkins et al. in review) and summarised in section 5.2.

3.6 Recruitment challenges and lessons learnt

It was challenging to recruit interview participants for this project for a number of reasons. First, it can be very difficult to identify the landscape contractor, landscape manager and also in some cases the main contractor (refer to Table 2). Main contractors are usually the link between landscape contractors and other actors in the project but were either hard to identify or did not feel that this project was of relevance to them as they themselves did not carry out the soft landscaping aspects. We also sometimes relied on the landscape architect to identify the individual in the local authority planning departments, or contacts with the client and/or developer. Due to this lack of transparency of the different actors involved, our sample success rate was higher at the specification-end of the pathways and lower towards the planting-end (Table 2). In general, we found that certain groups of actors, mainly clients, developers and contractors, did not consider themselves relevant for this study as biosecurity is only a small aspect, if at all, of their work. We also found that many actors in the pathways had increased workloads during the Covid-19 pandemic, which in some cases added complications to scheduling of interviews. In total, we tried to make contact with 47 projects-specific stakeholders, most of which were contacted on multiple occasions.

A significant amount of time and effort was put into reaching the target actors on each project. For example, we called participants who did not respond to email invitations to introduce ourselves and the project. In some cases, this worked well and scheduling of an interview could then take place. However, some calls were met with concerns such as providing details of the project without the client's permission, or scepticism (i.e. "*our company does not participate in market surveys*"). For some organisations or individuals multiple phone calls were needed, potentially as office phones were not set up remotely in the first phases of the pandemic, or staff were working flexible or reduced hours. However, recruitment rates are variable for research with landscape architects, potentially pointing to stakeholder fatigue. For example, a recent survey within the BRIGIT project (https://www.jic.ac.uk/brigit/) of specifiers of large-scale planting schemes including landscapers and landscape architects initially had responses from just 5 landscape architects when approached by the research team and contacts (personal communication, Glyn Jones, Fera Science Ltd). The 2019 survey of the Landscape Institute's membership received responses from just 7% of their members (Landscape Institute 2019). Based on this, we potentially reached equally many, or more actors than if we had used other methods such as a survey. It should be noted that we focussed efforts on selected development and response rates may have been better if we had chosen other projects but this is not certain.

Table 2. Sample of projects, project characteristics and research participants from each project. Cells in green indicate completed interviews, cells in red indicate rejected interviews, leaf icons indicate that ground-truthing has been undertaken and rows with striped lines are projects selected for case studies. The 'contacted stakeholders' column lists the number of individuals or organisations contacted to schedule interviews for each project.

Project	Contacted stakeholders	Region (NUTS2)	Landscape architect	Client	Developer	Landscape contractor	Landscape manager	Council planning	Stage of project	Mapping complete
Campus 1	3	Eastern Scotland	✓				✓		Not planted yet	
Campus 2	2	South Western Scotland							Not planted yet	
Campus 3	8	Eastern Scotland	✓✓			✓		✓	Planting carried out and maintenance being undertaken	
Campus 4	3	Highlands and Islands						✓	Planning resubmitted; planting scheduled for 2022.	
Campus 5		Eastern Scotland	×	×	×	×	×	×	Planning denied. **Excluded from tracing exercise**	
Infra 1	6	Eastern Scotland	✓	×					Planting partially completed	
Urban 1	3	Eastern Scotland	✓	✓					Planting scheduled for 2021	
Urban 2	4	Eastern Scotland	✓						Planning granted but on hold; planting not started yet	

Urban 3	3	Eastern Scotland	✓						Planting not completed yet	
Residential 1	3	Eastern Scotland	✓						Not planted yet	
Residential 2	2	Eastern Scotland	✓						Not planted yet	
Residential 3	4	Highlands and Islands	✓				(✓)	✓	Complete but not handed over to landscape manager yet	
Residential 4	3	South Western Scotland	✓	×	×				Planting completed and maintenance in place	
Residential 5	3	North Eastern Scotland							Planning decision pending. **Excluded from tracing exercise**	
Total	**47**		**11**	**1**	**0**	**1**	**2**	**3**		

4 Background and context

We found and reviewed datasets and reports from 11 studies related to the landscaping and horticultural industries. We further identified eight grey literature sources addressing biosecurity relevant to landscaping, horticulture and construction. These included toolkits, position statements and trade articles. A short summary is provided in this section. Note that this was not a literature review but rather an exploration for existing available datasets.

Previous research has also shown a general lack of experience in plant health within landscaping and construction industries. For example, a recent survey of 359 landscaping businesses documented an all-round “skills-crisis” within the landscape sector (BALI 2019a), and a third of the businesses typically only provided training on-the job, with limited staff time and costs of external training factoring as main barriers. Only a third of 38 participants who responded to a survey of landscape architects, Garden Designers and Landscape Contractors had received formal training or education courses on tree health and diseases in the past five years (Dunn & Marzano 2019). This survey also demonstrated low prioritisation of biosecurity.

4.1 Awareness

Analysis of a survey of landscape architects (Watkins 2018a) revealed that just 11% of the participants' organisations had biosecurity policies (12 out of 115 respondents), and their skills and knowledge in this area tend to be general as opposed to specialist. 83% of respondents felt that they have at least a general understanding of plant health issues but when it came to specification and knowledge of provenance, blindspots were identified. For example, almost half of the respondents (46%) did not know where their plants had been grown and 76% did not specify whether a plant passport would be required for any of the plants. Similarly, over half of respondents did not take an active interest in plant health (55% of the respondents stated that they do not take an active interest in plant health issues, with 20% taking ‘no’ or ‘little’ interest), although 45% stated that they did. One third of these respondents said that their organisation has measures in place to consider plant health issues although this did not always translate into practice. Accessing relevant information seems to be a key barrier, with most respondents (83%) reporting that industry-specific guidance from the Landscape Institute was needed to develop best practice and help them address plant health issues.

4.2 Sources of information

The recent Fitter Flora survey of landscape architects, contractors and nurseries highlighted that just 44% of respondents felt that information sources available, particularly for the specification of plants, were adequate for their needs. Industry guidance, nursery catalogues and specialist horticultural sources were used most, while respondents relied less on gardening encyclopaedia, academic research and design software (Watkins, 2020). A similar study carried out by the PHC knowledge exchange project showed that landscape contractors turn to ‘others in the trade’, the Royal Horticultural Society and the Forestry Commission for information. Among landscape architects, the most common sources were the same and included the Landscape Institute, British Association of Landscape Industries and other government departments (Creissen 2019). Returning to the survey of landscape architects, 83% of respondents called for the institute to develop best practice guidance and 24% asked for more Continual Professional Development (CPD) (Watkins 2018a). Responding to this need, the Landscape Institute has recently published a landscape consultant's toolkit on plant health and biosecurity (LI 2019). A flier by Forest Research on 'Plant health considerations for planting schemes' is also available on the Landscape Institute website at the request of their members (Forest Research 2020). Also addressing the need for focus on biosecurity, the British Association of Landscape Industries has released a biosecurity statement (BALI 2019b). Few other resources are available specifically on biosecurity in relation to landscaping for construction projects which is a clear information gap.

4.3 Specification and procurement processes

Key aspects that this project considered in the procurement process included decision-making for plant specification and how suppliers are chosen.

Specification: The Fitter Flora survey found that self-reported priority characteristics when specifying plants were ecological benefits followed by tolerance of urban stresses, visual and aesthetic qualities, the plant's competitive ability, and the price. Ten respondents (of 183) addressed tolerance/resilience to pests and diseases in some way as an "other" option to this question (Watkins 2018b). The survey respondents also indicated that one of the barriers to diverse species choice (especially for housing developments) is the limited list of acceptable plants to plant near houses without affecting insurance (due to perceived water demand from plants that might cause subsidence issues), referring to the National House Building Council advice. A different study suggests that ash trees no longer being accepted as specified planting stock due to experiences with ash dieback might be one potential explanation for a recent increase in awareness of pests and diseases among landscape architects, although this study had a small sample size (Dunn & Marzano, 2019). The same survey found that 53 % of the sample included pest and disease precautions in specifications.

Further bottlenecks are likely to take place after planting, as there is evidence to suggest that landscape architects often do not know or are not instructed to check what was planted in comparison with what was specified (Watkins, 2018a). Survival rates can be of particular concern, with one Fitter Flora survey respondent stating that: "*I would really like to know survival rates of plants once delivered to site. I suspect the rates are shockingly low. I have had projects where more than 50% of plants have been lost due to lack of understanding by main building contractors who think that they do not need to care for plants once they arrive on site*" (Watkins 2018b). The Landscape Institute survey found that approximately 60% of planting designs were implemented using the specified species, although 30% of respondents did not visit the site during or following planting to check whether the planting had been carried out correctly (Watkins 2018a). This point requires interpretation however as because most landscape architects act in a consultancy role their work needs to be instructed by a client, and as shown in this report, many clients frequently do not instruct this critical piece of work to be carried out. Critical inconsistencies are therefore present between landscaping intent and practice. It is thus important to examine in detail biosecurity actions and barriers in the planting pathway, to highlight where such inconsistencies occur and identify solutions.

Choice of supplier: The Landscape Institute's survey revealed that just over half of the respondents among the Landscape Institute's members or their designers specified a nursery or source for their plants. (Watkins 2018a). Apart from this finding there is very limited evidence of how suppliers are chosen.

5 Results

We completed 18 interviews in total for the tracing exercises. The interviewees worked on 11 of the projects. We were unable to get an interview with actors on one project and a further two were excluded as planning had not yet been granted (Table 2). We conducted an additional six interviews on two case studies relating to planting on trunk roads and an historic outbreak example. These are not included in this section but are summarised in the case studies under 5.4. This section outlines findings as they relate to decision-making and roles of pathway actors, biosecurity awareness and practices, procurement and changes to plans and planting. Where possible we explore the process from planning to planting, the different actions along the planting pathway and any key findings relating to biosecurity. In addition, we highlight key biosecurity relevant issues using evidence from specific projects that were explored, particularly where we interviewed more than one participant along the plans to planting chain.

The results section addresses the following research questions:
1) What are the flows of plants into or within Scotland for large infrastructure and landscaping projects?
2) What are stakeholders' awareness of
   a) plant pests and diseases?
   b) inclusion and visibility of biosecurity in specification and procurement processes?
   c) important factors influencing sourcing of plants (e.g. range, volumes, availability, cost, reputation of supplier) for construction and planting operations?
3) What are the roles and responsibilities of key players in promoting better biosecurity?
4) For soft landscape specifications that have received planning permission, how are these implemented in reality?

5.1 Roles and responsibilities on the planting pathway

Summary

- Roles and responsibilities vary across projects and organisations.
- Landscape architects sometimes recommend suppliers but are not usually able to specify one particular supplier.
- Many (10 of 16) actors did not know where their plants were sourced from.
- Large trees especially tended to be sourced internationally.
- Landscape contractors tend to be responsible for selecting plants from suppliers, but some landscape architects are involved in this process and sometimes the nurseries select the plants for the contractor.
- Seven of 11 landscape architects undertook checks and/or signed off on the planting.

The roles and responsibilities of actors of the same profession varied along the plans to planting pathway, from specification at the start of a project, through to long-term maintenance at the end. The reported involvement of different actors in different stages of the projects (as identified in Figure 1) is outlined in Table 3. From the small sample we were not able to make generalisations across all actor types and project types, so roles and responsibilities are summarised below according to the different actions taken along the planting pathway.

Table 3. Visualisation of actors' involvement in different stages of the project pathway.

		Specification of plants		Hiring contractors		Selecting suppliers		Selecting & delivering individual plants		Planting, establishment & maintenance	
Project type/ID	Actor type	Consulted	Responsible	Consulted	Responsible	Consulted	Responsible	Consulted	Responsible	Consulted	Responsible
Campus 1	Landscape architect	✓	**Full**	✓	Partial					✓	Partial
	Landscape manager			✓				✓			
Campus 3	Landscape architect	✓	-	-	-	-	-	-	-	-	-
	Landscape architect	✓	Partial			✓		✓	**Full**	✓	Partial
	Landscape contractor	✓				✓	**Full**				**Full**
	Local authority	✓	Partial								
Campus 4	Local authority		Partial								
Infrastructure 1	Landscape architect	✓	**Full**			✓	Partial	✓	Partial	-	-
Residential 1	Landscape architect	✓	**Full**				Partial			✓	-
Residential 2	Landscape architect	✓	**Full**	✓				✓	Partial	✓	Partial
Residential 3	Landscape architect	✓	Partial								
	Landscape manager	-	-	-	-	-	-	-	-		**Full**
	Local authority	✓	Partial							✓	-
Residential 4	Landscape architect	✓	**Full**								
Urban 1	Landscape architect	✓	**Full**					✓	Partial		
	Client		Partial	✓	Partial					-	
Urban 2	Landscape architect	✓	**Full**	✓	Partial			-	-	-	-
Urban 3	Landscape architect	✓	**Full**					✓	**Full**	✓	Partial

5.1.1 Specification

Landscape architects always had most influence over plant specification and landscape architects had sole responsibility for this on eight of the 11 projects, with another two stating they had some responsibility. All of the three local authorities stated they had some responsibility over specifications, and one client stated the same, explaining why some landscape architects reported partial responsibility. None of the remaining participants (including a landscape contractors and two landscape managers) felt they had responsibility for this part of the process, and all felt this was typical for their type of project.

5.1.2 Hiring contractors

Participants felt that responsibility for hiring landscaping contractors tended to be held by clients (seven of 13 interviews for which an answer was provided) but some acknowledged that this can vary between projects. Other actors identified as holding responsibility were developers and larger contractors who would sub-contract. Two interviewees (one landscape architect and one local authority) did not know who was responsible. A responsible landscape manager described only being able to select contractors from a list of pre-approved contractors supplied by their organisation.

Three landscape architects, one manager and one client said they were consulted or gave advice on the landscaping contractor to be hired for the project. Advice would often take the form of providing a list of recommended contractors from which those responsible could choose. Variously across those interviewed, recommendations were provided only if the client specifically asked and it was important to avoid favouritism. For larger projects a more formal tender process was used. On one project a council biodiversity officer gave advice on when during the year contractors should be hired for specific work.

5.1.3 Selecting suppliers

Two landscape architects stated that they had some involvement in choosing plant suppliers and one landscape contractor had sole responsibility. When asked which actor in the pathway would have the greatest influence on selecting plant suppliers, landscape contractors were chosen by ten (one chose the developer and two did not know).

The majority of respondents (10 of 16) did not know the location of the suppliers used on their project (excluding two projects which had not yet started planting). Six respondents (on five projects) were able to identify the location of suppliers (Table 4), although responses were often estimations.

Table 4 - Estimated proportion of plants and trees sourced from suppliers based in Scotland, the wider UK, or internationally. Remaining 11 respondents did not know where suppliers were based. LA: landscape architect, LC: landscape contractor

		Estimated proportion of stock from suppliers based in:		
Project	Actor type	Scotland	Wider UK	Outside of UK
Inf1	LA		20%	80%
Res1	LA	60%	20%	20%
Res2	LA		85-90%	10-15%
Cmp1	LA		100%	
Cmp3	LA LC		100% non-trees 100%	100% of trees

5.1.4 *Selecting individual plants*

Two landscape architects had sole responsibility for selecting the individual plants from the supplier and another three had some responsibility. No other interviewees had responsibility for selecting individual plants. When asked which actor type had greatest influence on individual plants and trees selected from the supplier, five stated the landscape contractor, three stated the landscape architect and one respondent stated “nobody”. One respondent added that plant selection was carried out by the supplier themselves but that the contractor had the right to refuse them. Five landscape architects and one landscape manager were consulted or gave advice on the individual plants to be selected from the supplier. This usually related specifically to high value items such as mature trees.

5.1.5 *Planting and maintenance*

Signing off the soft landscaping (checking that the planting has been finished to an agreed standard) was most commonly undertaken by the landscape architects (seven of the 12 projects) followed by the landscape contractor (5 projects) or both. Landscape architects sign off when instructed to do so by the client. Who holds the responsibility for sign-off was not consistent between projects and in some cases it was not clear or consistent between actors on the same project. For example, on one project the landscape architect checked the soft landscaping and the contractor signed off. In another, the landscape architect signed-off but the contractor held responsibility. On one project where there were two landscape architects, checks were done by both, but this was seen as unusual. Another project had to go to a planning committee because of its scale and the planning manager would sign-off the plans. This respondent from a local authority also pointed out that there has been a change in legislation and the developer now has a legal obligation to notify the planning authority upon completion of a scheme. The local authority does not have capacity to check all projects but will do for some larger schemes. Just a few respondents mentioned carrying out snagging, which is a formal, contractually binding check that the project has been delivered to an agreed standard. It is possible that other respondents assumed that this was inferred in the question, but it is also possible that a number of checks were conducted informally, without carrying contractual influence.

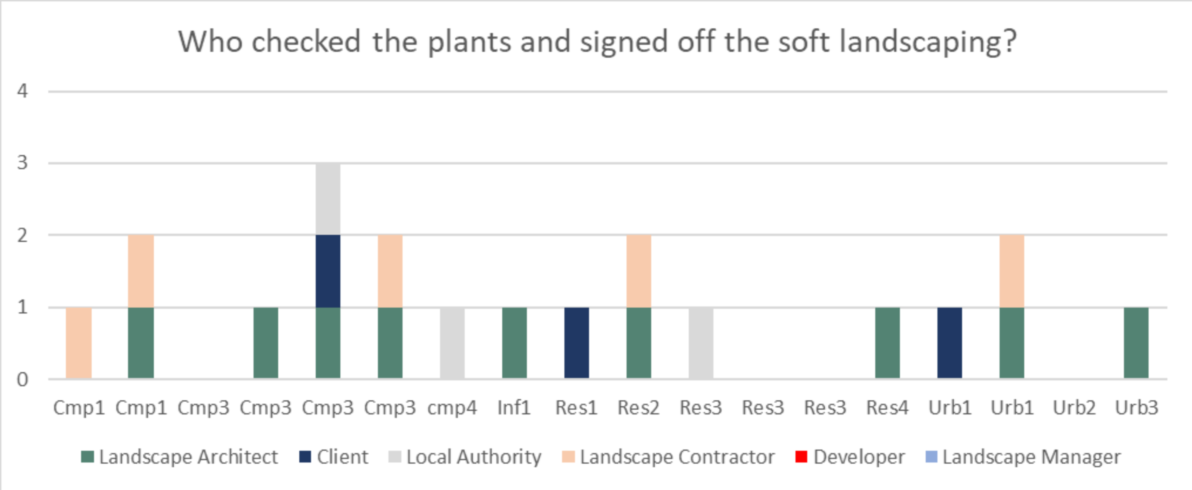

Figure 4. Actors responsible for checking and signing off the soft landscaping. On projects with multiple respondents, the responses of each respondent are included (represented on the x axis by their project name) allowing for a comparison of responses within projects

After planting, there is usually a rectification period during which the contractor is responsible for maintaining the plants planted, including replacement if necessary. Responsibility for monitoring and dealing with any plant health or pest and disease issues thus changes at the end of the rectification period. The rectification period of the projects in this study was typically 12 months (8 of 12 projects), but in larger infrastructure projects could be up to five years.

Following the end of the rectification period, responsibility is then handed over to the landscape manager for long-term maintenance. Planning permission often requires a five-year management plan, which guides how the site should be maintained following completion. Landscape contractors were thought to have most influence on managing plants during the rectification period (Figure 5). Landscape architects for five of the projects and one local authority gave advice on management after the plants and trees were planted. Three landscape architects did not. One landscape manager mentioned the use of an external contractor to undertake a small survey of trees on site every year, and a more in-depth tree survey every five years. The survey was for health and safety of trees on site, as well as tree health including for pests and diseases.

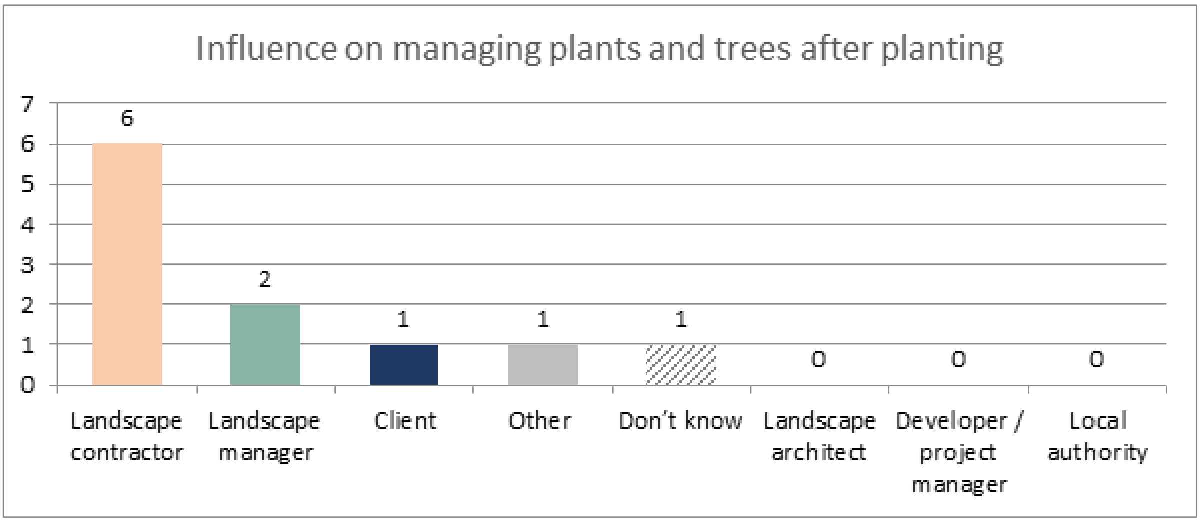

Figure 5. Stakeholders thought to have most influence on the management of trees and plants after planting.

5.2 *Biosecurity awareness and practice*

Summary

- Biosecurity awareness tended to be medium-low. Landscape architects had higher awareness than other actors.
- None of the participating organisations had formal biosecurity policies.
- Biosecurity was not prominent in discussion among actors.
- Standard biosecurity measures were included to a various degree in planting specifications by some landscape architects, such as the use of native stock, or requirements for plant passports/phytosanitary certificates.
- Some local authorities have specialised staff, such as biodiversity officers or landscape architects who provide input on selected schemes, while others do not. Capacity is an issue.
- Landscape architects tend to rely upon a narrow range of species for their plans, increasing the potential impact of pests and diseases.
- Biosecurity did not factor in decision-making about plant specification, selection of contractor/subcontractor and selection of plant supplier.
- Just one respondent was aware of a pest or disease on a project. This landscape contractor discovered aphids on planted bamboo, but did not believe the bamboo was the source of the aphids. Other actors on this project were not aware of this issue.
- The main sources of information were the Landscape Institute, environmental charities and trusts and governmental departments and agencies.

5.2.1 *Individual, business and project biosecurity awareness*

Levels of self-reported biosecurity awareness were generally low. Two of the 14 interviewees had high self-reported awareness of pests and diseases: one landscape architect and one biodiversity officer at a local authority. Six landscape architects and one landscape manager had medium to medium-low awareness and the remaining participants had low awareness. Biosecurity was also not prominent in conversations between project actors. In only three of the projects did the respondents state that they had conversations about biosecurity with other actors on the project.

None of the participating organisations (seven landscape architects, three local authority planning departments, two landscape managers, one client and one landscaping contractor) had a formal biosecurity policy for the project or as an organisation.

Biosecurity was not generally a prominent component of the projects among the actors we spoke to and the stages at which they were involved (see Figure 7). Landscape architects would consider biosecurity as part of the specification process and tended to seek advice from the Landscape Institute. One local authority had a biodiversity officer who, as part of their role, would disseminate information about pests and diseases to colleagues as they arise. Remaining responses indicated a perception that biosecurity was the responsibility of somebody else; one local authority thought that other departments would have specialists for this purpose but was not able to provide details (they also mentioned that local authorities need training to better undertake appropriate checks). Another landscape architect mentioned that some of the responsibility lies with the supplier.

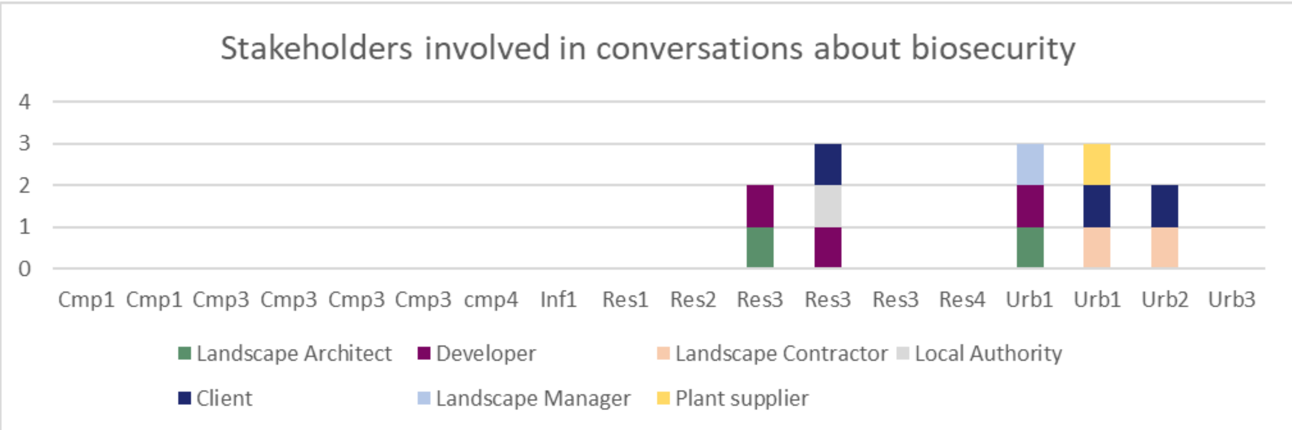

Figure 6. Other actors within the projects with which interview participants had discussions about biosecurity. The x axis represents each respondent by their project name

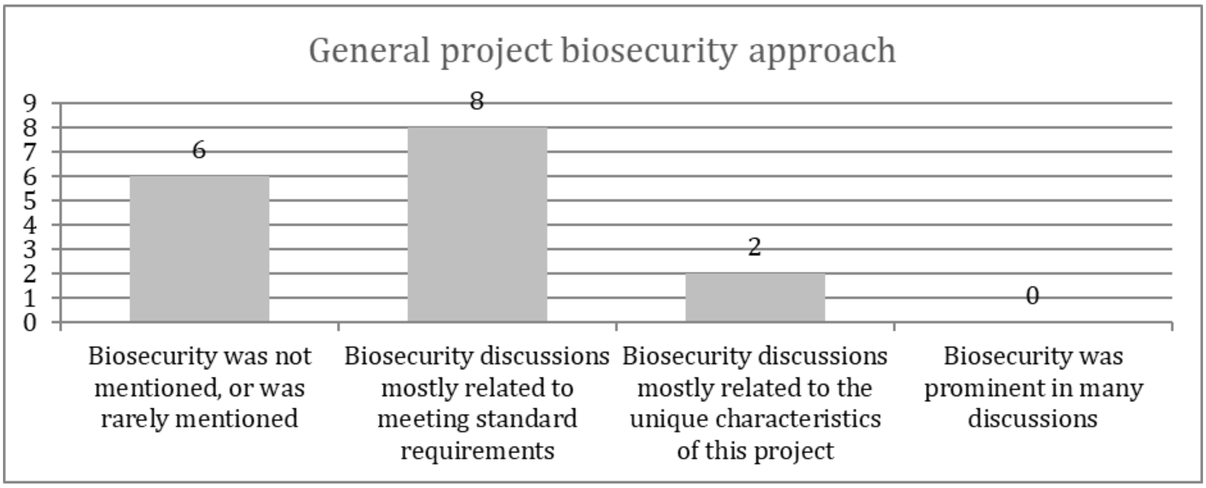

Figure 7. General biosecurity approach adopted by each project

5.2.2 Decision-making

Decisions are made throughout the plans to planting pathway that have potential implications for biosecurity. In this section, we describe how decisions are made in relation to specification processes (including detailed information on species choices), hiring of contractors and selection of suppliers. We also identify the main sources of biosecurity information used by the participants.

5.2.2.1 Characterisation of plants specified and planted

The quantities and diversity of plants specified and planted in large-scale projects have implications for species composition stability and ecological resilience, particularly in relation to potential impacts of pests and diseases. Here we provide a description of the diversity and quantities of species specified in 81 green infrastructure projects across Scotland and England.

5.2.2.1.1 Diversity of species

This study identified that landscape architects tend to have two 'modes' of planting: 'ornamental' plantings, which are typically near to buildings, and 'biodiversity' plantings which tend to act as buffers or are at the margins of a project. The finding that 'biodiversity' plantings were more diverse than other areas (Figure 8) whilst at the same time being lacking in diversity themselves (e.g., top 10 most frequently planted tree taxa accounted for 75% of all trees specified), indicates that landscape architects rely on a particularly small subset of the plants that are available in horticultural supply chains. This represents a missed opportunity for green infrastructure to create robust habitats by building in functional redundancy and complementing native assemblages in areas where they are not likely to be well-fitted. Ultimately, species diversity or assemblages did not vary in response to project type, geographic location, or local plant communities, identifying that planting palettes are rarely site specific.

5.2.2.1.2 Summary of plant species quantities

- Trees: 249 taxa across all projects were specified (including named cultivars). Of these, the top 10 most frequently planted taxa accounted for 75% of all trees specified.
- Hedges: 68 taxa across all projects were specified (including named cultivars). Of these, the top 10 most frequently planted taxa accounted for 85% of all hedge plants specified.
- Shrubs and Perennials: 973 taxa across all projects were specified (including named cultivars). Of these, the top 10 most frequently planted taxa accounted for 60% of all shrubs and perennials specified.

Refer to Watkins et al. in review for species specified for each project.

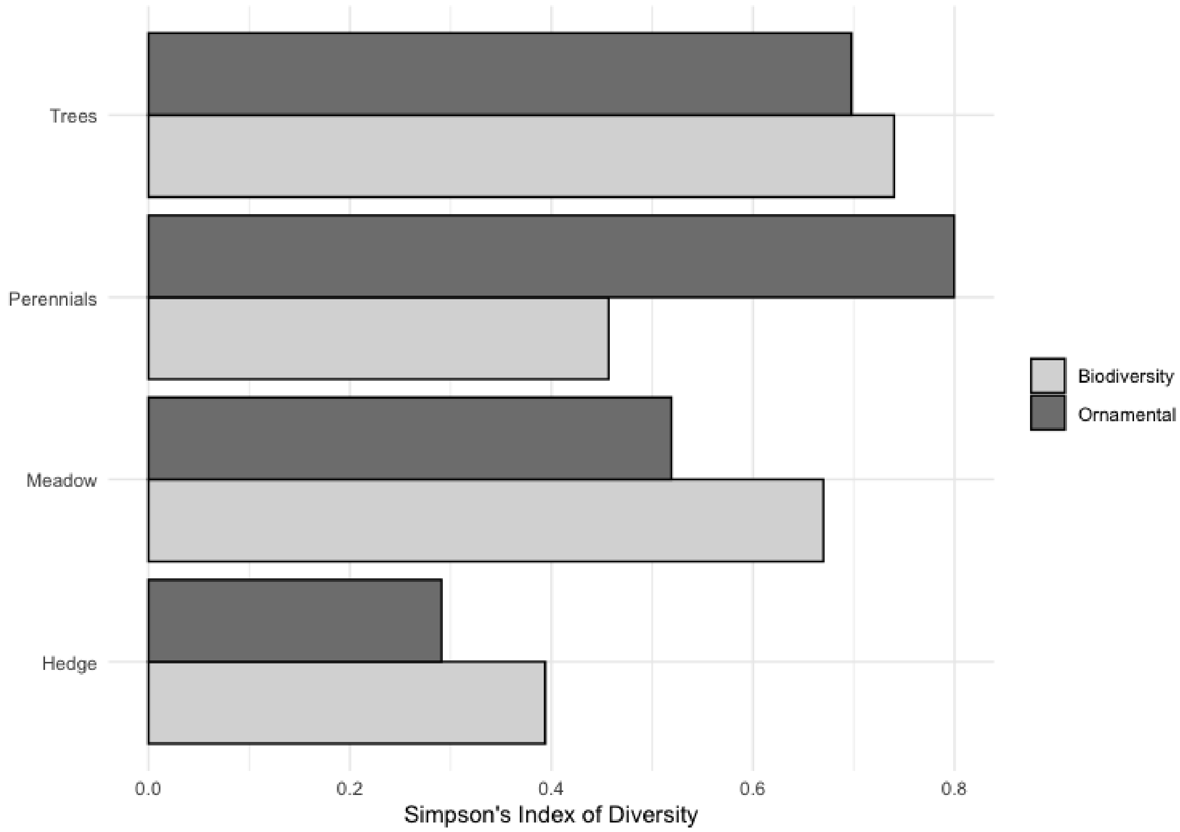

Figure 8. Species diversity in green infrastructure planting types

5.2.2.1.3 Curious features

It appears there are biases within the plant selection, for example when comparing similar but different species, we found that common oak is specified five times more frequently than sessile oak, silver birch was also planted five times as frequently as downy birch, and that wild cherry is specified sixty times more frequently than bird cherry. Yet, we found significant differences in approaches; one site we looked at (a large campus project) had a planting specification with one species of groundcover, one species of hedge planting and 7 taxa of trees, whilst other projects included a wide diversity of taxa across all plant forms.

Formats of drawings varied, with some presented in text documents, others in raster-based pdfs and others in vector-based pdfs, making it difficult to reproduce or transfer information between consultants, planners and contractors. The content and layout of specifications varied significantly, with a wide variety of abbreviations used for plant names, schedules with different types of information, and plant names frequently out of date, unclear or misspelled.

5.2.2.1.4 Invasion debt

- 57% of sites included species that are either known to be invasive or are likely to become invasive under future climate change scenarios.
- Most frequently used species of concern is *Euonymus fortunei* (fortune's spindle), which was specified in 27% of all projects.
- Whilst none of the projects included species that are prohibited from being traded or planted, this does identify a challenge for UK biosecurity.

5.2.2.1.5 Functional diversity

The functional diversity of the plants selected at the start of the project (and therefore approved by the Local Planning Authority) is illustrated in Figures 9-13. The species were ordinated within competitor, stress tolerant, ruderal (species that are first to colonize disturbed lands) (CSR) space using the StrateFy method (Pierce et al, 2017). In the CSR theory, C-species are optimised to survive in relatively stable habitats, S-species specialise in variable and resource poor environments while R-species can regenerate under repeated biomass destruction events (Pierce et al, 2017). The species positions were weighted to indicate the total number of plants in each species in the database. The results show that generally, specifiers tend to select plants that have more stress tolerant traits. This indicates that the habitats designed by landscape architects are likely to be predominantly composed of lower growing species than are found in naturally-occurring communities. As a result, the lack of functional diversity means that there are significant niches in green infrastructure planting that could be vulnerable to invasion by more competitive native and non-native species. This situation occurs regularly in urban environments and tends to result in declining site management and an increasing number of forbs such as dandelion and rosebay willowherb followed by competitive woody plants such as brambles and cotoneasters, followed in turn by complete replacement of a planting area for aesthetic reasons; the long term consequence of low functional diversity from the outset is that resilient, stable plant communities are rarely able to establish. In terms of vulnerability to pests and diseases, we found that a very narrow taxonomic diversity of plants is used in green infrastructure (see 5.2.2.1.2), increasing the potential impact of specific pests or diseases should they become present.

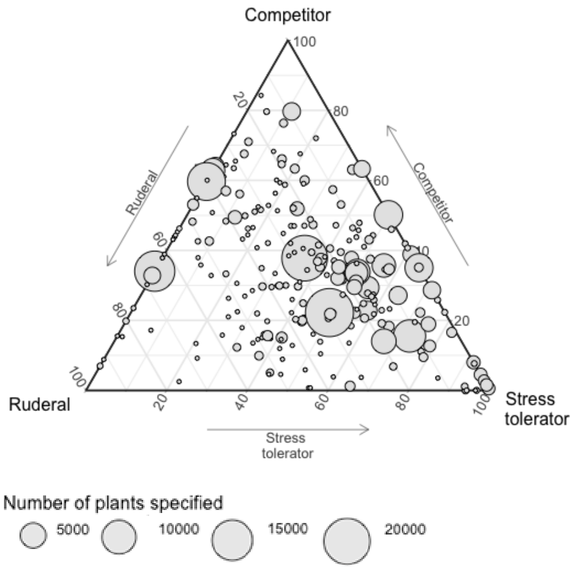

Figure 9. Ecological strategies of the most widely specified plants in UK green infrastructure

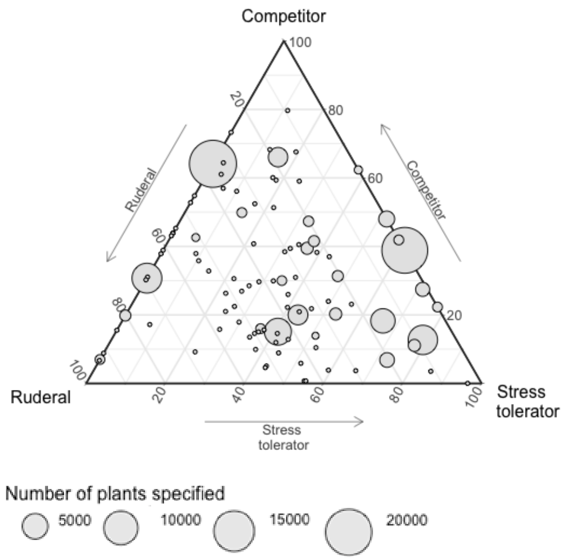

Figure 10. Ecological strategies of the most commonly specified grassland plants in UK green infrastructure

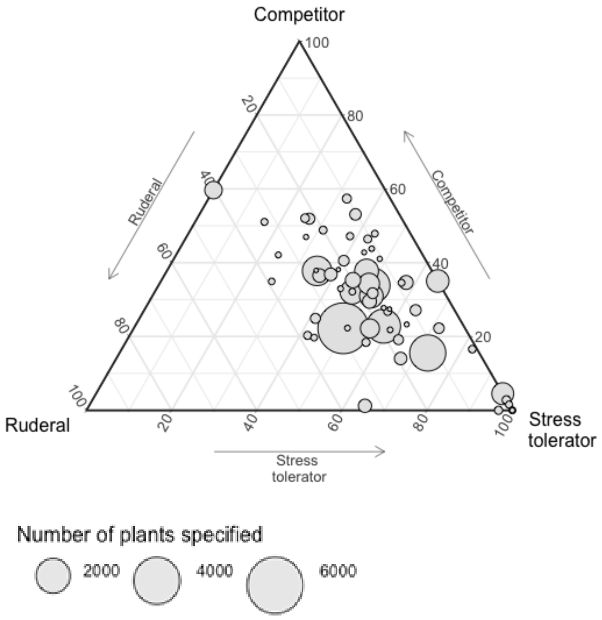

Figure 11. Ecological strategies of the most widely specified trees in UK green infrastructure

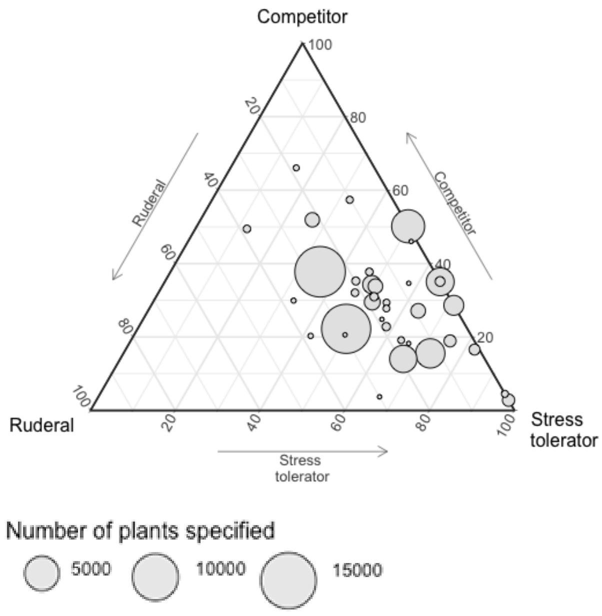

Figure 12. Ecological strategies of the most widely specified hedge plants in UK green infrastructure

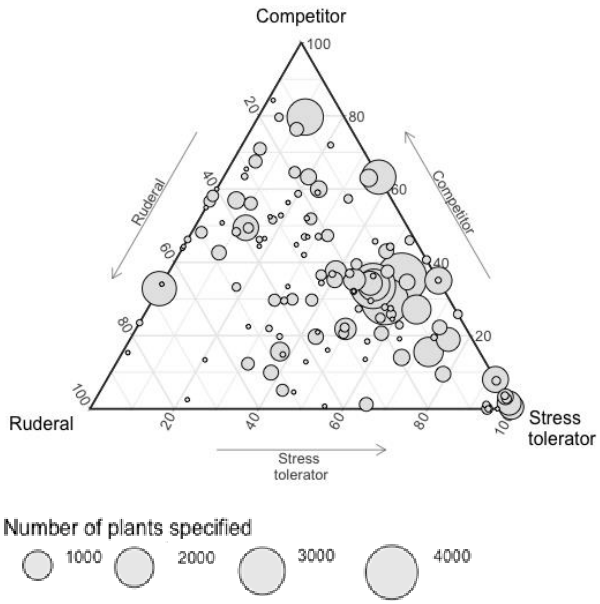

Figure 13. Ecological strategies of the most widely specified shrubs and herbaceous plants in UK green infrastructure

5.2.2.2 Factors influencing specification of plants

Biosecurity was not an influential factor when it came to specification (see Figure 14). During specification, biosecurity could be considered by adding National Building Specification pre-determined clauses for standard specifications (mentioned by eight of ten landscape architects). These can include specifying locally grown plants, that they must have a plant passport, that there must be an audit trail of the plant source, or that they must have a plant origin certificate. Two landscape architects mentioned using trusted suppliers. One landscape architect mentioned the use of Plant Partner which is a live plant database, and on one project conversations took place between the landscape architect and the planning authority about the use of native species and prevention of moving materials out from the site. Another landscape architect pointed out that the plant suppliers will provide information on which specified plants can and can't be used at the point of sourcing, again expecting biosecurity expertise will exist elsewhere in the pathway. Five respondents felt that biosecurity could/should be higher on the agenda and specifically, that biosecurity specifications could improve.

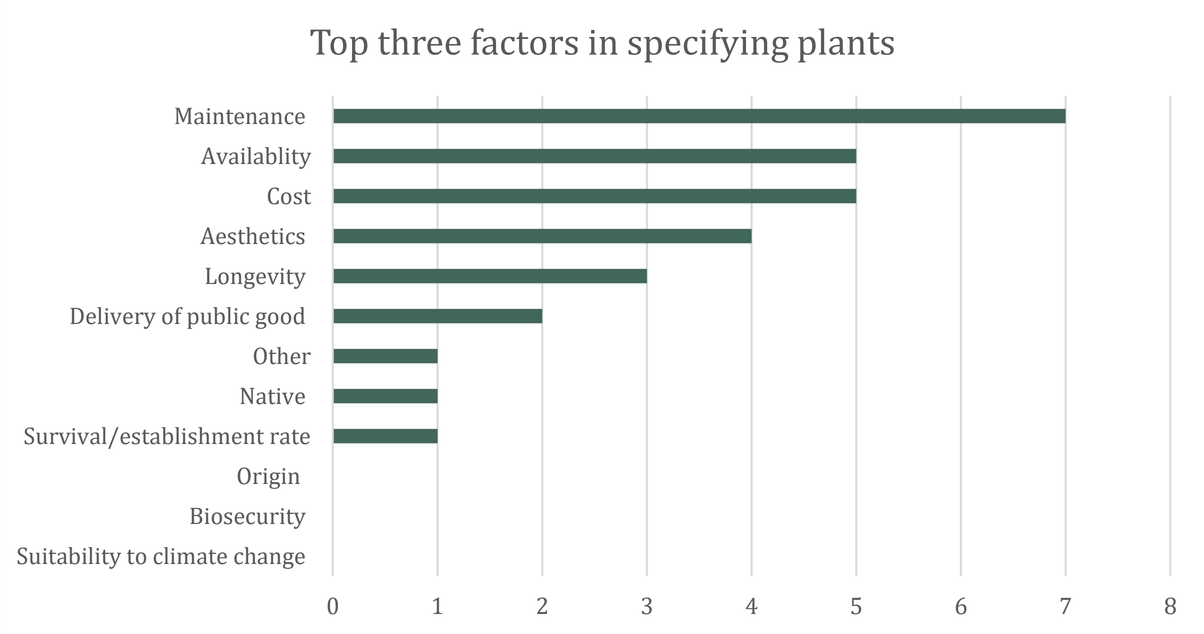

Figure 14. Top three factors influencing plant specification decisions.

5.2.2.3 Hiring contractors

Biosecurity did not feature as a consideration when choosing soft landscaping contractors and plant suppliers (see Figure 15 and Figure 16), although just 5 respondents had been involved in contracting (three landscape architects, one client and one landscape manager) and 3 in the supply (two landscape architects and one contractor). Only one landscape architect we talked to said they would make sure that the contractor understands legal requirements such as plant passports and phytosanitary certificates, and any project-specific reports on pests and diseases. They also said they would expect biosecurity to be built into the contractor's company awareness. Apart from this example, no biosecurity actions were taken by other participants specifically when choosing contractors.

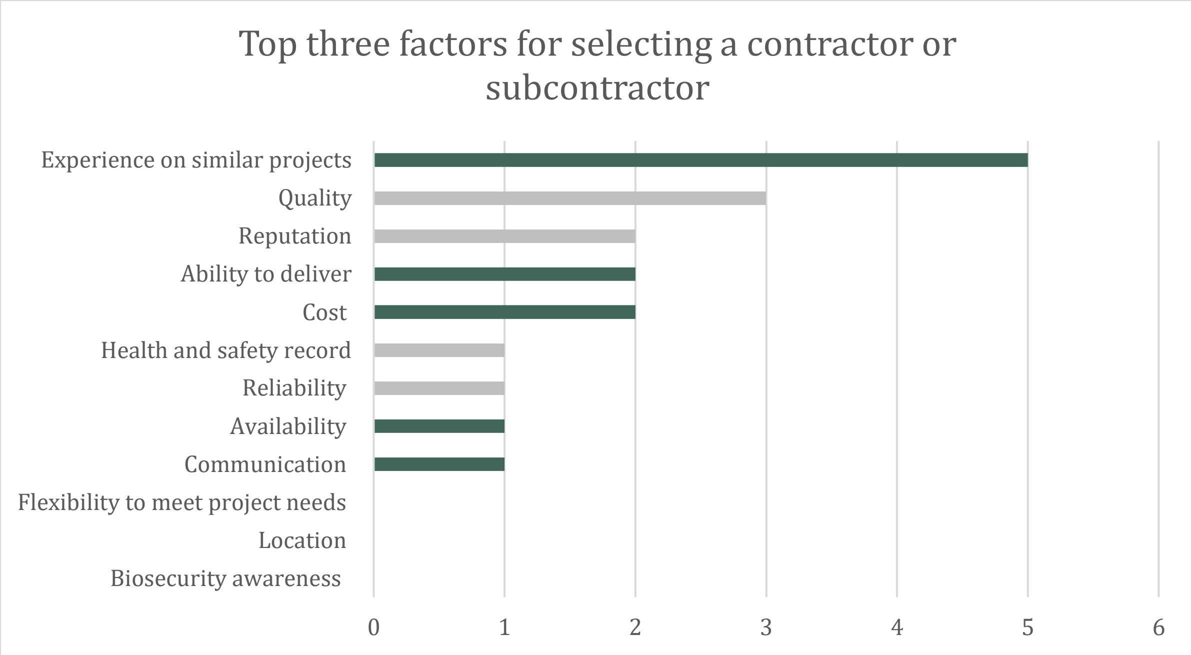

Figure 15. Top three factors influencing selection of soft landscaping contractor. Bars in grey were generated from statements following a choice of 'Other'

5.2.2.4 Selecting suppliers

When choosing suppliers, one landscape architect stated a "good track record" as their measure of biosecurity standard. The other two respondents (a landscape architect and a landscape contractor) involved in selecting a contractor responded that they had not taken any biosecurity measures when choosing the supplier for the projects. When asked about biosecurity actions taken in selecting individual plants for the projects, a few actions were listed by four respondents, all landscape architects. These included checking for drought, checking the stems, checking the provenance certification, investigating general plant health and structure, and following up with paperwork. One respondent stated that they "*would expect a good nursery not to have those trees in the first place*".

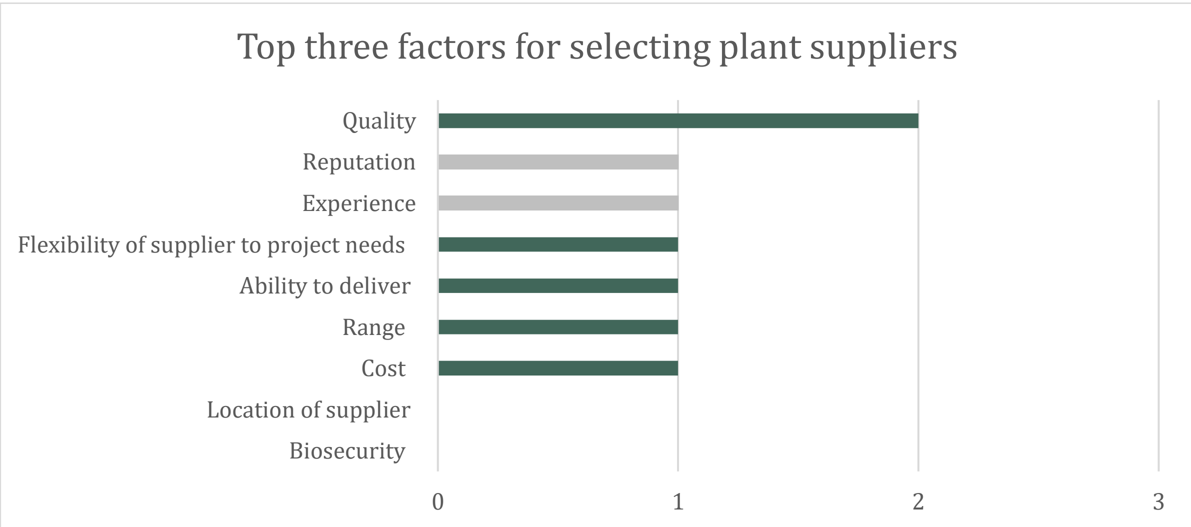

Figure 16. Top three factors influencing the selection of plant suppliers. Bars in grey are generated from statements following a choice of 'Other'

5.2.3 *Instance of pests and diseases on projects*

Just one participant, a landscape contractor, had experiences with pests and diseases impacting their project. This related to aphids on planted bamboo which was successfully treated. They believed the aphids must be native as there was no evidence they came on the plants. Another three participants (two landscape architects and the local authority) were interviewed for the same project but did not state or know of the aphids or any other pest or disease issues, highlighting a lack of information back up through the pathway. In addition, one project had a dialogue during the planning application process about a specific variant of lime tree not being suitable. The local authority's landscape architect was worried about a pest or disease specific to the species. The specification was changed based on this.

5.2.4 *Information*

The most common sources of information specifically on plant pests and diseases included environmental charities, governmental departments and agencies and the Royal Horticultural Society (Figure 17). Respondents could not think of any specific information on pests and diseases they feel they need but can't currently access, as two respondents put it: "*You don't know what you don't know*". None of the participants mentioned the UK Plant Health Portal. However, a number of participants were keen to increase their knowledge base.

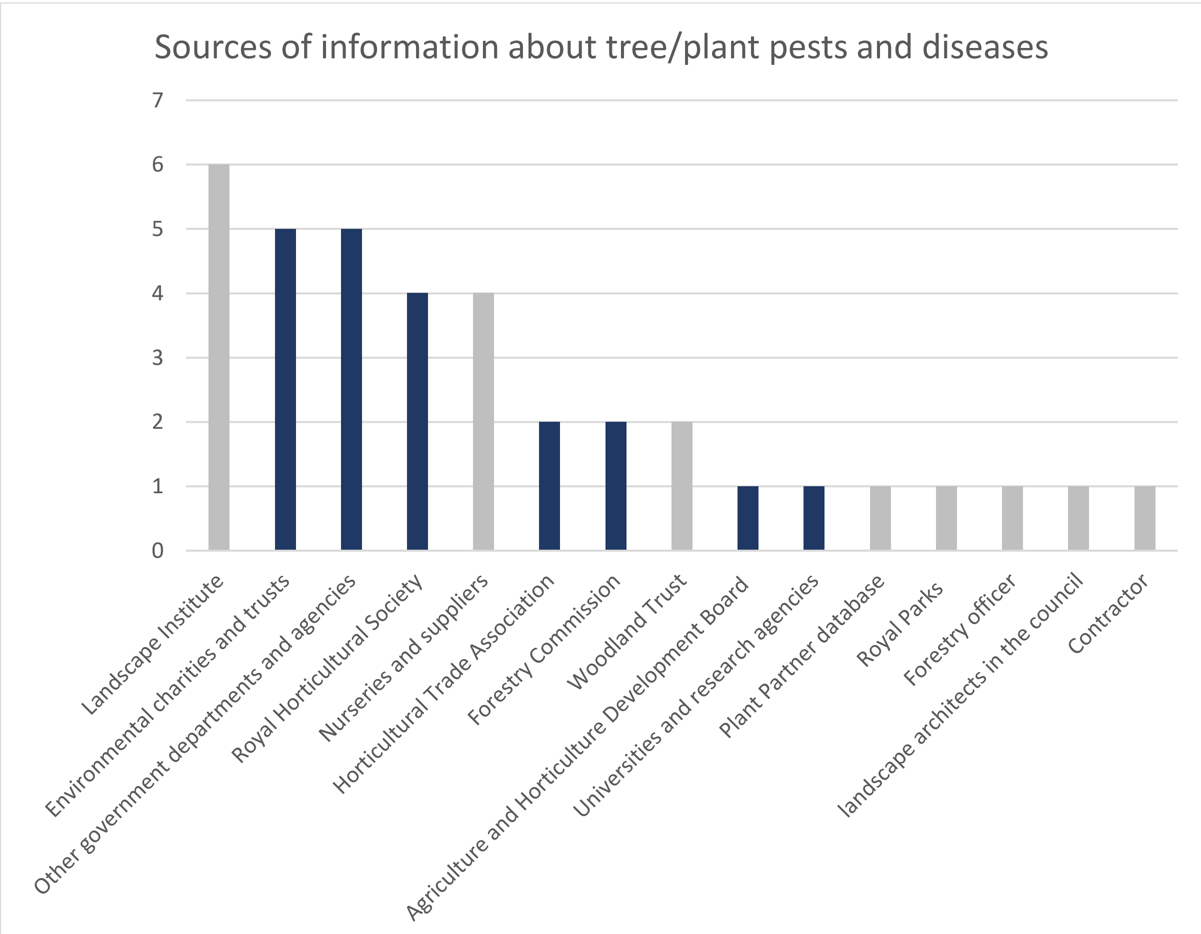

Figure 17. Sources of information on tree and plant pests and diseases used by the respondents. Bars in grey were generated from statements following a choice of 'Other'

5.3 Planting stock: sources and replacements

Summary

- Of all the respondents, four were aware of where stock had been grown.
- Replacement rates were estimated between 2 and 25%.
- While 67% of respondents reported that all the planting matched the plans, just a quarter of projects for which fieldwork was carried out matched plans.
- On 24% of sites, planting areas had not been created or plants had not been planted.

5.3.1 Where was the stock grown?

Landscape architects and other actors were often unaware of the source of stock used. Four respondents (two landscape architects, one client, and one landscape manager) were able to comment on where stock had been grown. This is fewer than were aware of the location of their suppliers (see Table 4 in section 5.1.3). One respondent (client) indicated they had used stock grown in Scotland where possible. The remaining three who estimated where stock had been grown, indicated the wider UK or beyond. One respondent said they selected native species for planting but did not know where stock was grown.

5.3.2 Planting and replacements

Some projects reported changes to planting compared to original plans (four respondents, see also Figure 18), or replacement of planted stock (seven respondents) although it was too early to tell whether replacements would be required on the remainder of the projects for which this data is available as planting had only recently taken place. Reasons for changes to planting compared to original plans varied. One project went through different phases of planning where changes were made due to the tree officer having specific views on species choice. On another project changes were down to a lack of availability of specified species and varieties. In this case the specifications were changed or higher numbers of other specified plants were used as replacements. However, the landscape contractor might not always inform others of substitutions, and therefore the real number of changes to plants on projects could be higher than that reported by other actors. Replacement rates were estimated for five sites and were between 2-25%. One participant estimated an average of 10-15% for projects in general. For two projects with high replacement rates this was due to the type of topsoil used on one, and on the other, the contractor suggested that the plant specification was incorrect. However, the landscape architect in the same project believed that the plants had not been watered by the contractor during the Covid-19 lockdown and the responsibility would therefore lie with the contractor.

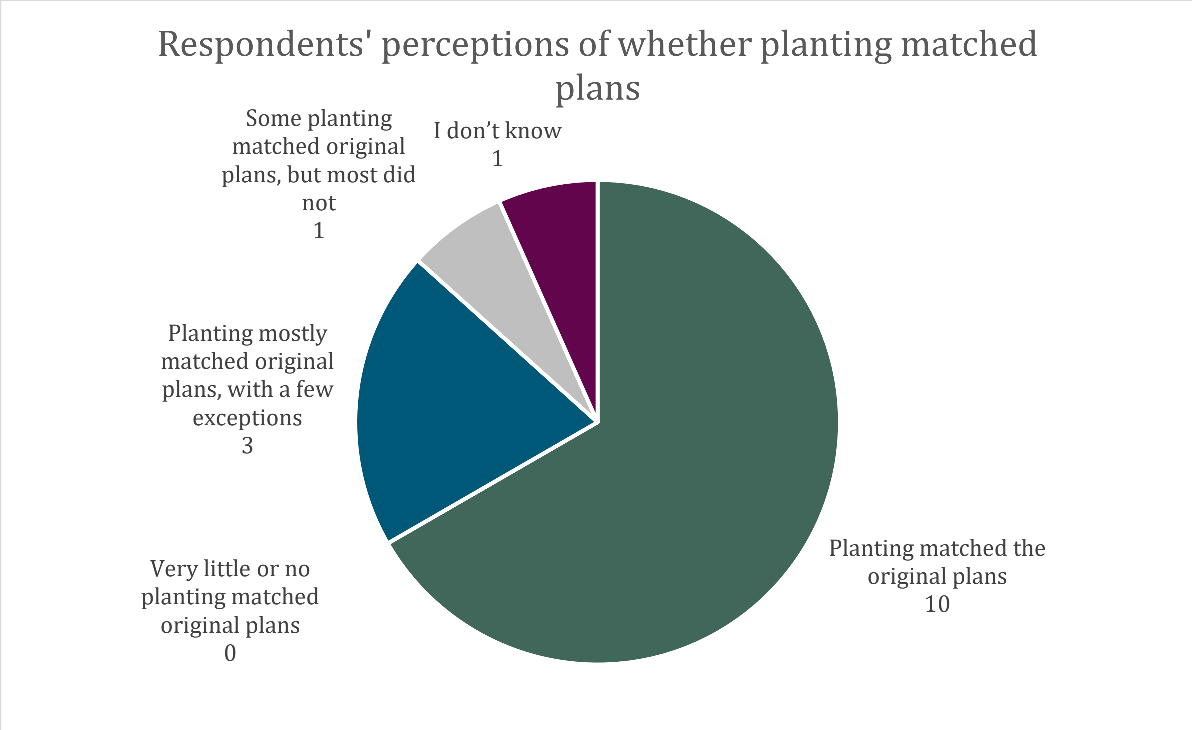

Figure 18. Respondents' perceptions of the degree to which planting carried out on a project matched the original plans

Just one participant said they were responsible for replacement costs – the landscape contractor. They estimated a replacement cost of £4000-5000 from a 2-3% replacement rate. Other respondents also uniformly agreed that replacement costs would lie with the contractor (n=5).

Fieldwork was conducted on 17 sites in Scotland and 14 sites in England to compare plant specifications and actor perceptions with actual planting practices. In contrast to the interviews, the fieldwork identified significant differences between reported and actual practices. For example, whereas 67% of the survey respondents reported that projects matched the plans (Figure 18), our fieldwork found that this figure is nearer a quarter of all projects. Approximately half of all planting areas featured species substitutions to some degree (Figure 19) and in the context of the interviews, it is likely that some of these substitutions were made without discussion with the landscape architect; for three of the four projects where both survey and fieldwork data is available, all respondents reported that planting matched plans, while the fieldwork showed little to moderate variations (Table 5). In addition, the four projects represent some of the most accurately delivered projects in this study, and even within these there were a number of issues including some planting areas not being planted at all. The degree to which these substitutions are noticeable varies: for example, in many cases the substitutions were to do with replacing one species within a genus with another, but in the most extreme cases, we observed plants such as *Phormium tenax* (New Zealand flax, a herbaceous perennial) being used in place of *Quercus robur* (English oak). These are obviously different species with different landscape characteristics and biodiversity value. Perhaps the most significant finding of the field work was that in 24% of cases studied, by completion of the development a planting area wasn't created at all.

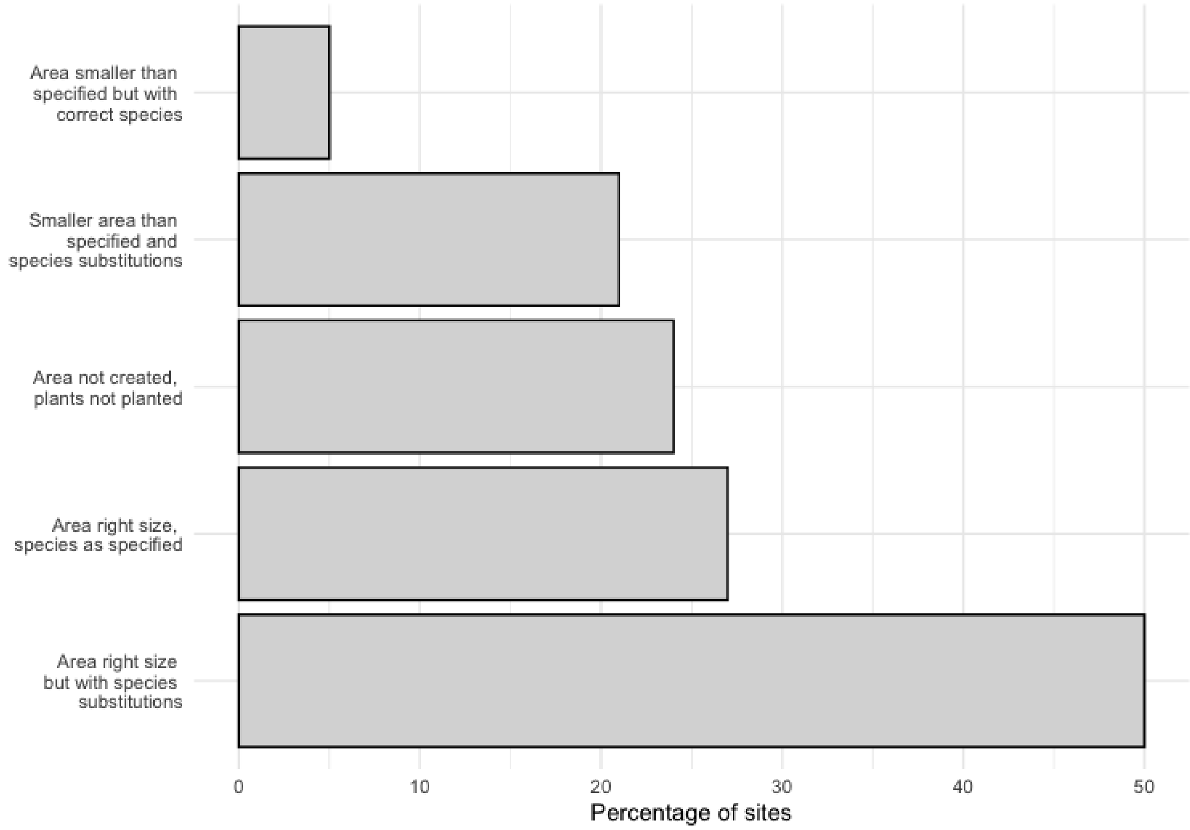

Figure 19. Survey of sites to assess the degree to which projects deliver the approved designs.

Table 5. Perceived and average actual planting accuracy from interviews and fieldwork data (where data was available for both).

	Perceived accuracy	Plant type accuracy	Species accuracy
Inf1 Landscape architect	All matched plans	89%	68%
Res3 Local authority	Mostly matched plans	94%	78%
Res4 Landscape architect	All matched plans	100%	63%
Cmp3 Landscape architect 1 Landscape architect 2 Landscape contractor	 Mostly matched plans All matched plans All matched plans	100%	98%

5.4 *Lessons learned: key issues highlighted through projects*

Summary

- There is a general lack of biosecurity communication between actors.
- Responsibilities are not always clear and can change throughout the project, with potential impacts on biosecurity measures undertaken.
- Projects can have complicated decision-chains with a large number of actors involved.

- Even when sourcing of local plants is desired, external pressures might lead to sourcing of plants – particularly trees, internationally.

Findings from several developments allow us to explore key issues and lessons learned. These provide narratives of the planting pathways from multiple perspectives.

5.4.1 *Case example 1: Communication forward and back along the planting pathway is an important component to promoting biosecurity*

One project we looked at involved a residential development near a woodland. The proposal included installation of a wildlife corridor leading to a local nature reserve and the woodland was retained as part of the scheme. Native plants and trees were specified for the wildlife corridor, with grass and meadow species to be sourced within Scotland. However, when it came to woodland plants, availability within Scotland was limited. Volumes of other species were increased to make up for those not available and some non-natives included. The local biodiversity officer stated that they had agreed to all changes before they were made.

Because of the wildlife corridor element of the project, the client was keen to increase engagement with the local community. The availability of a biodiversity officer at the local authority gave an added opportunity for increased biosecurity knowledge on the project. The biodiversity officer self-assessed their own biosecurity awareness as high, whereas the landscape architect and the factor (who subcontracts the landscape manager) rated their own knowledge as medium and low, respectively.

The biodiversity officer stated that planting mostly matched plans, which was reflected in the fieldwork sample plots where most had 100% correct species planted. Two plots had a total of eight species removed (i.e. substituted for something else or not planted at all) compared to the initial plans, and as a result had 70 and 40% planting accuracy. The biodiversity officer was able to recall three species changes, leaving some gaps in information.

The landscape architect on the project did not appear to be aware of species replacements made for this project, or even what stage the project was at the time of interview and had not been asked back to inspect planting. The landscape architect felt generally that there is a "broken link" in communication meaning important information will not always get back through to other actors in projects during later stages of the project. They felt this was a missed opportunity for learning. The biodiversity officer on the project equally felt it would be better to have a connection right through the project and be able to assess completed work and talk to contractors. Communication does happen but the officer felt it would be good to have this at the start of projects to make sure they meet all the requirements.

More so than other projects in this study, this case study showed a strong biodiversity focus, made use of the extra resource and knowledge of a biodiversity officer, and used the project as an opportunity for community engagement. However, even here, there were still gaps in communication leading to a deficit in sharing of information potentially important to biosecurity (e.g. choice of replacement species) between key actors.

5.4.2 *Case example 2: Shifting responsibilities for plant decisions along the plans to planting pathway risks no one taking responsibility for biosecurity*

This campus project included avenue trees, amenity grasses, ornamental grasses and bamboos, mixed perennial beds and areas with small shrubs and single trees. The client for this development was the institution which owns the existing buildings and they hired a landscape architect who created the initial specifications and designs. The landscape contractor interviewed was sub-contracted by the main contractor who also hired a second landscape architect to carry out the technical design and take the development to the handover stage.

Throughout the interviews conducted for this project (two landscape architects, a landscape contractor and local authority planning officer) there was agreement that biosecurity did not feature in many of the interactions or in making decisions about specification and choice of supplier. Nor were any formal biosecurity policies in place for the project, although the local authority planning officer did respond that they felt it was odd that this was the case for a council. The actors said there was good communication on the project in general.

The pathway of responsibility for choosing and approving which species of trees and plants actually ended up in the ground appeared to be passed along from the start of the chain (client) to the end (suppliers). Although the client had ultimate say over which plants were chosen, they passed this decision to the main contractor who then sub-contracted this decision to the landscape contractor who in turn, relied on the suppliers' availability and knowledge for deciding which plants and trees were chosen. The planting carried out was identified by the client's landscape architect as mostly matching plans and they noted a particularly good establishment rate. The contractor's landscape architect and the landscape contractor both stated that all planting matched the plans. This was largely accurate; the fieldwork showed 90-100% planting accuracy in the surveyed plots with two conifer species used as substitutes in one plot.

Nevertheless, this case example is indicative of large landscaping projects where there is opportunity for plant biosecurity to feature in decision-making, but this may be lost as decisions on species choice and procurement are shifted along the plans to planting pathway. It is a reflection of complexities of large-scale projects and the numerous stakeholders and processes. Biosecurity is unlikely to be intentionally ignored but is instead overlooked. However, the reliance on others to take responsibility for plant health risks potentially leads to no one taking responsibility at all.

5.4.3 Case example 3: A potential gap in the Scottish planting pathway

This project is a development in a public urban space. The original design aimed to recreate a specific type of Scottish landscape and was reflected in the care taken to specify native plant and tree species. Sourcing the plants and trees from Scotland was also important to the client. Species native to Scotland, and the UK more generally, have a higher chance of establishing well in the often-harsh Scottish landscape. However, the landscape architect noted that thus far on the project (25% of planting had taken place at the time of interview), plants were actually sourced from England and the trees from Europe. The landscape architect noted that it is common practice to source larger trees from Europe and highlighted the difficulties with sourcing large trees from the UK.

There were time and logistical pressures on the project: it was high profile locally with a certain amount of planting required to be complete before the official date of opening; uncertainty surrounding EU Exit and the future availability of trees from the EU increased the desire to receive stock prior to the end of the transition period in December 2020; and Covid-19 travel restrictions meant that identification and selection of individual trees from EU suppliers was not possible in person.

The landscape architect was confident that international suppliers were of high quality and that they had taken all biosecurity precautions possible. Plants from England were presumed to be pest and disease free. The landscape architect also noted that the landscape contractors, the council, and the plant suppliers communicated on biosecurity issues but that there was no formal policy relating to biosecurity. In general, biosecurity was discussed from a site-specific context but the environmental and climate requirements of the specific species appeared to be of greater concern. There were no reported instances of pests or diseases on the project nor were any replacements required at the time of interview.

This case study is particularly interesting because of the incongruence between the client's desire for the plants and trees to be sourced from Scotland and the actual origin of the plants and trees that were planted out. The client stated that biosecurity was assumed to be less of an issue due to sourcing within the UK. However, despite the effort to source from within the UK, larger and more mature trees had to be sourced from a supplier based in Europe. This inability highlights a gap in the supply and demand of Scottish grown plants, even in the case of a project which was focussed on Scottish species and the recreation of a Scottish habitat.

5.4.4 *Case example 4: Preparation, early commitment and timing is crucial to ensure that the correct plants are provided for trunk road schemes*

The main purpose of the landscaping associated with trunk road construction is to mitigate any adverse impact of the scheme and help integrate the new infrastructure into the surrounding environment. The planting component is typically included to 'replace, integrate, screen and enhance'; that is to replace any trees that are lost to the road building, integrate the new road scheme into the surrounding landscape, screen views of the new road from neighbouring properties, and enhance the visual experience of the road users and the local ecological connectivity.

The preparation and delivery of road contracts are complex operations, covering a broad array of detailed requirements governed by highly regulated standards. The multifaceted nature of the contracts inevitably leads to challenges and conflicts that need to be considered and resolved within the constraints of budget, programme and a host of external influences.

In terms of the control of potential biosecurity risks, there is currently no specific contractual measure to protect against the inadvertent use of plant material that may harbour disease or a pest of some kind. However, the plant procurement policy for all Scottish trunk road projects requires the use of native plant material grown from seed/cuttings collected from the same UK provenance zone as the proposed scheme or, if this is unavailable, from the closest zone. Imported material is not permitted. The procurement process is certified to allow a full review and approval of the material and its proposed supply source (reputable and appropriately regulated nurseries). Inspections of the approved nurseries are made by the overseeing landscape architect prior to material being delivered to site and further plant inspections are carried out on arrival to determine if the material is approved for use or rejected. There is a tacit assumption that this means any plants used on site will be pest and disease free.

It is recognised that the above procedures do not provide a biosecurity guarantee. There are significant pressures on the delivery of a road scheme, related to financial, operational and reputational risks, and this can affect operations such as the programming of sub-contractor appointments and the placing of plant orders etc. Such delays can, in turn, lead to supply difficulties, with limitations on the availability of the selected material through the open market due to competition from other infrastructure projects that may be underway within the UK at the same time. In such circumstances it can be politically and economically difficult to delay planting (and therefore, potentially, the road opening) and a pragmatic solution is required. The contractor will often seek a relaxation on the planting specification and this requires consideration from the client team as to the most appropriate way forward in order to continue to meet project objectives. This is likely to require a compromise in some form or another – size, number, quantity of planting stock, or approval to use a material from a provenance zone that is much further from the site.

This is not ideal and efforts are being made to arrive at a means to contractually require plant orders to be placed in good time to secure the specified material. Despite limiting planting to UK-sourced, native species of local provenance (as far as practicable) and including the safeguards of supply certification and checks at the nursery and site by experienced landscape architects, the process still largely relies on the integrity of the suppliers to manage disease/pest-free operations, and this remains a potential vulnerability in terms of biosecurity. To overcome this, and also provide a guarantee of the required plant material (correct species, size, quantity, quality and provenance), some projects are preceded by a plant supply contract, where the material is selected and grown-on ahead of the main works. This process inevitably must be commenced 2-3 years ahead of the project to allow the seed to be collected, processed and the plants established. This requires an early commitment that is not always possible.

5.4.5 Case example 5: Lessons learned from an historical disease outbreak in a country park

There are lessons that can be learned from past large-scale landscaping projects where large disease outbreaks have occurred. One example involves Balloch Castle Country Park, a large and popular visitor destination, which hosted the first recorded outbreak of an invasive tree pathogen, *Phytophthora lateralis,* in 2010. The country park was re-designed 16 years ago to enhance the historical features and natural environment and improve access for the visiting public. To recreate the ornamental garden, plants were a mix of woody hosts and non-woody (and likely non-native) ornamentals. It is unclear still where the introduction of *Phytophthora lateralis* came from but there were 30 nurseries supplying the project, half of which were based in Europe. The result was many dead trees, mainly Lawson cypress. There was a tacit assumption that plants arriving would be healthy and a reliance that everyone else had correct processes in place. Additionally, biosecurity was generally not thought about at that time although there were visits to European nurseries to select plants. After trees started dying and an investigation ensued the Park was issued with a Statutory Plant Health Notice and biosecurity measures were put in place, which was a costly process. Replanting continues and there are lessons learned from the aftermath of the outbreak. For example, managers keep a closer control in-house over plant procurement and check with nursery suppliers on where the plants are coming from and their biosecurity measures in place. Trusted sources are now generally used. Sites are monitored regularly, and any potential pest or pathogen outbreaks dealt with quickly. Since 2010, *P. lateralis* has been found causing disease outbreaks at several other locations in the Glasgow area. While it is difficult to identify sources of infection, it is likely that the series of multiple outbreaks resulted from infected batches of plants entering a complex supply chain. Reducing the number of nurseries supplying a planting scheme and ensuring that those nurseries have a robust biosecurity system in place is essential to reduce or remove plant health risks.

6 Discussion

Despite the challenges with recruitment during COVID 19, the actors within our sampling framework that did respond were open and engaging. There was a general lack of awareness about biosecurity but, aside from our historical case example, no interviewees reported significant incidences or experience of pests and diseases on the projects they were involved in. However, this research did reveal several missed opportunities for considering plant biosecurity threats. For example, comparisons between interview respondents and fieldwork data shows that there can be large variations between specification and planting, and these issues are common without considering the potential biosecurity issues associated with certain species of plants and trees. This study also highlights a number of blind spots in the plans to planting pathway, namely variable inclusion of biosecurity measures and lack of species diversity in plant specifications at the beginning of the pathway; low consideration of biosecurity in procurement processes throughout the pathway; and unauthorised changes to or lack of planting at the end of the pathway. Issues associated with these blind spots could be partially tackled with increased information flow (see Figure 20). but we also consider other options as highlighted below.

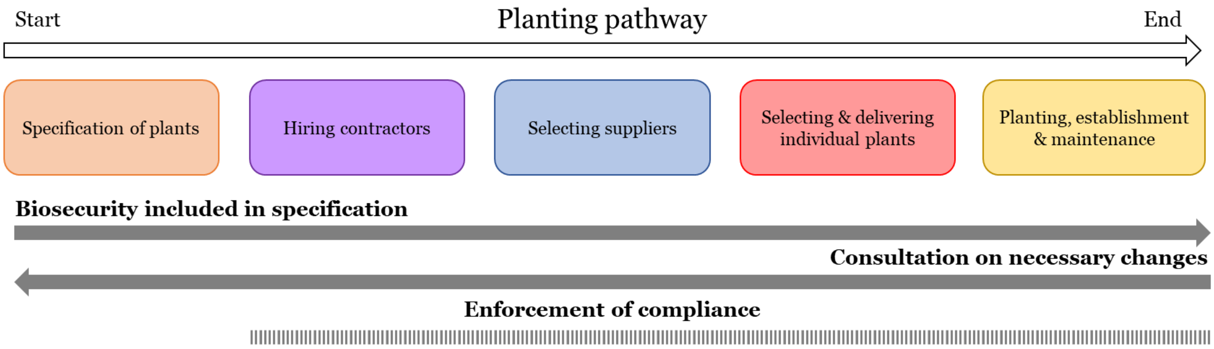

Figure 20. Recommended inclusion of biosecurity measures throughout the pathway. Green arrows represent an ideal flow of information across the planting pathway.

Biosecurity inclusion at the beginning of the pathway
A potential point of intervention is during planning and specification where biosecurity considerations can be included. For example, landscape architects generally follow the National Building Specification (NBS) Building Information Modelling (BIM) Object Standard. The Building Information Model is a digital description of the building and its surroundings. The NBS-BIM Object Standard defines the context and structure of a high-quality BIM object, to raise standards and consistency in the industry. Biosecurity is one of the clauses within the Standard and this is often the method by which questions surrounding biosecurity are brought to light. However, the software used has a series of built-in selections which cannot easily be altered. This has the advantage of ensuring a minimum standard, but potentially the disadvantage of a 'tick-box' approach where only the minimum requirements are fulfilled. A few landscape architects specified that for better biosecurity the plants must be sourced locally, be accompanied by plant passports, have an audit trail or a plant origin certificate. Consideration of biosecurity could also be achieved by encouraging Local Authorities to include biosecurity requirements in their planning policies, making it a requirement. Furthermore, the Building Research Establishment Environmental Assessment

(BREEAM) certification could be amended to include further biosecurity considerations for projects with a specific focus on environmental outcomes. A review of specification tools, processes and best practices can highlight opportunities for improved specifications. This would also help ensure that all actors throughout the pathway will be informed of responsibilities and requirements from the onset.

This study also showed a narrow range of species specified for planting schemes. Low diversity of specified species reduces ecological resilience as more plants are likely to be affected by some known and unknown novel pests and diseases. Plant survey data showed stress tolerant species were favoured, and interviews with landscape architects indicated the main drivers given for species specification were maintenance, availability, and cost. There are some challenges as increasing species diversity would likely not make maintenance easier, in fact a wider range of species on site may make maintenance more difficult if the plants used need different types of care. Increasing diversity of species specified could have a positive or negative effect based on the overall availability; easily sourcing all species from one supplier would be less likely if there were a higher diversity of species, but using fewer types of plant (less diversity) may also present a problem in sourcing the required volume for a large project. Specifying greater diversity may mean increases in cost of plants if economies of scale are lost. Thus, encouraging projects to specify a greater diversity of plants may have to overcome these significant barriers.

Landscape architects often reduce or discontinue engagement in projects past the initial stages, and all apart from one landscape architect had not been involved in the plant supply process. Case example 1 illustrated how important specification information did not filter down the pathway once the decisions had been made. This corroborates the findings of the Fitter Flora project (Watkins, 2020), which identified that most landscape architects spend most of their time working on project planning and early design stages rather than detailed design or contract management. This is likely a result of resource allocation by the clients. However, it carries the risk of reduced oversight of biosecure plants and planting practices. Landscape architects are more fully involved in Scottish trunk road schemes but as case example 4 demonstrates there are potential biosecurity risks if specified plants are not procured early enough in the process.

Lack of biosecurity visibility and ownership

Many actors did not consider biosecurity to be a key part, or any part, of their role, and understandings of the term varied. Communication must be clear about where biosecurity risks occur and what appropriate actions are required. For example, the relationship between tree stress and pest and disease impacts should be made explicit, including the importance on aftercare upon planting. Case example 2 & 5 illustrated how responsibility for biosecurity can get lost in the complexity of a project. Yet many actors expressed that they recognised the importance of biosecurity and would be willing to learn more about the topic and best practice. There is an opportunity to improve biosecurity awareness across all actor types in the planting pathway. Partnerships with professional organisations could help target plant biosecurity information to these actors. The review specifically highlighted a lack of biosecurity guidelines for workers in construction who might not traditionally consider biosecurity as part of their roles. Meanwhile, the Landscape Institute was used as an information source by landscape architects and should be considered a main partner for promoting biosecurity awareness and best practice recommendations to landscape architects through, for example, the Landscape Institute biosecurity toolkit (LI, 2019).

Biosecurity was not often included in conversations between pathway actors. Some projects highlighted a multitude of actors involved in the developments creating a complicated web of relationships. A multitude of other business priorities can take priority over conversations surrounding biosecurity. Many actors expected someone else to take biosecurity into account, although upon reflection, some were unsure why biosecurity did not feature more highly in their roles or organisations. Apart from the historical case example, none of our participants had yet experienced any serious pest or disease outbreaks, which may account for the limited attention paid to the potential threats. Nevertheless, there is a need to clearly identify responsibilities for biosecurity along the plans to planting pathway to prevent perceptions that 'someone else has taken care of it'. A two-way flow of information is also needed to ensure 1) biosecurity is considered from the beginning and implemented during sourcing, planting and maintenance; 2) necessary changes are discussed with all relevant actors; and 3) decisions are enforced throughout (see Figure 20).

Biosecurity at the end of the pathway

Potential biosecurity risks occur during the contracting and planting stages where decisions are made on sourcing of stock and changes to species and provenances. Increasing resilience involves inclusion of more diverse species but this may require continued importation of seeds and plants internationally. Case example 3 illustrated how large trees were perceived as difficult to source nationally and therefore incur increased risk. Large, mature trees pose an additional threat to biosecurity as they are transported with soil and the volume of roots make them difficult to inspect for pests and diseases. The specification of large trees in several projects warrants further investigation into why large trees are considered appropriate and ensuring that specifiers are aware of the associated risks. Promoting the use of trusted and certified nurseries (such as under the Plant Healthy Certification Scheme) will likely be important for the delivery of diverse, but safe plants. Most actors we spoke to were unaware of the source or origin of the planting stock used for the projects. Previous research similarly demonstrated that nurseries respondents did not know the provenances of the majority of their imported urban tree stock (Sjöman and Watkins 2020). Our study mainly captured responses from landscape architects and further research is therefore needed with hard to reach actors along the pathway including building companies and landscape contractors. Meanwhile, building national capacity for growing planting material nationally would also significantly contribute to biosecurity in the longer term.

There is a need for improved communication and consultation by actors at the end of the planting pathway (contractors, landscape managers and nurseries) with those involved at the beginning such as landscape architects and local authority planners to ensure that specified plants actually end up in the ground. In a lot of circumstances this cross-checking probably does happen but lack of communication about planting practices at the end of the project also presents missed opportunities for learning amongst other project actors. The difference between perceived and actual planting carried out also highlights potential issues with enforcement. Local authorities do not always have capacity to check planting, and there is no consistent allocation of responsibility for undertaking checks. Even when landscape architects are instructed to undertake checks, they can only recommend works and not instruct actual changes. Furthermore, it is likely that the projects included here are checked more often than smaller projects due to their scale and profile.

One comprehensive option for addressing biosecurity risks in a structured, systemic way could be the introduction of a biosecurity risk assessment process (similar to the health and safety process) that follows a scheme right through from the initial planning to planting and establishment assessments. The risk assessment would be overseen by a biosecurity manager which would have to be someone with an interest in the success of the final scheme. All actors would read and sign the biosecurity risk assessment and hold responsibility within their realms of influence that it is adhered to throughout the pathway. The biosecurity risk assessment could have a generic structure that covers all the bases in terms of plant diversity, size of plants, country of source, species pest and disease risks, supplier risks and establishment risks. This would ensure that biosecurity issues are flagged and tracked throughout the pathway. This would require significant investment, but the potential biosecurity threats highlighted in this study warrant a comprehensive approach.

7 Conclusions

This study has highlighted several potential blind spots in the plans to planting pathway that may pose biosecurity risks including a low biosecurity awareness, variable inclusion of biosecurity measures; lack of species diversity in plant specifications, changes to plants for planting or lack of completed planting. Comparisons between interview respondents and fieldwork data shows that there are some variations between specification and planting; this may be a common practice and could indicate a systemic challenge to biosecurity.

In spite of the constraints of the targeted approach applied to the tracing exercises, we argue that the ability to compare responses between different actors on specific projects and to evaluate their accuracy through ground truthing has provided valuable insights. Furthermore, it is likely that many of the participants we did reach would not have responded to a generic survey, and that further attempts to engage with the construction and landscape sector will be resource intensive but important to raise biosecurity awareness.

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