FUTURE PROOFING
Plant Health

A Defra Network partnership delivering interdisciplinary plant health research to improve biosecurity and build capability

Knowledge to Action: Overcoming the gap between knowledge into action with hard to reach (HtR) audiences

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Introduction

Global threats to plant health require urgent, strategic responses. However, plant and tree health arenas represent complicated knowledge and action economies. The knowledge landscape is characterised by contradictory messaging, contested response pathways and various levels of stakeholder engagement. Existing research, some of which has taken place within other FPPH projects, has revealed that:

1. Whilst plant and tree health stakeholders are relatively well served with technical information about pests and diseases and disease-host interactions (i.e. 'knowing that' and 'knowing what'), there is a significant lack of translation of science and other operational information into guidance about the practical actions different stakeholders might take as part of their plant health response and biosecurity behaviours.

2. The most effective mechanisms and pathways for delivering information and guidance to different kinds of stakeholders to influence decision making and prompt action are not well understood.

3. Stakeholders are either unaware of or are often not sure where to go to find reliable and practical advice, information and guidance.

4. Stakeholders find navigation of different viewpoints about the appropriate action to take very difficult, resulting in no action.

These challenges and barriers contribute to the creation of a "knowledge to action gap" or science-practice gaps. A review of the scientific literature conducted as part of this scoping study showed these knowledge to action gaps are widely documented in the conservation literature (Esler *et al.*, 2010; Costanza, Weiss and Moody, 2013; Toomey, Knight and Barlow, 2017; Brownscombe *et al.*, 2019), in climate change adaptation research (Dilling et al., 2015, Kirchhoff et al., 2013, Kirchhoff et al., 2015, Moss, 2016, Nisbet and Scheufele, 2009, Weichselgartner and Arheimer, 2019, Weichselgartner and Kasperson, 2010); and research into the management of common resources such as global fisheries (Wood et al., 2008, Brownscombe et al., 2019, Hartley and Glass, 2010, Nguyen et al., 2018, Soomai, 2017a). The barriers to the translation, dissemination, brokerage and uptake of knowledge resulting in action that was documented through the reviewed research were many and varied, including those connected with knowledge generation, the social and political context that information and knowledge are situated within, and the values and attitudes or induvial people, all impacting levels of awareness, trust, capacity to act and competing priorities (Fisher, 2013; Archie *et al.*, 2014; Marzano *et al.*, 2015, 2017; Addison, Cook and de Bie, 2016).

1.1. Research objectives and questions

The objectives of the scoping study reported here were to:

i. Initiate a pilot research process around a specific knowledge system/s (e.g. urban trees and urban treescape resilience),

ii. Investigate the key issues, factors and processes operating in the knowledge economy contributing to the knowledge to action gap, using evidence from exiting research to inform the research approach

iii. develop an ongoing research methodology and research plan that would contribute to the development of a 'knowledge into action' strategy for plant and tree health.

This has policy relevance for continuing development of the Plant Health Portal, potential revisions to the Plant Health Resilience Strategy (PHRS), and the Tree Health Resilience Strategy (THRS) and any action plans and interventions related to them during 2021-22 and 2022-23.

An additional objective of the scoping research was to identify other research institutions/groups working on similar knowledge-action issues who may have perspectives to share, as well as the potential for partnership working in future work. Initial suggestions included include for example, the University of Reading (communication/extension science), University of Exeter (farmer behaviour/communication) Sheffield (communication/behavioural science), Leeds (public health/behavioural science), Bristol UWE (science communication for change).

The specific research questions this scoping project addressed were:

1. What evidence is there from existing research about models of knowledge to action amongst natural resource managers, that has applicability/specificity for informing the plant/tree health context?
2. What do these models tell us about interventions and approaches that could overcome the knowledge-action gap?
3. Do these "solutions" offer perspectives on interventions which could engage stakeholders and plant/tree systems that are the highest priority in terms of improved knowledge navigation?
4. What factors and processes would overcome the specific barriers to implementation of knowledge experienced by stakeholders in these systems?
5. What are the implications of this understanding for the development of a plant and tree health knowledge to action strategy?

2. Methods

2.1. Rapid Evidence Assessment

We completed a two-step review of published literature on the topic as it relates to natural resource management issues, focusing on what is relevant to plant and tree health. The first step review synthesised findings from 205 papers selected from 1779 titles, investigating the process of transformation of information into action (i.e. the knowledge system). The second step review looked amongst 100 papers (84 papers from the initial sample with an additional 16), for specific examples of empirical studies that described and assessed the effectiveness of policy interventions to overcome barriers in the knowledge to action chain (i.e. solutions).

2.2. Case studies

Case study selection was deliberated and agreed with policy colleagues in the Defra plant health team and project Steering group. The main focus of the discussions was identifying the priority land managers and businesses, the priority plant/tree health issues, and the priority behaviours that the scoping research should focus on. These are reported below.

2.2.1. Hard to Reach (HtR) audiences as a policy priority

The next few years will see significant development of plant health and land management policy, at a time of significant change to socio-political and socio-ecological contexts. Defra have already identified a need to engage with as many people as possible during this period of change to ensure that new policy objectives are widely applied by land managers and other stakeholders along the value chain. Evidence suggests that stakeholders amongst "traditional audiences", e.g. those currently engaged with Forestry Commission and other agencies within the Defra group, or those who are members of sector organisations such as ConFor and the RFS with good connections to Defra group, are aware of and accessing policy support mechanisms including knowledge products[1]. However, there are a large number of stakeholders where engagement has been, and remains, more challenging. Generalised as Hard to Reach audiences[2], these stakeholders may have objectives, values, attitudes, beliefs, social networks and socio-economic circumstances which are quite different to traditional engaged audiences, and which present significant barriers to engagement with policy actors and the knowledge that they promote. Alternatively, and in the language of technology adoption science, they could simply be "*followers*" or "*late adopters*". Although "hard to reach" or "late adopter" or "un-engaged" are terms which have been criticised as leading to generalisation, stigma and prejudice (e.g. Whitnell 2004), in our use of these terms we recognise our own definitions of individuals and organisations who have seemingly little involvement with the policy and research activities Defra family organisations are involved with. It does not imply lack of interest or willingness to change in the light of policy developments or research findings.

For plant/tree health issues these HtR audiences may be particularly significant as we assume that:

- Engaged audiences are more likely to be in receipt of information/knowledge and more likely to act on it, thereby managing plant/tree health threats in the way policy and science recommend
- HtR audiences are not receiving policy endorsed information/knowledge even though they are a large constituency, and this represents a weak link in the biosecurity of supply chains and desired action at a landscape scale.

[1] Whilst these audiences may be aware and engaged, it is not certain how they use knowledge products and if this translates into action.

[2] See for example, https://www.sheffield.ac.uk/media/13830/download.

HtR audiences related to plant health

The plant supply system is complex with specialisations meaning that stakeholders within it have very different experiences and interactions with plant health issues. For example, the argument has been made that responding to biosecurity issues is simpler and more complete in the forestry nursery sector when compared to other parts of the forestry industry for a number of reasons: the impact of ADB having heightened awareness and the need for better biosecurity, a reduced pallet of products traded, and fewer supply and demand nodes in the supply chain. The complexity of the system increases in terms of the number of businesses participating and the number of species traded as we move to amenity trees and shrubs to ornamental plants. Further, the "system" extends to the sets of externally and self-imposed rules and regulations designed to promote good husbandry/biosecurity practices as well as the interactions between and within public and private stakeholders.

Whilst in one sense nurseries form a single system, in practice they are very different with different incentives for action based upon, amongst other things, the variations described above. The whole sector receives the same information but have different capacities to absorb the information, turn it into knowledge, and then knowledge into action.

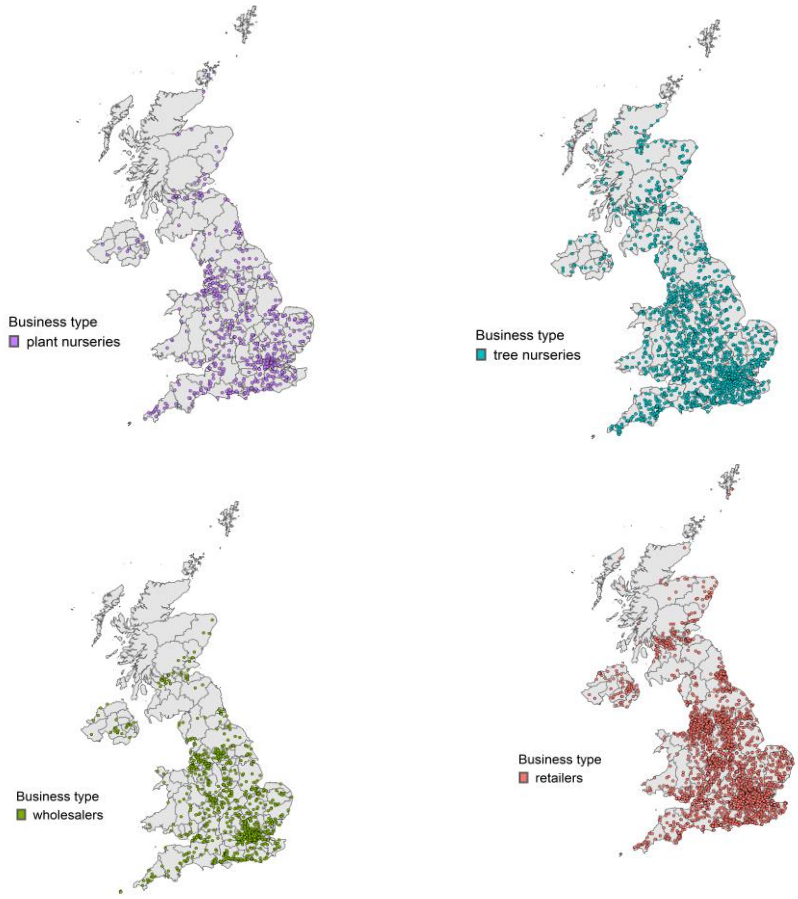
Looking at the plant health sector the question of Hard to Reach is very difficult to define since the industry and plant health issues of interest are large, significant, and connected to international trade and networks. Data on the structure of the sector is poor. Prior research into what actually constitutes the "sector" shows quite different results in terms of the businesses involved. This partially relates to its breadth – it includes wholesale and retail nurseries that often specialise in different species or groups of species.

In prior FPPH related research projects we have considered industry reports on horticulture, a Standard Industry Classification code search, one based on the pesticide usage survey, HTA and BALI memberships and Homebase and B&Q locations. In BRIGIT (NERC funded) we undertook a Companies House search for the following codes:

- 01300 (Plant Propagation): 591 businesses
- 02100 (Silviculture and other forestry activities): 1,914 businesses
- 46220 (Wholesale of flowers and plants): 1,159 businesses
- 47760 (Retail sale of flowers, plants, seeds, fertilisers, pet animals and pet food in specialised stores): 4,452 businesses
- 47910 (Retail sale via mail order houses or via Internet): 61,497 businesses

This suggests a sector with potentially thousands of varyingly engaged businesses, but we know little about the scope and scale of the industry, nor the structure and the flows. Most businesses were registered under a single code and there was limited overlap between the Companies House data and the HTA membership data. Figure 1 indicates the distribution of different kinds of businesses and their location generated with Companies House data. Given this lack of precise knowledge as to the shape and size of the sector it follows that HtR is also difficult to define.

Figure 1. The location of different plant-based businesses from SIC Companies House data



The larger businesses are engaged, in the sense that they seem to generally be members of the trade associations, but this does not mean that they are "easy to reach" when it comes to one-to-one engagement with either policy makers, policy initiatives or the research community. Hard to reach could be:

- Sector businesses that are not members of trade associations
- Sector businesses that are members of trade associations but are passive with respect to engagement – they receive information from various sources but do not provide feedback on its usefulness

It seems reasonable to assume that larger businesses with multiple sites will have staff with specific roles around quality control and compliance type issues. They will also be more likely to pay membership fees and be active in trade associations. However, many smaller businesses are equally engaged in that respect. Smaller nurseries and plant retailers could be more likely to be considered as HtR but this does not mean that their practices or knowledge of industry developments is any less. We only know it is less observed. There are other HtR groups that could prove intractable with respect to engagement – industry businesses that are opportunistic (e.g. pop-up nurseries in laybys or market traders) that could be poorly linked with industry developments and whose activities are only monitored by other local businesses. It is worth

noting that we are currently trying to engage with some HtR businesses as part of the FPPH CRS activity.

Unlike agriculture, there is no equivalent of the Farm Practice Survey and to that extent we do not know if the HtR (however defined) perform differently from those with HTA membership. To some extent this could be tested against APHA inspection data and membership of trade associations.

HtR audiences related to tree health

Looking at land managers involved with trees, woods and forests, there are two key groups that stand out as HtR that could be prioritised, namely:

- Those with responsibility for **Trees Outside Woodlands (TOW)**[3] include a heterogeneity of **farmers** as well as a diversity of **residents** and businesses across rural, peri-urban and urban contexts with poor, limited, or virtually no engagement with traditional forestry and woodland organisations and knowledge providers. This is despite TOW being an extremely important resource at risk from tree P&D as well as acting as vectors across the landscape. The NFI 2017[4] suggests that there are 742 thousand hectares of tree cover outside areas of NFI woodland in Britain, 74% in rural areas and 26% in urban contexts. Non-woodland tree cover amounts to 11% of land area in urban areas and 3% in rural areas. There is estimated to be a total canopy cover of 97 thousand hectares associated with lone trees in Britain, with the majority, 78 thousand hectares situated in England.

- Owners and managers of **small woodlands** which includes a heterogenous group of **farmers**, those with more **ecocentric**/conservation, **amenity** and multifunctional objectives. This too is despite the NFI recording small woods of over 0.1 hectare in extent cover 390 thousand hectares in Britain with the majority, i.e. 295 thousand hectares located in England. In addition, groups of trees (such as windbreaks common on farms) of less than 0.1 hectare in extent cover 255 thousand hectares in Britain of which 193 thousand hectares are in England.

2.2.2. Case study selection

Having accepted working with HtR audiences should be the focus of the scoping study case study selection was debated assessing:

i. **HtR audience** to sub-group level (e.g. ecocentric managers of small woodland)

ii. **Policy focus** (e.g. specific disease or generalised biosecurity practices that are common for multiple P&D)

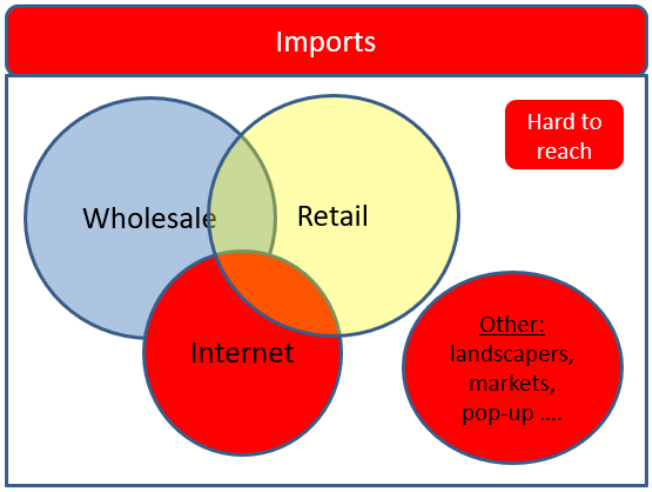
iii. **Desired behaviour** (e.g. recovery actions to replace ash in the landscape, cooperative activities across an industry)

[3] i.e. Trees Outside Forests is the internationally recognised term (see FAO http://www.fao.org/3/a-aq071e.pdf)
[4] https://www.forestresearch.gov.uk/documents/2698/FR_Tree_cover_outside_woodland_in_GB_summary_report_2017.pdf

Figure 2 below illustrates the nexus of audience type, policy issues, desired behaviours and knowledge issues relevant to HtR nursery businesses. For HtR nursery businesses upcoming changes in regulations requires them all to register as plant health professional operators as of December 14th 2020. Thus, theoretically, we should have a much more comprehensive list of businesses trading in plant material. They face some significant changes to the systems they need to deploy to monitor and record plant movements. Allied to this are the array of biosecurity options and the need for constant vigilance that lifts good husbandry toward higher and permanent levels of biosecurity.

Given our relative lack of knowledge, consideration of plant nursery HtR should begin with contact with smaller businesses that may or may not be part of trade associations. These could be contacted via snowballing. Those with more opportunistic sales methods (pop-ups, market traders) would need a different approach which could involve, for example, direct field work or trawling social media.

Figure 2. Selecting priority issues and HtR audiences for plant health knowledge systems case study



Policy

System BS v P&D BS

Regulation – effect of stick (*Xf*). Some want a bigger stick (but not for them)

The impact of grant schemes on demand (linked with perceived injustice of chalara outcomes)

Behaviour

Procurement – inclusion of biosecurity in supply chain decision making. Public procurement and supply chain (B2B)

Inspection capabilities – sector skills and physical capacity

Knowledge

Linked to capacity (size of business)

Perceived importance of P&D (link with costs and benefits of PHAS)

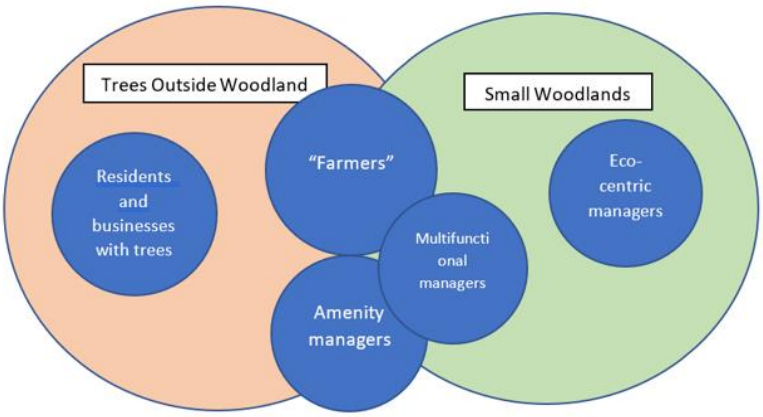
Biosecurity v good husbandry

Figure 3 below illustrates the combination of policy issues, desired behaviours and related knowledge issues relating to groups of HtR audiences. It was decided that two specific P&D issues and how these affected specific HtR audiences should be the focus of the case studies. *Ips typographus* (*Ips*) was chosen due to i. the early stage of arrival, ii. the economic importance of the host species, and iii. the need for land managers to understand the impending threat and engage in surveillance and management of spruce stands. *Ips* is present in most of continental Europe, but just one outbreak has been recorded in the UK in Kent in 2018 (Forest Research, 2021). High risk woodlands are mainly owned by a disparate group of often disengaged woodland owners including owners of small woodland in South East England. High risk woodlands are those which are under managed, and those which include small stands or intimate mixes of spruce trees. *Ips* dispersal is

enhanced where dead, stressed or weakened trees present optimal host material for the beetle (Forest Research, 2021), conditions which are often found in under managed woodlands.

Ash dieback was selected as the second case study policy issue. Since the arrival of ash dieback in the UK in 2012 the information available to land managers has gone through an evolution. In the early stages there was a lot of perceived fear-mongering and panic, and information was contradictory and confusing to land managers. Since then, several guides and toolkits have been developed to steer reasoned action among land managers through the use of clear, consistent messaging. However, ash is the one of the most common tree species in the UK and is present in a range of habitats including woodlands, hedgerows and in the urban landscape. Management therefore lies with a range of professional and non-professional managers with varying capacities, budgets and priorities. Encouraging a consistent approach among those stakeholders, with a focus on long term recovery of the treescape following ash dieback, remains a challenge.

Figure 3. Selecting priority issues and HtR audiences for tree health knowledge systems case study



Policy issues?
Adaptation for climate change
Ash dieback action and recovery
Acute oak decline management
OPM management
Phytophera action and recovery (inc. management of vectors such as rhododendron)
Xylella preparedness

Knowledge issues?
Lack of awareness/interest
Disbelief in "problematisation"/ need to act
Knowledge not tailored: language/translation/application
Social infrastructure for K dissemination lacking
Communication channels for dissemination not clearly identified
No/little research collaboration specifically addressing this group

Desired Behaviours?
Active TOW/woodland management
Silvicultural adaptation for tree P&D
Removal/control of P&D vectors
Diversity *wrt* restocking/tree planting
Biosecurity *wrt* restocking/tree planting

2.2.3. Case Study Methodology

HtR audiences related to plant health

This case study considered the different capacities and incentives for different scales of nurseries in the amenity and ornamental sectors to turn knowledge into action.

Potential questions to be explored in SSI:

- What are the primary sources of biosecurity information, who reviews it, and how is it used in business planning and activity?

- How does this information inform how they interact with business relationships upstream and downstream in the supply chain?
- What characteristics (or implications) of the information triggers the decision to make changes to biosecurity practices (and the converse)? To what extent is this reactive or proactive
- What examples are there of process changes/adapting business activity based on specific biosecurity advice?

After having prepared an interview protocol, and contacting potential small scale nurseries to take part during December-February, it was clear that the extra demands placed on businesses by COVID 19 restrictions was limiting their capacity to participate in the research. Only 1 nursery business was successfully engaged.

HtR audiences related to tree health: Ash dieback and Ips typographus

This scoping study used a mixed methods approach (semi-structured interviews, a short survey, and participatory sociogram (network) mapping) to investigate knowledge networks, actors (stakeholders in the knowledge economy) and processes of relevance to ash dieback and *Ips typographus*. A decision was made to focus the research on the "supply" side and engage with the organisations with responsibility for generating knowledge and information that is then disseminated and brokered to HtR audiences. This is an under researched area, whilst much work has concentrated on asking end users what information and knowledge they use, which organisations they engage with and what the barriers to action are, there is less work looking at the organisations perspectives. Engaging with the generators and brokers of information and knowledge was also critical to building stakeholder maps/network diagrams.

Semi-structured interviews

Questions explored in the SSI varied slightly according to the role of the participant in the knowledge network, but included:

i. What information about ADB/Ips is being generated? What kind of knowledge is it (i.e. What/That/How)? Who is involved, when and why?

ii. How is information about ADB/Ips biosecurity disseminated/communicated by "knowledge suppliers" to different kinds of land managers? Who is involved, what methods are employed? Is there any attempt to understand end users?

iii. How is information and knowledge accessed, and which other individuals/organisations are involved transforming the information into knowledge and action?

iv. What examples are there of process changes/adaption activity based on specific advice, and why did this happen? Do knowledge suppliers evaluate their impact?

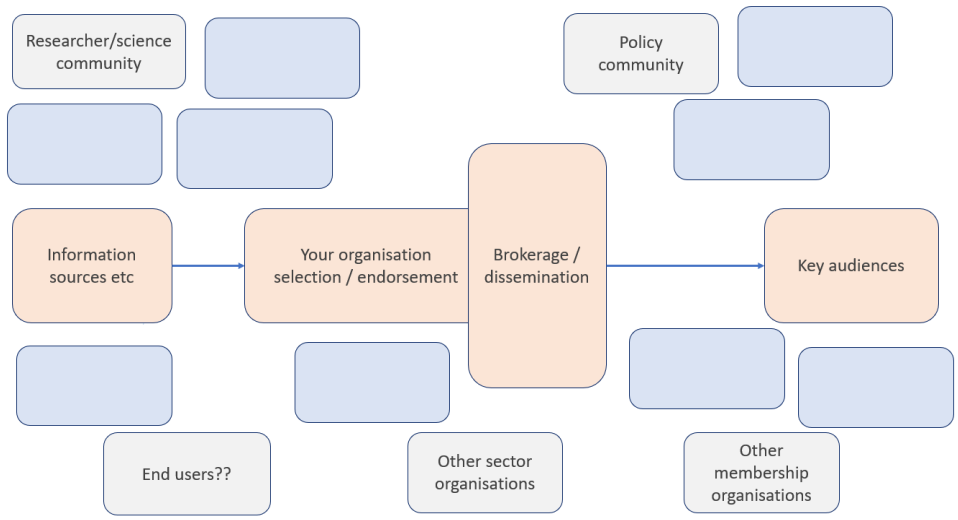
A total of 16 organisations were invited to take part in the SSIs. The invitations recruiting organisations explained the purpose of the research, including a consent form (see Appendix 2) and a short questionnaire on the organisation's learning and outreach activities (see Appendix 3). We completed a total of 10 semi-structured interviews (i.e. a response rate of 63%). We encouraged participation from multiple staff within each organisation to gain perspectives from different role holders and a holistic understanding of that organisation's knowledge system and role within a

knowledge network. We had between one and four participants from each organisation, so that a total of 20 organisational staff members took part in the research. The interviews were conducted over Microsoft Teams following an interview protocol (Appendix 4). The interviews typically lasted one hour but ranged between 35 and 80 minutes. Intelligent transcripts were produced from the recordings and imported into NVivo v.12. There were an additional set of email exchanges with staff from some of the organisations which were also added into the Nvivo dataset for analysis. The coding framework used to analyse the data is presented in Appendix 6, and was based on the research questions and issues and themes that appeared to reoccur through the transcripts.

Participatory sociogram

During the course of the interviews, a diagrammatic template was displayed to the interviewees which was then used to facilitate discussion around knowledge generation and dissemination processes and to more clearly describe the knowledge network or stakeholder map (see Figure 4).

Figure 4. Template for the participatory sociogram/knowledge network mapping



This social network diagram or sociogram mapped the key individuals and organisations involved in the provision, production, selection and dissemination of information and knowledge (i.e. the steps illustrated in the orange coloured boxes in Figure 4), with regard to tree health in general but focusing on ash dieback and *Ips typographus* and particular HtR audiences. The relationships between the organisation and other stakeholders on the map were described by the interviewees in terms of knowledge flows, influences and connection with HtR audiences and end users. Using the template in the form of a PowerPoint slide allowed for the easy addition of stakeholders, and movement of the organisations around the diagram in a way that made sense to the interviewees. Following the interviews, the maps were refined and emailed to the interviewee for final approval of the map's representation of their organisation and its place within the knowledge network. The maps were then converted to PDF and imported into the NVivo file for coding and analysis (see example of a completed map in Appendix 5). Sociogram metrics were produced in NVivo and we followed interpretations used by Saqr et al (2018), influenced by network roles defined by Marcos-García et al. (2015).

It is worth noting here, that, even though resources in this scoping study were limited, Nvivo is able to conduct powerful sociogram and network analysis, so there is potential to continue with more detailed qualitative exploration of the knowledge networks in future work.

Short survey

The short survey was prepared as a pdf form, and set out four multi-matrix questions asking about the type of information, advice and guidance organisations produced and how this was disseminated (see Appendix 3). This data was entered into EXCEL to produce simple count crosstabs.

3. Results

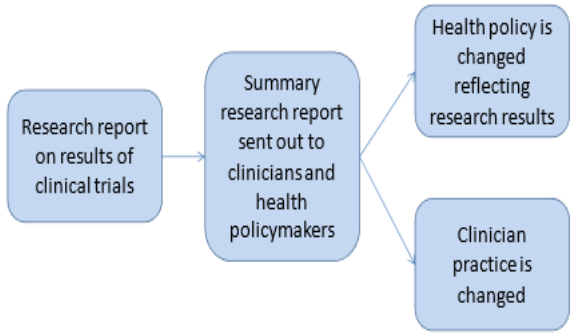
3.1. Rapid Evidence Review

The first review mapped out a complex landscape of factors that influence decision making systems around different kinds of knowledge, i.e. scientific knowledge, technical knowledge, tacit knowledge, practical knowledge. All four types of knowledge are implicated in the application of scientific and other information. The knowledge system itself includes the interpretation of information, which is influenced by comprehension, saliency, trust in the information and provider, and confidence to act. The interpreter's existing attitudes, beliefs and values will also be confounding factors, as will the wider external context including, the influence of others, financial capacity, local socio-ecological conditions, access, and time to assess information. It is therefore clear, that simply providing more or better information, does not lead directly to different or improved actions. The knowledge system involves a wide range of embedded internal and external factors that influence, i. awareness of information, ii. knowledge acquisition, iii. change in attitude/values in response to that knowledge, and iv. changes in practice. The complexity of the influencing factors along the knowledge to action pathway, means that simple linear models of information and knowledge dissemination and uptake, e.g. knowledge providers supply information and knowledge products to "receivers/users" who then act on it, are being replaced by more nuanced models including relationship and systems models.

Error! Reference source not found. demonstrates three different models as presented by Aus Aid/Defra (2010). These models are presented as both conceptual and practice based models. They describe situations where it is appropriate to apply the models as a heuristic device, or as a way to understand and effectively promote information and knowledge dissemination and uptake. The Aus Aid/Defra report also makes the point that the three models are not necessarily independent of each other: elements of each model may apply at different times while generating research and information through the course of a particular issue, and those dealing with research evidence and knowledge will need to understand when windows of opportunity are likely to arise, so that it is possible to 'push' the outputs of research at influential people or organisations when they are most receptive (utilising the linear model), or when working with specific groups, alliances or partnerships may be the best approach to carry research, information and guidance forward to end users (utilising the relationship model), or when taking a wider assessment of the knowledge network might be the only way to move forward to identify routes to impact with end users.

Figure 5. Three different knowledge to action models from Aus AID/Defra 2010

a. Linear model



Linear model can work where:

- Problem is focused
- Info/knowledge is widely generalisable
- The action is clearly defined
- The audience is very defined
- Strong infrastructure to reach audience and promote knowledge and action

b. Relationship model

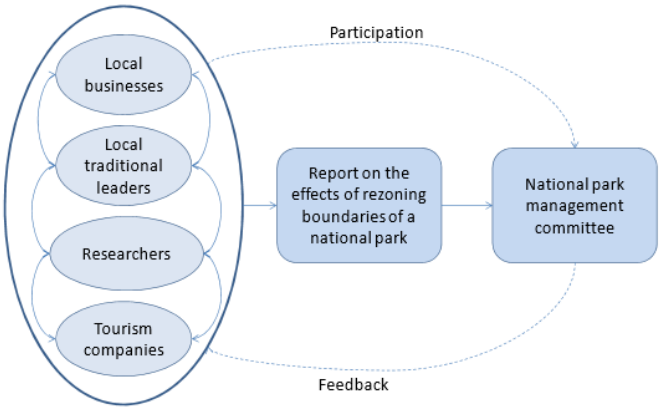


Fig 2: A stylised relationship model. Representatives from the local partnership participate in the national park management committee to ensure the results of collaborative research are taken forwards

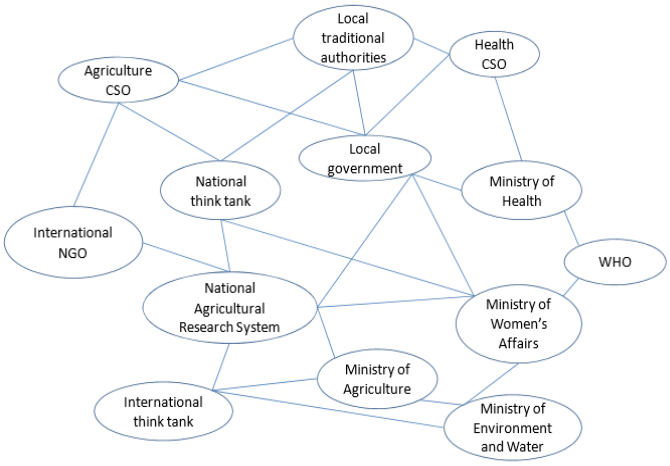


Fig 3: A hypothetical systems model, dealing with (for example) improving health services to women affected by waterborne diseases from irrigation systems

A relationship model can work where:

- clear boundaries around a place and/or issue of interest can be defined
- the knowledge applicable to that context/issue can be identified
- deliberation by all parties leads to agreement of the knowledge which should be acted on and the action that should be taken
- collaborators are provided with the support to put the action into practice by key opinion leaders and decision makers

c. Network model

A network or systems model may be best to describe and understand:

- issues with fuzzy boundaries and overlapping concerns/sectoral influences
- the large number of different actors who are involved to different degrees in the process of research planning, communication, uptake and use
- entry points and opportunities for change in contexts of complexity
- power dynamics within a system and how this impacts end users
- the systemic change that might be needed for end users to be fully able to apply and act on knowledge

The findings of the second step of the review revealed very little empirical evidence on the design and effectiveness of specific policy interventions in the knowledge-action system. The majority of presented examples focussed on participatory social learning interventions, such as, practitioner and boundary-organisational working groups, a participatory advisory committee, transdisciplinary social learning institutions and participatory approaches to designing and implementing research. This evidence largely echoed findings from the initial review: The way in which information is provided is perhaps as important as the information itself. The influence of peers and benefits of face-to-face dissemination is significant. The source must be trustworthy and able to translate the information to provide relevance to the context of the recipient with boundary organisations (i.e. organisations aimed at promoting science-policy integration by bringing together scientific and non-scientific stakeholders) and social learning institutions (which provide social learning opportunities through social interactions and processes among key stakeholders to facilitate evidence based adaptive land management) playing a useful part. Finally, when the target stakeholders take part in identifying problems, problem-solving (e.g. undertaking research and designing interventions) provides more relevant solutions and the uptake of these increases. Social learning allows for alignment of the aims and objectives of different actors during such problem-solving processes regarding research, policy or practice.

So, the key points to draw from the two step review are:

- A complicated set of factors influence the uptake of information, translation to knowledge and eventual action
- The way information is disseminated and built into knowledge is as important as the information itself
- Simple, linear models are discredited in situations of knowledge complexity, where there is a wide differentiated audience, fuzzy spatial and issues focused boundaries, and weak institutional structures
- Network and relationship models are likely to offer greater explanatory power and opportunities for finding points to make changes which increase the effectiveness of knowledge uptake and behaviour change
- Where collaboration, co-learning, and deliberation are part of the generation, dissemination, translation and brokerage of knowledge, there may be more effective outcomes

These key findings were used to:

- map potential policy interventions for plant/tree health knowledge systems has been undertaken around generalised issues and “solutions” as shown in Appendix 1.
- build the methodology employed in this scoping study to unpack the detail and specific knowledge system features around the case studies, including SSI question framing, and the use of the participatory sociogram technique.

3.2. Case Study: HtR and Ash dieback and *Ips typographus*

3.2.1. Description of the sample

Table 1 describes the key features of those organisations and staff that took part in the SSIs. Among the participating organisations, six were membership organisations, three were government organisations, and one was a research institution (also governmental). The sample has relatively good coverage of the organisations most active in engaging and working with the HtR land managers that were the focus of the scoping study

Table 1. Interview sample including organisational type and audiences

ID	No. in SSIs	Roles	Organisation type	Main audiences (form + int?)
KTA1	2	Development Director; Senior policy and research officer	Membership organisation	Forestry and arboriculture sectors including harvesters and arboriculturists and other sector stakeholder organisations and academics.
KTA2	2	CEO; Woodland Management Policy and Projects Manager	Membership organisation	Small woodland owners
KTA3	2	Chief Executive; Events Officer	Membership organisation	Woodland owners, managers, countryside professionals, academics and wider audiences
KTA4	3	Emerging Species Research Lead; Senior Communications Officer; Advisory Entomologist	Research	Policy makers and advisors, practical forest managers and practitioners, professional forestry and arboricultural bodies and interested publics and citizen scientists
KTA5	4	Biosecurity Officer; Biosecurity Officer; Plant Health Forestry Technical Support Officer; Communications project Officer	Policy/ practice	Landowners, professionals and the public
KTA6	2	Policy Advisor; Head of tree health policy	Policy	Local authorities, private landowners, woodland managers and the public
KTA7	1	Policy advocate	Membership organisation	Staff and volunteers, members, private landowners, small woodland owners, farmers, local authorities, neighbouring residents, policy makers and other decision-makers, corporate partners and the public.
KTA8	1	Technical Director	Membership organisation	Practitioners; tree owners, contractors, consultants, tree officers, other sector partners, policy makers, non-professionals and the general public
KTA9	2	Principal Advisor; Senior Forestry and Woodland Specialist	Policy/ practice	Small woodland owners, owners and managers of designated sites and other conservation stakeholders, internal staff and staff at other governmental institutions.
KTA10	1	Countryside Advisor	Membership organisation	British farmers and growers and interested publics
	20			

Most organisations we approached responded with an initial interest in the topics, perceiving knowledge exchange and hard to reach audiences as issues of relevance to their organisations. However, it was more difficult to recruit organisations that felt they had less to do with the management of trees, or had very little experience of working with the issue of ash dieback and *Ips*. This is a result in and of itself, emphasising that the knowledge networks surrounding some kinds of land managers, e.g. farmers with ToW, are separate from, or have few connections with the knowledge networks involving woodland and forestry sector stakeholders.

We interviewed 20 staff members among the participating organisations. Interviewees had a range of job descriptions, typically including policy, research and communication (see Table 1). We had an equal representation of male and female participants. The approach of including more than one respondent in the SSI was validated, and it was interesting to notice that respondents often debated answers to the questions we posed as they worked through their own understanding of the knowledge system within their organisation as well as between organisations in a wider network. Different role holders within one organisation all have a part to play in identifying what research and knowledge problems are of interest, how to interpret and translate that knowledge and how to disseminate and promote the information and knowledge in different contexts.

3.2.2. What kind of information about ADB/*Ips* is being generated, by whom, when and why?

The data illustrated which information was being generated by different organisations and how that was positioned within a knowledge network, with the evidence suggesting that this was affected by the organisation's:

- Perceived role within knowledge networks
- Ownership of tree health as knowledge issue of interest
- Perceived demands of membership and audiences
- Organisational capacity to play a part in the knowledge network.

Each of these areas of evidence are discussed in the subsections below.

Perceived organisational roles as part of the knowledge to action network

Figure 6 below summarises the variation in the roles organisations felt they played as knowledge producers, disseminators, translators and brokers. The chart shows the majority of organisations feel that they work towards supporting both the learning and the actions/behaviours of members and wider stakeholders. Many acknowledged their role as knowledge translators and brokers, i.e. disseminating knowledge and guidance produced by their organisations using evidence and information from other sources. Table 2 summarises more of the detail of these roles, as well as the barriers organisations recognise limit their ability to support learning and onward actions of members.

The importance of this translation and brokerage role is emphasised, since organisations are deciding on, filtering and promoting selected information and knowledge products to their audiences. This has a direct influence on what their audiences receive from them and what any behavioural/action outcomes might be.

Figure 6. The perceived role of organisations in the knowledge network (n=10)

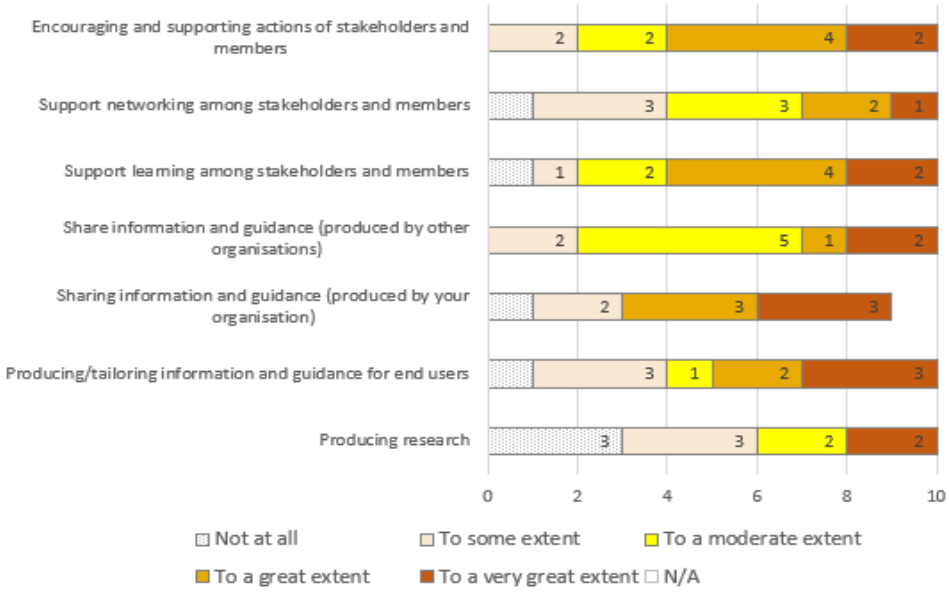


Table 2. The organisations' perceived role in the knowledge network

ID	Topics dealt with	Perceived organisational role	HtR audiences as defined by the organisation	Perceived organisational barriers to building knowledge among target audiences
KtA1	General tree health and ADB	Chartered professional certification body for foresters. Communication about key issues. Facilitate learning and workshopping events, often as part of members CPD, and with member input, but they themselves do not develop training materials or guidance for stakeholders.	Not specified	Very diverse audience and membership, so the communications and information dissemination is sometimes "a victim of being too general". Not able to monitor and assess what information is being taken up and used amongst membership or wider audience. Recognise they could do more around embedding learning.
KtA2	General tree health and ADB	Paid membership organisation. Provide information, knowledge and training to membership and wider audience. Present mixed view reflective of membership not to impose a single institutional view. Appreciate that they are able to communicate to people in ways that governmental institutions can't and see opportunities to act as a	Small woodland owners, farm woodland owners and supply chain actors who may not realise they need to be connected; agents, small contractors, small local markets etc.	External perceptions that it's an organisation for "amateurs", so it has limited inclusion among stakeholder groups in the knowledge network. Some audiences confuse them with free groups, so membership fee can limit access and uptake. Staff are from research background and sometimes struggle to integrate a practical element into guidance and knowledge dissemination activities. Would benefit from formal

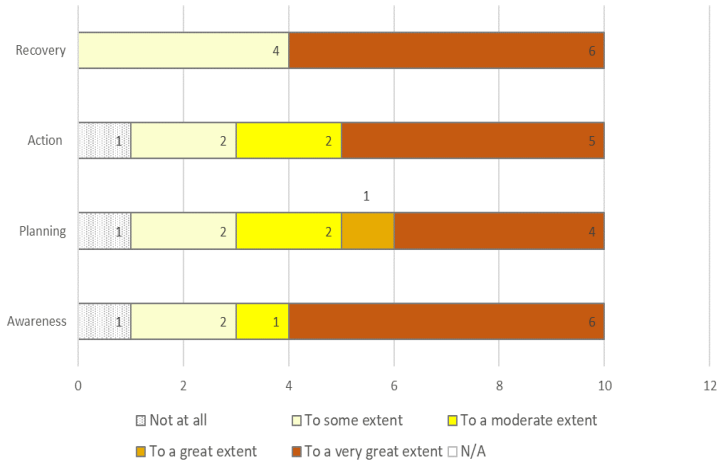
ID	Topics dealt with	Perceived organisational role	HtR audiences as defined by the organisation	Perceived organisational barriers to building knowledge among target audiences
		medium for two-way communication between the government and "the sector".		relationships with technology or policy translators.
KtA3	General tree health and ADB	See their primary role as a disseminator of research, making sure practitioners have the latest applied research about silvicultural practice to act on. See themselves as "an educational society, not a conservation society" and therefore aim to present a range of viewpoints allowing managers to make decisions based on their own objectives	Woodland owners including farmers with woodlands and other woodland owners without formal, UKFS compliant woodland management plans.	Perceived barrier in finding experts with teaching skills for training events, and lack of government support for training and education in forestry. Demand for training is high, but members have a price point, so supplying knowledge focused events can be limited. Don't perceive any issues reaching their members with information and knowledge, but find it challenging to engage non-members who should be concerned with ADB
KtA4	General tree health, ADB and *Ips*	Research organisation. Provide research which may be applied, but do not provide advice or training. Disseminate research evidence and information though a variety of mechanisms, including webinars and conferences as well as published material. Risk averse in messaging. Focus on corporate comms – promoting the institution and communicating tree health challenges more broadly.	Small woodland owners. For *Ips* specifically owners of small, unmanaged blocks of woodland	Restrictions in communication and dissemination style due to governmental status and need for Departmental approvals. Wide and undifferentiated audience makes comms strategy difficult to develop. Believe some small woodland owners don't perceive themselves as an audience for the research being undertaken and reported. Limited capacity to provide information, advice, and knowledge translation and brokerage functions.
KtA5	General tree health, ADB and *Ips*	Governmental organisation. Needs to represent all of the UK with its different governments and approaches to tree health issues. Maintains focus on developing simple, consistent high level messages for a range of organisations across the land-based sectors.	Farmers with woodland, landscapers and grounds maintenance and other disengaged owners of ash.	Some comms roles are told they don't have the capacity to target different audiences. Audiences often get information about pests and diseases from the media or from other websites etc. before they seek out official information, so they arrive with preconceived ideas and potentially conflicting messages which may not reflect best practice as promoted by policy.
KtA6	General tree health, ADB and *Ips*	Governmental organisation. To develop key messages in partnership with key stakeholders and policy makers and disseminate that through various channels including networks (both strategically and reactively).	Online sales and other retailers; landscapers and planners; SMEs; small woodland owners in Kent and farmers.	For *Ips* reaching landowners is challenging due to complex ownership with multiple site owners and many very small woodland owners. For ADB the issue is to encourage early action which can be challenging especially among groups that don't currently engage much with tree management such as farmers

ID	Topics dealt with	Perceived organisational role	HtR audiences as defined by the organisation	Perceived organisational barriers to building knowledge among target audiences
KtA7	General tree health, ADB and a bit on *Ips*	Charity. To communicate with members and the public through a range of mediums about woodland issues. Also involved in developing research programmes	The disinterested public.	Find it difficult to communicate pest and disease issues as they try to avoid too much doom-and-gloom messaging. Feel that this can conflict with messages to plant trees as they don't want to put people off. Encourage tree planting and restoration through some programmes which connect with land owners, but these are not the primary focus.
KtA8	General tree health and ADB, not much on *Ips*	Membership organisation. See their role to act as a conduit of information from researchers to their members, disseminating information in a usable format. Provide information to members who are already engaged enough to seek professional qualification.	Unregistered tree surgeons, the landscaping and horticulture sector and the general public.	They struggle to engage with tree surgeons who are not registered, and these are the people who need the information. Some tree surgeons do a number of jobs and won't even know the word 'arboriculture'. Represent a range of stakeholder so have to be careful with messages to avoid pointing fingers at any one of their stakeholder groups. Also highlight that biosecurity information within the tree health industry is not sufficient as landscaping and horticulture sectors and any members of the wider public purchasing plants from abroad also need to be made aware. Low levels of interest are also a barrier amongst these wider audiences.
KtA9	General tree health, ADB and a bit on *Ips*	Governmental organisation. Providing statutory advice to owners and managers of designated sites and to policy makers but they also recognise the importance of non-statutory information and advice to wider audiences. Do not feel that the organisation is set up to act as a knowledge promotion and messaging service, and it's not a target to share their message more widely. More one-to-one advice than one-to-many comms	Silviculturists for whom environmental outcomes are not a priority. 'Non-professional groups' like small woodland owners.	Don't worry much about *Ips* because spruce is a non-native species but worry more about mitigation methods due to SSSI sites near *Ips* outbreaks in Kent. Feel messaging and advice that's coming out of other organisations, contradicts their own, particularly as they deal with designated sites. Messages asking people not to do anything can be difficult as they can be perceived as defeatist.
KtA10	Tree planting and a bit on tree health	Not a forestry organisation and therefore don't have expertise or capacity to bring together and tailor information for their audiences.	Not specified.	Their members are time and resource constrained and a key barrier is therefore to communicate with members what the benefit of the information is to them, or what support is available.

Ownership of tree health as knowledge issue of interest

Following on from this are the different perceptions organisations had of whether tree health was a priority, and to what degree it should be viewed as a subject of interest for their organisational objectives. This impacted how far they brokered knowledge about tree health issues to their membership, and at what point in the pest-pathogen response cycle they felt they had a role to play. Figure 7 shows that the majority of organisations felt they had a part to play from awareness raising through to planning, as well as supporting and encouraging land manager action and work for recovery post-tree health issue.

Figure 7. Stages in the pest-pathogen response cycle organisations perceive they are addressing (n=10)



The organisations interviewed were able to make a distinction between general tree health information and knowledge compared to the specific products for ADB and *Ips*. Whilst most agreed tree health was important to their mission and memberships, there was a much more nuanced response around how far they engaged with ADB and *Ips,* and where they felt those "problems" were located in terms of which organisations should hold responsibility for moving land managers to action. For example, from a policy perspective the owners of small woodlands with small numbers of dispersed and stressed spruce trees are an important audience for raising the awareness of, and action for *Ips*. Since they represent a potential reserve, and pathway for *Ips* presence and spread. However, because the potentially large-scale economic impacts of *Ips* are a significant issue for commercial foresters, and it is commercial foresters who grow spruce and will be affected by the problem of bark beetles, it was thought that the problem belonged more to the organisations representing them, and the government organisations concerned with this commercial sector, who should be responsible for producing information and building knowledge on this issue. Organisations engaging with owners of small woodlands and those with conservation or amenity objectives did not necessarily see the issue as a problem for their organisation to engage with. As one of them explained:

> *Because it's a non-native species – the host is a non-native species – and its commercial – we see it as a commercial forestry issue. So not really our territory, if you like, to talk about that stuff. It's almost a case of "it's none of our business really. If you want to grow spruce and if you want to take the risk of Ips then crack on." But, yeah, it's not one for us to really shout about I don't think. (KtA7)*

This highlights the importance of the interconnections between different parts of the knowledge and action network. The network mapping revealed the critical importance of how organisations connected with policy fora, committees and other groups with this wider view of tree health issues. The interviews revealed that an important part of the way in which organisations distil their priorities comes from their understanding of what policy aims to achieve, and through the information and knowledge that flows through membership of these groups within the knowledge network. If personnel from organisations are not sighted on policy priorities and the rationale behind them, they do not necessarily see the need to prioritise for their members and key audiences. These opportunities for conversations and knowledge dissemination are often recognised as being significant but also undervalued, for example:

> *And I would like to see us coalesce around some ideas around how we might be used more consistently and productively as a two way means of communication between government and the sector. (KtA2)*

> *I went to this event just after I'd started… Pest and Diseases in Wales – and no-one there had heard of plant passporting and the guy from NRW was horrified that no-one knew it was coming in yet. And then things come in from DEFRA that there's a policy decision or a need to inform people but not only do the practitioners not know about it, but professional bodies as well (KtA1)*

Without inclusion within these "hubs" within a knowledge network, organisations can feel disempowered, or unsure about the role they might be playing, or how they might fully engage in the network and support specific audiences:

> *I think there's a sense of not quite having an understanding of where we fit in the landscape ….. I often say, "You do realise that the area owned by our members is the same area that the Woodland Trust own. So, if you're thinking of us in terms of impact on woodlands, you should be thinking of us slightly more" (KtA2)*

It is recognised that there is a clear role of leadership by government to keep stakeholders aware, and to broaden audiences:

> *Yeah, I think probably I would say that there's definitely a role to play for government. There's kind of a definite leadership role needed. I often use the example of New Zealand as good practice for this kind of thing and they engage the whole community in tree health based stuff – biosecurity generally – to the extent that they talk about "every citizen has a role to play and everyone is in a biosecurity army and that everybody is fighting off this stuff" you know. (KtA7)*

However, it was also clear that the policy community do not always appreciate the importance of the involvement of organisations in policy discussions and policy related groupings, nor of the direct comms work they do. As one person emphasised, political sensitivity, and low risk tolerance often play a part in this:

> *…there are a lot of political sensitivities towards some of the data which includes references to everyone's second least favourite word this year which is Brexit. So we*

try desperately to keep that on a very high level because, what we don't want to do, is put out misinformation or anything like that that may actually turn out not to be true. So we try and keep a pretty tight wrap on it… we've had far less press attention for something that's potentially far more damaging… but in terms of an outreach and communications side of things it's not great. (KtA4)

And, as another observed, resource constraints and assumed uptake via particular routes, can also play a part:

No. In fact, I was a wee bit disappointed… DEFRA did a press release and I said to the then head of whatever position, "You're sending this out to the forestry trade media?" because it was actually most useful to the foresters and stuff and she said, "Oh no, we haven't got the resources to do that. They'll just have to follow us on Twitter and pick it up that way you know." And I just quietly turned around, copied the text into an email, copied the editors of the forestry magazines email addresses into the "to" field and pinged it out. It went to about eight different forestry magazines and a couple of things. And you know, the resources required about three and a half minutes and I was very disappointed in the sort of lazy attitude that "we don't have the resources to target the forestry media anymore". (KtA5)

Some governmental organisations linked with, but not focused on policy, also felt that their role as translators of evidence and science and onward communications is restricted by their "official" position and connections, as illustrated by this comment:

I think there has always been a bit of a tension between our role ….. we're part of government – we're very closely linked to policy …. and [names institution] who issue guidance. And there's been times when we've been told that we shouldn't be issuing guidance now – that's not our role. So I think there's lots of potential for us to do a lot more outreach work but I think there's a lack of clarity about quite where research ... how far we should go in that (KtA4)

Perceived demands of membership and audience

The evidence showed that all organisations in the ADB and *Ips* knowledge networks respond to what they believe their membership and key audiences are looking for. Meeting member/audience demand for specific kinds of information is a large part of how tree health topics, issues and scientific evidence and other information was selected for translation and dissemination. As one organisation described it:

As an organisation, our starting point is always what the owners' objectives are for their wood and everything flows from there and we don't go with those who would like to tell woodland owners what they should and shouldn't be doing [laughs]. They need to be looking at all the information that's available and making their own decisions and so I think that's the approach that we tend to take. (KtA3)

The data showed that there were various ways in which organisations understood and responded to audience demand. Sometimes this was through direct interactions with them,

e.g. bringing out knowledge products in direct response to a number of ad-hoc requests on a related topic, feedback and frequent queries, as these quotes indicate:

> *Well sometimes it comes from members that are interested in specific areas – so somebody might just say they're interested in this, this and this. From the point of view of plant health, we've been pushing it out nearly every month if we can in some way, shape or form simply because, one of the ways we look at it is, "What are our frequently asked questions? What do our members come to us with enquiries? What do our non members come to with enquires?... (KtA2)*

However, there are limitations associated with this model of knowledge brokerage and provision of information and guidance. This approach tends to prioritise the pests and diseases that are of immediate concern to the majority of members and audiences, not necessarily issues that are growing in importance or with more local importance. The difference in the resources focused on providing information about ADB rather than *Ips* is a case in point, as these quotes illustrate:

> *Ips is so far not really on many of our members' radar screens. I would say they would be aware of the outbreak in Kent last year... So it's one of those latent threats which I think people prefer to ignore until such time as it becomes something more tangible. (KtA3)*

> *We haven't done anything to do with Spruce bark beetle yet simply because that's not so much a focus with our members as most of them have mixed hardwood woodlands as opposed to conifer plantation where Sitka may be growing. (KtA2)*

A consequence of this is that the objective policy makers have around land managers being aware of a range of tree health issues, to take part in surveillance, and to be ready to act at the point at which they are impacted, is compromised. Action is therefore likely to be a reactive response, rather than an anticipated and informed and considered course of action.

Organisational capacity to play a part in the knowledge network.

Organisational capacity was often cited as a reason for restricted ability to facilitate translation and learning for specific audiences based on available information. Eight organisations mentioned some form of capacity restriction, and this was a more significant barrier when communication with tree health audiences was not the main purpose of the organisation. In general, organisations had just a few staff members assisting with knowledge brokering and communication tasks as a core component of their job, and funding for knowledge brokerage and translation activities was also an issue.

> *We're such a small organisation and we're just not equipped really to do that sort of level of targeting.* (KtA1)

> *So, for example, if we had more staff on the ground as well, if we had a greater capacity in terms of staff on the ground then we would be able to disseminate more information on a one to one basis more efficiently regionally as well. (KtA2)*

Unfortunately, there are lots of people within [mentions research organisation] and the [mentions delivery organisation] world who could act as extremely good teachers but tend to be too expensive for us to take on. (KtA3)

We almost discourage people from calling in to actually ask questions because we don't have that time to be able to physically do that. (KtA4)

Organisations also differed in whether they disseminated or produced practical and applied knowledge products or those with more technical and scientific content. This difference was not necessarily to do with the organisation's mission, but could be linked to staff capability and their skills and background. For example, staff from a scientific background might struggle to make practical recommendations, even if they are trying to produce information and guidance for land manager end users. If the organisation is not a forestry-focussed organisation (such as farming organisations) there is very little capacity to translate relevant information into usable products for their audiences, and so dissemination to these audiences relies much more on a model of signposting to pre-produced, accessible content tailored to that particular audience. Research staff too said that they have limited capacity to produce different knowledge products from their research and engage with non-research audiences. These quotes are illustrative:

we get quite a lot of feedback from members… one of the things that does come up from time to time is that we've lost a bit of the practical edge. So this may reflect the fact that both [project manager] and I are both scientists and we're really interested in the science side of this… so it's trying to bring the conclusions of research to a point where the ordinary woodland manager can see, "OK. That means that. I need to do such and such with my soil. That means that. I need to have more of a focus on dead hedging. I need to stop burning brash." It's these little practical questions that, I think, are where woodland owners and managers can actually make a big difference as well. (KtA2)

It's something that I'm still getting to understand is how to read a scientific paper sometimes because there are an awful lot out there that are awful. They've probably got some very good information in them but they're so badly written you really don't understand what they're trying to say. (KtA4)

[the] job is not to go out there and talk to every single group that comes along. Because I could spend most of my time doing that if I wanted to and there's a bit of a stopper there which doesn't encourage us to go out and do that because the focus should be on the research and a scientific paper at the end of it and you move onto the next project. (KtA4)

I guess, for both of us, we probably only get familiar with these things if there were something that came up – like an event that came up or as members wanting an event on something (KtA2)

3.2.3. How is information about ADB/Ips communicated to different kinds of land managers?

The data illustrated that organisations communicate to different types of land managers including HtR audiences through:

- Varied methods, platforms and types of products
- Access to and knowledge flow through the network
- Knowing target audiences
- Demonstrating salience and crafting messages

Varied methods, platforms and types of products

Organisations involved in knowledge networks engage in many forms of information and knowledge dissemination and translation, including: relatively unidirectional dissemination of knowledge products, through to more interactive methodologies encouraging learning and deliberation, as well as participating in policy and research processes, developing specific projects and providing support and calls to action for their audiences. Figure 8 and Figure 9 show the range of products and events they provide for tree health in general, and for ADB and *Ips* in particular. It is interesting to note the reliance on webpages as a key information dissemination method, and that 30-60% of the organisations said they produced best practice guidelines describing how to respond to specific tree health threats: This is not always reflected in the view of end users who continue to state that practical guidance is lacking.

Figure 8. The type of information and knowledge products organisations produce (n=10)

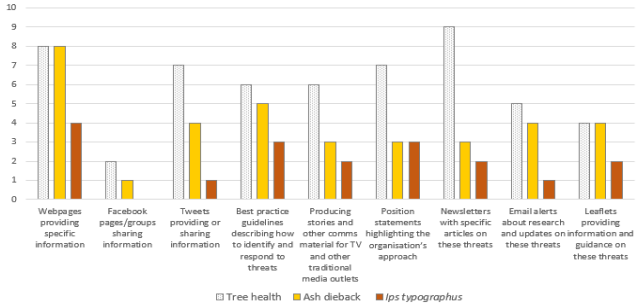
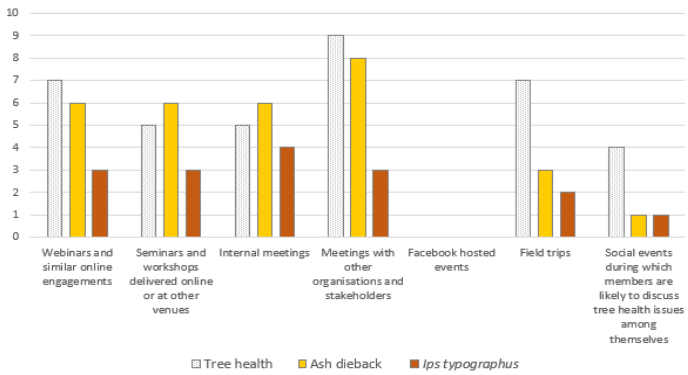


Figure 9. The range of dissemination events organisations are responsible for (n=10)



What is provided and how it is provided relates to the role and mission of the organisation, as well as their understanding of their key audiences and what they know about who those audiences respond to different forms of engagement, for example:

> *And I think woodland managers and owners we know respond really well to facilitation. They respond really well to events… as soon as people see that there is demonstration that's relevant to them, they're really, really motivated by that. (KtA2)*

> *But then, you know, I think it's fair to say that consultants or policy makers or tree officers, for example, they might be more inclined to sit down and watch a webinar of an evening or sit down and read a document. Whereas a lot of tree surgeons, a lot of arborists out there, either haven't got the time or that's just not the way they engage. So, for them, it might be more appropriate to have a two-minute video that they can watch when they're out and about on their phone or something. So I don't think it's so much the language – it's more the medium in which we're communicating. (KtA8)*

Access to, and knowledge flow through the knowledge network

Figure 13 and Figure 14 show how far different information and knowledge products are accessible to different kinds of stakeholders and audiences.

Figure 10. The audiences able to access knowledge products (n=10)

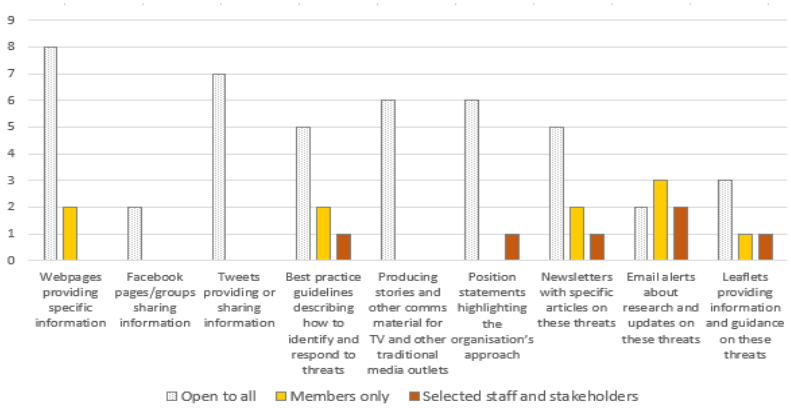
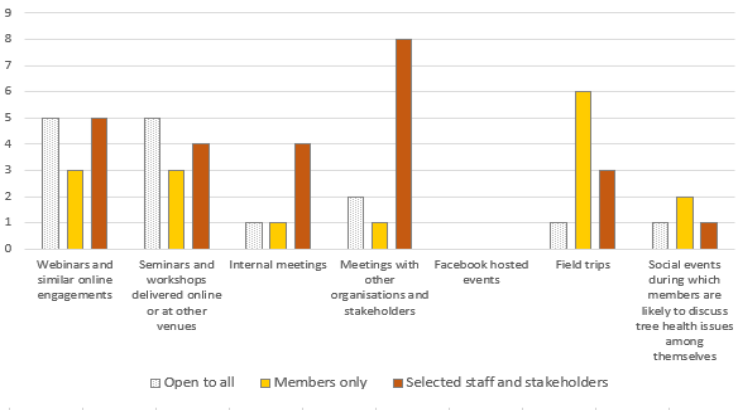


Figure 11. The audiences able to access dissemination events (n=10)



Whilst much content, information and guidance produced by different organisations is available to members and clearly identified audiences, non-members and wider stakeholders including HtR audiences tend to have access to a more restricted selection of resources. Looking at the way in which knowledge networks operate, it is possible to conceptualise a flow of information and knowledge moving through them. Figure 12 tries to indicate this. Within a specific tree health knowledge network, there may be a core set of organisations and individuals who have access to a very broad set of resources through their multiple relationships, and connections with different groups. Situated in 'knowledge hubs' they have access to information and knowledge that may be new, verbal and confidential, and be related to the scientific, technical or policy aspects of the issues. As this person recognised:

> *I suppose, as with all of our pests and disease management work, there's the element of certain information is sensitive and is not yet cleared to be shared externally and, I suppose, there's always a bit of a gap between what's actually shared externally and what people are aware of and then a lot more detail which obviously is for internal consumption and of sensitive content of some kind. (KtA5)*

Moving outwards from the most well connected and dense set of relationships within the network, access to information, knowledge and guidance changes in form and scope. Membership of organisations maintains access to some of the resources, including opportunities for taking part in events that help move information and guidance into tacit, practical knowledge that could move land managers to action.

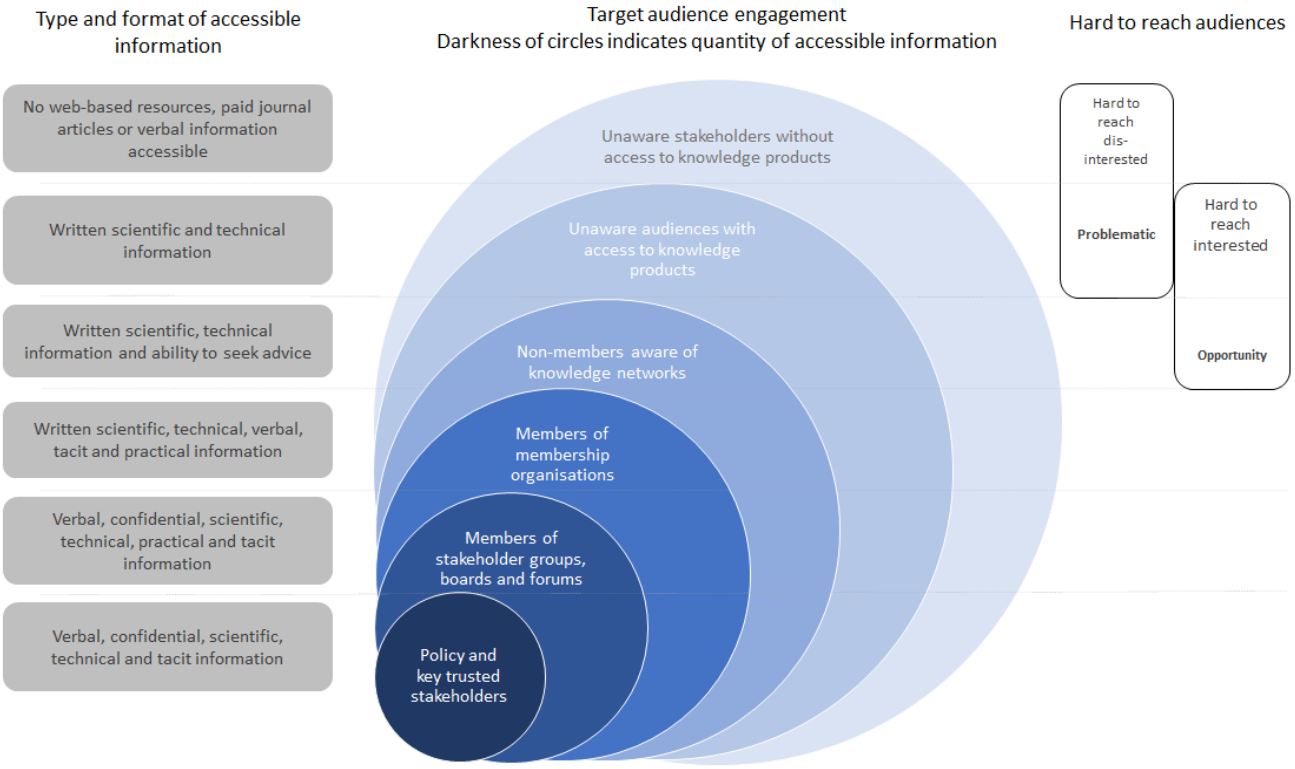


Figure 12. The flow of information through a knowledge network and differential access by different audiences

Knowing and tailoring to target audiences

Table 3 summarises the variation in how far different organisations have looked to identify, characterise and prioritise their audiences. Whilst some organisations feel they serve well defined target audiences, others know they have a very broad audience, and others know their reach extends past their core membership or intended targets. As Table 3 shows, of the ten organisations who took part in the research two (20%) had an audience segmentation model, three (30%) had access to basic membership data that could be used to direct communications, and five (50%) had little formal information about their membership and wider audiences. Although each organisation declared an interest in directing information to a core membership, they were conflicted about how far their responsibility lay beyond that.

> *And so there are almost certainly other places that we could publicise this message if we had decided that our strategy was going to be, "How many people can we get this message to?" Rather than "For our key user groups, are we getting the message out to them?" And I feel like I'm giving training advice to our staff who are the front line people and I'm doing a little outreach – mainly when I'm asked to if I'm honest. I'm not reaching out to do that. I'm being asked to do it and say, "OK. Go on then. I'll do it." So yeah, I don't feel possibly that our raison d'être is actually, "How can we get this message out there?" (KtA9)*

There was broad agreement that small woodland owners and farmers are among key hard to reach audiences. For both of these groups, a lack of self-identification as woodland managers presents a barrier in engaging with content aimed at forestry professionals. The landscaping and horticulture sectors were also mentioned by some as HtR audiences, because even though they play a key role in biosecurity, they are not necessarily connected into the tree focused knowledge networks. HtR audiences were also recognise as falling into two distinct groups, i.e. interested but unconnected with the knowledge network and unaware of where to find information or build their knowledge, or, alternatively, those who are disinterested whether or not they are aware of where to find information and how to build their knowledge.

While a few organisations made strategic attempts to reach identified HtR audiences, other organisations had not thought much, if at all, about whether or how to engage with these groups. One of the most obvious ways in which engagement had been attempted was through gatekeeper organisations and events, i.e. those institutions and occasions connected with HtR groups, or using a hook, e.g. to attract those audiences in. For example:

> *But, in terms of actually engaging other people – it's very difficult. We use events like… ARB Show – the contractor based trade show – that we hold at Westonbirt now and there you'll get a lot of tree surgeons coming along who aren't necessarily members. And through putting stalls up and information and trying to go round and talk to people you can try and work on them a bit but most one man band tree surgery companies are not easy to reach or even want to be reached. (KtA8)*

> *We did have some successes in Scotland with farmers coming to events because we had lots of nice pieces of equipment – but not actually getting them then to join the organisation. (KtA2)*

Table 3. Organisations' understanding of their audiences and differences in engagement based on different groups

	Segmentation	Other	Engagement practice	Barriers to tailoring information
KtA1	**Can segment membership by basic indicators of sector identity** including employment categories and by region	Do a members survey and also did a one-off training survey Can track engagement with web-based resources.	Tend to blanket-hit. Bottom-up approach to topic selection	Some of the older members love the science and the data. Younger members will need translation. Difficult to hit the right level.
KtA2	**Have segmentation model of membership and wider audiences** Have done an audience segmentation exercise in 2020.	Record attendee information. Establishing a new Customer Relations Management database to gain a clearer picture. Will also do a skills audit with woodland owners to see if they can deliver on a specific project they're collaborating on. Will get a Woodland Biodiversity Specialist on that project who will help them understand how they put messages out and the ways in which people respond.	Content bottom-up driven, including a lot on P&Ds	Difficult to turn attendee information into intelligence. Think there are some barriers in uptake of membership based on audiences' perceived relevance of the group to themselves (such as farmers).
KtA3	**Can segment membership by basic indicators of sector identity** Currently don't gather much data. In their membership database they can distinguish members as woodland enthusiasts, owners, practitioners, students and another one or two categories.	Do member surveys every three years. Also have 20 divisions with volunteers who organise events, which is seen as a good way to "*Stay in touch with the mood music*". Will start gathering more data on non-member attendees to events through ticket-booking system.	Bottom-up and top down driven content. Targeting driven more by silvicultural practices than specific demographics. Case studies used to demonstrate practicalities of specific approaches to key audiences.	Don't think there are barriers for engaging with members. The barriers lie in engaging with non-members.
KtA4	**No audience segmentation model, recognise broad "stakeholder groups"** e.g. policy-makers / advisors, practical land managers, interested publics and citizen scientists, and sometimes specific scientists. Could do more to segment and understand how to communicate with them.		Don't tend to focus on hard to reach audiences apart from some specific projects. Topic selection driven mostly by researchers.	Hard to reach audiences are often unaware of where to seek information. Restrictions in engaging with media limits the organisation's ability to communicate who they are and what they do more widely. Focussing communication efforts more would be good but would take away from other work and would need resourcing.

	Segmentation	Other	Engagement practice	Barriers to tailoring information
KtA5	**No audience segmentation model, recognise broad "stakeholder groups" for comms channels** Some communications produced in conjunction with Defra will have a specified audience for different messages		Some communicators will come up with communication strategies and tailor products for specific groups identified based on the message.	Perceived lack of resources by some to target specific groups for communication outputs. Sometimes there isn't a "fresh appeal" of biosecurity issues to those who have been in the industry a long time.
KtA6	**No audience segmentation model, recognise broad "stakeholder groups" for comms channels** e.,g, specify target audiences for specific campaigns, for example, the public, plant professionals, the scientific community	A lot of what is done is guided by knowledge and understanding from research into specific audiences.	Produce a set of messages and will then choose which among those messages to promote to different audiences. Both proactive development of messages and reactive in terms of P&D outbreaks.	Tree management is secondary to HtR audiences, so for those who have not yet experienced ADB, for example, their responses remain reactionary.
KtA7	**Have audience segmentation models for marketing and comms work** Do quite a lot of work on audiences and have the capacity to tailor messages if needed		Drive their own research prospectus based on practical knowledge requirements.	Try not to push out too much negative messaging
KtA8	**Can segment membership by basic indicators of sector identity** e.g. students, consultants, contractors, tree officers and policy makers			Find it hard to engage with unregulated practitioners as they might not see the need or desire to become registered,. Communication with the public can lead to misunderstanding
KtA9	**No audience segmentation model, recognise broad "stakeholder groups" for comms channels**, but some individual staff might think about it for their own work		Appears to be done on an opportunistic basis	Sometimes experience that audiences receive messages from other governmental institutions which they don't agree with in specific situations, leading to difficulties in communication.
KtA10	**Unclear if membership segmentation model exists** Have a variety of members – were not able to provide details of breakdown of audiences			Main barrier in communicating tree health actions is demonstrating feasibility and support for incentivised actions. Need clear, one-stop guidance outlining information and support specifically for this audience.

There was some appreciation that an ad hoc approach to connecting with HtR audiences was unlikely to produce lasting engagement, so some organisations understand the need for greater resource and capacity to bring HtR gatekeepers and end user/audiences into the knowledge networks.

> *I would say, particularly farm woodland owners… belonging to NFU and CLA… they don't see themselves as needing really to belong to many other organisations… But yeah, I think there's a big audience there that we would like to get closer to, but I think we need to do so in a very structured way and that's quite resource intensive." (KtA2)*

> *I've heard [mentions name] and I think [mentions name] and a couple of others talk on those but that's because I'm proactively looking. It's almost like they're all clubs. You've almost got to be a member. You've got to be able to join those. So the vast majority of people that might be interested probably don't even know these things exist. (KtA4)*

Demonstrating salience and crafting messages

Through the course of the research interviews it was clear that individuals had a clear sense they needed to demonstrate relevance/salience to audiences and end users. There was a general understanding that there would be little uptake of information and guidance, and the attendant building of knowledge and action, if that information and knowledge is not seen as pertinent and important by the end user. These comments were typical:

> *I think you have to make it applicable to them. You have to give them scenarios where they can see how it might apply to them. So if you're talking about some exotic pests and diseases, it's on its way over here and you've got to be able to demonstrate to them what that could mean for them. So they're very practical people so as long as you can relate it to something then that tends to bed in well. (KtA1)*

> *But when those colleagues are talking to the owners themselves it's moderated to include economic benefits and then how it might fit with that person's business. So it is modified slightly depending on the audience. (KtA9)*

However, as Table 3 showed, the barriers to demonstrating salience and crafting appropriate messaging, particularly for HtR audiences, were many and varied including building the right kind of intelligence about audiences, being able to use the right kind of media and communications channels to reach target audiences, and demonstrating feasibility and support for incentivised actions. Salience also varied based on the direct interpretation and usability of content for audiences. Prescriptive information which managers can translate to practical actions in their own situations was seen as highly desirable.

> *So a lot of it is about thinking about the messages that are going to resonate with those harder to reach audiences. So it might not be traditionally about protecting the values which is where a lot of our messages focus. It might be thinking about the benefits to them. By not planting diseased trees they don't have to go back to that site, rip them all out and then replant them and then face an additional bill. So it's about thinking about you engage to overcome some of those barriers. Does that make sense? (KtA6)*

Another factor which was also stressed through the research interviews was understanding that the other organisations and individuals within a knowledge network can act to reinforce trust, salience and influence different audiences around particular messages and actions. In some contexts the most trusted organisations were governmental, as they were seen as the fair arbiters of information, in other circumstances particular influencers might be trusted organisations or individuals with media/social media networks and connections. In other circumstances one-to-one relationships were still trusted as the more reliable sources of information and guidance that moved land managers to action. Such references highlight the importance of trust and relationships through a network, and the influence these factors have in uptake of messaging.

> *So there is not only a technical angle to this, there's an emotional value to this for them and, very often, the professional relationship you develop with these people becomes very, very important in the environmental delivery and ensuring the environmental delivery is successful. (KtA9)*
>
> *We work with key influencers to disseminate information and that works very well for us when we've rapidly got to get something out and it overcomes some of the barriers that we were previously highlighting around trust and trusting the source of information. (KtA6)*

One way in which trust and saliency can be built and maintained is through the consistency of messaging within a network, despite the different audiences and end users involved. Respondents felt that consistency is perhaps most important for non-specialist audiences such as farmers and other HtR parts of the audience spectrum. Some networks took clear steps to ensure not just internal consistency in their knowledge translation and messaging, but also consistency between organisations involved in the network, considering themselves as part of a chain of organisations sharing such information. There was also evidence of looking for consistency and knowledge pooling to prevent duplication of information, and they will seek input on drafts from policy to ensure accuracy and consistency. However, there are some key challenges to building consistency within a knowledge network that came through form the data, including:

- **Knowledge, particularly practice-based knowledge can change**. This is a significant issue in tree health, where understanding of new pest outbreaks needs to build before a consensus around the routes to action and the implications of those emerges. This uncertain and changing context for the knowledge around tree health issues can act as a major barrier to effective and consistent translation and messaging and ultimately to land manager action.

  - *Very early on in the ash dieback awareness and the pathogen outbreak, we were asked almost immediately, "What lives on? What's the biodiversity implications?" And realised, somewhat to our horror, that we had very little idea. (KtA9)*

    I think sometimes maybe a barrier is what we would say you say around Ash Dieback is not specific to a project – it's about research information, understanding that would evolve over time through a whole series of projects. Our research is quite often – the funding is for a particular project rather than something broader and longer term. So I think that can sometimes act as a barrier. (KtA6)

    "Every organisation nowadays says that they're evidence led and we follow the evidence but that's tricky. As we've seen with Covid, every government says they're following the

evidence but every government is doing something different. So it's all about interpretation of the evidence really." (KtA7)

- **Presenting balanced arguments.** Some organisations feel they should be facilitating debate and representing different points of view, as there is no "one source of truth" and land managers need to weigh up the evidence and different viewpoints to make their own decisions.

  in fact, I think sometimes members find it confusing. We had one edition of the magazine where we add a quite relaxed view of Ash Dieback in one article; another which was saying we're all doomed and then a full page advert on the back page saying essentially, "We are all doomed and do you want to sell us all your ash?" So these different perspectives are actually part of the way that we do business and I think that is appropriate and it's certainly – it is what it is – that is the way we approach it. (KtA2)

  Well we've published a range of viewpoints and there was an article that came from Forest Research last year that we published in the Journal about what species should replace ash which many of our members wouldn't have agreed with but we published it anyway because it's a relevant point of view... Also, in our fortnightly E-News, the editor of our E-News is very good at picking up research that's been published but not only that but also then pointing readers to people who have commented on that research or have published an alternative point of view. (KtA3)

  So ash dieback, for example, we focused on that in recent years. One of the reasons, as you said, about there being too much information sometimes is that there were all these documents coming out from all these different organisations about ash dieback. A lot of it was conflicting… So, slightly counter intuitively, we brought one out as well which kind of added to the problem in a way but it just tried to pull together some of the sometimes opposing points of view into one document that we could then disseminate to our members. (KtA8)

- **Organisational capacity to connect with the wider knowledge network.** If staff within an organisation are not connected into the wider knowledge network, the approach to knowledge brokerage and translation may not be systematic or accord with the emerging consensus:

  We would go through the information and distil the key messages and create a narrative – so create a storyline. I'm not sure we filter through research in any ordered way and make decisions about what bits to include or not. Quite often it's what we're aware of because obviously there's lots going on we're not aware of. I guess it's not done in a massively strategic way at the moment. It's more opportunistic I would say. (KtA4)

- **The need to provide information on a tree health issue with other more general information that acts as a hook for some audiences, may confuse the key message.**

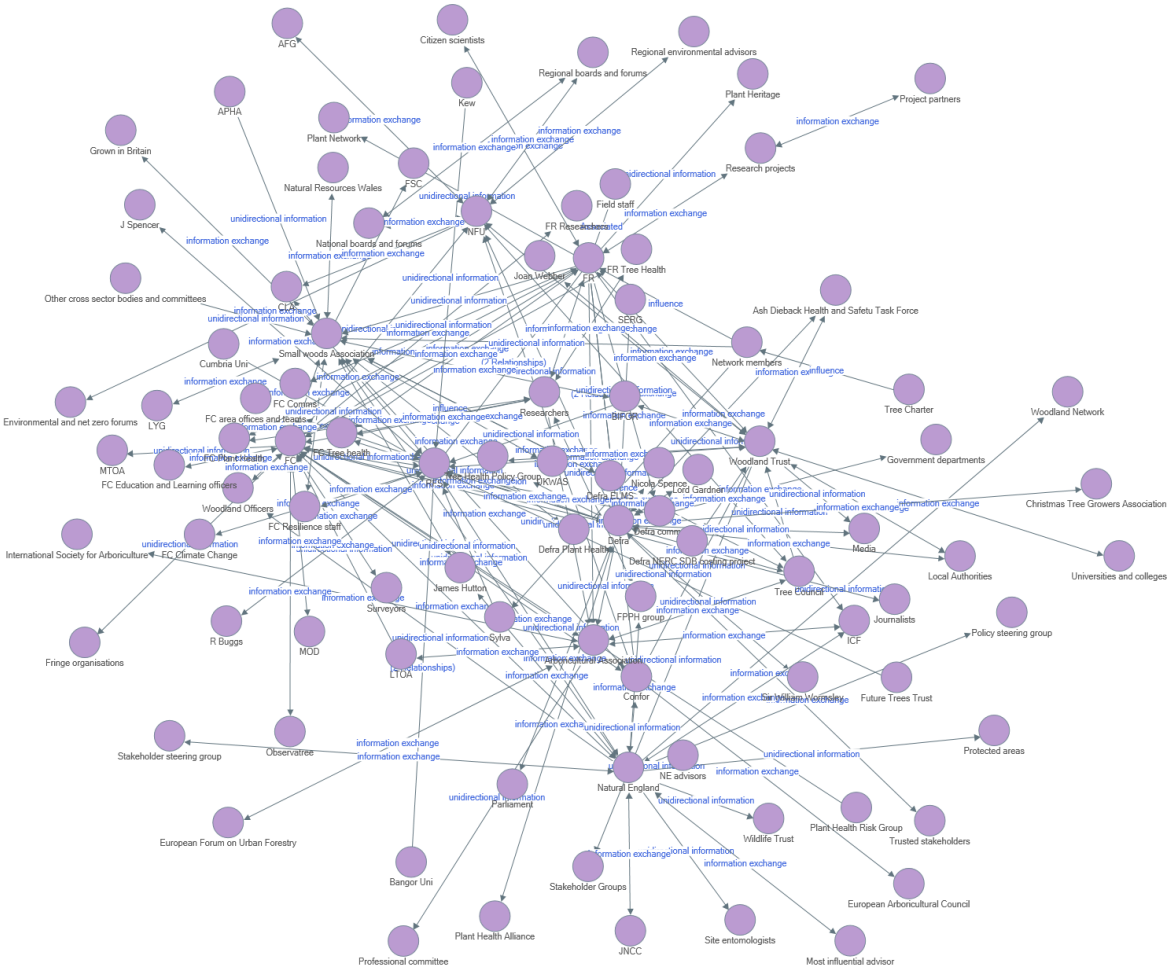
  We like to direct to information if it's incredibly clear and the messaging is appropriate for farmers. I suppose our issues with tree guidance and information is currently… that it's a complex area and farmers aren't foresters – they're farmers. So they do need the information all in one place and it to be really clear. And I haven't seen anywhere on the Forestry Commission website yet or gov.uk that has all the information if you are, for

example, to go and plant trees – all the different requirements that you need to adhere to – UK Forestry Standard or EIA blah, blah, blah – in an easily, readily available format for farmers to engage with (KtA10)

3.2.4. Which individuals/organisations are involved in transforming the information into knowledge and action?

The sociogram shown in **Error! Reference source not found.** was produced based on the information provided by participants during the participatory mapping exercise (see Appendix 5). The information collected was entered into Nvivo and coded for organisation type, and the relationships between them. This type of visual display immediately makes it clear which organisations are well connected and potentially influential, and which stand somewhat apart and are less connected. For example, on the far right of the figure, the Christmas Tree Growers Association is poorly connected to *Ips* knowledge networks even though it may have a significant interest and role to play in this tree health issue.

Figure 13. Connections and organisations involved within the *Ips* and ADB knowledge network



However, care must be taken when interpreting the results as they are highly influenced by the organisations that participated and were able to provide information, as well as the individual respondents' engagement with naming a range of information relationships. Furthermore, we did not incorporate the nature of all the interactions respondents mentioned or that would be needed

to provide a complete picture of the network, and the quality of some of the relationships. For example, in this testing and scoping phase of the technique, we did not manage to define whether flows of information were one-way, whether requested by the participant, or actively provided by the other party.

However, the measures we were able to generate do provide an indication of the levels of activity relating to knowledge exchange, and we have demonstrated the value of employing this kind of approach to understanding more about complicated networks and where perhaps some of the "solution spaces" connected with networks might reside. The data behind the figure is outlined in Table 4. The table highlights four useful metrics of influence: out-degree, in-degree, betweenness and closeness for all actors with a betweenness above 0. A higher number indicates a greater degree of centrality, betweenness or closeness.

- **Degree** centrality
    - Out-degree is based on the number of outgoing links from an organisation to others, i.e. when the organisation provides information or uses another actor/organisation for dissemination. This figure indicates the quantity of connections, i.e. relationships.
    - In-degree is based on the number of incoming links from other organisations, i.e. the number of other actors providing information to the organisation, or seeking input on brokerage and dissemination. This measure indicates a level of expertise, popularity or leadership accrued by that organisation
- **Betweenness** centrality measures the coordination of actions between otherwise unconnected actors operating as a sort of bridging actor, so this measure can indicate which actors are important for reaching hard-to-reach audiences (who are otherwise poorly connected in the network). It can also indicate which connections are most critical, but weakest and represent a potential break in a knowledge network if broken.
- **Closeness** centrality indicates the closeness of an organisation to others in the network and therefore higher potential speed of information dissemination. It's therefore a measure of reach. Lower closeness centrality, on the other hand, can indicate social isolation and poor communication.

Unsurprisingly, two of four participating government agencies came out as leaders; the Forestry Commission and Defra, measured by their high in-degree and out-degree scores, and moderate to high levels of betweenness and closeness centrality. This means that they are in a good information transfer position and have a high level of activity within the knowledge network. This could indicate that these organisations are proactively communicating about ash dieback and *Ips,* but also that they are actively sought out by other organisations seeking a steer on these topics, or are seeking to influence policy.

Another two government agencies, Forest Research and Natural England appeared to take on a more coordinating function, along with two membership organisations, the Small Woods Association and RFS. These organisations showed a moderate level of activity and are in a good

position to act as coordinators, with a wide reach to other actors with a stake in ash dieback and *Ips,* including otherwise poorly linked actors.

Individual researchers and network members also feature centrally on the list of scored measures. What is interesting to note is that Confor and the Tree Council appear with relatively high scores, as these two organisations were not included as respondents in the data collection. This means that they were mentioned frequently by the organisations and individuals who did participate, indicating a significant level of influence. Meanwhile, the media and individual policy groups/task forces feature towards the lower end of the scored list of measures. For those groups who seek to influence the management of ash dieback and *Ips*, or who would be valuable partners in the knowledge network, these lower ranked positions could indicate a need or an opportunity to improve engagement on plant/tree health topics. There were 70 organisations mentioned in the interview data, which, when coded, generated betweenness of 0 and were therefore excluded from the list shown in Table 4.

Table 4. Sociogram metrics for actors with a betweenness score above 0 in ADB/ Ips knowledge networks

Case	Degree	Degree In	Degree Out	Betweenness	Closeness
FC	23	16	21	2812.028	0.006
Defra	22	16	22	2227.926	0.005
FR	19	11	17	2118.551	0.005
Small woods Association	18	16	13	1941.049	0.005
RFS	16	16	10	1937.808	0.005
Natural England	17	9	17	1857.098	0.005
Woodland Trust	14	11	13	1069.087	0.005
NFU	11	11	9	1016.933	0.004
Arboricultural Association	11	10	7	819.089	0.005
Confor	6	6	3	334.289	0.005
Tree Council	5	4	5	274.188	0.005
Network members	4	1	3	222.333	0.004
Research projects	2	2	2	186.000	0.004
Researchers	7	6	7	138.270	0.004
ICF	3	3	2	89.079	0.004
BIFOR	3	2	3	73.323	0.004
FC Resilience staff	2	2	2	34.500	0.004
CLA	2	2	2	28.714	0.004
Sylva	2	1	1	18.000	0.004
FPPH group	2	2	2	15.579	0.004
Media	2	2	0	13.333	0.004
Ash Dieback Health and Safety Task Force	2	2	2	13.333	0.004
Local Authorities	2	2	2	13.333	0.004
Tree Health Policy Group	2	2	2	13.333	0.004
FC Tree health	3	3	2	10.822	0.004

While many of these were sub-groups within institutions (e.g. Research groups, policy groups or departments), and individuals or stakeholders with less relevant connections to the specific tree health topics we discussed, it also included organisations that were potentially highly relevant e.g. the Christmas Tree Growers Association and FC field staff. Such low betweenness scores can therefore indicate weakly linked groups who need to be better included in knowledge networks if they and the audiences they serve are to have some prospect of connecting with knowledge and information that moves them to desired actions.

Whilst we have cautioned that there are limitations to our ability to interpret these results, the purpose of testing this approach to mapping networks was to assess whether this provides an opportunity to further develop the method to better articulate and include the frequency, types and quality of interactions, that might add insights around identifying key bottlenecks and "solution spaces" that may drive audiences to action.

3.2.5. What examples are there of process changes/adaption activity based on specific advice, and why did this happen? Do knowledge suppliers evaluate their impact?

Evaluation and assessment of impact

We did not find any significant evidence that the organisations involved in the knowledge networks for *Ips* and ADB undertook impact evaluations connected with their information and knowledge dissemination activities. There may have been evaluations of course content in relation to training events, but follow-through on whether land managers had taken action, was not an activity that was carried out. One organisation explained that they had begun to think about producing "impact" metric, and was able to articulate assumed influence over members expressed in terms of "membership supported", as they put it:

> *So, in terms of impact in the things that many of our members want to have, I think that's an area where we need to be looking hard for science led, practical advice. And one of the things that ... we get quite a lot of feedback from members. They read the magazine very carefully and one of the things that does come up from time to time is that we've lost a bit of the practical edge. …… It's these little practical questions that, I think, are where woodland owners and managers can actually make a big difference as well. (KtA2)*

Another organisation appreciated the potential need for understanding more about impact, but said:

> *We could do follow up interviews or something to ask if their behaviour has changed as a result of what they've learned but that's not something we've done before. (KtA8)*

Collaboration in research and knowledge generation

Developing evidence and knowledge at an applied level can involve land managers in testing adaptation strategies through involvement in research. A few organisations had the capacity to be involved in influencing research agendas developing within the knowledge network, and a couple

ran their own research projects on questions seen have implications for practical management. For example, some of them had a research prospectus to investigate the impact of tree health issues on woodland management.

> *… we're not just doing research because it's interesting, we're doing it because it has some kind of use – whether that is about how we plant trees, where we plant them, at what age do we plant them – that kind of real applied stuff. (KtA7)*

> *new research is required but it's not essential to get someone on the path to managing a piece of woodland sustainably and for environmental outcomes. (KtA9)*

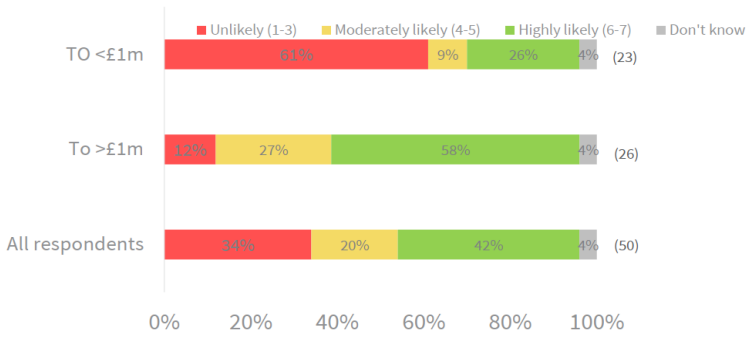
A couple of the organisations aimed to involve land managers in the research and evidence collection process, as well as use management of their own land and assets as an opportunity to demonstrate best practice:

> *I think one of the things we're also going to need to get to grips with is the fact that we're actually becoming responsible for a slightly growing estate of woodlands and we're going to need to be able to demonstrate that we're a good case study... So [staff are] doing the risk assessment around all the diseased trees and we will have a fairly expensive set of actions that we need to follow through on those because we're going to have to take out quite a lot of ash on quite difficult ground… So we do have to consider ourselves as a very visible component of this system and that we are representing good practice within it. (KtA2)*

3.3. Case Study 2: HtR Small scale nursery businesses

As it proved difficult to engage HtR businesses in the research we have chosen to present some evidence collected in other FPPH projects. If we consider HtR nurseries to be those who are smaller, with fewer staff and smaller turnovers, then Figure 14 below indicates 61% of smaller business in the sector said they would be unlikely to join Plant Healthy. The Phytothreats survey of smaller businesses shown in Table 5 below shows similar results, with 19/44 (43%) of micro-businesses declaring little likelihood of joining a biosecurity accreditation scheme, and 13/44 (c. 30%) saying their likelihood was 50/50.

Figure 14. Which nursery businesses are likely to act for plant biosecurity? Likelihood of joining the "Plant Healthy" scheme (source: HTA survey)



At a £1,000 price point, there are moderate levels of respondents saying that they would be likely to implement the PHAS in their business. Smaller businesses are substantially less likely than businesses with a turnover of more than £1m to be willing to implement the scheme.

Table 5. Small scale nursery businesses likelihood of joining a plant biosecurity accreditation scheme (source: Phytothreat project survey)

Counts (raw data)	Likelihood of joining an accreditation scheme				
Size	Extremely unlikely	Unlikely	50/50	Somewhat likely	Extremely likely
Up to 10 employees (Micro business)	11	8	13	6	7
11 to 50 employees (Small enterprise)	1	1	2	2	1
51 to 250 employees (Medium enterprise)	0	0	0	0	1
250+ employees (Large enterprise)	0	0	0	0	0

Where some key policy supporting plant biosecurity information and knowledge is concerned, even larger and more engaged businesses recognise limitations in terms of accessibility and usefulness. For example, discussing the Plant Health Risk Register (PHRR) with non-HTR businesses, they have emphasised the need for information, guidance and knowledge to be presented in accessible and relevant formats tailored to the audience. As one person said:

> *I personally use it [i.e. the Plant Health Risk Register] often – however, if I'm honest I use it to find details about a pest I have learnt about elsewhere – I rarely use it to find a brand new (to me) high risk pest. So I would follow Twitter, articles etc to stay aware of a threat and then search them out on the PHRR.*

In addition, knowledge can be perceived differently by different individuals and businesses, and this can have a significant impact on the behaviour it incentivises, with some knowledge leading to perverse actions, for example:

> *I know that across the industry there are some people who are scared to report possible pests or diseases because they think 'statutory action' will mean their entire business will be shut down. Is it possible to give some better indication of what 'Statutory action' means for the specific pest, e.g., destruction in local area (10m), wider restrictions on sale for a limited period (3 months). I realise action will depend on the situation and pest, but just some indication might encourage more people to report suspicions. Alternatively, maybe link to some general articles in non-legislative speak, eg on what statutory action actually means, with examples for relatively common regulated pests like P. ramorum or X. arboricola pv. prunii.*

Knowing about plant biosecurity, understanding the policy context as well as the means to improve nursery production with respect to biosecurity introduces a "load" in terms of action, staffing, finance required as a response. For example:

> *Also thinking about useful linked articles in non-legislative speak to make it easier to understand– something explaining current pest regulatory status would be useful. We had just got our heads around EU regulatory status, and now we are unsure again…. I wrote this attached schematic last year for Johnsons, but to be honest I don't really know how to*

update it in light of Brexit!

Some of these issues were also recognised by HtR businesses, in the issue of information presentation:

> *I know that my colleagues find it [i.e. the Plant Health Risk Register] too overwhelming and 'too sciency' to feel comfortable using it. Although there are a few options in the advanced search tool, the long list of search results returned (just with Latin names) is unfriendly for a non-scientific audience. Perhaps this could be overcome by adding in sector searches e.g 'ornamental plant production' or 'horticulture', to narrow down relevant search results. And maybe also a feature in the search results which gives a common name or at least type of pest eg 'nematode'. Eg, a nursery owner probably has heard of longhorn beetles, but can't recognise the Latin names.*

And on the issue of behaviours and barriers to change, amongst hard to reach businesses, there is an element of ingrained pride – they don't want to admit that they don't know as much as perhaps they should. Despite some of these businesses having more permanent labour (not seasonal), owners often lack the time, confidence, and awareness required to nudge them towards information seeking, learning and training.

As well as making the knowledge tools and products more user friendly, the issue of messaging has emerged as important. For some businesses, it might be suggested that messaging should be less about biosecurity, which is negative, "sciencey", and slightly "scary", it might be more effective to promote better plant protection/husbandry as a route to good biosecurity.

Overall, the key areas in terms of promoting, translating, and disseminating knowledge for action are:

- Improving the understanding of biosecurity as a general concept
- Explaining the implications of biosecurity for a business as well as for the wider context
- The benefits of biosecurity for the business and the wider context
- Building capacity & skills to respond to biosecurity requirements

4. Discussion and Conclusions

The evidence review and the empirical research undertaken in the two case studies suggests there are five key areas in the knowledge to action process and networks which could hold potential "solution spaces" to improve policy ambitions driving hard to reach audiences towards desired actions for plant and tree health.

1. Developing organisational capacity and mission

Scope remains to improve the capacity and capability of organisations involved in the knowledge networks. This uplift in capacity does not only relate to the resources available for knowledge translation and dissemination, but also continuing development and learning within the organisations including:

- Reviewing and developing their role around the generation or translation of knowledge about specific plant health issues and their engagement with audiences. Formulating a clear view of the organisation's role in terms of the potential for addressing plant and tree health issues in a way that carries key audiences with them.
- Building staff understanding of, and capability around, plant and tree health issues through their active involvement in the knowledge network
- Moving from reactionary responses to plant and tree health issues to a more proactive approach that builds early understanding and the potential for early response amongst staff in the organisation
- Identifying ways in which the organisation can better translate science and other evidence into practice-based information and advice to end users.

2. Building understanding of key audiences

Some of the organisations generating information or providing knowledge translation within knowledge networks have a poor understanding of their key audiences. Similarly, different segments of the land manager community do not necessarily perceive organisations providing information about tree health issues as being relevant to them as these organisations do not appear to "speak to them". This limits the impact on identifying key behaviours that could be targeted, how they might be targeted, what target audiences need to know to move to action, and the development of appropriate materials and messages. HtR land managers will not use scientific and policy information as a basis for action unless translated into guidance which is practical, feasible, and aligned with their management objectives and values. This is especially important when target audiences do not consider themselves to be foresters as these groups need clear, simple and easily located communication products tailored to their situations. Areas that may represent solution spaces could include:

- Organisations within a knowledge networks improving their awareness of their actual and potential audiences
- Organisations developing audience segmentation models or similar
- Using understanding of audiences to more clearly respond to audience need around salience, practical advice, and signposting additional resources

3. Improving the timeliness and relevance of topic selection

The influence of knowledge networks on the organisations involved as well as land managers and other audiences, is critical, particularly in awareness raising in advance of an issue and as part of monitoring and preparedness actions. Land managers question why they should take action, particularly where there is uncertainty about the risks and impact of those actions to their own objectives as well as environmental outcomes. Building a sense of ownership and responsibility around P&D issues would go some way to building resilience across treescapes. However, this relies on organisations refining their approach to topic prioritisation and selection and:

- Continue to take an active part in the knowledge network, connecting with a range of organisations and fora within the sector, to increase their understanding of new and evolving plant and tree health issues and the range of appropriate responses.
- Developing a broader view of who should be interested in plant and tree health issues, and what practical steps need to be taken to take these issues into account. This could overcome the issue of "ownership fragmentation" and perceptions that particular plant and tree health issues are somebody else's problem.
- Implementing a more strategic approach to the provision of information about issues, rather than waiting for land managers and other audiences to ask for relevant information, organisations within the knowledge network should be supplying this in as early as possible in the course of an issue and providing this information in the form of practical advice.

4. Crafting a salient and consistent message

The content, language and medium used for communication with HtR audiences and others less familiar with the forestry sector as professionals will need to be clear, easy to access, demonstrate support for and benefits of actions. This suggests that there is work organisations within a knowledge network could do on:

- Working together to reach some sector consistency – what behaviours should be encouraged across the land manager landscape, and what are the key messages that should be used to frame actions?
- Using evidence and case studies to provides balanced arguments for action that make sense to target audiences, and which focuses on the practical steps they can take, rather than just describing the problem.
- Demonstrating salience. Organisations need to show why specific issues, knowledge and actions are relevant to clearly defined audience segments, including the specific benefits to those land managers and businesses including the hard to reach targets.

5. Improving collaboration and co-creation/co-production between stakeholders and target audiences

Greater involvement of end users and key audiences in the research cycle may add to the complexity of knowledge networks, but can have positive impacts on problem definition, articulating knowledge needs, undertaking applied research and the efficacy of uptake and behaviour change. Finding ways to enhance collaboration between different governmental institutions around messaging and management approaches could help remove some confusions and contradictions on specific topics. This suggests that organisations within the knowledge networks, including research organisations, should be:

- Involving target audiences in "problem" and issue identification

- Connecting with researchers and becoming more involved in the traditional research cycle, in terms of providing user perspectives and taking part in collaborative ventures or case studies
- Involving target audiences, through e.g. users testing, in the final translation of information and the practical steps recommended for action

4.1. Outline plan for continuing research

Taking all these factors into consideration it is proposed that on-going research should:

- Use a a co-design, action-oriented approach to enable deliberation and *testing of changes to practice* within identified solution spaces.
- Be case study focused on a particular issue or target group
- Involve an operational partner, i.e. an organisation working with HtR audiences and able to test "solution space interventions" around the case study focus
- Involve an academic partner with expertise on working with HTR land managers, risk assessment, innovation and behaviour change
- Involve the Defra Plant Health team and other stakeholders e.g. Forestry Commission, HTA, including teams working on the Plant Health Evidence Strategy, Plant Biosecurity Strategy and Tree Health Resilience Strategy and those involved with the case study

It is proposed that the research methodology should follow these five broad steps:

i. Initiate a Co-design action-research process

Confirm the priority knowledge issues, specific hard-to-reach audiences and desired behaviours that will be the focus of the work in the case study. This could be done through a co-design workshop (on-line or IRL depending on COVID etc circumstances) and should include Defra/FC stakeholders and potential delivery partners related to the case study.

ii. Map the knowledge system and network associated with the case study to identify and agree specific "solution space" and practice improvements

Following through on the focus provided through the first step, identification of the knowledge network including key stakeholders, flows of information, weak links and bottlenecks could be achieved through semi-structured interviews and collaborative workshops on-line or IRL depending on COVID etc circumstances.

iii. Identify and agree specific "solution space" and practice improvements

After considering the evidence mapping the knowledge network and suggesting areas in which practice improvements might be applied, potential interventions will be deliberated and agreed with operational partners and target audiences. This could be done through collaborative workshops on-line or IRL depending on COVID etc circumstances

iv. Implement and test practice improvements

Practice interventions will be developed and applied in collaboration between the operational partner, research team, Defra stakeholders and other key stakeholders identified as important in the knowledge network mapping. Testing will be carried out through focus groups with the intervention users.

v. Evaluate practice improvements

Evaluative assessment of the intervention will be conducted through the most appropriate means to engage the case study participants and the wider HTR audience, this could include a survey and/or semi-structured interviews with end-users to evaluate the impacts of the designed interventions more broadly. Findings should be validated and deliberated with key stakeholders including target audiences, this could be done in a deliberative workshop. These data will feed into the continued adaptation of knowledge interventions.

vi. Synthesise recommendations

A final co-design workshop should be organised with Defra family and other stakeholders to agree on key findings and implications to ensure long-term integration of the implemented learning within the plant and tree health knowledge landscape.

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Appendix 1. Knowledge to Action "Problems and Solution Spaces" (Anna Molyneux)

What is the problem?	Type of problem (e.g. Type of information, Method of communication, incorrect interpretation, research design)	Why is this a problem?	What potential solutions to this problem are there?
Practitioners are not homogenous: they have different beliefs, opinions, levels of understanding, circumstances etc.	Type of information	If information is focussed towards a specific type of land manager, others are alienated even if that information could be useful. E.g. ecocentric managers are not brought into the conversation with timber producers.	<u>Survey to assess practitioner needs</u> An interactive page where users complete a survey which assesses their needs, then generates information which may be useful for them through an algorithm could be created. <u>Change of language</u> Need more layman terms, information for the small/private LO with less knowledge. Potential completing online forms and getting answers through an algorithm, then providing advice/signposts depending on the outcomes.
	Type of communication	People flock to ideas which already echo their own. Unable to change practices or introduce new ways of thinking/working if the information isn't being accessed by those that need to implement it.	<u>Provide a set of principles for comms/publications to follow</u> Deliver more targeted and persuasive communication, appropriate info, support and incentives aimed at influencing the behaviour of specific types of woodland manager. Research being published should be future oriented and adaptive to multiple types of site and level of experience of reader.
Members of the sector access information in different ways	Type of communication	If new information is always published in journals, the majority of operational workers may not have access to those journals.	<u>Develop diverse communication products/channels</u> **Tree Health Landing Page on Plant Health Portal** Provide tree health specific information on the PHP. **Newsletters**

			Newsletter from trusted stakeholders/partners which reach a large number of practitioners.
Lack of engagement with operational workers and land managers in designing research	Type of communication	One way information dissemination doesn't engage managers. This perpetuates the stereotype that scientists are 'arrogant' and conduct research for intellectual curiosity, not implementation	<u>Deliberative forums</u> Deliberative forums between land managers and scientists would aim to improve perceptions of both sides and improve relationships to facilitate involvement of land managers in the creation of the research agenda.
Perception of scientists is low amongst land managers; perception of land managers is low amongst scientist	Incorrect interpretation?	Mismatch in perceptions mean less trust. If trust is low then less likely to engage and eventually implement change if land manager. If scientist, less likely to have conversations with LMs as to what research would be useful to them.	<u>Research collaboration</u> Multiscale projects commissioned to coordinate broader goals with local actions.
Ambiguity and lack of consensus on what management practices should be recommended to practitioners	Research design?	Practitioners don't know how to translate science into practice so new methods struggle to be implemented. Without firm guidance, some practitioners are reluctant to take a risk on a new method of which the result won't be seen for many years	<u>Deliberative forums</u> Include operational workers in the creation of new research. This creates user inspired, high quality basic research that answers questions workers are genuinely interested in.
	Type of communication/type of information	Practitioners find it more difficult to translate basic research into action, so they don't.	<u>Deliberative forums</u> Communicate research results in a forum/invite comment from practitioners before publish. This helps both parties to understand the other's constraints/aims etc.
Mismatch between what scientists think practitioners need and what they really need	Research design	Operational workers not necessarily consulted on work before it starts. Perception that scientists are driven by intellectual curiosity not what is needed in the sector.	<u>Research collaboration</u> PhDs and other projects supervised by both academics and practitioners. This provides education in both delivery and discovery.
	Type of communication	Only 9% journals are open access. Material is not reaching practitioners so no feedback being given back to scientists to inform further policy	<u>Research collaboration</u> Twin site programme: larger sites/local authorities could link up and act as critical friends for each other. This would help to build trust and understanding of each other's

			fields. This also would help the transfer of tacit knowledge.
Lack of time for policy professionals to consult with practitioners/other stakeholders during outbreaks	Policy design/Type of communication	In the high paced outbreak environment, it is difficult to build relationships to foster trust; difficult to share information due to sensitivity; the pace of the situation is moving quickly	Foster good working relationships with all parts of the sector as part of BAU to increase trust ahead of outbreaks.
Poor knowledge of where to access advice and information relevant to practitioners' needs	Type of communication	If unsure of where to find advice, practitioners may be drawn towards only hearing the viewpoint of those most similar to theirs creating an echo chamber (homophily).	<u>Plant Health Portal</u> The refresh of the PHP will result in more hits due to DDTS aligning with google analytics. There should be appropriate press around the relaunch to ensure that accurate information is signposted for practitioners to access.
Currently, most policies emphasise link between resilience and resistance, not resilience and adaptation.	Policy design	Contributes to the lack of engagement with the resilience cycle and therefore decreased application of the principles.	<u>Focus on adaptation in policy papers/policy decisions</u> - Pests and disease adaptation - Genetic diversity - Tree Council and Fera developed Local Action Plans – these need signposting

Appendix 2. Consent form

Department
for Environment
Food & Rural Affairs

Your consent

Thanks again for agreeing to take part in this piece of research which is focused on understanding more about the production and translation of information that prompts action amongst hard-to-reach audiences. Your support is much appreciated.

- The research will explore the knowledge landscape in relation to ash dieback and *Ips typographus* as a key focus
- This interview will explore how organisations decide what information to use and produce, how this is disseminated to your audiences, and how this might influence management actions
- This information will be used by Defra and partners to understand how better to engage hard-to-reach stakeholder in policy discussions, and ultimately how to encourage improved management practices
- In the first instance, the research evidence will be presented in the form of written documents for internal audiences within Defra
- None of the research evidence will be attributable to, i.e. linked with, specific research respondents or the organisations they represent unless we have specifically gained their permission to do so
- If you have other questions or complaints about the research, please contact the lead researcher Dr Bianca Ambrose-Oji Bianca.ambrose-oji@forestresearch.gov.uk or 0777 587 0865

Please tick

Please read the following statements carefully	Yes	No
1. I understand that my participation is **voluntary**, that I do not have to answer any of the questions if I don't want to, and that I can end the discussion at any stage	☐	☐
2. I understand that if I wish to terminate the interview before it's end, the researchers will not use the information that I have already given	☐	☐
3. I understand that the discussion will be **audio or video recorded**, so the research team will remember what was said in my own words	☐	☐
4. I understand that my responses will be **confidential**, which means the information i.e. the research notes or recordings, will not be shared outside of the research team	☐	☐
5. I understand that any research information used in any reports or other things the researchers write or produce will be **anonymised**; which means my name will not be used	☐	☐
6. I understand that the information collected today will be treated, stored and analysed in line with the requirements of the **Data Protection Act 2019**	☐	☐

Your name _____ Date _____

Your title _____

Your signature _____

Please return your completed consent form to Berglind.karlsdottir@forestresearch.gov.uk or by post to Berglind Karlsdóttir, c.o. Forestry Commission, 620 Coldharbour Lane, Bristol BS16 1EJ.

Appendix 3. Additional information form: ADB/IPS Case Study

BACKGROUND INFORMATION ABOUT YOUR ORGANISATION AND TREE HEALTH COMMUNICATION

1. Do you/your organisation produce any of the following about tree health and specific threats? ***Please tick all that apply***

Products	Topic focus			Who has access?		
	Tree health	Ash dieback	*Ips typographus*	Open to all	Members only	Selected staff and stakeholders
Webpages providing specific information						
Facebook pages/groups sharing information						
Tweets providing or sharing information						
Best practice guidelines describing how to identify and respond to threats						
Producing stories and other comms material for TV and other traditional media outlets						
Position statements highlighting the organisation's approach						
Newsletters with specific articles on these threats						
Email alerts about research and updates on these threats						
Leaflets providing information and guidance on these threats						

2. Do you/your organisation organise any of the following events, wholly or partly focussing on the following tree health and specific threats? ***Please tick all that apply***

Learning/knowledge events	Topic focus			Who has access?		
	Tree health	Ash dieback	*Ips typographus*	Open to all	Members only	Selected staff and stakeholders
Webinars and similar online engagements						
Seminars and workshops delivered online or at other venues						
Internal meetings						
Meetings with other organisations and stakeholders						
Facebook hosted events						
Field trips						
Social events during which members are likely to discuss tree health issues among themselves						

3. Do any of the following factors play a part in your communication role? ***Please indicate the extent for each factor***

Factors	Score					
	Not at all	To some extent	To a moderate extent	To a great extent	To a very great extent	NA
Producing research						
Producing/tailoring information and guidance for end users						
Sharing information and guidance (produced by your organisation)						
Share information and guidance (produced by other organisations)						
Support learning among stakeholders and members						
Support networking among stakeholders and members						
Encouraging and supporting actions of stakeholders and members						

4. Are any of the following stages of response to tree health threats covered in the information and communications you/your organisation provides.
Please indicate the extent for each stage

Stage in tree health response	Score					
	Not at all	To some extent	To a moderate extent	To a great extent	To a very great extent	N/A
Awareness (ID, lifecycle, distribution, potential impacts)						
Planning (Readiness for action, legal obligations, understanding of impacts on individual/organisations woodland holdings)						
Action (What organisations or individuals can/should do to mitigate and adapt to pest presence)						
Recovery (How to maintain valuable treescapes in the long term, for example, replanting choices after a specific infestation)						

5. Who are your audiences in relation to ADB and/or IPS?

Appendix 4. Interview guide: ADB/IPS Case STudy

Interview guide for stakeholders in Knowledge to Action case studies

Aim of interview
Look at resources and training etc. provided by the organisation in advance of the interview. Outline three topics: About their roles; information into action; network analysis; and Barriers.

Recording the interview
Seek permission to record the interview.

Gaining consent
Ask the interviewee **to fill in the consent form before you start**. Outline that the interview will take between 30- 60 minutes and they are free to stop at any time. They do not have to answer questions if they do not want to.

Questions

About the interviewee (settle down and into context)

Choose focus P&Ds

1. What is your role, and what does that involve in terms of developing and disseminating information and knowledge about:
   i. plant health/tree P&D
   ii. ADB
   iii. *Ips typographus* (Spruce bark beetle)

Your audiences

2. Do you define your audiences? How do you do this? (segmentation/insight/by priority for action or something else?)
3. Do you recognise any important "Hard To Reach" audiences you feel you may be failing to engage around (tree health), ADB, *Ips typographus*
4. How do you decide what information/research will be produced as outputs for particular audiences?

Who is involved, how do they decide on their messages and/or products? Especially when there are contradictions (e.g. …….. best to have some examples ….. what are the contradictions for ADB ??? the fell/do not fell argument seems to have evolved to something pretty clear? I don't know much about Ips but as a notifiable pest it's a nuclear policy response!)

Science to information

5. When you think about ADB, or IPs what do you know about the science and research, and do you feel that research is focused on the right issues/information and knowledge gaps as it relates to your audiences?

Prompt: Can you comment on any stakeholders (internal or external) you feel are critical to driving forward research/information provision? How are these stakeholders important? What kind of relationships do you have with them, and what function do these stakeholders have? (trying to build a picture of the knowledge network)

6. Who is involved in deciding on what information and key messages to communicate

Prompt: are they comms, researchers, policy?

Prompt: is there engagement with audiences within the process of information being shared and turned into knowledge?

Disseminating information and supporting knowledge development

7. What are the different ways in which the information is disseminated?

8. Who is involved in the dissemination of the chosen information and research?

Prompt: Can you comment on any stakeholders (internal or external) you feel are critical to driving forward research/information provision? How are these stakeholders important? What kind of relationships do you have with them, and what function do these stakeholders have? (trying to build a picture of the knowledge network)

9. Do you support learning activities among your audiences in relation to the information you provide?

10. Who is involved in supporting learning and developing understanding around knowledge products?

Prompt: Can you comment on any stakeholders (internal or external) you feel are critical to driving forward research/information provision? How are these stakeholders important? What kind of relationships do you have with them, and what function do these stakeholders have? (trying to build a picture of the knowledge network)

11. Do you do anything to move audiences from gaining knowledge to actually acting on that knowledge?

Prompt: Do they see their role as promoting action, or is it just about knowledge? What other types of support do they provide? M&E and impact assessment.

Network analysis

12. Can you look at this diagram and can we map those organisations you have just mentioned onto this template to show the kinds of relationship they have with you/your organisations at different points in the process?

Barriers

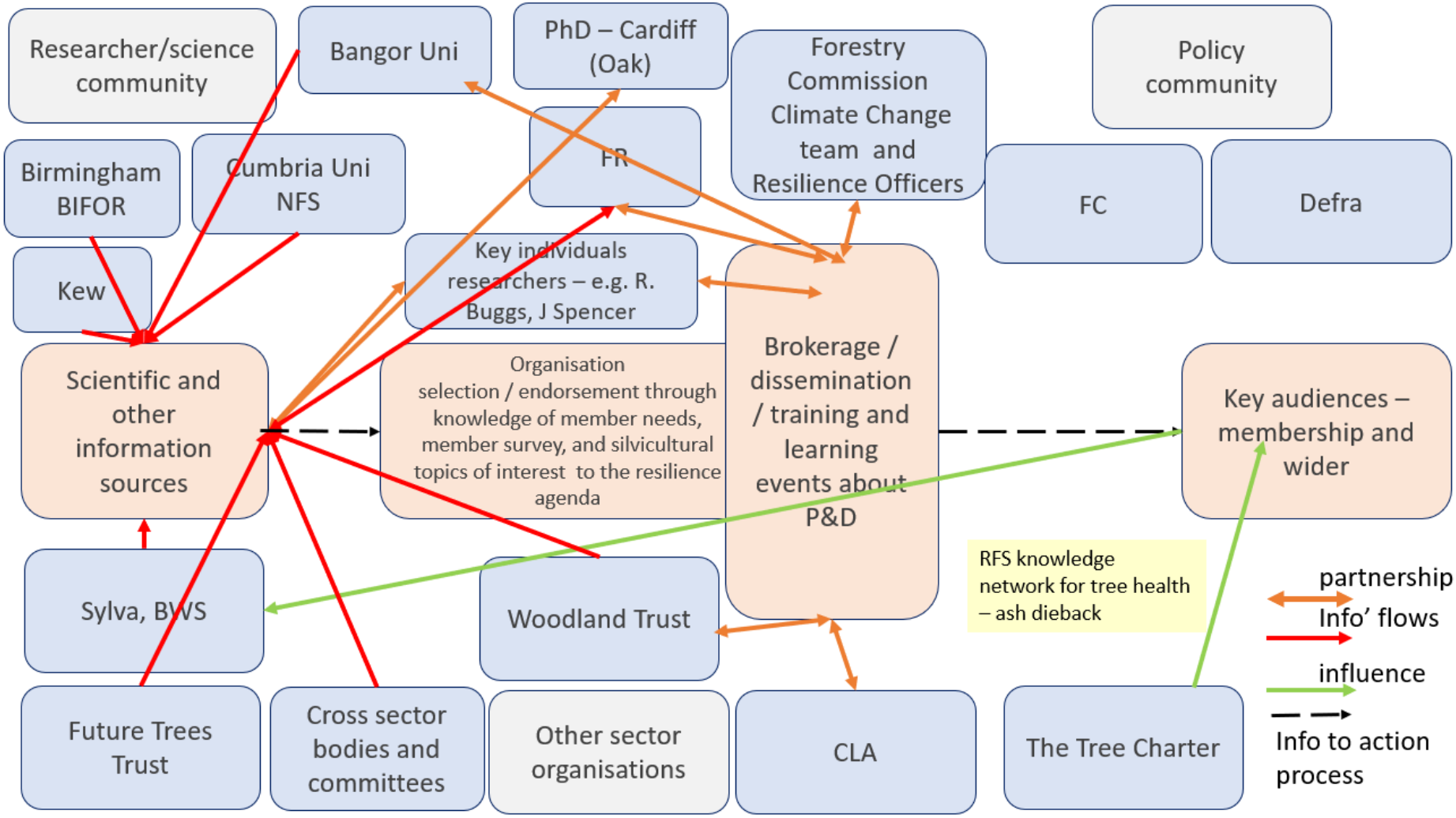
13. Do you feel there are any barriers and issues that prevent you as a communicators in translating information into usable content for your audiences?
14. Do you feel there are any barriers and issues that may be preventing audiences from understanding and interpreting these information products and what it means to them?
15. Are there any key differences in your communication between tree health issues, specifically between Ips versus ADB?
16. Do you feel there are any barriers and issues that may be preventing audiences from acting on your information/knowledge/or that from other sources?
17. How might any of those barriers be overcome?

Endings

18. Any other comments?
19. Other questions?

Thank the respondent and explain what happens next.

Appendix 5. Example of a participatory sociogram (network/knowledge system): ADB/IPS Case Study



Appendix 6. Coding framework: ADB/IPS Case Study

Name	Description
Audience	Any information on their audiences
access to info	Limitations in audiences finding and accessing relevant information to themselves due to lack of awareness, the information not being formally communicated, or only being accessible through memberships or payment for journal articles etc.
Audience engagement	Are the audiences felt to be engaged with the topics
Hard to reach / engage	Audiences perceived to be hard to reach or hard to engage
Understanding of audiences	The organisation's understanding of their audiences, through segmentation, other audience analysis, project-based analysis or general informal understanding.
Barriers	Any barriers in the information-action gap, both for organisational and perceived barriers to audiences.
Capacity	Organisational capacity to engage audiences through a range of comms and events
Dissemination	Means of delivering information and engagement content
Events	Any events
Guides	Specific mentions of guidance and toolkits
written outputs	Any written outputs – journal articles, websites, twitter etc.
one on one	Face to face or other one-on-one interactions with audiences
info to knowledge	Anything relevant to choosing and disseminating information
Choosing topics	How organisations choose their topics of focus
Confusion	Any confusion about information or other messages on a topic
Filtering	Any organisational or individual process of filtering through information
Info issues	Any other issues relating to information
Learning	Processes through with information is transformed into social and individual knowledge
Messages	Any particular messages an organisation is trying to convey, and how they are chosen (if at all)
regional networks	Regional dissemination and learning activities (including organisations with formal regional structures)
Salience	Relevance and interest in information
signposting	Sharing information sources
Tailoring / translating info	Tailoring information for specific audiences
Knowledge-action	Anything relevant to acting on knowledge
action	Any examples of action
Projects	Organisations engaging in projects (organisational action)
support	Any mentions of support provided to audiences
Network	The organisational and individual networks and processes of communication. Any information that has gone on the organisational maps and any other descriptions of relationships and information – dissemination – knowledge flows

Name	Description
Bottom-up	When information is requested by members and others and is fed up to information providers, producers and policy makers
Collaboration	Any collaborative relationships such as partnerships, co-production of engagement materials and events.
Experts	Use of experts for understanding and disseminating topic-related issues
Internal comms network	The knowledge network and flows, but internal processes as opposed to the wider network
Personal expertise	Interviewee's expertise and how that influences their comms processes
opportunities	Suggestions for system improvements or other positive changes that have taken place
Org factors	Any institutional cultural and structural factors influencing information topics and messages
Org size	Mentions of the organisation's size
Role or stance of org	The individual's or organisation's perceived role in the information-action system and their network
Research	Any mentions of research on the discussed topics
collecting and storing data	Organisations conducting research or otherwise collecting and storing data of relevance to research
Feeding into research	Any audiences or organisations feeding into the production of research
Research relevance	The relevance of available research to the discussed topics
Topics	The content of disseminated information.