# Tree Health Citizen Science in UK

## Opportunities, Challenges and Future Roadmap

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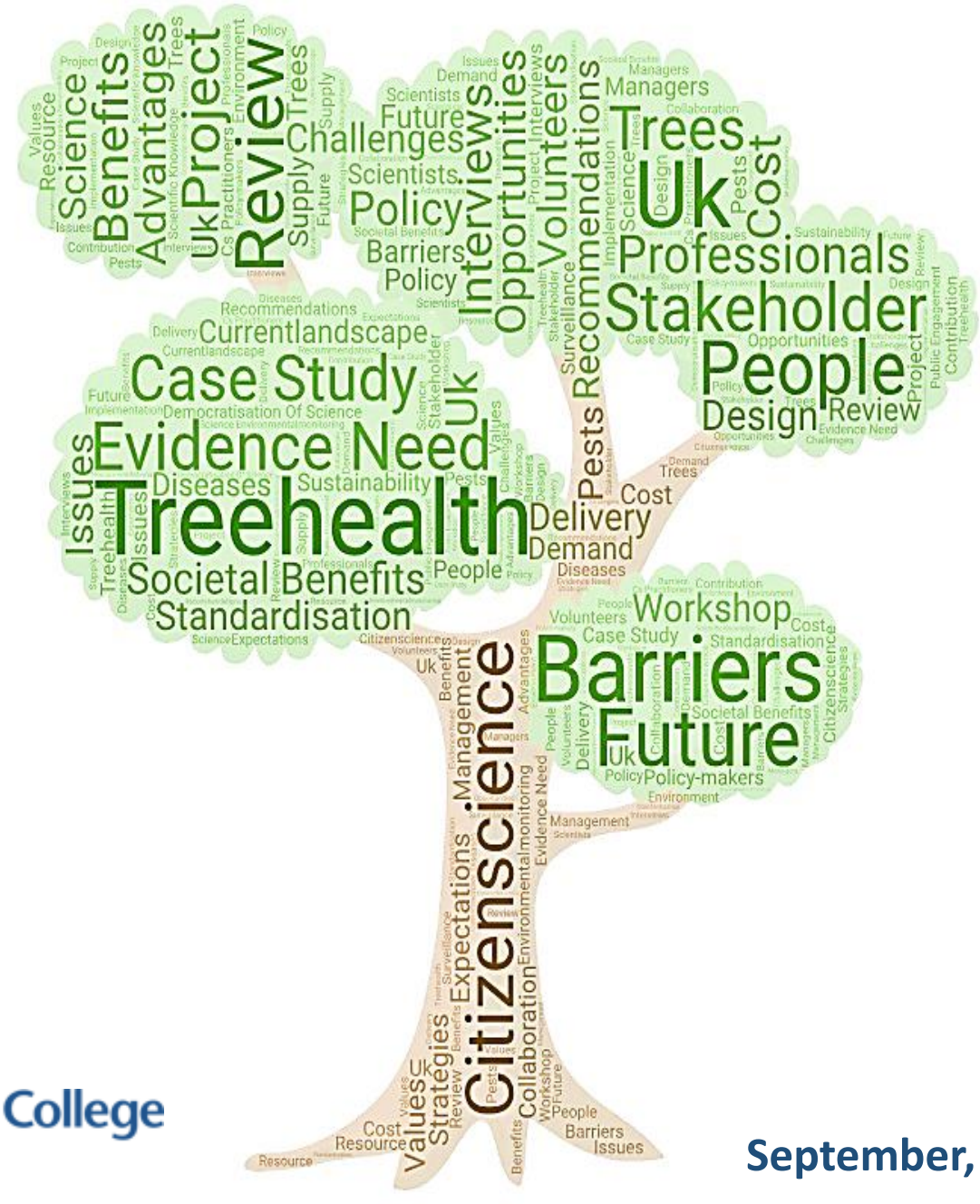


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# Contents

# Executive Summary

## Introduction & Research Context

The UK's trees, woodlands and forests are a vital national asset providing multiple economic, social and environmental benefits. However, in recent years there has been an increasing number of pest and pathogen incursions and outbreaks on trees. Increased global plant trade (more volume, from more countries and of more exotic plant species), the effects of climate change and changes in nursery practices (e.g. public demand for large semi-mature trees) are believed to be contributory factors in the increase in incidents. Threat from pests and pathogens increases the risk of incurring severe economic, social and environmental losses, not only through the loss of trees but also potentially through losses of other native flora which may be susceptible to the same pests and pathogens. Early identification of these pests and pathogens increases the chance of successful eradication, containment or control. In the face of the potentially large geographical scale of pest and disease spread across trees, woods and forests, both in commercial forestry settings, but also the wider environment, the government has limited institutional capacity to provide for effective tree health surveillance on its own. Part of the solution to this challenge is to have effective support from a wide range of stakeholders including the public.

Citizen Science (CS) provides opportunities for engaging people and is seen as a powerful research tool for undertaking environmental monitoring and scientific research. It involves the collection and analysis of scientific data by volunteers (members of the public) and encompasses a broad range of projects. One advantage of CS is that volunteers can make observations over large geographical scales that can be too large for teams of professional scientists to study alone. The discovery in 2012 of *Chalara fraxinea* (now called *Hymenoscyphus fraxineus*) on ash in the UK significantly raised the public and political profile of tree heath. The confirmation of Chalara generated extensive media comment, followed by a range of government initiatives and interventions by citizens and other concerned stakeholders. During this time, several CS projects were set up to mobilize and involve the general public in spotting infected trees in their local areas.

Recognising that CS represents a key dimension of a collaborative approach to safeguard the health of the nation's trees and forests, and given that the current tree health CS landscape is still fairly nascent, now is an appropriate time for a stock-take of the portfolio of projects and the data they are producing. In order to do so, Defra commissioned the research presented in this report to develop an understanding of the current and potential contribution of citizen science to tree health by reviewing CS projects on tree health in the UK and by exploring different stakeholder views. The research was also intended to propose policy recommendations and strategies to shape the future delivery of tree health citizen science projects in the UK and to maximise the usefulness of the data they produce.

This research presents a comprehensive analysis of the current landscape of tree/plant health citizen science (CS) projects in the UK. It has brought together the views of many of the relevant stakeholders involved in tree health and CS and who are likely to shape the future application of tree health citizen science. Their opinions are therefore highly valuable and timely to inform the planning and delivery of future CS initiatives related to tree health. Most of the research done on CS in the past has explored the views and experiences of the volunteers alone. Research reported in this

report adopted a unique approach of exploring the opinions and experiences of professionals working within projects as well as volunteers. The rationale being that their continued involvement and motivation is key to the design, delivery and implementation of successful CS projects in the future.

## Methodology

This publication reports the results of interviews and workshop (N = 110) conducted with professionals and volunteers involved in tree health science, management and policy and in CS projects, in order to learn from their experiences. This report is divided into four chapters.

Chapter 1 explores the potential for CS across tree health science, management and policy in the UK by mapping the current tree health evidence needs, types and sources, and analysing requirements for additional, improved or enhanced evidence. Interviews were conducted with respondents from science, management and policy stakeholder groups to develop understanding of the current evidence landscape in tree health and the role of CS in addressing evidence needs, i.e. how can the 'supply' of CS be best configured to meet these demands.

Chapter 2 presents details on the current landscape of tree health CS projects in the UK. Interviews were held with professionals and volunteers involved in five specific case studies of CS projects to obtain information on volunteer and professional motivations and experience of participation, and their views on CS in general.

Chapter 3 reports on the findings from the participatory research workshop titled "The Future of Tree Health Citizen Science: Opportunities and Challenges" hosted by Defra and Centre for Environmental Policy, Imperial College London, on July 5th, 2017 at Fera, Sand Hutton, York. The Workshop involved policy-makers, scientists, managers (of either land or organizations) and CS practitioners with an informed interest in tree health citizen science. Through a mixture of presentations, break-out discussions/feedback and voting on priorities, a collective consensus was obtained on (a) issues, barriers and challenges; (b) values opportunities and advantages; and (c) future of tree health CS.

Chapter 4 brings together the final recommendations for future delivery of tree health CS based on the findings from the empirical research reported in the first three chapters.

## Key Findings

In chapter 1 the most frequent tree health evidence need cited was scientific knowledge on pests and diseases including surveillance information. Although well-addressed by current information sources, improvements were sought on: accessibility and compatibility of different data sources; additional information on the distribution of species and habitats; and on the movement of plant material. Even though the CS landscape if fairly nascent in the UK tree health sector, a very high level of awareness of CS was highlighted by the interviews. In general, there was a high level of appreciation among the stakeholders that CS has a role to play in addressing their evidence needs. Trained volunteers emerged as a highly valued resource, with recognition that participation should be extend to anyone with an interest in trees (one respondent held the traditional view that a qualified scientist is always preferable). According to tree health professionals, among the key benefits of adopting a CS approach reported were: the power of a large number of observations; support to official surveillance by increasing the number of people 'on the ground' looking;

occasional volunteers with a high level of expertise; and the value of wider benefits including awareness raising, public engagement, environmental stewardship and involving the next generation – the scientists and citizens of the future. The most common disadvantages of a CS approach identified were: the perception of low data quality; lower identification skills which may results in swamping officials with false reports; the additional burden of volunteer management; the time, effort and money needed to train volunteers; and the geographic bias introduced by higher numbers of volunteers in urban as opposed to rural areas. It was accepted that CS was less suited to address some evidence needs e.g. data on commercial trade in plant imports. The consensus was that CS can be a useful tool to meet tree health evidence needs provided the above stated disadvantages are addressed.

In chapter 2, twenty UK tree health projects with an element of citizen science were identified between 2005 and 2013, thirteen of which are still ongoing. Most of projects included an element of surveillance for Chalara ash dieback illustrating the scope of CS in addressing an immediate evidence need in the case of pest/disease outbreak. The resulting catalogue of projects shows that CS is providing data on: pest, diseases and host species distribution; surveillance and spatial data; and the behaviour and attitude of participants. CS project are currently not covering some of the variables for quantitative modelling (e.g. bio-economic or climate data); strategic information (e.g. data enabling cost and benefit estimates of different management options or evaluations of the economic value of trees and how it can contribute in decision making at the policy level); information on international pest disease management; interception data at points of entry for commercial plant trade in the UK. While the first two identified gaps can be potential areas for future application of CS, for the latter, CS was thought not to be feasible or appropriate. Of particular interest were the many similarities in the attitudes and motivations of volunteers and professionals involved in five different CS projects. These included a personal desire to make a valuable contribution to the environment and society, being appreciated for contributing something useful and worthwhile, gaining new skills and knowledge, receiving feedback, and generating useful data. Of high significance was the broad consensus amongst volunteers and professionals that projects were exceeding or living up to the expectations and a desire for projects to continue in the future. This not only indicates how well the projects have performed in addressing the expectations and concerns of project participants, but also highlights the success of the relatively new approach of CS. One of the biggest advantages of a CS approach identified was the number of societal benefits that can be achieved, including raising public awareness, promoting public engagement, raising the public's levels of scientific understanding and literacy, encouraging positive behavioural change and fostering an environmentally-proactive society. In particular, CS projects have been very effective at engaging the next generation and hard to reach sectors of society which are of the most impacted by environmental change, and at involving people at the local/community level. Key improvements suggested for future projects included: direct inter-personal support to volunteers, volunteer training (to provide confidence in the work of volunteers and ultimately in data quality) and, the need for supporting project infrastructure to be developed and maintained. Improved understanding of the costs of CS was also recommended. Professionals felt that their capacity to deliver initial training and provide continued support were neither recognised nor resourced adequately. The point was made that funders need to appreciate that CS is not a 'low cost' option. The sustainability of projects was also identified as a real concern, with the risk that the investment in creating an engaged public and project infrastructure will be lost if this issue is not addressed.

In Chapter 3, four main themes emerged out of the workshop discussions.

(1) Collaboration. There is a need to build relationships and foster collaboration between projects, between the various stakeholder groups, and especially between policy-makers and citizen science practitioners and volunteers, as well as policy-makers in different policy areas. The nascent tree health citizen science network was proposed as one means to build better collaboration.

(2) Standardisation. The statement "standardisation to improve consistency without stifling innovation" summed up a consensus view of the need for a degree of standardisation on methodology, especially to ensure data quality and to facilitate data sharing. One proposal was to engage with the European and Mediterranean Plant Protection Organisation who have a long history of producing guidelines.

(3) Sustainability. The transient nature of funding of citizen science projects was noted as a serious risk to maintaining momentum and avoiding the loss of hard-earned public participation. Suggested solutions included the need for development of a 5-year strategy, mainstreaming activities into 'business as usual', for example, making CS part of mainstream, official surveillance.

(4) Volunteers. There was the need to understand, support and truly value public participants. Noted was their potential to become a so-called 'standing army' providing valuable long-term records on their own patch and at times when officials might not be available. Increased scientific literacy, greater engagement with nature, improved employability especially in disadvantaged rural communities were a few of the additional, yet important benefits noted. Provision of learning pathways, gateways to opportunity and local community ambassadors were suggested as solutions. The quote "Science is not just done in a laboratory by people in white coats" perhaps provides the best vision of the future role of citizen scientists in tree health.

## Key Recommendations

Based on the research findings of this study, recommendations aimed at improving the future design and delivery of citizen science in tree health can be grouped into six emergent themes:

*People:* A range of varied and often inter-connected motivations and expectations exist among the volunteers and professionals involved in CS projects. Also, to note is that these may change or evolve over the course of time during the project. Therefore, it is important to take account of these needs on a continuous basis (from the outset until the various stages of the project). In terms of volunteer support, initial and continued training, and pathways for further learning must be provided to volunteers as it not only contributes to increased personal satisfaction but also opens the possibility for volunteers to fulfil higher level tasks (e.g. report verification) which can be of greater value to official surveillance and/or the biological recording community. Volunteers require personal contact with a project coordinator and opportunities to network with each other (also relevant to project design) and therefore steps should be taken in this direction to ensure volunteer retention and satisfaction.

*Projects:* Improvements are needed at the project level to ensure better design and delivery of CS projects. There is a need for a degree of standardisation on methodology, especially to ensure data quality and to facilitate data sharing. One of the ways to ensure this could be improved interoperability of all data sources including those from citizens. This need should be addressed at

the project design stage itself to ensure acceptable data quality and transferability. Confidence in citizen data can be increased by making sure that participants are required to complete tasks commensurate with their ability. Design of tree health CS projects needs to factor in realistic expectations of the work done by the volunteers, should take account of volunteer expertise and, where necessary, follow well-established official procedures for confirmation of identification. Future projects can gain immensely if they are co-created or co-designed between project managers and policy makers. Project managers should engage policy-makers and volunteers early in the project design process. This open and collaborative approach should be reciprocated, with adequate resourcing for policy input into setting the scope and informing the design of projects. Infrastructure (e.g. websites, apps, data entry mechanism, databases etc.) needs to be developed, tested and in operation to underpin a good project. Constant input must be made to keep content fresh and regular technical maintenance is required to ensure the infrastructure operates effectively. CS practitioners are encouraged to prioritise evaluation and communication of experiences (both successes and challenges) with other practitioners and with the science and policy communities. This step in the process is needed to build the trust and confidence in the value of tree health citizen science with key influencers in science and policy communities and, critically, to feed learning from experience back into an ongoing and dynamic programme of improvement and change.

*Collaboration:* In order to maximise the impact and capitalize on the success of CS projects, there is a need to build relationships and foster collaboration between projects, between the various stakeholder groups, especially between policy-makers and citizen science practitioners and volunteers, and indeed between policy-makers in different policy areas. Some of the ways to achieve this could be through networks (e.g. the nascent UK Tree Health Citizen Science Network) and/or workshops (e.g. British Ecological Society funding, EU COST Actions); expansion of the network of participants contributing to tree health citizen science/surveillance; emphasising the role of 'local ambassadors' as a potential way to enthuse local public participation in tree health and citizen science.

*Society & Democratisation of Science:* Some of the biggest contributions made by tree health CS are to raising public awareness, promoting public engagement, raising the public's skill levels in and understanding of science, encouraging behavioural change and fostering an environmentally-proactive society. In particular, CS projects have been very effective in engaging the next generation, as well as hard to reach sectors of society who are often the most impacted by environmental change, and in involving people at the very local/community level. Citizen science is also recognized as one of the ways of democratizing science by providing people with direct experience of scientific practice and by facilitating communication and collaboration between professional and citizen scientists. Serious consideration needs to be given to how to increase appreciation and recognition amongst policy-makers and politicians of the wider social and societal benefits of CS.

*Cost & Value*: Measures are needed to accurately assess the direct and indirect costs and benefits of CS to inform future funding and resourcing decisions. Project budgets should better reflect and record all associated costs. A wider systematic evaluation of cost and benefits is required, taking account not only direct costs but also the value of indirect benefits associated with improved skills, greater engagement with and awareness of tree health and the value of larger numbers of observations than is possible through official observation alone.

*Sustainability:* Tree Health Citizen Science projects are virtually all funded by time-limited grants. This transient nature of funding poses a serious risk to investment through disengagement of trained volunteers, cessation of surveillance and associated data and the loss of expensive project infrastructure. Innovative funding mechanisms need to be developed to sustain citizen involvement in tree health.

# Chapter 1

## Evidence needs and the role of citizen science in tree health science, management and policy in the UK


### ABSTRACT

This chapter explores the potential for Citizen Science (CS) across tree health science, management and policy in the UK by mapping the current tree health evidence needs, types and sources, and analysing requirements for additional, improved or enhanced evidence. Semi-structured interviews were conducted by telephone with respondents from science, management and policy stakeholder groups (N = 40) to develop understanding of the current evidence landscape in tree health and the role of CS in addressing the evidence needs, i.e. how can the 'supply' of CS be best configured to meet these demands.

The most frequent evidence need cited was scientific knowledge on pests and diseases including surveillance information. Although well addressed by current information sources, improvements were sought on: accessibility and compatibility of different data sources; additional information on distribution of species and habitats; and on movement of plant material. Even though the CS landscape is fairly nascent in the UK tree health sector, a very high level of awareness of CS was highlighted by the interviews. In general, there was high level of appreciation among the stakeholders that CS has a role to play in addressing their evidence needs. Most desired were 'trained' volunteers with recognition that participation should be extended to anyone with an interest in trees (one respondent held the traditional view that a qualified scientist is always preferable).

Key benefits of adopting a CS approach reported were: the power of a large number of observations; support to official surveillance by increasing the number of people looking over the relatively small number of official inspectors; occasional volunteers with a high level of expertise; and the value of non-data benefits including awareness raising, public engagement, environmental stewardship and involving the next generation – the scientists and citizens of the future.

The most common disadvantages of CS approach identified were: the perception of low quality of data; identification problems; swamping officials with spurious reports; management of volunteers – "not as easy to control as officials"; time, effort and money needed to train volunteers; and a bias of location towards urban rather than rural areas. It was accepted that citizens were not relevant to address some evidence needs e.g. data on commercial trade in plant imports. The general consensus was that CS can be a useful tool to meet tree health evidence needs provided the above stated disadvantages are addressed.



**Keywords** – Tree health; Evidence needs; Citizen Science; Policy, management and science stakeholders

# Introduction

## Tree health in UK

UK's trees, woods and forests are a vital national asset providing multiple economic, social and environmental benefits. According to the Forestry Commission Natural Capital accounting report[1] published in 2016, the net asset value of the services delivered by England's woods and forests is estimated to be £11.9 bn. Over 95% of this value is as a result of the benefits it provides to society, for example through recreation and climate regulation. Preserving tree health across the UK is therefore essential if losses to the societal value that trees, woods and forests represent are to be avoided. In recent years, there has been an increase in the number and frequency of new pests and pathogens that threaten tree health coming into the United Kingdom. This can be attributed both to the increased globalization of trade wherein free trade policies[2] allow large volumes of diverse plant and plant products to enter the country; and to the altered climatic conditions such as warmer and wetter winters and changes in seasonal rainfall and storm patterns, which in turn increase the risk of pest establishment, spread and impact. These factors combine to increase the health risks to native flora and, by implication, the risk of incurring severe economic, social and environmental losses. It is estimated that at least £1.7 billion per year is spent on tackling so-called invasive non-native species, including pests and diseases of plants[3]. Some pests and pathogens that threaten the UK's trees pose particular challenges for policy and management responses, including the various species of Phytophthora, Oak Processionary Moth, Acute Oak Decline, Asian Longhorn Beetle, Dothistroma Needle Blight and Chalara ash dieback[4]. Whilst the most effective control is always to exclude the pests from the country, early detection has emerged as a crucial factor determining the scope for controlling outbreaks and facilitating possible eradication or containment.

## Role of stakeholders in addressing tree health issues

Traditionally, implementation of international (e.g. regulation (EU) 2016/2031 of the European Parliament of the Council of 26 October 2016 on protective measures against pests of plants, amending Regulations (EU) No 228/2013, (EU) No 652/2014 and (EU) No 1143/2014 of the European Parliament and of the Council and repealing Council Directives 69/464/EEC, 74/647/EEC, 93/85/EEC, 98/57/EC, 2000/29/EC, 2006/91/EC and 2007/33/EC; WTO/SPS Agreement) and national (e.g. The Plant Health Act 1967; The Plant Health Order 2005; SI 2005 No. 2517)[5] plant health legislations largely shapes and governs the preventative measures to combat incursion of pest and pathogens affecting tree health. Measures such as certification schemes, official checks and surveys of imported plant material are in place to screen for potential pests and pathogens. Largely, the management of tree disease outbreaks has been undertaken by a limited set of professionals,

primarily plant health professionals such as public sector inspectors and foresters, risk analysts, and regulatory scientists[6]. Other stakeholders, including a wide range of public, private and commercial actors have been much less involved.

Mitigating threats to tree health from unexpected disease outbreaks hinges on public authorities' ability to detect and predict the spread of the disease across broad spatial extents in a timely manner[7]. Given the potential geographic scale of incursions and spread of pests and diseases across trees, woods and forests both in commercial forestry settings but also the wider environment, the government has limited institutional capacity to provide for effective tree health surveillance on its own and, therefore, requires effective support from a wide range of stakeholders. In addition, recent events such as *Phytophthora ramorum*, Oak Processionary Moth and Chalara outbreaks, have highlighted the need to involve other stakeholders in order to widen the geographical scope of the surveillance effort, but also to address and change key risk behaviors, to improve communication and build public support for, and involvement with, a more effective and comprehensive tree health protection strategy.

The move to engage and collaborate with a range of stakeholders was echoed in the "Action Plan for Tree Health and Plant Biosecurity" (APTHPB)[8], published by the Department for Environment, Food and Rural Affairs (Defra) and the Forestry Commission (FC). The action plan centered around four main themes: 'Protecting the UK-import controls'; 'Practical actions'; 'Public and stakeholder engagement'; and 'Research opportunities and evidence priorities'. Need to include wider range of stakeholders was also identified in Defra's key document 'Protecting Plant Health - A Plant Biosecurity Strategy for Great Britain'[9] and was reflected in the 'Tree Health and Plant Biosecurity Expert Taskforce' that was convened by Defra's Chief Scientific Adviser at the request of Defra's Secretary of State in 2012[10].

In bridging research and policy, stakeholder engagement can be used to identify all parties engaged in conducting the research, those who make or implement policy, and the intermediaries between them. Also, of prime importance during stakeholder participation is the need to identify and use evidence to enhance policy impact. Defra and its network have a strong focus on the use of evidence to support current policies and shape future policies[11].

**Evidence** is information used to support decisions. Defra and its network use evidence to develop, implement and evaluate policy, to inform their operations and services, and to demonstrate the wider value of their investments. Evidence supports all stages of the policy cycle and is an essential component throughout the decision-making process in Defra and its network.

Making the most of our evidence: A strategy for Defra and its network. June 2014. www.gov.uk/government/publications

## Citizen Science - an opportunity to engage the public

Citizen Science (CS) provides opportunities for engaging people and is seen as a powerful research tool for undertaking environmental monitoring and scientific research[12]. It involves collection and analysis of scientific data by volunteers and encompasses a broad range of projects that are spread over geographical scales that are too large for teams of professional scientists to study alone[13]. Technological innovations such as smart phones, internet and GIS enabled web applications have facilitated the collection of location-based data and its submission electronically to centralized databases[14]. Based on the extent of volunteer participation and involvement, CS projects have been classified into three broad categories[15,16]: *contributory projects* in which volunteers primarily contribute data; *collaborative projects* in which volunteers collect data but may also help in refining project design or in the analysis and dissemination of the analysis; and *co-created projects* in which projects are co-designed by the scientists and the volunteers. More recently, Haklay (2012)[17] extended Bonney et al.'s (2009) model[18] to propose a four-level classification of CS projects by defining the least involvement as 'crowdsourcing' and independent action as 'extreme CS'. To date most of the CS projects in plant health are contributory projects[19,20]. Engaging citizen scientists not only allows for cost effective means of collecting high volumes of data but also creates avenues for outreach and public support for research[21], thereby leading to its wider use to inform policy and practice related to environmental issues. Recognition of the benefits resulting from public participation in scientific research has led to an increase in CS projects across numerous disciplines and it is now seen as an important tool for addressing challenges and opportunities such as scarcity of data[22], public participation in science[23], in decision making and planning[24], science education[25] and policy making[16].

## Tree health Citizen Science in the UK

Due to its potential to act as a mechanism both for raising public awareness and providing the lay-person with a policy voice, CS has been taken up as an important approach by the UK statutory bodies to address tree-health issues[26] (for example a recent Defra/Forestry Commission initiative in

the UK). The discovery in 2012 of *Chalara fraxinea (now called Hymenoscyphus fraxineus)* on ash in the UK has significantly raised the public and political profile of tree heath. The confirmation of Chalara generated extensive media comment, followed by a range of government initiatives and interventions by citizens and other concerned stakeholders[27]. During this time a number of CS projects came into existence to mobilize and involve the general public in identifying infected trees in their local areas. Given that the current tree health CS landscape is still fairly nascent, Defra recognized the need for analysis of the current evidence needs across different stakeholders involved in the tree health sector and to investigate the scope of using a CS approach in addressing the evidence needs associated with tree health in the UK.

## Aim & Objectives

There has been increasing social scientific research on citizen science, covering the experience and motivations of the participants[28], the characteristics and dynamics of expert-public relationships[29], and the learning outcomes of participants both in terms of traditional scientific knowledge and scientific method[30,31,32,33]. Focus of most of these studies has been either on what learning outcomes CS can deliver, or on issues surrounding public participation in CS. While this literature has been insightful about the citizen science approach, there is still a need for analysis of other issues surrounding CS, and in particular critical assessments of the contribution and relevance of CS projects in terms of policy, management and science. Critical reflections and insights from science, management and policy stakeholder groups themselves on their expectations from CS, and where they see the real challenges and opportunities are also lacking.

The present research aims **to develop understanding of the current and future evidence needs across tree health science, management and policy and whether CS approach can be used to address these evidence needs.** Specific research questions are:

1. **What are the current and future evidence needs across tree health science, management and policy?**

    1.1 What are the current information and data needs across the 3 stakeholder groups to address tree health?

    1.2 What are the current sources of information/data?

    1.3 Is the current information / data sufficient to address tree health issues?

    1.4 Are the current information / data sources sufficient to address tree health issues?

2. **What is the scope for using CS to collect information and relevant data for addressing tree health in the UK?**

   2.1 Can CS make a contribution to meeting the evidence needs, and how?

   2.2 Who are the potential actors who can collect and or provide information and data?

   2.3 What are the potential opportunities and barriers in using a CS approach?

Definition of terms used in this research

'**Tree health**' refers to biotic factors that affect the vigour and productivity of a tree, as expressed by different symptoms and types of damage. This research places particular focus on tree pests and diseases (including bacteria, viruses, fungi and invertebrate pests), as opposed to other biotic factors such as vertebrate pests (e.g. squirrels and deer).

'**Science**' refers to tree health research (natural and or social science) by various organizations and research institutes in the UK (e.g. Forest Research, Food and Environment Research Agency, Centre for Ecology and Hydrology)

'**Management**' refers to the act or manner of managing tree health i.e. handling, direction and or control. This would cover a broad range of relevant activities, protocols, instructions, action plans etc. on inspection (at border), inland surveillance and enforcements (imports – APHA and FC; nurseries/gardens – APHA; and woodland / tree management – FC; landowning conservation bodies - Woodland Trust, National Trust, etc.; Tree Council and local government).

'**Policy**' refers to the tree health relevant legislation and policy documents (a course of action adopted and pursued by the government); action plans and evidence needs and research priorities in Plant and Tree Health policy laid out in published documentation.

'**Citizen Science**' refers to the collection and or analysis of data relating to the natural world by non-professional volunteers, typically as part of a project involving professional scientists.

# Methodology

Semi-structured interviews were conducted by telephone with respondents from science, management and policy stakeholder groups (N = 40). Based on the authors' networks an initial list of potential participants was compiled for each of the stakeholder groups. From that list, invitations were sent to 40 participants via email requesting them to take part. All participants agreed to take part in the research study. The interviews were conducted between January and March 2016 using an interview guide containing 13 open ended questions (**Appendix A**). On average the interviews took 45 minutes to be completed. All the interviews were recorded and transcribed.

Qualitative data analysis was done using NVivo software. NVivo is a qualitative data analysis software package that supports qualitative and mixed methods research. Within NVivo, transcripts of the interviews were imported and then coding was done based on a thorough read-through of each transcript. Based on the content analysis of the interviews, general meaning was interpreted, with individual phrases highlighted and added to appropriate emergent themes. Once the interviews were coded, Microsoft Excel was used to create tables showing the frequency at which each theme was mentioned. Phrases in the interview transcripts that discussed these themes were extracted and used to illustrate particular themes.

# Results & Analysis

Thirteen broad themes emerged from the analysis of the interview transcripts. Each of these themes is discussed below.

## Respondent profile

Forty respondents across the science, management and policy stakeholder groups took part in the research interviews. 12 respondents indicated they belonged to science, five to policy and 12 to management. In addition, many respondents said they belonged to more than one category: five belonged to science-policy (SP), three to management-policy (MP), two associated themselves with science-management-policy (SMP) and one associated with science-management (SM). For purposes of analysis, and frequency of counts of the various themes that emerged from the coding in NVivo, participants belonging to more than one category were counted twice for each of the relevant individual categories. For example, respondents belonging to science-management category were counted once for science and once for management categories. This made the total number of respondents in each of the groups to be 20 in science, 15 in policy and 18 in management.

## Role of evidence in general in addressing tree health issues

The role of evidence in general was explored with the participants (**Figure 1**). Nearly 50% of them find evidence absolutely essential for their work on tree health:

> *"I'd probably describe the role [of evidence] as really underpinning and driving the policy direction."* (Policy)

They indicated that evidence can be used for a few purposes, such as assessment and management of risk, to inform policy, to report new or already established pests, or to provide data to take stock of the current forests and woodlands and to inform inspections of plant material imports, and domestic certifications. Evidence could also help in developing understanding of the relationship between tree health and wider environmental issues, such as biodiversity:

*"Data and evidence really important for three things: to prevent the arrival of new tree pests and pathogens; data and evidence on the spread and epidemiology of outbreaks, and data and evidence on the ongoing treatment in forestry and horticulture of established endemic pests"* (Science-Policy)

A few participants also indicated that they use evidence for proposing treatment for endemic pests, to target intervention and commission more research in the field if needed.

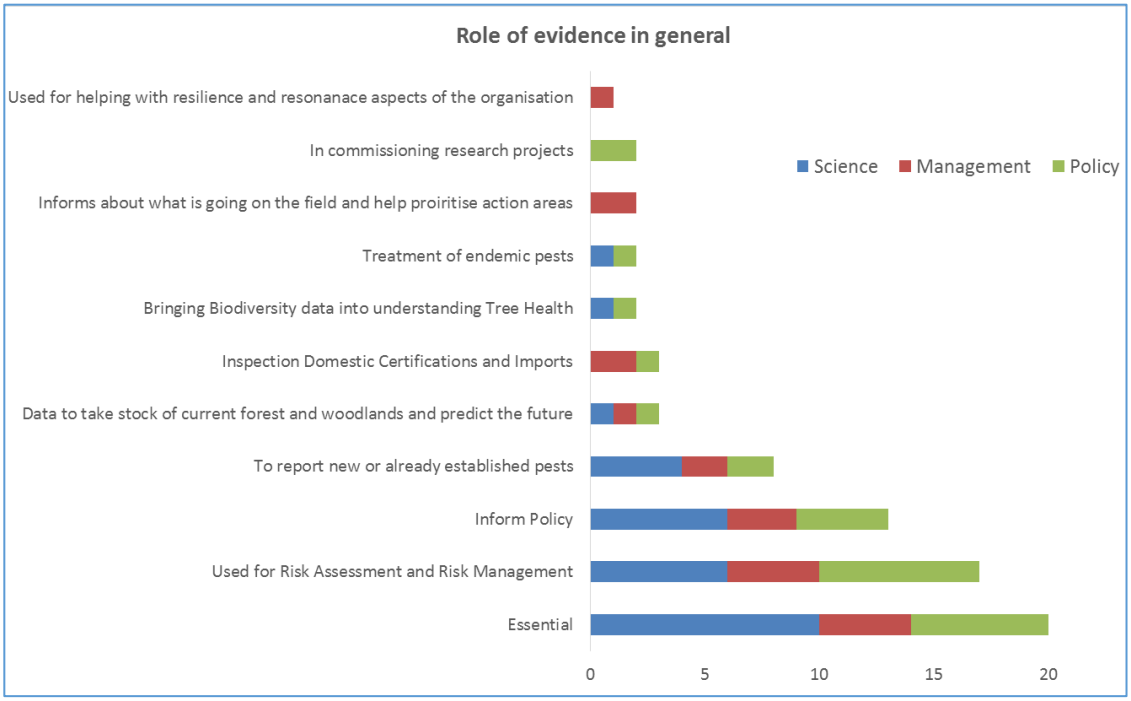


**Figure 1.** Role of evidence in general

## Uses of tree health evidence across science, management and policy

A range of technical, scientific and regulatory information is used by different participants to address tree health issues. Specifically, eight different types of information were identified (**Table1**). Scientific information and or data related to the pest, disease and host species was cited as the information type used by most participants (75%). The second most prominent data type was surveillance and spatial data. This was followed by (in order of prominence) regulatory or policy related information; interception data at the ports; economic appraisals; social science information; modelling information and information on the international experience of dealing with pest and disease outbreaks. Important to note is that some of these information types overlap and are not mutually exclusive. For example, data around tree species can come under both scientific knowledge as well as surveillance information.

**Table 1**: **Current evidence used by tree health science, management and policy**

| Types of information used | Details |
|---|---|
| **Scientific Knowledge or info on pests, pathogen, host trees etc.** | ➢ Pest and pathogen details (e.g. life cycle; hosts; geographic distribution; disease symptoms; interaction between host and pest and the interaction with the wider environment; absence or presence of the pest; information on how diseases are being transferred and their impact on different trees; spread of the disease)<br>➢ Treatment<br>➢ Diagnostics<br>➢ DNA Sequencing<br>➢ Reports from TreeAlert<br>➢ Statistical info about tree volume<br>➢ Habitat Linkage Data<br>➢ Scientific data on how Ash Dieback is managed<br>➢ Consultations for new plant health or emerging new pests and diseases<br>➢ Plant passport registration information<br>➢ Tree health updates<br>➢ Field guides and ID guides for symptoms of things like Phytophthora Ramorum and Chalara<br>➢ Current woodland structure and how is it likely to evolve into the future<br>➢ Pest life cycle<br>➢ Different parts of the pest risk analysis<br>➢ Plant Health Register<br>➢ Trade/Risk pathway<br>➢ Plant Risk Assessments |
| **Surveillance & spatial data** | ➢ GIS data<br>➢ Canopy cover<br>➢ Satellite Imagery<br>➢ Location of different types of trees across UK<br>➢ Aerial Surveillance data<br>➢ Surveillance information on distribution of the disease on the ground<br>➢ Surveillance information on distribution of the pest or the pathogen<br>➢ Surveillance information of health status of the host population and what the risk factors might be in terms of the spread of the disease, understanding where it's come from, understanding where it might spread to next<br>➢ Annual helicopter survey in SE England. |
| **Economic Appraisals** | ➢ Strategic info on how much money is being spent overall on the research into tree health, who is doing it, what the projects are about, and how they're going to deliver to policy customers, and what difference they will make to policy making, or to policy delivery<br>➢ Costs and benefits of different management options |

| | |
|---|---|
| | ➢ Evaluation and economic value of trees and how it can contribute in decision making at the policy level |
| **Regulatory/policy Information** | ➢ Plant health directive<br>➢ Tree health and plant biosecurity strategy<br>➢ Regulatory and legislation issues/information<br>➢ Legislations from Defra<br>➢ Guidance from EPPO<br>➢ The Plant Health Risk Group |
| **Social Science Info** | ➢ Personal data of the people making the enquiry<br>➢ Drivers of different stakeholder behaviour/ stakeholder attitudes<br>➢ Social impact studies |
| **Modelling Info** | ➢ Bio-Economic modelling<br>➢ Climate data modelling |
| **Interception data on the ports** | ➢ Interception data<br>➢ Port inspections and monitoring<br>➢ Trading info<br>➢ Import data |
| **International experience and or lessons from pest disease management** | ➢ Evidence coming through from different countries, what other countries have done to manage a pest or disease. What their experience has been, what their impact has been<br>➢ Biosecurity threats across different EU countries<br>➢ Interception data from other countries |

Certain types of information were found to be used by all the participant types, such as scientific knowledge, surveillance and spatial data, social science information and interception data. However, some information was also found to be more specific to individual respondent groups (**Figure 2**). Economic appraisals and modelling information was used by policy and science stakeholder groups; regulatory and policy related information is largely used by management and to a lesser extent used by science. Evidence in the form of international experience from the past on pest or disease management was found to be used by management and policy stakeholder groups and not by the science stakeholder group.

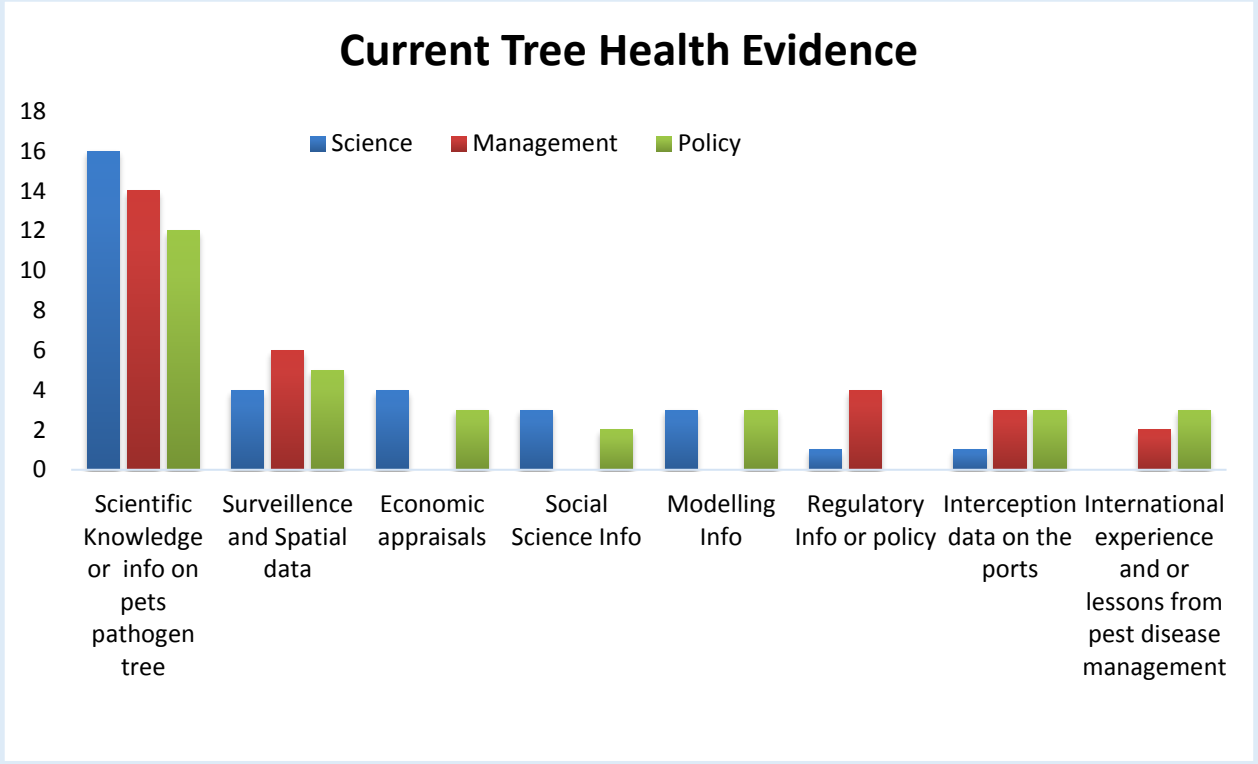


**Figure 2.** Current tree health evidence used across stakeholder groups

## How is the current evidence used?

Participants use information and data for many purposes (**Table 2**). For the most commonly cited uses relate to risk analysis and management, and to the provision of guidance and communication. Other than these, information is also used for managing imports and domestic certifications; to inform policy advice or statutory action; to study the impacts of diseases in terms of tree loss in the landscape and the potential trade impacts. A few participants also mentioned using the evidence to monitor trends in diseases and the spread of pests, to identify more evidence needs and commission research, and also to build the case for intervention to protect tree health.

All the three stakeholder groups were found to use evidence for risk analysis and management, for providing guidance and communication, and for providing advice or recommendations to policy. The science respondent group emphasised the use of evidence for monitoring trends in diseases and pest progression and for justifying budget spend on tree health issues. Both management and policy respondent groups emphasised the use of evidence to study the impacts of the loss of trees in the landscape, and trade impacts due to disease outbreaks. They also indicated the use of evidence to identify more evidence needs that can be used for commissioning research relevant to tree health, and in managing imports, inspections and domestic certifications (**Figure 3**).

**Table 2**: **Current use of the tree health evidence**

| How the information is used | Details |
|---|---|
| **Risk analysis and management** | ➢ Risk Analysis/assessment<br>➢ Risk Management<br>➢ Outbreak management<br>➢ Take stock of the current operational and management options and to revise them if need be<br>➢ Diagnosis<br>➢ Identify areas of highest risk in terms of pests and treatment<br>➢ To decide on the best approach to manage the disease<br>➢ To create more resilient forests in the future<br>➢ Risk mitigation<br>➢ To share information with other national plant protection organisations to increase surveillance and inspections<br>➢ To study the potential for pest control<br>➢ Future proofing for risks coming into UK from different parts of the world to propose risk mitigation plans |
| **To study impacts** | ➢ Trade impacts<br>➢ Look at the impact of the loss of trees in the landscape |
| **To identify more evidence needs and commission research** | ➢ Identify more evidence needs<br>➢ Commission research on the evidence gaps |
| **To monitor trends in diseases and pest attack progression** | ➢ Look for occurrence, the spread and the trends in both the hosts and the pests<br>➢ Monitor trends in diseases and pest attack progression across the country |
| **To inform policy advice or statutory action** | ➢ To report back to the Government (GB/ and devolved administrations)<br>➢ To take decisions on current statutory policy with regard to disease management<br>➢ To inform internal policies with respect to quarantine pests<br>➢ To support policy development |
| **To provide guidance and communication** | ➢ To communicate with the public or govt. bodies regarding the identified pest/diseases<br>➢ Report to relevant authorities<br>➢ To inform member groups (e.g. Royal Horticultural Society members)<br>➢ Follow up anything that's relevant to our plant health leads<br>➢ Plant health notice board<br>➢ Disseminating information in interpretable ways to stakeholders<br>➢ Inform the design of public engagement<br>➢ Prepare communication material for Defra<br>➢ Communicate to practitioners |
| **Manage Imports, Inspections and domestic certifications** | ➢ Inspections of the quarantine material & of non-controlled materials that might pose a risk<br>➢ Target inspections at places of high risk and potential for faster spread<br>➢ To check imported material |
| **Justify spending on tree health issues** | ➢ To help make better decisions about how money is spent in tree health sector as compared to other priorities. |

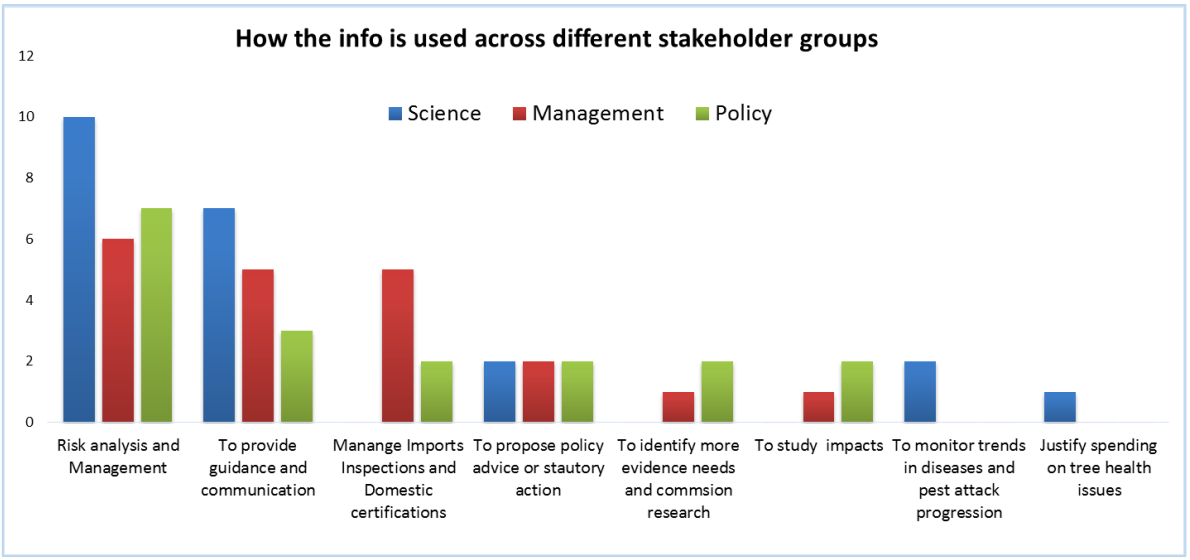


**Figure 3.** Current use of tree health evidence used across stakeholder groups

## Challenges in acquiring information

Participants were asked to articulate the different challenges and barriers in acquiring information and data to meet the needs of their work (**Table 3**). Access to data came out as the most frequently cited challenge, followed by limited resources (financial and time), and limited availability of expertise or experts working on tree health:

> *"I think access to information is probably the key issue. We don't know where to find things quick and easy, so you have to go back to Forest Research. They are under a lot of pressure so it's trying to get the right people at the right time; it takes a bit of time." (Management)*

> *"There is no end to the amount of knowledge that we need; the question is just how accessible it is, and what it would cost to get it." (Science)*

> "Another issue is the availability of expertise. If we're focusing particularly on tree health, then we're very reliant on experts in the Forest Research Agency who are excellent technically, but they have a range of responsibilities and only one of those responsibilities is to contribute to the pest risk analysis that we seek their input on. So it means they're being spread very thinly and it means that they're not always able to meet some of the deadlines that we set for the production of pest risk analysis." (Science-Policy-Management)

Other barriers mentioned were: reliability and robustness of data, barriers in gaining trade and industry information (especially related to the movement of plant material within Europe), reluctance by industry stakeholders to report pests and diseases due to concerns about possible trade impacts, institutional barriers and lack of trust among different organisations, and a general lack of information. Communication challenges were mentioned by some respondents, in particular

how to communicate information to different stakeholders and the reluctance of people to be contacted for follow-up enquiries.

**Table 3**: **Challenges or barriers in acquiring the information**

| **Challenges or barrier in acquiring Info** | | **Details** |
|---|---|---|
| **Data & Information** | Data Accessibility | ➢ Not knowing where to find the information<br>➢ Reports disappear in the black hole<br>➢ Reports are available but drilling into them for more info is difficult<br>➢ Challenge to find the latest information<br>➢ Locating, finding and interpreting the research<br>➢ Availability of data<br>➢ Accessibility of data that is not free |
| | Robustness and reliability of Data | ➢ Quality, robustness and reliability of data<br>➢ Different mechanisms of collecting and storing data leading to incoherent databases<br>➢ Challenges in terms of refining the data to get clear and accurate reports<br>➢ Fragmented reports across Britain, Wales and Scotland<br>➢ Getting high quality habitat mapping is a challenge<br>➢ Huge amount of uncertainty to deal with while doing tree health modelling |
| | Lack of Info | ➢ Lack of information because the work hasn't been done or the evidence just hasn't been produced for e.g. in case of a new pest |
| **Project Management** | Availability of expertise or limited expertise in the area | ➢ Limited expertise in this area<br>➢ Very few people able to interpret the research/data<br>➢ Challenge about making sure there are enough people coming through the pipeline i.e. more people are brought into this profession |
| | Limited Resources (time and cost) | ➢ Takes time to build good evidence, particularly on the natural science side that can have a longer timescale especially if you're testing or piloting something<br>➢ Cost of accessing the information or gathering evidence<br>➢ Limited resources to carry out the scientific work |
| | Institutional barriers, | ➢ Lack of trust and communication between organisations<br>➢ Complexity of the range of stakeholders<br>➢ Tree health and plant health is still slightly disjointed and need more improvement in terms of working together |
| **Trade** | Information from the Industry, EU trade | ➢ Very little information on EU trade as it is not regulated. Little information available on how plant material moves through the EU and of where it ends up<br>➢ Trade bodies not paid to provide government with information<br>➢ No compensation systems in plant/tree health for traders<br>➢ Private companies tend to be reluctant to share their information |

| Challenges or barrier in acquiring Info | | Details |
|---|---|---|
| | Reluctance of reporting due to possible trade impacts | ➢ Countries may be reluctant to report the presence of something because of the impact that it might have on their export trade<br>➢ Reluctance of importers to be honest about or to inform the authorities of trades coming in |
| **Communication** | Reluctance of people to be contacted again for a follow up | ➢ People submitting the report don't want to be contacted |
| | Communication Challenge | ➢ How to get the information to the land managers and forest owners |

Resource constraints and issues concerning robustness and reliability of data were expressed more by policy and science groups and less by the management group. Challenges of receiving information related to imports and EU trade was most articulated by the management group. Communication challenges were found to be most prominent amongst the management and policy groups, while institutional barriers and trust issues were emphasised by the management and science stakeholder groups (**Figure 4**).

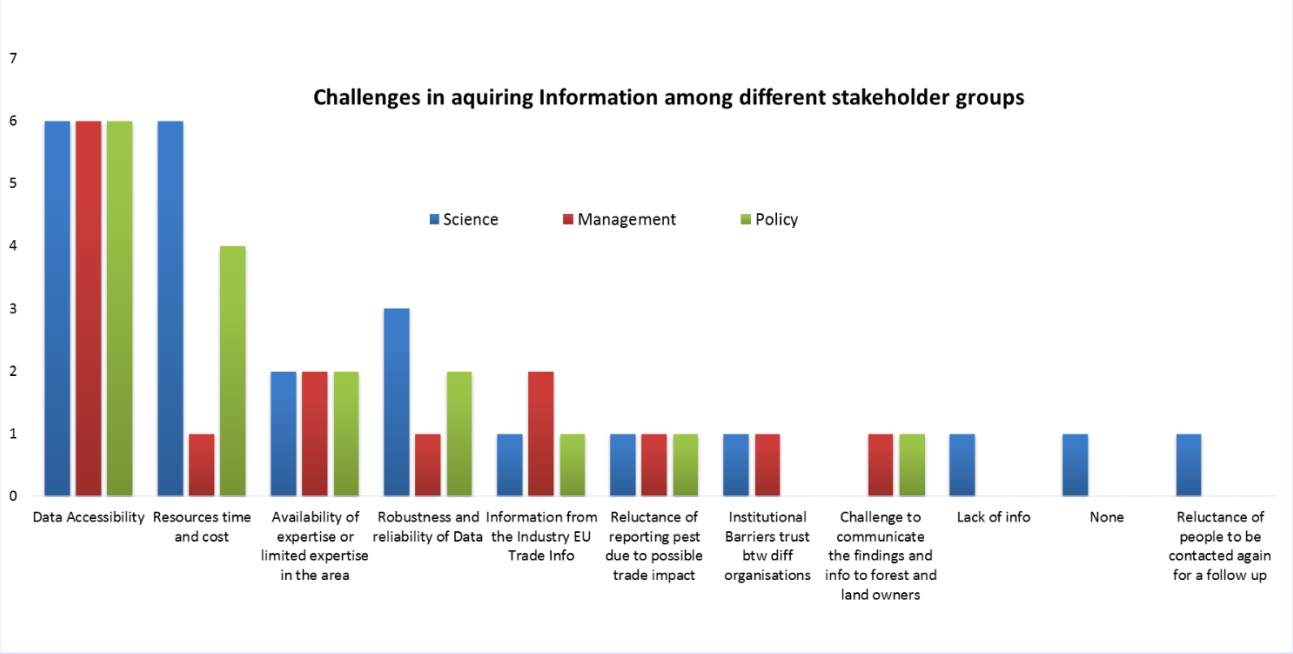


**Figure 4.** Challenges in acquiring information across different stakeholder groups

## Additional evidence needs across tree health science, management and policy

The interviews also explored what additional evidence is required across tree health science, management and policy (Table 4). The participants expressed the need for more information about: species (hosts and pests), the movement of plant material within the UK and across EU, pest and disease impacts, pest distribution through surveillance, and pest distribution data owned by private companies:

> *"We don't have good information on the non-regulatory diseases and pests that are out there." (Management)*

In addition, there is also a need to have more evaluation to understand the effectiveness of previous / existing policy and management, social science data on the current stakeholder landscape, and improved understanding of people's behaviour and attitudes and the impacts of behaviour on risk pathways:

> *"The thing that I find a real huge challenge is measuring behavioural change, which is always difficult….But that's something that I still don't think anybody has managed to measure properly yet." (Management)*

A need for a single reporting system was expressed by many participants, as well as access to hand held devices to gather information, up to date satellite imagery and upgraded systems to allow data capture through smartphone applications as well as from web-based applications. More evidence is also required in terms of the analysis of the relationship between consignment size and the risk level, analysis of how information is cascaded during an outbreak and how risk is mitigated and managed across different countries. A few participants mentioned that there is no need for additional information as such and that we need to learn to use the existing information in an efficient manner:

> *"I think at the moment the key challenge is to reflect on what we've already done. It's been a flurry of funding I think, in the last four years, So it's very difficult to get a handle on what evidence has been produced in the last couple of years, and what we've learnt from it." (Science)*

**Table 4**: **Additional evidence or information required**

| Additional information Required | Details |
|---|---|
| **More information at the species/habitat level** | ➢ Non-regulatory diseases and pests<br>➢ Habitat data<br>➢ How to manage forest in the light of all these health issues, what species should we be planting, what species are going to be resistant and resilient<br>➢ Information at species and cultivar level<br>➢ Taxonomic detail all the way through to epidemiology or life cycle to control and management<br>➢ Knowledge of the location of trees and how susceptible they are to those infectious agents<br>➢ Mode of delivery of the infectious agents<br>➢ Extent to which individual trees can develop certain amounts of resistance to some of these pathogens |
| **Movement of plant material within UK and across EU** | ➢ Tracking information on the movement of plants across EU<br>➢ Access to data held at private level on the movement of plant material within Europe Track and trace internet trading of tree materials |
| **One-spot reporting system** | ➢ Single source (website/portal) to obtain information<br>➢ Data sharing between different projects at one source<br>➢ One spot reporting system in place where data is accumulated from national organisations<br>➢ Need to make use of bioinformatics to handle big data |
| **Evaluation Data** | ➢ Need to reflect on what has been done already<br>➢ Understanding of what has worked and why to improve interventions and the effectiveness of interventions<br>➢ Access to the evidence that has been produced in recent years, and lessons learnt from it |
| **More understanding of the impacts of a disease** | ➢ Track the impacts of a disease, that can be used in future incidents or outbreaks |
| **Social science data** | ➢ Understanding about social impacts of a disease outbreak, and behavioural science for e.g. why people might be doing the things that they do and what does that mean then in terms of risk and risk pathways?<br>➢ Knowledge of the current stakeholder landscape and how people operate and where influences are coming from and how this knowledge can be used to inform and improve different approaches and interventions<br>➢ Understanding of what motivates people to participate in citizen science; and then using that information to inform the development of citizen science projects<br>➢ Measure behavioural change |
| **How risk is mitigated and managed across different countries** | ➢ How different European countries approach disease and pest management |
| **Data sharing** | ➢ Data sharing or acquisition from large data set companies on pest, risk and threats |
| **Access to hand held devices to gather info** | ➢ Hand held devices that might enable the industry to diagnose pests and diseases in advance in the field, before they even got to importing or exporting them |
| **Analysis on correlation btw size of consignment and the risk it poses** | ➢ Need to analyse the correlation between the size of a consignment and the risk it poses |

| Additional information Required | Details |
|---|---|
| **More surveillance pest info** | ➢ More information in terms of surveillance and presence of pests, or potential presence of pests, within Great Britain |
| **App development** | ➢ Development of apps for identification of pest, diseases and trees |
| **Access to up-to-date satellite imagery** | ➢ Access to up-to-date satellite imagery |
| **Analysis on how the info is cascaded during an outbreak** | ➢ Analysis on how the information is cascaded during an outbreak |

Analysis of stakeholder responses for each of the additional evidence requirements shows that certain types of information are given higher priority by certain respondent groups (**Figure 5**).

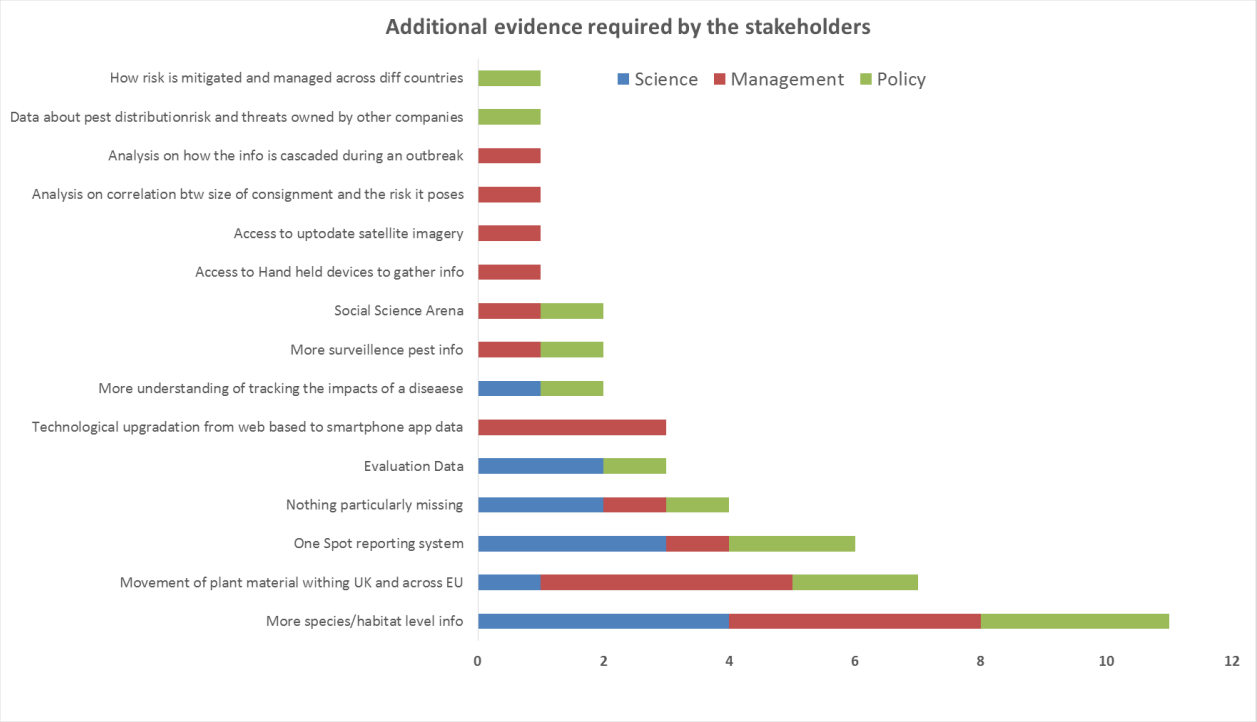


**Figure 5.** Additional information required by different stakeholder groups

## Current sources for gathering information and evidence

Participants were asked about the different sources they use to gather information for their work. A range of different sources were elicited in the interviews (**Table 5**, **Figure 6**). These sources can be broadly categorised as government, international, private, academic or research institutes, trusts / charities /Non-government organisations (NGOs), in-house expertise, participant observation and citizen science projects. In the main, participants were found to acquire evidence, data and information from government sources followed by private sources and NGOs, trusts and charities. Some of the participants also relied on in house expertise to gather tree health evidence, for

example Forest Research (FR), Forestry Commission (FC), Defra, APHA, Fera and Woodland trust. Citizen science projects such as OPAL, Observatree and TreeAlert were also mentioned as sources for gathering tree health evidence.

**Table 5**: **Current sources for gathering information**

| | **Sources** |
|---|---|
| **Government** | ➢ Forest Research Agency<br>➢ Defra<br>➢ Risk Register<br>➢ FERA<br>➢ Forestry Commission<br>➢ Government plant health services<br>➢ Scottish Agriculture Science Agency<br>➢ Welsh Government's tree health steering group<br>➢ APHA<br>➢ National Forest Inventory<br>➢ Natural England<br>➢ JNCC<br>➢ Councils, Town Halls<br>➢ Tree Health Advisory Service (Forest Research)<br>➢ Government and Inspectors<br>➢ Biological Records Centre<br>➢ Natural Capital Committee (independent advisory committee) |
| **Private** | ➢ Industry<br>➢ Blue Sky Company for satellite imagery<br>➢ Confederation of Forest Industries<br>➢ Private owners<br>➢ Nurseries<br>➢ Consultants<br>➢ Direct info from Clients<br>➢ Garden managers |
| **International** | ➢ International Evidence<br>➢ Overseas Scientific expertise<br>➢ European Plant Protection Organisation (EPPO) |
| **Academia** | ➢ Scientific and grey literature<br>➢ University/ Research Institutions<br>➢ Conferences / personal meetings / word of mouth |
| **Trust/NGO/ Charity** | ➢ Woodland Heritage<br>➢ Woodland Trust<br>➢ Kew<br>➢ RHS<br>➢ Small Woods Association<br>➢ Royal Forestry Society<br>➢ Surveys done in partnership with NGOs |

| | Sources |
|---|---|
| **In house expertise** | ➢ FC<br>➢ Defra<br>➢ Forest Research<br>➢ Fera Diagnostics<br>➢ APHA<br>➢ Woodland Trust |
| **CS project** | ➢ OPAL<br>➢ Observatree<br>➢ TreeAlert |
| **Participant Observation** | ➢ Participant observation<br>➢ Stakeholder participants for research |
| **Other** | ➢ Forest centres<br>➢ Internet and email |

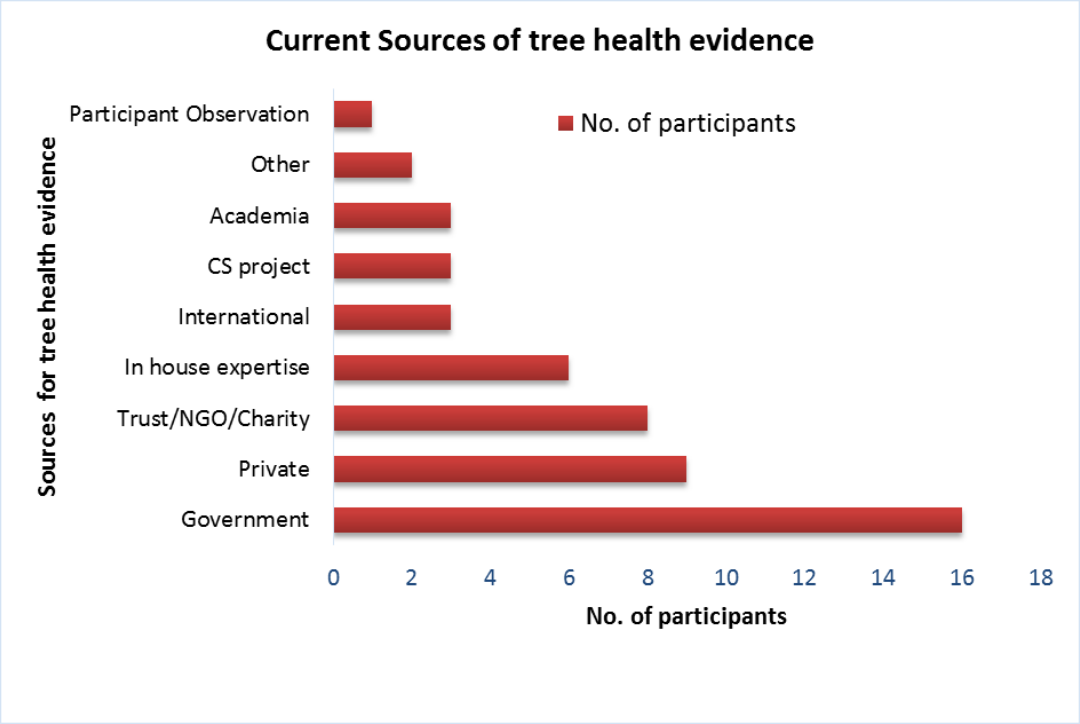


**Figure 6.** Current sources for gathering tree health evidence

## Satisfaction and scope for improvement in the tree health evidence sources

Respondents were asked about how well the current sources meet their evidence needs and whether there is a need for improvement. Most of the respondents said that the current sources of

information met their evidence needs (35% indicating good and 30% indicating sources meeting their evidence needs as very good but can be improved):

> "I think the information sources are probably - they could always be improved but I don't think there is the bottleneck… but I think the main issue that I am often dealing with is the lack of information rather than its accessibility or its presentation." (Management-Science)

The other 7% thought that the sources could be better in future. Fewer found the question difficult to answer while 5% of the remaining respondents thought the sources met their needs poorly. Some of the respondents indicated that their level of satisfaction about the information sources depends on factors such as the type of pest, and the availability of resources, such as time and cost (**Figure 7**):

> *"So there is no end to the amount of knowledge that we need; the question is just how accessible it is, and what it would cost to get it." (Science)*

78% percent of the participants felt that there can be improvements in the sources:

> *"So, it's making sure that information is accessible and presented in the best possible formats…. there is probably scope for us to be a bit more innovative about how we approach that stage, sort of, dissemination of findings and things." (Policy)*

20% did not feel any need for improvement. One participant did not answer this question as it was not relevant for their work (**Figure 8**).

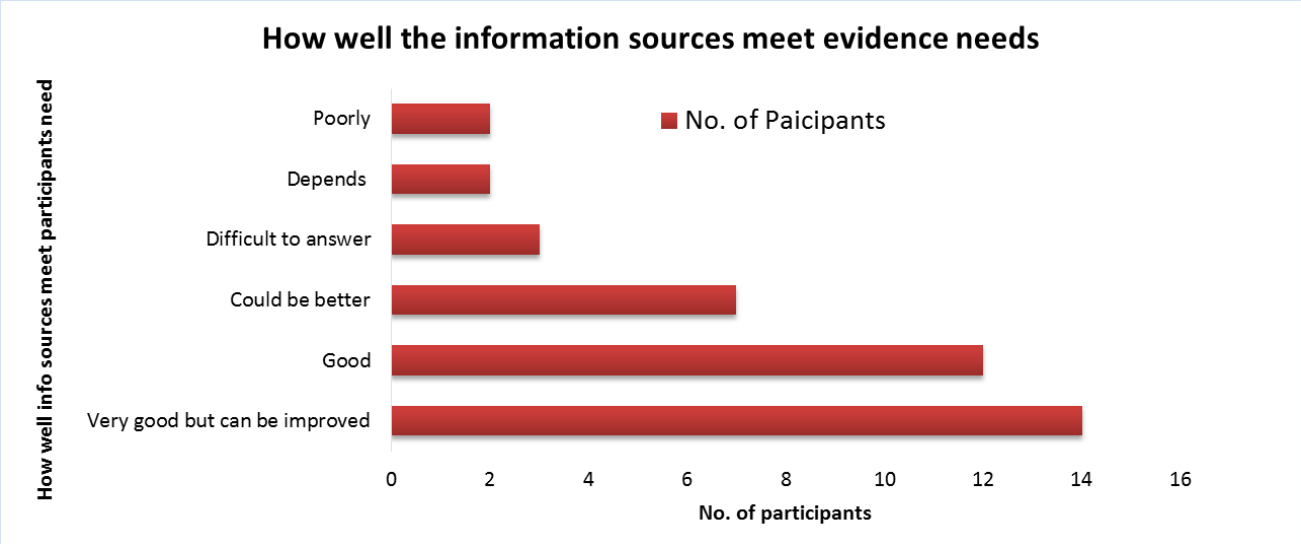


**Figure 7.** How well the information sources meet tree health evidence needs

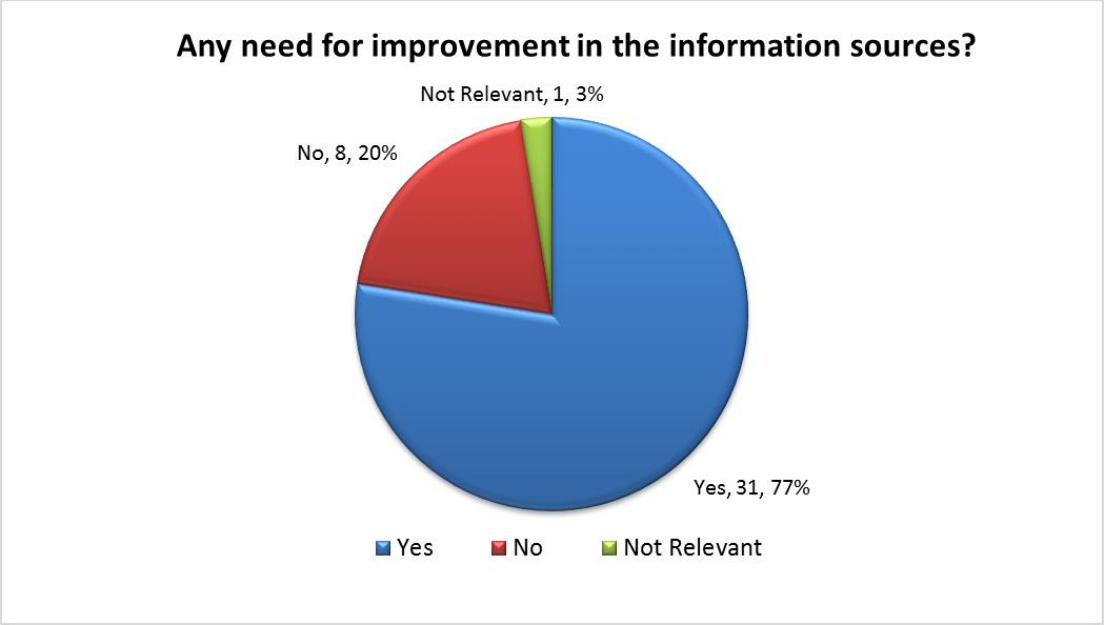


**Figure 8.** Opinion about the need for improvement in the information source

In terms of improvement with or in the current evidence sources, participants envisaged improvements mainly in four areas: *Data and information; project management; trade* and *communication* (**Table 6**, **Figure 9**). Most participants highlighted the need for improved availability and accessibility of data in the right format and usable form:

*"I think, and also we get a lot of information and you have only got so much capacity and time to, kind of, digest that. So, it's making sure that information is accessible and presented in the best possible formats." (Policy)*

**Table 6**: **Improvements in evidence sources**

| **What Improvement is required** | | **Details** |
|---|---|---|
| **Data & Information** | Access to the info | ➢ Information accessible and presented in the best possible formats<br>➢ Need for a central repository or system where we have all the info<br>➢ Precise and clear presentation of the information |
| | Data in right format or usable form | ➢ Consistency on data reporting<br>➢ More joined up linkages btw different agencies for data sharing<br>➢ Information presented in simple words that can be understood by layman |
| | Need more species-level data | ➢ Need to address information gaps at the species level for e.g. more understanding of the distribution of different species of trees, especially in non-woodland environments<br>➢ Broaden the scope of risk register from just pest based to more species and geographic level |
| | More volume of research and or research publications | ➢ Need more volume of literature and information in the area |

| What Improvement is required | | Details |
|---|---|---|
| | Research on lessons learnt and the origin of the disease | ➢ Research and analysis on how the disease got introduced into the system, what lessons have been learnt from the previous outbreaks |
| | Better understanding of social science aspects of tree health issue | ➢ Better understanding of social science aspects of tree health issue |
| | More statistical analysis of the evidence to inform future actions | ➢ More directed statistical analysis of the evidence that we already have |
| | Updated Info | ➢ Updated country side survey/ maps |
| **Project Management** | More cohesion among different projects on TH or btw government departments | ➢ Improve and streamline the channels for more efficient and effective information sharing<br>➢ More linkages between different tree health projects<br>➢ Greater connection between scientific researchers and forestry practitioners |
| | Timely Delivery | ➢ Quick dissemination of information<br>➢ Timely availability of the data |
| | More budget for more research | ➢ Additional funding for fundamental research<br>➢ Bigger plant health team with more budget |
| | More manpower or contractors | ➢ More contractors or trained officials to do detailed site monitoring |
| | Improve the detection of new pests | ➢ Improvise detection techniques to find outbreaks at an early stage |
| | Adopting from international models | ➢ Replicate and adopt from international models on public awareness about threats e.g. Australia |
| **Trade** | More info about what's coming into the country | ➢ More information about what is coming into the UK<br>➢ More information on the mail orders from third world countries |
| **Communication** | Create more awareness about the issues to wider audience | ➢ general public should be made aware of these issues as well |
| | More clear advice at the beginning of the outbreak | ➢ Clear advice at the beginning of an outbreak |

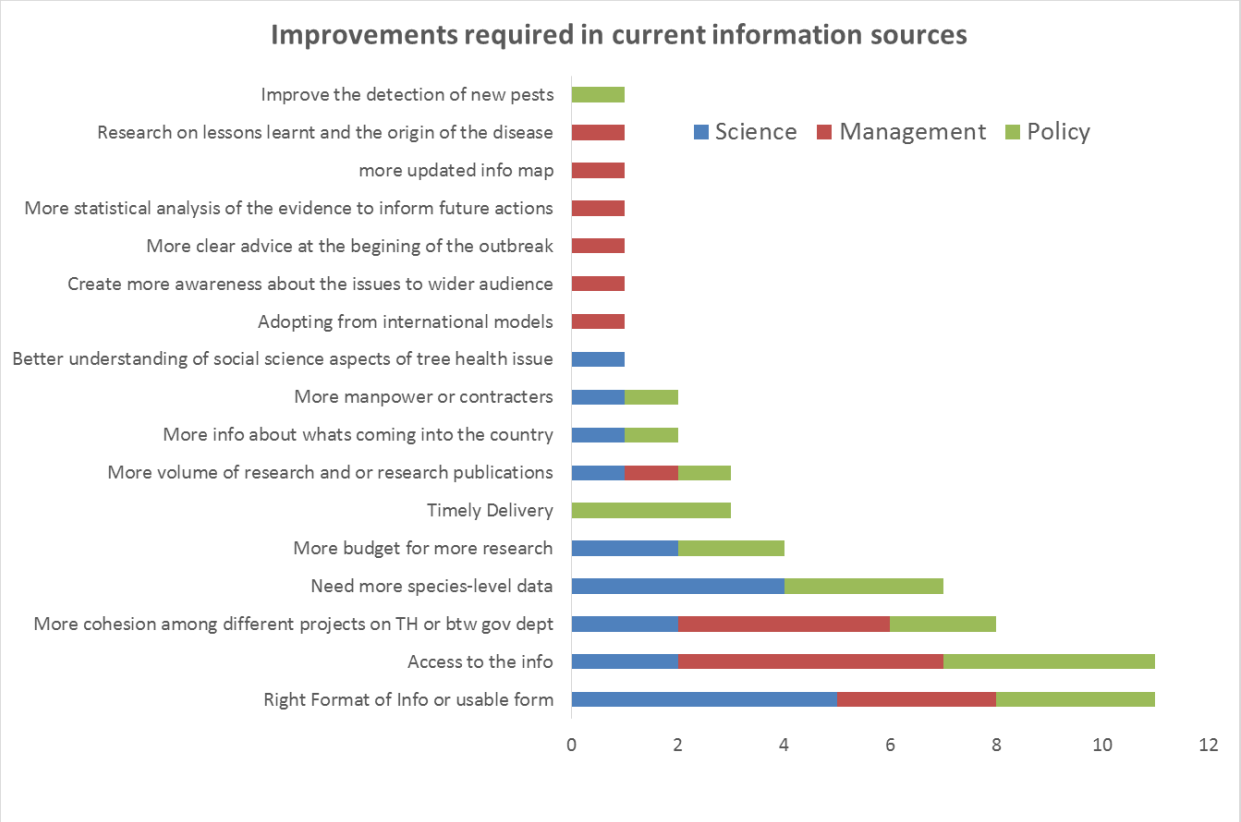


**Figure 9.** Improvements required in evidence sources across different stakeholders

## Citizen science: experience, awareness and future use

All the participants were aware of the term CS and the use of CS approaches. 90% had experience working with or on a CS project. Among the different CS projects known to them, participants mentioned a few tree health and non-tree health CS projects. Out of the tree health CS projects, Observatree was known to most of them, followed by OPAL (Open Air Laboratories), Tree Alert, Ashtag, Conker Tree Science, and the Longhorn beetle pheromone trial project.

Participants were asked about the scope of CS in providing them with additional or improved information to support their role in dealing with tree health issues (**Figure 10**). Thirty-four participants affirmed that CS can play an important role:

> *"It can be quite rapid if it is organised well and I mean IT based. And if you do train people and keep them interested you can achieve a substantial amount... So, you know, there is obviously good potential." (Science-Policy)*

> *"Citizen Science isn't exact and it doesn't have the same kind of robustness that, you know, formal science would have. And I think we do recognise that... I think you can take a lot of the noise out of that and it starts to give you a very clear picture of what's happening across the country. Which you wouldn't be able to do or fund through your normal science programmes." (Science)*

Two respondents said that CS cannot play an important role (for one respondent it was not useful in imports from third countries and for the other it was not a useful approach in general):

*"No I don't think so actually, because my role is very specifically about imports from third countries, so I'm not sure in terms of import controls I think we are the people who need to do that." (Management)*

Other two respondents said that CS cannot contribute directly (as their current job profile does not require the use of CS) and one respondent said it is too early to judge whether citizen science has made a significant contribution:

*"it can obviously make a contribution but I think the discussion around whether the significant investment in training and informing and liaising with lay citizens, let's say that, to what extent that investment is the most effective way of spending resources, I think that we don't have a scientific answer yet." (Science)*

The potential use and application of CS in the future was also explored in the interviews. The majority of the participants (N = 36) were positive in terms of their understanding of the role of CS to support their work:

*"I think the Observatree project is a very worthwhile one to pursue and I would think that there will be a significant contribution but that's me hoping and it's me crystal ball gazing. I don't have the evidence to say categorically the case is true... You asked me do I believe we should do and the answer is yes we must, we must take this route until such time as we realise that it clearly isn't delivering what we want it to." (Science)*

'Well, currently the collection of data, they do that already, and I think they are very effective at doing it in…you know, they can collect large amounts of data. It can be relatively low quality data, but because you're collecting large amounts of it, then you can interpret it, based on quality criteria. In terms of the analysis, I would be quite careful about using citizens in the analysis of data." (Science)

"Well, I think I have hinted that we are now using citizen science more than we were previously, and I mean that has been a huge benefit." (Science-Policy)

Three participants said they would not consider using a CS approach:

*"No, I don't think so actually, because my role is very specifically about imports from third countries, so I'm not sure in terms of import controls I think we are the people who need to do that." (Management)*

*"Hopefully no I wouldn't. If I had the opportunity or the resources, I would rather take a qualified and trained scientist" (Science)*

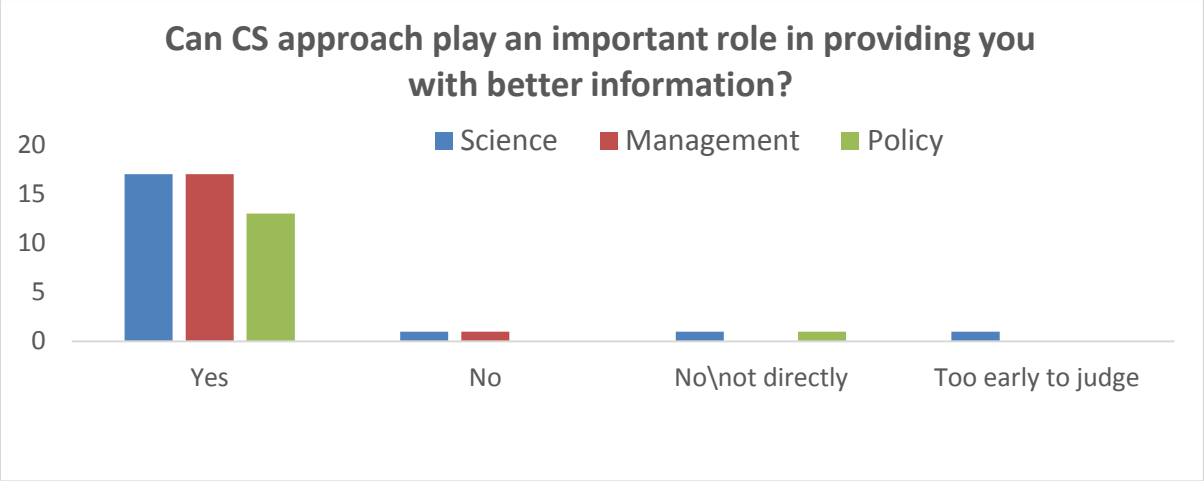


**Figure 10.** Stakeholder opinion on whether CS can provide them with better information

## Potential players in a citizen science project

Respondents were asked about their opinion on who all should participate in a CS activity. Involvement of a whole range of different actors was thought to be important for carrying out a CS project, ranging from trained volunteers, general public, academia, and NGOs (**Figure 11**). Trained volunteers or people belonging to special interest groups were the most cited among the interviewees:

> *"So, from a tree health perspective you have got to have a, kind of, basic level of technical expertise in order to undertake citizen science. So, for example you have got to know what different types of trees are." (Policy)*

> *"Looking for tree disease, I think, is a harder one to sell almost… you will probably get better bang for your buck in terms of having to process that data and everything else having that expert group." (Science-Policy)*

> *"I think it's a very difficult ask to get people to learn 20 or 30 different tree species and then look at what an unhealthy tree might look like or what might be unusual. If you've got someone that's got a lifetime of knowledge of trees, then it's quite easy to add in the bit about looking for pests or disease. So, it's easier for the volunteer, because they're building on existing knowledge and it's easy for the manager, because you're not starting from scratch." (Management)*

Many respondents felt the need to have a case-by-case assessment to decide who should be involved in the process, the argument being that it is too difficult to generalise who should be involved in the CS projects and should be dependent on aim of the project, the activity that needs to be done, the pest involved, and the target audience, as all of these would decide the different profiles of people who should be involved in a given CS project:

*"Yeah. And in my head, there's really a sort of landscape map of citizen science projects, and we shouldn't be trying to make them all do the same thing; we should be recognising which ones are valuable for what purpose." (Policy)*

"I think it's very much a case by case type of assessment. So, it's really about what information a group can, or an activity bring, and does it meet the requirements that we have to answer the questions that we are trying to answer?" (Science-Policy)

Some respondents were of the opinion that anybody with genuine interest in the issue could participate in a CS project. Few also stressed the importance of the involvement of academia (schools and universities) in citizen science activities. Individual responses favoured the involvement of farmers, urban population, National Plant Protection Organisations (NPPOs) and ministers.

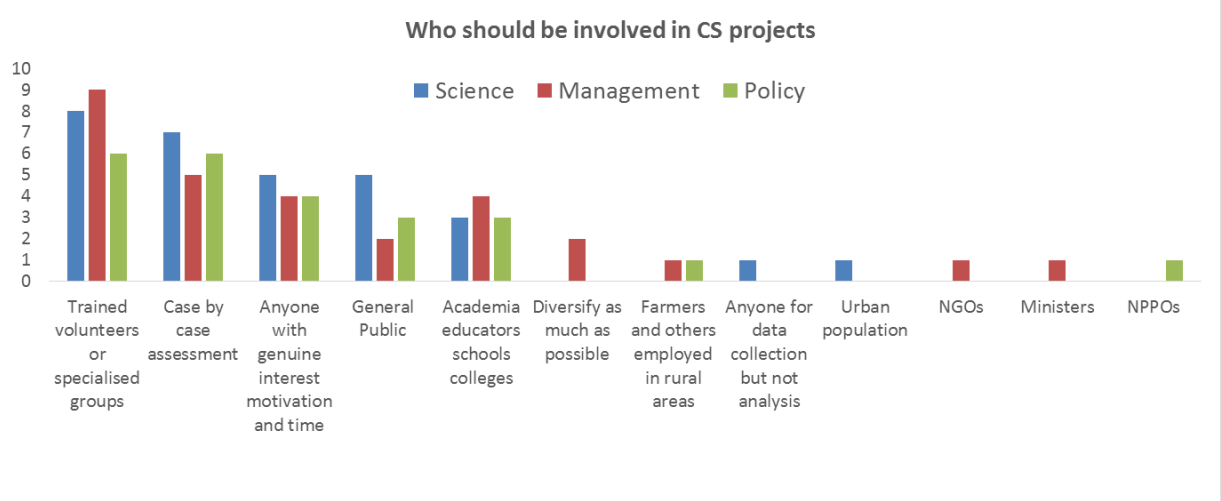


**Figure 11.** Stakeholder opinion on who should be involved in a CS project

## Citizen Science: Advantages, Benefits & Opportunities

Respondents were asked to identify the advantages and opportunities of using a CS approach. These can be broadly classified into *data and information* related benefits, *resources* benefits, *engagement* benefits and a potential to act as a mitigation tool for preventing future outbreaks (**Table 7**).

Data and information related benefits included availability of more people looking out for tree pests and diseases, providing more 'eyes and ears' and also allowing for data collection across wider geographical areas:

"we shouldn't underestimate the power of citizen science…so there are huge numbers of protocols that we can put in place, and people will volunteer for, and you know, if they have that interest and passion, we will get excellent data from those projects." (Science-Policy)

CS can positively contribute to early warning systems, detection and surveillance:

> *"The UK maybe has two hundred plant tree health inspectors, and you know, if that's sufficient to keep this country free of pests and diseases, the answer is no. So, the idea is can you increase that number to two thousand by bringing in a, sort of, a volunteer army of trained, but amateurs, to help you with that surveillance?" (Science)*

Also, CS presents an opportunity to do research on social factors such as motivations and interests of the general public participating and also the potential for collecting additional data through the volunteers:

> *"So, you know, it's understanding some of the subtleties and…of why people get involved in things and just because somebody may have been on a training course doesn't mean that they're necessarily going to do what you think they're going to do. So, if…I think an opportunity through citizen science is sort of opening that up to understand that people don't experience the world in sort of spatial or economic models." (Science)*

In terms of resources, some of the most notable benefits of doing a CS project are to overcome resource pressures of cost, time and limited manpower:

> "Citizen Science is happening all the time, even if it's not through one of these more formal mechanisms. It's really helpful to have given how stretched resources are, particularly within, you know, government bodies these days it's very useful if we are to have a wider network of people who are trying to help spot these issues." (Management-Policy)

Some respondents felt that CS also allows offers opportunities to tap into the expertise and experience of volunteers who sometimes have more knowledge in the field than officials.

A large number of engagement benefits were also found to be associated with CS. Participants largely considered that CS presents a platform for public engagement, participation and raising awareness around tree health and environmental issues and also allows them to appreciate their surroundings and environment:

> *"So, I think it is a big advantage, because it engages more people with the issue and people are very interested and wanting to do something practical to help." (Management)*

> *"I think the huge advantage of citizen science is just getting people aware and interested in the world around them, and valuing their local environment, and wanting to look after it…turning a disengaged public to an engaged public, I think, is the main value of citizen science." (Management)*

> *"I suppose, I mean, to do it you have to get people walking outside and therefore you have some sort of health and wellbeing kind of positives as well." (Science)*

One of the benefits of CS is also that it could be perceived friendlier than the official visits for tree health inspections and, therefore, might have advantages in terms of data collection.

Another benefit associated with CS approach is its potential to be used as a mitigation tool for preventing future outbreaks:

> "I think another area….we haven't really explored this very much, is whether we can use citizen science to prevent outbreaks. For instance, can we use citizen scientists to look beyond our borders and look for potential to add what people could, for instance, bring homes from their holidays [sic]? Could we work with many more formal sort of groups like industries or landowners or special interest groups and work with them to help detecting plant health?" (Science-Policy)

**Table 7**: **Advantages and opportunities associated with CS approach**

| | Advantages of CS | Details |
|---|---|---|
| **Data & Information** | More people looking | ➢ More 'eyes and ears' on the ground<br>➢ Being able to carry out very large-scale projects over a relatively short period of time<br>➢ Data collection in areas where inspectors aren't routinely engaged in |
| | Early detection, surveillance and monitoring | ➢ CS provides critical monitoring and surveillance resource<br>➢ Can be used for early warning system, detection & surveillance<br>➢ CS can help to supplement or complement official surveillance |
| | Valuable way to collect information | ➢ Useful approach to collect data |
| | Wider geographical coverage | ➢ Allows for wider geographical/spatial spread<br>➢ Provides greater human resource to cover the ground<br>➢ Allows for better geographical, representational, temporal representation |
| | Potential for volunteers to do beyond reporting presence of diseases | ➢ Potential to provide a full range of data from presence surveys to reporting more details for e.g. biology and life cycle of the pest and host species |
| | Greater confidence in dealing with absence of pests | ➢ Provides greater confidence in dealing with 'absence of disease' when it is not reported by large number of volunteers |
| | Research opportunity to study public awareness on tree health and their motivations | ➢ Opens up conversations about science and society<br>➢ Allows for understanding and analysis of people's motivations and capabilities required to participate in a CS project |
| **Resources** | Overcome resources pressure and cost saving | ➢ Overcomes surveillance pressure<br>➢ Overcomes government's limited funding in tree health sector<br>➢ Provides support to the government's inspection services that are limited by resources |
| | Tap into volunteer experience and expertise | ➢ Potential to use knowledge and expertise of the volunteers<br>➢ Some volunteers are more knowledgeable than professional inspectors<br>➢ Potential to have more competent volunteers collect as well analyse the data |

| | Advantages of CS | Details |
|---|---|---|
| Engagement | Public engagement and participation | ➢ Enhances mass participation and engagement |
| | Generate positive public perception and awareness | ➢ Generates enthusiasm among the general public on tree health issues<br>➢ Raises public awareness on plant health risk, tree management issues and environmental issues in general<br>➢ Potential to improve bio security measures in the future<br>➢ Initiative to involve the next generation and increase their knowledge about tree health issues |
| | Good way to enable people to appreciate the environment | ➢ Health and wellbeing benefits<br>➢ Enables general public to appreciate the environment<br>➢ Allows people to get more connected with nature<br>➢ Long-term gains such as people appreciating of the value of the natural environment |
| | Build future scientists and community advocates | ➢ Citizen scientist could become trainers or advocates in their communities for people to get involved in CS activities<br>➢ Volunteers could disseminate messages about biosecurity and behaviour in terms of purchasing plants and trees, and walking in woods<br>➢ Likelihood or potential of people involved in citizen science through school projects becoming field scientists of the future |
| | Perceived to be more friendly than official visits on land | ➢ Volunteer visits perceived to be more friendly than official visits for tree health inspection |
| Mitigation tool for preventing outbreaks | Explored as an option for prevention of outbreaks | ➢ Potential of CS for preventing outbreaks by involving them to look beyond borders to explore what people bring from their holidays<br>➢ Potential to involve industries, landowners or special interest groups to work together in identifying and addressing tree health issues |

## Citizen Science: Disadvantages & Barriers

During the interviews, respondents were also asked about the barriers and disadvantages of CS spanning the following categories: *data and information* related concerns, *project management* challenges, *lack of understanding about CS* and *legal* issues (**Table 8**). Data quality, analysis and validation were the most cited concern across the different stakeholders:

> "I think that perception of problem…or that citizen science isn't giving high quality answers is shifting, but it is still a barrier." (Science-Policy)

> *"Major barriers we have on the citizen science side of things is the data quality and verification of the records, and I think that's a common thing with citizen science projects." (Policy)*

Also, the tree health system was feared to be swamped by false reports and there is a huge amount of effort and manpower that is required to analyse and validate the data. In terms of managing CS

projects, the biggest challenges were associated with maintaining the motivations, interest and enthusiasm of the volunteers, volunteer retention and, thereby, safeguarding the huge amount of resources and time that goes into training volunteers and setting up the project:

> *"You need to manage them [volunteers] if you're going to do it … you retain their enthusiasm, motivation and, you know, the quality of the information they're collecting. So that requires management…good communication…It requires finding ways to motivate them either through highlighting successes that they'd had….or through formal get-together sessions where they can share experience and that sort of thing, so it's not without cost. And I think that has to be recognised." (Science)*

> *"There aren't that many barriers I can see really other than the fact is that when you do set up citizen science initiatives, quite often there is a lot of effort put into setting them up in the first place and it's just maintaining the momentum of what you had when you started off and the enthusiasm for the groups and to keep things growing." (Management)*

> *'If you want citizen scientists to go out and find tree problems, once they understand that a potential consequence of their citizen science is that the tree gets chopped down… they might not be terribly enthused with that idea in that they are the ones that found it and led to the, not only that tree, but sort of a radius of 100 meters or whatever it is, they all get chopping down as well…it provides them with a negative incentive to actually find something. (Science)*

Concerns around the geographic bias posed by volunteer activity and uneven volunteer recording across UK was also discussed. Challenges surrounding project co-ordination, adequate staff, different personalities of the volunteers and communication expectations among the different actors involved in the project were also articulated:

> *"I think there is sometimes some risk that it could potentially overwhelm the organisation if it was very successful and a lot of people became engaged in it, they could present an awful lot of feedback that then you have to deal with, so you've got to be careful of the scale of it I suppose." (Management)*

> *"In terms of the public giving us information to support our work or to do some of our work, I don't think that's realistic for imports." (Management)*

> *"You create perhaps an expectation of successful intervention. So, you have to say if you see this, report this and the implication is that something will be done about that and so you have to be careful about expectations are created." (Policy)*

Some participants also raised questions and doubts on the definition of CS and cautioned that it should not be conceived as being just an exercise in gathering data without any application to scientific research. In addition, CS could get a bad name if it's perceived to be a cheap way of collecting data:

*"It is not a cheap way of getting data, it is a way of collecting information from a mass participation audience but it is not necessarily cheap because to do it properly you have to have the resources to be able to collect or inspire to collect, to handle, to process and to reflect back that data. And that maybe as expensive as paying a researcher to go out and answer the same questions, it should never be even though it's the cheap alternative." (Science-Policy-Management)*

*"Second problem is it takes tremendous amount of resources to organise all that and I believe that money will be better spent on a proper scientific project or supporting a scientific institute." (Science)*

For some respondents, there is a fear that CS could be perceived to be a replacement for official surveillance. One of the areas that CS cannot contribute is the import controls and trade of plant materials. This was articulated by some members of the management stakeholder group as such activities are taken up by trained staff or government bodies (e.g. APHA). Legal challenges, such as legal right to visit someone's land and data protection were also found to be associated with CS.

"One barrier is that that data wouldn't necessarily be able to contribute to the official surveillance that's carried out in terms of our legal obligation to provide reports to, for example, the European Commission." (Science-Policy-Management)

**Table 8**: **Disadvantages and barriers associated with CS approach**

| **Barriers/concerns and disadvantages of CS approach** | | **Details** |
|---|---|---|
| **Data & Information** | Low data quality | ➢ Perceived by some to produce low quality data<br>➢ System could break down because of the sheer volume of reports<br>➢ Technical challenges to identify species<br>➢ Risk of being swamped with spurious reports |
| | Data analysis and validation | ➢ Create lot of data with no meaningful interpretation<br>➢ Need to have a validation/verification step<br>➢ Chances of misidentification |
| | Trust issues with CS Data dealing with confidence of absence | ➢ Doubts around how sure we can be when volunteers do not find anything |
| **Project Management** | Retaining motivation, interest, enthusiasm and number of volunteers | ➢ Turnover and retention of volunteers is a challenge<br>➢ Challenges in maintaining interests, enthusiasm and motivation of the participants.<br>➢ Participant fatigue can occur when relying on few sets of people<br>➢ Final intervention of spotting an infected tree is it being cut down, which in turn provides a negative incentive for volunteers |
| | Resources and effort in training volunteers and setting up projects | ➢ Time, money and effort to train people<br>➢ Lead to huge waste of money and time if not done properly<br>➢ Challenges with partnerships in the project that can lead to longer timescales for achieving success |

| Barriers/concerns and disadvantages of CS approach | | Details |
|---|---|---|
| | Location of volunteers & Geographic Bias | ➢ Missing data from rural areas as volunteers tend to be around urban areas<br>➢ Geographic bias lowers the value of the data as when have done using randomised sampling |
| | Project management constraints | ➢ Challenges around communication with volunteers asking them to report pests<br>➢ Challenges around communicating expectations of managers and volunteers. Volunteers may report something and expect a response while manager receiving the data may have no intention of providing a response or taking immediate action (for e.g. cutting a tree)<br>➢ Limited staff to respond to public query<br>➢ Limited resources available to local authorities<br>➢ Confusion and lack of coordination could occur if volunteers are using different methods for data collection and analysis |
| | Not very helpful for import controls and official inspections due to statutory obligations | ➢ CS not very helpful for managing import controls and traded materials |
| | Definition of CS | ➢ No clarity on the definition of citizen science<br>➢ Scientific question is often not clear or well designed |
| | Right kind of technology to engage volunteers with | ➢ Accessibility to right technologies to enhance volunteer engagement |
| | Less number of volunteers in certain locations | ➢ Few volunteers participating from certain locations for e.g. Wales and Yorkshire |
| | Unclear at the moment how people are contributing to science | ➢ Unclear from the CS projects so far to what extent volunteers are contributing significantly towards scientific research |
| | Different personalities of the volunteers | ➢ Challenges around volunteer reliability for active participation<br>➢ Incidents of volunteers not behaving in professional manner |
| | Creating an expectation of successful intervention | ➢ Accountability issue towards participants to show them the result<br>➢ Create an expectation of successful intervention |
| **Lack of understanding about CS** | Gets a bad name as it is perceived to be a cheaper way to collecting data | ➢ Sometimes, CS gets a bad name as it is perceived to be a cheaper way of collecting data |
| | Perceived to replace official surveillance | ➢ Concerns that volunteers should not be thought to have the same level of training and aptitude as that of a professional tree or plant health inspector<br>➢ CS could be perceived by the general public an initiative to replace official surveillance activity that the government was supposed to do |
| **Legal** | Legal issues with data and land access | ➢ Legal permission required to go on someone's land/property<br>➢ Issues of data protection for e.g. if somebody's accessed a land owners private land and found something<br>➢ Data wouldn't necessarily be able to contribute to the official surveillance that's carried out in terms of our legal obligation to provide reports to, for example, the European Commission |

## Potential improvements for successful delivery of Citizen Science

Many participants felt that CS has enormous potential provided it's done correctly by ensuring that projects are tailored to specific needs and objectives, and by overcoming the barriers (discussed in the section above). Participants suggested improvements in five key areas to ensure successful delivery of citizen science in the future: 1. *data and information, 2. extension and capacity building, 3. project management, 4. building intelligence and understanding around CS* and 5. *Strategic issues* (**Table 9**).

High quality data that is easily accessible was felt to be crucial in delivering successful CS projects. CS data should be pooled within a central repository to ensure wide and easy access to data. In terms of management of any CS project, a number of considerations can enhance its quality. First and foremost, there has to be clear understanding of the rationale and need for doing a CS project:

> "I do find that citizen science is banded about without really necessarily thinking about what does it mean and why are we doing it. I think citizen science definitely is a fantastic methodology to get some really good data, to test hypothesis, to get people involved, but I think that it sometimes is just the wrong way around." (Management-Science)

Secondly, there has to an appropriate infrastructure (such as the right technologies) and manpower in place to support the various activities:

> *"I think that there is enormous potential for citizen science, I think it can be a really powerful tool in answering questions that lead widespread data gathering but it isn't cheap, I'm sorry to repeat this but it is my main contention, it isn't cheap, it has to be done in a targeted fashion and it has to be done properly." (Management)*

The motivations and aspirations of all the different participants in a given CS project need to be considered and effective communication should be in place to maintain their motivation:

> *"So, we do have to take into account, you know, their expectations and feeding back to them and communicating with them and I think that is a challenge." (Science)*

> *"It's also important that they (volunteers) see what happens to the data that can effect…So we need to think about how do we share and communicate the results so that they feel that… You know, a nil result is just as important as a finding, you know, it's not all about what have we found, but it's also about what haven't we found in a certain location." (Policy)*

Since most CS projects are time bound with funding for a specific time period there is a need to address the sustainability of these projects:

> *"You know, it (CS) is born, it lives and then it dies...whereas the institutional framework for…you know, if it does work, it…well is it going to keep going? Is it going to lead to some,*

*sort of, sustainable future or is it just a project? And then it all evaporates at the end of it". (Management)*

Many participants highlighted the need for evaluation of the various CS projects in the tree health sector. These evaluations would help in understanding the real value and contribution of the projects. Also, some form of external audit of these projects can be helpful in the future:

*"The whole idea of citizen science in tree health is an experiment and scientifically it needs to be evaluated in a rigorous way and we're not yet at the end of the experiment such that we can say that it has succeeded, failed, partially succeeded, partially failed and all those outcomes are possible and the ones in the middle, the partly succeeded, partly failed are no disaster because it could identify where we need to go next." (Science)*

At present development and execution of most of the CS projects have been top down and in future a more co-created approach would be more useful:

*"I think a lot of it [CS] still is top down, it's very much a contributory approach …this audience seems willing to help us, that's all fantastic but I think if we're really going to push citizen science to where it can go then we need more co-design of activities... you're actually engaging with potential participants from the very beginning because their motivations for doing something may be very different from the project." (Science)*

Suggestions also touched upon a number of strategic issues, such as future scope for including citizen science in a national voluntary response to help the government (Defra) to look for new threats.

**Table 9**: **Potential improvements in CS**

| Potential improvements in CS | | Details |
|---|---|---|
| Data & Information | Better Accessibility and sharing of CS Data | ➢ Easy accessibility of data<br>➢ Data sharing in place between different CS projects |
| | CS better for finding pests than diseases | ➢ CS more apt for finding some pests than diseases |
| | Need to build a national map of CS data with positive and negative findings | ➢ Build a national map of all the CS data including both the positive and negative findings |
| | CS should be used for data collection not for data analysis | ➢ CS use only for data collection and not data analysis |
| | Put checks or filters on the data quality | ➢ Data in a consistent format<br>➢ Integrate data with existing systems |
| Project Management | Explore real motivations of the volunteers | ➢ Understand volunteer motivations |
| | A long-term focus | ➢ Real benefits will start coming with long term volunteer engagement<br>➢ CS as a concept is very valuable. |

| Potential improvements in CS | | Details |
|---|---|---|
| | | ➢ Long term benefits of social science research and inter disciplinary work in tree health domain<br>➢ Long term advantage in terms of raising awareness and also changing behaviour |
| | Important to report the negative or problems encountered in CS projects | ➢ Useful to know about the negative reports that come in<br>➢ Good to know what people think they're seeing, as opposed to what the problem actually is to understand what people are misinterpreting and why |
| | Need to be embedded at an early stage in our education system | ➢ Embed awareness and culture change of tree health, and plant health early in education system<br>➢ Include awareness and culture change of tree health in general training for professionals in forestry or horticulture |
| | External Audit and evaluation are useful | ➢ External audit of CS projects can be useful to take stock of the current situation |
| | Clear incentives for different parties involved in CS | ➢ Clear incentives and rationale for different people involved in CS<br>➢ Sense of contribution should be conveyed to the volunteers |
| | Change the focus of what volunteers are actually doing over time | ➢ Change the focus of what volunteers are recording over time to keep them interested. For e.g. starting off mapping trees in local area and then get people to start adding extra details about them over time. |
| | Need to identify the real need or use of CS | ➢ CS should not be done for the sake of doing it<br>➢ Clear rationale for doing CS |
| | Need to identify the right tools and technology to be more confident of the results | ➢ Appropriate tools and technologies to help volunteers for recording and giving them confidence in their findings |
| | Need to address the multi disciplinarity and multi partnership side of CS | ➢ Funding comes from multiple sources and therefore connection between all the partners needs to be thought out at the beginning keeping the different motivations in mind<br>➢ The issue of tree health demand multi-disciplinary work and there needs to be a way to connect these disciplines |
| | Sustainability of CS projects have to be addressed | ➢ Sustainability of a CS project needs to be kept in mind to realise its full potential |
| | Need clear communication with volunteers and access to citizen scientist | ➢ Clear communication with volunteers<br>➢ There must be feedback at the end<br>➢ Share and communicate the results with the volunteers so that they feel that they have contributed even if they have reported absence of pest and disease data<br>➢ Need scientists to manage volunteer expectations<br>➢ Presence of a coordinator of a project who readily communicates with the volunteers and hold face-to-face meetings<br>➢ There should always be a professional point of contact<br>➢ Citizens have access to expertise whether in terms of actually meeting the scientists or the line facilities |

| Potential improvements in CS | | Details |
|---|---|---|
| **Extension & Capacity Building** | Need to share experience and expertise in CS internationally | ➢ Share experience between countries who have done work in citizen science (such as Italy, Portugal and the UK) with countries having no prior experience in CS |
| | Develop an interface between public data (CS data) and private data | ➢ Develop a model that has both the CS public data and private data that is shared between the inspectorates and regulators |
| **Building intelligence and understanding around CS** | CS projects with clear objectives and appropriate infrastructure | ➢ Right type of citizen science with clear objectives and research purpose<br>➢ Clarity on how the information and data will be used<br>➢ Capability to provide people with the necessary information to report findings correctly<br>➢ The technology has to work<br>➢ The members of the public have to be supported |
| | Top down approach of involving public in CS projects | ➢ Need to move from top down to more co created approach in doing CS |
| | Evaluation of CS projects | ➢ Tree health CS needs to be evaluated scientifically to understand its real potential and value<br>➢ More tangible evidence is required to demonstrate the value of having volunteers and justifying the funding for CS projects, and also make a case for future funding |
| **Strategic Issues** | Build CS into Defra's emergency response plans | ➢ Future scope to include CS into the national voluntary emergency response to help Defra look for new threats |

## Discussion

This chapter explored the demand for CS across tree health science, management and policy in the UK by mapping the current tree health evidence types and sources, and analysing requirements for additional, improved or enhanced evidence. After understanding the current evidence landscape in tree health, the role of CS in addressing the evidence needs was investigated, i.e. how can the 'supply' of CS be best configured to meet these demands. Interviews with a diverse range of stakeholders across tree health science, management and policy provided a range of insights related to these questions. One of the participants in this study provided a research council's perspective (see box) on tree health CS.

**Funder's perspective on tree health citizen science**

Excerpts from the interview:

- The research council does not commission research but fund research in response to applications
- 'Tree health' is very minor component of BBSRC's remit. This area of research is not one of the 'priority' areas for the research council. However, they would continue to accept applications in this area in a responsive mode
- Consultations and meetings with Defra, in the past have led to funding calls in the area of tree health citizen science research

Our results show that evidence is used for a variety of applications within science, policy and management, ranging from collecting data for horizon scanning, gauging the present situation, and proposing policy recommendations. Key areas where evidence is used are risk assessment and risk management, formulation of guidance and communication, inspection and domestic certifications and policy advice. The biggest challenges associated with acquiring information are data accessibility and data quality, time and cost, the limited availability of experts in the tree health domain, and the difficulty in securing reliable information related to trade and imports. For future work on tree health, additional information at the species-level (including taxonomic, and ecological details), import and trade related data will be very useful. A central repository of data or a one-spot reporting platform where all the tree health data can be pooled can help to address the challenges related to poor data accessibility.

Tree health evidence is collected from various sources, the most prominent being government agencies (FR, FC, Defra, APHA), trusts/NGOs/charities and private sources. Interestingly, CS also emerges as an important evidence source, indicating it's actual and potential contribution to tree health evidence. As one of the potential improvements in these sources, there is a need for more coordination between government departments working on tree health and the wide range of tree health research projects.

Even though the CS landscape if fairly nascent in the UK tree health sector, a very high level of awareness of CS was highlighted by the interviews. This could either be due to CS gaining importance, profile and recognition within the tree health sector, or due to direct professional experience of working on CS projects. There is a generally positive stakeholder perception regarding the prospects for further development of CS within tree health, indicating that there is scope and appetite to develop CS as a mainstream method for gathering and analysing evidence. There is also

general willingness among the stakeholders to incorporate CS into existing ways of working and tasks.

Regarding participation in CS projects, case by case assessment and inclusion of trained volunteers and / or specialised groups is largely favoured. For a case by case assessment to select the potential participants for a CS project, there is a need to critically look at the objectives and rationale of a given project. In cases where the objective is to collect high-quality data, more trained volunteers should be included. On the other hand, if the objective is to create more public awareness and outreach, lower levels of training and experience are required from volunteers.

A number of advantages and disadvantages of using a CS approach were discussed in this research. From the interviews, it appears that CS is not just seen as a useful way to increase the volume and geographic coverage of data collection, or an efficient way to collect information given current resource constraints in the tree health sector but is also associated with a number of societal benefits. CS can be an important tool for many tree health initiatives to raise public awareness, participation and engagement. It can help bring people closer to nature and appreciate their natural environment. Therefore, CS is much more than a way of collecting data. In future, it could be perfectly legitimate to adopt a CS approach if the broad policy objective is to raise public awareness or achieve public outreach and engagement.

Challenges around data quality and validation of results need to be addressed and appropriate infrastructure including human resources, technology and funding should be in place to ensure smooth operation of CS projects. It is important to realise that in tree health, even trained officials submit samples to the laboratory for identification. Therefore, volunteers only need to be sufficiently trained on specific pests or to know that the symptom is unusual and to submit a sample.

The interviews also highlighted issues related to a lack of understanding of citizen science. CS should not be seen as a way to replace official surveillance, nor as a cheaper way of collecting data. The biggest challenge with CS activity is to retain motivation and volunteer numbers, and this needs to be addressed as a priority. In the future, key factors underpinning successful delivery of CS will be:

- Clarity on the main purpose or objective of a citizen science project to ensure if its needs to be done in the first place;
- Good data quality and validation (done by the professional scientists) to give confidence in the results;
- Sound understanding of the real motivations of the volunteers to ensure volunteer retention and their interest in the project;

- Clear knowledge of the incentives and expectations of different participants involved in the project to ensure smooth delivery and execution of projects;
- Well defined communication strategies for CS projects.

Based on the findings of this study and stakeholder opinion on CS, areas where CS can contribute in gathering tree health evidence can be identified. Recommendations and implications for future delivery of CS to meet tree health evidence needs are:

- CS can be a useful tool to meet tree health evidence needs;
- Types of data or information that can be collected using CS in tree health sector are: scientific information on pest/diseases/host species; surveillance and spatial data; social science data;
- CS can be used to address the additional evidence needs of stakeholders by allowing more species level data collection, access to and collection of social science data, developing more understanding of the impacts of a disease or pest and the generation of more surveillance data;
- CS approach is not useful in managing imports and domestic certifications;
- CS can help in overcoming some of the barriers in evidence gathering by providing information and data in areas where there is less or no knowledge, and also by exploiting the experience and knowledge of 'expert' volunteers in the field to plug gaps in coverage by professionals;
- Trained CS volunteers can help in addressing key skills shortages in tree health sector, particularly if there are initiatives in place to develop skills to a higher level, thereby increasing capacity and capability (a Government priority set up in the Taskforce report).
- Understanding motivations of volunteers in tree health CS will enhance recruitment, ensure good retention rates and ultimately make CS projects a success

# Chapter 2

## Tree Health Citizen Science: Exploring the current landscape, opportunities, barriers and underlying motivations


### ABSTRACT

This chapter reports on the current landscape of tree/tree health citizen science projects in the UK. Interviews were held with professionals (N =26) and volunteers (N= 20) involved in five specific case studies of CS projects to obtain information on volunteer and professional motivations and experience of participation, and their views on citizen science in general.

Twenty projects were identified with an element of citizen science between 2005 and 2013, 13 of which are still ongoing. Most of the projects included an element of surveillance for Chalara ash dieback illustrating the scope of CS in addressing an immediate evidence need in response to a pest/disease outbreak. This current portfolio of CS projects provides evidence on: scientific data and information on pest, diseases and host species; surveillance and spatial data; and the behaviour and attitudes of participants. They do not provide evidence on modelling information (bio-economic or climate data); collection of strategic information (estimated costs and benefits of different management options and evaluations of the economic value of trees and how valuation can contribute to decision making at the policy level) and; information on international pest disease management; interception data at points of entry for commercial plant trade in the UK. While the first two identified gaps can be potential areas for future application of CS, for the latter, CS is not feasible or appropriate.

The evidence presented in this chapter demonstrates the importance of understanding the expectations and views of both the volunteers and professionals, which need to be taken into account in future project design. Of particular interest were the many similarities between volunteers and professionals, including a personal desire to make a valuable contribution, being appreciated for contributing something useful and worthwhile, gaining new skills and knowledge, receiving feedback, generating useful data and contributing to environmental and societal benefits.

Of high significance was the broad consensus across volunteers and professionals of projects exceeding or living up to the expectations and a desire for projects to continue in the future. This not only indicates how well the projects have fared in addressing expectations and concerns of the participants involved, but also highlights the success of these projects over a relatively short time span.

One of the biggest advantages of a CS approach identified was the number of societal benefits that can be achieved, including raising public awareness, promoting public engagement, raising the public's skill levels and understanding of science, encouraging behavioural change and fostering an environmentally-proactive society. In particular, CS projects have been very effective at engaging the next generation, and hard to reach sectors of society which are often the most impacted by environmental change, and involving people at the very local/community level.

Key improvements suggested for future project included: support to volunteers by a real person rather than by automated systems or impersonal forms of communication, volunteer training (to provide confidence in the work of volunteers and ultimately in data quality) and, the need for supporting project infrastructure to be developed and maintained. The need for improved understanding of the costs of CS projects was also highlighted. Professionals felt that their capacity to deliver initial training and provide continued support were neither recognised nor resourced adequately. The point was made that funders need to appreciate that CS is not a free or cheap option.

Finally, the sustainability of projects was also identified as a real concern with the risk that the investment in creating an engaged public, increased capacity and capability, as well as valuable project infrastructure will be completely lost when a grant ends.

## Introduction

Chapter one of this report highlighted the current evidence needs of tree health science, policy and management stakeholders in the UK and also their views on the use of citizen science (CS) in general to address the evidence needs. In the chapter, a number of benefits of CS were widely recognised across the tree health professionals. However, in order to maximise the potential of using CS approach in tree health, they also stressed the need to take stock of all the different CS projects and to understand the underlying factors influencing people's participation in such projects.

A review of the CS projects in tree health should facilitate our understanding on what has and has not worked in these projects; the impacts; outputs, benefits and the challenges associated with project participation and project delivery; and ultimately help to evaluate whether a CS approach is useful to address tree health concerns. Some of the most important challenges associated with the CS project are related to the recruitment and exit rates of the volunteers[34]. Therefore, it becomes important to investigate volunteer background, motivations, expectations and goals. To improve the effectiveness of citizen science projects and ensure their successful delivery, professionals involved in the project need a thorough understanding of why volunteers make the commitment they do and, their expectations and experiences during the project, so that they can be responsive to the needs and concerns of the volunteers[35].

This chapter aims to provide a comprehensive review of the different citizen science projects related to plant/tree health and to map perceptions of professionals and volunteers involved in CS projects on the different factors influencing their participation in the CS projects and their views on their respective projects and CS in general. Specific research questions addressed in this chapter are:

RQ.1. What is the current tree health citizen science landscape in the UK?

RQ.2. How has the current portfolio of tree health citizen science projects contributed to the evidence needs across science, management and policy in a tree health system in the UK?

RQ.3. What are the key stakeholders' capacity, capabilities and motivations associated with their participation or involvement in THCS? OR What are the factors influencing stakeholder participation and or involvement in THCS?

RQ.4. What are the benefits of CS project involvement to (a) individual participants/volunteers and (b) wider society e.g. influence tree policy, help forest and tree managers, engage people with the natural environment and science, environmental resilience, societal well-being etc.

RQ.5. What are most prominent issues and challenges of (professional or volunteer) involvement in participating in THCS? And how can we best address or overcome these?

RQ.6. What are the key stakeholder perceptions on use of citizen science in tree health system and the use of citizen science for addressing evidence needs or evidence-based policy/decision making?

# Methodology & Analysis

## Mapping the current landscape of tree/tree health citizen science projects

To address research question 1 and 2, a list of all the CS projects in the UK was prepared. Some projects that did not have tree health focus were also included to broaden the scope of projects with a plant and or tree focus and to provide useful lessons for the future delivery of THCS projects. In total 20 projects were identified. Project leads were contacted via email and were requested to complete a sheet on background information and details of the projects. Content analysis was used to screen through the key parameters of these projects that included information about the project infrastructure and funding; its objectives; focus on tree health; volunteer activities and support; and project outputs (**Appendix B**).

## Case Studies to explore CS project participant's experiences and perceptions

***Research method*** – Case study method was adopted to address research questions 3-6, and to gain detailed insights of the participants involved in CS projects. Case study method enables a researcher to closely examine the data within a specific context. Yin[36] defines the case study research method "as an empirical inquiry that investigates a contemporary phenomenon within its real-life context; when the boundaries between phenomenon and context are not clearly evident; and in which multiple sources of evidence are used." Case study research method has been used for research across a variety of disciplines especially in the social science domain. It is ideal and robust methodology when a holistic, in-depth investigation is required[37]. Salient feature of using this method is that it allows for multi-perspectival analyses, i.e. the researcher considers not just the voice and perspective of the actors, but also the relevant group of actors and the interaction between them. Also, this method aids in developing understanding behavioural conditions through the actor's perspective[38].

***Case study selection –*** Information sheets of all the twenty selected projects were screened to select five case studies for in depth analyses. Multiple case studies were selected in order to maximise our understanding of participants' views on their participation in CS projects; on their CS projects and on the use of CS in general in Tree Health. Selection criteria that were used to screen and finalise the

case studies were: 1. Project addressing tree health, 2. Project including a non-tree health community such as biological recording to investigate if these communities might be willing to look out for tree health issues, 3. Projects representing a spectrum from research to outreach; answering a hypothesis (direct?) or contributing to monitoring etc. which also gathers data which might be put to scientific use (indirect?), 4. Variety of projects that cover the UK region (England, Scotland, Wales and Northern Ireland) and 5. Projects that are willing to take part in the current research. The Citizen Science projects selected as case studies were: OPAL Tree Health Survey - tree health focus; Observatree - tree health focus; *Ceratocystis platani* and *Xylella fastidiosa* Protected Zone Status Survey 2016 (CSP) - tree health focus; Ancient tree inventory (ATI) project - tree and not tree health focus; and the National plant monitoring scheme (NPMS) - non-tree and non-tree health focus.

***Data collection-*** Project leads provided contact details of participants willing to take part in the research interviews. Participants were broadly categorised as professionals (project manager, scientist, policy lead) or volunteers. These participants were then contacted by email and appointments were agreed for interview. Semi-structured telephone interviews were conducted between March and May 2017. In total 46 interviews were conducted and it took 45-50 minutes on an average to complete an interview. All the interviews were recorded and transcribed with the permission of the participants. The interview guide was nearly the same for all the five CS projects, however a few questions were added or deleted based on the unique characteristics of the project. Also, there were specific questions asked to the professionals or volunteers to capture their experience and perceptions (**See Appendix C for the interview guides**).

***Data analysis-*** All transcriptions were imported into NVivo software and coded to identify the emerging themes from the interviews. Based on the research and interview questions, an initial coding framework was pre-designed which provided Tier one and two nodes (**Figure 1**). Subsequently, a third tier of nodes was added, based on content analysis of the data, thereby relying on the themes that emerged from the responses of the participants. The tier two nodes provide the structure of the results section of this chapter, while the tier three nodes provide the detail included in each section. Direct quotes are provided to illustrate the points being made.

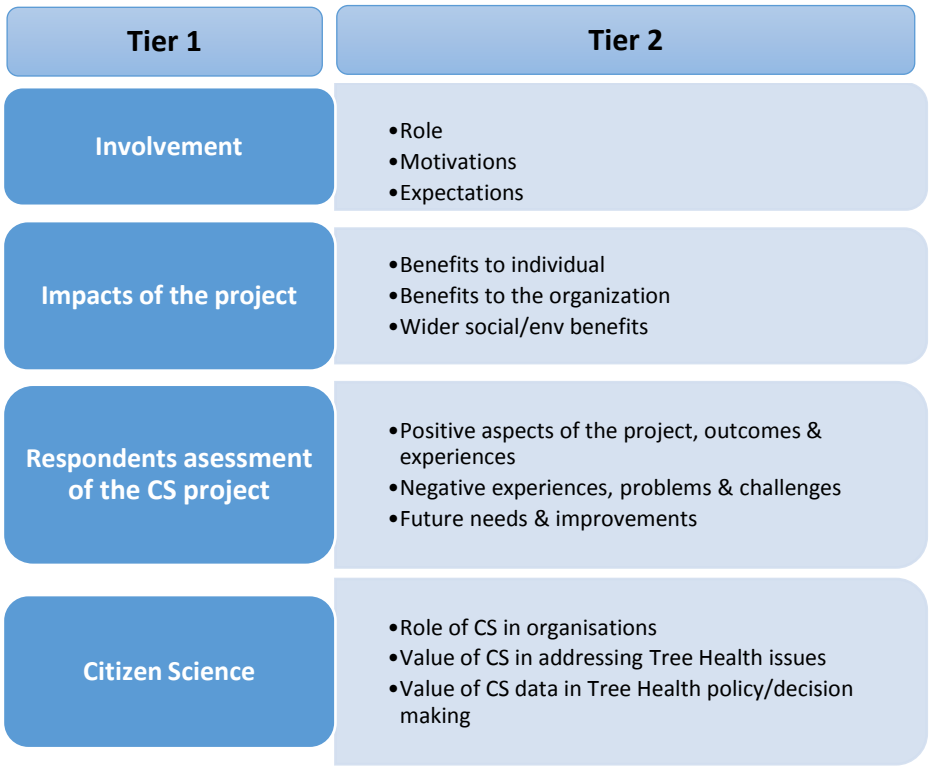


**Figure 1. Coding framework showing tier 1 and 2 nodes**

# Results

## Current THCS landscape in the UK

In total twenty projects with citizen science focus on tree/tree health have been set-up in the UK (**Table 1**; for detailed summary refer to **Annex B**). Analysis of the information sheets for nineteen projects (no response from one project) showed that some date back to 2005 with the majority starting around 2012-2013. Thirteen projects are still on-going and six have concluded. Of all the projects, eleven projects had tree health as their primary focus, six had tree health as secondary focus and three projects did not address tree health at all. Projects with a tree health focus, involved observations on for various pests and pathogens on many different species of tree. However, the majority of projects involved screening for *Chalara* Ash Dieback, indicating the relevance and timeliness of setting these projects during and after the *Chalara* crisis in the UK. Project objectives varied across the different projects. The most common objectives were data collection using surveys, data analysis, public awareness and engagement. Other objectives cited in some projects included environmental stewardship, volunteer support, "protecting trees", long term environmental management, habitat condition assessment and development of resource to highlight the importance of trees. Projects involved a variety of volunteer types, ranging from general public in most of the cases, to trained volunteers, keen naturalists, woodland users, staff from botanical gardens and nature reserves and professional tree managers. This range demonstrated the vast spectrum of volunteers who can contribute in scientific research related to tree health in the UK. The majority of these projects are "contributory" citizen science projects

wherein volunteers are involved in the process of data collection. Two of the projects are "contributory-collaborative" CS projects and one of the projects is "collaborative" wherein volunteers provided their own suggestions and improvements in the project. Two projects that were contributory in nature indicated inclusion of volunteer views and feedback for developing the next phase of the project, showing a paradigm shift from involving the volunteers for collecting data but to also include them in the process of data analysis and project improvisation.

Information obtained on these various CS projects allows for analysis of how the current portfolio of tree health citizen science projects contributed to the evidence needs across science, management and policy in a tree health system in the UK identified in chapter one. Key evidence needs addressed by the projects were:

- ***Scientific data/information***- data and scientific information on pest/diseases/host species.
- ***Surveillance and spatial data*** - surveillance data and spatial mapping of different trees and plants across UK; ground-truthing? Distribution of pests or pathogens.
- ***Social science data***- In chapter one, professionals indicated the use of social science data as evidence to make tree health related decisions. The social science data they referred to included personal data of the people making the enquiry; drivers of different stakeholder behaviour/ stakeholder attitudes and social impact studies. The current CS projects partly address these evidence needs as some of them collect information on the volunteer profiles, and also on social science data related to their behaviour and attitude change post participation in the projects.
- ***Utilising the experience and knowledge of 'expert' volunteers*** – Volunteers involved in a number of CS projects at present are having volunteers with varying knowledge and scientific skills. Some of them being veteran and highly knowledgeable.

The analysis also allows identified gaps in the evidence needs and CS deliverables. This essentially does not reflect on the shortcomings of adopting a CS approach but helps to identify areas where a CS approach cannot be used or where it might not be the best approach. At the same time, it enables us to highlight potential areas of CS application. Some of the tree health evidence needs not addressed by the current portfolio of citizen science projects are:

***Modelling Information:*** At present none of the CS projects focus on Bio-Economic or climate data modelling. This could be an important area for future application of CS.

***International experience from pest disease management***: Data and information coming through from different countries (regarding what other countries have done to manage a particular pest or

disease; what their experience has been, what their impact has been and what are the biosecurity threats across different EU countries) is used as important evidence by the professionals. However, none of the CS projects address this issue and understandably quite so as CS approach is not feasible or appropriate for collecting this kind of information.

***Interception data at points of entry*** (e.g. sea ports or airport's): - CS is not used at points of entry for commercial plant trade into the country. Here officials conduct inspections to ensure compliance with regulations and monitor consignments for the presence of quarantine pests and pathogens.

***Economic Appraisals*** - Tree health professionals utilise a gamut of information to make strategic decisions on how much money is being spent overall on the research into tree health, who is doing it, what the projects are about, and how they're going to deliver to particular policy customers, and what difference they will make to policy making, or to policy delivery. They also estimate costs and benefits of different management options and evaluate economic value of trees and how it can contribute in decision making at the policy level. The current profile of CS projects does not help in collection of such strategic information. However, a few projects do attempt to estimate the biodiversity value and economic value of tree and ecosystem services. This type of information can largely contribute into decision making and can be taken up in future CS projects.

***Regulatory/policy Information*** **-** Tree health professionals also use a wide variety of regulatory (e.g. EU Plant Health Directive, GB Plant Health Orders) and policy information (e.g. EPPO guidelines, national strategies, instructions from the Plant Health Risk Group) to guide their work. Though none of the projects are directly involved in collecting this information, some of the CS projects indirect feeding information at the policy level that can shape the future strategies and policies associated with tree health.

**Table -1: Summary of 20 projects addressing citizen science in tree health/plant health and or plants in the UK**

| ***Project Details – funding & Tree Health focus*** | | | | | |
|---|---|---|---|---|---|
| **Name of the CS project** | **Lead institution** | **Start date and duration** | **Tree health a primary or secondary focus:** | **Tree Species** | **Pest/Pathogen** |
| **Track a Tree** | The University of Edinburgh. Track a Tree was set up by Christine Tansey as part of her NERC-CASE funded PhD. CASE partner was the Woodland Trust | Track a Tree pilot conducted in 2013, and project launched in 2014. Ongoing. | Not a direct focus, although we link to The OPAL Tree Health Survey, and provide a field for recorders to specify whether they have conducted the Tree Health Survey on the tree that they monitor for Track a Tree. | Pedunculate and Sessile oak, Silver birch, Sycamore, Beech, Rowan, Hazel, Ash. | N/A |
| **Open Air Laboratories (OPAL) tree health survey** | Centre for Environmental Policy, Imperial College London who manage the tree health survey through an official partnership agreement with Forest Research and the Food and Environment Research Agency (Fera) | 2007 – ongoing (OPAL); 2013 (Tree health survey) | Primary; also includes general activities on tree identification, measurements of height, girth and observations on general condition of trees | Any (specific activity on Oak, Ash and Horse Chestnut) | Oak (Tortrix roller moth, Oak mildew, Oak Decline and Knopper gall); Ash (Ash bud moth, Ash key gall, Nectria canker and Ash Decline); Horse Chestnut leaf-miner, leaf blotch, scale and bleeding canker); plus "6 Most Unwanted" (quarantine pests): Emerald ash borer, Citrus longhorn beetle, Asian longhorn beetle, *Chalara* Ash Dieback, Oak processionary moth and Pine processionary moth |
| **Observatree** | Forest Research | October 2013 (4 years) | Primary | All – but with focus on host species for priority pests and diseases | Sirococcus tsugae, Phytophthora austrocedri, Great Spruce Bark Beetle, Oriental Chestnut Gall Wasp, *Phytophthora lateralis*, *Dothistroma* Needle Blight, Bronze Birch Borer, Sweet Chestnut Blight, Plane Wilt, Mountain Ash Ring Spot, Oak Lace Bug, Red-necked Longhorn Beetle, Pine Processionary Moth, Emerald Ash Borer, Plane Lace Bug, Horse Chestnut Leaf Miner, Citrus Longhorn Beetle, Acute Oak Decline, Asian Longhorn Beetle, Oak Processionary Moth, Chalara Dieback of Ash |
| **TreeAlert** | Forest Research & Forestry Commission | 2012 | Primary | All, but with dedicated reporting lines covering some host species (see P&D list below) | All, but dedicated reporting lines for AOD, ALB & CLB, Chalara, DNB, *Phytophthora lateralis* |
| **i-Tree Eco (NB i-Tree Eco in itself is not de facto CS, although discrete Eco 'projects' have been run by volunteers in Petersfield, Sidmouth and Lewes)** | Forest Research (FR), Treeconomics and the Arboricultural Association collaborate to bring i-Tree to the UK from the US (termed i-Tree UK throughout), funding and delivering the adaptation of the software for use in the UK. This 'national' and steering group level of work is very different to discrete i-Tree Eco project work. | i-Tree UK 2012-(to date); cf. individual projects tend to have a duration of ~1 year | Secondary | Yes | Not specifically |
| **Ancient Tree Inventory** | The Woodland Trust who set up and manage the on- line database and website, recruit and train volunteers especially volunteer verifiers to ensure the data is as robust as possible. | 2005 - ongoing | Primary focus. The project involves gathering information on tree condition. The overall data also enables us to identify what the impact of deteriorating tree health and loss of trees would have on heritage, biodiversity and landscapes. | Yes. There is a list of c 600 tree species on the recording form. These are the most likely species to be encountered although it does not reflect all species in the UK. | Not specifically but there are options for additional comments to be added |
| **Survey of Plants and Lichens on Ash** | | | Secondary (recording plants/lichens around ash trees/woodland) but motivated by ash dieback | Ash/ash woodland | *Chalara* ash dieback |
| **Conker tree science** | Centre for Ecology & Hydrology, University of Newcastle. (Formerly University of Hull & University of Bristol.) | 2010 – 2015 (notionally ongoing but less active now) | Primary | Horse chestnut | *Cameraria ohridella* (and some data on *Guignardia*) |
| **Longhorn beetle pheromone trial** | CEH, NRI (Greenwich University) | 2015-16 | Primary | Various | Asian longhorn beetle (passive surveillance for this) |

| *Project Details – funding & Tree Health focus* | | | | | |
|---|---|---|---|---|---|
| **Name of the CS project** | **Lead institution** | **Start date and duration** | **Tree health a primary or secondary focus:** | **Tree Species** | **Pest/Pathogen** |
| **International Plant Sentinel Network** | Botanic Gardens Conservation International, Fera, CABI UK, Royal Botanic Gardens, Kew (all Defra funded), plus many European partners and APHIS | First phase: Nov 2013-Mar 2016, second phase: Jan 2017 – Dec | Primary | Primary, though we do ask for information about all plant species | Primary, focus on both |
| **Urban Tree Survey** | | 2010; 5 years | Not a focus at all | | |
| **RHS surveys on the spread of non-native garden insects** | Royal Horticultural Society (RHS) | Start 2008 - ongoing | Secondary | Box, Buxus other hosts of survey insects are not trees | Lily beetle, *Lilioceris lilii*; Rosemary Beetle, *Chrysolina americana*; Berberis sawfly, *Arge berberidis*; *Hemerocallis* gall midge, *Contarinia quinquenotata* and box tree moth, *Cydalima perspectalis* |
| **National Plant Monitoring Scheme** | Overall project management is within CEH | March 2015 – present. Ongoing long-term monitoring scheme | Neither | At the two more basic recording levels, information on tree species is not collected, only information on % tree cover. Some species on which data is collected in hedgerows can also grow as trees, however collecting information on these species is a focus only in hedgerows where growth form is more likely to be shrubby. At the highest recording level, volunteers record all species in their plots which could include tree species | No |
| **LeafSnap UK** | Natural History Museum | 2014 | Not a focus at all | | |
| **PTES Traditional Orchards Project** | People's Trust for Endangered Species | 2006 – 2011. Mapping the habitat in England; 2011 – 2012. Mapping Wales; 2012 – present. Continuing to support the habitat and acting as a central national body with an interest in orchards; 2015 – 2016. Varieties Database and website update project | Secondary | All top fruit and nut trees | N/A |
| **Ceratocystis platani and Xylella fastidiosa Protected Zone Status Survey 2016.** | The London Tree Officers Association (LTOA). The LTOA coordinate the project, analyse the data obtained from the surveys and produce the final report | Approximately June – September 2016. The current survey is a repeat of the surveys undertaken by the LTOA in 2014 and 2015 | Primary | London plane | *Ceratocystis platani* and *Xylella fastidiosa* |
| **AshTag** | University of East Anglia | Feb 2012- ongoing | Primary | Ash Trees | *Chalara* ash dieback |
| **The Living Ash Project** | Earth Trust (Project lead and field trials; Future Trees Trust (Knowledge exchange); Sylva Foundation (CS) and Forest Research (Genetic Research) | 2016 - (6-year project) | Primary | Ash | Resistance to *Chalara fraxinea* |
| **Treezilla- the Monster Map pf Trees** | Faculty of Science, Technology, Engineering and Mathematics (STEM), The Open University | June 2013. The project is ongoing | Secondary | Yes | Yes |
| **Fraxinus** | The Sainsbury Laboratory, John Innes Centre and Earlham Institute (formerly The Genome Analysis Centre) | August 2013 - on-going | Primary | Ash | *Chalara* ash dieback |

| *Purpose/Objective of the project (indicate yes or no from the options below)* | | | | | | |
|---|---|---|---|---|---|---|
| **project** | **Surveillance/ Data collection/ Evidence gathering** | **Data Analysis** | **Awareness and Engagement:** | **Changing Behaviour (Environmental Stewardship):** | **Support to other volunteers** | **Other (please specify)** |
| **Track a Tree** | Yes | Yes, part of Christine Tansey's PhD work. | Yes | Indirectly, by improving observational skills. | No | |
| **OPAL** | Yes | Yes (Forest Research) | Yes | Yes (one aim of the Defra/Forestry Commission Tree Health & Plant Biosecurity Action Plan) | No | |
| **Observatree** | Yes | Yes | Yes | Yes (although not formally stated objective) | Yes | Protect trees, woods and forests |
| **TreeAlert** | Yes | No | Yes | | Yes | |
| **i-Tree Eco** | Yes | Yes | Yes | for some projects YES; but not always | For some projects YES; but not always | Longer term environmental management |
| **Ancient Tree Inventory** | Yes – individual tree records | Yes, analysis of the date to identify important concentrations of ancient and other veteran trees at a landscape scale for resilient landscape activity | Yes, through drawing attention to the remarkable heritage and biodiversity value of the trees | Yes: gathering the tree records is the first step towards making sure the trees are properly recognised. It is an aim that these trees of special interest should be properly cared for and protected through legislation, policy and guidance. | Yes, volunteer verifiers give guidance to recorders and through the project we have developed lead verifiers who support less experienced verifiers | |
| **SPLASH** | Yes, data collection | | No – working with experienced volunteers who already have knowledge/awareness | No – though provides baseline data for monitoring impacts of ash dieback | No | |
| **Conker tree science** | Yes (by participants) | Yes (by scientists) | Yes | No (not specifically) | No | |
| **Longhorn beetle pheromone trial** | Yes | No (small scale assessment, didn't need formal analysis) | No | Yes | No | |
| **IPSN** | Yes | No | Yes | Yes | Yes | |
| **Urban Tree Survey** | Yes | Yes – by researchers, not public | Yes | No | No | |
| **RHS surveys** | Yes | | Yes | | No | |
| **NPMS** | yes | Yes | Yes | Not a primary aim | Not to volunteers in other CS projects, but volunteers support one another in the NPMS through a mentoring scheme | |
| **LeafSnap UK** | Yes | Yes – by researchers, not public | Yes | No | No | |
| **PTES Traditional Orchards Project** | Yes | Yes | Yes | Yes | Yes | Habitat condition assessment |
| **CSP** | Yes | Yes | Yes | Yes | Yes | |
| **AshTag** | Yes | No | Yes | Yes | No | |
| **The Living Ash Project** | Yes | Yes | | | | |
| **Treezilla- the Monster Map pf Trees** | Yes | Yes | Yes | Yes | Yes | 1) To develop a resource which highlights the role of trees: (as species habitats; as landmarks adding to people's sense of wellbeing; in providing environmental benefits improving air quality in towns, moderating air temperature and capturing CO2) and<br>2) To help the public learn and contribute in the care and welfare of trees as citizen scientists with the ability to design, execute and publish their own, autonomous investigations based on Treezilla data. |
| **Fraxinus** | No | Yes | Yes | Yes | No | None |

| *Volunteer profile & activities* | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Project** | **Profile (volunteers, general public, school etc.):** | **Survey and report/Data collection/Evidence gathering:** | **Data Analysis** | **Reporting:** | **Support to other volunteers** | **Project administration/support** | **Other (please specify):** |
| Track a Tree | Regular woodland users (e.g. walkers, dog-walkers, volunteers, naturalist groups). Aimed at those with an interest in woodland plants and who may already have some knowledge about woodland trees. | Observational data collection and submission of records online. Participants are able to view and download their own records from their recording space on the website. | Recorders do not analyse data. | Online submission | One off training in 2015 included sessions aimed at educators (e.g. Forest Schools leaders) who could conduct Track a Tree recording with their groups. | Not provided by participants. | |
| OPAL | Everyone (across the spectrum of people having no experience to more professional), with a focus on people from disadvantaged and deprived communities | Survey and Report | Volunteers do not analyse the data | Hardcopies and online recording | Some organisations are trained by OPAL and then conduct the survey with their stakeholders e.g. National Resources Wales educators and John Muir Trust | None from participants | |
| Observatree | Trained volunteers – volunteers are selected by Woodland Trust engagement officer. Volunteers selected following initial application, telephone interview and questionnaire. Required to have existing knowledge of tree identification, biological surveying, and existing tree disease knowledge also desirable | Yes | Yes (if report verification counts here) | Yes | This is an area of development, but I believe has started to happen. An increasing number of our volunteers have been carrying out surveys together, new recruits are given the opportunity to buddy up with an existing volunteer, volunteers also offer support to each other during training events and via the forum | a. I would agree if verification is being counted as 'b' above. | Volunteer working group has contributed feedback to Tree Alert/verification portal development and e-learning (FC biosecurity modules) |
| TreeAlert | Data not available | Submit reports through 'General Tree Health' reporting line, or thought one of dedicated P&D reporting lines (AOD, ALB & CLB, Chalara, DNB, Phytophthora lateralis) | No | Submit reports through 'General Tree Health' reporting line, or though one of dedicated P&D reporting lines (AOD, ALB & CLB, Chalara, DNB, Phytophthora lateralis) | No | No | |
| i-Tree Eco | Project dependent; projects can be delivered by trained volunteers, trained surveyors or professional arborists recruited for the project | Yes | No | No | No | No | Data input into the Eco model |
| Ancient Tree Inventory | Everyone - across the spectrum of people with very little experience to tree and other professionals. Also used by university and other institution researchers. The project has also worked with the Ministry of Justice recording trees in prisons and with MOD on inaccessible land. Many people have recorded through other organisations who have engaged them directly in recording – these organisations may have a species-specific interest e.g. Ancient Yew Group or a geographic focus e.g. a county-based organisation e.g. Worcestershire Wildlife Trust or a site-based focus e.g. National Trust. We are particularly delighted when private owners record their own trees. | In the field identification of trees to record, recording according to a set form and input of information into the system on return to computer. Volunteer Verifiers visit trees to substantiate the record details and can amend the tree record on line. | On line search facility that allows volunteers to search all the records according to any criteria they wish e.g. number of oaks above a certain girth in a particular county. Spatial data analysis using GIS techniques is not possible by volunteers. Results of spatial analysis are used to inform designation of SSSIs, planning applications and biodiversity action plans. | Volunteer verifiers use the information gathered to inform owners of value of trees/collection of trees in some instances. | Lead volunteer verifiers and volunteer verifiers support and contact recorders and help researchers | None from volunteers | |
| SPLASH | | | | | | | |
| Conker tree science | General public recruited via media (TV, radio, newspaper), school children (mainly via visits by volunteers in 2011) | Yes | No | | No | No | |
| Longhorn beetle pheromone trial | keen naturalists, including nature reserve managers | Yes | No | No | No | No | Informing method development |

| *Volunteer profile & activities* | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Project** | **Profile (volunteers, general public, school etc.):** | **Survey and report/Data collection/Evidence gathering:** | **Data Analysis** | **Reporting:** | **Support to other volunteers** | **Project administration/support** | **Other (please specify):** |
| IPSN | Botanic garden and arboreta staff, volunteers, and where applicable visitors | N/A | N/A | N/A | N/A | N/A | N/A |
| Urban Tree Survey | General public (8774 sites surveyed, although this may reflect fewer participants if there was repeat participation) | Data collection | No | No | No | No | |
| RHS surveys | General public | Survey and report/Data collection | No | Web form | No | None from participants | |
| NPMS | Skilled volunteers. Free training provided as part of the scheme to boost skill levels in plant identification, so it is not essential to have previous skills in plant ID (though many of the current volunteers do) | Yes, volunteers gather data from the field as evidence | Not undertaken by volunteers | Volunteers report their findings from field work; then the partnership reports the findings from the analysis of the data back to volunteers via annual newsletters | Volunteers support one another through training and peer mentoring activities, and through creating volunteer communities (e.g. online/in different geographical regions). | Not undertake by volunteers | |
| LeafSnap UK | General public via a mobile phone app | Data collection | No | No | No | No | |
| PTES Traditional Orchards Project | Volunteers, scientists, other projects, General public – press campaigns to help raise awareness, farmers, landowners | Paper form or phone app | N/A | Sent back by post or we download data | | | |
| CSP | All participants are professional tree managers and tree officers working in London, volunteering their time in order to undertake the surveys | Site visits to allocated plots (typically 3-10 per participant). The project lead provided a template survey sheet to ensure consistency | The project lead collated all data from the participants and inputted it into a master spreadsheet for review and analysis | All initial findings were reported to the project lead. If further investigation was required into any sites, then relevant information was reported to the Forestry Commission via TreeAlert | The project lead was engaged in regular correspondence with participants and all volunteers were provided with direct contact details for the project lead to ensure that support was available if and when required. | All project administration, including the writing of the final report, was undertaken by the project lead | |
| AshTag | General public | Survey and report/Data collection | No | App based recording | No | None from participants | |
| The Living Ash Project | | | | | | | |
| Treezilla- the Monster Map pf Trees | Treezilla is a platform, rather than a single project, therefore it caters to the widest possible audience; the general public, community groups, school children etc.; alongside local councils, tree officers or anyone with an interest in or responsibility for trees, can use Treezilla and add to this growing database. | Tree record / data entry on website which is immediately added to the database. Evidence gathering: Once a tree is recorded, Treezilla provides an estimate of the value of the ecosystem services it provides. Tree data can be selected and exported as a csv file | Volunteers can request access to download data for analysis | Online recording | Stakeholders have developed their own bespoke training using the materials, guides etc. provided as well as their own resources. To support this type of activity, in collaboration with our VITAL project partners, new resources are being created i.e. Training for Tree Council Wardens and Milton Keynes Parks Trust Volunteers, school and youth groups | Participants support each other by adding tree information to each-others records | |
| Fraxinus | Everyone who has access to Facebook and willing to contribute | No | Yes, players solve alignment puzzles and the progress is stored | Solved puzzles are saved in a database | Community page provides chance for between volunteer support as well | None from participants | None |

## Case studies

Five case studies selected for this study are:

***Case Study 1 – National Plant Monitoring Scheme (NPMS)***

The National Plant Monitoring Scheme (NPMS) is a habitat-based plant monitoring scheme designed by BSBI, CEH, Plantlife and JNCC to assess trends in the abundance of plant species within communities in the United Kingdom. This scheme utilises volunteer recorders to monitor changes in the abundance of plant species in semi-natural habitats throughout the UK over the long-term to detect changes in the quality of habitats, to develop understanding pressures and drivers of these changes and to produce meaningful data on the ecological indicators and other relevant reporting products on semi-natural habitats across UK. NPMS was partially developed from an existing project called Wildflowers Count which was run by Plantlife, with the aim to increase the robustness of the data collected through a scientific survey conducted by the volunteers. Anybody who is interested in nature and can identify plants can participate in the scheme. The survey requires volunteers to select a 1 km square to visit and record 'indicator species' in around 5 plots in semi-natural habitats.

***Case Study 2 – Ancient Tree Health Inventory (ATI)***

The Ancient Tree Inventory is a campaign led by the Woodland Trust used to map UK's ancient and special trees. It is a living database of ancient and special trees. The ATI began in 2004, as a joint venture with the Tree Register of the British Isles and the Ancient Tree Forum. By October 2011, more than 110,000 trees have been recorded by volunteers and partners. Underlying aims of setting up this inventory is to support biodiversity, help in tree protection and to propagate ancient tree seed. Volunteers involved in the project can chose to become ancient tree verifiers/recorders or lead verifiers. Ancient tree verifiers or recorders are trained volunteers who go out and look at the trees which have been recorded and verify their location and give them a status of ancient, veteran, or notable trees. Lead verifiers are the regional leads and they help to look after the other verifiers in their area.

***Case Study 3 – OPAL Tree Health Survey***

The Open Air Laboratories (OPAL) network is a UK-wide citizen science initiative that that inspires communities to discover, enjoy and protect their local environments. OPAL is funded largely by the Big Lottery Fund t and began in 2007 operating across England. Since January 2014, the project has expanded to Scotland, Wales and Northern Ireland. OPAL provides the skills and materials needed for national community-led studies, including national surveys, which allow the volunteers to get closer to local environment while collecting important scientific data. One of their surveys is the Tree Health Survey, launched in May 2013. Forest Research and the Food and Environment Research

Agency (Fera) are partners in a Tree Health Survey. The Survey asks members of the public to examine the trees in their local area and to keep a special eye out for pests and diseases, particularly those affecting Oak, Ash and Horse Chestnut. The activities include identification of trees; measuring their girth and height; examining the trunk, branches and leaves for signs of poor health; and recording the presence of specific pests and diseases. The survey includes a guide to six of the 'most unwanted' pests and diseases in the UK such as Ash Dieback and Emerald Ash Borer. The survey packs are also available for download, which include a tree identification guide, field notebook and field guide and 'Six Most Unwanted' card.

***Case Study 4 – Observatree***

Observatree was a four-year citizen science project (2013-2017) funded through the EU Life+ programme. It was a collaborative project between Forest Research, Forestry Commission England, Forestry Commission Scotland, APHA, Defra, Fera Science Ltd, the National Trust, Natural Resources Wales and the Woodland Trust. The project aimed to develop a UK-wide 'Tree Health Early Warning System' (THEWS) to enable early detection of tree pests and diseases, thereby supporting efforts to protect woodlands and forests. This was achieved by building capacity amongst a group of trained volunteers to carry out surveys for tree pests and diseases, and to assist with processing and verifying tree health incident reports. A UK network of over 200 specialist volunteers recruited and supported by the Woodland Trust, were trained to undertake a range of surveys to assist with spotting new tree pests and diseases across England, Scotland and Wales. Training provided to the volunteers was in monitoring and surveying for specifies tree pests and diseases, submitting the survey reports, verification of reports and use of Tree Alert online reporting tool.

***Case Study 5 – Ceratocystis platani and Xylella fastidiosa Protected Zone Status Survey 2016 (CSP)***

Funded by the Forestry Commission, the CSP project was set up in 2016 to screen through the Plane trees to monitor and detect for *Ceratocystis platani* (plane wilt/canker stain of plane) and *Xylella fastidiosa*. Even though *Xylella* is not currently present in the UK, it is present in neighbouring EU states and is considered to pose a great threat to plane trees in the country. The London Tree Officers Association (LTOA) coordinates the project, analyse the data obtained from the surveys and produce the final report. It is unique case of citizen science, as in all the participants or volunteers are basically professional tree managers and tree officers working in London, volunteering their time in order to undertake the surveys. The survey includes 58 plots located across all 33 Boroughs of London. All participants were given training in the identification of *Ceratocystis* and *Xylella* and in the use of TreeAlert that was used as a reporting tool. All initial findings were reported to the project lead. If further investigation was required into any sites, then relevant information was reported to

the Forestry Commission via TreeAlert. The on-going survey is a repeat of the surveys undertaken by the LTOA in 2014 and 2015.

## Interviews

Forty-six interviews were completed, twenty-six with the professionals, and twenty with the volunteers involved with the five case study projects (**Table 2**). The interviewees were from locations across England, Scotland and Wales. Professionals interviewed for this study had varied roles that ranged from those involved in project management (part of the project board and partner lead), high-level decision making, funding and promotion. Some of the professionals were also involved in tasks associated with the volunteers, such as recruitment of volunteers, providing scientific training, development of learning materials and reporting tools and logging data provided by the volunteers.

The roles fulfilled by the volunteers in different projects were more simply defined according to the broad task areas to which they were originally assigned. Most of them have been involved in carrying out tree health survey, looking and reporting for pests and diseases. More specialised volunteer roles involved verifying or quality checking records submitted by other volunteers.

**Table 2. Case study interviews with the professionals and volunteers**

| Name of the CS project | No. of Professionals Interviews | No. of Volunteer Interviews |
|---|---|---|
| Observatree | 9 | 8 |
| OPAL | 6 | 6 |
| National Plant Monitoring Scheme (NPMS) | 3 | 6 |
| Ancient Tree Inventory (ATP) | 3 | 0 |
| ***Ceratocystis platani*** and ***Xylella fastidiosa*** Protected Zone Status Survey 2016 (CSP) | 5 | 0 |

## Motivations

Both the professionals and the volunteers were asked what motivated them to get involved in their respective projects in the first place and also what motivations had sustained their interest and involvement over time. Analysis revealed a wide range of motivations for the professionals and volunteers which have been classified as personal, professional/organisational, social and environmental. Notably, a number of similarities in motivations was seen between the two groups of interviewees and also some unique set of motivations found for each of them (**Table 3**).

***Personal motivations***: When considering personal motivations, the chance to be outside featured as a common motivation among both the professional and volunteer groups, highlighting an intrinsic feature of CS projects being an outdoor activity. Personally, some of the professionals were

motivated to get involved in the project when they perceived the project to be worth their time and efforts and or scientifically challenging while others were motivated by the fact that they can bring the required expertise and skill set to project. Volunteers on the other hand expressed motivations to do something they enjoyed and was not too time consuming and was easy to do. At a practical level, some volunteers were motivated to be involved because they could gain confidence and learn new knowledge. Some of the volunteers viewed their participation as an opportunity to rekindle their old interest areas such as environment conservation, plants, trees etc. Availability of time to carry out the activities was expressed as an important motivation among the senior and retired volunteers.

*"for me personally it's a huge adventure, you go out and you look at a new area, a new footpath, that you walk along a new…go to a new public space, you go to meet somebody who owns a parkland and you find new trees. And constantly being challenged scientifically, aesthetically, landscape-wise and for biodiversity"- Professional*

*"I liked botany at school, so I wanted to sort of build on that knowledge. I thought, you know, it might be good to know a little bit about that sort of thing"- Volunteer*

***Professional/organisational motivations***: Under 'professional motivations', both professionals and the volunteers mentioned gaining new knowledge and skills to advance their careers or employment prospects. Not surprisingly, professionals came up with more responses under 'organisational motivations than the volunteers. Building capacity to address tree health concerns against the backdrop of limited funding, time and availability of scientists were all reported. For many of the professionals, involvement was driven by the fact that "it was part of their job" and funding was available to carry out the project. Conducive work environment, successful collaborations and good outputs in the form of data collected by the volunteers were among the other factors that encouraged professionals to get involved in CS projects. Volunteers on the other hand, stressed on the logistics. Projects with clear and easy tasks, accessible locations, and good support from the project coordinators as their key motivations.

*"And I think we would also face up to the fact that government now doesn't have that amount of money that means that they don't have lots of inspectors themselves"- Professional*

*"One of the other key motivations was that we at the time had a pretty limited amount of key capability and expertise in plant health. Often the scientists who are very expensive, would get a call and go out, look at that call and then realise that, you know, it wasn't anything, you know, particularly important. So, they effectively might have wasted several hours, a half a day or a day, something like that. What I wanted to do was, you know, free up the scientists to do the science if you like and use the system to handle the calls and the enquiries coming in so that we made sure that when the scientists did go out it was very strongly targeted on the most important enquiries that we'd received- Professional*

***Social motivations***: Under the 'social' category of motivations both groups were in part motivated by meeting new people and building networks. Engagement with the public to involve communities

at the local level, and pass on knowledge to the volunteers were the most important motivations echoed by both the professionals and the volunteers. In addition, professionals also viewed these projects as an important platform to raise public awareness around the tree health issues as well as about the profile of the project.

*"It's good to engage and have lots of opportunity to speak to people that you otherwise wouldn't be dealing with through work. So, kind of increasing the network and then it's fairly common for the volunteers to bring along some of their friends and colleagues when they come along to training events. So that's good"- Professional*

*"Particularly on the tree health, we have fantastic woodland. And to be able to share that…it was the appropriate level for the local community to get involved in"- Volunteer*

*"the motivation to some extent was to create new ground-breaking approaches to how we dealt with pests and diseases, but to engage a much wider range of stakeholders and public participation in that process"- Professional*

**Table 3: Motivations outlined by interviewees for getting involved and continued involvement**

| | Professionals & Volunteers | Professionals | Volunteers |
|---|---|---|---|
| **Personal Motivations** | **Chance to be outside** | Right skills to bring to the project | Fun and easy - fun to go out; tasks not onerous; not too technical |
| | | Adventure- Sense of real discovery in finding new trees; adventure to be constantly challenged scientifically | Opportunity to rekindle an old interest |
| | | Thought it to be a worthwhile/interesting project | More free time available to participate – retired |
| | | Emotional attachment to the project | Gain more knowledge and confidence due to participating |
| **Professional/ Organisational Motivations** | New Job- new job; career change; opportunity to gain some work experience | Part of the Job - 'it's part of my job' | Followed on from previous volunteering work |
| | Learn new skills to identify and learn about tree diseases | Self-Motivation as there is limited Govt. funding and officials to inspect tree health | Good support from the project team |
| | Good training courses and workshops | Beneficial collaboration among different partners | Enthusiastic volunteer coordinator |
| | | Good for proof of concept- to explore the real potential of the idea behind setting up the program | Easy to do - ease of finding a research plot/easy to commute to the area/ease of recording |
| | | Save time for scientists - often expensive, less in number | |

| | | | |
|---|---|---|---|
| | | Funding is available | |
| | | Able to see growth and development of project | |
| | | Good working environment- nice team of people | |
| **Social Motivations** | **Public engagement**- Help volunteers/pass on the knowledge; work/engage with people; local community involvement | Generate public awareness- to raise the profile of the project both at national and international level | |
| | Opportunity to meet new people | | |
| **Environmental Motivations** | **Interested in particular species - for e.g. interest in recording wildflowers, ancient trees, specific pest and diseases** | Data collection - collecting botanical data; information on non-statutory pests | Interested in conservation |
| | **Education/Professional background in environment or life science** | To show public steps taken by the government to address environmental concern | |
| | Wanted to do something for the environment | Build strategic approach to manage pest and risk | |
| | To protect the trees | **To play an active role in preventing a disease to enter the country** | |

***Text indicated in bold was cited the most by the interviewees**

***Environmental motivations***: Interest in specific species investigated under the different projects and education background in the similar areas were seen as important factors shaping environment motivations for both the groups. Also, motivations that were more broadly expressed were the desire to "do something for the environment" and to "protect trees". In addition, professionals came up with a more exhaustive list of motivations in this category that ranged from actively playing a role in preventing a disease outbreak in the country, building strategic approach for pest and disease management, and collecting data on non-statutory as well as he statutory pests.

*"I think, part of the motivation is for people who are doing it – the Tree Officers – they're the people who really care about the trees and the urban forestry and they recognise the importance and significance this disease could have. And I think they like to be playing a part – or I certainly like to be playing a part – in knowing that I'm, you know, taking an active role in stopping this disease from coming over" – Professional*

*"My continued motivation is the fact that early detection and early management will hopefully allow some sort of protection of some of our important trees, and if we don't have this in place and if we don't have the not only resilience but the kind of aggressive…I can't think of the word I'm looking for really but the aggressive monitoring that we do, then our trees our trees that provide great social and economic benefits and assets are going to be lost"- Volunteer*

## Expectations

Both professionals and volunteers were asked to reflect on the expectations they had from participating in the project and whether and in what ways the project has fulfilled or failed these expectations. Similar to the motivations explained earlier in this chapter, the expectations spanned personal, professional/organisational, social and environmental expectations (**Table 4**).

***Personal expectations***: For both the groups, personal expectations revolved around being appreciated and recognised, and being able to do something useful and of value. Volunteers emphasised the value of personal satisfaction, sense of enjoyment and fun they experience by taking part in the projects. Professionals stressed on the importance of doing tasks independently.

*"it's not necessarily an immediate result because you know that what's to be done is going to have an effect in the future but as long as you can see a pathway and where your bit fits in with the journey to that end result and you can see that what you've done is, I suppose, being appreciated; it's useful – then that's the immediate reward, I suppose, the immediacy of that" – Volunteer*

*"And then also, you know, even if it's something as simple as making sure their names are put in the report at the end or when I do a presentation I'll be lucky enough to give a couple of presentations and say about this, making sure their names are on the slide at some point, saying these are the people who made it possible. I guess a bit of appreciation of the fact that they are putting that work in" - Professional*

***Professional/organisational expectations***: In regard to professional expectations, both the groups expected to gain new skills and knowledge during their participation. They also stressed the importance and need for feedback, which needs to be both ways between the professionals and the volunteers. The need to feel supported was reported again by volunteers. Professional interviewees identified additional expectations in this category that focussed primarily on the deliverables of the projects such as recognition for their work, capacity building in tree/plant health, meeting the project objectives and delivery of good quality reports.

*"I don't actually feel I need to get anything out of it because for me the fact that we're out there monitoring, the fact that we are considered as experts to monitor and hopefully manage this if it ever comes in is enough, is enough for me to know that I'm doing what I need to do in terms of doing my part"- Professional*

*"I think the other positive thing out of this as well for both sides really, for the volunteers, some of them are fairly knowledgeable anyway, but others are starting on their career, it's given that experience and some of them have got a job as a result of it, so again in terms of spin-offs we get people into the industry that actually will be the next generation of plant and tree health inspectors or policy people. I think for inspectors on the ground it's also given them another string to their bow of working with other people and as I say building those networks on the ground in their own region" – Professional*

*"It's good to see that kind of feedback, to see what the results are, to see what…you know, if you just did it blind and you didn't get any feedback, you probably wouldn't keep going for very long" – Volunteer*

**Table 4: Expectations from the project outlined by interviewees**

| | Professionals & Volunteers | Professionals | Volunteers |
|---|---|---|---|
| **Personal Expectations** | **Appreciation/Recognition** | Independence of doing things | Enjoyment & fun doing the tasks and going outdoors |
| | **Feeling valued - able to make valuable contribution** | | Personal satisfaction |
| **Professional/ Organisational Expectations** | **Feedback (from volunteers and to volunteers)** | Viewed as an expert in the field | Access to data |
| | **Gain new skills or knowledge** | Spin offs from the project - e.g. volunteers getting good jobs afterwards, officials getting recognition for their work | |
| | Keeping the volunteers interested | Deliver outputs from the project | |
| | Being supported | Good quality reports coming in from volunteers | |
| | | Keeping the unwritten contract btw professionals and volunteers - volunteer need to keep their bargain long term. Embedding it long term and cascade to others and continue to report beyond end date of the project | |
| **Social Expectations** | Public engagement/community involvement | Working with enthusiastic people | |
| | | Active engagement with the volunteers | |
| **Environmental Expectations** | **Generating useful data -** collection of useful information; able to see the where the data is used | Data being used for policy decisions | Encouragement to go out |
| | **Sense of contributing to the environment and society** | | Participants understand their significance to the study; building more knowledge of the local environment |
| | **Able to prevent disease outbreak** | | |

*****Text indicated in bold was cited the most by the interviewees

***Social expectations***: Both the groups expected to promote engagement with the public and local communities via CS projects. Professionals viewed these projects as an important platform to actively work with the enthusiastic volunteers.

*"It's the number of young people that are actually then engaging. So, for me it's always about the impact on others and enabling others to have a positive experience"- volunteer*

*"I think it's as important that the community involved in the project, and that includes people who did the survey and the people whose properties were addressed during the survey, people who had trees in their garden, the owners of the trees whose trees were surveyed, that they were involved as well, that they feel that the project was valuable" - Professional*

***Environmental expectations***: Both the groups expected to generate useful environmental data, experience a strong sense of contributing something useful to the environment and to able to prevent or control tree pests and diseases.

*"I think it's important for me when they understand why they have done it. That no matter who it is that do it that they realise that they are a scientist, they are contributing to research and that, more importantly, and they learn something new"- Volunteer*

*"I think from my point of view on this project and my personal involvement I need to see that there is science coming out of it, that the data isn't just being collected and then left to sit somewhere. Because otherwise it is just the engagement project, and there's nothing wrong with an engagement project but if you sell it as sort of a science I think the data needs to be being used and it needs to be seen to be being used, so make it clear to the people who are collecting data, including myself, that this is where the data goes and this is how it's used" – Volunteer*

*"I need to feel that I'll be contributing something useful, so I need to feel that I'm a part of something bigger and I'm part of a national effort. And if I can see that that, if I can see even in my small way that my activity has contributed to that bigger effort then I think that is probably...well, that's one thing that would help me feel that I got something out of it" – Professional*

*"Feeling you're making a difference I think to the environment, you know, even though it's probably a very small difference, but to actually think that you're making a difference, you're not just doing something just for money or whatever"- Volunteer*

Interviewees were asked on their opinion on whether the above stated expectations were met by their respective projects (**Table 5**). Notably, forty-one out of the forty-six interviewees mentioned that the project has either exceeded or lived up to their expectations. Three of them expressed dissatisfaction from the project with respect to their expectations. Two of the volunteers said that it was too early to judge the projects against their expectations.

**Table 5: Project evaluation as per interviewee expectations**

| Participants expectations from the project | Professionals | Volunteers |
|---|---|---|
| Exceeded the expectations | 16 | 10 |
| Lived up to the expectations | 9 | 6 |
| Not lived up to the expectations | 1 | 2 |
| Too early to say | 0 | 2 |

Various reasons were proposed by both the groups of interviewees to explain why the project has exceeded or lived up to their expectations. This included generation of useful data as there were clear goals and objectives of the project, and learning materials (online material, survey guides/packs, and training products) and success in attaining wider public engagement and raising public awareness on tree health. Also, in terms of capacity building, the projects were able to retain a lot of volunteers and had a good base of very knowledgeable and committed volunteers.

*"I think it's [project] succeeded my expectations really, especially when you start talking to the volunteers and how knowledgeable they are and how committed they are to getting trees recorded and to protecting the trees, it's really, really good to hear, and when you get talking to people like that it motivates you to want to do more for it" – Professional*

*"I signed up for it and I got sent the information about how to record, what to record, and got some booklets which were given to me of the species that they wanted me to identify, and then I went out and it was quite straightforward, and I just basically filled in the documents that they wanted me to fill in and send them back. And I did that year on, year on, initially on the same areas so that there was a degree of continuity, but I've since moved away from that" - Volunteer*

*"I think getting the volunteer network up and running I think has been a major achievement and you know, I think that's been extremely well done" – Professional*

*"So, you know, with that aside I think some of the things that the project has already delivered and the way that we are raising awareness of tree health to the wider public" - Professional*

Reasons cited by professionals for projects exceeding or meeting expectations included satisfaction among all the partners in the project, professional growth and development wherein their roles evolved and their knowledge increased over time. They also indicated that the projects evolved over time becoming more structured with clear objectives, and successful in terms of meeting the objectives and receiving funding support. Some of the projects were realised to have gone beyond the data collection and have had policy implications as they were well-received by the government and regulatory agencies such as Defra and Forestry Commission.

*"Now we're at the point that we have a functioning scheme that all the partners of the scheme support, and are happy with, is something that's probably exceeded my expectations" – Professional*

*"I'm amazed how much my own knowledge and my network of contacts has grown" – Professional*

*"Again, I think at the beginning, we were literally just thinking of putting dots on a map and saying, these are old trees, but it's just moved on so much from that, and the fact that we now have large government organisations such as[Names of the organisations], now really looking seriously at the data we've got, and how that can influence some of their policies, certainly on the protection of trees, and the landscapes around those trees, that's really, really inspiring, and that certainly wasn't really considered or thought about at the beginning" – Professional*

Volunteers placed more emphasis on the level of support provided to them, enjoyment that they got in doing the surveys, and them being valued for their contribution. Some of the volunteers were able

to get a job based on their participation in the projects, whilst for some participation helped in reviving old interests in environmental issues. Many volunteers felt that the project raised awareness and learning around the environmental issues and in some cases have allowed the participation of young generations and disadvantaged groups of the society.

*"Yeah it has, because I see any time you go out with either teachers or students, when you conduct a survey, and I've done it with university students as well, no matter who I do it with, not only do they thoroughly enjoy it and learn something it actually changes their opinion of going outside and about their green spaces not matter how big or small it is and the fact that they actually go home and put the data onto the internet, onto the website, it's amazing" - Volunteer*

*"And so, for me it's opened my eyes about personally my interest...I studied ecology when I was at university and got into this job, I was initially a ranger. I think at some point I became removed from fieldwork, I became working in an office promoting the park but not being out there as often. So, for me it's really opened that interest again to what's going on out there in your surroundings" – Volunteer*

Reasons cited for dissatisfaction in a project were few and varied between the professional and volunteers. For the single professional to report that the project had not lived up to expectations, lower acceptance or use of tree health surveys by people and organisations, less participation from volunteers in Wales, and deviation from a scientific focus to more of a public engagement focus, were cited as concerns. Volunteers on the other hand had issues with the lack of feedback from the partner organisation and a lack of dissemination of results; all of which made them question the value of their participation.

*"It was, in a sense, disappointing that not more people took it up and ran with it. So, I can't say it exceeds my expectation in as much as the data approving that it wasn't entirely successful"- Professional*

*"It's been a frustrating ride, to put it in one word. That is because of a lack of feedback from [Name of the organisation] and a lack of dissemination of results. That's the two things together, really. There's plenty of information around for Forest Research et cetera. But having sent in samples for analysis and everything else, particularly acute oak decline, you wait for ever for the results to come back. You have to chase them as well. There's a disconnect down the line, there always has been, but it is extremely frustrating for surveyors and, I know from the landowners of the trees involved" – Volunteer*

## Benefits from CS projects

Both professionals and volunteers were asked to detail the benefits they had observed, received or perceived from involvement in the citizen science project. These benefits covered personal, professional/organisational, and wider environmental and social benefits (**Table 6**).

***Personal benefits***- The two groups of interviewees identified some of the same 'personal' benefits, including gaining new skills, knowledge development and enjoyment. Also, both the groups identified health benefits and positive self-image as a result of participating in CS projects. Improving and developing confidence was also a benefit that both professionals and volunteers experienced. Both the groups acknowledged that they have become more aware of the role and value of

volunteering/volunteers in projects related to tree or plant health. Consistent with volunteer motivations and expectations described earlier in this chapter, the opportunity to do something new and rekindling an old interest were the personal benefits highlighted by the volunteers. Recognition as an expert in the field, publications based on data collection from the projects and increased exposure and learning from international experience were the personal benefits identified by the professional interviewees.

*"So, I've learnt a lot from this project in terms of, you know the communications, the techniques that go on, working with volunteers, working with different stakeholders, yeah, tree health. I've benefited a lot from this" – Professional*

"Well, yes, I think identifying trees, identifying diseases within the trees, map reading skills, definitely yes. Various pieces of botany I suppose, that I knew that I probably built on. Yeah, the importance of things like biosecurity, which I hadn't really considered before. Skills, well tree identification, the knowledge of the diseases I suppose it's a skill isn't it, knowing those diseases and how to identify them and where they can lead" – Volunteer

*"So being a community scientist, it's great and it's fun and I've got opportunities to do things and I love my job and it's really stress-free compared to some of the other crap I've had to do over my life. But I'm not sure whether I've learnt much, I've certainly benefited from the experience" – Professional*

"It's strengthened my knowledge of tree pests and diseases, and found me new places of interest, and particularly woodlands, to go and look at and enjoy" - Volunteer

*"Well, I was involved with volunteers before I knew that it was valuable, but I think because, over the last few years, because of the problems we've had with pests and diseases, I think it's highlighted the fact that with some good training, volunteers, members of the public, can learn to record quite accurately, some valuable information and be real good eyes in the countryside as it were. So, I think it's certainly highlighted how valuable good volunteers and good training, for those volunteers, is" - Professional*

"I get backache a bit more often, but I suppose it has benefited my health, I'm not putting on weight, and I'm not getting breathless" – Volunteer

"I always feel much more relaxed after we've done an [Name of the project] survey. So, it's great to get outside"- Volunteer

*"I suppose there's a benefit of a feel-good factor that you are doing something worthwhile"- Professional*

"I think it gives you…certainly when you hit retirement it gives you a sense of worth when your main job has gone, it gives you a purpose, it keeps you learning, you know, it keeps your brain ticking over. Absolutely; everybody needs to volunteer really. I don't know how, if people are working full-time…yeah, it helps them have a complete break"- Volunteer

"I think in some ways citizen science leaves you feeling like you're feeding into something that has greater worth and you're feeding into a much bigger picture I suppose and the benefits of that"- Volunteer

"Yeah, as I say, it's been a win…it's been a doorway back in to a world that I haven't been involved with for 30 years"- Volunteer

***Professional/organisational benefits***- Obvious benefits identified by both the groups were gaining work experience and finding a new job or increased prospects of getting a job. Recognition as being an expert in their fields was also described as an important benefit by professionals. They also

recognised fostering important collaborations and networking with other organisations as a benefit. In addition, the whole experience strengthened the case for partnership working and provided valuable lessons for professionals on working with the volunteers.

*"From my point of view, it's been fantastic for learning lots of things about environmental monitoring, about working with volunteers, and all of the things both social and scientific that go with that"- Professional*

*"It's having a project that's worked and has been successful for three years. You know, it's really demonstrated that it is possible to do it. So, I think yeah, from an organisational perspective we've always been keen but it's just having that proof that it can work, and it can really work for the organisation"- Professional*

*"I get the impression that in the past different organisations have been doing their own thing and going off in different directions with regards to some of the tree health issues. I think [Name of the project] has helped to open lines of communication and dialogue between some of these different organisations. I think, to be fair, a lot of the communication possibly was going on at a personal level, perhaps not at an organisational level, and I think, you know, because we are now having board meetings, partner meetings with the different groups" – Professional*

*"So, I have definitely seen examples where people working as volunteers have got a job directly due to the fact that they were able to say on their CV"- Professional*

***Environmental & social benefits-*** The wider social and environmental benefits identified across the two groups were many and varied. Both groups expressed that the project provided them with increased new social interaction and networking opportunities that otherwise they would not have experienced. Increased knowledge about the plant and trees investigated in the projects and improved attitude towards environment in general were the environmental benefits recognised by both the groups. Benefits of staying outdoors and better appreciation of woodland and local environment were the benefits perceived by the professionals. Volunteers on the other hand felt more informed about tree and plant health issues and felt that they are more able to voice their concerns and raise awareness around these issues.

*"I think also there has been a more social interaction with a group of people that I would never have normally associated with and I thoroughly enjoyed that. I think that will only grow as the project grows, maybe as the network becomes a little bit more clustered and may be works together a bit more, so yeah I think it's benefited socially"- Professional*

*"It makes you look at the trees as you're going through the woodlands, with a different light. You're not just looking at it because it's beautiful and it's got lovely leaves. You're looking at it from…more from the point of view, is it healthy, you know. Does it look as if it's deteriorating and then hence why and investigating that further" – Volunteer*

*"The way that people consider the importance of woodland trees has really changed. It's opened their eyes to the…you know, the intrinsic value of trees. And I think a few of our volunteers have gone in to other jobs. So here at the Woodland Trust, for example, although not working in tree health, we have some volunteers who've become site managers, so they're there clearly to protect our woodland trees" – Professional*

*"I'm a little bit more active in voicing my concerns over issues to do with the environment. I know it's a modern thing now, isn't it, but my social media presence is much more focussed on environmental issues. I comment*

*on things and have an opinion on things that in the past I would have scrolled through and not maybe paid attention to, so yeah, it has definitely changed my attitude" – Volunteer*

*"So, if I'm out for a walk now and I'm in…I don't know, anywhere where there are trees, I'm sort of consciously looking for tree disease. …so, I think yes, I think it has and I think I've taken much more of an interest in trees now than I did. I notice an awful lot more and I know more about trees than I did really" – Volunteer*

**Table 6. Benefits arising from the CS projects**

| | Both (Professional & Volunteer) | Professional | Volunteer |
|---|---|---|---|
| Personal Benefits | **New Skills (volunteer management/project management; identification/ sampling and testing techniques)** | Recognition as an expert | Rekindle old interest |
| | Boosted confidence | Learn from international experiences | Doing something new |
| | **Enjoyment** | Publications | |
| | **Increased knowledge** | | |
| | **More awareness of role of volunteering** | | |
| | **Health benefits - address mental health issues** | | |
| | **Positive self-image - Doing something worthwhile** | | |
| Professional/Organisational Benefits | Employment- new job; work experience; improved job prospects | **Enhanced organisation's connections with other organisations - enhanced international links; increased collaboration with Defra/FC/FR** | |
| | | **Stronger case for partnership working** | |
| | | Good lessons on working with volunteers | |
| | | Credibility on the subject | |
| Environmental & Social Benefits | Participants/volunteers learn more about the environment/plants/trees | Allow people to be outdoors | Raise interest in environmental issues among youngsters |
| | **New social contacts - good networking (professional); meeting new people; more social interaction** | Better appreciation of woodlands and trees | More vocal about voicing concerns and raising awareness on environmental issues |
| | **Improved attitude towards environment in general** | | More awareness on tree health issues |

*Text indicated in bold was cited the most by the interviewees

## Project Assessment - Positive aspects of the project, outcomes & experiences

Professionals and the volunteers reflected on the many positive aspects of the project and described a range of personal and project related positive outcomes and experiences that they experienced during their participation in the project (**Table 7**).

Many of the personal outcomes identified by both the groups repeat the benefits reported in the section above. For example, both groups stated that they have experienced an increase in knowledge and gained opportunity to meet new people while working on the project.

*"I have broadened my knowledge about tree health and so instead of being quite narrow just about fungal diseases I now have a much broader appreciation of pest and diseases but also woodlands and woodland management" – Professional*

Volunteers on the other hand also re-emphasised that participation in these projects have led to an increased sense of contributing to a 'greater whole' or 'something useful'.

*"It's very early days, but the surveying that I've been involved in is just a small part of a jigsaw, isn't it, that they're trying to put together in terms of a map of the spread of wild flowers. I think you feel part of a jigsaw. I'm not looking for credits, and this sort of thing that's the feeling you have, I have" – Volunteer*

In addition to personal positive outcomes, both the groups highlighted a number of project-related positive outcomes and processes. Many of the interviewees applauded the design, production and communication of the training materials, guides and training sessions that were used to support the volunteers. Also, they commended the level of support provided to the volunteers in form of regular feedback and direct communication.

*"Well they do regional training, so that's very, very good. Their monthly newsletters are excellent"- Volunteer*

*"I would say that teacher training seems to be successful. The teacher training element has probably been our biggest...our biggest surprise in terms of large numbers of people wanting to be involved"- Professional*

*"But, yeah, it's brilliant, it guides you through how to identify trees by their leaves, it asks you the questions that are, you know, the health of the tree there and then and then it even lets you find easy ways to measure things without having to take huge…well, I don't know how you'd measure some trees without doing it the way they've suggested, but I mean that's just brilliant" - Volunteer*

*"I think one of the big positives is the high level of support and professionalism that I think we get from the project officer. I must admit she is very good" - Volunteer*

Most of the interviewees recognised the contribution of the project in terms of raising public awareness and promoting public engagement to address environmental issues. Many of the positive comments were around how the project has helped in involving people at the very local/community level to initiate a two-way dialogue and discussion around the tree/plant health issues.

*"I think the elements of public engagement, trying to get people interested in what we're doing and interested in nature more generally have been very effective, very positive"- Professional*

*"I think the other thing that has been really impressive, that's worked really well has been that real bottom up community engagement, you know, I know lots of people have felt this across the portfolio, is working with individuals or individual community groups who kept coming back and back and back to work with you"- Professional*

*"Another positive output has been our ways of communicating to other groups say parish councils much more at the local level. I think that's something that really took me by surprise how successful that was and how much feedback you get from those local groups"- Professional*

**Table 7. Positive Aspects/outcomes of the project**

| | Professional & Volunteer | Professional | Volunteer |
|---|---|---|---|
| Personal Outcomes | **Increased knowledge** - understanding of tree health, woodlands, and pest and diseases; identification of plants/flowers | Experience working with volunteers | **Acquired a strong sense of contribution -** contributing to something useful |
| | **Working with new people** – wider network; meeting likeminded people | Recognised as an expert - Spoken at conferences; authored a book | Enjoyment |
| | | | Getting a job |
| | | Enhanced management skills - project management; to develop a research idea; more skills in working with volunteers and NGOs | Becoming a Mentor |
| | | Opportunity to attend training seminars | Led to subsequent involvement in various other environmental activities |
| | | | Access to new places |
| | | | Motivated to study forestry |
| Project Outcomes | **Production of high-quality guides and materials for the volunteers** | **Good quality and quantity of volunteers -** engaged, enthusiastic and committed volunteers; Retention of the existing volunteers in the project; volunteers disseminating the findings and information to wider community | |
| | **Providing good level of support to volunteers -** feedback, contact and communication with the volunteers | **Successful Partnership -** partners working more closely; more trust; good working relations with the partner agencies | |
| | **Design and implementation of excellent training courses** | **Data collection -** high number of records; robust data; good quality scientific outputs; generated useful information | |
| | **Public engagement and generating awareness -** more engagement at the local level; generated interest in trees amongst school children; led to attitude change towards environment | **Able to demonstrate role of public in TH detection** - general public can be trained to identify tree pests and diseases; highlighted importance of CS; Public actually finding and reporting the pests | |
| | **Protecting Trees** - monitoring for pest and diseases; early warning system; proactive role in detecting and managing tree health | Policy Implications - impact of the project on policy making and operational delivery | |
| | Clear Methodology - for the volunteers to follow; ease of doing the surveys; not time consuming | Exemplar to show tree professionals can go beyond their job and do extra work to protect trees | |
| | | gaining visibility and recognition as a project and (not as a govt. institution) | |

*Text indicated in bold was cited the most by the interviewees

Another salient aspect of the project was the capacity and contribution of the project in protecting the trees and plants in the UK, which in turn had also been the prime objective of the project.

*"I think as the network grows and develops in both capacity and expertise, we will hopefully manage to find a lot more of the threats to forest trees and woodlands at a much earlier stage and then be able to take action to prevent them from becoming damaging"- Professional*

Professional interviewees highlighted more diverse positive outcomes related to the project than the volunteers. They not only recognised the vast amount of data collected via these projects but also praised the quality of data and or information collected by the volunteers.

*"The gathering of so many records. I've been astounded at the dedication and commitment and the length that people will go to make sure their records get onto the system" - Professional*

Professionals were also appreciative of maintaining an excellent volunteer base comprising of very committed and enthusiastic volunteers engaged in the project and also being able to retain those volunteers, which in general is considered to be one of most challenging tasks to achieve in any CS project.

*"For some of the volunteers you see they have taken this role to their hearts kind of thing, and you see they are fully motivated, and it's such a pleasure to work with them actually"- Professional*

Notably, most of the professionals emphasised that that through their CS projects they are able to demonstrate the role and contribution of the public in identifying pests and diseases, thereby highlighting the importance of adopting a CS approach for addressing tree health issues.

*"We've proved that volunteers and members of the public can be trained to spot tree disease. That was something that our partners at the [Name of the organisation] were always a bit unsure about. And we've also proved to them that this is not, you know, replacing professional trained staff. This is just adding to capacity to, you know, a very talented team of people who are very stretched and under resourced" – Professional*

## Project Assessment - Negative experiences, problems & challenges

In addition to being offered the opportunity to describe the positive aspects of the project from their own observations and experiences, the interviewees were asked to discuss the problems and challenges they faced during their involvement and project delivery phase. They also shared their experiences in adapting to those challenges. Challenges described by the professional and volunteer groups ranged from personal challenges to challenges related to project delivery and more specific challenges related to the volunteers (**Table 8**).

The time constraint in balancing their work life balance was one personal challenge raised by both the interviewee groups. Although many of them also acknowledged it to be a challenge that comes with doing any other activity and to overcome this most of them work on weekends or in the evenings for extra hours to finish up their tasks.

*"Balancing around my paid work. Fortunately, this ties in directly with my professional work so it's been easy for me to balance. But there are people who had to drop out last year and previous years because they couldn't manage the workload"- Professional*

*"Work more in the evenings or more at weekends. Which probably isn't that healthy but it's only for a couple of months at a time. And yes, I think it has been successful. And I think the success that all of us have put into this project is reflected in the fact that, you know, we've been asked to do it for the fourth year running" – Professional*

Volunteers on the other hand raised a number of specific personal challenges encountered during their participation. These related to their perceived feelings and expectations from themselves and the project. For most of them, disappointment of not finding any pest was a less desirable aspect of the project. Since their prime motivation to participate in most of these projects was to cite and report occurrence of pest and diseases, not finding any was 'not so exciting' part in the project.

*"So, it's been…it's a good thing that it hasn't happened, but on the other hand all this training and all the work that I do, is just observation at the moment and not a lot of action" – Volunteer*

*"I think also actually spotting disease, because I think there's a perverse pleasure in actually spotting disease and thinking well, yeah, actually I've seen that, so that's quite good to look for more. I think if you were looking trees all the time for disease and you didn't actually see any, then you might get a bit fed up with it" - Volunteer*

There was some dissatisfaction relating to expectations volunteers had about their role as a citizen scientist. These suggested that their expectations had not been met, as they thought they would be asked to do more. Some of the volunteers expected to have a greater role to play and more surveying work to do.

*"The fact that I've done the training but, you know, I haven't actually been able to help anybody. That's a seems a bit of a waste"- Volunteer*

*"I failed some of my expectations in that I just haven't submitted as many reports as I would have liked to" - Volunteer*

There was disappointment and frustration among some of the volunteers regarding working in isolation and no contact with other volunteers. This instilled feeling of loneliness and worry about 'doing it right' amongst them.

*"I suppose the only worry or challenge has been that my knowledge is good enough. Because nobody has checked whether I am writing down a lot of nonsense or accurately defining the plants" - Volunteer*

Interviewees also raised a number of project related issues that threw light on some of the challenges faced during the execution and delivery of the projects and also issues around the project outputs. Technology was one of the issues flagged by both volunteers and professionals. Professionals articulated delays in setting up and updating the website, whilst for the volunteers the challenge was to record their submissions online.

*"It's an old website, it's been up for over ten years and it's not really been updated in that time. And it's just the process of recording it is quite a struggle to get through, and so often people get in touch and say, I want to record these trees but I don't really understand your system of recording online"- Professional*

*"There were issues around IT, which were difficult to solve and were always going to be difficult to solve. So, in that sense maybe the sense of over optimism or just being unrealistic, that some of these issues are difficult and take time to solve"- Professional*

*"The challenge is putting it into the computer. I can't do that at all. That's hopeless. I use Map Mate for my ordinary recording and I'm thoroughly used to that but getting used to a system that is completely different, I just can't get my mind round it so, yes, not user friendly" - Volunteer*

Another issue raised by both the groups related to the limited window of opportunity to do the surveys as most of these surveys could be done only in particular seasons, an issue topical and unavoidable to tree health surveys that limits the popularity of such surveys.

*"It's been a while now because obviously you can't do it over the winter and that is a drawback of the survey, it is only really useful when the trees are in full leaf so that does limit a little bit" – Volunteer*

Volunteer interviews revealed that at times they found the methodology to be tough and had difficulties in identifying species. Also, they expressed concerns over finding and accessing the survey plots. Absence of regional contact person from the project also came up amongst the challenges discussed.

**Table 8. Negative experiences, problems & challenges**

| | Professional & Volunteer | Professional | Volunteer |
|---|---|---|---|
| **Personal Challenges** | **Balancing life and professional work** - time constraints | | Working in isolation – lonely activity; Personal worry about doing it right |
| | | | **Disappointment of not finding any pest** |
| | | | Different expectations from participation- less activity as expected; Challenges in drawing a line as to how much one can do and get involved in the project; Not submitted enough records as per owns expectation |
| **Project Related Challenges** | **Technical Problems-** website need an update; website does not engage people; problems uploading and saving information/data; IT support is needed; difficulty in recording submissions on the computer/website | **Limited funding/ reliance on Funding - challenges** to continue the project after the end of funding or to run the project with limited amount of money and capacity | Difficulty in methods - Tree health survey confusing for school kids; difficulty in identifying species |
| | **Seasonality with tree health surveys -** useful only in certain seasons limiting its use and popularity | Limited scope**: surveys only in London and less known to wider industry | Accessibility - to places that are hard to commute (North Wales); to the survey plots |
| | | Limited capacity - not enough staff, time and resources to help everyone who wants to get involved | Lack of regional contact person |
| | | Key people dropping out of the project** - losing its champion; loss of enthusiasm and energy; Key players drifted towards other | Duplication of work - different organisations doing the same thing |

| | Professional & Volunteer | Professional | Volunteer |
|---|---|---|---|
| | | CS project - project not reaching its full potential; chances of underestimating the contribution of the project due to other projects/schemes | |
| | | Managing expectations- Over expectation from trained volunteers; Living up to the success of the previous project; Confusion within partners regarding the time and effort that needs to be put in by them and the volunteers | |
| | | Time consuming during initial setup | |
| | | **No communication of results**-** lack of sharing best practice into Europe; no visibility of the outcomes of the project; Not available for diverse audiences - restricted to professional audiences; need to broaden the awareness of the project to general public | |
| | | Weak integration of the project outputs with key organisations - data from the survey did not find its way to the key organisation (FR) on time | |
| | | Policy makers/govt. not picking the project and miss to realise the wider benefits from the project (such as mental and physical health of children) | |
| **Volunteer Related Challenges** | | **Geographical spread** -** Limited/very few number of volunteers in Scotland and Wales and in rural areas | |
| | | Low turnout of volunteers for training events | |
| | | Low rate of survey returns | |
| | | Accommodating varying skill levels of volunteers - compromise between expectations from scientist and the actual work that can be done by the volunteer | |
| | | Volunteer drop out - personal circumstances (relocation to different country; bereavement; change of job) lead to changes in their motivation and willingness to work | |
| | | Maintaining volunteer engagement & motivation | |
| | | Very short engagement by the public** - take part only in once in a survey; difficulty in getting audiences for community events; reluctance from school teachers to do the survey themselves with the children; not able to follow up with the volunteers | |

*Text indicated in bold was cited the most by the interviewees

** These challenges were raised for a specific case study

Professionals also raised a gamut of concerns and challenges while executing the project. From initial delays in setting up the project, to limited capacity of people available to provide support for the project, they expressed their biggest concerns over the limited funding available to run these projects. Limited funds not only put constraints on the existing capacity and resources available for running the project but also raise worry regarding the continuity and sustainability of these projects in the future. However, they acknowledged that the problem is inherent to such type of projects and the one of the ways to address this concern is by looking at alternative funding opportunities.

*"The biggest issue has been the lack of long-term stability and long-term funding and that really does hamper how much you can kind of get into things" - Professional*

*"Least successful I feel that there is limited funding really. Like we are sort of struggling, we try to do as much as we can with the limited pot that we have and that's in terms of money and capacity for people. That has led us to kind of look to other funding streams"- Professional*

*"This year that we're in at the moment our attention has been focussed on financial sustainability, I suppose, to continue to do all the surveys and the engagement activities. So that's a huge challenge. So, the danger there is that all the interest and the engagement that we've generated for the benefit of, I suppose, government and for society could be lost, which would be an absolute crying shame. I mentioned earlier that the fact that Chalara isn't in the public mind at the moment, awareness has dropped, if things like [Name of the project] disappeared then it would drop further. And that foundation level of engagement would be lost and then there could be fewer people to contribute in a more expert way" - Professional*

Interviews with professionals also highlighted confusion between different stakeholders in a project regarding their workload and managing expectations around what and how much volunteers can do. Also, since there are many CS projects running around the same theme, there are key players dropping out from one project to join the other, thereby limiting the project to reach its full potential.

*"I think for a citizen science project to be truly successful it needs its champions and it needs its scientists to be fully engaged and involved and wanting to see the data, analyse the data and report on the data. And we, probably through people changing roles and retiring, have lost some of those people who were there at the early stages. So, some of that energy and enthusiasm into the project has been lost because other people have had to pick it up and it might not be as high on their priorities as it was on the original people's involvement of the people involved" - Professional*

Professional interviewees also highlighted challenges around the final output of the projects. The most salient being the limited dissemination of results and communication about the project. Need for inclusion of wider audience and communication about the results of the project was widely recognised. At present, there is weaker integration of these projects with key organisations and low recognition of wider benefits from these projects amongst the government or policy makers.

*"I suppose the weaker aspects of the project; we haven't done as much in terms of communicating what we've learned with other countries in Europe. I don't think we've gone far enough with that"- Professional*

*"I don't see summaries of what the volunteers have found or not found or… I think that's a real…and then I think the consequence of that is that other people involved in the project are starting to get a bit sort of more reticent about the value of it going forward. I think the project really needs to put some sort of resources into promoting what it's actually delivered more"- Professional*

In addition to personal and project specific challenges, professionals also raised a number of challenges regarding working with the volunteers. The geographical coverage of the volunteer network was seen to be patchy, with some areas having much larger numbers of citizen scientists than others. This meant there was a lack of volunteer contact particularly in Scotland and Wales meaning that geographic bias is introduced in the data collection stage.

*"I think for me on Scotland's perspective, given the number of trees and the volume of wood we have, and the conservation efforts we have, it's the number of people. I would like to…it would be good to see more people"- Professional*

Some of the professionals were disappointed by the low rate of volunteer attendance during the training sessions and the low number of reports from some volunteers, something they recognised as inherent challenge in volunteering activities.

*"You know, some people who always come to training but then you don't often get any reports from them. So that can be really frustrating. You know, that's the nature of volunteering, I suppose. People do go quiet on you" - Professional*

This also led to another prime concern around maintaining volunteer engagement and motivation through time. Some professionals found accommodating the varying skill levels of different volunteers a challenge. However, alongside this it was acknowledged that there will always be limits to what volunteers can be asked to do, and a recognition that the professionals need to have more realistic expectations around how much the volunteers can deliver, given that the volunteers have limited time and other responsibilities and priorities.

*"The other one I guess has been the way in which the volunteer network has operated in that we've spent a lot of time and effort and money in training volunteers and some of them have been absolutely fantastic and, you know, are really enthusiastic and some of them really haven't delivered on the sort of investment we've made in them so far" – Professional*

*"I suppose with all of that comes an expectation that volunteers will be able to deliver and I think that could be a negative, that we could get pulled in different directions by [Name of the organisation] and, you know, this, sort of the sense of the [Name of the project] could be lost because they have an expectation of what our volunteers might get involved with or might be able to deliver. That they're there now and so, you know, they're at [Name of the organisation] beck and call almost to be able to be used in any way that they see fit. And I think for volunteers, that can be quite demotivating if they get dragged in too many different directions or their role changes too much" - Professional*

Some of the measures taken by the professional to address these concerns were to involve the volunteers from the beginning of the project so as to include their views and considerations from the very start of the survey/project. To accommodate varying skill levels, some projects adopted a flexible approach by giving freedom to the volunteers to choose their level and habitat for data

collection. Also, to keep them motivated and engaged, two-way feedback systems are put in place. Feedback from the volunteers is sought on their concerns and views on the project and feedback is provided to volunteers on project progress and outputs. Targeted recruitment has been used to increase the number of volunteers in areas of known low representation.

*"We did a lot of research, questionnaires, little surveys, residential workshops with volunteers to make sure that we were accommodating their [volunteers] point of view as much as possible...we've also had annual questionnaires sent out to volunteers and they've been instrumental in informing how we provide training in the following year"- Professional*

*"We send them out regular updates so they're aware of what everyone's been doing. We do activity reviews which is, sort of, a summary of all the survey data that they've contributed, showing maps and tables of the number of reports submitted in each region"- Professional*

*"Encouraging volunteers to come to the communication events that we're doing. We've invited them to the meeting with our funders that took place in March. So, giving them other opportunities to get involved in the project and see the bigger picture. And that can help to really motivate volunteers to get more involved again"- Professional*

## Project Assessment - Future needs & improvements

Having described their "not-so-positive" experiences, interviewees were asked of their opinion about continuation of the project and their feedback was sought on improvements and changes to project design to overcome any challenges experienced and improve project delivery.

Forty-four out of forty-six interviewees affirmed the need to continue the project in which they were involved. Common to both groups of interviewees was the belief that there is a need to continue the project in order to continue to collect data and to raise public engagement and awareness around tree/plant health issues.

*"We're kind of picking off the best, and there's a lot of other, more trees and types of information, we can go back and record. So, there's still plenty to record, and there's also, this sort of next level of going back and updating how these trees are surviving and what's influencing any loss or decline that may be affecting them"- Professional*

*"And there is still the work to be done, of course, because you've still got the emergence of different pests and diseases each year, you know; it's still a critical part of looking at our environment and ensuring the conditions, wider than just trees, you know, are supported – the insects, the birds, everything depends on the woodlands. It's our future, so I think to stop something like this would be wrong. And it's not a whim, you know; let's continue it because we're really enjoying it – it's an absolutely need, I think, for our future and our children's futures really that we do this research" – Volunteer*

*"So, yeah, definitely the need to keep it going even more so, I think, because public awareness has dropped since we've had a crisis. At the height of the crisis the public's awareness is high and then people forget about it, but the threat hasn't diminished in any way so, yeah, it's got a very, very important role play going forward"- Professional*

*"We make more people aware of the issues for the British landscape and the British economy and, you know, take an active part in helping to help the government resolve them"- Professional*

The majority of the interviewees urged that the projects continue as they felt that a lot of time, hard work and resources have gone into setting up these projects and only now they have begun to reap real benefits of the project. Stopping the projects would not only stall important data collection but would also lead to loss of important connections/networks established during the project.

*"Yes definitely, so it needs to be an on running project in order for it to be meaningful and for its benefits and for the benefits to start to sort of reveal themselves" - Professional*

*"Oh absolutely, because I do feel that because of the early stages to it an awful lot has gone into putting the ground work in and like anything, I think, it was brand new when it was begun, so you get to a point where you feel, oh yeah, it's doing what it was intended to do. To stop it then would be completely wrong; you need to carry on that momentum" - Volunteer*

*"It would be really good to…I think we're kind of…it feels like in the last six to 12 months the project has kind of begun to reach maturity where it's actually only just started beginning to reap rewards from the hard work that's gone into it... would be really good to build on that. It would be interesting and good to see how much better it can become" – Professional*

*"I think it would be a real shame not to maintain and build on the networks that are being established already"- Professional*

Both the groups insisted that these projects can be the first gateway to citizen science amongst school children and can be one of the ways in complimenting work done by the government on tree health.

*"For the projects we work with a lot of them it's their first introduction to doing citizen science and for a lot of the schools that we work with it's their first introduction to outdoor learning in a constructive way "– Professional*

*"The government funding has been reducing over, you know, the last decade and what we don't want to do is simply substitute volunteers for government funding. What we want to do is ensure that they complement what the government funding is doing"- Professional*

Some of the professional interviewees stressed the need to collect data for over a longer period of time (longitudinal data) for more meaningful data analysis. Many felt that now they have acquired the right expertise in the field and have learnt how to incorporate 'people-focus' in the projects and therefore the project would largely get benefitted from it.

*"But even when we've recorded all of the trees I feel we need to keep it as a living database so that we can look at trees that may have been lost or fallen over, or been horribly cut down, for one reason or another, and we need to keep that information up to date so we can have an overview of how many ancient trees and veteran trees we have in the UK. And we can also start looking into the sort of rates of loss and things like that and then looking for sort of planting rates and everything else, because you can get so much information from it in the future"- Professional*

Volunteers on the other hand felt that the project needs to continue to ensure regular environmental monitoring, timely actions as and when required and to encourage outdoor learning that in turn is an important perceived benefit of CS approach.

*"because the environment is changing, isn't it, with various climatic changes that come and go; and, as I said, I volunteer with the Wildlife Trust and there are people in that group who are birdwatchers and they'll say, oh, we haven't seen many of these for a few years; and there's people into butterflies, and oh, we haven't seen so-and-sos very much. So, you get a feel for how the environment is under pressure; but I suppose new things can come in with pressure"- Volunteer*

Interviewees also shared their views and suggestions for future improvement in the development and delivery of the projects. These were broadly related to improvements needed at the project level and others related to volunteers (**Table 9**).

Both professionals and volunteers noted that there is a need to update, revise, and improvise the surveys to collect more information and longitudinal data. They also recognised potential improvements related to volunteer support, proposing more feedback to the volunteers and sharing of the data with the volunteers so that they feel part of the project. Both groups suggested some form of "volunteer accreditation" to address varying skill levels between volunteers and to increase confidence in their ability.

*"I also wonder whether it would be useful to encourage people to repeat the survey in the same area over a period of time because then they might see changes. So, at the moment it's just…..so as people look at the same few trees over a period of time might be quite a useful thing to do"- Professional*

*"You need to get some kind of formal recognition for their expertise would be good. I need some kind of accreditation or they reach a certain standard that they are now a fully trained and competent volunteer. There's no sort of grading within the volunteers. I think that might be quite helpful. That might motivate some volunteers because they'd be quite enthused by that"- Professional*

Volunteers also echoed similar sentiments around revising volunteer role in the future. They also stressed the importance of interaction and networking between the volunteers so that they do not feel lonely in the process, gain more confidence in data collection and also enhance their social interaction.

*"I suppose what would be nice, would be that people like myself to be invited to attend a course or a day seeing other volunteers, seeing…chatting through wildflowers and making sure that I'm identifying the right things, or even a day in the field somewhere with a group. That would obviously limit the number of flowers that you could possibly see in one day, but it would give one a certain amount of confidence I think"- Volunteer*

*"It would be very useful I think and I think it would…you know, it…for those people that might think about giving it up, I think it might make all the difference if they knew there was somebody else they could go out with, you know" – Volunteer*

**Table 9. Suggestions for improvements in the future development and delivery of the project**

| | Professional & Volunteer | Professional | Volunteer |
|---|---|---|---|
| *Project related improvements* | **Survey quantity & quality**- more surveys and data collection (look at more trees; surveys targeted to just trees and not pests to get people involved); Changes in ways to do the surveys- revising the surveys; to repeat the surveys for the same patch over a certain time to collect longitudinal data; more clear and definite guidelines regarding data collection and submission; more targeted surveys (more focused on sites and issues rather than individual discretions; surveys in appropriate seasons) | **Project design**<br>Updating - surveys; websites and records<br>More Resources - funding and staff time<br>Data- monitoring env. changes; threats to the trees; saving the databases for future use; to explore other aspects of plant health<br>Embedding CS concept within government - exploring with the policy makers about their needs; co-design of CS<br>Better ways to make the project appealing to the younger generation | Review roles of volunteers |
| | | **Project delivery**<br>Quality assurance of the project to identify strong and weak aspects of the project<br>Simplify and streamline the processes - need to reduce the less mundane tasks; reduce bureaucracy; Time compensation or funds for training courses abroad for the professionals | |
| | | **Project communication**<br>putting data to work - Processing data into useful information; Linking the data with the policy/local level<br>More communication about absence of pest data; Freedom to widely talk about the project; communication with external stakeholders promote the findings and tangible benefits of the project to funding organisations<br>Devise a strategy to inform public in case of disease outbreak | **Networking between volunteers** - short- or one-day course to be with other volunteers; field studies/surveys done with other volunteers working on the same project to boost confidence |
| | | **Project extension**<br>Apply more widely across UK; Collaboration btw different tree or other CS projects; Expansion of the project internationally | Setting up regional coordinators |
| *Volunteer related improvements* | More feedback to volunteers - more communication between the professionals and volunteers; share results with the volunteers | **Volunteer resource**<br>Better geographic representation among volunteers<br>Recruit more volunteers | |
| | Differentiation and accreditation of volunteer: More clarity on differentiation of roles or different levels at which volunteer can participate; accreditation of volunteers to acknowledge and recognise expertise of volunteers | **Volunteer support**<br>Training workshops; survey guides made simpler<br>Flexibility in doing surveys as per the client needs<br>Specific task for good volunteers - more focused monitoring in specific sites<br>Manage expectations of the volunteers<br>Building of volunteer network regionally - volunteers supporting and mentoring other volunteers in their local area | |

*Text indicated in bold was cited the most by the interviewees

Professional interviewees made a number of suggested improvements across all stages of the project. At the project design level, many professionals proposed the need to have more resources and the need to upgrade the current project by updating and revising the surveys and the websites. In terms of data collection, projects need to broaden their remit and collect data to monitor more long-term environmental changes, threats to trees and more issues related to plant health. Many professionals also emphasised the need to co-design the project with the policy makers so that project outputs are "in sync" with the policy needs and have real policy implications.

*"I think so far we've focused very much on tree health side of things, so we may want to look at a little bit more about other aspects of plant health maybe more broadly" - Professional*

*"What I think I would like to see more of is more connection with the policy, at least on a local level and on a broader scale"- Professional*

*"If we can look at working with them at a more strategic higher level and embedding citizen science as a concept within the government organisations….the problem is these organisations, all these whatever they are, going back to departments, you can find individuals who are very supportive and very enthusiastic, but suddenly they're gone, moved somewhere else. So, you're back to square one selling the thing to someone completely different" – Professional*

At the project delivery stage, professionals suggested the need to streamline and simplify the processes and proposed to have adequate project quality assessment measures to identify the strength and weakness of the project. Few professional participants suggested ways to compensate their time via funds or sponsorship for attending training courses abroad. Other professionals suggested the need to find ways of making CS interesting for younger generations.

*"I suppose there's ways of simplifying things. You know, obviously we're hoping that we won't have a funder that we have to, you know, report to and jump through hoops for. So, things like…you know, the basic things like not having to fill in timesheets and those sorts of mundane tasks that really take you away from your core role. So, you know, that would be good to not have those hoops to jump through" - Professional*

*"From a scientific point of view, it would be good to do more quality assurance. Because any project of this nature of this nature is going to have compromises, it's not just about saying whether the data are good or bad, it's also about identifying which aspects of the project might be weak or strong so that that might also inform how we put effort into developing volunteers in the future, for instance, whether we do have more training courses on identifying grasses or whether we have more training courses on identifying habitat, whether we have, for instance, YouTube videos or more printed resources in certain areas" - Professional*

*"Sometimes pests and diseases can be perceived as being a negative topic because they kill things and they harm it, so maybe we could have a new project that's a bit more a positive tree health citizen science activity on trees that might be actually just generally getting people involved with trees as opposed to a pest and disease aspect, as a starter to draw them. So, I think there's so many ways we could do but probably a moment of reflection and review of what we've done would be appropriate"- Professional*

Interviews with the professionals also highlighted the need to address the communication aspect of the project. Not only should the data collected be used at the policy level, but also the findings of

the project are circulated among wider audiences both at national and international level. Number of professionals stressed the need for communication about absence of pest as informing public about the absence of the disease or pest is as important as information about disease/pest outbreak. In the cases of an outbreak of a pest or disease, communication strategies should be in place to inform the public. Professionals suggested the need to showcase the real tangible benefits and value of the project to the funding bodies to strengthen the case for future funding.

*"I don't see summaries of what the volunteers have found or not found or… I think that's a real…and then I think the consequence of that is that other people involved in the project are starting to get a bit sort of more reticent about the value of it going forward. What I meant is in terms of what it's delivering in benefits on the ground, sharing that more. So, what I just said, what are…what has…what are the tangible benefits the project has delivered and being…you know, putting some effort into sort of sharing that more widely, particularly with the organisations that are providing funding"- Professional*

Suggestions were also made regarding project extension, especially the need for international collaboration and integration with existing citizen science projects. The point was made that the UK's biosecurity could be enhance by increasing awareness and surveillance for tree pests and pathogens in other countries.

*"I think we need to explore expansion or extension of the models, as it were, beyond the borders, not just in the UK because lots of these pests and diseases move into Britain from, say, continental European so if we've got people...So a good example to give you one is that Emerald ash borer is present in Russia and is moving west, although it's moving a bit more south west than due west. But wouldn't it be marvellous if we'd got people doing the [Name of project] and [Name of project] type material activities in Eastern Europe and that might then even protect Britain better because people will be doing it so far away from our country really which would enhance the UK's bio security"- Professional*

*"I think we possibly need to look closer at some collaboration working because as citizen science as a whole has been expanding, there's a lot more projects out there compared to say when [Name of project] started. I think if we could get, as a sector, better collaboration and working together, then the data we can collect could be even more useful"- Professional*

Volunteers themselves acknowledged the issue uneven geographic coverage and the importance of allocating tasks commensurate with available capacity and/or the need of targeted recruitment to improve geographic coverage of the network. They again emphasised the importance of continued support, including a suggestion of regional volunteer network.

*"Targeted recruitment I guess is probably the wrong word but encouraging people in certain areas to get involved in [Name of project]. I feel that that might allow a better product if we had a proper, reasonably well distributed network of volunteers, you wouldn't get black holes in areas and massively over-reported areas in most places. So, I think, yes, a better geographical distribution or trying to recruit in those areas would be something that I would probably look at as the next step" – Professional*

*"I think there would be more benefit if we actually directed them a bit more, so we sent them to places we wanted them to look. So, it might be that, you know, we make improvement to the triage process. It might be*

*that we're more directive in terms of the work that the volunteers do so we send them to places where we actually want them to look for particular pests and diseases rather than them being quiet, you know, passive…rather than us passively receiving reports"- Professional*

*"I think it would be good to have more of a regional focus for our volunteers. So, it is quite hard currently to sort of get that community feel going. So, we now have [Name of project] Mentors who are volunteers that have volunteered again for another role, and they are there to help support volunteers that are local to them and mainly through email support currently but hopefully we will be able to give them the confidence to actually meet people face to face"- Professional*

## Role of CS in Tree Health and relevance of data in providing evidence for policy

In addition to the views on citizen science projects, the interviews also explored views and opinion of professionals and the volunteers regarding the potential for using CS approach in addressing tree health issues and the relevance of CS data in tree health policy or decision making (**Table 10**).

Overall, both the groups stressed on the importance of adopting a citizen science approach in dealing with tree health issues. Most of the interviewees noted that CS approach allows for early detection and surveillance of pest and diseases, helps raise public awareness and enables public involvement at the very local level. Professionals also indicated that CS can potentially bring positive behavioural change towards the environment.

*"I think it's the citizens that are actually out there more often than the professionals. So, they have a chance to see how things are changing, they have a chance to notice things and the like, so I think actually that's probably the way most pests and diseases will get noted" – Professional*

*"Because it's a way of getting local information, local people to identify local issues, because they're the eyes on the ground, and they can see change, and once they've had their eyes opened to what to look for, they really can see on the spot changes happening" - Professional*

Volunteers, on the other hand viewed this approach to be much more appealing and simpler way than 'pure science' to generate public interest in tree health issues. Also, it allows for data collection across wider geographical locations.

*"Well, I think what it helps is that it increases the number of people who are looking so your chances of finding it are higher, and the earlier you find it the greater the chances of successful eradication" – Professional*

**Table 10. Views on Citizen Science in tree health**

| | Professional & Volunteer | Professional | Volunteer |
|---|---|---|---|
| *Role of CS in Tree Health* | ***Positives*** | | |
| | **Detection and early surveillance** | Potential for having THCS- Tree health is accessible to people - people have access to woodlands | Easier way to generate interest in public than 'pure science' |
| | **Builds awareness** | Valuable in bringing behavioural change | Geographical coverage |
| | **Contribute at local level - involves people at local level; allows for data collection at a local level** | | Helps to flag tree health issue |
| | Compensates/helps in absence of already limited professional tree health specialists | | |
| | ***Concerns/Improvements*** | | |
| | CS is valuable provided there is adequate support- initial training; clear identification guides | Useful if the issue of continuity is addressed - longevity of the project | |
| | | Need to consider the aim of CS - actual research vs mass participation | |
| | | Require involvement of the wider network of stakeholders - tree enthusiasts, tree wardens, government bodies etc. | |
| *Value of CS data* | **Valuable provided it's of good quality -** Collected responsibly; verified by an expert; clear understanding about the data caveats or limitations | Complements govt. data | **Benefit of numbers -** more eyes and years given the limited funds and manpower to do so |
| | **Should be used as evidence for tree health policy** | | Generate public awareness |
| | **Aids in making decisions about control and mitigation of pests** | | |
| | **Allows to tap the very good 'non-experts' knowledge and expertise** | | |
| | More public voice can influence policy using CS data | | |

*Text indicated in bold was cited the most by the interviewees

However, both the groups cautioned that there needs to be adequate volunteer support in form of training sessions and survey guide and materials for CS to be successful. Professionals also indicated that tree health CS require participation of a much wider network of stakeholders, continuity of funds to sustain the project and clear objective from the very start as to whether it aims for mass participation, scientific research or both.

*"As long as the training's there and people know what they're looking for. I don't like excluding people but I do think there should be vetting, just to make sure that it's someone who's genuine and interested...But then you*

*do get people who just make up bogus claims, or go to the training and don't do anything beyond it" – Professional*

*"You're also going to get a lot of false positives, and that kind of project therefore, yeah, necessarily requires a certain amount of resource on behalf of the funder to sift through all of those records, provide feedback to those people and sift out the positive identifications from the false positives. Which takes a lot of resource and a lot of effort, so I think when you're at a mass participation end, you perhaps need more consideration of what's likely to, you know...whether it's really sensible to conduct that type of project and what the real aims are, whether it's about education and those types of aims, rather than the actual scientific aims"- Professional*

*"You need participation from citizens, Citizen Science, you need different local government tree officers, you need it from national government, and you need it from contractors and consultants. It's all the different levels of governance need to be working together as an organisational jigsaw to make this evidence valid and use it in policy"- Professional*

*"There is another issue though, which is continuity, because if we're going to use citizen science, citizens to help in the monitoring of pests and diseases in a strategic way, then we have to consider their involvement in more than two- or three-year tranches of project time, which is where I think we are at the moment. So, these issues do require strategic thinking. It may be that the answer is, well we can't find a mechanism to manage citizen scientists in anything other than three-year projects, in which case I personally would say, well then maybe it's better to find another way to deal with the issue of tree health, because this is too uncertain. You're dealing with tree health, you know, you've got a serious issue there which is a strategic nature. It has a greater value to the nation state and therefore you have to really think about how citizens are going to be managed in perpetuity" – Professional*

When asked about the value of data collected using CS, both the groups opined that the data should be used in policy and decision making. Most of them mentioned that provided the data is collected in a rightful manner and verified by an expert, it can provide evidence for policy. In particular, the benefit of increased surveillance above the level achievable by officials alone (given budget constraints and lack of manpower) was highlighted. Also, data collected in such a manner could be one of the ways to tap in the knowledge and expertise of the 'non-experts' and possibly a way to include public voice in policy.

*"You haven't got many expert plant pathologists living in most neighbourhoods. But a lot of people with some very basic training could report those sort of diseases" – Volunteer*

*"If you rely simply upon the professionals in the field, because of funding if nothing else, they are few and far between. So, if you've got a body of citizen scientists assisting. That's building up a far more worthwhile global picture that can and should be used statistically to develop wider policies, there's no doubt about it in my mind"- volunteer*

*"I guess there's a lot of scope, there's a lot already being done, but I think we're seeing that non-experts are actually really quite good and really quite interested in these things, so as long as there's proper mechanisms to check the data quality then absolutely there's a role for citizen science" – Professional*

*"I would say you can get meaningful data but you probably have to check some of it to have some levels of confidence in it. Then if you wanted to draw a fact from it, you'd have to get a team to do everything" – Volunteer*

*"I mean I know that there is scepticism amongst what you might term real scientists, the professional scientists, that citizen science doesn't have the same rigour as professional science. But I think in terms of tree health pests and diseases, you know, if someone finds a pest that's not present then it's pretty black and white because it can be identified and acted upon. But equally, if you have a large number of reports then you can monitor trends, I think through citizen science without being too fussy about whether every single one of the reports is exactly right, because it's the volume of data which enables you to make deductions from, rather than individual pieces of work. So, you know, I think it's a very useful complement to mainstream science" – Professional*

*"I hate to think the information that we're doing wasn't being used, really. I'd like to make sure that, you know, if there's people recording disease and pests and trends. That they're fed back and those trends impact on policy and delivery" – Volunteer*

*"And I think it also is good for if people know that the records they're submitting is having an actual effect on how policy decisions, that would probably be a key drive to keep people involved and they can feel like they're doing something"- Volunteer*

*"But I think in a policy sense, I think that it also helps to improve policy by engaging a wider range of stakeholders and policy formulation and, you know, a sort of…if one appreciates the work that citizen science delivers, then it will inevitably get taken into account in policy development and improve it I think, because it adds an extra data source and an independent source of data as well which is often quite useful" – Professional*

## Discussion & Conclusion

This chapter has allowed comprehensive analysis of the current landscape of tree/plant health CS projects in the UK. It also enabled reflection and valuable insights on the experiences and views of professionals and the volunteers who have been involved in some of the projects. Most of the literature on CS has focussed on the motivations and expectations of the volunteers. This study has taken a more holistic view by incorporating motivations, expectations and views of both the volunteers as well as professionals involved in CS projects as continued involvement of both these groups is key to successful design, delivery and implementation of CS projects.

The interviews in this study were able to capture overlapping and divergent themes and ideas amongst the professionals and volunteers. Notably, a number of similarities were found between the two groups around several of the issues explored in this study, indicating that both the stakeholder groups agree with many of the facets and processes associated with a CS project.

Another important aspect that emerged from these interviews was the overlap among different categories of motivation, expectation and benefits. Broadly these were categorised into personal, professional, social and environmental themes, many of them were not exclusive to just one category and could be attributed to another category. For example, sense of contributing to the environment and society emerged as an important motivation and expectation and could be categorised as both personal as well as environmental motivation and expectation. This raises an important characteristic of CS projects where such issues are interlinked quite strongly and more specifically one process leads to another.

Interviews highlighted several important motivations ranging from personal motivation such as staying outdoors to more social and environmental motivations, including public engagement, social bonding, helping the environment and protecting tree health. Also, individual's educational background and personal interest in certain species were central motivations for many of the interviewees. The current study also explored expectations of the participants to understand important determinants of participation in CS projects. The interviews showed that for both professionals and volunteers, important expectations are driven by personal belief to be able to make valuable contribution in the project and also being appreciated for contributing something useful and worthwhile in the project, gaining new skills and knowledge, receiving feedback, generating useful data and contributing to the environment and society. Future design of CS projects should take these motivations and expectations into consideration to best address participant's needs.

One of the most important conclusions of this study is the broad consensus regarding projects exceeding or living up to the expectations of the participants and the need to continue the project in the future. This not only indicates how well the projects have fared in addressing expectations and concerns of the participants involved in the project but also highlights the success of these projects in a short time span of their existence.

This chapter further considers the impacts that have arisen or might potentially arise from a citizen science project, by building a series of benefits associated with project participation. These cover issues such as new social contacts, improved attitude towards the environment, enhanced collaboration and connection with other organisations; gaining knowledge and skills, enjoyment, health benefits and positive self-image as a result of doing something worthwhile. These projects have demonstrated the value of 'learning by doing' as participation in the projects made the participants realise the value of volunteering in addressing tree/plant health issues and also put forth a strong case for partnership working.

Participants were given an opportunity to reflect on their experiences and assess the projects in which they were involved, with potential to inform current projects and other citizen science projects. Participants articulated their thoughts in their own words regarding the positive as well as less positive aspects of the project. Clear linkages and connections are seen between the motivations, expectations, benefits and positive experiences. These in turn can help us to understand the overall positive feedback on the projects. In terms of challenges and problems, a number of issues raised by the participants related to the challenges encountered and reported for other CS projects in the literature such as limited geographical representation of volunteers and issues with the technology. However, certain challenges were specifically related to tree/plant

health CS projects and associated due to the inherent nature of working with trees, pest and diseases. These were related to the limited time of undertaking the tree surveys due to seasonality and also the challenge of coping up with the 'disappointment of not finding the pest or disease'. The latter needs to be addressed in future communication of project results and better ways of promoting the value of 'absence of pest' needs to be in place.

Key themes emerging for future improvement related to project update in terms of design and technology, delivery, communication and extension; volunteer as resource; volunteer support and developing volunteer network.

# Chapter 3

## The Future of Tree Health Citizen Science: Deliberations from a Participatory Research Workshop


### ABSTRACT

This chapter reports on the findings from the participatory research workshop titled "The Future of Tree Health Citizen Science: Opportunities and Challenges" hosted by Defra and Centre for Environmental Policy, Imperial College London, on July 5th 2017 at Fera, Sand Hutton, York. The Workshop involved policy-makers, scientists, managers (of either land, organisations or projects) and citizen science practitioners (N = 24) with an informed interest in tree health citizen science. Through a mixture of presentations, break-out discussions/feedback and voting on priorities, a collective consensus was obtained on (a) issues, barriers and challenges; (b) values opportunities and advantages; and (c) the future of tree health citizen science. The main themes that emerged out of the workshop discussions were:

Collaboration: a need exists to build relationships and foster collaboration between projects, between the various stakeholder groups, especially between policy-makers and citizen science practitioners and volunteers, and indeed between policy-makers in different policy areas. The nascent tree health citizen science network was proposed as one means to start better collaboration.

Standardisation: the statement "standardisation to improve consistency without stifling innovation" summed up a consensus view of the need for a degree of standardisation on methodology, especially to ensure data quality and to facilitate data sharing. One fresh idea to achieve this aim was to engage with the European and Mediterranean Plant Protection Organisation who have a long history of producing guidelines.

Sustainability: the transient nature of funding of citizen science projects was noted as a serious risk to maintaining momentum and avoiding the loss of hard-earned public participation, capacity and infrastructure. Suggested solutions included the need for development of a 5-year strategy, mainstreaming activities into business as usual e.g. citizen and statutory surveillance.

Volunteers: last but by no means least, was the need to understand, support and truly value public participants. Their potential to become that 'standing army' to help with pest and disease outbreak response, provide valuable long-term records on their own patch and at times when officials might not be available was noted. Increased scientific literacy, greater engagement with nature, improved employability (especially in disadvantaged rural communities) were a few of the benefits noted. Provision of learning pathways, gateways to opportunity and local community ambassadors were suggested as solutions. The quote "Science is not just done in a laboratory by people in white coats" perhaps provides the best vision of the future role citizen scientists in tree health.



**Keywords** - Participatory research workshop; Policy makers; Managers; CS practitioners; CS Challenges; CS opportunities; CS future

## Background & Objectives

In recent years, one of the key components of the government's action to better protect the country against the growing threat of tree pests and diseases has been to involve the wider public in engagement, awareness raising, environmental stewardship and direct support for official surveillance.

In March 2015, Defra commissioned a tree health citizen science fellowship on the basis that:

- Citizen Science (CS) represents a key dimension of a collaborative approach to safeguard the health of the nation's trees and forests
- Appropriate time for a stock-take of the portfolio of projects and the data they are producing
- Outputs will be used to shape future delivery of tree health citizen science to support policy, management and science

The results of this fellowship have been presented in this report. Chapter one, reported on the research exploring the current tree health evidence needs and the scope of citizen science to address the evidence needs as identified by tree health science, management and policy stakeholder groups in the UK. In Chapter two, the current landscape of citizen science projects related to tree/plant health was outlined and a comprehensive list of motivations, barriers and opportunities of using CS approach in tree health issues was presented using case studies of five distinct CS projects.

The current chapter reports on the findings from the participatory research workshop titled “The Future of Tree Health Citizen Science: Opportunities and Challenges” hosted by Defra and Centre for Environmental Policy, Imperial College London, on July 5$^{th}$ at Fera, Sand Hutton, York. The purpose of the workshop was to bring together a variety of stakeholders involved in tree health science, management, policy and tree health citizen science to discuss and explore the findings of the research fellowship (chapter one and two) and to seek their opinion on the potential issues, opportunities and priorities for action for enhancing future delivery of Tree Health Citizen Science (THCS).

## Participatory Research Workshop

The workshop was attended by 24 participants with an informed interest in tree health citizen science. Participants were allocated to a stakeholder category (science, policy, management and citizen science practitioners) according to what best-suited their role. The numbers of participants in each of the four stakeholder groups for the workshop were as follows: (a) policy-makers (N = 5); (b)

scientists (N = 8) (c) managers (of either land, organizations, or projects) (N = 6); (d) citizen science practitioners (N = 5). During the workshop, short presentations were given by Dr David Slawson and Dr Jake Morris on the background of the research fellowship. This was followed by two power point presentations by Dr Nidhi Gupta on findings from the research project highlighting 1. The issues, barriers and challenges and 2. The values, opportunities and advantages associated with THCS. After each of these presentations, three breakout sessions were conducted during which the four key groups (Science, Policy, Management, CS Practitioners and volunteers) participants discussed and presented their opinions on three key themes: (a) “Issues, barriers and challenges”; (b) “Values, opportunities and advantages”; and (c) "Future of tree health Citizen Science" (**Table 1**). At the end of break out session 2, an opinion poll was also conducted where participants voted for the five most important values, opportunities and advantages of Citizen Science in tree health that we need to protect in the future. The workshop was moderated by Dr Slawson and Dr Gupta and final conclusions from the workshop were presented by Dr Charles Lane from Fera (see **Appendix D** – agenda of the workshop).

**Table 1. Breakout Session Themes and Research Questions**

| Breakout Sessions | Research Questions |
|---|---|
| Session 1: Issues, barriers and challenges | Q1: Are there any other important issues, barriers or challenges identified by the research so far that you would like to add to the list (provided in the presentation – Appendix B)?<br><br>Q2: What are the three most important issues, barriers or challenges & why? |
| Session 2: Values, opportunities and advantages | Q1: Are there other values, opportunities or advantages of CS identified by the research so far that you would like to add to the list (provided in the presentation – Appendix C)?<br><br>Q2: What are the three key values, opportunities or advantages that we need to protect in the future & why? |
| Session 3: Future of tree health citizen science | What are the three priorities for action in order to secure and enhance the value of Citizen Science in tree health? |

# Workshop results

## Session 1: Issues, barriers and challenges

An initial list of the issues, barriers and challenges associated with tree health citizen science based on the findings from the research project (**Appendix E**) was provided to the participants and they

were requested to identify any additional issues that they thought were missing from the list in a break out session. All the four stakeholder groups identified issues, barriers and challenges that they considered important for applying a citizen science approach in tree health (**Table 2**).

**Table 2. Issues, Barriers and Challenges associated with THCS**

| Stakeholder Group | Additional Issues, Barriers or Challenges |
|---|---|
| **Science** | ➢ Lack of standardization- of data, terminology and methodologies<br>➢ Geographical gaps in data - Volunteer activity in certain areas<br>➢ Consequences of reporting - concern over operational consequences of finding and reporting a pest/disease in a particular place (e.g. sanitation felling)<br>➢ Democratization of science would lead to changed relationship between government and the citizen involving greater transparency from government and ceding some responsibility to the citizen; and the citizens having greater responsibility especially give the potential consequences arising from their surveillance e.g. destruction of trees.<br>➢ Care needs to be taken not to ask citizens to undertake tasks beyond their abilities e.g. identify to species level. The solution is a two-tier approach where citizens observe and send suspect samples to an expert who performs the identification (using technology e.g. molecular technology) |
| **Management** | ➢ Timely feedback to those collecting data<br>➢ Being aware of new CS initiatives & existing CS projects<br>➢ More awareness of wider CS landscape to maximize volunteer potential<br>➢ Competing priorities between the plant health authorities (APHA, Forestry Commission) between doing their 'day job' and CS<br>➢ Emphasizing the importance and value of taking part rather than finding a pest/disease: negative findings are also valuable<br>➢ The need to motivate volunteers: start with something that they can find because that gives them a platform to work from, a balance and a starting point and motivation<br>➢ Investing in technology to aid in data collection & data analysis<br>➢ Resources needed to triage the findings<br>➢ Volunteers need to be 1. Fully informed about the purpose (spot outbreaks early so that they can be controlled before they spread to the rest of the country) of their activity and of 2. The possible consequences (infected plants may be destroyed) resulting from the activity. |
| **Policy** | ➢ Understanding among different stakeholder groups on the purpose and mission of CS project<br>➢ Gaining understanding of different CS projects from a policy perspective<br>➢ Need for co-design between policy and CS projects<br>➢ Evaluation of projects: to assess where to spend the money; what is the best value for money for policy to spend with respect to surveillance? Is it citizen science? Is it statutory surveillance? Is it a mix of both and how do we gather information to inform decision-making?<br>➢ Identify policy needs to identify areas where policy can strengthen or support the CS network |
| **CS Practitioners** | ➢ Trusting the volunteers - making sure volunteers working on behalf of your project don't bring the project and, therefore, the partners and organizations, into disrepute<br>➢ Keeping pace with devolution - at the moment if we are talking GB/UK wide projects it's making sure that there is buy-in at a national level (Scotland, Wales, England). |

These issues and challenges can be broadly grouped into five categories: data; volunteers; democratization of science; stakeholder roles and expectations in THCS; and wider networking and collaboration of CS projects.

**Data**: One of the challenges to assure good quality of data was the lack of standardization of data, terminologies and methodologies used for different CS projects and within different stakeholder groups. Also due to limited volunteer activity in certain areas, there could be geographical gaps in the data. Some of the solutions proposed to tackle these issues included the need to standardize the data and methodologies for THCS and to invest in technologies to aid in data collection and analysis.

> *"How do we get standardization, of methodologies, how do we get standardization of data and things like terminology, real basics about are people calling them"- Science*

> *"It's about standardizing the common collected data, you know, just simple things like grid references. So, we actually start with a core, if you like, of data to which we bolt on more specific things to different projects. So, we mentioned about sort of almost like an ISO standard for citizen science" – Management*

**Volunteer:** Volunteer motivation came up as one of the most prominent challenges. The view was expressed that in the case of tree health, volunteers could become demotivated when they are unable to find the pest or disease they are looking for (which essentially is a good thing). Also, many of the volunteers take part in THCS due to their passion and love for trees and can get demotivated to report a pest or disease because of their concern over the consequences of doing so which in this case would be cutting the infected tree. Trusting the volunteers also came out as a challenge. The need to ensure that volunteers can be trusted to not bring disrepute to the project was recognized.

> *"Then they [volunteers] start to question, what if I find a quarantine one, what are you going to do to my patch? This is my wood, are you going to come and chop all the trees down? So, you start to get in this de-motivation, this conflict of interest for those volunteers."- Science*

Some of the solutions proposed to address these concerns regarding volunteer motivation were to inform the volunteers fully about the purpose (spot outbreaks early so that they can be controlled before they spread to the rest of the country) of their activity and of the possible consequences (infected plants may be destroyed) resulting from the activity. Also, to keep them motivated, there is a need for timely feedback to them on the data collected and its use. Emphasis should be given on their participation rather than finding a pest or disease and the importance of negative findings should be communicated to the volunteers.

**Democratization of Science:** Often citizen science is touted as a powerful way of democratization of science and research. However, there are challenges associated with the process as it has real consequences in terms of roles and responsibilities both for the individuals and also for policy-makers and the government. To address these challenges, the policy-makers and government need to acknowledge whether they are prepared to handle the process and its consequences such as how prepared they are to tackle chance findings of new or unknown pests or diseases by citizens.

*"As you start to democratize science and you start to put things into the hands of citizens you don't necessarily have control anymore…..What would be the example if they found quarantine pests? What if they find anthrax in their back garden, what are the policy implications for those? …..When you find the unknowns, what do you do about them?" - Science*

**Stakeholder roles and expectations in THCS:** One of the issues concerning THCS is the lack of understanding among different stakeholder groups on the purpose and mission of CS project. There could be competing priorities and or agendas for various stakeholders involved in CS projects.

*"Competing priorities between the plant health authorities (APHA, Forestry Commission) between doing their day job and CS" - Management*

Careful consideration should also be given to setting realistic and practical expectations from the volunteers involved in CS projects. Volunteers need to be given tasks according to their abilities and skill set and a two-tier approach should be in place where citizens observe and send suspect samples to an expert who performs the identification (using technology e.g. molecular technology).

*"So, this idea that maybe in tree health context you've got this piece of detection versus identification. So, it actually may be citizen inspectors are very good at detecting something but maybe you don't want to trust them with the final identification of something. So, again, that actually maybe you've got citizen science as part of a two-tier process and it's not a standalone part of your surveillance mix" - Science*

There is a need to understand different projects from a policy perspective or needs in order to identify potential areas where policy can contribute in strengthening and or supporting the wider tree health citizen science network. Potential solutions proposed were to encourage more co-design between policy and CS projects and also to carry out evaluation of different CS projects to assess where to spend the money to maximize the benefits.

*"When we're talking about evaluation, and it's not just at individual project level, it's across the citizen science landscape, that's what's really missing, we also need" - Policy*

*"So, exposure of the scientific community and the policy community to the realities of citizen science who also built the strength of their constituency in how they might visualize and, therefore, use citizen science" – Policy*

**Wider networking and collaboration of CS projects:** A need for awareness and collaboration between existing CS projects and new CS initiatives was realized across the stakeholder groups. A more joined up approach would help in maximizing volunteer potential and allow for more partnership opportunities. Also, there is a need to have representation from Scotland, Wales and England for GB/UK wide projects.

*"Being aware of new citizen science initiatives, existing citizen science projects, I think that would be more helpful. That would help us maximize the use of volunteers" – Management*

*"Coordinating the whole of the CS landscape really so that we actually get value for money and efficiency" – Management*

*"Different organizations have different priorities, different mechanisms of working, different methods. Different ways of working and it's finding that common ground, those common interests, to allow us to move forward" – CS Practitioners*

## Session 2: Additional values, opportunities and advantages

Similar to session one, an initial list of values, opportunities and advantages associated with tree health citizen science that was based on the findings from the research project (**Appendix F**) was presented to the participants. The groups were then requested to discuss and identify any additional values that they thought were missing from the list. **Table 3** summarizes the outputs, covering the additional values, opportunities and advantages associated with THCS identified by each group.

The values and opportunities can be broadly grouped into five categories: data; democratization of science; tapping the 'non-expert' knowledge; public engagement; Lessons for future delivery of CS.

**Data**: Participants emphasized that citizen science is one of the ways to collect useful and good quality data related to tree health. Also, there is a huge potential to gather additional data of relevance to tree health, including other pest and diseases. Furthermore, there are advantages in terms of longitudinal data collection and analysis, with volunteers looking at the same patch for many years.

**Tapping the 'non-expert' knowledge**: CS was also seen as a way to tap into long term local knowledge of people and volunteers and an opportunity to build capacity by engaging and making use of the knowledge of certain groups, such as retired professionals who can make valuable contributions to tree health.

*"We feel there's a real value to this long-term local knowledge. You've got people who've been living in an area maybe for many, many years, are going to be living there, lots of employees of organizations and NGOs come and go, they're not in the same place for long, they're not in the same job for long, but actually having people on the ground who the example I've said have been maybe looking at that oak tree outside their window for the last 40 years" – Management*

*"There's a lot of other people out there that could make very good benefits to these sorts of projects, one that was mentioned, obviously Forestry Commission Retired Association for example, again there's a lot of retired people out there, an awful lot of knowledge, perhaps some more time on their hands that are perfect for involvement with some of these things"- CS Practitioners*

*"whole continuity perspective, you're moving away from what can sometimes be a very transient workforce with all due respect in the professional sectors that we work in to people who live and breathe that community and that area and can offer that long-term continuity and perspective" - Management*

**Table 3. Values, Opportunities or Advantages of associated with THCS**

| Stakeholder Group | Additional Values, Opportunities or Advantages of CS |
|---|---|
| **Science** | ➢ Potential to collect unexpected/additional data<br>➢ Open data to make it useful for others<br>➢ Longevity and sustainability - volunteers looking at the same patch for years<br>➢ Democratization of science<br>➢ Building knowledge and experience of how to do it (CS) better in future<br>➢ Fun for all- 2-way process between the professionals and volunteers |
| **Management** | ➢ Value of long-term local knowledge of people and volunteers<br>➢ Availability of people looking at alternative hours other than specified times that the professionals work<br>➢ Opportunity to have transfer of knowledge and engagement with younger generation<br>➢ Tapping into community assets (cameras/drones etc.) |
| **Policy** | ➢ Potential for people to get interested and involved in other areas beyond tree health<br>➢ Profiling volunteers to understand their motivations- match making opportunities<br>➢ Integration of statutory surveillance programs and CS surveillance programs to identify where is the greatest value<br>➢ To explore how do we celebrate success, are we doing that well, could we be doing it better, are we doing it in the right way |
| **CS Practitioners** | ➢ Reach wider audience<br>➢ Capacity- tapping knowledge of certain groups (e.g. retired professionals)<br>➢ Quality assurance- data coming from trained volunteers |

***Democratization of science**:* One of the values of CS is the democratization of science, whereby science is not seen as the preserve of scientists and professionals but can be supported by a much broader societal contribution.

> *"democratization of science, this idea that you're endearing a cultural shift in the way that we look at science, it isn't just something done by people in white coats in big white buildings, it's actually something that can be done by everyone and everyone can engage with it" - Science*

***Public engagement**:* One of the biggest positives around THCS is the opportunity to engage a wider audience, general public and transfer of knowledge to younger generations.

> *"public engagement, about that's absolutely key that this is this point of bringing people into the process and getting them engaged with their local environment, their local communities, and I think that needs to be preserved" - Science*

> *"CS is a way of bringing new people in, but also it gives value to people who have retired from their careers but actually have still a huge amount to offer to society, and then you actually get this connection and a younger feeding off the older and the wisdom and experience, so this lovely connection between the two, the transfer of knowledge"- Management*

Another major advantage is the 'fun element' of doing science not just for the volunteers but also for the professionals.

> *"They talk about enjoyment and fun and the idea that it's probably very good for the volunteers, but actually it's a two-way process, and actually there's definite fun through the engagement and positive feedback for those on the research side and the officials as well. If you're working with a load of enthusiastic volunteers or kids, you're more likely to get very positive, rapid feedback than say if you're engaging with the local policymakers" – Science*

Public engagement can also open doors for making use of community assets (participants gave examples of equipment such as cameras and drones) for data collection.

> *"there's a load of enthusiasts out there who have these things [cameras/drones/gadgets] and actually want to use these things, and it's just a cheap way of getting your hands on those things, so tapping into community assets"- Management*

***Lessons for future delivery of CS**:* Participants also reflected that the practice of THCS allows for building understanding and knowledge about how to do CS better in future. It may open doors to understanding volunteer profiles to provide for better match making opportunities across different CS projects and to identify opportunities for integration of statutory surveillance programs and CS surveillance programs.

## Top Three

In the workshop, Participants proposed three most important issues, challenges and barriers to THCS and three most important values, opportunities and advantages associated with THCS (**Table 4**). Similar categories as discussed in the above sections emerged from the discussions across the groups. However, some issues emerged, as follows:

**Mainstreaming CS**: One of the key challenges associated with CS is that it is being led primarily by the researchers or scientists and the life of the project is limited to the availability of funds allocated for that specific piece of research. There is a need to move citizen science beyond research projects into the mainstream, making it part of business as usual of surveillance.

> *"Actually, we need to start to move citizen science into the mainstream and it becomes part of business as usual of surveillance. So, things move from research pots into operational pots, for example, in terms of finance"- Science*

**Sustainability of CS**: Challenges associated with the sustainability of CS in tree health were also discussed. Once the core funding comes to end, the next issue is how do we conserve and not lose the vast pool of talented volunteers and the whole system of resources developed during the lifecycle of the CS project.

> *"Lots of researchers, less policy people. That's because citizen science is currently done by researchers, it's done as research projects. It came up on this point that actually you have funding for three years, how do you carry it on for the next three years?" - Science*

> *"We talked about the sustainability of skills and the presence of both volunteers, those in between people who we have nurtured, and so on, how do we sustain and not lose them in the future? So, that when policy say, you know, we want these things going on in ten years and still there and continuation, and all that, how do we ensure that actually happens?" - Policy*

One of the ways to ensure sustainability is communication about the broad range of benefits of THCS to ensure that value for money is recognized.

**Collaboration and partnership challenges:** Another issue identified related to the challenges faced in working in collaboration and partnership. Often the different organizations or parties involved have different ways of working and it becomes necessary to find common ground and compromises to ensure the smooth working of a CS project.

> *"Different organizations have different priorities, different mechanisms of working, different methods. Different ways of working and it's finding that*

*common ground, those common interests, to allow us to move forward"- Management*

Another challenge is that the different organizations under the partnership or the potential collaborators are often competing for same source of funding. This can lead to lack of trust and transparency between the partners and other potential collaborators.

*"One of the issues there is that when you've got different organizations, different groups, they're often competing perhaps for the same pot of funding, different pots. Protective of your pots and your research ideas and it's how to take that forward, I think, is, again, an interesting challenge, how to be more open and collaborative whilst dealing with these potential sort of funding hurdles"- Management.*

New categories that emerged under the values associated with THCS were:

**Getting greater impact for lower costs**: CS allows for greater impact and data collection for lower costs.

*"It might be that you're just raising the whole profile to the wider public about many of these issues. I remember when the ash dieback thing happened and suddenly, we had Ashtag and all these things, Observatree and the papers were reporting on it and people who would never have read about these things before, understood them, were suddenly getting involved" - Management*

*"A lot of people who are doing research as their paid job will work from Monday-Friday from 9:00-5:00 or whatever, and more no doubt, but actually you've got people going out at weekends and in evenings and in the mornings which might actually bring a value to the data you're collecting, so you're getting people going out at alternative hours" - Management*

**Celebrating success**: Participation in CS projects can lead to volunteers acting as ambassadors of citizen science in their local area or community, encouraging others to get involved in THCS.

*"to have ambassadors strategically really growing the numbers of people involved, telling stories on their own and to local media and so on, and perhaps encouraging people in the local area also to get together as groups, they can form their own clubs and so on and do a range of things besides the project that you're actually doing, so that in between they also have other things to do so they actually build some sustainability of the activity and their skills as well" - Policy*

Another way to involve more people is to consider best ways of communicating success of CS projects.

*"Celebrating success, how do we tell those stories, what is the best way of telling those stories, how much does that actually motivate people to want to do more, and how much is that community-driven and led, or is it actually the policy and*

*the science people writing about a successful citizen science project. So, who is sharing those stories and who is celebrating it"- Policy*

**Growing Science**: The value of using CS approach is to bring people closer to science and their engagement with scientific research.

*"People become more attuned to science and they become more inspired and hopefully we inspire more people to go into some form of science" – Policy*

**Table 4. Three most important issues and values associated with THCS**

| Stakeholder Group | 3 most important issues, barriers or challenges | 3 most important values, opportunities or advantages of CS |
|---|---|---|
| Science | 😐 Standardization- of data, terminology and methodologies<br>😐 Democratization of science has real consequences both for the individuals and also for policy and Government and nationally<br>😐 Need to start to move citizen science from research projects into the mainstream and it becomes part of business as usual of surveillance | ☺ Maintain the element of fun<br>☺ Good quality data collection through a more open and democratized mechanism<br>☺ Public engagement: supporting local environments and local communities |
| Management | 😐 Coordinating the whole of the CS landscape: to achieve value for money and efficiency; standardizing the common collected data;<br>😐 Barriers to outreach: building volunteer networks; Feedback to volunteers on the data; making them feel part of the policy decision making<br>😐 Data: quality of data and the large volume of data, how we capture that and how we utilize it? | ☺ Getting greater impact for lower costs<br>☺ Gateway of opportunities (public engagement; raising profile to the wider public; stimulating a general interest in the countryside for school children; gateway to a career)<br>☺ Long term continuity and perspective provided by local knowledge and participation |
| Policy | 😐 Lack of national coordination, among different CS projects for e.g. multiple projects with different data collection and storage systems<br>😐 Policy support to different CS projects such as financial support, provision of expert training and supporting IT systems<br>😐 Future sustainability of CS: how do we communicate and ensure that we're getting the best value for money out of a national strategic drive? | ☺ Skills development- opportunities for a skills and knowledge development pathway for individuals and groups<br>☺ Celebrating success- opportunities for celebrating success by participants, organizers, funders etc.<br>☺ Growing Science - people become more attuned to science and they become more inspired and hopefully we inspire more people to go into some form of science |
| CS Practitioners | 😐 Balance between quality and quantity of data<br>😐 Collaboration and partnership challenges- different ways of working; competing for same funding<br>😐 Managing expectations across the board for all the stakeholders involved in a project (funders and volunteers) | ☺ New audience engagement<br>☺ Tapping into capacity of potential collaborating organizations and initiatives, e.g. nursery sector, retired professionals, getting the message out and getting more and more people aware of what's going<br>☺ Collaboration with the different organizations, government, NGOs |

## Opinion Poll

Based on discussions of values, opportunities and advantages of THCS, participants were asked to discuss among their group and present a list of five most important values that they would like to protect in the future. **The participants picked five of them from the entire list of values that were presented by the authors and also that were proposed during the breakout sessions** (**Table 5**).

**Table 5. Top 5 values, opportunities and advantages of THCS to protect in the future**

| Stakeholder Group | 5 most important "values, opportunities and advantages" of citizen science in tree health that we need to protect in the future |
|---|---|
| Science | • Fun - policy celebrating success<br>• Valuable data through democratized process<br>• Public engagement and increased scientific literacy<br>• Collaboration<br>• Resilience, social capital, trust building |
| Management | • Increased capacity, more data for less cost, need for greater collaboration across citizen science landscape<br>• Gateway for opportunities – collecting data enables others to access the data – a platform of information<br>• Mechanism for delivering wider benefits to society- physical and mental health, part of new schemes etc. link it to trees being planted for you<br>• Democratizing science, becoming the acceptable "norm", community ownership. Getting "buy in", stakeholder engagement<br>• Historic continuity – ability of citizens to make regular observations of and detect changes of the same site which may not be detected by infrequent visits by an official |
| Policy | • Co-ordination at project level as well as policy level<br>• Develop a funded strategy for Citizen Science in 5 years (needs a strong evaluation foundation)<br>• Inspiring the next generation – new audiences (not just the older people) as there is a need for community level ambassadors<br>• Democratization of science; exposure of people to science and exposure of scientists to people (building reciprocal trust through co-design)<br>• Understanding the audience; treating the public as citizen science customers |
| CS Practitioners | • Raising awareness<br>• Education and dissemination<br>• Collaboration between partners and organizations<br>• Quality Data<br>• Motivation and enjoyment |

Though once again, overlap was seen across the responses from the different groups, certain groups placed more importance on certain values. The *Science* group placed highest priority on the 'fun element' that CS approach can provide both to the volunteers and the professionals and also highlighted its importance in collecting valuable data using a more democratized process. The

*Management* group placed highest importance in the value of networking across the broader THCS landscape and the value of getting more data and impact for less money. The *policy* group identified coordination among the CS projects and policy and development of funding strategy for future delivery of THCS as priorities for protection. The *Citizen Science practitioners* group placed highest value on the role of THCS in raising public awareness and education and dissemination of useful knowledge and information on tree health.

## Next Steps

To summarize the discussions and knowledge generated in the workshop, the last session explored participants' opinions about priorities for action in securing and enhancing the value of citizen science in tree health (**Table 6**). Each group was offered an imaginary pot of money and was asked to discuss and agree a list of three priorities for action from the perspective of their group. The results are summarised in Table 6.

**Table 6. Three priorities for action to secure and enhance the value of citizen science in tree health**

| Stakeholder Group | 3 priorities for action in securing and enhancing the value of citizen science in tree health |
|---|---|
| Science | 👍 Evaluation of data that has been collected so far- to turn into useful knowledge and learning for future delivery of CS<br>👍 Preserve the element of fun in CS activities<br>👍 Standardize or normalize CS to improve consistency without stifling innovation |
| Management | 👍 Standardization of data, information, and terminology<br>👍 Recognizing the value of what you know - Having a local advocate or champion (somebody from the community) for citizen science<br>👍 Bringing together a common thread among the different THCS projects |
| Policy | 👍 Co-design - Clarity of what policy stakeholders want from CS and vice versa<br>👍 Building relationships between policy and CS<br>👍 Finding ways to make citizen science part of statutory delivery on policy -conversation across government departments to look at how citizen science becomes part of their business-as-usual day job |
| CS Practitioners | 👍 Funding - long term and resourcing from within core budgets<br>👍 Collaboration<br>👍 Dissemination and engagement |

Some of the quotes from the participants to reflect on their priorities for action are:

*"There's been lots of work going on, there's lots of data already been collected, both about how we do citizen science but also as part of the tree health*

*surveillance and other associated things. So let's take stock of them and see what we've already got, and let's see how we can turn some of that data into some useful knowledge: and also then look again at new ways of how we use the data again, so when you go back to it can you cross-cut it and can you do new things" – Science*

*"Bringing together a sort of common thread. Well, the data ownership is part of that, but it's about that common thread that allows us to bring those projects together on perhaps a certain day"- Management*

*"How can we get to a model where the funding moves to be core business as usual or the funding streams are more long term; because that's clearly an issue in terms of loss of staff knowledge, loss of volunteer knowledge, loss of continuity, if that doesn't happen"- CS Practitioners*

*"Be clear what is needed, what policy wants from citizen science. So that then turns it back on its head, what does citizen science want from policy. How do we build those relationships to be more effective and more inclusive?" – Policy*

*"As part of dissemination and feedback we want to ensure that all the projects are valued more widely, and we take every opportunity to celebrate success and just raise the profile of Tree Health Citizen Science work" - CS Practitioners*

# Chapter 4

# Future Delivery of Citizen Science in Tree Health: Recommendations

This research presents a comprehensive analysis of the current landscape of tree/plant health citizen science (CS) projects in the UK. It has brought together the views of many of the relevant stakeholders involved currently in tree health and CS and who are likely to shape the future direction and application of tree health citizen science. Their opinions are therefore highly valuable and timely to inform the planning and delivery of future CS initiatives related to tree health.

Most of the research done on CS in the past has explored the views and experiences of the volunteers alone. Research reported in this report adopted a unique approach by exploring the opinions and experiences of professionals as well as volunteers. The rationale being that continued involvement of both these groups is key to the successful design, delivery and implementation of future CS projects. This report reveals behavioural and motivational aspects of both professionals and volunteers. It also highlights the importance of adopting a CS approach and provides the basis for setting out some key recommendations for how to conduct successful CS projects.

Based on the key research findings of this study, recommendations aimed at improving the future design and delivery of citizen science in tree health are presented below.

## 1. PEOPLE

**(a) Motivations:** A range of varied and often inter-connected motivations and expectations exist among the volunteers and professionals involved in CS projects. There is a need to understand, support and truly value public participants/volunteers and their knowledge. Project managers need to take account of these needs when designing a CS project in order to encourage initial and continued public participation. A good example cited by volunteers was the satisfaction of finding something. Therefore, for a tree health citizen science project, including non-statutory pests that volunteers might find is important otherwise they might lose motivation from never finding a statutory pest that may never be found. During the course of the project, some of the expectations, motivations and needs might change or evolve over time and needs to be reviewed (discussed later

in the chapter under recommendation 13 and 17 regarding project evaluation) and taken into consideration during the project execution.

> ***Recommendation 1:*** *Project managers need to engage with their public participants to better understand and to cater for their needs in the project design and implementation.*

Perhaps for the first time, this research highlighted that the participation of professionals (policy-makers, managers and scientists) is also influenced by a complex range of motivations. Of great significance in this respect is the finding that involvement in a CS project exceeded expectations of most professionals. Recognition of the value of their input was also important to professionals. Therefore, it is important to take note of the motivations of professional participants as well as volunteers as they have significant effects on CS project outcomes e.g. the effect when they moved to another role (policy-makers) or to another research grant (scientists).

> ***Recommendation 2****: Understanding professional motivations is needed on a continuous basis (from the outset until the various stages of the project).*

**(b) Training and pathway for further involvement*:*** Training is vital to give the public the confidence to participate in a project and, at the same time, increases confidence in the work of volunteers and, ultimately, improves data quality. Continued training and a gateway to allow participants to develop their skills to a higher level not only contributes to increased personal satisfaction but also opens the possibility for volunteers to fulfil higher level tasks (e.g. report verification) which can be of greater value to official surveillance and/or the biological recording community.

> ***Recommendation 3:*** *Initial and continued training, and pathway for further learning must be provided to volunteers.*

**(c) Support:** Support from a 'real person' is extremely important to volunteers. Whilst some information can be provided 'virtually', volunteers confirmed the value of direct contact with a professional and / or volunteer coordinator. Related to this was disappointment and frustration among some of volunteers regarding working in isolation with no contact with other volunteers. This instilled feelings of loneliness and worry about 'doing it right'.

> ***Recommendation 4:*** *Volunteers require personal contact with a project coordinator and opportunities to network with each other (also relevant to project design).*

## 2. PROJECTS

**(a) Standardisation:** The statement "*standardization to improve consistency without stifling innovation*" sums up a consensus view of the need for a degree of standardization in methodology, especially to ensure data quality and usability. For plant/tree health, where pests and diseases do not respect borders, opportunities should be sought to share lessons learnt on standardization within the UK and with other countries, thereby enhancing the potential for reports in one geographical area to act as early warning for other areas, ultimately contributing to increased international, national and sub-national biosecurity.

> ***Recommendation 5****: Improved interoperability of all data sources including those from citizens should be addressed at the project design stage itself to ensure acceptable data quality.*

> ***Recommendation 6****: Possibilities should be explored to engage with the European and Mediterranean Plant Protection Organization (EPPO) who have a long history of producing guidelines.*

**(b) "Realistic expectations":** Confidence in citizen data can be increased by making sure that participants are required to complete tasks commensurate with their ability. Identifying many pests and pathogens to species level can require highly technical identification methods, often using molecular analysis. A point often overlooked by those unaware of official procedures is that official inspectors submit suspicious samples to reference laboratories for confirmation of identification. Like inspectors, volunteers need to be trained to identify those suspicious symptoms which warrant a sample (or photograph) for expert identification.

> ***Recommendation 7****: Design of tree health CS projects needs to factor in realistic expectations of the work done by the volunteers, should take account of volunteer expertise and, where necessary, follow well-established official procedures for confirmation of identification.*

**(c) Co-creation/Co-Design**: In order to maximise the benefits and success of CS projects there is a need for a more inclusive approach whereby policy stakeholders and projects work together and co-design projects that cater to both their expectations and needs, where relevant.

> ***Recommendation 8****: Project managers should engage policy-makers and volunteers early in the project design process. This open and collaborative approach should be reciprocated, with adequate resourcing for policy input into setting the scope and informing the design of projects.*

**(d) Infrastructure:** Infrastructure (e.g. websites, apps, data entry mechanism, databases etc.) needs to be developed, tested and in operation to underpin a good project. Constant input must be made to keep content fresh and regular technical maintenance is required to ensure the infrastructure operates effectively.

> ***Recommendation 9:*** *Effective 'IT' infrastructure is often required and needs constant maintenance.*

***(e) Communication*:** Tree health citizen science in the UK has now involved several projects, which have produced useful data, engaged the public and have generated a wealth of practical experience. However, given its relatively short history, evaluating and communicating key lessons learnt is less well developed. This step in the process is needed to build the trust and confidence in the value of tree health citizen science with key influencers in the science and policy communities and, critically, to feed learning from experience back into an ongoing and dynamic programme of improvement and change.

> ***Recommendation 10:*** *CS practitioners are encouraged to prioritise evaluation and communication of experiences (both successes and challenges) with other practitioners and with the science and policy communities.*

## 3. COLLABORATION

The research interviews and the workshop, in particular, highlighted how disconnected the various parties were from each other: tree health citizen science practitioners from each other and from citizen science practitioners in other areas, which may have greater experience of CS and from which useful lessons can be learnt e.g. biological recording. Also, there is a need for the ongoing engagement between tree health policy makers and CS projects to maximise impacts and capitalize success of CS projects.

The study also identified that participants have tremendous potential to act as a 'standing army' to provide valuable long-term records in specific geographic areas and/or to provide a valuable 'up-lift' of capacity at times when official surveillance is stretched (e.g. during pest or disease outbreaks). Potential to expand this surveillance capacity was suggested either through involvement of other 'professionals' whose work involves monitoring trees (e.g. other government agencies, local councils, non-government conservation bodies and forest industries) or by volunteers 'multi-tasking' (e.g. bird-watchers looking at trees on their local patch). In relation to this vital aspect of public

engagement at a local level, the research highlights the importance of local ambassadors (engagement officers) to act as that crucial interface between science and the public was stressed.

> ***Recommendation 11:*** *Greater collaboration and knowledge-sharing are required between organisations involved in CS. For example, through networks (e.g. the nascent UK Tree Health Citizen Science Network) and/or workshops (e.g. British Ecological Society funding, EU COST Actions)*
>
> ***Recommendation 12:*** *Opportunities to expand the network of participants contributing to tree health citizen science/surveillance need to be developed.*
>
> ***Recommendation 13:*** *The role of 'local ambassadors' is considered essential to enthuse local public participation in tree health and citizen science.*
>
> ***Recommendation 14****: Policy-makers involved in tree health are encouraged to consider how to engage with counterparts in other policy areas e.g. environment quality and biodiversity.*

## 4. SOCIETY AND DEMOCRATISATION OF SCIENCE

One of the biggest advantages of using a CS approach identified in the study is the number of societal benefits that can be achieved. CS brings some of the most important and relevant national and international environmental challenges into the homes of the public. It raises people's awareness of these challenges and involves them in finding solutions. Therefore, some of the biggest contributions of CS to address environmental issues including tree health are with respect to raising public awareness, promoting public engagement, raising the public's skill levels in and understanding of science, encouraging behavioural change and fostering an environmentally-proactive society. In particular, CS projects have been very effective in engaging the next generation, as well as hard to reach sectors of society who are often the most impacted by environmental change, and in involving people at the very local/community level.

The quote from the workshop: "*Science is not just done in a laboratory by people in white coats*" perhaps provides the best vision of the future for tree health citizen science. Citizen science is recognized as one of the ways of democratizing science by providing people with direct experience of scientific practice and also by facilitating communication and collaboration between professional and citizen scientists. Reciprocal trust is vital if projects and initiatives are to fully realize the potential of professionals and volunteers working together to address tree health and other environmental challenges and concerns in the UK.

***Recommendation 15:*** *serious consideration needs to be given to how to increase appreciation and recognition amongst policy-makers and politicians of the wider social and societal benefits of CS (see also Cost and Value below).*

## 5. COST AND VALUE

Concerns were raised about the funding of CS projects. Professionals expressed concern that they were not adequately funded nor had the necessary capacity to support CS projects, citing their input into vital elements such as initial training of volunteers, on-going verification support, data analysis and the feedback of results. The cost of developing and maintaining IT infrastructure were also mentioned. Overall, responses indicated that the perception of CS projects as either free or cheap is incorrect. It is possible, however, that although not free, CS projects are likely to offer considerable 'value for money' compared to traditional research or surveillance where only experts and officials are involved, especially when the wide range of societal benefits delivered by CS projects is considered. What was evident was that measures need to be developed to more accurately assess the direct and indirect costs and benefits of CS to inform future funding and resourcing decisions.

***Recommendation 16:*** *Project budgets should better reflect and record all associated costs.*

***Recommendation 17****: A wider systematic evaluation of cost and benefits is required, taking account not only direct costs but also the value of indirect benefits associated with improved skills, greater engagement with and awareness of tree health (see also Recommendation 13 above) and the value of larger number of observations than is possible through official observation alone.*

## 6. SUSTAINABILITY

Tree Health Citizen Science projects are virtually all funded by time-limited grants. This transient nature of funding poses a serious risk of loss on investment through disengagement of trained volunteers, cessation of surveillance and associated data and loss of expensive project infrastructure. This point was well-illustrated by the wave of CS projects that started around the height of the Chalara crisis and will become vulnerable once political and public interest in Chalara begins to subside.

This research also revealed the threat to sustainability of CS projects when politicians, civil servants and scientists move on to new roles/projects. Continuity is lost along with 'institutional memory', and with the need to train new staff being inefficient and expensive. The continuous engagement between the volunteer and professional (science, policy and management) communities is vital to

maintaining the profile of citizen science. Also, of importance is that the tree health sector often relies on a very transient professional workforce which may also affect the continuity of CS projects.

> ***Recommendation 18:*** *Innovative funding mechanisms need to be developed to sustain citizen involvement in tree health.*

Some of the findings and recommendations from this research resonate with the need for including CS approach in addressing pressing Tree Health issues in the UK, that are raised in various Tree Health policy documents[39404142]

The Tree Health Resilience Strategy, prioritises the following action points:

- Secure the long-term future of our nation's ash trees
- Improve the resilience and long-term future of our nation's oak trees
- Manage the cumulative pest and disease pressure on sweet chestnut
- Slow the spread and reduce the impact of Phytophthora ramorum and
- Protect our nation's trees from the impacts of Xylella

The strategy highlights 'surveillance' (extensive aerial and ground-based inland surveillance programmes to monitor a range of pests and diseases, covering the wider environment, nurseries and farms) as an important tool to achieve the above stated objectives and emphasizes the need for a broad and collaborative approach involving government, industry, conservation groups and the public. Addressing 'public involvement' the strategy explicitly mentions including and supporting Observatree, a nationwide network of over 200 volunteer tree health surveyors; making it easier for people to report suspect cases through Tree Alert. The strategy also draws attention to Action Oak, a public-private initiative committed to: "using established professional and citizen science networks to record changes in the distribution, age and health of our oak trees to identify priority areas for action".

> ***Recommendation 19:*** *Where CS projects provide direct support to government policy such as the Defra 25-year Environment Plan, "Tree Health Resilience Strategy", "Protecting Plant Health - A Plant Biosecurity Strategy for Great Britain" and the "Tree Health Management Plan" or contribute to official statutory surveillance/monitoring, consideration needs to be given to "mainstreaming" the citizen science element into official programmes and funding the input from official budgets.*

# Appendix A. Interview Protocol – Chapter 1

## Interview Questions

1. Can you tell me about your job and, in particular, what you do to support efforts to protect tree health?
2. Broadly speaking, what is the role of information, data, and evidence in the work you do on tree health
3. What types of information do you use? (prompt: scientific knowledge (on threats / hosts), spatial data (on threats / hosts)
4. How do you use these different types of information?
5. What are your current sources of these information?
6. How well do these information sources meet your needs?
7. Can you identify any challenges or barriers in acquiring the information you need?
8. Any additional information you would like to have to address your needs?
9. Do you see any need for improvement regarding the information sources?
10. Are you aware of citizen science approach or initiatives? Do you have any experience with CS? At this point if they do not know about CS then give a brief description of citizen science i.e. CS is the collection and  or analysis of data relating to the natural world by non-professionals, typically as part of a collaborative project with professional scientists.
11. If yes, can you tell me about the CS project(s) you've been involved with and what data they have provided?
12. Do you think citizen science could play a role in providing you with additional / better / different types of information to support your role?
13. Would you consider involving and engaging citizen scientists in the collection and / or analysis of data to support your work?
14. What advantages or opportunities can you foresee in using a CS approach?
15. What barriers or disadvantages can you foresee in using a CS approach?
16. Who in your opinion could be involved in collecting data/information?
17. Any additional remarks or insights that you would like to share
18. In terms of your work, which category among the 3 you think would you fit in: science/management or policy?
19. Is there anyone else related to your role (policy, science, management) that you think it would be useful for me to talk to?

# Appendix B. Summary of 20 projects addressing citizen science in tree health/plant health and or plants in the UK [Compilation of the information sheets filled by the project leads/representative]

## Section 1 – Project Details (General)

| Project Details | | | | | | |
|---|---|---|---|---|---|---|
| **Name of the CS project** | **Lead Institution** | **Partners** | **Start date and duration** | **Funding Source** | **Collaborations (with other projects):** | **Geographical scale/location:** |
| **Track a Tree** | The University of Edinburgh. Track a Tree was set up by Christine Tansey as part of her NERC-CASE funded PhD. CASE partner was the Woodland Trust | The Woodland Trust | Track a Tree pilot conducted in 2013, and project launched in 2014. Ongoing. | Initially funded entirely through Christine Tansey's PhD research. Currently assessing future funding options. | 1. Featured by the Woodland Trust as a sister project to Nature's Calendar, and some results reported through them. | UK wide – Scotland, Wales, N. Ireland and England |
| **Open Air Laboratories (OPAL) tree health survey** | Centre for Environmental Policy, Imperial College London who manage the tree health survey through an official partnership agreement with Forest Research and the Food and Environment Research Agency (Fera) | 13 partner organisations: Cofnod, Field Studies Council (Scotland and Northern Ireland), Glasgow City of Science, National Museum Wales, Newcastle University, North Wales Wildlife Trust, Plymouth University, Queen's University Belfast, TCV, University of Aberdeen, University of Nottingham and University of York. Associate partners: Environment Agency, DEFRA, Food and Environment Research Agency | 2007 – ongoing (OPAL); 2013 (Tree health survey) | Big Lottery Fund | Link TreeAlert (for all suspect findings of suspect quarantine pests and pathogens); signpost Observatree and member of Tree Health Citizen Science network | England, Wales, Northern Ireland and Scotland |
| **Observatree** | Forest Research | Fera Science Ltd, Woodland Trust, Forestry Commission, National Trust, APHA, NRW, Defra | October 2013 (4 years) | EU LIFE+ (with match funding from delivery partners) | TreeAlert | Scotland, England, Wales and NI |
| **TreeAlert** | Forest Research & Forestry Commission | | 2012 | Initial funding from FC (GB), redevelopment project was funded by FCE, FCW, FCS, FCGB and Defra | Observatree. Some FR work streams / programmes – e.g. research on AOD. | England, Wales, Scotland |
| **i-Tree Eco (NB i-Tree Eco in itself is not de facto CS, although discrete Eco 'projects' have been run by volunteers in Petersfield, Sidmouth and Lewes)** | Forest Research (FR), Treeconomics and the Arboricultural Association collaborate to bring i-Tree to the UK from the US (termed i-Tree UK throughout), funding and delivering the adaptation of the software for use in the UK. This 'national' and steering group level of work is very different to discrete i-Tree Eco project work. | However, FR and Treeconomics also deliver such individual projects, and mostly in collaboration | i-Tree UK 2012-(to date); cf. individual projects tend to have a duration of ~1 year | i-Tree UK: FR has received funding from the Forestry Commission (GB, England and Scotland, and NRW). AT the project level, FR and Treeconomics have received project funding from the lead partners | Treezilla/ViTAL with the Open University | city scale primarily, though sometimes at district or park level; UK wide |
| **Ancient Tree Inventory** | The Woodland Trust who set up and manage the on- line database and website, recruit and train volunteers especially volunteer verifiers to ensure the data is as robust as possible. | The Tree Register of the British Isles and the Ancient Tree Forum | 2005 - ongoing | Various but the initial phase (2005-2011) of the project (which had the working title of Ancient Tree Hunt) was substantially funded by Heritage Lottery Fund and Esme Fairbairn | | UK wide primarily but through our partners includes some records for the Republic of Ireland. |
| **Survey of Plants and Lichens on Ash** | | | | | | |
| **Conker tree science** | Centre for Ecology & Hydrology, University of Newcastle. (Formerly University of Hull & University of Bristol.) | | 2010 – 2015 (notionally ongoing but less active now) | NERC (initially BES, University of Bristol and RCUK). For app: CEH and JISC | No formal links | Mainly England and Wales, but advertised as UK and RoI |
| **Longhorn beetle pheromone trial** | CEH, NRI (Greenwich University) | | 2015-16 | Tree Health Initiative grant (LWEC) | None | 10 sites in England |

| Project Details | | | | | | |
|---|---|---|---|---|---|---|
| **Name of the CS project** | **Lead Institution** | **Partners** | **Start date and duration** | **Funding Source** | **Collaborations (with other projects):** | **Geographical scale/location:** |
| **International Plant Sentinel Network** | Botanic Gardens Conservation International, Fera, CABI UK, Royal Botanic Gardens, Kew (all Defra funded), plus many European partners and APHIS | | First phase: Nov 2013-Mar 2016, second phase: Jan 2017 – Dec | A Euphresco project where all countries input their own funding; UK contribution is funded by Defra | Conference ran with Observatree, collaborates with a European Cost Action: A global network of nurseries as early warning system against alien tree pests (Global Warning) | Global |
| **Urban Tree Survey** | | Natural History Museum | 2010; 5 years | Calouste Gulbenkian Foundation | Collaboration with the Conservation Foundation's Ulmus Londinium project | UK |
| **RHS surveys on the spread of non-native garden insects** | Royal Horticultural Society (RHS) | | Start 2008 - ongoing | RHS core funded | | Britain and Ireland |
| **National Plant Monitoring Scheme** | Overall project management is within CEH | JNCC, CEH, Plantlife, BSBI | March 2015 – present. Ongoing long-term monitoring scheme | JNCC (UK government) | Supported by FSC's Tomorrow's Biodiversity project. Some informal collaboration with other JNCC monitoring schemes and initiatives | UK |
| **LeafSnap UK** | Natural History Museum | | 2014 | Calouste Gulbenkian Foundation | Collaboration with Columbia University, University of Maryland, Smithsonian Institute | UK |
| **PTES Traditional Orchards Project** | People's Trust for Endangered Species | | 2006 – 2011. Mapping the habitat in England; 2011 – 2012. Mapping Wales; 2012 – present. Continuing to support the habitat and acting as a central national body with an interest in orchards; 2015 – 2016. Varieties Database and website update project | Natural England; Natural Resources Wales; Esmée Fairbairn; Public donations | Too many to list | UK wide |
| **Ceratocystis platani and Xylella fastidiosa Protected Zone Status Survey 2016.** | The London Tree Officers Association (LTOA). The LTOA coordinate the project, analyse the data obtained from the surveys and produce the final report | Surveys are undertaken on a voluntary basis by tree managers and tree officers from Transport for London, the City of London, Royal Parks, London Borough (LB) of Camden, LB Islington, LB Southwark and LB Croydon | Approximately June – September 2016. The current survey is a repeat of the surveys undertaken by the LTOA in 2014 and 2015 | Forestry Commission | Suspected findings of Ceratocystis platani (plane wilt/canker stain of plane) or Xylella fastidiosa are reported via TreeAlert | The survey included 58 plots located across all 33 London Boroughs |
| **AshTag** | University of East Anglia | | Feb 2012- ongoing | No funding initially later sylva foundation | | UK wide as well international |
| **The Living Ash Project** | Earth Trust (Project lead and field trials; Future Trees Trust (Knowledge exchange); Sylva Foundation (CS) and Forest Research (Genetic Research) | | 2016 - (6-year project) | Defra | | Britain and Ireland |

| Project Details | | | | | | |
|---|---|---|---|---|---|---|
| **Name of the CS project** | **Lead Institution** | **Partners** | **Start date and duration** | **Funding Source** | **Collaborations (with other projects):** | **Geographical scale/location:** |
| **Treezilla- the Monster Map pf Trees** | Faculty of Science, Technology, Engineering and Mathematics (STEM), The Open University | Forest Research and Treeconomics | June 2013. The project is ongoing | 1. Initial funding was provided by the Wolfson Foundation and The Open University (OU), as part of The OpenScience Laboratory (www.opensciencelab.ac.uk). In addition to OU support, work involving Treezilla is currently funded through a two-year grant (January 2016 – December 2018) from the NERC Green Infrastructure Innovation Programme as part of the Valuing Green Infrastructure through Tree Assessment tools (VITAL) project. | Under the VITAL project the OU continues to collaborate with Forest Research and Treeconomics to improve and develop the system. We are also working with partners Natural Resources Wales, The Tree Council and The Parks Trust Milton Keynes as key stakeholders in the sector to embed this into practice through their everyday work and in communicating the importance of trees to the wider public | UK and Ireland / British Isles |
| **Fraxinus** | The Sainsbury Laboratory, John Innes Centre and Earlham Institute (formerly The Genome Analysis Centre) | The Sainsbury Laboratory, John Innes Centre and Earlham Institute (formerly The Genome Analysis Centre) | August 2013 - on-going | BBSRC | Open; Ash DieBack | Worldwide via Facebook |

## Section 2 – Project purpose and or objectives

| Purpose/Objective of the project (indicate yes or no from the options below) | | | | | | |
|---|---|---|---|---|---|---|
| **Project** | **Surveillance/ Data collection/ Evidence gathering** | **Data Analysis** | **Awareness and Engagement:** | **Changing Behaviour (Environmental Stewardship):** | **Support to other volunteers** | **Other (please specify)** |
| **Track a Tree** | Yes | Yes, part of Christine Tansey's PhD work. | yes | Indirectly, by improving observational skills. | No | |
| **OPAL** | Yes | Yes (Forest Research) | Yes | Yes (one aim of the Defra/Forestry Commission Tree Health & Plant Biosecurity Action Plan) | No | |
| **Observatree** | Yes | Yes | Yes | Yes (although not formally stated objective) | Yes | Protect trees, woods and forests |
| **TreeAlert** | Yes | No | Yes | | Yes | |
| **i-Tree Eco** | Yes | Yes | Yes | For some projects YES; but not always | For some projects Yes; but not always | Longer term environmental management |
| **Ancient Tree Inventory** | Yes – individual tree records | Yes, analysis of the date to identify important concentrations of ancient and other veteran trees at a landscape scale for resilient landscape activity | Yes, through drawing attention to the remarkable heritage and biodiversity value of the trees | Yes: gathering the tree records is the first step towards making sure the trees are properly recognised. It is an aim that these trees of special interest should be properly cared for and protected through legislation, policy and guidance. | Yes, volunteer verifiers give guidance to recorders and through the project we have developed lead verifiers who support less experienced verifiers | |
| **SPLASH** | Yes, data collection | | No – working with experienced volunteers who already have knowledge/awareness | No – though provides baseline data for monitoring impacts of ash dieback | No | |
| **Conker tree science** | Yes (by participants) | Yes (by scientists) | Yes | No (not specifically) | No | |
| **Longhorn beetle pheromone trial** | Yes | No (small scale assessment, didn't need formal analysis) | No | Yes | No | |
| **IPSN** | Yes | No | Yes | Yes | Yes | |

| Purpose/Objective of the project (indicate yes or no from the options below) | | | | | | |
|---|---|---|---|---|---|---|
| **Project** | **Surveillance/ Data collection/ Evidence gathering** | **Data Analysis** | **Awareness and Engagement:** | **Changing Behaviour (Environmental Stewardship):** | **Support to other volunteers** | **Other (please specify)** |
| **Urban Tree Survey** | Yes | Yes – by researchers, not public | Yes | No | No | |
| **RHS surveys** | Yes | | Yes | | No | |
| **NPMS** | Yes | Yes | Yes | Not a primary aim | Not to volunteers in other CS projects, but volunteers support one another in the NPMS through a mentoring scheme | |
| **LeafSnap UK** | Yes | Yes – by researchers, not public | Yes | No | No | |
| **PTES Traditional Orchards Project** | Yes | Yes | Yes | Yes | Yes | Habitat condition assessment |
| **CSP** | Yes | Yes | Yes | Yes | Yes | |
| **AshTag** | Yes | No | Yes | Yes | No | |
| **The Living Ash Project** | Yes | Yes | | | | |
| **Treezilla- the Monster Map pf Trees** | Yes | Yes | Yes | Yes | Yes | 1) To develop a resource which highlights the role of trees: (as species habitats; as landmarks adding to people's sense of wellbeing; in providing environmental benefits improving air quality in towns, moderating air temperature and capturing CO2) and 2) To help the public learn and contribute in the care and welfare of trees as citizen scientists with the ability to design, execute and publish their own, autonomous investigations based on Treezilla data. |
| **Fraxinus** | No | Yes | Yes | Yes | No | None |

## Section 3 – Tree/Tree Health Focus

| Tree/Tree - Health Focus of the project | | | | | | |
|---|---|---|---|---|---|---|
| **Project** | **Tree health a primary or secondary focus:** | **General tree health (other than pest / pathogen)** | **Tree Species** | **Pest/Pathogen** | **Presence or absence** | **Other (please specify)** |
| **Track a Tree** | Not a direct focus, although we link to The OPAL Tree Health Survey, and provide a field for recorders to specify whether they have conducted the Tree Health Survey on the tree that they monitor for Track a Tree. | Yes, looking at how their phenology responds to spring environmental conditions. | Pedunculate and Sessile oak, Silver birch, Sycamore, Beech, Rowan, Hazel, Ash. | N/A | N/A | |
| **OPAL** | Primary | Yes (height, girth, canopy density, leaf yellowing, browning and damage); including rudimentary 'health score' | Any (specific activity on Oak, Ash and Horse Chestnut) | Oak (Tortrix roller moth, Oak mildew, Oak Decline and Knopper gall); Ash (Ash bud moth, Ash key gall, Nectria canker and Ash Decline); Horse Chestnut leaf-miner, leaf blotch, scale and bleeding canker); plus "6 Most Unwanted" (quarantine pests): Emerald ash borer, Citrus longhorn beetle, Asian longhorn beetle, Chalara As Dieback, Oak processionary moth and Pine processionary moth | Presence | |

| Tree/Tree - Health Focus of the project | | | | | | |
|---|---|---|---|---|---|---|
| **Project** | **Tree health a primary or secondary focus:** | **General tree health (other than pest / pathogen)** | **Tree Species** | **Pest/Pathogen** | **Presence or absence** | **Other (please specify)** |
| **Observatree** | Primary | Yes (secondary focus – volunteers may report tree health issues not related to pests / diseases) | All – but with focus on host species for priority pests and diseases | Sirococcus tsugae, Phytophthora austrocedri, Great Spruce Bark Beetle, Oriental Chestnut Gall Wasp, Phytophthora lateralis, Dothistroma Needle Blight, Bronze Birch Borer, Sweet Chestnut Blight, Plane Wilt, Mountain Ash Ring Spot, Oak Lace Bug, Red-necked Longhorn Beetle, Pine Processionary Moth, Emerald Ash Borer, Plane Lace Bug, Horse Chestnut Leaf Miner, Citrus Longhorn Beetle, Acute Oak Decline, Asian Longhorn Beetle, Oak Processionary Moth, Chalara Dieback of Ash | Both are recorded | |
| **TreeAlert** | Primary | Yes | All, but with dedicated reporting lines covering some host species (see P&D list below) | All, but dedicated reporting lines for AOD, ALB & CLB, Chalara, DNB, Phytophthora lateralis | | |
| **i-Tree Eco** | Secondary | | Yes | Not specifically | N/A | |
| **Ancient Tree Inventory** | Primary focus. The project involves gathering information on tree condition. The overall data also enables us to identify what the impact of deteriorating tree health and loss of trees would have on heritage, biodiversity and landscapes. | The project collects information on whether the tree is alive or dead and other aspects of tree condition and associated decay fungi. Measurements of girth over time or comparison with historic records gives an idea of the growth rates of trees in different conditions or altitudes. | Yes. There is a list of c 600 tree species on the recording form. These are the most likely species to be encountered although it does not reflect all species in the UK. | Not specifically but there are options for additional comments to be added | | |
| **SPLASH** | Secondary (recording plants/lichens around ash trees/woodland) but motivated by ash dieback | | Ash/ash woodland | Chalara | Abundance of different plants & lichens.<br>Presence of Chalara | |
| **Conker tree science** | Primary | No | Horse chestnut | Cameraria ohridella (and some data on Guignardia) | Damage score (can equal zero = absence) | Rearing leaf miner parasitoids |
| **Longhorn beetle pheromone trial** | Primary | No | Various | Asian longhorn beetle (passive surveillance for this) | Presence of longhorn beetles | Testing suitability of methodology for detection |
| **IPSN** | Primary | Primary, assessing a tree's health and determining if diminishing health is biotically or abiotically caused | Primary, though we do ask for information about all plant species | Primary, focus on both | Primary, targeted surveys to determine where a P&D is present | |
| **Urban Tree Survey** | Not a focus at all | | | | | Tree health was not a focus of this survey |
| **RHS surveys** | Secondary | No | Box, Buxus other hosts of survey insects are not trees | Lily beetle, Lilioceris lilii; Rosemary Beetle, Chrysolina americana; Berberis sawfly, Arge berberidis; Hemerocallis gall midge, Contarinia quinquenotata and box tree moth, Cydalima perspectalis | Presence | |

| Tree/Tree - Health Focus of the project | | | | | | |
|---|---|---|---|---|---|---|
| **Project** | **Tree health a primary or secondary focus:** | **General tree health (other than pest / pathogen)** | **Tree Species** | **Pest/Pathogen** | **Presence or absence** | **Other (please specify)** |
| **NPMS** | Neither | Not explicitly collected | At the two more basic recording levels, information on tree species is not collected, only information on % tree cover. Some species on which data is collected in hedgerows can also grow as trees, however collecting information on these species is a focus only in hedgerows where growth form is more likely to be shrubby. At the highest recording level, volunteers record all species in their plots which could include tree species | No | No | |
| **LeafSnap UK** | Not a focus at all | | | | | Tree health was not a focus of this survey |
| **PTES Traditional Orchards Project** | Secondary | Condition – veteran features | All top fruit and nut trees | N/A | N/A | |
| **CSP** | Primary | No individual tree data recorded other than presence/absence of Ceratocystis/Xylella symptoms | London plane | Ceratocystis platani and Xylella fastidiosa | Surveys are intended to determine whether or not the pathogens are present in London | |
| **AshTag** | Primary | No | Ash Trees | Chalara | Presence | |
| **The Living Ash Project** | Primary | | Ash | Resistance to Chalara fraxinea | Absence | |

| Tree/Tree - Health Focus of the project | | | | | | |
|---|---|---|---|---|---|---|
| **Project** | **Tree health a primary or secondary focus:** | **General tree health (other than pest / pathogen)** | **Tree Species** | **Pest/Pathogen** | **Presence or absence** | **Other (please specify)** |
| **Treezilla- the Monster Map pf Trees** | Secondary | Yes | Yes | Yes | Yes | Treezilla.org is a citizen science platform for mapping and valuing trees. Based on user-generated data, it enables people to record, learn about different tree species and understand more about the ecosystem services they provide in an accessible, easy to understand way. The fundamental aim is to create an online map of all the trees in the UK that can be used for education, outreach, research, inventory and biological Surveillance through citizen science. The system generates the “Yearly Eco Impact” of trees with a summary of the environmental benefits i.e. the greenhouse gasses reduced as well as the water, energy and air quality pollutants reduced. The monetary value of the savings generated is also included. Each tree has a profile page outlining known information including address, species, diameter, height, date it was planted, ecosystem services provided, condition, etc. This profile also includes a map showing the location, Google Street View (if available), a comment field, and images of the tree. Treezilla is based on OpenTreeMap, an open source software tool for mapping and valuing trees. When the site was developed in 2013 valuations were based on what was available and adapted from US data and algorithms referenced to UK conditions. Under the VITAL project work is underway refining these reference data to better match the UK and link Treezilla’s output to other tools for ecosystem services valuation, e.g. iTree Eco, building in a mechanism for continuous refinement. |

| Tree/Tree - Health Focus of the project | | | | | | |
|---|---|---|---|---|---|---|
| **Project** | **Tree health a primary or secondary focus:** | **General tree health (other than pest / pathogen)** | **Tree Species** | **Pest/Pathogen** | **Presence or absence** | **Other (please specify)** |
| **Fraxinus** | Primary | No | Ash | Ash Dieback | Presence of resistance to dieback fungus | None |

## Section 4 – Volunteer Profile & Support offered to them

| | **Participants (kindly provide details about the following):** | | **Support to participants (kindly provide details about the following):** | | | |
|---|---|---|---|---|---|---|
| Project | Profile (volunteers, general public, school etc.): | Length of engagement (e.g. single activity for few hours or repeated activity for few hours/or repeated activity for a month/year): | Project support to participants (e.g. source material for participants: web links, online resources, training): | Level and Intensity on how the support is provided to the volunteers: | Feedback to participants: | Other (please specify): |
| Track a Tree | Regular woodland users (e.g. walkers, dog-walkers, volunteers, naturalist groups). Aimed at those with an interest in woodland plants and who may already have some knowledge about woodland trees. | A weekly visit throughout spring to their local woodland to conduct an observational survey of an individual tree(s) (taking ~15 mins each visit. Ideally, we ask recorders to participate in at least two successive spring seasons, monitoring the same tree each year. | Web links, online resources, training): Downloadable field guide and recording sheets from www.trackatree.org. All support provided via website forum, blog, email, Facebook and twitter accounts. Three one off training workshops run in 2015, after funding sought to put on these events. | Some recorders only use the field guide, others require more direct email support. Responding to queries and blog posts are more regular in the run up and during the spring recording season. | Primarily via the project blog and email news. Interactive results maps on the website also provide immediate visual feedback of records. | |
| OPAL | Everyone (across the spectrum of people having no experience to more professional), with a focus on people from disadvantaged and deprived communities | Single activity of around one hour; participants are free to repeat | Survey packs; Community scientist delivering training to volunteers; in-depth info on website and link to TreeAlert app for more info; a “train the trainers” and a “tree heath buddy scheme” (where those with expert/professional knowledge assist beginners) were adopted to support the survey launch | Varies among volunteers (some just use the pack) and others have a Max 1-day training | Interactive results map; Opal newsletter with updates of findings; summary report on website | |
| Observatree | Trained volunteers – volunteers are selected by Woodland Trust engagement officer. Volunteers selected following initial application, telephone interview and questionnaire. Required to have existing knowledge of tree identification, biological surveying, and existing tree disease knowledge also desirable | Repeated activity over months / years (most volunteers for the 4yr duration of the project) | Online resources, phone inductions and training, volunteer forum, webinars, field ID guides, symptom calendar, e-newsletters, mentoring from other volunteers, engagement officer offers ongoing one to one support | Compared with other CS projects, I would say high level and intensity of support. On average, the engagement officer spends between 25 and 30 hours per week supporting the volunteers and logging the data they submit. As their first and main point of contact, the engagement officer is responsible for most one to one communication. Support also given by FR team and all partners during training events (24 events/year). | Automated email response through TreeAlert when volunteers submit reports; email feedback from FR advisory team and engagement officer, volunteer newsletters, mentoring events, forum area on website, latest news page of Observatree website | Face-to-face training and mentoring sessions |
| TreeAlert | Data not available | Single reporting event, except for Observatree volunteers who will be involved and submit reports over the long term. | Links to online resources – e.g. tree identification | Online resources only. More intensive support given to Observatree volunteers (who use TreeAlert for report submission and verification duties | Automated email response to every report. Follow-up enquiry if report is suspected to be of quarantine organism (follow up by FR’s Tree Health Diagnostics and Advisory Service) | |
| i-Tree Eco | Project dependent; projects can be delivered by trained volunteers, trained surveyors or professional arborists recruited for the project | A city-wide project typically takes 4-6 weeks to deliver with 2-3x two-person survey teams working full time | Core/basic training, standard equipment such as diameter tapes, and resources to measure tree height | Basic training (1 day) plus on-going information provision as required | None specifically, though they can access (or are provided with) the final report once generated | |

| | Participants (kindly provide details about the following): | | Support to participants (kindly provide details about the following): | | | |
|---|---|---|---|---|---|---|
| Project | Profile (volunteers, general public, school etc.): | Length of engagement (e.g. single activity for few hours or repeated activity for few hours/or repeated activity for a month/year): | Project support to participants (e.g. source material for participants: web links, online resources, training): | Level and Intensity on how the support is provided to the volunteers: | Feedback to participants: | Other (please specify): |
| Ancient Tree Inventory | Everyone - across the spectrum of people with very little experience to tree and other professionals. Also used by university and other institution researchers. The project has also worked with the Ministry of Justice recording trees in prisons and with MOD on inaccessible land. Many people have recorded through other organisations who have engaged them directly in recording – these organisations may have a species-specific interest e.g. Ancient Yew Group or a geographic focus e.g. a county-based organisation e.g. Worcestershire Wildlife Trust or a site-based focus e.g. National Trust. We are particularly delighted when private owners record their own trees. | Many volunteers have recorded for years and have added thousands of records to the database encompassing many hundreds of days' work and recorded while travelling for business or while on holiday. Other tree recorders have added a single tree in their garden/ nearby park or street involving perhaps an hour of activity. | Support given through the website to first time recorders with downloadable resources e.g. how to measure the girth of a tree. Specific training and ongoing support for volunteer verifiers and lead verifiers. | This can vary, the majority are very inspired by the aims of the project and are very self-motivated and learn very fast. But for difficult assessments or unusual species then there is access to a Senior Verifier who can provide one to one feedback. Most training these days is done over the phone on a one to one basis but modern systems could provide the potential for multiple video training sessions. | Interactive map, newsletter, journal articles, news pages on the website, events and one to one engagement. | |
| SPLASH | | In depth – volunteers experts sent to specific locations and undertaken detailed monitoring, following a protocol (randomised, systematic), for several hours | Yes – including web-based upload of data | | | |
| Conker tree science | General public recruited via media (TV, radio, newspaper), school children (mainly via visits by volunteers in 2011) | single activity (rearing parasitoids requires observations a fortnight after collection) | Yes via www.conkertreescience.org.uk | | Via intermittent emails (up to 2015), blog (active up to 2015), website | |
| Longhorn beetle pheromone trial | Keen naturalists, including nature reserve managers | Requires regular checking (typically twice per week) over several months | Emailed instructions and email discussion | Reasonably high support, responding to individual queries. The experimental nature of the project meant there were queries. | Via emails 2-per year | |
| IPSN | Botanic garden and arboreta staff, volunteers, and where applicable visitors | Repeated activity to be worked into normal working | A website with members login access which includes online resources, training, web links, protocols to download | Made freely available to access any time. Gardens responsibility to encourage gardens to contribute | Occasional emails, news on the IPSN website, twitter | |
| Urban Tree Survey | General public (8774 sites surveyed, although this may reflect fewer participants if there was repeat participation) | 30 mins (unless they participated more than once – but we don't have data on that) | Online ID Guide (which could be printed), schools' resources | Provided remotely, there was no face to face training | Via website | |
| RHS surveys | General public | Single activity - A few minutes to report sightings | Web links, online resources, training): Web information | Low – web information | Thank you and blog results shared via web, including social media and blogs | |
| NPMS | Skilled volunteers. Free training provided as part of the scheme to boost skill levels in plant identification, so it is not essential to have previous skills in plant ID (though many of the current volunteers do) | Twice yearly visits to the same vegetation plots (usually between 1 and 5 per volunteer) each year. This equates to approximately 2 days' work per year on average per volunteer including travelling, planning, data entry etc. | Identification guides, support from volunteer coordinator, mentoring from other volunteers, free training days on ID and survey methods, online resources on dedicated website, web support | Some forms of support are advertised to volunteers (e.g. training day, mentoring) so they can engage with them as they wish; other forms of support are given on an ad hoc basis as requested | Is given frequently, exclusively via electronic means such as email, or through the annual online scheme newsletter | |

| | Participants (kindly provide details about the following): | | Support to participants (kindly provide details about the following): | | | |
|---|---|---|---|---|---|---|
| Project | Profile (volunteers, general public, school etc.): | Length of engagement (e.g. single activity for few hours or repeated activity for few hours/or repeated activity for a month/year): | Project support to participants (e.g. source material for participants: web links, online resources, training): | Level and Intensity on how the support is provided to the volunteers: | Feedback to participants: | Other (please specify): |
| LeafSnap UK | General public via a mobile phone app | A few minutes per leaf – no requirement for repeat participation | App with interactive ID guide based on an algorithm which analyses the leaf outline | Only via app, there was no face to face training | None | |
| PTES Traditional Orchards Project | Volunteers, scientists, other projects, General public – press campaigns to help raise awareness, farmers, landowners | Each orchard survey takes however long it takes to travel to plus anything from 2 – 20 minutes to complete depending on access and level of interest. Volunteers have done from c.10 up to hundreds of orchards over several years | Web links, online resources, training): Volunteer pack provided with all instructions and paperwork that they'll need. | | | |
| CSP | All participants are professional tree managers and tree officers working in London, volunteering their time in order to undertake the surveys | All participants attended a half day refresher training course at Alice Holt prior to the project starting. The length of engagement with the project varied; each participant surveyed between 3-10 plots and reported the results back to the project lead, who analysed the data and wrote the final report | All participants were given training in the identification of Ceratocystis and Xylella and in the use of TreeAlert, the Forest Research reporting tool. Identification guides were also provided. Four of the surveying team undertook a study trip to Italy (coordinated by Treework Environmental Practice) in order to see Ceratocystis in the field and to learn from experts in the disease. The LTOA project lead ensured that all participants were comfortable with the methodology of the survey and that they knew what steps to take if and when symptoms were identified | One day of training for all participants; three-day study trip to Italy for those who attended. Regular updates and email correspondence from the project lead | The project lead provided feedback to the participants and sought to receive feedback from them with regard to how the project was managed in order to improve for future surveys and reports | |
| AshTag | General public | Single activity - A few minutes to report sightings | Web information; guide on the app | Low – web information | 'Thank you' automatic email | |
| The Living Ash Project | | | | | | |
| Treezilla- the Monster Map pf Trees | Treezilla is a platform, rather than a single project, therefore it caters to the widest possible audience; the general public, community groups, school children etc.; alongside local councils, tree officers or anyone with an interest in or responsibility for trees, can use Treezilla and add to this growing database. | Variable - can be a single or repeated activity. Users can search for tree information, add a tree or update this or another entry by another user | Tips and how to use guides: http://treezilla.org/faq/; as well as links to additional tree identification resources: http://amanita-photolibrary.co.uk/Tree_guide.pdf. Learning resources and activities etc. are currently provided as 'experiments' via the Open Science Laboratory: www.opensciencelab.ac.uk. New resources are under development as part of the VITAL project and will be made available and accessible through a number of sources including The Tree Council | Resources are easily accessible with user friendly videos etc. More bespoke training, materials etc. to be confirmed under development under the VITAL project | Currently users can log in and review latest activity on the Treezilla website, look at the map which also highlights the total number of trees recorded. They can also go to their user profile to check on updates to their tree records. There are also Treezilla forum discussions: http://www.ispotnature.org/forum/19507. Users are also encouraged to www.iSpotnature.org to help with queries and identification of other species | Other system for providing feedback are under review as part of the VITAL project |

| | Participants (kindly provide details about the following): | | Support to participants (kindly provide details about the following): | | | |
|---|---|---|---|---|---|---|
| Project | Profile (volunteers, general public, school etc.): | Length of engagement (e.g. single activity for few hours or repeated activity for few hours/or repeated activity for a month/year): | Project support to participants (e.g. source material for participants: web links, online resources, training): | Level and Intensity on how the support is provided to the volunteers: | Feedback to participants: | Other (please specify): |
| Fraxinus | Everyone who has access to Facebook and willing to contribute | single activity of around few minutes and participants are free to repeat | Fraxinus - Ash Dieback Game Community, provides help and updates and allows regular interaction with players. (https://www.facebook.com/fraxinusgame) | Varies and mostly through the community page and tutorial before the game starts | | Game score board and Leader board provides update on the player progress |

## Section 5 – Volunteer Activities

| Participant (volunteers) activities (e.g. mode of data collection / reporting, data analysis, support to other volunteers, project administration / support) | | | | | | |
|---|---|---|---|---|---|---|
| Project | Survey and report/Data collection/Evidence gathering: | Data Analysis | Reporting: | Support to other volunteers | Project administration/support | Other (please specify): |
| Track a Tree | Observational data collection and submission of records online. Participants are able to view and download their own records from their recording space on the website. | Recorders do not analyse data. | Online submission | One off training in 2015 included sessions aimed at educators (e.g. Forest School leaders) who could conduct Track a Tree recording with their groups. | Not provided by participants. | |
| OPAL | Survey and Report | Volunteers do not analyse the data | Hardcopies and online recording | Some organisations are trained by OPAL and then conduct the survey with their stakeholders e.g. National Resources Wales educators and John Muir Trust | None from participants | |
| Observatree | Yes | Yes (if report verification counts here) | Yes | This is an area of development, but I believe has started to happen. An increasing number of our volunteers have been carrying out surveys together, new recruits are given the opportunity to buddy up with an existing volunteer, volunteers also offer support to each other during training events and via the forum | I would agree if verification is being counted as 'b' above. | Volunteer working group has contributed feedback to Tree Alert/verification portal development and e-learning (FC biosecurity modules) |
| TreeAlert | Submit reports through 'General Tree Health' reporting line, or thought one of dedicated P&D reporting lines (AOD, ALB & CLB, Chalara, DNB, Phytophthora lateralis) | No | Submit reports through 'General Tree Health' reporting line, or thought one of P&D reporting lines (AOD, ALB & CLB, Chalara, DNB, Phytophthora lateralis) | No | No | |
| i-Tree Eco | Yes | No | No | No | No | Data input into the Eco model |

| Participant (volunteers) activities (e.g. mode of data collection / reporting, data analysis, support to other volunteers, project administration / support) | | | | | | |
|---|---|---|---|---|---|---|
| Project | Survey and report/Data collection/Evidence gathering: | Data Analysis | Reporting: | Support to other volunteers | Project administration/support | Other (please specify): |
| Ancient Tree Inventory | In the field identification of trees to record, recording according to a set form and input of information into the system on return to computer. Volunteer Verifiers visit trees to substantiate the record details and can amend the tree record on line. | On line search facility that allows volunteers to search all the records according to any criteria they wish e.g. number of oaks above a certain girth in a particular county. Spatial data analysis using GIS techniques is not possible by volunteers. Results of spatial analysis are used to inform designation of SSSIs, planning applications and biodiversity action plans. | Volunteer verifiers use the information gathered to inform owners of value of trees/collection of trees in some instances. | Lead volunteer verifiers and volunteer verifiers support and contact recorders and help researchers | None from volunteers | |
| SPLASH | | | | | | |
| Conker tree science | Yes | No | | No | No | |
| Longhorn beetle pheromone trial | Yes | No | No | No | No | Informing method development |
| IPSN | N/A | N/A | N/A | N/A | N/A | N/A |
| Urban Tree Survey | Data collection | No | No | No | No | |
| RHS surveys | Survey and report/Data collection | No | Web Form | No | None from participants | |
| NPMS | Yes, volunteers gather data from the field as evidence | Not undertaken by volunteers | Volunteers report their findings from field work; then the partnership reports the findings from the analysis of the data back to volunteers via annual newsletters | Volunteers support one another through training and peer mentoring activities, and through creating volunteer communities (e.g. online/in different geographical regions). | Not undertake by volunteers | |
| LeafSnap UK | Data collection | No | No | No | No | |
| PTES Traditional Orchards Project | Paper form or phone app | N/A | Sent back by post or we download data | | | |

| Participant (volunteers) activities (e.g. mode of data collection / reporting, data analysis, support to other volunteers, project administration / support) | | | | | | |
|---|---|---|---|---|---|---|
| Project | Survey and report/Data collection/Evidence gathering: | Data Analysis | Reporting: | Support to other volunteers | Project administration/support | Other (please specify): |
| CSP | Site visits to allocated plots (typically 3-10 per participant). The project lead provided a template survey sheet to ensure consistency | The project lead collated all data from the participants and inputted it into a master spreadsheet for review and analysis | All initial findings were reported to the project lead. If further investigation was required into any sites, then relevant information was reported to the Forestry Commission via TreeAlert | The project lead was engaged in regular correspondence with participants and all volunteers were provided with direct contact details for the project lead to ensure that support was available if and when required. | All project administration, including the writing of the final report, was undertaken by the project lead | |
| AshTag | Survey and report/Data collection | No | App based recording | No | None from participants | |
| The Living Ash Project | | | | | | |
| Treezilla- the Monster Map pf Trees | Tree record / data entry on website which is immediately added to the database. Evidence gathering: Once a tree is recorded, Treezilla provides an estimate of the value of the ecosystem services it provides. Tree data can be selected and exported as a csv file | Volunteers can request access to download data for analysis | Online recording | Stakeholders have developed their own bespoke training using the materials, guides etc. provided as well as their own resources. To support this type of activity, in collaboration with our VITAL project partners, new resources are being created i.e. Training for Tree Council Wardens and Milton Keynes Parks Trust Volunteers, school and youth groups | Participants support each other by adding tree information to each-others records | |
| Fraxinus | No | Yes, players solve alignment puzzles and the progress is stored | Solved puzzles are saved in a database | Community page provides chance for between volunteer support as well | None from participants | None |

| Project | **Project Outputs:** | *a. Has your project objectives changed?* | **Project evaluation (for e.g. details of evaluation scope):** | **Type of CS (Contributory/ Collaborative/Co-Created- please provide details):** |
|---|---|---|---|---|
| Track a Tree | Two thesis chapters based on Track a Tree have been written by Christine Tansey, one of which is currently being written up as a paper. After completion of her PhD work, the Track a Tree dataset will be made openly available. The project has an ongoing collaboration with Dr Ria Dunkley from the Sustainable Places Research Institute in Cardiff, who has conducted interviews with Track a Tree recorders about their experiences volunteering for the project. These interviews are also expected to contribute to a paper. | The overall research-based objective has not changed. However, should the project continue the objectives are likely to be re-assessed? | Primarily, Track a Tree has been evaluated in terms of the scientific value of the records contributed by participants. Social outcomes are being investigated by Dr Dunkley in her use of Track a Tree as a case study of how taking part in citizen science can influence a person's relationship to the environment. | This has been primarily a contributory project. However, volunteers in the pilot study helped refine the project protocols. Recorders were also invited to nominate and vote on an additional species to include in the project. |
| OPAL | Tree health paper (ongoing); Dataset (website) due to be made open access; Social outcomes (statistics on how it changed people's attitude/behaviour/learning) | No | All OPAL projects are evaluated in terms of events held, participant numbers, along with various social indicators (e.g. conducted with others, learnt something new, developed new skills, think differently about/amend behaviour towards the environment | OPAL tree health survey can be defined as contributory CS project |

| Project | **Project Outputs:** | *a. Has your project objectives changed?* | **Project evaluation (for e.g. details of evaluation scope):** | **Type of CS (Contributory/ Collaborative/Co-Created- please provide details):** |
|---|---|---|---|---|
| Observatree | Network of 235 trained volunteers, training materials, verification portal, newsletters and other comms materials, events (project conference), reports (project deliverables), wider promotion and awareness raising of tree P&D, survey data, improved working relationships between partner organisations | | Evaluation focuses on 2 areas: 1. Capacity and capability – is the project contributing capacity and capability in terms of tree health early warning? 2. Volunteer support – is the project providing the right level and intensity of support to volunteers? | Contributory-collaborative. |
| TreeAlert | Annual THDAS Database reports | | N/A | Contributory |
| i-Tree Eco | A project report / as an online document (see for example www.forestry.gov.uk/fr/itree although this list of online reports does not yet contain any projects that involved volunteers; except student volunteers helped alongside professional in the field surveying for the Wrexham Borough Council project) | | None to date | Contributory |
| Ancient Tree Inventory | An online database of high-quality tree records. Articles from scientific journals to local newspapers | There will be some changes anticipated with the upgrading of the current system to provide easier, mobile access to records and recording. This gives us an opportunity to fine tune the recording details. | Evaluated by numbers and quality of trees recorded and volunteer verifiers engaged. | The ATI can be mainly described as a contributory project but our volunteers and recorders are engaged in the project currently underway to upgrade and improve the system. |
| SPLASH | | | | |
| Conker tree science | Distribution maps of Cameraria passed to Forest Research annually; scientific paper (Pocock & Evans PLOS ONE) | Yes, we slightly changed emphasis during the life of the project, added app, revamped the app, simplified reported etc. | Internal document to RCUK after pilot in 2010. Internal document after year 1 in 2011. Occasional reporting of participation via blog. | Contributory – people just collected data. They could contribute to an online poll about whether the data matched our initial expectations. Almost no one did. |
| Longhorn beetle pheromone trial | A decision on the suitability of pheromones for longhorn trapping – and sadly it is not suitable | Yes, we adapted methods in the second year to try to increase capture rate. | None formal – the project is only just finishing, however will be evaluation of participants responses and data collected to recommend the potential for future work in this area | Collaborative – participants provided their own suggestions for improvements, trap placement etc. |
| IPSN | Some small-scale presence/absence data, resources (such as training materials, poster, protocols etc.), increased awareness and engagement in plant health from those working in botanic gardens and arboreta | Yes, we've had to change greatly in order to work towards making the network a user-friendly tool for garden staff to ensure its uptake | As we've come to the end of our initial phase, we carried out a final report which evaluated the success of the project compared to our initial aims and objectives. We achieved and surpassed these. We are in the process of putting together a work plan which will be used to monitor/evaluate the new phase of the project | Not sure if relevant as not CS – but if anything, the last… We greatly utilise the involvement of botanic garden and arboreta staff to develop the network and all associated materials |
| Urban Tree Survey | Dataset | The project has now closed. The objectives did not change during the programme | None | Contributory |
| RHS surveys | Informing advice and updated distribution maps, data shared with the National Biodiversity Network | No | Project evaluated annually | Contributory: CS provide data on presence of selected non-native garden insects |
| NPMS | To date, the scheme has been collecting data for just under 2 field seasons, so it is not yet possible to derive reliable trends. However, the longer-term aim is that the scheme will provide information on status and trends for UK plant species and semi-natural habitats | No | The scheme is continuously being evaluated in relation to its success as an evidence gathering activity through tracking of volunteer engagement and quantity of data received from volunteers. There are a series of other milestones throughout the course of the scheme's development relating to analysis, communication and training against which scheme success is evaluated | Contributory |
| LeafSnap UK | Dataset | No | None | Contributory |
| PTES Traditional Orchards Project | Habitat inventory published by Natural England. Grants for orchard improvement. Large web resource. Assistance with orchard protection | A little | | Contributory |

| Project | **Project Outputs:** | *a. Has your project objectives changed?* | **Project evaluation (for e.g. details of evaluation scope):** | **Type of CS (Contributory/ Collaborative/Co-Created- please provide details):** |
|---|---|---|---|---|
| CSP | The outputs of the project were to survey plots for symptoms of Ceratocystis and Xylella and to report the results to the Forestry Commission | The objectives of the 2016 Protected Zone Status survey have not changed during the project. If the 2014, 2015 and 2016 surveys are regarded as one project then the main objective change between 2014 and 2016 was the inclusion of Xylella in 2015; the 2014 survey only required inspections for Ceratocystis | | From the classifications provided, this project would fall into the 'contributory' or 'collaborative' categories. All participants – including the project lead – contributed data through the surveys. The project lead designed the project (with the client) and analysed/disseminated the results |
| AshTag | Oover 20,000 recordings were done using the app | Yes | Funding not available to do that | Contributory |
| The Living Ash Project | Identify individuals that show tolerance of Chalara ash dieback to a good degree, within selected and tested populations; use citizen science to find tolerant individuals in the wider population; screen these individuals using markers developed by other Defra funded research; secure this material in archives for further breeding purposes; and develop techniques for rapid bulking up of tolerant genotypes for deployment to the industry | | | Contributory |
| Treezilla- the Monster Map pf Trees | i. A free, accessible catalogue of UK trees as a resource which also provides an estimate of the number of urban trees in the UK and provides a UK-wide map of individual trees; ii. A user-friendly approach to calculating the ecosystem service value of trees and iii. A tool that expands the focus of citizen science activity around trees, i.e. data will be used in a range of scientific investigations from new and emerging tree diseases, evaluation of ecosystem services provided by trees, effects of climate change on tree growth, health and macro ecology, etc. | Under the VITAL project our project objectives have been further defined: I. Developing Treezilla as an entry point for individuals and organisations to carry out ecosystem service valuations of UK trees to internationally recognised standards; II. Integrating Treezilla with other systems and broadening the basis of its ecosystem service valuations i.e. enhancing its capacity to contribute to larger-scale ecosystem service valuation initiatives; III. Fostering partnerships with end users, production of training / learning resources and promotion of the innovative tools developed through this project and; IV. Improving the use of tree-based green infrastructure valuations (using Treezilla) | | Treezilla.org can currently be defined as a platform that facilitates collaborative citizen science. The goal is that as it grows it will develop into a platform that facilitates more co-created citizen science activities |
| Fraxinus | Be to match computational alignments of genetic sequences in 78% of cases, and to improve them in 15% of cases. We also found that most players were only transiently interested in the game, and that the majority of the work done was performed by a small group of dedicated players. Based on our experiences we have built a linear model for the length of time that contributors are likely to donate to a crowd-sourced citizen science project. This model could serve a guide for the design and implementation of future crowd-sourced citizen science initiatives. | No | | Contributory |

# Appendix C. Interview Protocol – Chapter 2

## Interview Questions - Volunteers [All case studies except Observatree]

1. When did you become involved, and in what role are you involved, in (name of the CS project)?
2. Have you ever participated in a CS project before (name of the current CS project)?
3. What motivated you to take part in the CS project, the very first time?
4. How has your level of involvement in (name of the CS project) changed over time?
5. Has your activity/tasks that you were doing initially, changed over time?
6. What factors have played a role in maintaining or changing your levels of involvement over time?
7. Did your involvement in the project motivate you to do more citizen science (in other projects)?
8. Has the project lived up to or exceeded your expectations? [explore why /in what ways the project has fulfilled / failed to fulfil expectations]
9. What you need to get out of a citizen science project for you to feel your participation has been worthwhile?
10. Would you like to work more closely with other volunteers in your area?
11. Do you believe there continues to be a need for the project or something similar?
12. Would you be willing to continue working on the project beyond the current end date?
13. Do you consider yourself to have gained better awareness/knowledge about trees and tree health issues as a result of involvement in (name of the CS project)?
14. Do you consider yourself to have gained better awareness about the important role of (citizen) science in identifying and combating tree pests and diseases?
15. Do you consider yourself to have gained new skills relevant to tree pest and disease identification as a result of involvement in (name of the CS project)?
16. Has involvement in (name of the CS project) changed your attitude or behaviour towards the natural environment in general? [In what ways?]
17. Has involvement in (name of the CS project) provided you with improved job prospects?
18. Has involvement in (name of the CS project) resulted in valuable new social contacts?
19. Has involvement in (name of the CS project) resulted in improved health and wellbeing as a result of spending more time outdoors?
20. Has involvement in (name of the CS project) led to a more positive self-image as a result of contributing to a 'greater good' or supporting a worthwhile activity?
21. Are there any other positive outcomes that you wish to highlight?

22. What have you found to be the best and/or most rewarding aspect of the project to date?
23. Are there any issues/challenges associated with your participation in (name of the CS project) that you wish to highlight?
    a. How have these challenges influenced your activity and participation?
    b. Were any steps taken to address these issues?
    c. Is there anything else that you or the project coordinators could do to address these issues for you or others?
    d. Based on your experience, how important is the 'communication and feedback' from the project manager/scientists to your continued participation in the project?
    e. Did the feedback motivate you to do further activities?
24. Do you think citizen science can play an important role in identifying and combating tree pests and diseases?
25. How has your project contributed in addressing tree/plant health issues?
26. Do you think CS data can be used to provide evidence for tree health policy/decision making? (Kindly elaborate the reasons)

### Interview Questions - Professionals [All case studies except Observatree]

1. When did you become involved, and what do you do within (name of the CS project)?
2. What motivated you to take part in the CS project, the very first time?
3. How has your level and type of involvement in (name of the CS project) changed over time?
4. What factors (capacity, capabilities and motivations) have played a role in maintaining or changing your levels of involvement over time?
5. Has your level of support/engagement for (name of the CS project) changed over time? [in what ways]
6. What project elements have been most and least successful in your eyes?
7. Do you see opportunities for expanding the role citizen science plays in supporting your role or that of your organisation into the future?
8. Did your involvement in the project motivate you to do more CS?
9. Has the project lived up to or exceeded your expectations? [In what ways?]
10. What you need to get out of a citizen science project for you to feel your participation has been worthwhile?
11. Are there any other positive or negative outcomes that you wish to highlight?
12. Do you believe that there remains a role for the project, either in its current, or a revised form?

13. If you would have the funds to extend (name of the CS project) for another three years, would you be happy to commission these? Would there be anything you would like to change about how the project is delivered? How could this be achieved?
14. To what extent has your participation in the project led to positive attitude or behaviour towards the environment?
15. Do you consider yourself to have gained better awareness about the important role of citizen science in identifying and combating tree pests and diseases?
16. Has involvement in (name of the CS project) enhanced your organisation's connections with other organisations?
17. Has involvement in (name of the CS project) changed your organisational culture in the sense that it is more open to partnership working and/or citizen science?
18. Has involvement in (name of the CS project) resulted in valuable new social contacts for you personally?
19. Do you know of any examples in which involvement in (name of the CS project) has improved a volunteer's job prospects?
20. Do you know of any examples in which involvement in (name of the CS project) has improved a volunteer's attitude and behaviour towards the environment?
21. Do you know of any examples in which involvement in (name of the CS project) has improved a volunteer's health and wellbeing?
22. In your experience what have been the most prominent issues/challenges of professional involvement in the project?
23. What have you done to overcome these? How successful were you?
24. Is there anything else that you or the project coordinators could do to overcome these challenges for you or others?
25. Is there anything else that you or the project coordinators could change within the (name of the CS project) project to improve your or others' ability to work effectively?
26. Do you think citizen science can play an important role in identifying and combating tree pests and diseases?
27. How has your project contributed in addressing tree/plant health issues? Has it changed over time? [in what ways]
28. Do you believe CS data can be used to provide evidence for tree health policy/decision making? (Kindly elaborate the reasons)

### Interview Questions - Volunteers [Observatree]

1. When did you become involved, and in what role are you involved, in Observatree?
2. What motivated you to take part in the project, the very first time?

3. Have you ever participated in CS project before Observatree?
4. How has your level of involvement in Observatree changed over time?
5. What factors have played a role in explaining your sustained / shifting levels of involvement over time?
6. Has the project lived up to or exceeded your expectations? [explore why /in what ways the project has fulfilled / failed to fulfil expectations]
7. What do you need to get out of a citizen science project for you to feel your participation has been worthwhile?
8. Do you believe there continues to be a need for the project or something similar?
9. Would you be willing to continue working on the project beyond the current end date?
10. What are your general thoughts about the provision of training within the project?
11. Was the training pitched at the right level? Was there enough training for you to feel supported in your role?
12. How could the training be improved?
13. Do you feel you understand what's expected of you as a volunteer within the project (both in terms of what you do and when you do it)?
14. How could things be made clearer in the future?
15. Do you feel you've had enough support and collaboration with other volunteers / experts / scientists within the project?
16. Why is this collaboration important? How could this be improved?
17. Based on your experience, how important is the communication from the volunteer coordinator and feedback in terms of what you report, to your continued participation in the project?
18. Would you like to work more closely with other volunteers in your area?
19. Are there any other issues/challenges associated with your participation in Observatree that you wish to highlight?
20. What could the project coordinators do to address any issues or challenges for you or others?
21. How has your involvement in the project benefitted you (in person or at professional level?)
22. Do you consider yourself to have gained better awareness/knowledge about trees and tree health issues as a result of involvement in Observatree?
23. Do you consider yourself to have gained better awareness about the important role of (citizen) science in identifying and combating tree pests and diseases?

24. Do you consider yourself to have gained new skills relevant to tree pest and disease identification as a result of involvement in Observatree?
25. Has involvement in Observatree changed your attitude or behaviour towards the natural environment in general?
26. Has involvement in Observatree provided you with improved job prospects?
27. Has involvement in Observatree resulted in valuable new social contacts?
28. Has involvement in Observatree resulted in improved health and wellbeing as a result of spending more time outdoors?
29. Has involvement in Observatree led to a more positive self-image as a result of contributing to a 'greater good' or supporting a worthwhile activity?
30. Did your involvement in the project motivate you to do more Citizen Science?
31. Are there any other positive or negative outcomes that you wish to highlight?
32. Do you think CS data can be used to provide evidence for tree health policy/decision making? (Kindly elaborate the reasons?)

### Interview Questions - Professionals [Observatree]

33. When did you become involved, and in what role, in Observatree? What are some of the responsibilities in relation to Observatree in your role?
34. What motivated you to take part in the project, the very first time?
35. How has your level and type of involvement in Observatree changed over time?
36. What factors (capacity, capabilities and motivations) have played a role in explaining your sustained or shifting levels of involvement over time?
37. Has your level of support for Observatree and its potential to contribute to early detection of tree pests and diseases changed as a result of your involvement?
38. What project elements have been most and least successful in your eyes?
39. Do you see opportunities for expanding the role citizen science plays in supporting your role or that of your organisation into the future?
40. Did your involvement in the project motivate you to do more Citizen Science?
41. Has the project lived up to or exceeded your expectations? In what ways?
42. What do you need to get out of a citizen science project to feel your participation has been worthwhile?
43. Are there any other positive or negative outcomes that you wish to highlight?
44. Do you believe that there remains a role for the Observatree project, either in its current, or a revised form?

45. If you had the funds to extend Observatree for another three years, would you be happy to continue with the project? Would there be anything you would like to change about how the project is delivered? How could this be achieved?
46. Tell me about ways in which work done by volunteers is supporting your work as a tree health professional?
47. Are there any issues with the way volunteers work or the tasks that they perform that limit the usefulness of their work and the data it produces?
48. What could be done to remedy these issues?
49. To what extent have you, and others around you, experienced a change to your ability to work effectively as a result of Observatree? Is there anything else that you or the project coordinators could change within the Observatree project to improve your or others' ability to work effectively?
50. To what extent have you experienced these challenges arising from the quantitative data, and how have they influenced your activity in Observatree?
51. If having experienced one or more of these challenges emerging from the quantitative data, what have you done to overcome these? How successful were you?
52. Is there anything else that you or the project coordinators could do to overcome these challenges for you or others?
53. Based on your experience, how important is the communication and feedback given to volunteers?
54. How has your involvement in the project benefitted you (in person or at professional level?)
55. To what extent has the improved early detection of tree pests and diseases as a result of Observatree led to increased environmental resilience? In what way?
56. Do you consider yourself to have gained better awareness about the important role of citizen science in identifying and combating tree pests and diseases? In what way?
57. Has involvement in Observatree enhanced your organisation's connectivity with other organisations? In what way?
58. Has involvement in Observatree changed your organisational culture in the sense that it is more open to partnership working and/or citizen science? In what way?
59. Do you believe that CS data can be used to provide tree health evidence and can be used for policy or decision making? (Kindly elaborate the reasons)

# Appendix D. Agenda - The Future of Tree Health Citizen Science: Opportunities and Challenges Workshop

| | |
|---|---|
| 10:30 - 11: 00 | Arrival and Coffee/Tea |
| 11:00 – 11.15 | Welcome and introduction (David Slawson & Jake Morris) |
| 11:15 - 11:30 | Presentation "*Tree health citizen science landscape and emerging issues, barriers and challenges*" (Nidhi Gupta) |
| | **<u>Breakout Session 1:</u> "Issues, barriers and challenges"** |
| 11.30 – 12.00 Discussion | Break into 4 stakeholder groups: Science, Management, Policy and Practitioners to discuss and from the perspective of your group answer: |
| 12.00 – 12.30 Feedback | *Q1: Are there any other important issues, barriers and challenges that we have missed that you would like to add to the list?* |
| | *Q2: What are the 3 most important challenges & why**?*** |
| 12.30 – 13.00 | Lunch |
| 13.00 – 13.10 | Presentation "*Tree Health Citizen Science: Emerging values, opportunities and advantages* (Nidhi Gupta) |
| | **<u>Breakout Session 2</u>: "Values, opportunities and advantages"** |
| 13.10 – 13.30 Discussion | Break into same four groups to discuss and from the perspective of your group answer: |
| | *Q1: Are there other values, opportunities or advantages that we have missed that you would like to add to the list?* |
| 13.30 – 13.50 Feedback | *Q2: What are the 3 values, opportunities or advantages that we need to protect in the future & why?* |
| 13.50 – 14.10 | Audience Poll to prioritise five most important suggestions |
| | **<u>Breakout Session 3:</u> Future of tree health Citizen Science** |
| 14.10 – 14.30 | |
| Discussion | Identify three priorities for action in securing and enhancing the value of Citizen Science in tree health |
| 14.30 – 14.50 Feedback | |

14.50 – 15.00 Reflections and conclusion (Charles Lane)

## Appendix E

### Emerging Issues, Challenges & Barriers

| THCS value categories | Examples |
|---|---|
| **Data** | - Data quality<br>- Validation of observations<br>- Data analysis<br>- Trust in absence data |
| **Volunteers** | - Lonely<br>- Lack of support/management<br>- Lack of feedback/communication<br>- Availability of time<br>- Retaining motivation, enthusiasm; meeting expectations<br>- Geographic location – not always in right place |
| **Officials** | - Threat to jobs, replace official surveillance<br>- Cheap way to collect data<br>- Work-life balance<br>- Pressure on limited number of experts<br>- Constraints on time and funding<br>- Mixed skills of volunteers; Time taken to train volunteers<br>- Integration into existing processes, technology<br>- Expectation around success of the projects<br>- Duplication between Citizen Science projects |

## Appendix F

### Emerging Issues, Challenges & Barriers

| THCS value categories | Examples |
|---|---|
| **Institutions** | - Lack of trust between institutions<br>- Difficulties in sharing data |
| **Statutory** | - Access of non-officials on to private land<br>- Statutory – reluctance to report when statutory action likely |
| **Technology** | - Need for appropriate technology for volunteers (e.g. apps, hand-held devices)<br>- Integration of technology with and between official systems |
| **Overall** | - Challenge of meeting dual objectives of data and outreach<br>- Challenge of sustaining the benefits and value of Citizen Science projects beyond when funding runs out |

### Emerging Values, Opportunities & Advantages

| THCS value categories | Examples |
|---|---|
| **Valuable data source** | - Data to support tree health science<br>- Data to support surveillance and monitoring<br>- Data about volunteers (motivations, benefits, needs) |
| **Capacity** | - Increased geographical coverage<br>- Addressing pressure on resources (e.g. official surveillance) |
| **Capability** | - Volunteer experience (e.g. local knowledge)<br>- Volunteer expertise (e.g. knowledge of trees / pests & diseases)<br>- Volunteers perceived by landowners as 'more friendly' then officials |
| **Communication and engagement** | - Public engagement in TH<br>- Public engagement in natural environment<br>- Public engagement in science<br>- Volunteers can provide local community advocacy |
| **Mechanism for delivering wider benefits to society** | - Enjoyment and fun<br>- Education and learning<br>- Physical health (being outdoors)<br>- Mental health (improved self-esteem)<br>- Improved employment prospects |
| **Social capital** | - Meeting new people and making friends (volunteers)<br>- Building links between organisations through partnerships<br>- Trust between the public and Government / research institutions / 3rd sector |

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