

PHC2018/07 – Final Report on ‘The Use Of Mobile Technology To Enhance Plant Health Monitoring And Awareness In Scotland’

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Introduction

Plant health is a major issue worldwide with many pests and diseases threatening different plant-based sectors such as forestry, agriculture, environment and horticulture. Websites and smartphone apps, are being used in a range of circumstances to facilitate pest and disease identification, monitoring of outbreaks and geographic spread.

Aims & Objectives

The aim of this project is to review existing websites and smartphone apps currently available and applied in the plant health sector and to assemble a detailed overview covering the following points:

- What options are available in terms of mobile software applications for plant health?
- What is their primary purpose?
- Who is the target audience (growers, plant health professionals, citizen science, ...)?
- Which plant health sectors do they cover?
- Are they reliable and accurate?
- Is information submitted to a central database? If so, how is this information used?
- Could they be used globally, or are they limited to certain geographic regions?

Plant Health in Scotland

There are many pests and diseases that can seriously damage crops and plants in Scotland. These pests and diseases can be divided into two categories; existing ones and those posing a potential threat. This report is to look at how the use of mobile software applications could be used to enhance plant health monitoring and awareness in Scotland, focussing on the introduction of new pests and pathogens.

However, several of the websites and smartphone apps reviewed within this report focus on aiding identification and subsequent control options for existing pests and pathogens.

Existing mobile software applications for plant health in the UK

There are numerous mobile software applications designed for use in the field of plant health both within the UK and internationally (see Table 1). Their complexity and the depth of information supplied varies significantly, ranging from smartphone apps to help identify and report one specific threat to more comprehensive tools covering a multitude of hosts and threats. The range of functions they include also varies widely. The following paragraphs highlight representative mobile software applications with their strengths and weaknesses, categorised according to the sectors they support.

Plant health resources across sectors

There is a wealth of information available via websites regarding potential threats from pests and pathogens to the UK and Scottish agricultural, horticultural, forestry and environmental sectors. DEFRA'S UK Plant Health Risk Register (<https://secure.fera.defra.gov.uk/phiw/riskRegister/>) was created to facilitate the implementation of recommendations of the independent Task Force on Tree Health and Plant Biosecurity. It is a tool for government, industry and stakeholders to prioritise action against pests and diseases that threaten our crops, trees, gardens and countryside. The Register is publicly available. In association with the risk register is the UK Plant health information portal (<https://planthealthportal.defra.gov.uk/>) also a DEFRA supported resource.

Additionally, the objective of EPPO (European and Mediterranean Plant Protection Organization) is to protect plants, by developing international strategies against the introduction and spread of pests that are a threat to agriculture, forestry and the environment, and by promoting safe and effective pest control methods. EPPO promotes the exchange of information between its member countries by maintaining information services and databases on plant pests (<https://www.eppo.int/>).

Therefore, all sectors are well served in terms of resources pertaining to plant health issues in the Risk Register, Plant health information portal and EPPO websites. With respect to new threats, there is no single online resource with identification keys and the ability to submit a report on a suspected sighting of a pest or pathogen. Indeed, the signposting of 'how to' and 'who to' submit potential sightings of

new pests and diseases is vague, and consequently 'what to do' following a suspected finding of a new pest or disease is often not clear.

The Forestry Sector

The forestry sector, represented by Forest Research and the Forestry Commission, is perhaps the most advanced in terms of developing online resources and smartphone apps to underpin its objectives, which include issues relating to tree health. A particular challenge for the sector is that it encompasses not only commercially managed areas but trees within both private and public spaces. There has therefore been a huge effort to engage members of the public in citizen science, for example, the OPAL tree health survey (<https://www.opalexplornature.org/>) which collects a broad range of information from members of the public encouraged to provide survey data, and Observatree (<https://www.observatree.org.uk/>) which aims to encourage members of the public to help spot new pest and disease threats to UK trees (reports are submitted via TreeAlert). Additionally, tools have been rapidly developed in response to specific introductions, e.g. the AshTag app, developed to enable members of the public to submit reports of suspected Chalara ash die-back soon after it was first reported in the UK.

Forest Research have developed an online tool called "TreeAlert" to gather information about the health of the nation's trees, woodlands and forests (<https://www.forestresearch.gov.uk/tools-and-resources/tree-alert/>) "This information will support important tree health monitoring and surveillance work, contribute to ongoing scientific research in this field and, ultimately, support efforts to protect the nation's trees". The TreeAlert online tool enables anyone to submit either 'specific' or 'general' reports on suspected findings of pests and diseases. It is underpinned by detailed knowledge and images relating to tree and woodland problems collated in "Pest and disease resources" (<https://www.forestresearch.gov.uk/tools-and-resources/pest-and-disease-resources/>), an additional online tool to aid identification. Users of TreeAlert (which range from members of the public to land managers) are taken through pages in which information including personal contact details, level of experience, location type and specific location (grid reference or point on map) are collected. The user is then taken through a series of identification keys, both for the host plant (if relevant) and pest/disease observations which leads to a decision regarding likelihood of symptoms being correctly identified (if a specific report) and submission of photographs. The identification key may result in an alternative disease/pathogen being identified as the likely cause or it might remain unknown, either

way photos must be submitted through the channel identified as being most suitable based on the information provided.

The first iteration of TreeAlert was as a smartphone app - this was later redeveloped into a website format, which enabled a more sophisticated reporting network to be implemented. However, the system also works well on mobile phones, and it is hoped that a specific smartphone app version will be developed in the future. The value of any data submitted via an interactive website or smartphone app depends on its quality. According to the experience of Forest Research when developing TreeAlert, making fields mandatory when submitting a report reduces the submission of incomplete and/or low-quality reports.

The team behind TreeAlert and Observatree is extensive, including data managers to triage the submissions and allocate them to the most relevant diagnosticians within the Advisory team. There are desk-based workers tasked with gaining additional information if required to make a confident assessment of the submission. TreeAlert is designed to inform Forest Research of pest and disease outbreaks at the earliest opportunity, maximising the likelihood of controlling or eliminating outbreaks of new pests and diseases.

As a user you are prompted to indicate your level of knowledge/experience, allowing management of the data collected to be filtered. A similar system could be developed for the agriculture and horticulture sectors, where it could include an additional category of "official inspector" – the information collection for this category may differ from that required for the non-official data collection.

TreeAlert

Tree Pest & Disease sighting reporter



This site has been set up to gather information about the health of the nation's trees, woodlands and forests. This information will support important tree health monitoring and surveillance work, contribute to ongoing scientific research in this field and, ultimately, support efforts to protect the nation's trees.

For an overview of what information will be required, [get info here](#) (opens a new tab)

This site uses cookies. We have already set cookies which are essential for the operation of this site.

Please be aware you will not be able to submit a report without uploading photographs of your observation.

TreeAlert has been developed to make use of the features provided by the latest generation of web technologies, and has been tested on the most recent desktop and mobile browsers. Thus it cannot be guaranteed that TreeAlert will perform optimally on all forms of hardware and software.



Submit a general report of a problem affecting the health of a tree(s), including Oak Processionary Moth and Oriental Chestnut Gall wasp.



Submit a report of a specific tree pest or disease that you have seen.



If you own or manage trees you can request a diagnosis of a pest or disease problem. This may be a chargeable service.

[Home](#)

[Forestry Commission](#)

[Observatree](#) – an early warning system for tree health

Resources For Report Submission

[UK Grid Reference Finder](#)

[What You Need To Make A Report](#)

Useful information

[Forestry Commission - tree identification guide](#)

[Forest Research - research into tree pests and diseases](#)

[Forestry Commission - top tree pests and diseases](#)

[Chalara map](#)

[UK Plant Health Risk Register](#)

[Plant Health \(Forestry\) Order 2005 \(pdf download\)](#)

Login Form

Username

Password

Figure 1 Front page of the TreeAlert online tool

Table 1 Existing technologies. *: Reporting is possible, but it is unclear what this data is used for and what information is sent, ^: Available for a subset, •: PlantVillage Nuru was not available for testing during the project period; rating is based on screenshots, Sectors: 🌱 (agriculture), 🌿 (environment), 🌲 (forestry), 🌻 (horticulture); Platforms 🤖 (Android) 🍏 (Apple) 🌐 (Website).















	Tool	Sector	Threat focus		Threat breadth		Features								
			Existing threats	New threats	Number of hosts	Number of threats	Platforms	Identification guide	Fact sheets	Image recognition	Report positive identifications	Threat alerts	Spread map	Mobile friendly	Community
Smartphone apps	Agrobase	🌱	✓	✗	Many	Many	🤖 iOS	✗	✓	✗	✗	✗	✗	✓	✗
	Agronomy Tool	🌱	✓	✗	Many	Many	🤖 iOS	✓	✓	✗	✗	✗	✗	✓	✗
	AHDB Crop Walkers' Guide	🌱🌻	✓	✗	Many	Many	🤖 iOS 🌐	✓	✓	✗	✗	✗	✗	✗	✗
	Asian Hornet Watch	🌿	✓	✓	1	Few	🤖 iOS	✓	✓	✗	✓*	✗	✓	✓	✗
	Buntata	🌱	✓	✗	1	Many	🤖 🌐	✓	✓	✗	✗	✗	✗	✓	✗
	Cropalyser	🌱	✓	✗	Many	Many	🤖 iOS	✓	✓	✗	✗	✗	✗	✓	✗
	Croprotect	🌱	✓	✗	Many	Many	🤖 iOS	✗	✓	✗	✓*	✗	✗	✓	✗
	Crop Disease AU	🌱	✓	✗	Few	Many	🤖 iOS	✗	✓	✗	✗	✗	✗	✓	✗
	Pestoz	🌱	✓	✗	Many	Many	🤖	✗	✓	✓	✓*	✗	✗	✓	✗
	Plantix	🌱	✓	✗	Many	Many	🤖 🌐	✓	✓	✓	✓	✗	✗	✓	✓

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	PlantVillage Nuru*		✓	✗	Few	Few		✗	✓	✓	✗	✗	✗	✓	✓
	Plantwise		✓	✗	Many	Many		✓	✓	✗	✗	✗/✓	✗/✓	✗/✓	✗
Web resources	Chalara map (reporting via TreeAlert)		✓	✓	1	1		✗	✓	✗	✓	✗	✓	✓	✗
	Forest Research Pest and Disease		✓	✗	Few	Few		✗	✓	✗	✗	✗	✓ [^]	✓	✗
	ObserveTree (reporting via TreeAlert)		✓	✓	Many	Many		✓	✓	✗	✓	✗	✓ [^]	✓	✗
	TreeCheck		✓	✓	Few	Few		✗	✗	✗	✓	✗	✗	✓	✗
	PestDisPlace		✓	✗	2	Few		✗	✓	✗	✗	✗	✗	✓	✓

Natural Environment Sector

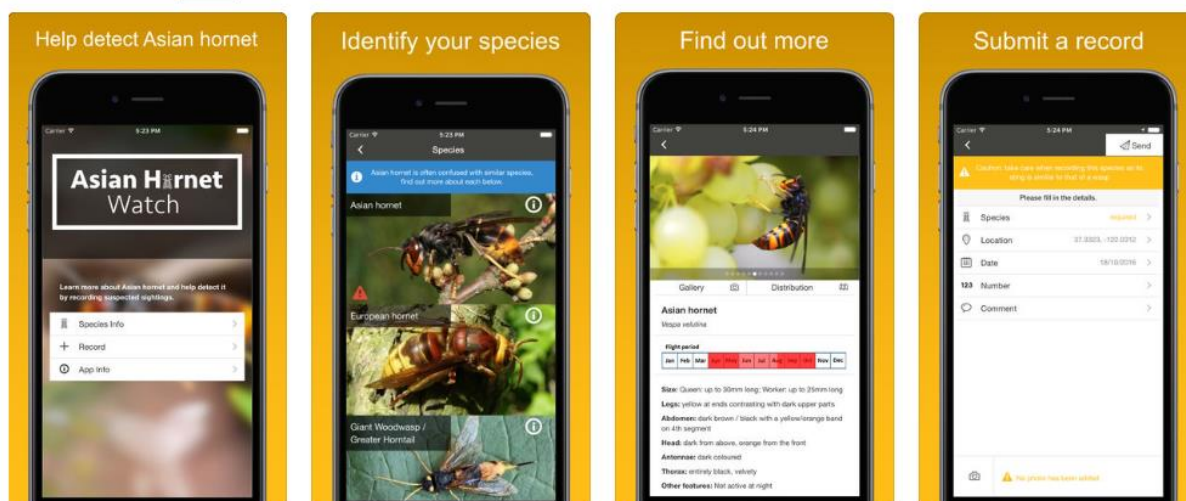
The natural environment sector is probably the least developed sector in terms of mobile software applications – which is being addressed to some extent by a PHC project running concurrent to this one (Development of an online, user friendly plant health resource bank for the Natural Environment PHC2018/11). This sector cannot be considered as stand-alone as there will be crossover with the forestry sector in relation to trees in the natural environment.

Agriculture and Horticulture Sectors

For existing pests and diseases the AHDB Crop Walkers' Guides are designed for use in the field (<https://horticulture.ahdb.org.uk/publication-category/crop-walkers-guides>) to help with accurate identification of pests, diseases, nutrient deficiencies and disorders within a crop. If a pest or disease is identified in a crop, growers are guided towards other AHDB Horticulture publications that contain information on a range of control measures.

Across sectors: The Asian Hornet Watch app

Introduction of the Asian Hornet into the UK would pose a threat to native pollinators, and therefore to plant health in general. This very specific threat (there have been thirteen confirmed sightings to date) is being tackled with the assistance of the smartphone app "Asian Hornet Watch" which was launched in March 2017. The app was an initiative of the Great Britain Non-native Species Secretariat which is a joint venture between DEFRA, the Scottish Government and the Welsh Government. The free to download app is available from both the Apple and Android app stores.



This smartphone app focuses on informing the general public about the dangers of the Asian Hornet and emphasizes the visual differences between this new threat and similar domestic species. It offers identification guides and distribution maps and, importantly, a system for reporting suspected sightings. The reporting system is managed, and once a positive identification is confirmed it results in a clear action.

Asian Hornet Watch focuses on a single threat, but it incorporates a wide range of functions; from raising awareness of threats, identification guides, reporting, mapping spread and control advice. It is an excellent example of a very narrowly focused application developed to a high standard.

Mobile software applications developed for use outside the UK

There are other mobile software applications which have been designed for use in the field of plant health internationally; the applications listed below demonstrate how different functions can be combined according to their specific application.

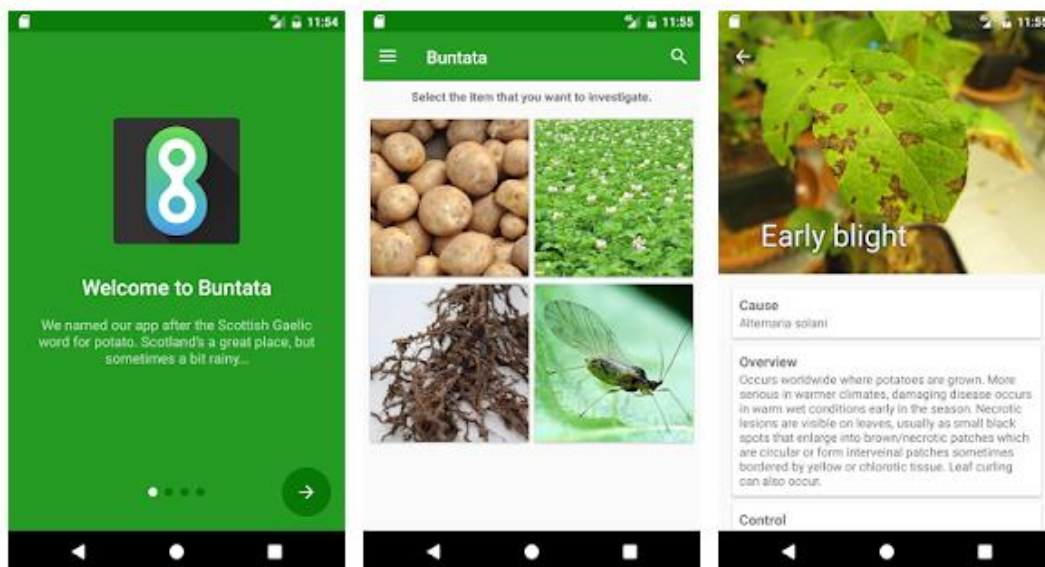
Buntata is a smartphone app developed in 2017 to assist growers in areas of Africa with the identification of existing pest and disease symptoms on potato. It is targeted at a single host but covers a wide range of pest and disease symptoms – and crucially includes information on control options. Buntata acts as a visual key during the identification process and guides users through the procedure by suggesting exemplar images of pests and diseases. It was specifically designed for use in the field where there may be limited access to alternative sources of information, and consequently it has off-line capability.

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Plantwise is a global programme led by CABI “which aims to increase food security and improve rural livelihoods by reducing crop losses. Through a network of plant clinics, Plantwise helps smallholder farmers lose less of what they grow to pests and diseases”. Plantwise have developed web-based resources – which are also available as an off-line smartphone app. This application utilises the ‘Plantwise Knowledge Bank’ to provide information including factsheets, distribution maps, alerts and control options. The primary focus of Plantwise is to help small scale farmers particularly in developing countries but the search functions cover all countries, across all crops and all pests and diseases, and it therefore sits at the far end of the spectrum with regards to the sheer number of hosts and threats covered – although the scale can perhaps interfere with the quality of data supplied, particularly outside its target countries.

Plantix is a mobile crop advisory app for farmers, extension workers and gardeners. It can diagnose disease, pest damage and nutrient deficiencies affecting crops and offers corresponding treatment measures. Plantix is the most developed application we found in terms of incorporating functions to diagnose and report plant health issues, e.g. pest/pathogen identification (including image recognition), reporting of positive identifications and threat alerts. However, the focus of the application is on existing pests and diseases, rather than as a tool for enhancing plant health monitoring and awareness in relation to new threats. Additionally, Plantix attempts to extend its application by having regional weather reports and incorporating a community feature like a discussion board – which could assist in decision support systems.

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Another innovative tool has been developed by the International Institute of Tropical Agriculture (IITA) and Pennsylvania State University, USA, who have collaborated to develop and launch Nuru, an Artificially Intelligent Assistant. Nuru uses machine learning to accurately recognize leaves damaged by two important viral diseases of cassava (Cassava Mosaic Disease and Cassava Brown Streak Disease) as well as damage by red and green mites. The smartphone app connects with the knowledge within the PlantVillage open access library of crop health. The project is on-going and new developments are being incorporated into updates.

Mobile Application Technology

Application platforms

Available technologies can be split into two groups: *traditional websites* and *smartphone apps*. Both categories fulfil different roles. Smartphone apps try to bundle as much functionality as possible within a small package. They tend to be very user friendly and intuitive and offer tight integration with the mobile device's capabilities like taking pictures and providing geographic location information. The downside of smartphone apps is the fact that they are often only developed for a single ecosystem (Android, iOS) and can therefore only be used by a subset of the potential users. Out of the smartphone apps listed, Buntata and Plantix offer a web version of their apps, making them available to a wider audience.

Traditional websites (like the forestry research website) on the other hand work across all devices that have a web browser and internet connectivity and can therefore be used by most people. Their strength lies in the wealth of information that can be displayed and easily browsed. Unfortunately, traditional websites often are not easy to use on mobile devices and do not integrate well with the camera and GPS location. The web-based Plantwise and Bunata apps are also available as offline versions for Android mobile devices, enabling users to access plant health information and management advice in remote rural areas with poor data coverage.

Efficiency, effectiveness and accuracy of existing approaches

There are very few publications that evaluate the efficiency, effectiveness and accuracy of mobile technology for use in plant health. However, Barbedo (2018) recently reviewed factors influencing the use of deep learning technology for plant disease recognition. Whilst the author recognises that the

application of this technology to plant pathology problems is growing rapidly, it is clear there are still many challenges to overcome, and some problems still do not have suitable solutions. The author states that, currently tools for automatic recognition of plant diseases, rather than offering a definite answer, can at most provide a very educated guess that will allow its users to take some action (pest and disease control) in a timely manner, especially when specialised technical assistance is not available. The effectiveness of deep learning algorithms is often hindered by low quality input. In the case of image recognition, users will need detailed guidelines in order to take high quality pictures that the algorithm can use to make good predictions. As technology evolves, some of those limitations may be overcome but there is still much to be investigated. Developments in this area should be closely monitored.

Challenges

The General Data Protection Regulation (GDPR) became effective in May 2018. It is a regulation in EU law on data protection and privacy. Any information collected by a reporting mechanism would have to comply with GDPR.

Additionally, reporting a pest or disease along with geographic information may make the submitting person identifiable. This may lead to a reluctance by individuals to be associated with the report and consequently with the disease outbreak. To mitigate this, location information could be pseudo-anonymised by sufficiently decreasing the precision of this information. Extra care needs to be taken due to the relative sparseness of population density in some regions of Scotland which could potentially make it possible to identify the source.

Allowing users to easily submit data (photos, locations, timestamps) introduces a new challenge, since the quality of user-submitted data will vary significantly based on their experience and available guidelines, or even walkthroughs, for data submissions. It would have to be ensured that sufficient administrative resources are available to process the potentially large amounts of submitted data. Making fields mandatory when submitting a report can help increase the quality of submissions.

New technologies

Recent advances in the area of web development have made it possible to create websites that have most of the advantages of traditional websites and smartphones apps with almost no downsides.

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Progressive Web Apps (PWAs) can harness the power of mobile devices by integrating with its sensors while also being able to display lots of information on PCs and laptops. This technology, however, has not been applied in the plant health sector, yet seems to be the most promising approach. Good examples of PWAs outside of the plant health sector are Twitter (<https://mobile.twitter.com>) and Uber (<https://m.uber.com>).

Stakeholder engagement

An informed perspective on who currently uses websites and smartphone apps and how these applications could potentially benefit those involved in the key plant health sectors was sought through stakeholder engagement.

We engaged with a variety of stakeholders: at the Scottish Society for Crop Research (SSCR) Potato and Soft fruit meetings and within SASA and HMU and asked “which websites and smartphone apps do you currently use?” and “what in your view would be beneficial in terms of new mobile resources?”. It became apparent, that whilst plant health is pertinent to a wide range of stakeholders, they interact with the topic in a very diverse range of ways. For some, it will simply be controlling existing pests and diseases in the most efficient way, while for others being aware of new pest and pathogen threat is very important.

For existing pests and diseases a number of the approached stakeholders use the AHDB crop walkers' guides to aid in-field identification of pests and diseases they are likely to encounter in a specific crop. Whilst for those with a responsibility for maintaining plant health (for example, the Plant Health Officer at the James Hutton Institute and the inspection team at HMU) the “Risk register” and “EPPO alerts” are used to keep informed of new pest and disease threats. There is also a strong emphasis on training and personal communications to keep team members informed.

Online resources may be used to help identify pests and diseases, although there was generally little if any use of smartphone apps being used outside the forestry sector by the stakeholders we engaged with. A more detailed account of where people get their plant health information is being collated in a concurrent report (PHC2018/10).

Future developments

Due to the wide-ranging interests of different stakeholders both within and between sectors, the stakeholder engagement did not identify a single set of functions deemed beneficial if incorporated into a mobile software application. However, our review of the existing applications revealed that their functions can be broken down into five key features that cover the basics of what can be achieved to facilitate plant health in Scotland using mobile software applications:

- 1) Receiving alerts. When new risks to plant health in Scotland are identified, alerts can be sent with supporting identification guides, this function raises awareness and provides the relevant information to those working in the plant sectors.
- 2) Identification guides. This could range from simple identification guides with photographs that guide you through multiple steps to an identification, to advanced (keyword) searches and image recognition algorithms that would return a result with minimal interaction by the user. The relevant information is available to create identification guides, which could be made easily accessible in a mobile platform. In its simplest format, pest and disease threats identified in the risk register could be sorted according to the level of risk they pose to Scotland and divided into categories depending on the sector(s) they threaten. Identification guides with photographs, could be created using resources within the UK Plant health information portal and would act as a visual key to aid identification.
- 3) Reporting suspected pests/diseases. A mechanism to report a suspected identification of a pest or disease threat to the appropriate authority would allow new outbreaks to be monitored and controlled. This may include uploading images of the suspect along with geographic location information. A notable weakness in existing websites (Risk register and Plant Portal), is a lack of clear instructions on how to report a potential identification of a new pest or disease. The links available on these web-pages often simply refer to the Scottish Government or Horticultural Marketing Unit, but without clear guidelines on what should be reported and how.
- 4) Mapping threats. Geographic visualizations of the spread of a threat could be beneficial. Ideally, this could be offered in a time context so that not only the current state but also historic spread information is available.
- 5) Control options: The final key feature would inform users (farmers, growers, agronomists, land managers, general public) about possible solutions to deal with the threat.

It would be essential for any technology to be underpinned financially to support and continue its development to maintain its relevance to plant health. Any interactive functions, such as submitting images of suspects, verification of suspects and mapping of outbreaks would require a supporting framework. The management of data collection and response is essential, which could be a centrally co-ordinated activity or may be devolved according to sector.

Conclusion

Plant health is a very complex and diverse field. It covers four sectors (agriculture, horticulture, forestry and environment) and numerous hosts, pests and pathogens. Two examples of mobile software applications currently in use in the UK reflect this diversity, one being a comprehensive website based tool to monitor pest and disease threats in the forestry sector (TreeAlert) the other a smartphone app developed in response to a very specific threat (Asian Hornet Watch). These tools are interactive and are supported in terms of maintenance, data curation and if necessary – appropriate action is taken.

The underpinning information and technology are available to develop new tools, either to support other plant health sectors or in direct response to specific new threats if required in the future. The larger the coverage in terms of hosts and threats, the larger the commitment in terms of resources to ensure that the usability, sustainability and value of the system is secured.

References

Barbedo J.G.A. 2018. Factors influencing the use of deep learning for plant disease recognition. Biosystems Engineering 172: 84-91

Resource	Source
AHDB Crop Walkers' Guide	https://horticulture.ahdb.org.uk/publication-category/crop-walkers-guides https://play.google.com/store/apps/details?id=uk.org.hdc.cropwalker&hl=en https://itunes.apple.com/gb/app/ahdb-crop-walkers-guide/id1188385754?mt=8
Buntata Web	https://ics.hutton.ac.uk/buntata-web
Chalara map	http://chalaramap.fera.defra.gov.uk/
DEFRA'S UK Plant Health Risk Register	https://secure.fera.defra.gov.uk/phiw/riskRegister/
OPAL tree health survey	https://www.opalexplorenature.org/
Observatree	https://www.observatree.org.uk/
Pest and disease resources	https://www.forestresearch.gov.uk/tools-and-resources/pest-and-disease-resources/
PestDisPlace	https://pestdisplace.org/
Plantix	https://plantix.net/en

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TreeCheck	https://www.treecheck.net/
Agrobase	https://play.google.com/store/apps/details?id=lt.farmis.apps.farmiscatalog
Agronomy Tool	https://play.google.com/store/apps/details?id=com.bayer.identificationapp
Asian Hornet Watch	https://play.google.com/store/apps/details?id=uk.ac.ceh.hornets&hl=en_GB
Buntata	https://play.google.com/store/apps/details?id=uk.ac.hutton.ics.buntata
Cropalyser	https://play.google.com/store/apps/details?id=com.webuildapps.bejo.cropalyser
Croprotect	https://play.google.com/store/apps/details?id=com.croprotect.app
Crop Disease AU	https://play.google.com/store/apps/details?id=com.outware.cropdiseaseau
Pestoz	https://play.google.com/store/apps/details?id=com.pestoz.pestoz
Plantix	https://play.google.com/store/apps/details?id=com.peat.GartenBank
PlantVillage Nuru	https://play.google.com/store/apps/details?id=plantvillage.nuru
Plantwise	https://play.google.com/store/apps/details?id=org.cabi.pfff https://www.plantwise.org/

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