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Viewpoint

Ethical dilemmas when using citizen science for early detection of invasive tree pests and diseases

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Abstract

The early detection of tree health pests and disease is an important component of biosecurity to protect the aesthetic, recreational and economic importance of trees, woodlands and forestry. Citizen science is valuable in supporting the early detection of tree pests and diseases. Different stakeholders (government, business, society and individual) will vary in their opinion of the balance between costs and benefits of early detection and consequent management, partly because many costs are local whereas benefits are felt at larger scales. This can create clashes in motivations of those involved in citizen science, thus leading to ethical dilemmas about what is good and responsible conduct for the use of citizen science. We draw on our experience of tree health citizen science to exemplify five dilemmas. These dilemmas arise because: the consequences of detection may locally be severe (e.g. the destruction of trees); knowledge of these impacts could lead to refusal to make citizen science reports; citizen science reports can be made freely, but can be costly to respond to; participants may expect solutions even if these are not possible; and early detection is (by definition) a rare event. Effective engagement and dialogue across stakeholders, including public stakeholders, is important to properly address these issues. This is vital to ensure the public's long-term support for and trust in the use of citizen science for the early detection of tree pests and diseases.

Key words: alien species; volunteer; eradication; participatory research

Introduction

Recently there has been increased focus of tree health in policy because of significant and high profile tree pests and pathogens and the impact of future threats on the aesthetic, recreational, ecosystem service and economic importance of trees and woodlands (Boyd et al. 2013). The early detection of tree health pests and disease is an important component of biosecurity (Aukema et al. 2011). The widespread appeal of trees, the need to engage the public about tree health and the search for more "cost effective" solutions to natural resource management (White et al. 2019) has led to citizen science being given importance in tree health and invasive species policy, as exemplified in the UK (House of Commons Environmental Audit Committee 2019; Tree Health and Plant Biosecurity Expert Taskforce 2012).

Citizen science is the intentional involvement of the public in scientific research and monitoring, and has great potential for invasive species, including tree pests and diseases (Groom et al. 2019). Broadly, citizen science ranges from *mass participation* in which records can be made by any individual typically using smartphone apps and websites (Adriaens et al. 2015), through to *structured monitoring* in which volunteers will follow protocols (Pocock et al. 2017b). Mass participation can be especially effective for the detection of rare events, at large spatial extents and over long time periods (Pocock et al. 2014), although recording effort will be uneven across space, thus requiring careful analysis to take account of this bias (Bird et al. 2014). Citizen science can also include participation of people in the creation of research questions, design of monitoring programmes and planning action on the basis of results (Haklay 2013). It can complement traditional awareness-raising campaigns by enhancing public awareness and engagement leading to more pro-environmental attitudes and behaviours (Japelj et al. 2019; Klapwijk et al. 2016).

Ethics are the principles defining good conduct and the ways of acting responsibly. Ethics are important in science, and are especially pertinent in participatory forms of science (including citizen science) due to the need to consider issues such as data ownership, power relations and responsibility (Lawrence 2006; Rasmussen and Cooper 2019; Resnik et al. 2015). Ethical dilemmas can occur when what is perceived as "good conduct" differs between stakeholders, due to differences in their motivations, opinion about management impacts, or the value that they place on nature (Heink et al. 2018).

Here we identified ethical dilemmas that are pertinent to citizen science for the early detection of invasive tree pests and diseases. Firstly, we discuss the motivations for citizen science and when motivations between stakeholders might clash. Secondly, we draw on existing knowledge from a range of projects to illustrate how clashing motivations lead to ethical dilemmas. We used evidence from semi-structured interviews conducted for the New Technologies for the Early Detection of tree pests and pathogens (NTED) project in the UK (Marzano et al. 2018; White et al. 2018, 2019). Interviews were conducted with a broad range of actors, including six participants in a citizen science project using pheromone traps to detect longhorn beetles. Interviews (30–90 min) were professionally transcribed and coded using both inductive and deductive coding (Bryman 2012) against themes (including personal experience, motivation, implications of results, perceived efficacy of citizen science) and actor roles (including forest manager, government agency, expert volunteers). In addition we draw on experience from the LIFE ARTEMIS project in Slovenia and the Box Tree Moth Citizen Science Campaign in Canada plus other published work. Finally, we discuss the role of dialogue in mitigating ethical dilemmas in tree health citizen science.

Clashing motivations leads to ethical dilemmas

Understanding the motivations of those involved in citizen science, both as participants and as organisers is important. The motivations of organisers tend to be primarily functional, e.g. collection of biodiversity data to contribute evidence to policy, inform land management, and raise awareness (Geoghegan et al. 2016). Recent interviews with science, management and policy practitioners showed that citizen science was valuable for tree health monitoring and policy (Gupta and Slawson 2019). One science interviewee said: "The UK maybe has two hundred plant tree health inspectors… can you increase that number to two thousand by bringing in… a volunteer army of trained, but amateurs, to help you with that surveillance?". This leads to recommendations, such as made recently by the UK parliament, to develop "a 'biosecurity citizens' army' of 1.3 million volunteers to identify and respond to outbreaks of invasive species" (House of Commons Environmental Audit Committee 2019).

The motivations of volunteers in citizen science may differ substantially from those of organisers. Volunteer motivations are often framed as intrinsic (offering internal rewards stemming directly from involvement), or extrinsic (offering external rewards) (Finkelstien 2009; see also Rotman et al. 2012). In a survey of environmental citizen science volunteers, West et al. (2016) found that intrinsic motivations were most common among volunteers, e.g. wanting to benefit science or protect trees, enjoying the process of participating, or appreciating learning. The most frequently mentioned extrinsic motivation was that "someone else wanted me to take part". One of the NTED interviewees was typical: "now in retirement I've got time to sort of get involved, and contribute a bit more, both sort of contribute to knowledge and also because I love being out in the countryside"; while another emphasised the importance of friendship and learning: "I suddenly found this community of people… a couple of them have really nurtured me… you start picking things up and learning for yourself".

In many types of environmental citizen science the motivations of organisers and participants align, e.g. wildlife monitoring is often conducted by volunteers who are interested in nature, and the data are used by organisations to support nature conservation. This is not necessarily the case for tree health biosecurity citizen science because the activity has the outcome to detect or study problematic species, for social and ecological benefit. This means that participants align with a set of values that privilege some species over others and show altruism for these, as expressed in management for eradication. However the concepts of species' status, such as native, alien or pest, are contested, likely to shift over time (Head 2017) and likely to vary between stakeholders, e.g. individuals, government and business. For example, "protected zone" status, defined under the European Union Regulation (EU) 2016/2031, means that a country must ensure that specific harmful organisms remain absent by following EU measures and carrying out surveys. Protected zone status provides economic benefits to businesses through trade but maintaining this status requires authorities to undertake monitoring and to eradicate outbreaks, even if this comes at societal cost. Stakeholders will vary in their opinion of the balance between costs and benefits of maintaining protected zone status, partly due to their different expectations and the spatial scale at which costs and benefits are experienced. This can create clashes in motivations, thus leading to dilemmas about the ethics, i.e. what is good and responsible conduct for all those involved? Below we consider case studies where ethical dilemmas may occur in tree health citizen science projects.

Case studies of potential ethical dilemmas in citizen science for the early detection of tree pests and diseases

The consequences of detection may be locally severe

The early detection of a "problematic" species, such as some tree pests or diseases, is important because it allows a rapid response that can limit or eliminate any negative impacts. However management can be locally severe because it will often impact upon the trees themselves (Vicent and Blasco 2017), their associated biodiversity, and the benefits that people gain from the trees, even if the health of the trees themselves is not imminently at risk. This can create a clash of motivations between individuals and authorities (Marzano et al. 2015). This is particularly pertinent for citizen science if the person making a report is unaware of the potential consequences of management, unwilling to accept these consequences, or disagrees about the value of management.

Control efforts for pests such as Asian longhorn beetle (in the UK: ALB; *Anoplophora glabripennis* (Motschulsky, 1853)) and emerald ash borer (*Agrilus planipennis* Fairmaire, 1888) (in the USA and Canada) can lead to large-scale tree loss. This is likely to cause a serious negative impact in communities and underlines the importance of community engagement, being sensitive to the range of feelings people will have about this impact (Mackenzie and Larson 2010; Porth et al. 2015). At the time of the NTED project, positive identification of Asian longhorn beetle in the citizen science traps would have resulted in many trees in the vicinity being felled. One NTED individual stated that "I was dreading that happening [finding ALB]…. Absolutely dreading that!" Many of the interviewees in the NTED project understood the benefits of early detection and eradication: "you have a chance of keeping them [tree pests or diseases] at bay or eradicating them…". Some individuals expressed altruism based on their understanding that suffering local impacts is worthwhile for the greater good (see also Andow et al. 2016); one individual was worried about ALB being found in an ecologically and culturally important woodland, but would report an ALB finding since "as sad as it would be to see, it's for the greater good that it wouldn't spread". In the NTED study, we ensured that participants and landowners were fully aware of the consequences of ALB detection. One interviewee said that "what was really interesting is that I was really worried that I might find an Asian longhorn and nobody else seemed particularly bothered by it", nevertheless he talked of the responsibility he felt in relation to the consequences of a detection. However, since more people are being encouraged to become engaged with tree health citizen science, there is greater likelihood that the people contributing records are not aware of the consequences of their records, and may be shocked by the severity of local management in response to a confirmed citizen science report. The local communities can be disproportionately affected because negative impacts are experienced at a local scale, while the benefits of extirpation (lack of species' establishment) are gained at the larger national scale. This poses problems in the perception of justice, and citizen science organisers need to engage with public stakeholders to understand the upset that action may cause (Lecuyer et al. 2018).

One NTED interviewee took this further in stating that the risks are also experienced locally. He indicated that eradication may not be effective: "it's one of these things if you say well, have they got a good chance of actually controlling or eliminating the beetle, or is it just something which they feel they should do, but they've actually got no chance of getting rid of it?" He went on to express the fear that some of the actions were not proportionate. Also, regulations will change as a species becomes established, so that after some time it is "no longer a notifiable pest" and no action is required. When this happens, sites with early detections will have disproportionately suffered the cost of management. Indeed, one person withdrew from the NTED research study over concerns such as these.

The impact of the changing status of a species is exemplified in the Observatree project. This has trained over two hundred people in the UK to support the early detection of priority tree pests and diseases (Observatree 2019). In 2015, Observatree volunteers were alerted to the first UK occurrence of Oriental chestnut gall wasp (*Dryocosmus kuriphilus* Yasumatsu, 1951) and asked to check local sweet chestnut (*Castanea sativa* Mill.) trees. The story of one volunteer is reported in a promotional video (Youtube: https://www.youtube.com/watch?v=xKaw3LkX9g8). She found the species, its second sighting in the UK, and immediately reported this to the Forestry Commission in England, "so that they can pick it up and act on it… The next thing I knew was… I saw the remains of the trees being swept up and taken away in a van. So, very quickly what I said and what I found had had really quite a big impact." Government agency staff acted in accordance with best practice based on the information available to them. They also carried out wider surveillance but there were no further detections (Morath et al. 2015). Unfortunately, the story did not stop there: in 2016 *Dryocosmus kuriphilus* was found to be relatively widespread in London and no further management of sweet chestnut trees was undertaken within the infestation zone (Forest Research 2019). So, in 2015 felling the sweet chestnut trees in response to the report was a justifiable action, but by 2016 felling was deemed unnecessary. This exemplifies the ethical dilemma of rapidly responding to citizen science reports, while recognising that early detection information from citizen science will always be incomplete.

Knowledge of the management impacts could lead to refusal to report

Responsibility and trust are issues both for citizen science participants and for those organising or responding to citizen science contributions. Participants need to ensure due diligence and care in reporting, whilst organisers need to respond appropriately and to robustly address the impacts of detection. Good communication is required because people who could be effective early detectors may be dissuaded from reporting due to their concerns about the impacts of eradication measures, both to methods used (e.g. insecticides or culling mammals) or their outcome (felling trees or restricting recreational access). For instance, one UK outbreak of oak processionary moth (*Thaumetopoea processionea* Linnaeus, 1758) was from a small town bordered by native woodland 60 km west of London. The introduction site was located and destroyed, but monitoring continued to detect oak processionary moth individuals and the government agency decided to use an insecticide spray in nearby woodland nature reserves – a highly controversial decision (Butterfly Conservation 2013). The network of volunteer moth recorders is potentially valuable in early detection of oak processionary moth (Pocock et al. 2017a), but moth recorders have alleged, in conversations with the authors, that fellow volunteer recorders would (or have) withheld records of oak processionary moth due to the controversy of its management. This reveals the clash of values: government agencies undertake eradication for the benefit of tree health (the caterpillars possibly can cause defoliation), human health (the caterpillar hairs can cause skin and lung irritation) and economics (Protected Zone status under EU regulations); in contrast some local naturalists may disagree that the perceived costs to local woodland biodiversity outweigh the perceived national benefits, yet they may be holding records of value to government agencies.

Citizen science is also valuable in situations where invasive species are becoming established and management of populations is required to reduce impacts of the invasive species. For example, citizen science is considered vital in involving people in the detection of invasive grey squirrels (*Sciurus carolinensis* Gmelin, 1788), especially in forests occupied by native red squirrels (*Sciurus vulgaris* Linnaeus, 1758) (Shuttleworth et al. 2020). Yet established invasive species can offer economic and societal well-being benefits (e.g. fuel wood or hunting opportunities) that would be lost as a result of management of populations (Hanley and Roberts 2019; Shackleton et al. 2019a). While the culling of grey squirrels is argued as important for the greater good (because they cause red squirrel extirpation and damage commercial timber crops), in many areas grey squirrel may be the only squirrel species people see and their removal may be difficult for the public to accept (Crowley et al. 2018; Dunn et al. 2018; Japelj et al. 2019).

Increasing public awareness through the provision of information can support the acceptance of management, but this varies by species and context (Novoa et al. 2017). In the examples above increased public awareness may be sufficient to persuade non-reporters to change their mind, although dialogue would also be valuable (see also Novoa et al. 2016). Of course, even if some people do withhold records, there may still be sufficient citizen science records from other people to support adequate monitoring of an invasive species.

There is little cost to participants in reporting, but high costs may be borne by stakeholders

The costs borne by different stakeholders in projects will vary, e.g. there may be little cost to making a report, but a high cost of responding to the report. This can become an ethical issue because it raises the question of "acting responsibly", both for project organisers and participants. The confirmation of ash dieback (*Hymenoscyphus fraxineus* (T. Kowalski) Baral, Queloz & Hosoya) in the UK in 2012 created a challenge for citizen science. There was public concern about the disease, which was amplified through the media (Urquhart et al. 2018). A smartphone app for reporting suspected ash dieback cases was developed, downloaded 12,000 times in two months and 1,000 geo-located photos were received (University of East Anglia 2014). Only 70 reports were classed as likely to be correct so there was little gain in information compared to the cost to the government agency in checking all the records. However, since then the Observatree project in the UK was developed to build an expert citizen science network to verify records of tree pests and diseases and reduce the burden on the agency (https://www.observatree.org.uk/).

Spurious records could also be costly. In the LIFE ARTEMIS project in Slovenia, a photographic record of Asian longhorn beetle *A. glabripennis* was submitted via the information system "Invazivke" (https://www.invazivke.si/). The information came from a student who participated during one of the

Invasive Species survey weeks organised for schools. Further investigation revealed that the image was from the internet and submitted as part of a school assignment and the student did not understand the potential cost to the authorities in assessing and acting upon this record.

Another type of cost is the cost of management to the landowner after making a report (Andow et al. 2016). For example, reports of oak processionary moth in "control zones" in the UK can carry a cost to the government agency (verifying the record and issuing a Statutory Plant Health Notice) and to the landowner (paying for a contractor to undertake the legally-required management). But what about when other people make a report from someone else's land of an invasive or protected species, which leads to costs or restrictions on landowners? These dilemmas are important but thus far there is no clear guidance for citizen science practitioners.

Participants may expect solutions to tree health concerns even when these are not possible

It may be appealing for citizen science organisers to appeal to extrinsic motivators, such as fear and threat, because these support recruitment to projects and garner media attention (Blackmore et al. 2013). However, the use of language must be carefully moderated to ensure the citizen science is not misconstrued and trust is maintained. For example, the Conker Tree Science project enabled people to report on the spread of the horse-chestnut leaf-miner *Cameraria ohridella* Deschka & Dimic, 1986 in the UK (Pocock and Evans 2014). In a press release issued in 2011, the wording was emotive: "Conker fans from across the country are being called upon to help save the beloved trees from a perilous moth which is threatening their beauty." (http://www.bris.ac.uk/news/2011/7744.html). Correspondence with some participants showed that they expected that their records would lead to direct action to "save" individual trees, yet previous work suggested that this was not possible (Gilbert et al. 2005). Therefore, to reduce potential misunderstanding, the wording on the website was updated: "...we have been inviting people to take part in real science to discover more about conker tree health by taking part in our missions." (http://www.conkertreescience.org.uk/home, accessed 9 November 2019).

Early detection is (by definition) a rare event

One of the paradoxes of citizen science for early detection is that very few people, or none at all, will record the species they are being asked to look for. The emerald ash borer (*Agrilus planipennis*) is a priority species that is not (yet) known to be present in the European Union, but it is likely to arrive (Gallardo et al. 2016). There is great benefit to authorities in receiving records of the species in Europe, because of the potential to undertake eradication and avoid the potentially vast social, economic and biodiversity cost of the species' establishment (Herms and McCullough 2014), but the chance of any individual person finding the species is vanishingly small. Some people who were running traps in the NTED project for Asian longhorn beetle were philosophical, saying "you have to accept in nature that you don't always find things… a negative result is what it is, isn't it?" They were relieved not to find the invasive species, but found it difficult to maintain momentum to check traps. Another interviewee said that "it got less and less exciting… you think your motivation is helping science… but actually the longer time went on, and the less there was in the trap… the less motivation there was there to kind of leap out of bed in the morning and go 'aah, I must check the trap on the way into work'." However, for the occasion when a target species is detected, the emphasis needs to be on developing efficient data flows (Pocock et al. 2017a), while seeking to minimise the costs associated with dealing with incorrect reports.

Solutions to address ethical issues in citizen science for early detection of tree pests and diseases

For every project, it is critical to consider the data requirements, interests and concerns of all participants through the project design and implementation (Ryan et al. 2018). Emphasis should be placed on identifying potential clashes in motivations and addressing potential ethical dilemmas through engagement and dialogue.

Recruitment of citizen scientists from target interest groups can be beneficial to ensure that the expectations of organisers and participants align. For example, "Master Gardeners" were recruited to support the 2019 Box Tree Moth Citizen Science Campaign in Ontario, Canada (Canadian Food Inspection Agency 2019a; https://twitter.com/InvSp/status/1116064574439133186) to look for *Cryptographis perspectalis* Walker, 1859. They were substantially more active with respect to reports, sample submissions and inquiries than citizen participants recruited more passively through social media and email. The shared interest in protecting the host plant helped support a control program in industry and provided data to help inform regulatory decisions.

Developing greater connection among stakeholders creates a shared responsibility towards biosecurity. In Canada, this has been addressed by establishing pest-specific technical advisory committees to support ongoing communication and action to mitigate risks associated with priority plant pests. Utilising such committees to design and implement citizen-based monitoring programs has fostered a greater connection among citizens, stakeholders, industry and all levels of government. The shared responsibility can be formalised through the development of collaborative preparedness and response plans. These enable a thorough understanding of pest problems, management options, risks and consequences as well as associated economic and social costs that may be incurred at various levels.

It can be particularly difficult to engage with potential participants in mass participation citizen science, because their identity is not known in advance. However, the Oak Wilt Response Framework for Canada demonstrates how multiple levels of government and partnering organizations can work collaboratively, including representation from publics, to define comprehensive measures that may be implemented in the event of a new pest incursion (Canadian Food Inspection Agency 2019b). This demonstrates the role of citizen science by motivated participants being involved in monitoring and stakeholder engagement (Aceves-Bueno et al. 2015).

The management of alien species is often surrounded by conflicts of interest (Shackleton et al. 2019b). Empowering people through citizen science co-design can help to reduce conflicts of interest that otherwise may emerge in conventional policy development (Kythreotis et al. 2019). We have illustrated ethical dilemmas in citizen science with examples of tree health from a few countries (UK, Slovenia and Canada), but effective engagement and dialogue will ensure that policy development and management solutions are sensitive to the differences in culture and motivation of people within and between countries (Loos et al. 2015; Pocock et al. 2019).

Conclusions

Citizen science is a valuable tool for engagement and data collection, especially in issues of public concern such as tree health, but ethical dilemmas about the use of citizen science can arise due to clashes between the motivations of different stakeholders and participants. This creates potential for unintended consequences and unexpected impacts of management (e.g. the local destruction of trees). Addressing these ethical dilemmas in using citizen science is vital to maintain society's continuing support for, and trust in, citizen science. We have provided an overview of some ethical issues pertinent to tree health citizen science based on our experience, but we recommend that ethical issues are considered thoroughly and addressed directly in the development of citizen science projects on tree health and invasive species more generally in the future.

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