



Identifying synergies between citizen science and Long-Term Socio-Ecological Research (LTSER) in the Cairngorms National Park

Dewhurst-Richman, N., Dick, Jan, Andrews, C., Haklay, M



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Author Dewhurst-Richman, N., Andrews, C., Dick, Jan Haklay, M.

Approved by M. Haklay

Signed

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Executive Summary

Citizen science is a powerful tool for monitoring natural resource use: active involvement of citizens in monitoring activities can yield a powerful additional data source and improve dialogue between citizens and researchers and therefore trust and support in monitoring activities and outcomes. Recognising the value of citizen science to environmental research, the purpose of this project was to build the knowledge base necessary to develop a citizen science program to support long-term environmental monitoring. We used the Cairngorms Long-Term Socio-Ecological Research (LTSER) platform as a testbed for examining the potential synergies between citizen science and upland change research. We carried out two online workshops with members of the local citizen science and upland change research community in May and June 2020 in which we aimed to: 1) better understand the critical knowledge gaps in upland change research in the Cairngorms and co-create citizen science activities to address these knowledge gaps, and 2) document the design challenges for a citizen science activity within the Cairngorms.

Workshop participants identified a number of variables that would be of interest for monitoring upland change using citizen science, but two of particular note were the need for monitoring habitat/ land-use change, and people’s attitudes towards the changing landscape and land management practices, as well as health and wellbeing in the changing landscapes. While there were a great number of design considerations that are needed in order to capture robust data to inform decision-making, it was recognised that a citizen science approach for addressing these knowledge gaps offers a great opportunity alongside the detailed long-term monitoring conducted within the LTSER platform to capture temporally and spatially broad data that might be otherwise unfeasible, while simultaneously raising local awareness of the drivers of change, and creating local support for the research agenda within the park.

Participants also identified that gamekeepers and land managers have had relatively little involvement in local citizen science and would be target groups for involving in new activities. Their involvement would be important not only for accessing new knowledge on

habitat/ land-use change but to provide a forum in which they can have dialogue with researchers and decision-makers in helping to shape the research agenda within the park.

Workshop participants were also keen to see an effort to partner with local projects and initiatives to maximise re-use of existing methodologies, where applicable, and data sharing e.g. using the National Biodiversity Network.

In order to progress the outcomes of the workshops, a 'road-map' was created for the next stage of the project, this would involve: 1) a detailed stakeholder mapping exercise to identify the broader community, their level of interest in the research focus of upland change, and their expertise/ contribution to the project, 2) a review of the literature to identify multi-disciplinary opportunities for overcoming some of the methodological/ survey design knowledge gaps as presented in the workshop, 3) using existing projects, to trial a range of interventions that test these approaches for enhancing the sustainability of citizen science within the Cairngorms.

Background

Over the past century, human-dominated land uses have spread rapidly across landscapes around the world. Approximately 38.2% of land globally is devoted to agriculture (FAO, 2007). Other land is devoted to urban development, roads, and timber lands. It is estimated that over 60% of the world's temperate forests and grasslands ecosystems have been converted to human-dominated uses (MEA, 2005). In response to this rapid growth, all developed regions of the UK are active in monitoring and planning (e.g. [State of Nature Scotland](#)), and creating strategies for land use and forestry (e.g. [Getting The Best From Our Land: A Land Use Strategy For Scotland 2016 - 2021 and Scotland's Forestry Strategy 2019–2029](#); the [Department for Environment, Food and Rural Affairs \(DEFRA\) 25-year environment plan](#)). The latter sets out for England the government's goals and measures for the sustainable use of natural resources. Embedded in its environment plan, DEFRA seeks to employ an 'environmental net gain' principle for all development, along with other quantified targets such as a "doubling in resource productivity by 2050". As such, effective land management interventions seeking to manage natural resources has never been more imperative.

Central to the design of sustainable, effective management interventions are public trust and support, and robust monitoring data, covering broad temporal scales. However, given the sheer scale of land management and a lack of resources available for monitoring, relatively inexpensive monitoring tools are key. While citizen science - projects that involve non-experts in the collection, analysis and interpretation of data for scientific research - has been around for over 100 years, only in the last decade has it gained broader recognition as a powerful tool to support environmental monitoring that also serves to address many of the socio-ecological challenges now faced. Citizen science can improve the scientific literacy of the participant resulting in more environmentally responsible behaviours and improved support for measures that seek to reduce the use of natural resources. Similarly, citizen science can increase the level of engagement between land managers, scientists and citizens, empowering citizens to find creative solutions to common problems. However, the science of citizen science is relatively new, and amalgamating it is made complex by the variety of disciplines leading on this research. As such, no formal framework exists for the integration of citizen science, based on the most up-to-date multidisciplinary research, into broad-scale environmental monitoring programmes.

The International Long-Term Ecological Research (ILTER) network is a collection of over 800 sites across the globe that are centres of long-term research (in some cases over 40 years) that examine environmental change over time. The initial research focus was ecology

but has since broadened to encompass socio-ecological research leading to the creation of Long-Term Socio-Ecological Research (LTSER) platforms, sites where research is focused on the temporal trend in the way society and the environment interact. Since the 1980s, a network of hundreds of ecological study sites has emerged across the globe. These sites are part of a network of long-term ecosystem (or ecological) research sites (LTER for short). Since the early 2000s, some of these sites became part of the larger-scale Long-Term Socio-Ecological Research (LTSER) platforms, which are made up of multiple LTER sites and undertake research at a scale that is relevant to many of the major social and environmental interactions of interest. The purpose of the network is to understand environmental change over time, with the long-term and place-based research allowing for site-based study/exploration and monitoring. The science that is emerging is contributing to international assessments, such as the International Panel on Biodiversity and Ecosystem Services (IPBES), as well as regional, national and international policies.

Citizen science represents a potentially valuable tool for meeting LTER and LTSER research objectives, but at the same time LTSER platforms serve as a great testbed for developing a framework to support the integration of citizen science into a broad-scale monitoring hub.

Project objectives

Considering the UK is one of the leading countries in the development and utilisation of citizen science, and in particular the integration of citizen science into strategic plans this project aims to build the knowledge base necessary to develop a citizen science program including the following components: tool for data collection, community engagement, awareness-raising, and environmental stewardship. The project focuses on the Cairngorms LTSER platform as a testbed for examining the potential links between citizen science and ongoing LTSER research. This project is the pilot-phase of what is planned as a three-year project that will further develop the framework. This pilot phase study will use a two half-day workshop in Aviemore to explore the opportunities and challenges for citizen science in the Cairngorms National Park (CNP). The workshop will provide participants with:

1. an opportunity to learn about the current citizen science landscape in the Cairngorms National Park;
2. an opportunity to network and meet other members of the environmental monitoring community in the Cairngorms National Park;
3. an opportunity to learn about the types of citizen science used in environmental and ecological research and the key elements to think about when designing a citizen science project (e.g. recruiting volunteers, engagement, technology for data collection, managing data);
4. an opportunity to co-design a citizen science project for monitoring the uplands in the Cairngorms National Park.

Workshop

Workshop outline

This workshop was originally planned to run in a face-to-face format in Aviemore (within the Cairngorms National Park) on the 17th and 18th of March 2020. Given the rapidly escalating covid situation in the UK at the time we cancelled this workshop and changed it to an online

format. The online workshop was run twice, one in May (20th and 21st) and again in June (2nd and 3rd) to improve participation rates and hopefully provide as many people as possible with the opportunity to attend in light of all the added work complications that come with being in isolation.

Each online workshop comprised three 1.5 hour sessions using Microsoft Teams. The May workshop was almost entirely composed of presentations and activities that the participants were given to complete using a live shared document. For the June workshop we followed almost exactly the same format as we used in May but introduced, as suggested by the feedback from the workshop, live discussion sessions in which the participants could speak with the entire group and share further thoughts and comments on the activities.

Session One

11:00 - 11:10 | Presentation: A virtual welcome and an introduction to the project by Jan Dick (Centre for Ecology and Hydrology)

The workshop commenced with a rapid introduction repeating much of the information provided to participants prior to the meeting i.e. explain again the aim of the workshop, our process to achieve our aim (mixture of presentations and interactive sessions utilizing Google documents) and the final outcome to take the pulse of citizen science activities in the Cairngorms National Park and co-develop key design components of a citizen science project for monitoring the uplands with a view to submitting a proposal to a new call launched by UK Research and Innovation (UKRI) "The Citizen Science Collaboration Grant".

The presentation was the same at both workshops although the second workshop had images to explain the use of the living document. A copy of the slides can be found online on slideshare, details are in the appendix.

11:10 - 11:30 | Presentation and Task: How can citizen science benefit your work programme? Citizen science for local stakeholders by Muki Haklay (University College London)

The presentation provided an overview of the types of activities that fall under the umbrella term citizen science - from activities that people do at home using the computers and the internet (volunteer computing or volunteer thinking) to ecological monitoring of landscape change in an opportunistic way. The presentation also pointed out the multiple goals of citizen science projects - from engaging people in environmental issues, to providing opportunities to disadvantaged groups in society. The level of participation across projects was also highlighted, indicating that as requirements and knowledge increase, the number of people that are currently engaged in citizen science project decreases. A detailed explanation of the presentation along with a link to the slides can be found in the appendix.

Task One - What is your experience of citizen science, either as a data user or a participant?

In this first task, workshop participants were asked to write down their experience - if any - of citizen science.

Responses show that just over 10% of the participants had no prior experience of citizen science, either as a citizen or scientist. Of the activity types that participants

had been involved in, ecological activities were by far the most popular activity type, reflecting the historic focus and number of initiatives focused on ecological aspects. Relatively few people reported participation in activities collecting medical, wellbeing or meteorological data or involvement in participatory mapping exercises (Figure 1).

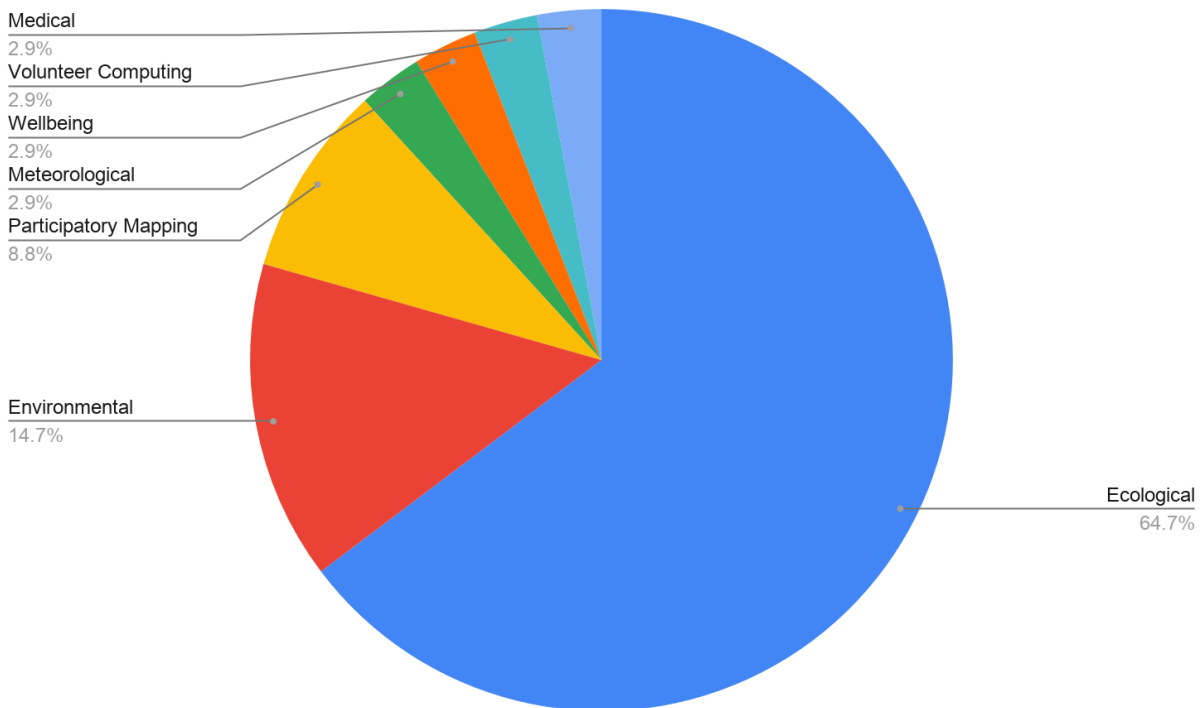


Figure 1: Task one responses from the workshop participants regarding the citizen science activity types that they have experience of participating in.

11:30 - 11:50 | Presentation and task: Citizen science in Scotland and in the Cairngorms National Park by Nadia Dewhurst-Richman (University College London)

This presentation gives an overview of the benefits of citizen science using examples of existing projects in Scotland, along with an introduction to Scotland’s Environment Web. A detailed explanation of the presentation along with a link to the slides can be found in the appendix.

Task Two - A review of the past and present citizen science activities in the Cairngorms National Park

See the data here: <https://docs.google.com/spreadsheets/d/1imG0ELjmk0QopHZWB5jlu-EnOi4vRPSafozhambE10/edit#gid=0>

Background

To better understand the citizen science landscape within the Cairngorms National Park, who’s involved, what activities have historically taken place or are currently underway we compiled a list in collaboration with the Lucy Ford from the Cairngorms National Park Authority, using web-based searches of past and present citizen science activities in the Cairngorms National Park. In an effort to fill any missing gaps we asked participants to add any other activities that they knew of to the list.

Results

We do not anticipate that this is an exhaustive list of all activities in the park but we anticipate that the exercise has captured the majority of activities. Of the projects captured before and during the workshop **the vast majority of activities are nature surveys, and contributory** (i.e. the project is designed by a scientist and the participants primarily collect or analyse data).

11:50 - 12:20 | Task – Ideas for citizen science activities to fit within current and future work programmes by Muki Haklay

Task Three - Designing a citizen science project.

Background

While the focus of the workshop was to explore how citizen science could support monitoring upland vegetation change, we wanted to provide participants with the opportunity to present and discuss ideas for activities that they'd like to see in the park and/ or would fit within their existing/ future work programme.

Results

The workshop participants proposed a range of activity types (Figure 2) and for monitoring a range of different variables (Figure 3). While there was significant interest in developing activities involving the use of **nature surveys particularly of vegetation (trees and alpine plants), a lot of the ideas involved surveys of people's perceptions, feelings and/ or attitudes towards landscape/ habitat management practises**, and the use of **photo brackets for repeat capturing large-scale landscape/ habitat change**.

Thematic analysis of the responses from the question in which participants were asked "Why do you think this activity would be suitable for your current/ future work programme or for the Cairngorms National Park?" along with the responses from the voting and discussion session, a number of themes emerged (Figure 4):

1. **Complexity:** Participants were largely in favour of simple activities that require little training of and time commitment from the volunteers.
2. **Attitude:** *"definitely think we should be collecting more data on how people feel about different types of land management options"*. Participants showed strong support (as demonstrated by the frequency of mentions and the voting session) for surveys of people's attitudes on landscape management practices. Further discussions with the Cairngorms National Park Authority (CNPA), Cairngorms Connect and the East Cairngorms Moorland Partnership confirmed that this is a major management/policy knowledge gap.
3. **Methods:** Workshop participants frequently mentioned the need for more methodological considerations of the project ideas, perhaps inevitable given the short duration of the workshop and the little time available for discussions to clarify methodological questions. But several mentions were made of the need for consideration of *"how much access and [data] coverage there is across the park if we want people to add information while out and about"*, and the need to consider the standardising of data collection to enable meaningful interpretation.
4. **Impact:** this was a major theme in the context of ensuring that projects were policy/ management relevant. There was also a lot of support for the idea of a project monitoring snow coverage as it was felt that there would be a lot of local interest in

such a project and therefore receive a lot of local support. In addition there was a lot of support for projects where the data could be easily re-used for other research purposes. Data-sharing platforms/ networks such as iRecords, local records centres and the National Biodiversity Network were all identified as possible mechanisms to facilitate data-sharing.

5. **Participants:** this theme was about exploring discussions/ mentions of the citizen science project participants. Participants were most frequently mentioned in the context of not just appealing to the “usual audience” of volunteers and making sure that project organisers know who the audience is for the data.
6. **Resources:** the theme of resources was most often referred to in the context of where possible trying to use existing methodologies and/ or linking up with existing projects to avoid wasted resources.
7. **Awareness-raising:** while it didn't receive many mentions, this theme was mentioned in the context of a need to raise awareness of park management/ research activities.

The benefits (empowerment, learning opportunities, health, ownership, community-forum) to the project participants featured less heavily in the discussions/ mentions of this section of the workshop possibly due to the nature of the questioning.

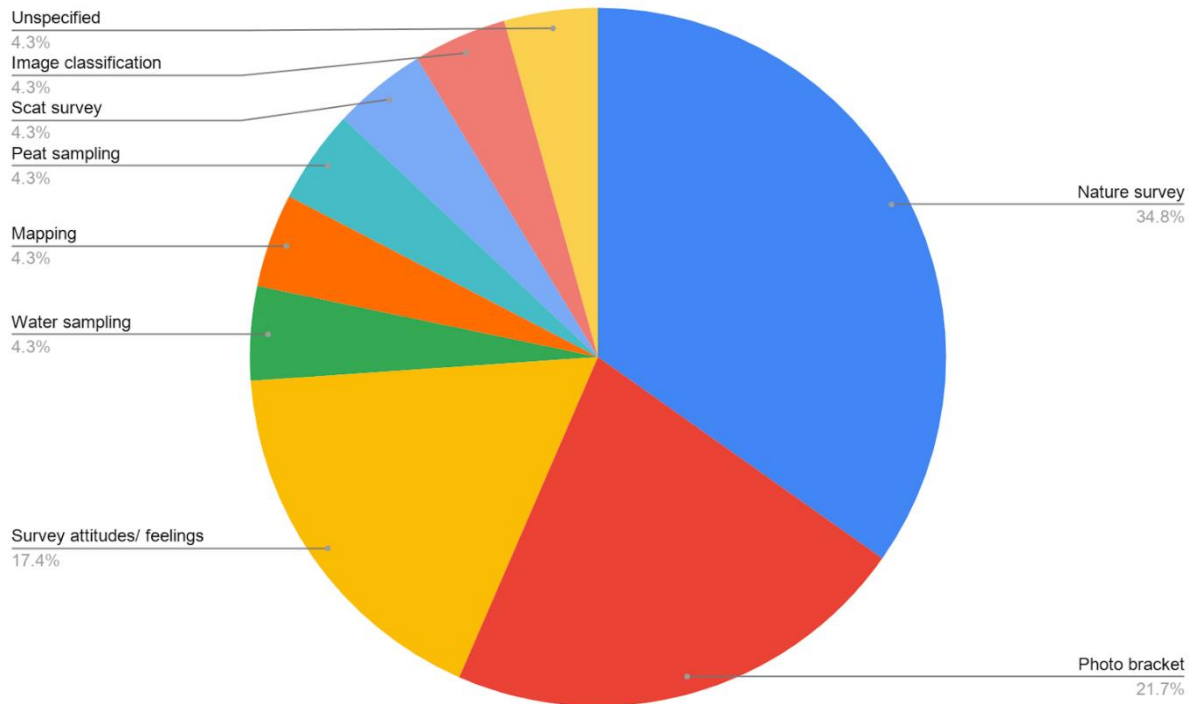


Figure 2: Ideas for citizen science activities proposed by the workshop participants.

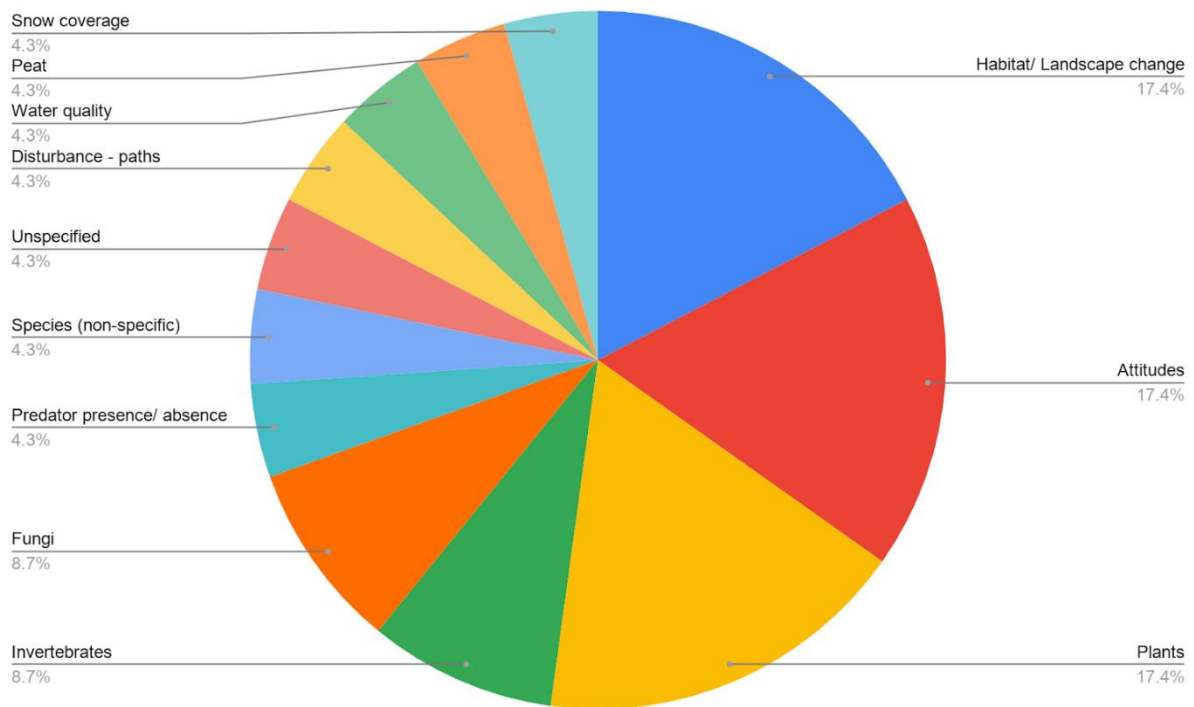


Figure 3: Ideas for the purpose of the citizen science activities proposed by workshop participants.



Figure 4: Thematic analysis of the responses from the question in which participants were asked “Why do you think this activity would be suitable for your current/ future work programme or for the Cairngorms National Park?” along with the responses from the voting and discussion.

Session Two

14:00 - 15:30 | *Presentation and Task: How do we want to monitor upland regeneration? Current research & knowledge gaps by Chris Andrews (CEH) followed by an activity on the design considerations for a citizen science activity to support monitoring upland change by Nadia Dewhurst-Richman*

This presentation was designed to get the group thinking about why and what we might want to monitor in the Cairngorm uplands. It provided background on how we define uplands, how they are managed, how they provide societal benefits, and how they might be changing. Finally, it focused on providing a case study on monitoring upland regeneration at the ECN/LTER Cairngorm monitoring site in the Allt a’Mharcaidh, and how we might frame a new citizen science monitoring programme around some scientific themes. A detailed explanation of the presentation along with a link to the slides can be found in the appendix.

Task Four - Design considerations for a citizen science project to support monitoring of upland change

Background

In this activity, workshop participants were asked to come up with an idea for a citizen science activity that would support monitoring of upland change. For each activity idea they came up with, they were asked to think about the challenges, barriers, opportunities and the benefits associated with such a project as well as the resources and expertise that were available and that were needed.

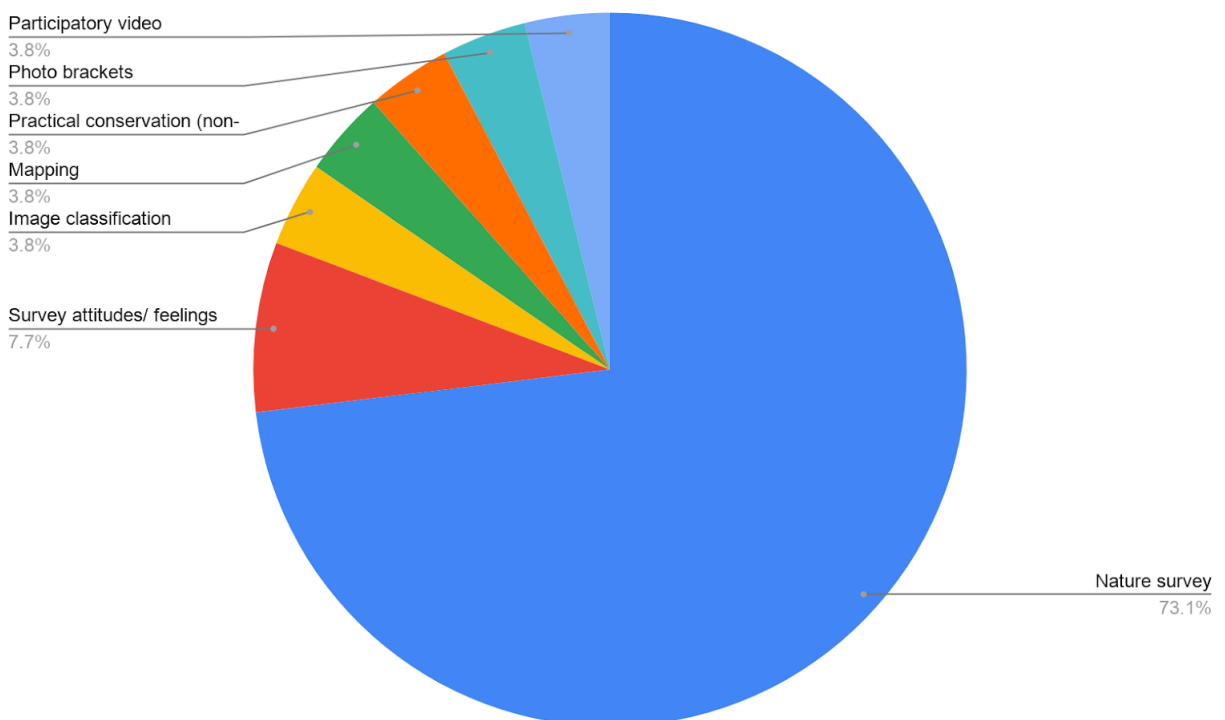


Figure 5: A summary of the ideas for activity types proposed by workshop participants as part of task four.

Results

Nature surveys (largely surveys of tree regeneration, tree and vegetation diversity) were the most commonly designed activity type (Figure 5). For most, it was not specified how data would be recorded but where mentioned apps were the most commonly mentioned method. Following nature surveys, **surveys of people's feelings in different managed landscapes and attitudes towards management practices** received a number of suggestions.

Workshop participants identified many of the same design and implementation challenges, barriers, opportunities and benefits as presented in task three. While many of the points were specific to an activity idea, there were **a number of cross-cutting key points** that emerged:

- Obtaining **adequate spatial coverage** of all the necessary survey sites **to obtain representative data** might be a problem. Consideration needs to be given on how to survey the difficult to access and 'less-interesting' sites.
- **Feedback to the volunteers** is critical both in terms of recognising their contribution and also keeping them motivated to contribute to the project again. For projects that plan to monitor long-term change this might present a new challenge in terms of what you want to feed back to the volunteer.
- **How to reach out beyond the usual audience.** How do we reach the groups of people who do not usually participate in citizen science?
- There were lots of concerns and comments regarding the level of expertise (e.g. plant identification skills) that would be required by volunteers in order to participate in particular activities. These may pose a barrier to entry for some but as someone commented there might be **opportunities to create several levels and different types of engagement within a single project.**
- There are numerous **Health & Safety considerations** (e.g. remote working, challenging weather conditions) that need to be considered when working with volunteers in the Cairngorms.
- There is **considerable local expertise** on the various elements of establishing and implementing citizen science within the park. Where possible these should be utilised to reduce wasted resources, and in order to make best use of local knowledge of what works and what doesn't.
- Increasing engagement with citizen science in the park would be a useful tool for **building awareness of local environmental management issues.** One example was to create greater collaboration between local schools and citizen science projects.
- **Sustainability and longevity of projects.** How do we ensure valued projects live on beyond the end of their funding cycle? How do we fund projects with long-term monitoring objectives that span beyond the length of most funding cycles? Can working in a LTSER platform be beneficial?

Session Three

In this last session we asked participants to develop some of the broader themes that we'd covered earlier in the workshop.

11:00 – 11:25 | A task in which we explore the key design elements of a citizen science activity on upland vegetation regeneration for the Cairngorms National Park | Topic One: Data quality, data management (Jan Dick and Chris Andrews)

Task Five - Data quality and data management design considerations for a citizen science project to support monitoring of upland change.

Background

For the first task in this session, participants further developed ideas on methods for data capture, data quality, data sharing protocols and feedback to volunteers.

Results

The following is a summary of the feedback from participants from workshop one and two.

Methods for data capture

- Digital methods: there was overwhelming support for the use of digital methods (largely apps) for data capture. However, it was frequently noted that given the likelihood of mobile phone signal issues within the park these would need to have an offline facility preferably with automatic download when signal or wifi available). It was also frequently mentioned that where possible designers of data capture systems should try to use reuse or repurpose existing apps/ data capture systems, both to save resources and as a means to share knowledge and improve upon the design of data capture systems.
- Analogue methods: while digital methods were the preferred option for data capture it was also noted that these might pose a barrier to entry for some user groups and so where possible analogue methods (such as the well-used data recording sheets developed by OPAL) should also be considered.

Data quality assurance/ control

- Suggested quality assurance/ control procedures were specific to a method e.g. adequate training for volunteers undertaking more time-intensive fieldwork; use of AI for validation of app-based data collection. However, it was regularly noted that there are a range of methods already available for controlling data quality and where possible these should be used. Furthermore, one of the advantages of using existing apps/ data capture systems is that many of these systems already have quality control procedures in place.
- Given the existing concerns across the wider scientific community around data quality, efforts should be made to advertise/ communicate the data quality procedures in place.

Methods for data sharing

- It was frequently commented that where possible, data should feed into the National Biodiversity Network and the Habitat Map of Scotland. Data could also be made

available on Scotland's Environment Web platform as this aims to become a one-stop-shop for citizen science in Scotland.

- *“Balance the value of sharing data versus sharing information from the data. Often people care less about individual data points – also individual data points can be misinterpreted (e.g. lack of a record is not information about absence).”*

Giving data back to the recorders

- The feedback from workshop participants highlights the importance of this topic not only for thanking recorders for their contribution but to keep them engaged. Appropriate data feedback mechanisms will require that you know your audience and therefore what they want to know about the project and the data use (e.g. how their data has been used, how well they have performed compared to others), how they want to know it (e.g. newsletters, face-to-face annual forums), and how regularly they want to know it (e.g. instantly, every two weeks, once a year).

Getting feedback from the recorders

- There was a general consensus that face-to-face feedback sessions/ forums were the most effective means for collecting feedback from volunteers, while simultaneously making volunteers feel that their feedback mattered. Where face-to-face forums are not possible then online forums/ chat sessions with project organisers can work as long as feedback is responded to within a timely manner (look at the San Diego Burrowing Owl project on Zooniverse for an example of a chat mechanism with project organisers).

11:25 - 11: 50 | A task in which we explore the key design elements of a citizen science activity on upland vegetation regeneration for the Cairngorms National Park | Topic Two: Volunteer management and recruitment, and motivation (Nadia Dewhurst-Richman)

Task Six - How to think about volunteer motivations for a citizen science project to support monitoring of upland change.

Background

This task was thinking about 1) characterising a typical volunteer for a particular citizen science activity and 2) introducing the workshop participants to a technique that can be used for identifying the driver of a volunteer's motivation for participating in a project. Once you understand the true cause for their participation and the project has been designed accordingly then the project is more likely to appeal to that volunteer and likely to result in a higher retention rate. As was noted by a participant with extensive experience of citizen science projects *“Interestingly some of the projects I know that have looked at motivations & citizen science often ask the first 'why' (e.g. 'contribute to science'), but I agree that digging down to the 'whys' below that is important”.*

1. **Don't try to be something for everyone**, know your audience and give them what they want for long-term loyalty.
2. **Know the root cause of their motivation** so you know how to attract your audience and so you know whether you can deliver what they want: an emotional connection

to a project leads to higher participant value or loyalty. So for projects that are interested in retaining volunteers for a long time it's important to know what emotionally drives them to participate in the first place. In fact a fairly recent paper entitled '*Recruiting Messages Matter: Message Strategies to Attract Citizen Scientists*' showed that messaging that appealed to altruism (e.g. come and help us save the native white-clawed crayfish which has declined by 90% in ten years) was relatively ineffective. There's often something deeper that drives altruism, an emotional driver.

For this task, participants were first talked through a technique for studying participant motivation: The Why Technique. See here for more information on the technique and how to use it: https://link.springer.com/chapter/10.1007/978-981-10-0983-9_32.

Here is an example of how the Why Technique might be applied when trying to find out why someone would participate in a monthly outdoor tree survey:

1. Facilitator - "Why do you want to participate in this tree survey?"
 1. Respondent - "Because I thought it would be fun"
2. Facilitator - "Why did you think it would be fun to participate in this tree survey?"
 1. Respondent - "Because I'd get to meet new people"
3. Facilitator - "Why do you want to meet new people?"
 1. Respondent - "Because I feel a bit lonely and isolated"

The response after question three has now clearly elicited a response that demonstrates the real reason why the respondent wants to participate in a tree survey project. In some cases it may take a couple more rounds of questioning to get this level of response and in other cases you may get the deeper response after only one round. Had it been taken at face-value that the reason people participate in the tree survey project was to engage in something that was fun then project organisers may simply focused on designing an activity that was fun when in fact the activity should be enjoyable but also have a social element to address the feeling of loneliness.

Using the project ideas from session two, participants had to:

A) Create a persona for the most common participant in a project of this type. Think about their characteristics:

- Where do they live?
- How much spare time do they have?
- What's their experience level with technology?

B) For the persona you've created, using the why, why, why technique describe the motivation for participating in that particular citizen science activity.

C) Describe the needs (the type of activity, the type of resources, the amount of face-to-face time) of the participant based on the motivation you've outlined and the associated project requirements.

D) How would you market your project to that type of person e.g. via Twitter, email lists, academic journals, local newspaper, radio, local community noticeboards?

E) Can you think of where there might be an opportunity to reach out to another group/ individual who isn't currently involved in this type of project but where they meet the persona characteristics you've outlined.

Results

This session didn't work as well as planned. This is likely due to the fact participants were expected to implement the Why Technique on their own. While an easy technique to use and implement it is made significantly easier by working through the process a few times first with someone who can guide respondents in the way in which they answer each question. This session would have benefitted from more time in which to work through some examples together first. However, the raw data and responses can be accessed in the appendix.

11:50 – 12:15 | A task in which we explore the key design elements of a citizen science activity on upland vegetation regeneration for the Cairngorms National Park | Topic Three: Funding & coordination e.g. data sharing agreements followed by questions by Muki Haklay

Task Seven

Background

For this task workshop participants were asked to think about some of the key funding and organisational considerations when designing a long-term citizen science project.

Results

The following is a summary of the feedback from participants from workshop one and two.

- **Coordination:** the need for a project coordinator was one of the most frequently mentioned organisational requirements for any project. Discussions during workshop two highlighted that insufficient human infrastructure is often one of the greatest limiting factors when it comes to managing the task load of a citizen science project.
- **Policy-relevant:** the aims of the project need to be strongly linked and responsive to the research priorities set out by the Scottish Government in order to ensure a continued source of long-term public funding.
- **Data repository:** participants identified the need for identifying and using an adequate open-access data repository that adhered to current GDPR regulations.
- **Species/ Habitat Licences:** given the range of protected species and habitats within the Cairngorms, consideration will be needed as to whether licences are needed for working on or within protected species/ habitats respectively.

Conclusions

Citizen science is already well-established within the Cairngorms National Park but short-term research objectives and/ or inadequate resources have often limited these projects to short (typically <5 years) operational timeframes. The outputs from the workshop highlight some of the key design considerations for a citizen science project within the CNP and some of the challenges to be overcome for designing a project with longer-term research objectives.

Which aspects of upland change do workshop participants want to study and why?

Workshop participants identified a number of variables that would be of interest for monitoring upland change using citizen science, but two of particular note were the need for monitoring habitat/ land-use change, and people's attitudes towards the changing landscape and land management practices, as well as health and wellbeing in the changing landscapes. Representatives of Cairngorms Connect, the CNPA and the East Cairngorms Moorland Partnership confirmed that these are major knowledge gaps in upland change science and both policy and management knowledge gaps. While there were a great number of design considerations that are needed in order to capture robust data to inform decision-making, it was recognised that a citizen science approach for addressing these knowledge gaps offers a great opportunity alongside the detailed long-term monitoring conducted within the LTSER platform to capture temporally and spatially broad data that might be otherwise unfeasible, while simultaneously raising local awareness of the drivers of change, and creating local support for the research agenda within the park.

What infrastructure exists for developing and implementing citizen science in the CNP?

As demonstrated by the review of past and present citizen science activities in the park, there is already a wealth of citizen science activities within the park and a number of local and national and international-scale organisations coordinating these activities. The make-up of the organisations involved in coordinating these projects is diverse and includes local NGOs. The vast majority of these activities are focused on species monitoring and are short-term in nature (typically less than 5 years).

What are the key considerations for designing a citizen science project monitoring upland change in the Cairngorms National Park?

Broadening the spatial and temporal coverage

Citizen science offers the benefit of obtaining spatially and temporally broad data, though consideration needs to be given as to how to obtain data that is representative (e.g. how to survey the difficult to access and 'less-interesting' sites). However, discussions highlighted the opportunity to involve gamekeepers/ land managers in monitoring activities - particularly those concerned with monitoring land-use/ habitat change - as they typically work "off the beaten path" and have a substantial untapped knowledge of the key variables of interest.

What are the key considerations for designing a citizen science project monitoring upland change in the Cairngorms National Park?

Broadening the spatial and temporal coverage

Until now gamekeepers and land managers have had relatively little involvement in local citizen science. Their involvement would be important not only for accessing new knowledge on habitat/ land-use change but to provide a forum in which they can have dialogue with researchers and decision-makers in helping to shape the research agenda within the park. New knowledge from previously uninvolved groups may also enable methodological innovation in the way monitoring activities are carried out as has already been seen by involving gamekeepers in the monitoring of hares in the CNP.

Long-term sustainability: buy-in/ local support

Involvement of a wide range of volunteers e.g. gamekeepers, estate owners, farmers, tourists, school children, along with projects designed in collaboration with key stakeholders who are data users will likely create more buy-in for the research aims and therefore more local support. Besides the support gained from working with key stakeholder groups, working closely with organisations/ partnerships such as the Cairngorms National Park Authority, Cairngorms Connect, the East Cairngorms Moorland Partnership, local development trusts and nature groups will enable project coordinators to keep informed of the park research agenda, key knowledge gaps and other organisations working on similar topics. The opportunity to keep well informed of the most current research needs for the park and therefore design/ adapt citizen science activities to address these needs would also create more funding support.

Long-term sustainability: methodological and data re-use

Participants discussed frequently and at length the theme of data re-usability. In addition to working at the local scale with key stakeholders, which might enable project partnering and/ or data-sharing, efforts should be made to survey and identify the plethora of existing methodologies that have been created, many for a citizen science setting, for project and survey design. It was felt more had to be done to improve access to the range of established methodologies and survey design principles that have been created for citizen science activities as much time is wasted in design time and resources where adequate options have already been created. Similarly, partnerships with well-established data-sharing mechanisms such as local records centres and the National Biodiversity Network should be a mainstay of ecological citizen science and would enable wide-scale data-sharing resulting in greater data impact.

Long-term sustainability: human infrastructure

Citizen science activities require considerable coordination and so an efficient project coordinator will be a key determinant of long-term project success. The scale of this task is often under-estimated and so adequate funding to finance the human infrastructure needed for large-scale, long-term projects also needs to be considered. Inadequate human infrastructure will limit the degree to which project coordinators can deliver quality feedback to the volunteers. Inadequate feedback will negatively affect volunteer motivation and therefore retention time.

Next steps

A road-map for developing a long-term programme of citizen science focused on upland change within the Cairngorms National Park was identified:

1. Carry out a detailed stakeholder mapping exercise to identify the broader community, their level of interest in the research focus of upland change, and their expertise/ contribution to the project.
2. Undertake a review of the literature to identify opportunities for overcoming some of the methodological/ survey design knowledge gaps as presented in the workshop.
3. Using existing projects, trial a range of interventions that test these approaches for enhancing the sustainability of citizen science within the park.

Additional Resources

- EU-Cit.Sci - <https://eu-citizen.science> - The platform for sharing knowledge, tools, training, and resources for Citizen Science
- Coreo - <https://www.natural-apptitude.co.uk/project/coreo/> - a tool for building data collection apps.
- Scotland's Environment Web - <https://www.environment.gov.scot/> - The gateway to everything you want to know about Scotland's environment. This website brings together environmental information and data in one place so that is easy to search, discover, analyse and interpret.
- Pocock, M.J.O., Chapman, D.S., Sheppard, L.J. & Roy, H.E. (2014). Choosing and Using Citizen Science: a guide to when and how to use citizen science to monitor biodiversity and the environment. Centre for Ecology & Hydrology. https://www.ceh.ac.uk/sites/default/files/sepa_choosingandusingcitizenscience_interactive_4web_final_amended-blue1.pdf
- UCL's online course 'An Introduction to Citizen Science and Scientific Crowdsourcing' <https://www.ucl.ac.uk/short-courses/search-courses/citizen-science-and-scientific-crowdsourcing-introduction>
- The Open University's online course 'Citizen Science and Global Biodiversity' <https://www.open.edu/openlearn/science-maths-technology/citizen-science-and-global-biodiversity/content-section-overview?active-tab=description-tab>
- Mappiness - <http://www.mappiness.org.uk/> - a happiness mapping app.

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