

UK Environmental Observation Framework

Guide to Citizen Science

developing, implementing and evaluating citizen science
to study biodiversity and the environment in the UK





Written by scientists at the Biological Records Centre and the Natural History Museum Angela Marmont Centre for UK Biodiversity, on behalf of the UK Environmental Observation Framework.

UK Environmental Observation Framework

The UK Environmental Observation Framework is a partnership of the major public funders of environmental science and was launched in 2008 to address issues of fragmentation, data access and a lack of strategic direction in environmental monitoring.

'Changing the way the UK perceives, values and uses environmental observations'



The Angela Marmont Centre for UK Biodiversity is a hub for amateur naturalists, enthusiasts and other societies studying British wildlife. A place to investigate all aspects of the natural world, from animals, insects and plants to fossils and minerals.



The Biological Records Centre (BRC) is within the NERC Centre for Ecology & Hydrology and jointly funded by NERC and the Joint Nature Conservation Committee. The BRC, established in 1964, is a national focus in the UK for terrestrial and freshwater species recording. BRC works closely with the voluntary recording community, principally by supporting national recording schemes and societies.



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About this guide

Citizen science – the involvement of volunteers in science – isn't new. Within the UK we have a long and rich tradition of scientific discovery by unpaid individuals and interest groups. Indeed our current understanding of UK wildlife and the wider environment is due in large part to the dedication and expertise of the naturalist community.

Over the past decade, there has been a rapid increase in the diversity and scale of citizen science. Initiatives range from crowd sourcing activities, in which the time and effort of large numbers of people are used to solve a problem or analyse a large dataset, to small groups of volunteers, who are experts in their own right, collecting and analysing environmental data and sharing their findings.

The range of possible approaches can be bewildering, but when it is planned and executed well, citizen science can increase scientific knowledge, raise people's awareness of their environment and allow like-minded people to share enthusiasm and knowledge.

This guide aims to support people already involved in citizen science, and those new to it, within the UK. It is based on detailed information gathered and analysed as part of the UK-EOF funded project "Understanding Citizen Science & Environmental Monitoring", which semi-systematically reviewed 234 projects and included 30 case studies (Roy et al., 2012). It will help you to design and implement a citizen science project relating to biodiversity or the environment.

Please see this guide as a starting point that you can add to and adapt to meet your needs and above all, remember to have fun... enthusiasm is infectious!



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Glossary

For the purposes of this guide...

The term **citizen science** is restricted to studies of biodiversity and the environment, and is defined as volunteer collection of biodiversity and environmental information which contributes to expanding our knowledge of the natural environment, including biological monitoring and the collection or interpretation of environmental observations.

Scientists leading or participating in citizen science projects are primarily interested in the scientific outputs. They may be professional scientists or leaders or coordinators of natural history groups, environmental charities, governmental agencies or non-governmental organisations (NGOs).

A **community** is a group of people with a common interest relevant to a citizen science scheme (e.g. a group of people from a local geographic area, a school group, or the members of a natural history group).

A **participant** is an unpaid person who takes part in a project by helping to define its focus, gather or analyse data – a 'citizen scientist'.

A **project** is a citizen science activity. We use this word to incorporate the full range of citizen science including crowd sourcing, long-term monitoring schemes and environmental surveys.



1 Before you start

Is citizen science the best approach?

You should first ask whether citizen science is the best approach to answer your research question. Consider up-front how involving volunteer participants will benefit your project and the participants themselves. Is it critical, desirable, or will it detract from the overall aims of the project?

Citizen science can be a great tool for scientific discovery and engagement, but it is important to recognise that it is not always the best approach to take. Whilst it may cost less than many other methods, it is not necessarily a cheap fix, and citizen science lends itself better to certain types of data gathering and analysis than to others. It also requires ongoing support and engagement with the participants if it is to be successful. This is time-consuming but essential; the more you put in, the more you and your participants will get out of citizen science.

In the right situations, citizen science can be extremely effective, not only for carrying out environmental surveys, wildlife recording or monitoring, but also for engaging people with how science works and for increasing their awareness of environmental issues and their local environment. One of the core strengths of the approach is that it can be used to present

global issues - such as the impacts of climate change or biodiversity loss – in a way that is locally relevant and meaningful. For many people the opportunity to make a difference at the local level provides the motivation to get involved.

It is important to bear in mind at all times that participants take part of their own free will, and are motivated by many factors. They may enjoy taking part, wish to acquire new skills or knowledge, want to contribute to a greater good, or volunteer for other reasons that you may not have even thought about. They are giving their time and efforts voluntarily. It is critical to respect their contributions, to use them wisely and to best effect, and to give something back to the volunteers, wherever possible, in the form of training, feedback of results, or simply by saying 'thank you'.

Key considerations

- What geographic or temporal scale are you aiming to cover?
- How much data do you want to gather and analyse?
- Can volunteers help to gather and analyse these data?
- Are there other ways of gathering or analysing the data?
- To whom will your project appeal?
- What might be their motivation for taking part?
- Can you support participants' involvement by providing training and co-ordination?
- Do you have the resources to develop and publicise the project and share findings with participants?
- Are similar projects already in existence? It may be more efficient to add to existing schemes or work with other organisations than to set up a new project.



Is citizen science the best approach? - continued

Citizen science works best when:

- it works for the benefit of you (or other end user of the data) and for the benefit of the participant;
- the project aims are clearly defined and communicated from the outset;
- the members of the project team have the appropriate expertise, not just in data collection and analysis, but also in communication and publicity;
- evaluation is built into the project design and there is a willingness to listen and adapt as necessary;
- small scale trials are undertaken to test the approach with potential participants;
- the participants are carefully targeted and supported;
- the motivations and skill-sets of all parties (project team and participants) are understood, because they may vary considerably;
- participants feel part of the team, understand the value and relevance of their role(s) and (especially for long-term projects) gain new skills;
- the project is an efficient and enjoyable way to gather and analyse the required dataset;
- the quality of the scientific data generated is measurable.



Choose a citizen science approach

In most citizen science to date, volunteers have been asked to act as data collectors: making and reporting observations. Volunteers have also been successfully involved in labour-intensive analytical tasks that require human expertise in pattern recognition - so-called crowd sourcing of data interpretation. Increasingly, scientists are making use of data that are generated automatically (or with minimal management) from sensors used by volunteers.

For the purposes of this guide, an emerging classification of citizen science is useful (Bonney et al. 2009). It focuses on the different methods through which the project is developed. Three main approaches are recognised:

- 1. Contributory projects** are designed entirely by scientists. Participants primarily collect, or in the case of crowd sourcing, analyse data.
- 2. Collaborative projects** are also designed by scientists, but participants are involved in more than one stage of the scientific process (perhaps contributing or analysing data, helping to inform the way in which the questions are addressed or communicating findings).

- 3. Co-created projects** are designed collaboratively. Scientists and participants or communities work together in partnership. At least some of the volunteer participants are involved in most or all steps of the scientific process.

If you are considering the option of citizen science, we recommend that you weigh up the relative costs and benefits of the various approaches and decide which is most appropriate. This will have a strong influence on the overall feel of your project and how you should go about setting it up.

In reality, some projects use a combination of approaches, perhaps including a core group of highly involved participants who help to develop new research questions and methods, alongside a wider group of participants who contribute their observations. Within the UK, voluntary biological recording schemes and societies are extremely active within the field of citizen science and have a long history of developing projects using each of the above approaches.

The contrasting approaches to development of contributory and co-created citizen science are explored further here.

Contributory citizen science

Contributory citizen science features a top-down approach. Scientists and/or policy makers set the questions, design the survey protocols, process and analyse the data, then communicate the results. Participants are generally invited to collect and submit data according to clearly defined guidelines, but that's the limit of their involvement. Crowd sourcing projects in which participants help interpret existing datasets can also fall into this category. Most citizen science projects to date have followed this approach, but we anticipate that the proportion of collaborative and co-created projects will increase.

Contributory citizen science is well suited to engaging diverse participants, raising awareness of an issue and gathering lots of data over a wide geographic area. However, participants are less involved, so scientists risk developing a project that is not socially relevant to the intended audience; the focus is primarily on the scientists' needs rather than on those of the participants.

Choose a citizen science approach - continued

Contributory citizen science works well for projects that:

- capture the imagination of a broad audience, e.g. projects on charismatic wildlife, biodiversity and environmental health issues, public health or human interest stories, interesting and topical science questions, and projects that link to the school curriculum;
- require large volumes of data that could not be collected efficiently through other routes, for example over large geographic scales or fine resolutions;
- involve recording regularly encountered species or phenomena. Conversely, involve species or phenomena that are not often encountered, and for which people are simply asked to 'keep an eye out', e.g. recording the arrival or spread of non-native species;
- require large-scale analyses that are better done by humans than by computers (e.g. identification of photos of wildlife species or museum specimens). For this, a crowd sourcing citizen science project may be appropriate, provided that the subject matter is sufficiently

interesting to participants (e.g. oldWeather and Herbaria@Home).

Co-created citizen science

At the opposite end of the spectrum from contributory citizen science is the completely open, collaborative approach called co-created citizen science. The project team may be established by a community approaching a group of scientists with a question or issue they would like to resolve, or vice versa (e.g. it could be several members of a natural history group approaching their committee with an idea). The project team includes individuals from the voluntary community working alongside scientists (and/or policy makers) in partnership. The project team members work together to define goals, set the experimental approach, and analyse, interpret and communicate the findings. This approach requires willingness from all parties to listen and adapt, and an ongoing commitment to the project.

Co-created citizen science works well for projects that:

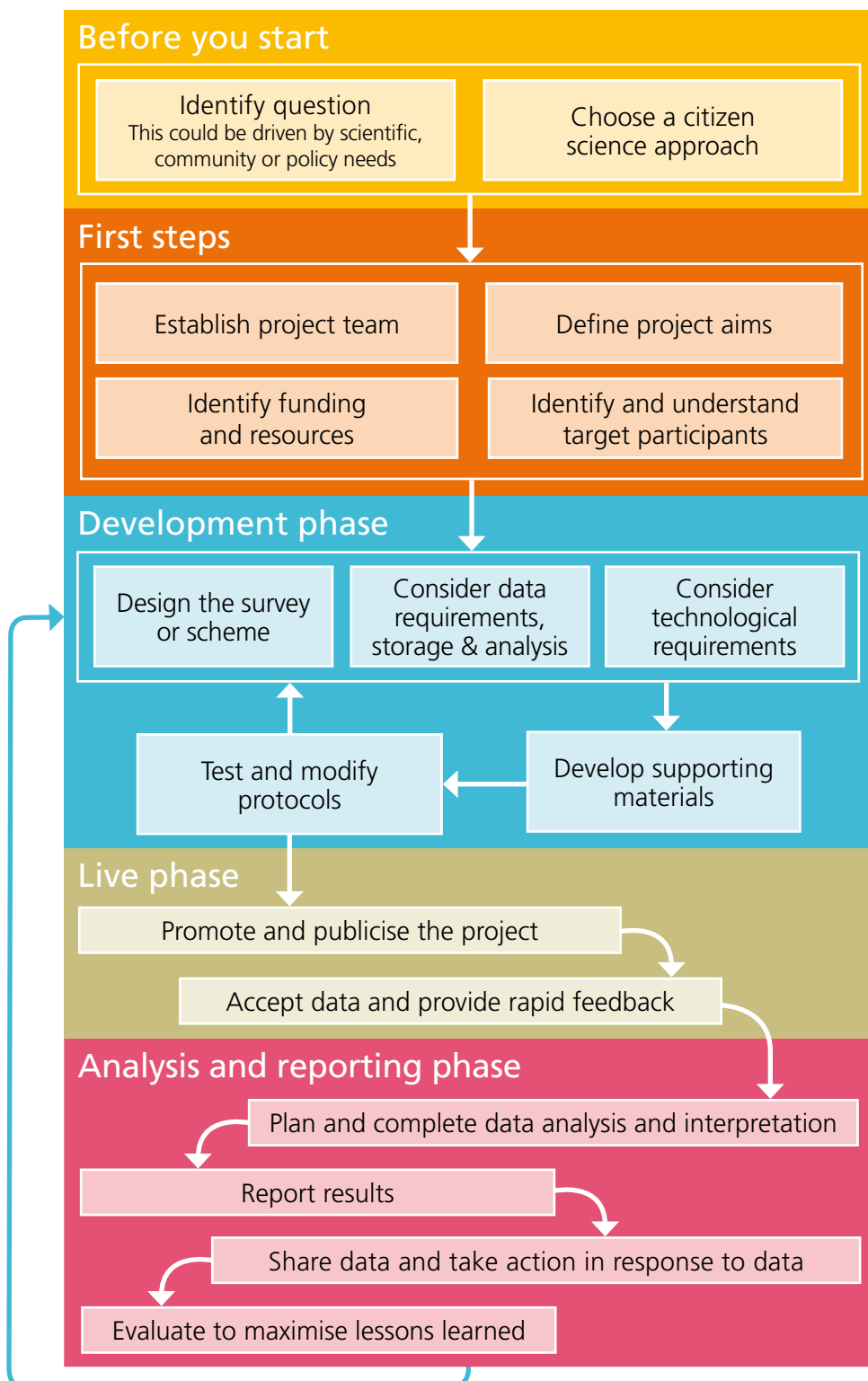
- benefit from establishing a community-led or volunteer-led monitoring scheme. All parties have a stake in the project and the longevity of

involvement provides opportunities for training and sharing of expertise. It does, though, require time and ongoing commitment;

- involve small numbers of participants and in situations where all parties are willing to listen and adapt, so that a consensus can be reached;
- require repeat measurements over time (and which therefore need a greater commitment from participants);
- are targeted at a specific, locally relevant environmental problem or question.

Figure 1: (Opposite)

Proposed method for developing, delivering and evaluating a citizen science project within the UK



2 First steps

Establish project team

First establish your project team and engage with all relevant stakeholder groups. These could include researchers or naturalists who are interested in the data that your project will generate, community groups, members of your club or society, landowners and even local and national businesses.

- Investigate the benefits of a partnership approach. Teaming up with others is an excellent way to share ideas and expertise, spread resourcing and maximise publicity. It can also help to avoid duplication of effort.
- Build a team with the required experience, ideally including communication and promotional skills. You may want to involve participants in shaping the project.
- Remember that for co-created citizen science, the project team will be a true partnership between scientists and the community, so ensure that the community is well represented within the project team. Each will bring their own expertise and ideas to the table. Amongst other benefits, community members will be best placed to advise on what will and won't appeal to their community or peer group.

When establishing a team or partnership remember that:

- From the beginning, your attitude and commitment set the scene.
- Think about the style of language that you use. Don't overcomplicate, and remember that scientific terminology and acronyms are not always understood outside the academic community. Use accessible language and make every effort to include all interested parties in conversations.
- Be open to change. Just because you find an idea exciting doesn't mean that others will.
- When beginning a relationship with a new group, try to meet face to face at their location – it shows that you are both approachable and committed.

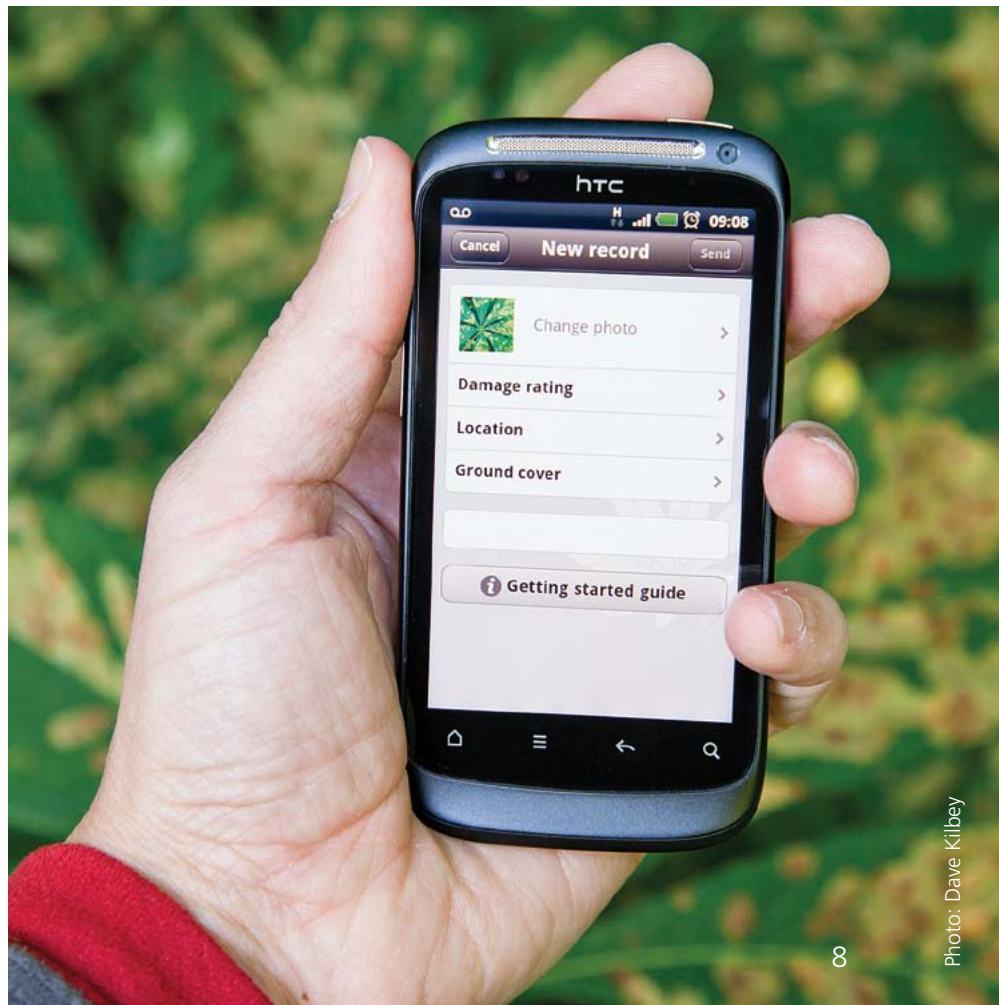


Define project aims

- As with any project, it is important to agree the overall aims at the outset and to establish processes that allow progress to be tracked.
- Citizen science projects often have multiple aims, from meeting policy needs to gathering biological data and engaging participants with local environmental issues. Managing these aims can be demanding, in particular the balance between engagement and data gathering. Be clear about what balance you are trying to achieve.
- Team members may have their own goals, from delivering policy objectives to tackling a local environmental question. Ensure that communication is effective within your team. Get to know one another. Find common ground, openly explore topics of interest and discuss potential questions that the project might address. Aim to establish consensus - strike a balance that everyone is happy with.
- Can you maximise the usefulness of the results to additional end users (e.g. by ensuring data quality is good)?

When defining your aims, keep asking:

- What are we trying to achieve?
- Can we do this with existing resources?
- Is someone else already doing this?
- Can we work in partnership to adapt an existing project, or utilise another group's volunteers and tools?
- What type and volume of data are needed to meet the scientific aims?
- What is the spatial and temporal scope of the project?
- What defines the target participants for the project?
- What's in it for the participant and are we asking too much?
- What is our selling point?
- What will success look like and how will it be assessed?
- What is the end point of the project?



Identify funding and resources

It is important to remember that citizen science is not free! It can represent a highly cost-effective approach, but always requires resourcing in one way or another (e.g. staff time to develop materials and support participants, costs of promotional and training materials etc.). The funding and resources required vary depending on the aims of the project and the aspirations of the people involved, but here are some general considerations:

- For projects with an on-line interface, consider using free and open-source software such as Drupal (content management system), Indicia (on-line recording toolkit) and iRecord (general purpose implementation of Indicia for recording projects). This can help to minimise the costs of building a website.
- Working in partnership is highly recommended (see Example A, overleaf). Included amongst the many benefits is the opportunity to pool resources.
- Ensure that you consider funding and resource requirements within your project plan (see James [2011a] for further information). What staff or volunteer resources are available within your team? How much accessible funding is there?
- Seek external funding where necessary (e.g. grants, commercial sponsorship), but plan well in advance and allow enough time for the application process.
- The most costly phase of the project is often the start when resources are required, e.g. to establish a website, a smartphone app, produce a participants' pack, or create publicity materials.



Photo: Courtesy of the MBA

Identify and understand target participants

It sounds obvious, but we're all different. Our individual motivations, interests and concerns differ widely. In project terms, what works for one group of potential participants (e.g. naturalists) may be less effective with another (e.g. school children). Research has shown that many people participate in citizen science projects for social reasons (e.g. to meet new people) and to gain practical skills (e.g. botanical

identification skills, team working), rather than to gain knowledge. It is important to respect the diverse motivations of volunteers.

Identify your target participants early on as the choice will affect the protocols, data capture systems and training approaches that you develop, and the style of language used within these. It will also affect the type, geographical spread, sampling frequency and volume

of data that can be gathered. So get the participants involved as early as possible – you may think you understand them, but it is easy to miss something obvious or unexpected about their needs or ways of doing things. Remember that when developing a co-created project, the target participants should be represented on the project team.

Hints and tips

- It is easy to say that a project is aimed at the 'general public' and some mass-participation surveys can be, but in most circumstances one size doesn't fit all. Supporting materials generally need to be tailored to specific audiences and 'hooks' to attract publicity may also differ according to the potential participants.
- Try to share ideas with potential participants at an early stage, gauge their response and identify local or social relevance. What are their interests and motivations? Do they have specific technology, access or training requirements?
- We often make assumptions concerning what will work with a given group of participants. These are usually based on our own personal experiences, which are unlikely to be representative, so take the time to listen to your participants.
- If you have the time and existing materials, one of the best ways to learn about participants is to run a small-scale trial. Visit a local community (e.g. a school, residents' association or local natural history society), present your ideas, and give the audience a chance to try out your

initial protocols. A good response does not inevitably mean that your idea would work as a national mass participation project, but a poor one suggests that you need to change your approach, or perhaps even focus your resources elsewhere.

Photo: Michael Pocock



Example A: Working in partnership - UK Ladybird Survey

The UK Ladybird Survey is not eligible for direct funding, because most funding bodies require projects to be run by a legally recognised entity, such as a properly constituted society or charity, or to be associated with one. However, the list of partners that the UK Ladybird Survey has worked with is extensive. This is exemplified by the support received following the selection of the UK Ladybird Survey for the Royal Society Summer Science Exhibition in 2009.

The Biological Records Centre (BRC) supported the overall design and implementation of the exhibit.

A number of items were provided on loan for the exhibition, including a high specification microscope (Leica), plasma touch-screen (Microsoft Research), and display cabinets containing live plants and insects (Rothamsted Research).

Some organizations provided resources, including ladybird mini-identification guides (Field Studies Council), UK Ladybird Survey comics (Rothamsted Research), harlequin ladybird information sheets, podcasts and on-line publicity (Royal Society). Others contributed staff time, including the National Biodiversity Network, University of Cambridge, Anglia Ruskin University and University of Hull.

The UK Ladybird Survey is hosted by the Biological Records Centre within the NERC Centre for Ecology & Hydrology.



3 Development phase

Design the survey or scheme

Once you've established your team and agreed your aims and target participants, you're ready to design the practical aspects of your project. Remember to keep the participant audience in mind as this will strongly influence what participants are willing and able to do and the support mechanisms that you'll need to provide. Whilst designing the survey you should bear in mind your data requirements (p14) and available technology (p16).

Develop the survey protocol

- What are you asking participants to do and how will they do it? What type of data (p14) do you need, and at what spatial and temporal coverage and resolution?
- Don't overcomplicate – keep protocols as simple as possible, whilst still enabling capture of the data you require. Complex protocols can be off-putting and are likely to result in errors. There is often a trade-off between complexity or length of task and the number of participants.
- Can you build in progression for participants, so they begin with a simple task, then progress to more complex tasks as their skills and confidence increase?
- Consider standardising the method because this could increase the statistical analyses that are possible. To what extent do you need participants to collect the data in the same way and will this be feasible? Will survey sites need to be pre-allocated, or can participants choose them? These are particularly important questions for projects that aim to monitor wildlife.
- Bear in mind the health and safety of the participants and give advice or guidance where necessary (e.g. for the safe handling of equipment or wildlife).
- Consider whether any equipment is required, and how participants may obtain this. Will you provide it as part of a project pack? Search for other projects like yours. Look for opportunities that will benefit both you and your potential collaborators. Try not to reinvent the wheel. Will your protocol produce data that can be shared or added to existing datasets, to provide greater value?
- Don't be afraid to contact people developing existing projects. Most scientists are keen to share ideas and experiences (see Resources and Links).



Design the survey or scheme - continued

Develop supporting materials and mechanisms

- What supporting materials (e.g. instructions sheets, identification guides etc) will participants need and what form will these take (p17)?
- How will training and support be funded and coordinated? Can it be handled centrally, or do you need to establish (and help maintain) a network of local hubs and expertise?

- Remember what your participants hope to get out of taking part (e.g. knowledge, skills, entertainment, an understanding of their local area) and ensure that support mechanisms allow them to achieve their aims.
- Once they've gathered the data, how will participants give them to you, how will you provide feedback and in what format (p22)?
- Remember to test supporting materials with potential participants (p19).

Plan evaluation

Plan evaluation methods at this stage – don't leave it until the end. Evaluation is often left too late to be useful (p26).



Consider data requirements

If your project aim is to generate new data (rather than simply analyse an existing dataset) then data requirements will be highly variable. As a general rule, try to maximise the value of your data to others by using accepted data and metadata standards. These are agreed formats for storing and describing your data which make it easier for you to share your information with others. For biodiversity data, James (2011b) provides an excellent overview. Plan how you will analyse your data before you begin collecting them.

Quantity of data

There is usually a trade-off between the number of active participants you attract and the complexity of the protocol. Are you hoping to engage large numbers of people in collecting a small number of records each, using a simple protocol, or a smaller pool of people who may each collect large volumes of data perhaps following a complex protocol? Be sure to consider how you are going to store the data securely (be aware of data protection legislation if storing personal data) and make them available in the long-term.

Quality of data

The quality of data collected by volunteers is heavily influenced by the survey design, training materials and support that you provide. Data accuracy can

be excellent, but, as with any project, it's important both to minimise the opportunities for errors to occur and to understand how data quality varies between samples or even participants. Data of known quality are scientifically useful and are also more likely to be used as evidence by policy makers; data of unknown quality are open to scientific criticism. Validation and verification are two ways in which you can reduce error rates within your data:

Validation is an automated process of checking if something satisfies a certain criterion and can therefore be interpreted successfully. It is possible to add validation checks to web-based data entry forms (e.g. ensuring that dates, grid references or postcodes are given in the correct format and within valid ranges).

Verification (or ground-truthing) is an additional, usually manual, process through which data can be checked. For example, a photograph of a plant, animal or physical feature (e.g. the amount of water in a stream) can be checked visually to confirm that the information that has been provided is correct. Asking participants to provide photos can add huge value to the data by allowing verification (see Ball 2011). Another approach is to verify

a subset of the data, e.g. by requesting samples to be sent in or by accompanying a few participants and observing the measurements that they take. Verification can also be crowd sourced, for instance by asking people to assess each other's photographs or asking different people to take measurements at the same site.

Understand the quality of your data by observing participants and identifying the types of errors they make. Ensure that your protocol allows you to check the quality of a subset or all of the data and maybe even investigate ways to rate and reward participants' abilities. iSpot assigns badges in recognition of expertise. The Weather Observations Website uses a star rating to indicate data quality (see Example B, overleaf). Although poor quality data can be omitted, this represents a waste of participants' time! Instead, variation in data quality (including between participants) can be modeled statistically and taken into account when undertaking analysis.

Plan data analysis

Plan how you will analyse the data, how you will store them and who will have access to them (p23-25). Involving a statistician at an early stage of project development is highly recommended.

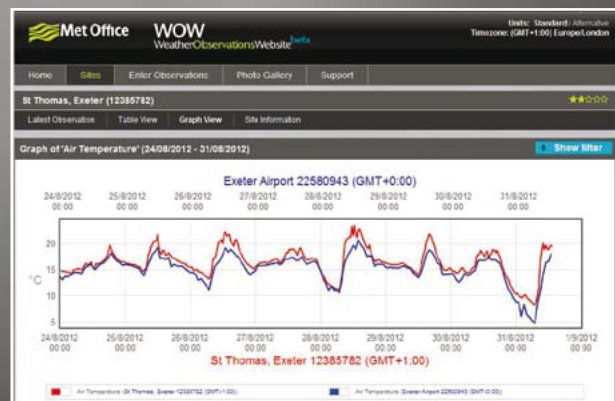
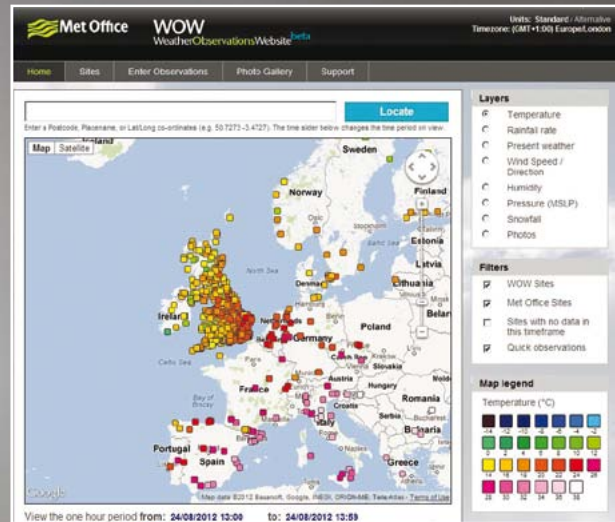
Example B: Understanding the quality of your data - the Weather Observations Website

The Weather Observations Website (WOW) was launched by the Met Office in June 2011, and offers a new way for weather enthusiasts to submit and share their own manual and automatic weather observations and photographs online. In the near future the website will be updated to enable users to report the impacts of weather (e.g. flooded roads, or damage to trees or property caused by strong winds).

In the first 12 months more than 38 million observations were submitted to WOW; over 2000 separate observation sites created, and there were over 165,000 different visitors to the site from 152 different countries. These observations form a valuable extra source of meteorological information for forecasters, particularly in forecasting severe weather events and their onset, and research is planned to evaluate the benefit of using the data within weather forecast models.

WOW uses a star rating to reflect the user supplied information about the quality of the observing equipment being employed and the exposure of the weather station location. There are also various quality control rules for identifying gross errors, and it is possible for registered users to flag data that they suspect are erroneous. Finally, specialist software is used to scan photos and text for inappropriate content – thankfully, despite concerns at the outset of the project, this has not been an issue at all for the website.

The Weather Observations Website is hosted by the Met Office.



Consider technological requirements

Technological developments are revolutionising citizen science: web-based data capture, analysis and presentation tools and smartphone apps are in common use, and a wide range of next generation environmental sensors are under development. From online recording and real-time mapping to digital photography, there are tools for most tasks. See *Understanding Citizen Science and Environmental Monitoring* (Roy et al., 2012) for more detail.

A good website can enable online data entry, data validation and real-time mapping of participants' results. It can also provide

background materials, training resources and forums and blogs through which participants and project developers can interact as part of a project community. Websites can also serve as foci for promotional activity. Insisting on the entry of data to be via the web can, however, deter some participants from sending in data, so consider accepting paper entries too.

Case studies within *Understanding Citizen Science and Environmental Monitoring* (Roy et al., 2012) include numerous excellent examples of:

- Web-based data entry forms (e.g. Indicia, iRecord, BirdTrack, UK Ladybird Survey).

- Real-time web-based data visualisation using GoogleMaps and other free software (e.g. The Open Air Laboratories Network - OPAL, Plant Tracker, WOW).
- Web-based crowd sourced identification of wildlife photos (e.g. iSpot; NHM forums) and museum herbarium specimens (e.g. Herbaria@Home).
- Social media as tools through which to establish and maintain citizen science communities.
- Smartphone apps that serve as training guides and data upload tools (e.g. mySoil, OPAL Bugs Count, Plant Tracker).

Hints and tips

- Be flexible. Can you include different approaches within your project?
- Citizen science should be innovative and imaginative, combining the collation of high quality and useful data while appealing to the volunteer community.
- Select technology appropriate for your target participants. By opting for a particular technology you will be implicitly engaging particular communities, so

choose an approach that is both interesting and accessible to your potential participants. If physical items are required (e.g. sampling kits), remember that you'll need to distribute them.

- Mobile phone signal strengths are variable throughout the UK. This can affect projects that rely on data upload via mobile phone or tablet. If you plan to use this technology, consider allowing mobile devices

to store data for upload when a signal is available.

- Consider the risks of the technology failing (e.g. launch-day website crash) and what you can do to address these.
- Only be as high-tech as necessary. Cutting-edge projects can capture people's imaginations, but there is a cost to all development, and some of the most successful projects rely on simple face-to-face interactions.

Develop supporting materials

Well-supported citizen science participants will not only produce higher quality data, but will gain more from participation - from increased skills to improved confidence and new social networks. The OPAL project has found that a common reason for participants not uploading their data is a lack of confidence in the accuracy of their results. Providing supporting materials can help to minimise the risk of this.

Hints and tips

- Training provides an excellent way to build skills and retain involvement in a project, and therefore provides rewards for participants and scientists alike.
- Develop supporting materials, such as identification guides and survey instructions, with input from participants – testing by users is vital.
- Will downloadable or printed guides be sufficient, or will face-to-face training be necessary? Identification workshops are extremely popular. Consider running 'train the trainer' courses, so that the training you give can be shared with others.
- When developing supporting materials, pick the format that works best for your participants (see Example C, opposite).
- Use as little text as you can get away with.
- Video clips can be an excellent way to demonstrate techniques and introduce your team.
- Consider developing a project Frequently Asked Questions page or a web forum that allows participants to share skills and experiences. This could also be done via social media such as Facebook or Twitter. Anything interactive will need to be moderated and requires someone with a passion for new communication technology, otherwise it will quickly become out-of-date.
- Consider mentoring (either locally in person, or virtually via the internet) as an approach to developing skills over time. Can you build a network of regional mentors, coordinators or champions?
- Make use of existing materials. Contact groups that specialise in the species or environmental topics or training that you are investigating and ask their advice. They may be happy to share their resources or contribute to your project.



Photo: Heather Lowther, CEH

Example C: Developing supporting materials - The OPAL Bugs Count Survey



The OPAL Bugs Count Survey

investigated the effects of urbanisation on terrestrial invertebrates. A wide range of training materials and supporting resources were developed to accompany the survey. Each element was designed and tested with input from the target audience, or colleagues who had extensive experience of working with the relevant group. The resources were aimed at improving participants' confidence, increasing both survey uptake and the quality of the resultant data. A teachers' pack linking the project to relevant areas of the national curriculum and outlining suggestions for extension activities was particularly well received.

Resources included:

Identification guides tailored to the audience.

Identification quiz and Powerpoint training presentation.

Teaching supplement.

Group leaders support pack.

Poster showing where to look for invertebrates in urban settings.

Bugs Count was developed by the Natural History Museum with the University of York, University of Birmingham and Imperial College.



Test and modify protocols

A critical step now is to test the survey protocols, data entry forms and training materials to ensure that they are fit for purpose. It is easy to make assumptions about what appeals to different people, what kind of language is appropriate and whether instructions are clear or not. To ensure your project has the best chance of success, test all elements with potential participants under realistic conditions. It can be tempting to skip testing when deadlines get tight, so allow plenty of time!

Hints and tips

- Trial the survey protocol and supporting materials with potential participants. Observe how people use materials and ask for constructive feedback. Where do participants go wrong, and what questions do they ask?
- Take all constructive feedback on board and adapt your protocol and supporting materials accordingly. How can you amend your approach to maximise both the clarity of materials and the quality of data generated?
- Testing by users is often an iterative process. Be prepared to re-test the refined materials and adapt again if necessary.
- Testing should be viewed as part of a broader, continuous evaluation process (p26).
- Be prepared to make radical changes to your project or even discontinue it if feedback from participants suggests that it will not be successful in its current form.

Once initial testing and modification is complete, you are ready to produce and distribute the materials. However modification may continue over months or years as projects evolve. (See Example D, opposite.)



Example D: Testing and modifying - Conker Tree Science

Conker Tree Science is a national citizen science project in which scientists seek to answer specific questions about the biology of an invasive non-native insect, the horse-chestnut leaf miner. Conker Tree Science has progressed through a series of steps including the launch of three hypothesis-driven 'missions'.

Two scientists decided they wanted to undertake hands-on communication about the way that people depend on nature. So they:

1. ran a public engagement event in a shopping centre in which they gave out 1,100 pots for people to observe and report insects emerging from horse-chestnut leaves.
2. worked on the horse-chestnut leaf miner with 1,000 local school children. Children reported their results via a website and could view graphs of the overall results.
3. received funding from the Natural Environment Research Council to implement the project at a national scale. They switched to map-based (rather than graph-based) feedback for participants and included log-in procedures for entering data on the website. They worked with a subset of participants to validate the accuracy of the records they received. For part of the project, the participants' 'mission' was to collect horse-chestnut leaves during one week of the year and rear insects from them.
4. widened participation through development of a second 'mission' that anyone in the UK could take part in at any time. This second 'mission' was developed into a smartphone app.
5. developed a third 'mission' in response to enquiries from participants and a project blog was added to the website.

Conker Tree Science is run by scientists from the NERC Centre for Ecology & Hydrology, the University of Hull and the University of Bristol.



4 Live phase

Promote and publicise the project

Spend time planning how you will publicise and promote your project – this is critical to the successful recruitment of participants, and should be tailored to your participants. The amount of promotion required depends on the approach you have taken and the size of audience you are aiming to reach. If you've been interacting with potential participants through the project development process, then you have already started to promote the project.

If you are targeting an existing membership, then promotion via email newsletters, Twitter, Facebook etc. can be very effective. Capturing a new audience of potential participants requires more effort. Start with your contact network. Local subject-related websites and email newsgroups can be particularly useful for reaching enthusiasts, who can then spread the word in their local area.

For smaller, local projects, think about promoting the project by means of posters in local parks, post offices and businesses. Local or regional newspapers may also be receptive.

Hints and tips

- Focus on your target participants.
- Identify a news 'hook' – something catchy that the press and potential participants will pick up on.
- Write a press release and prepare what you'd like to say before you contact anyone.
- Approach different sectors of the press depending on your aims (national press, local press, specialist publications), and consider different media (TV, radio, print, online).
- Don't assume that press coverage will ensue – it is never guaranteed.
- Social media, such as Facebook and Twitter, provide exciting opportunities for citizen science and enable you to reach a broad range of potential participants.
- Maximise face-to-face promotion through events and talks.
- A launch event can be a great way to kick-start your project, as it gives a focus for participants and press alike. It is often easier and more cost effective to piggy-back on existing events and to work through others than to organise your own events. It is usually inexpensive to hold a stand or run an activity at an existing event, and you can often reach a large audience this way. Some examples include: county fairs, green fairs, BioBlitzes, science festivals.



Accept data and provide rapid feedback

Accepting data

Once your project is live, participants will be actively sending in data (hopefully lots!) through the mechanisms that you've set up – be that online, via smartphones or as paper records. Keep checking that these mechanisms are working – you may not have spotted all glitches during testing, and websites occasionally crash when traffic is particularly heavy.

Providing rapid feedback

Thanking participants for taking part not only shows that they are valued, but encourages their continued involvement and gives them a sense of achievement. Rapid feedback is a powerful way of motivating participants. The

more instantaneous the better! How you provide feedback will depend on your budget and the routes through which data are received.

- Email – think about sending personal or automated replies to thank participants.
- Phone – automated text messages can be used to show that data have been received and to thank participants, but can be costly depending upon volume.
- Web – real-time results maps are a good way to show that data have been received and have already been incorporated into the dataset. The OPAL project and WOW both show how GoogleMaps can be used to good effect.

If you are able to provide participants with a brief summary of results on a regular basis via a newsletter, blog or email then this will also be well received. Don't swamp your participants though – a monthly update is usually sufficient. If sending an email update, remember to check that any embedded links work.

Ideas for rewarding your citizen scientists

If your project sounds fun, is interesting and produces useful data, hopefully you will attract a good number of participants. In return for their input and to encourage further participation you could:

- hold a feedback or closing event, perhaps incorporating a social activity, to thank them for their input and present results to them;
- give free access to all non-sensitive records;
- run a competition to encourage repeat participation;
- simply say thank you!



5 Analysis and reporting phase

Plan & complete data analysis & interpretation

Planning data analysis before you begin to collect data is vital to ensure that you gather the data required. Can analysis be done continually throughout the project, providing you and participants with a regularly updated picture of the results, or will it be conducted only at the end? Here are some general considerations.

- **Data cleaning**

It is inevitable that the data will need to be cleaned to remove (or investigate) spurious results. In part this may have been done through validation and verification (see p14) at the point of data entry or afterwards by experts. You may also need to arrange the data into a format from which you can begin the analysis, although giving thought to subsequent analysis at the start of the project is essential.

- **Visualising the data**

Before you begin the statistical analysis, it is useful to visualise the data and produce a range of summary statistics to gain an overall view of the dataset. Which summary statistics you use will depend on the data – perhaps a mean, median, running average or maximum and minimum values. You may want to look

at the variation within the data, and produce graphs, charts or maps. Do wildlife distributions or physical environmental measurements appear as expected?

- **Statistical analysis**

Which statistical analyses you choose for your data will depend entirely upon the type of data collected, and you may need an expert to help you with this. Most scientists seek either to answer a question or to estimate parameters. Consider what level of precision around the estimate is acceptable. Is power analysis needed to determine the sample size required? As a dataset builds up, new questions may arise and the power to answer them may increase. It may be preferable to undertake simple analysis for quick feedback to participants, followed by thorough analysis later.

- **Data quality assessment**

Confidence limits and verification levels should be documented alongside all data, whether gathered through citizen science or not. Clearly stating the quality of your data is likely to increase its use by scientists and policy makers vastly, and will enable you to act on your conclusions with confidence.

- **Interpretation**

Once the statistical analyses are complete, you will be able to compare the results to your hypotheses or project aims.

- **Qualitative analysis**

Whether you intended to or not, it is likely that you have gathered some qualitative data from participants in the form of comments and feedback given during training, on feedback forms, or at the point of data entry. It is labour-intensive, but worthwhile, to look through these data carefully (perhaps categorising them), as they may provide insights that you had never considered before, or useful evaluation and feedback for improving the project.



Photo: Helen Roy

Report results

You will almost certainly need to report and present your results to different people: your participants, data users, funders or the press. Different levels of detail and different types of visual representation of the data will be required.

Participants will be interested in seeing how their efforts have helped the project. Audiences vary, but most will be interested in the general trends (a summary of the overall findings), so your summary statistics and visualisations of the data may be most appropriate. Think about what would be the most informative and rewarding way for participants to view the data. You may wish to provide some interpretation of the data, but could also invite interpretation from participants. Try to present your results in a way that shows their local relevance.

Present your data through the most appropriate route for your participants – there's no point making the effort to create a report if no-one reads it! This could mean through your website, group mailing list, or social media. For a community-based project, nothing beats a face-to-face presentation and question and answer session.

Scientists and policy makers will be interested in the broad results – what your data

show and how the results fit with the wider picture - but also in the details. For example, the methods and analyses employed, data quality, comparison with previous understanding, and types of graphical or statistical outputs. The written communication style for this audience will usually be very different to that used for a public or media audience.

The value of citizen science in helping to meet the need for environmental monitoring and to address the challenges outlined within the emerging governmental biodiversity and environment strategies is widely recognised. Effective communication of your project will help to ensure the maximum use of the data you collect - which could also inform future strategies.

Media and press want to hear sound bites. Short, snappy phrases that explain what you did, for what purpose and just why your results are so fascinating! Make your communication relevant to the audience (viewers or readers) by phrasing it in a way that will capture their interest and imagination. Regional press will be particularly interested in local stories – what your results mean for local wildlife, which schools or community groups took part, etc. Seeking advice from a press officer or communications expert is recommended.

Remember to acknowledge and thank participants – they've played a critical role in making your project a success!

“The value of citizen science in helping to meet the need for environmental monitoring and to address the challenges outlined within the emerging governmental biodiversity and environmental strategies is widely recognised”

Share data and take action in response to data

Sharing data

Sharing non-sensitive elements of the data that you collect will allow them to be used by others, maximising the value of the data. Remember to consider potential intellectual property rights and data protection requirements at an early stage. Try to make data available in electronic format wherever possible, as this will increase their accessibility to others.

The **UK-EOF** aims to promote access to and awareness of current and future information from observation activities across government departments and agencies, the voluntary sector, industry and academia. Their on-line catalogue can be searched to identify environmental observations being undertaken within the UK, including citizen science data.

UK-specific suggestions for sharing your data are given below.

Biodiversity data is best stored and shared through the **National Biodiversity Network Gateway**. You may or may not have already planned where you will store the data collected, both in the short and long term. It is important to talk about this during the planning stages to ensure all members of your project team are happy.

Data may be passed to a local Environmental Records Centre or National Recording Scheme or Society for verification but you will also need to consider where they will be stored in the long term and how you will share them with others throughout the country, or even globally. Marine data can be shared and formatted through the **Data Archive for Seabed Species and Habitats**, a service managed by the Marine Biological Association.

Environmental data should be shared with relevant organisations, for example the **British Geological Survey** will be interested in soil data and the **Met Office** in weather related observations. The **Marine Environmental Data and Information Network** promotes sharing of, and improved access to, marine data. The **Environmental Information Data Centre** can host and share environmental datasets of long-term value to future science. Get in touch with relevant organisations early in the project development process and they will be happy to advise.

The data can also be hosted on your own website or in repositories such as Dryad, and then listed on international initiatives such as **DataONE**. DataOne is a repository that lists where different

environmental datasets are stored and how they can be accessed by others. Archiving your dataset, in a way that complies with modern data storage guidelines, ensures the data are stored in a secure and accessible place and will reassure participants of the long-term value of their data.

Take action in response to data

Data collated through citizen science can be used in many ways by many people. In some cases there may be appropriate action arising from the information gathered. For example, both Plant Tracker and the Recording Invasive Species Counts initiative encourage people to gather data on a number of non-native species in the UK. The information can be used for appropriate action such as containment or removal of the species. In other cases citizen science can inform management of specific sites for example through the implementation of measures to improve water or habitat quality.



Photo: Met Office

Evaluate to maximise lessons learned

Evaluation is an ongoing process through which you can improve your project. For convenience we have placed this section at the end of this guide, but to be effective, evaluation should occur throughout your project.

Evaluation will help you to improve your citizen science, both in terms of the data collected and analysed, and in terms of the experiences of your participants. It can help you determine strengths and weaknesses, gather evidence of success, understand your participants' needs, improve your project, and apply for funding. It also helps you celebrate your achievements!

Types of evaluation:

Baseline evaluation occurs prior to project development. It helps you to set a baseline (e.g. of scientific understanding, people's attitudes etc.) from which to measure change.

Formative evaluation is carried out as you develop the project and whilst it is running. It will help strengthen and improve your product (in this case your website, survey protocol, supporting materials etc.). It involves assessing the effectiveness of the delivery of the project, and should inform changes that improve your project's effectiveness.

Summative evaluation happens at the end of the project or during a natural break, e.g. over the winter for summer surveys. It focuses on the effects and outcomes of the project. Return to the aims you set at the beginning and assess the extent to which each was met. What were the results in terms of e.g. habitat improvement, peer-reviewed papers, or solving an environmental problem? How did the project affect participants' learning, attitudes and behaviour?

Hints and tips

- You can evaluate in many ways. Build an evaluation strategy appropriate to your project.
- Evaluation is best viewed as an ongoing process, not just a final activity.
- Invite all stakeholders to assess the project critically, at suitable stages.
- Invite and incorporate feedback from participants and your project team.
- Share your findings with other project organisers. What worked well, what didn't, how would you adapt your approach in the future?

“What worked well, what didn't, how would you adapt your approach in the future?”

Resources and links

The guide is based on information gathered and analysed as part of the UK-EOF funded project “Understanding Citizen Science & Environmental Monitoring”:

Roy, H.E., Pocock, M.J.O., Preston, C.D., Roy, D.B., Savage, J., Tweddle, J.C. & Robinson, L.D. (2012) Understanding Citizen Science & Environmental Monitoring. Final Report.

Citizen science web portals

UK-EOF Catalogue: www.ukeof.org.uk/catalogue/default.aspx

Citizen Science Central: www.birds.cornell.edu/citscitoolkit

SciStarter: www.scistarter.com

Internet-based citizen science: www.citizensciencealliance.org

Examples of UK projects: www.nhm.ac.uk/nature-surveys

National Recording Schemes and Societies: www.brc.ac.uk/recording_schemes.asp

Selected citizen science projects

Crowd sourcing

Galaxy Zoo: www.galaxyzoo.org

Herbaria@home: <http://herbariaunited.org/atHome>

OldWeather: www.oldweather.org

Community based

OPAL: www.opalexplornature.org

British Trust for Ornithology: www.bto.org/volunteer-surveys/core-surveys

Scotlands Counts: www2.tcv.org.uk/display/scotlandcounts

Mass participation

Big Garden Bird Watch: www.rspb.org.uk/birdwatch

Conker Tree Science: www.ourweboflife.org.uk

iSpot: www.ispot.org.uk

mySoil: www.bgs.ac.uk/mysoil

OFS Pollinator Survey: www.farmsunday.org/of12b/visit/Pollinator.eb

OPAL: www.opalexplornature.org/surveys

Recording Invasive Species Counts: <https://secure.fera.defra.gov.uk/nonnativespecies/index.cfm?sectionid=81>

The Great Egg Case Hunt: www.eggcase.org

The Shore Thing Project: www.marlin.ac.uk/shore_thing

UK Ladybird Survey: www.ladybird-survey.org

UK Mammal Atlas: www.mammal.org.uk/nmap

Weather Observations Website: wow.metoffice.gov.uk

Long-term monitoring

Birdtrack: www.birdtrack.org

Botanical Society of the British Isles: www.bsbi.org.uk

National Bat Monitoring Programme: www.bats.org.uk/pages/nbmp.html

Predatory Bird Monitoring Scheme (PBMS): wiki.ceh.ac.uk/display/pbms/Home

Rothamsted Insect Survey (RIS) Light Trap Network: www.rothamsted.ac.uk/insect-survey

UK Butterfly Monitoring Scheme: www.ukbms.org

Wetland Bird Survey: www.bto.org/volunteer-surveys/webs

Wider Countryside Butterfly Survey: www.ukbms.org/wcbs.aspx

Wildflowers Count Survey: www.plantlife.org.uk/things_to_do/wildflowers_count

Planning and running your project

Guide to running a BioBlitz: www.opalexplornature.org/BioBlitzes

Running a biological recording scheme or survey:

James, T. (2011a) www.nbn.org.uk/Tools-Resources/NBN-Publications/NBN-52-Bio-Recording-web.aspx

Improving wildlife data quality:

James, T. (2011b) www.nbn.org.uk/Tools-Resources/NBN-Publications/NBN-16-Improving-Wildlife-Data-Quality.aspx

NBN Record Cleaner user guide:

Ball, S. (2011) <http://data.nbn.org.uk/recordcleaner/documentation/NBNRecordCleanerUserguide.pdf>

Project evaluation techniques:

www.socialresearchmethods.net/kb/intreval.php

Working with communities, designing and evaluating your project:

www.audubon.org/toolkit

Citizen science approaches:

Bonney, R. et al. (2009) Public participation in scientific research. Center for Advancement of Informal Science Education (CAISE), Washington, D.C.

Working with new audiences:

Tweddle, J. & Scott, S. (2009) Developing participative natural history and environmental projects. 1. Practical approaches for engaging and working with 'hard to reach'

communities. Unpublished OPAL Partnership Report (available from the authors of this guide).

RCUK evaluation guidelines:

www.rcuk.ac.uk/documents/publications/evaluationguide.pdf

Technology

Indicia: Open source data capture, reporting and mapping software specifically designed for environmental monitoring: www.indicia.org.uk

iRecord: A recent implementation of Indicia in the UK providing a peer-review system for species experts to assure the quality of data collected via citizen science projects. iRecord also provides a mechanism for onward data flow and use, by exporting data in standard formats: www.brc.ac.uk/iRecord

Sharing data

NBN Gateway: <http://data.nbn.org.uk>

Data Archive for Seabed Species and Habitats: www.dassh.ac.uk

British Geological Survey: www.bgs.ac.uk

Marine Environmental Data and Information Network: www.oceannet.org/about_us

Met Office: www.metoffice.gov.uk

Environmental Information Data Centre:

www.ceh.ac.uk/data

DataOne: www.dataone.org

Data visualisation

Google maps - extremely widely used for mapping results from citizen science projects. It has excellent tools and an active community supporting its development.

Google charts - a set of customisable tools that allow the visualisation of data in user-defined ways. These tools are free and well-resourced, with a large community of developers.

Fieldscope - a platform under development that provides mapping and analysis tools and is seeking to be strongly linked to citizen science projects.

Analysis

Analytical techniques:

Hill, M. O. (2012) Local frequency as a key to interpreting species occurrence data when recording effort is not known. *Methods in Ecology and Evolution*, 3: 195–205.

Occupancy modelling:

Van Strein, A.J., Termaat, T., Groenendijk, D., Mensing, V. & Kéry, M. (2010) Site occupancy models offer new opportunities for dragonfly monitoring based on daily species lists. *Basic and Applied Ecology* 11:495-503.

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The UK Environmental Observation Framework is a partnership of:



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