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Wales

Evidence Report 90: Monitoring Review – Citizen Science and the Delivery of Monitoring in NRW.

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Summary.

This overview provides a brief introduction to citizen science projects and summarises their strengths and weaknesses. To enable appropriate use of citizen science as a monitoring tool, a decision tree is provided to help in the identification of potential citizen science projects as part of the wider NRW corporate monitoring strategy.

Suitable projects are characterised by having a solid concept with clear drivers and an understanding of outcomes. When such projects are developed the data and scheme requirements must also be clearly understood together with the target audience and the protocol to be used.

Given the wide-scale popularity of citizen science as a delivery mechanism a representative selection of citizen science projects are provided to illustrate their diversity across a range of NRW operational areas.

Introduction.

The fields of astronomy and ornithology have led the charge for citizen science with prominent efforts beginning at the end of the nineteenth century. In 1874, the British government funded the 'Transit of Venus' project to measure the Earth's distance to the Sun. The project engaged the admiralty to support data collection across the globe and recruited the services of the most prominent amateur astronomers of the time.

Bird monitoring goes back even longer, with amateurs collecting data on timing of migration beginning in Finland in 1749. In 1900, the American Museum of Natural History's ornithologist, Frank Chapman, initiated the Christmas Bird Count as an alternative to regular holiday bird-shooting contests. This project popularized ornithological monitoring in the US and is now run by the Audubon Society. The US Geological Survey began engaging the public in bird monitoring even earlier, in 1880, and became a major player in monitoring of birds with the well-known Breeding Bird Survey launched in 1966. (Dickinson et al., 2010).

Given the interest and popularity of citizen science projects in the UK there have been a number of exercises to investigate and review the role, extent and value of citizen science projects. This work has been led by the UK Environmental Observation Framework (UK-EOF) through a series of reports and reviews (Roy et al., 2012; Pocock, et al., 2014a; Pocock, et al. 2014b). These reviews have primarily focused on environmental/biological monitoring in freshwater and terrestrial environments. Key extracts from these reports form the basis of this overview.

Definition.

Given the extent of work investigating the role of Citizen Science in the UK the definition adopted by the UK Environmental Observation Framework forms the basis of this review:

“volunteer collection of biodiversity and environmental data which contributes to expanding our knowledge of the natural environment, including biological monitoring and the collection or interpretation of environmental observations” (Tweddle, et al., 2012).

Categories of citizen science projects.

Reviews of existing citizen science activities have enabled the identification of a number of categories which describe the range of activity types identified (Roy, et al., 2012). :

1. **Contributory projects** – Projects lead by professionals or professional bodies to which members of the public contribute data.
2. **Collaborative projects** - designed by professional scientists; members of the public contribute data and inform the way in which the questions are addressed, analyse data and disseminate findings
3. **Co-created projects** - designed by professional scientists and members of the public working together and for which some of the volunteer participants are involved in most or all steps of the scientific process.

The use of citizen science as a delivery mechanism has been demonstrated across a range of sectors and emphasises their role in the environmental field.

Ecosystems used by citizen science projects.

Recent reviews of the range of citizen science projects demonstrate that the vast majority were focussed on terrestrial environments (64%) with smaller numbers being associated with marine/shore (14%) and freshwater (16%) ecosystems (Roy, et al., 2012).

The review by the UK-EOF (Roy, et al., 2012) also demonstrates how such projects fall across the above project categories, with the vast majority of projects falling into the contributory (96%) category. Collaborative or co-created projects were disproportionately likely to be local projects; the local geographic scope making the creation of such projects more likely.

Popularity of citizen science projects.

Citizen science projects have arisen in popularity for a number of reasons, driven by both available resources and a more outward focus of research and public agendas (Roy, et al., 2012). During 2007, volunteer observers for biodiversity surveillance in

the UK were estimated to contribute time in-kind worth more than £20 million (Tweddle, et al., 2012). Some of the key reasons for the increased popularity are as follows:

Valuable engagement tools.

The engagement of the public with the environment through citizen science is a potentially powerful tool that supports many policy agendas. Whilst the motivations of individuals vary it can be an effective way for the public to feel they are contributing to valuable work.

Enabling popular species recording through NRW Habitats Directive licensing.

Citizen scientists play a vital role in collecting marine mammal survey data – both on land and at sea – through a number of organisations including the SeaWatch Foundation, Cardigan Bay Marine Wildlife Centre and Whale and Dolphin Conservation. NRW support this data collection in several ways, such as issuing licences to photograph dolphins and by commissioning surveys. In turn, we use a number of comprehensive data sets such as the Atlas of Marine Mammals of Wales, and the Joint Cetacean Protocol data, to inform our evidence based advice. These data sets, and others like them, often rely heavily on voluntary organisations who use volunteers on organised surveys as well as encouraging citizen scientists to submit ad-hoc observations.

Resource efficient data collection at varied scales.

Citizen science data collection can both provide the potential for collecting data at large spatio-temporal scales and enable the intensive collection of data at specific local sites.

Technological change.

Developments in communication technology is now enabling the efficient establishment and running of citizen science projects through data collection via on-line systems and efficient data flow and validation mechanisms. New developments around smartphone technology is also opening new areas for phone applications and additional phone technology for new projects. Some areas of citizen science such as crowd sourcing can be entirely dependent on the use of home computer availability and processing power e.g. herbaria@home (<http://herbariaunited.org/atHome/>)

Data reliability.

Following on from technological change there have been methodological ones that results in citizen science projects increasingly incorporating data validation and verification procedures in the data to provide information of a known quality. This improved methodology now enables the outputs of such projects to be published in scientific literature and used in national statistics e.g. National Bat Monitoring Programme.

History of volunteer work in science.

There is a long history of public voluntary involvement in data collection e.g. UK Breeding Birds Survey (see table 1). These long running schemes now fall under citizen science work and often form the major vehicle for biodiversity related data delivery in the UK. The participants for citizen science projects now extend from mass public involvement through to targeted audiences such as volunteer experts.

Advantages & disadvantages of citizen science projects.

Given the wide and diverse nature of citizen science projects, reviews have enabled the identification of a series of generic advantages and disadvantages.

These reviews (Pocock, et al., 2014a; Pocock, et al., 2014b ; Roy, et al., 2012) reveal the following:

Advantages of a citizen science approach.

- By getting people to be hands-on with data, it engages them with important issues, including the complexity of the issues of concern and the challenge of monitoring impacts on the environment.
- It can help to build trust in NGO & public sector organisations.
- It can be a cost-efficient way of gathering data, especially at large spatio-temporal extent and fine spatio-temporal resolution. That is, the cost of acquiring suitable data 'professionally' is more than the cost of supporting volunteers to acquire the data.
- For long-term monitoring, committed volunteers could provide a more reliable way of gathering data, less subject to the vagaries of agency funding than professional monitoring.
- It can permit many more simultaneous observations than would otherwise be possible.
- Where rare but significant events are noteworthy to members of the public (e.g. diseased wild animals, otters killed on roads, landslides etc.) it can permit the reporting of these events across large spatial and temporal scales, whereas using paid surveyors to report such events would not be practical.
- It need not be restricted to what people can see; people can use sensors, or they can collect samples for analysis by volunteers or by professionals.
- Many potentially interested people are willing to be directed and to be 'useful'. Collecting data gives them purpose and helps them feel involved – thus encouraging commitment.
- By allowing lots of people to each undertake small or simple tasks (i.e. 'crowd sourcing', often of tasks that are simple for humans to undertake but difficult for computers, such as image recognition), it can provide a means of analysing large datasets for properties that cannot be picked up by automated processes and have so much data that it cannot realistically be achieved by a smaller number of people.
- Even the most unlikely subjects can be made engaging by applying the creativity and imagination of communicators – therefore almost any subject is potentially suitable for a citizen science approach.
- In some cases the expert amateur could have superior skills to the professional – this is particularly the case when surveying for and identifying plants and animals.

- It can help build environmental and technical competencies (especially taxonomic) at the community level. A resource that can then be drawn on for other projects.

Disadvantages of a citizen science approach.

- It may be more efficient (and cost-effective) to undertake systematic sampling with paid professional surveyors. The average costs of citizen science projects where finance data is available indicates an average of £100,000 per project per annum.
- Data acquisition becomes reliant on a resource that is outside of your control. That is, citizen science is most suitable where data cannot be collected any other way (i.e. you are not diverting resources from currently adequate monitoring), or where the data will be useful but not essential.
- Providing feedback to volunteers can be costly, in terms of time, but has to be maintained for the life of the project in order to motivate participants.
- The expense in providing secure infrastructure for data acquisition (e.g. online databases and web interfaces, or smartphone apps) can be relatively high.
- There can be tensions between the motivations of volunteers and the needs of the organisers. People take part because they are motivated through interest, curiosity, fun or concern. People may not be motivated to take part because they are told they ought to, or because it is for someone else's good.
- Often citizen science data (especially mass participation) is *ad hoc* in its collection (i.e. the times and locations of samples are not subject to statistical design), so can require complex analytical approaches or may not be suitable for the purpose for which it was intended.
- Data quality may be variable, so its suitability for scientific research or regulatory purposes needs to be carefully evaluated. There is a risk of not having adequate data to meet regulatory requirements (e.g. data is not collected over suitable time periods, or patterns of data collection change over time).
- For long-term surveillance, either considerable commitment by individual volunteers, and/or a long-term commitment to recruiting volunteers, is required.
- For long-term surveillance, organisers of citizen science need to have a long-term commitment to supporting and retaining volunteers (e.g. through training, mentoring, providing feedback, refreshing materials etc.)
- Volunteers need to be recruited. Therefore knowledge of your audience and what may interest them is essential, but it can still be challenging to 'pitch' the project to people, especially when done through the media. The success of projects may also be limited by a patchy or inadequate distribution of potential volunteers, their demographic profile or changes to other policy areas e.g. social security policy towards volunteering.
- The success of recruiting participants may depend on the reputation of the recruiting organisation. Government agencies may find recruiting harder, either because people trust them less than charities or universities, or because people believe that the activity should be supported with public funds, but working with partner organisations may lead to greater success in recruiting volunteers.
- Organisations bringing in or utilising volunteers need to be aware of the potential liabilities associated with volunteering, especially around health & safety practices.

Selecting citizen science as a delivery mechanism.

In an environment with shrinking resources and shrinking organisations there has been an obvious focus on the potential to deliver monitoring data acquisition through

the establishment and running of citizen science projects to provide a cost effective alternative.

To guide the thinking around the potential of citizen science as an evidence delivery vehicle, a decision framework has been developed. This decision framework includes two elements:

- A series of preliminary questions as a pre-filter.
- A decision framework for iterative application to project ideas.

There are many different ways of delivering monitoring programmes and citizen science remains one of the delivery options. For any given proposal it is recommended to consider them in the light of the pre-filter questions. If a given proposal appears to strongly satisfy these questions then it is likely to be more suitable as a citizen science project. The type of project can then be investigated through the decision framework. The fact a particular project may be suitable does not mean it should be delivered through that mechanism. The option should be weighed against other delivery mechanisms and the wider evidence strategy of the organisation.

Pre-filter questions:

1. Is the question/aim clear?
2. Is engagement an important component?
3. Are plenty of resources available?
4. Is the spatio-temporal scale of sampling large?
5. Is the protocol simple rather than complex?
6. Would there be good reasons for motivation of participants?

Decision framework.

A decision framework developed by the UK-EOF (Pocock et al., 2014b) helps guide users in the assessment of projects to see if they are suitable for delivery through citizen science (see Fig. 1). During the planning and design of a given monitoring project the proposal can be assessed against the framework and so adjustments made to improve the citizen science relevance.

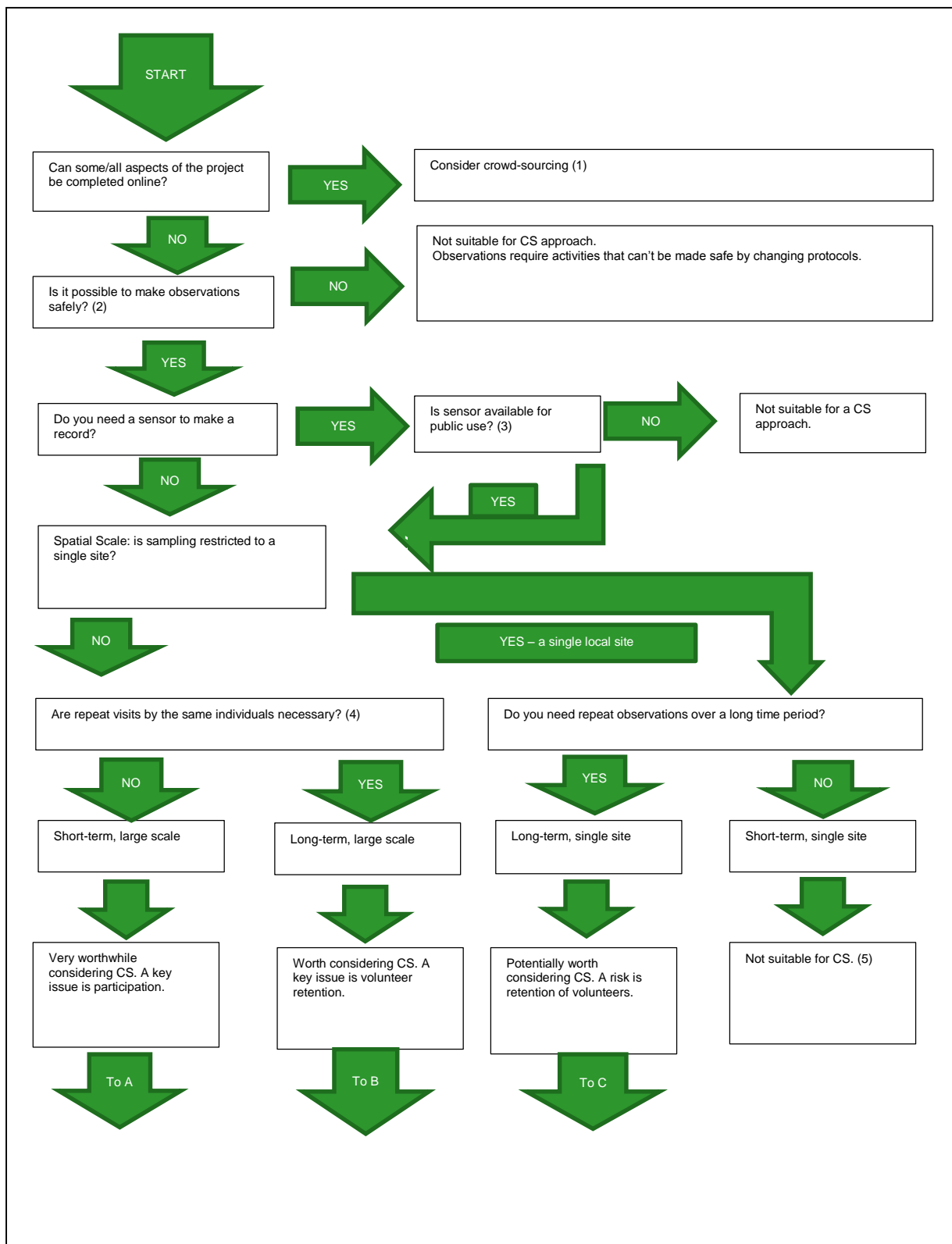
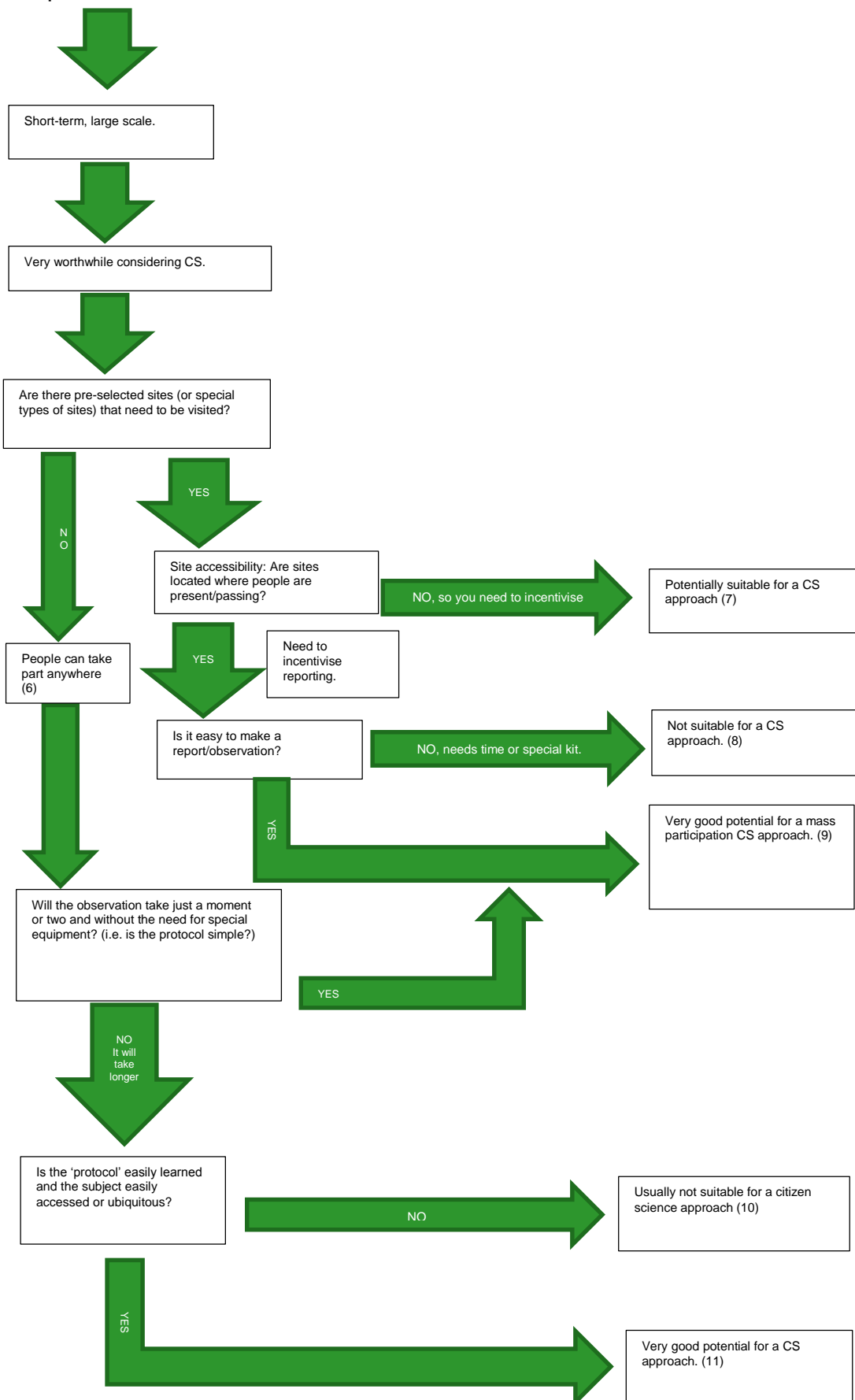
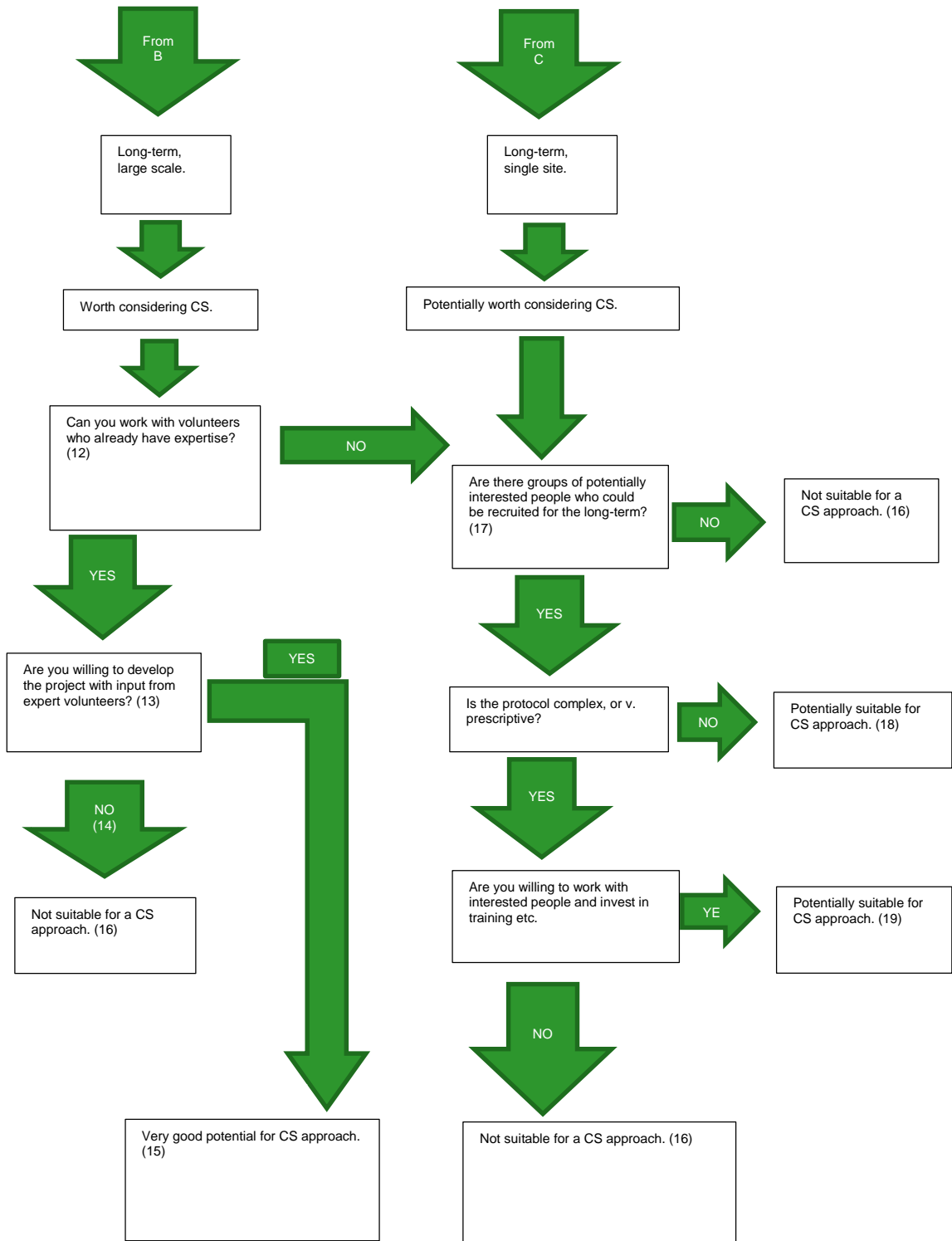


Fig 1: A decision framework for Citizen Science Projects (from Pocock et al., 2014b)

From option A



Part 2: CS decision framework from options B and C.



Notes to support the Citizen Science (CS) decision framework.

1. Here we use the term 'crowd-sourcing' to describe the sort of tasks that can easily be distributed for people to do on their own terms, especially at the computer. This is ideal for tasks that require human intelligence for problem solving or pattern recognition. Sometimes projects can be broken down to separate out-of doors observations from a crowd-sourced (computer based) component, thus permitting people to be engaged with the crowd-sourced components even when they are unable to make observations outside.
2. Safely does not mean risk free. Risk can be reduced with appropriate training but risk assessment is always needed for citizen science projects.
3. Limitations to a sensor being 'available' for public use include it being too complex or too expensive. However technological advances may quickly make sensor approaches affordable and tractable. Sensors could be made available by providing them free, or making them available to purchase (a form of 'crowd funding' of the project), hire or borrow.
4. We use the question about repeat visits rather than 'long-term', because monitoring can be long-term but collected by multiple people (from the same site or from multiple sites). Our distinction here makes clear an emphasis on volunteer retention, not just recruitment.
5. Short-term, single-site projects can be ideal to engage with people and provide education, but are less suitable for citizen science. 'Bioblitzes' (recording as many species as possible on a site in one day) are short-term, single site projects; their scientific value is due to the presence of experts, but they have an important role in public engagement with nature.
6. 'Anywhere' means people do not have to travel to somewhere specific to take part, though they may need to be in a suitable habitat. Clearly, there is a judgement to be made for each circumstance and each intended audience whether locations could be viewed as 'anywhere'. For example, depending on the audience 'large rivers' or 'arable fields' could be argued either way (most people are not near large rivers or spend time in arable farmland, but equally, a lot of people will visit large riversides, and many people could choose to visit arable farmland). Equally, a project requiring a visit to 'woodland' might require a special trip, but many people could choose to make that trip easily.
7. There are relatively few citizen science examples of trying to incentivise the visiting of sites (as is done with geo-caching), but there is potential for this.
8. Usually not suitable for citizen science due to a mismatch between the intended audience and the ease of reporting.
9. Mass participation projects can be ideal in gaining a 'snap-shot' overview of the state of something. Its success can rely on being featured in the mass media; alternatively it can take advantage of breaking stories in the news, in which case rapid response is necessary. You need to think clearly about the prompt for

involvement (why would someone take part?), and whether sample sizes will be sufficient. Asking people to record something too infrequently is not ideal because they may forget the prompt to report it (unless it is very memorable). Asking people to record something too frequently (e.g. all sightings of a common animal, or reports of river quality) is not ideal because there are too many prompts to record, hence it becomes too overwhelming and reduces motivation to submit reports. Making these observations more structured is an alternative (e.g. report your local river quality each month), but this comes under the sections regarding 'long-term' surveillance.

10. Usually not suitable for citizen science due to a mismatch between the intended audience e.g. the general public and the accessibility of the project.
11. Engaging with wide audiences to undertake something reasonably detailed is one of the classic examples of citizen science. Key questions for project organisers is why people would get involved – what is the prompt to get involved now rather than later (and potentially forget to take part), and why people would take part a second time – what are the incentives for continued engagement? Such a project definitely needs sufficient (i.e. substantial) investment in supporting resources and in recruitment.
12. It can be more successful to work with people who already have expertise (and interest) in the subject, e.g. working with birdwatchers to undertake surveys, rather than trying to recruit people who do not already have an interest in birds.
13. This question is important because, although there may be a regulatory desire to collect data in a certain way, if the intended volunteer participants are not amenable to that approach then pushing ahead with the project has a high chance of failure. However, by working with the intended participants you could work collaboratively to develop a project that is acceptable for the intended participants.
14. If you require long-term large-scale monitoring by volunteers but do not have a ready pool of willing expert volunteers then you need to think carefully about their incentive to be involved.
15. For this long-term surveillance, you need to demonstrate a long-term commitment to the project to fully engage with volunteers.
16. For this long-term surveillance, the issue of working in collaboration with your intended audience is important (see [13]).
17. This question is about the audience that you have identified. Groups of potentially interested people are often people who have a vested interest in the outcome of the surveillance, e.g. local action groups, or anglers concerned about river quality, mountain walkers concerned about invasive plants etc.
18. A key question that you need to consider is why someone would start to get involved and why they would continue to be involved.

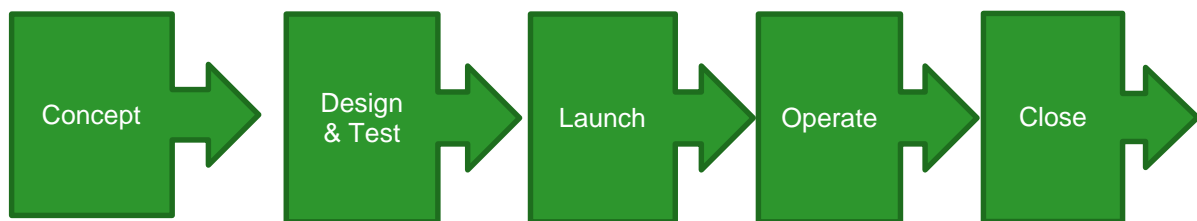
19. A key question here is whether you have the commitment to provide sufficient resources for long enough. Training participants requires time and investment. You could have quite high drop-out rates, but this approach has the potential to produce some really committed volunteers.

The life cycle of citizen science projects.

If a citizen science approach has been selected as a viable option following the pre-filter and decision framework it is important that the appropriate planning and resourcing is implemented to support the full life cycle of the project. In systematic reviews of citizen science projects the mean duration of projects appears to be 11-13 years (Roy, et al., 2012), it is sensible to consider the resources availability over such time scales.

The full project life cycle should be a key resourcing issue for each of the stages of a citizen science project (see Fig: 2)

Fig. 2: Stages in the life cycle of a citizen science project.



Successful projects have a solid concept with clear drivers and an understanding of outcomes. When such projects are developed the data and scheme requirements are clearly understood together with the target audience and the protocol to be used. At launch, the aims of the project are clearly communicated to the target audience together with the expected life span. During operation of the scheme the feedback to the stakeholders/volunteer community is essential and, at close, the outcomes and legacy of the scheme need to be communicated to all those involved. Maintaining an engaged volunteer community can be essential for future projects.

EU drivers of citizen science.

The European Environment Agency (EEA) has compiled a list of projects on biodiversity monitoring across Europe that use citizen science. This followed an Eionet consultation involving the then 32 member and 7 cooperating countries of the EEA. In citizen science biodiversity reporting schemes, those devoted to general flora and fauna are the most common (22 %), followed by those dedicated to birds (19 %), invasive alien species (13 %) and butterflies (8 %). Also 8 % of the schemes (almost 10 % including those dealing with marine invasive alien species) are especially designed for the marine environment (EEA, 2013).

Giving citizens a greater role in science is seen as a key EU engagement mechanism with a vision of "science for the people, by the people" for Europe. Some of the benefits of this concept are seen as:

- efficient and transparent use of public and private science and research funding,
- better engagement in research, governance and accountability,
- bringing European policy making closer to the people whilst basing it on scientific evidence.

European policy activities on citizen science are part of the Open Science dossier, seeking potential benefits for European researchers, competitiveness and society at large. In addition the European Commission continues to promote delivery through research policy formulation and direct support.

Europe continues to mainstream Open Science activities through '[Horizon 2020](#)', particularly through the Open Research Data pilot where valuable information produced by researchers in many EU-funded projects will be shared. The pilot supported by '[OpenAire](#)' aims to improve and maximise access to and re-use of research data generated by projects. This also contributes to economic growth through open innovation and leads to a better, more efficient and transparent science for citizens and society.

EU supported environmental programmes have also been a driver of citizen science work in the UK. Some of which are aimed at driving innovation such as the European Union's Seventh Framework Programme (FP 7) in the Environment "Developing community-based environmental systems using innovative and novel earth observations applications".

Two other key examples are firstly the LIFE programme where a total of 224 projects have been co-financed in the United Kingdom. Of these, 157 focus on environmental innovation, 61 on nature conservation and biodiversity and six on information and communication. These projects represent a total investment of €458 million, of which €207 million has been contributed by the European Union (EC Life, 2015).

The second example is INTERREG, based on 11 priorities as a contribution to the delivery of the Europe 2020 strategy for smart, sustainable and inclusive growth. At least, 80% of the budget for each cooperation programme concentrated on a maximum of 4 thematic objectives among the EU priorities. These priorities include: Research & Innovation, Environment & Resource efficiency plus better education and training (INTERREG Europe, 2015).

Mammals in a Sustainable Environment (MISE).

MISE was a c.€1.7M partnership project funded by the European Regional Development Fund under the Ireland Wales Programme 2007-2013 (INTERREG IVA) that aimed to foster involvement of communities in Wales and Ireland in mammal monitoring and conservation.

The partnership was between Waterford Institute of Technology (WIT), Waterford County Council and the National Biodiversity Data Centre in Ireland and The Vincent Wildlife Trust (VWT), Natural Resources Wales (NRW) and Snowdonia National Park Authority (SNPA) in Wales. The project aimed to survey and monitor mammal species of conservation interest, using novel non-invasive genetic techniques, and work with volunteers to raise awareness, and engage the public in mammal survey and conservation work. The training and engagement events involved nearly 400 volunteers. Priority mammals included: red squirrel, pine marten, carnivore surveys (stoat, weasel and polecat), otter, bats, harvest mice and dormice.

Outcomes of the work have been improved evidence on a number of European Protected species and other priority species supporting national reporting obligations as well as improved understanding of species ecology. Trained, engaged public are now equipped to continue to contribute to the evidence base for these species. Formation of a number of local mammal groups also remains as a lasting legacy. (see - <http://www.miseproject.ie>)

A third area where there is a major EU level initiative is the 'Citizen OBServatory WEB (COBWEB)' which seeks to empower citizens to collect and contribute data for use in policy formation and governance.

The €8.5 million, 4 year, project will develop an "observatory framework" that will enable citizens to collect environmental data suitable for use in research, decision making and policy formation. The project is built around UNESCO's World Network of Biosphere Reserves (WNBR), with test areas in Biosphere Reserves within the UK, Germany and Greece.

The infrastructure developed will explore the possibilities of crowd sourcing techniques around the concept of "people as sensors", particularly the use of mobile devices for data collection and geographic information.

The project seeks to increase the value and interoperability of crowdsourcing technology to policy makers by enabling the fusion of citizen-sourced data with reference data from a range of sources including data published by public authorities. This will be achieved through operationalization of the European INSPIRE (Infrastructure for Spatial Information in Europe) Directive, compliant national SDIs (Spatial Data Infrastructures) and GEOSS (the Global Earth Organisation System of Systems).

Concentrating initially on the Welsh Dyfi Biosphere Reserve, the project aims to leverage the WNBR and the enthusiasm of local Biosphere Reserve communities for improved environmental decision making to help develop technology that will eventually be more widely applicable.

Dyfi biosphere project.

COBWEB is currently working on the co-design and field testing of projects in the Dyfi Biosphere, with local organisations. This phase of the project provides opportunities for small groups that are already key contributors and representatives of the local community to run projects that will contribute to the development, pilot data collection.

A project aims to commence in 2015 and recruit citizen scientists from the 3000+ inhabitants of the Penparcau ward (Aberystwyth) to record observations of butterflies and their food resources (larval and adult) using innovative mobile phone and web technologies.

Indicators of volunteer involvement.

The interest in citizen science volunteering has helped inform a number of national and devolved indicators being established to help track the outcomes of policies aimed at increased volunteer involvement in the natural environment.

UK level indicators.

‘Taking Action for nature’.

<http://jncc.defra.gov.uk/pdf/UKBI2014.pdf>

Indicator A2 of the UK Biodiversity Indicators is ‘Taking Action for nature: volunteer time spent in conservation’.

The data for this indicator come from a wide ranging series of environmental bodies, many of which lead on the delivery of some of the UK’s major citizen science driven surveillance schemes. These bodies are: Bat Conservation Trust, Botanical Society of Britain and Ireland, The Conservation Volunteers, British Trust for Ornithology, Butterfly Conservation, Canal & River Trust (formerly British Waterways), Loch Lomond and The Trossachs National Park Authority, Natural England, National Parks England, Plantlife, RSPB, The Wildlife Trusts, Woodland Trust.

Wales level indicators.

‘The number of environmental volunteers.’

The Welsh State of Environment Report provides a key indicator, 24c, which includes data on the citizen science related volunteer activity levels in Wales.

<http://gov.wales/docs/statistics/2012/120725stateofenvironment12en.pdf>

<https://statswales.wales.gov.uk/Catalogue/Environment-and-Countryside/State-of-the-Environment/Our-Local-Environment/NumberOfEnvironmentalVolunteers-by-Year>

The data for this indicator is derived from the Wales Environment Link (WEL); the number of environmental volunteers in a sample of 14 WEL member organisations.

Wales Outdoor Recreation Survey – environmental volunteering.

The Welsh Outdoor Recreation Survey (WORS) measures participation in outdoor recreation by adults living in Wales, including the associated health and economic benefits. It also covers public attitudes towards biodiversity, along with actions that people take to protect the environment. The survey is classed as an official statistic.

The 2014 survey does not differentiate those undertaking citizen science specifically as part of their outdoor activities but does investigate 'pro-environmental' behaviours this include those involved in active volunteering. From the survey 12% of those undertaking outdoor activity were found to be undertaking environmental volunteering (WORS, 2015).

Welsh level activity & drivers.

There are a number of initiatives and drivers in Wales which are supporting the development of programmes leading to new or extended citizen science associated programmes.

Some of the key drivers indirectly arise from the Convention on Biological Diversity Aichi targets within the Strategic Plan for Biodiversity 2011-2020. Two targets are of particular relevance:

Target 1: 'By 2020, at the latest, people are aware of the values of biodiversity and the steps they can take to conserve and use it sustainably.'

Target 19: 'By 2020, knowledge, the science base and technologies relating to biodiversity, its values, functioning, status and trends, and the consequences of its loss, are improved, widely shared and transferred, and applied.'

Within Wales a series of Task and Finish Groups are now established to focus on the initiatives necessary to contribute to delivery.

Other initiatives include both governance (see text box) and policy initiatives which lead to Wales wide partnerships such as the Wales Biodiversity Partnership (WBP).

Citizen Science Committee for Wales.

A Wales wide body drawing membership from statutory, community and voluntary sectors which aims to:

- To collate and share good practice on Citizen Science and where possible provide inclusive guidance and advice for Wales at both the national and local scale.
- To provide specific guidance and help to deliver the OPAL-UK programme's objectives and outcomes for the long-term.
- To help ensure Citizen Science initiatives are integrated and co-ordinated with similar environmental monitoring and education initiatives in the statutory, voluntary and community sectors.
- To promote relevant activities and raise awareness of Citizen Science in Wales. Where possible ensuring support and co-ordination is given to grow the Citizen Science network in Wales, so that it is best placed to help deliver Citizen Science programme outcomes
- Developing plans for securing future sustainability of Citizen Science projects and programmes.

WBP brings together key players from the public, private and voluntary sectors to promote and monitor biodiversity and ecosystem action in Wales.

The WBP contributes to the delivery of Global, European and national targets for biodiversity and ecosystems. The role of the Wales Biodiversity Partnership focuses on:

- Prioritising and promoting activity to ensure biodiversity conservation (protection, enhancement and restoration) and associated benefits for ecosystem structure and function are planned and delivered at the appropriate scale.
- Developing and communicating the understanding of the dynamic relationship within species, between species and their abiotic environment in order to conserve ecosystem structure and function.
- Providing expertise on the conservation and sustainable use of natural resources.
- Working with local and regional partners to ensure management of the environment, and of human activity which impacts on the environment, at the appropriate level incorporating local knowledge, innovations and practices.
- Identify evidence requirements and build consensus on priorities to inform the development and delivery of biodiversity conservation and the Ecosystem Approach.

New policy initiative within Wales such as the Nature Recovery Plan, Natural Resource Management Programme and the Wellbeing of Future Generations Act will create new drivers, setting out the goals and ambitions necessary to improve the management of the Welsh environment and reverse the decline of biodiversity.

Valuing the evidence - volunteer data mobilisation.

Whilst there are some citizen science projects with the aim of generating specific types of evidence, there are a wide range of activities where volunteer data is of great value for a wider understanding of environmental change. The UK has such a long history of volunteer biological recording that work has been undertaken to attempt to improve the wider benefits of this valuable volunteer data. Two key areas of work have been the local record centres (LRCs) and the UK National Biodiversity Network.

Local Record Centres (LRCs):

Wales is in the unique position of being the first country in the UK to have a full coverage of local record centres who aim to:

Support and facilitate cooperation within and between recorders and the wider biological data community. Including arranging Annual Recorders Forums, the use of on-line & social media etc. and the provision of tools and databases for biological data.

They also organise and support events such as biodiversity recording days, other surveys and recording initiatives and capture and mobilise the resulting data.

They provide training events for biological recording with particular focus on data and records management, under recorded taxa, hard to identify taxa and taxa of local importance.

Encourage the recruitment, retention and engagement of local recorders and the mobilisation of their records through regular communication via a range of media e.g. including engagement with Schemes and Societies and Recording Groups etc.

National Biodiversity Network (NBN):

The NBN is a network of over 250 organisations coordinated by a Secretariat. Their vision is that "Biological data collected and shared openly by the Network are central to the UK's learning and understanding of its biodiversity and are critical to all decision making about nature and the environment".

The NBN collates wildlife data on-line to enable it to be used many times in accessible formats that can be widely used. It now holds c. 100million records. The vast majority of these records have been collected by volunteers (e.g. c.80% of UK invertebrate records are volunteer generated.).

The UK government, local government and non-government wildlife-related organisations all collect and use biodiversity data. One of the principal means of collation and interpretation of this data is the network of local records centres and at the national level, the Biological Records Centre that collates and interprets data from national recording schemes.

This information is vital to enable an understanding of distribution, and abundance of species and habitats. Supporting the UK's ability to fulfil EU reporting obligations, national indicators and the delivery of biodiversity obligations.

Assessing the evidence - quality assurance of citizen science generated data.

There are a large number of volunteer survey programmes active in Wales and across the UK. These include programmes run by the British Trust for Ornithology (BTO), Bat Conservation Trust and Botanical Society of the British Isles (BSBI). A number of these programmes are used by NRW and other SNCBs as a key source of data. Such uses include designated site selection as well as subsequent monitoring. For example:

- Bird features on RAMSAR sites and estuarine SPAs are designated and monitored using WeBS (Wetland bird surveys) data.
- BSBI's County Rare Plant Registers have been used extensively to revise SSSI qualifying features. The Threatened Plants Project is used to report trends and feed into revision of the British Red List and stimulate further surveys and research on these species as well as informing improved conservation protection and management.

Given the significance of the role that volunteer data can play, concerns have been raised over the risk of legal challenges to decisions based on such data. Particularly the concern that evidence derived from data collected by volunteers could be considered inherently weak simply because it is collected by volunteers (Gardiner, 2012). It is also possible that challenge may arise if such volunteer data is withheld during significant decisions e.g. designated site selection.

By following good practice in project design, training and data validation such challenges can be managed. Case law has also arisen where such issues have been considered (see European Court of Justice text box).

European Court of Justice – case law on volunteer generated data.

There is ECJ case law relevant to the use of information derived in part from data collected by volunteers. In case c-235/94, the ECJ found Spain in breach of the Birds Directive for failing to classify as SPAs a sufficient number of sites that were identified as "Important Bird Areas" (IBAs) in a list of IBAs drawn up by the Spanish Ornithological Society, an affiliate of Birdlife International. The preparation of national and regional IBA lists is coordinated by Birdlife International, but the work is undertaken by national NGOs, who rely heavily on volunteers. This case provides an example of evidence derived ultimately from volunteers, working for NGOs, being considered by the ECJ as not only robust, but sufficiently robust to be used to help determine a member states' compliance with EC legislation.

Work is also being undertaken to compare the ability of citizen science projects to detect change. Recent work has compared long-term changes to coral reefs detected by both professional and volunteer monitoring programs. Overall, site-specific temporal trends revealed by professionals were more often statistically significant than those from volunteers, which implies greater precision of the scientists' counts. Nonetheless, volunteers were able to detect important changes in benthic communities and so can have a valuable role to play in assessing change on coral reefs (Forrester, G. et al., 2015).

Overview of NRW linked citizen science projects.

As the term citizen science has only recently become popular, there are potentially a number of projects where citizen science is used as the delivery model but not explicitly associated with the project.

As a result a generic assessment has been made of the range of monitoring and surveillance activities undertaken by NRW and identified through the 2015-2020 Monitoring Review Project.

The following (Table 1) is a representative selection of activities falling within the scope of the monitoring review which have a full or partial citizen science function. The selection incorporates examples from both functional areas e.g. large-scale UK surveillance schemes and ecosystem themes e.g. terrestrial, marine or freshwater. In reviewing this picture of the diversity of activities, it is worth noting that the vast range of public reporting to NRW over environmental issues such as species protection and pollution can also be regarded as a form of citizen science.

Table 1: Citizen science examples where NRW may be a contributor to and/or a user of the generated evidence.

To illustrate the diversity of subjects and approaches.

Category of CS project	Scheme Name	Partners	Description	Drivers	Volunteers & activity	Comments
UK level surveillance scheme.	Wetland Bird Survey (WeBS)	BTO, JNCC, RSPB, WWWT	1947 – current. Around 2,400 wetlands in GB monitored monthly. All major wetlands covered and revisited each year. Count units related to designation unit. c. 100 sp. recorded.	UK and country indicators. Birds Directive reporting. Site condition assessment. SPA site selection.	Online recording and reporting now used. Further development plans include linking the results to flyway population estimates and trends from the International Waterbird Census.	NRW contribution to UK level surveillance via JNCC.
UK level surveillance scheme.	Breeding Bird Survey (BBS)	BTO, JNCC, RSPB	1972 - current 3,430 sites in UK reported in 2012, covering 219 species. Recorders detect birds along transects on random stratified 1km squares, and revisit same site each year.	UK and country indicators. Birds Directive reporting	Online recording and reporting now used. Involves c.2,800 volunteers. Currently working on how to statistically describe change in communities so we can better understand environmental change.	NRW contribution to UK level surveillance via JNCC.
UK level surveillance scheme.	Bird demographic monitoring: National Ringing Scheme & Nest Record Scheme	JNCC, BTO	CES 1986 – current. RAS 1998 – current. Almost 1 million birds of c.260 sp. ringed yearly, including birds from over 120 Constant Effort Survey (CES) sites and 163 Re-trapping Adults for Survival (RAS) studies. 35-40,000 nests recorded annually in GB, covering >150 sp.	Detecting impacts of pressures and interventions.	Strategy is to deliver demographic information for a range of species with a wide range of functional and habitat requirements. Aims to be able to use the data more routinely to interpret the likely environmental factors affecting the species in the UK.	NRW contribution to UK level surveillance via JNCC.
UK level surveillance scheme.	Rare Breeding Bird Panel (RBBP)	JNCC, RSPB, BTO	1972 – current. Scheme collates records of rare breeding birds, including up to 76 regular breeding species in the UK.	UK and country indicators. Birds Directive reporting.	Currently investigating whether it can cover a wider range of species to meet reporting requirements. May be a more efficient means of getting data than periodic single	NRW contribution to UK level surveillance via JNCC.
UK level surveillance scheme.	National Bat Monitoring Programme.	JNCC, NE, SNH, BCT, NI	A large-scale monitoring scheme which uses standardised methods for assessing population trends at a national scale. It consisted of four survey types, each designed to monitor different species and undertaken by volunteers.	UK and country indicators. Habitats Directive reporting. Site condition assessment.	Since 1996 c. 2200 volunteers have contributed to the scheme. Four surveys provide the required data: i) Field and Waterway Surveys ii) Hibernation Surveys in the winter iii) Maternity Roost Counts	Sufficient data are collected to produce population trends for 11 of the UK's 17 resident bat species. Separate trends have been included for England and Wales where coverage is sufficient.
UK level surveillance scheme.	UK Butterfly monitoring Scheme	CEH, BC, JNCC, NRW, NE, FC, SNH. (BTO are partners in the Wider Countryside Butterfly Survey component of the scheme.	Large scale UK level scheme focussed on transect surveys covering 71 species. c. 30 species for Wales reported as individual trends.	UK indicators, Habitats Directive reporting and Site condition assessment.	Since 1976 around a quarter of a million weekly visits to more than 1,500 separate sites, walking over half a million kilometres and counting over 16.4 million butterflies	2013 1,212 sites were monitored including 65 in Wales.
UK Level NGO scheme	Open Air Laboratories - OPAL	Multi NGO programme partnership led by Imperial College London	2007- current. Started via a £11.7M grant from the Big Lottery. Aims to: Engage people with nature and key environmental issues. Provide a learning experience and all the health and well-being benefits from being outdoors. Provide valuable data to help professional scientists understand the state of the environment.	Delivers information on Biodiversity, Water & metals, Air, Soils and INNS.	Since launch OPAL has: 23,000 sites; involved 850,000 volunteers and 6 active surveys in Wales.	6 active surveys in Wales but with intentions to expand e.g. Observatree is a collaboration between Forest Research, the FC, APHA, Defra, Fera, the NRW, NT and the Woodland Trust. Funded by the EU's Life programme. Monitors the health of and identify pest and disease threats to UK trees.
UK level Terrestrial NGO schemes	Bees Wasps & Ants Recording Scheme (BWARS)	Volunteer recording society, operating under the UK Biological Records Centre	1978 – current. Voluntary recording scheme with 500,000 records. aims to promote the recording of aculeate Hymenoptera in Great Britain and Ireland.	Species distributions site based assessments, Species Recovery programme and Red listings of threatened invertebrates.	c.500 members. The vast majority of members are volunteer naturalists.	Provides advice, via Hymettus, to the 3 statutory countryside agencies in England, Scotland and Wales.
UK level Terrestrial NGO schemes	British Mammal Society - Atlas	Multi-agency sponsored charity.	The Mammal Society runs surveys and ongoing monitoring projects. Surveys collect statistical, detailed information on mammals, while monitoring projects collect vital distribution records and can identify population change. This feeds into The National Mammal Atlas Project (NMAP), which aims to produce a thorough, recent baseline of mammal distribution	Habitats directive and national status and distribution reporting.	Volunteers can contribute to a number of surveys: - Footprint Tunnel Survey - National Owl Pellet Survey - National Harvest Mouse Survey - Mini Mammal Monitoring & Harvest Mouse Survey	

			data. Data contributes to the National Biodiversity Network.		And submit records via a mobile phone app.	
UK level Terrestrial NGO schemes	Botanical Society of the British Isles.	Multi-agency sponsored body with a charitable basis.	Plant survey and recording work delivering records of plant species on SSSIs and the wider countryside. Development of a threatened plant project methodology.	Habitats Directive reporting and Site condition assessment.	Volunteer recording has produced the County Rare Plant Register as well as site based information.	
UK level joint Terrestrial & Freshwater scheme	Mammals in a Sustainable Environment (MISE)	Multi-agency supported programme from Ireland and Wales.	The project aims included engaging the public in mammal survey and conservation work using novel genetic techniques. Priority mammals included: red squirrel, pine marten, carnivore surveys (stoat, weasel and polecat), otter, bats, harvest mice dormice and small mammals.	Distribution and status of mammals including Habitats Directive species.	The training and engagement events involved nearly 400 volunteers.	
UK level freshwater scheme.	Anglers' Riverfly Monitoring Initiative (ARMI).	Rivers' Trusts, Wildlife Trusts	2007 – current. Simple monitoring technique, using caddisflies, mayflies and stoneflies as water quality indicators, which groups can use to detect any severe perturbations in river water quality.	Instigate pollution incident investigations under WFD by NRW. Not used for WFD classification.	App "Match A Hatch", that identifies all riverflies launched in May 2015. Online Riverflies Monitoring database developed by Freshwater Biological Association (FBA) 2014.	Formerly known as Anglers' Monitoring Initiative (AMI). Distributed across Rivers Trusts in Wales. Severn Rivers Trust has trained 2,017 volunteers in the Severn catchment (England & Wales). Only one site on River Wye SAC is regularly sampled (Nyth) = 3 hours survey per annum.
Local freshwater scheme.	Irfon Special Area of Conservation (ISAC) Project	Wye & Usk Foundation (WUF), Rivers' Trust, CCW, EAW & National Museum Wales	2010 – 2013 EU LIFE project. River Irfon (sub-catchment of River Wye SAC) restoration project.	Monitoring data re-used for SAC species population condition assessment. Provides supporting information on barriers to migration, water quality and site management.	Project completed.	This is the only example of FW SAC features being surveyed by an NGO, with EA hired to do the lamprey electro-fishing. Volunteer effort focussed on walk over surveys, barriers etc.
Local freshwater scheme	Project Usk River Restoration (PURR2)	WUF, NRW, Beacons Trust	2012 – 2013. Japanese knotweed survey of River Usk SAC & tributaries.	INNS survey & management.	Project closed.	N/A
Local freshwater scheme	Protecting Wales' pond wildlife	Freshwater Habitats Trust, WG & NRW	A PondNet element of the People, Ponds and Water Project. The trial phase was funded by the EA and Natural England in England (4 counties only) over 2 years.	Section 43 NERC Act freshwater pond species	No. volunteer hours and sites (the whole project involves other volunteer activities but only biological monitoring data is provided here): 2015: 910hrs on 76 sites (5 of which SAC/ SSSI)	Heritage Lottery funding is supporting the roll out over the whole of England and Wales. Data used to monitor: great crested newt, common toad, 11 other S42 plant and invertebrate pond species in Wales. Also used for change in condition of ponds in wider countryside and condition of ponds on Flagship Pond sites (pond sites identified as priority habitat in the UK Pond HAP).
Local freshwater scheme.	Great crested newt – annual monitoring programme	North East Wales Wildlife Trust (NEWWT) & NRW through a Section 15 SSSI management agreement.	Annual population counts of great crested newts at all life stages and annual training course. Records shared with NRW, WG, 2 L.As, ARC & Cofnod.	NRW uses data for: SAC & SSSI condition assessments. Reporting population trends for Article 17 and site management agreement.	Provide an annual protected species & survey methodology training course. In 2015, 115 hours of volunteer survey time including night time visit were conducted in numerous ponds on the a number of SAC newt sites.	Proposing to undertake Habitat Suitability Index (HIS) surveys
UK level Marine scheme	Seascope	Multi-agency supported body.	Mid 1980s – current. For volunteer sports divers to undertake recording. The main aim is to map out the various types of sea bed found in the near-shore zone around the whole of the Britain and Ireland. In addition to recording what lives in each area, establishing the richest sites for marine life, the sites where there are problems and the sites which need protection.	Base-line mapping.	2013 data produced 96 surveys generating 51,000 species records from 933 species, 1,825 biotopes identified and 1,773 reports submitted (11% from Wales). Range of training courses provided maintain data quality.	Ongoing.
UK level Marine scheme	Seawatch Foundation	Supported by a multi-agency partnership programme from both a	Aims to involve the public in scientific monitoring and so improve the understanding of the pressures on the marine mammals.	Marine mammal monitoring.	Cardigan Bay Monitoring Project gathers data on marine mammal use of the local area using photo-identification, line transects, land-based and acoustic	Ongoing.

		UK and wider sponsor base.			surveys which are used to monitor their abundance, reproductive success, population structure and distribution.	
Local Marine scheme	Cardigan Bay Marine Wildlife Centre		1996 - current Aims to conserving Cardigan Bay's marine wildlife through education and research. Licences (issued by NRW) enable photo- ID work used to investigate connectivity between sites, which helps inform NRW advice.	Cetacean monitoring	Comprising land based and boat based survey data, a large amount of which were collected by volunteers either as part of organised surveys or through ad-hoc observations.	The volunteer generated data contributes to important bodies of evidence such as The Atlas of Marine Mammals of Wales, which was commissioned by CCW, is a collation of data from across Wales.
UK level Marine scheme	The Great Eggcase Hunt	Membership based charity.	2003 – current. Run by the Shark Trust from original work by the Welsh Skate and ray group. Aims to engage the public in hunting for spent shark, skate and ray egg-cases along the UK coastline ever since. Helps gather more information on the important nursery grounds for sharks skates & rays.	Distribution of British sharks, skates and rays.	Volunteer generated data has contributed to an extensive database of egg-case records, which continues to provide crucial information about the distribution of British sharks, skates and rays.	Ongoing.

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