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PERSPECTIVE

The role of 'Big Society' in monitoring the state of the natural environment

Colin Mackechnie,*[a] Lindsay Maskell,[b] Lisa Norton[b] and David Roy[c]

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Environmental monitoring is essential for assessing the current state of the environment, measuring impacts of environmental pressures and providing evidence to government. Recent UK government announcements have indicated an increased role for 'Big Society' in monitoring. In this paper, we review available literature concerning the use of citizen science for monitoring, present examples of successful volunteer monitoring work and highlight important issues surrounding the use of volunteers. We argue that in order to ensure that environmental monitoring continues to be effective it is important to learn from examples where volunteers are currently used, acknowledging constraints and identifying potential approaches which will help to maximise both their engagement and data quality. Effective partnerships between environmental monitoring organisations and volunteers may thus aid the UK in developing robust coordinated monitoring systems that will be less vulnerable to funding variances.

Introduction

The world faces fundamental environmental issues and challenges. Human activities have led to substantial and potentially irreversible loss in the diversity of life, brought about through changes to ecosystems to meet rapidly growing demands for natural resources such as food, fresh water, energy and materials.[1] Monitoring the state of the natural environment is essential to identifying environmental problems, helping to understand drivers of change and testing the effectiveness of national and international policies to reverse declines. In addition, governments have a multitude of legislative and statutory obligations and commitments to meet. Measuring and monitoring the natural environment provides evidence for such reporting obligations.[2] and underpins the development of environmental policies.

The ongoing economic crisis has left many governments with large budget deficits. One solution is the reduction of government expenditure. For example the Republic of Ireland's National Recovery Plan[3] aims to reduce expenditure by €15billion by 2014. In the UK, the latest government spending review aims to reduce spending by £81billion (~€90billion) by 2014.[4] Such reductions in government expenditure could mean a reduction of funds for environmental monitoring. Continuing to use the UK as an example, recent UK Government policy speeches[5,6] have described the use of Big Society as a way to compensate for reduced funding. In particular, the Secretary of State for the UK's Department for the Environment and Rural Affairs (Defra) when launching the consultation on the Natural Environment White Paper, described the 'new opportunity to hand over control to local people'.[7] In the field of environmental monitoring, this policy potentially results in changes to the interaction between environmental science and local communities. Thus, to reduce costs, the implication is that government intervention will be reduced and the current mixed environmental monitoring market will move to become closer to a free

[a]*Centre for Ecology & Hydrology, Maclean Building, Wallingford, OX10 8BB, UK. E-mail: cmackechnie@ceh.ac.uk*
[b]*Centre for Ecology & Hydrology, Lancaster Environment Centre, Bailrigg, Lancaster, LA1 4AP, UK*
[c]*Centre for Ecology & Hydrology, Maclean Building, Wallingford, OX10 8BB, UK*

Environmental impact

The recent austerity measures announced by various governments *e.g.* Greece, Ireland and UK will have a significant effect on public spending, and potentially on government funded environmental monitoring. The paper aims to review current volunteer monitoring (particularly in conservation) and identify the common aspects for big society environmental monitoring. Scientists and stakeholders across all types of monitoring (some of whom may be less familiar with volunteer monitoring) will have improved knowledge of the process and can design monitoring schemes to maximise the use of volunteers and minimise the effect of government austerity measures. The intended outcome is to ensure that high quality, scientifically robust environmental monitoring can be maintained despite decreasing government funding.

market. At the same time it remains essential that the evidence from environmental monitoring continues to be reliable because it underpins policy decisions and wider public benefits *e.g.* the annual £88m spent on environmental monitoring underpins up to £6,000m of benefits to the UK.[8] The use of 'Big Society' within science is a long established tradition, although it is more normally referred to as citizen or volunteer science.[9] Within biodiversity monitoring, and for particular taxa the voluntary sector has been central to the delivery of monitoring over several decades[10,11] with around 22% of UK environmental monitoring activities receiving no government funding.[8] However, a reliance on volunteers to fulfil all environmental monitoring requirements could potentially lead to a failure in those areas where citizen science is not likely to be effective.

The purpose of this paper is to:

1. Highlight the need for and stimulate the debate within and between environmental monitoring organisations about how they respond to this new policy.

2. Highlight best practice examples where citizen science engagement is already integral to monitoring important elements of the environment.

3. Identify advantages and disadvantages of a citizen science approach and develop an understanding of limitations.

4. Identify the factors that need to be considered in adapting monitoring schemes to enable significant citizen science involvement which will result in a robust, validated evidence base.

Using the UK situation as a case study, two examples of monitoring schemes which involve volunteers are presented – one using pre-existing individual interest monitoring (*e.g.* bird watching), and a second where there is little pre-existing volunteer activity. These monitoring schemes are explored, alongside, further examples, to indicate how Big Society involvement may or may not contribute successfully to environmental monitoring. Although the case study is the UK, the conclusions are applicable across monitoring schemes elsewhere.

Biodiversity monitoring by volunteers

Terrestrial biodiversity surveillance in the UK involves at least 30 organisations, including the regional administrations and their agencies, Non-Governmental Organisations, societies and research bodies, often in partnership.[12] Many schemes rely on volunteer observers to some extent; with an estimated value of over £20 million during 2007–08, supported by approximately £7 million of government funding.[12] Species recording has a long tradition in Britain and Ireland with the earliest records dating from the early part of the 17th Century. This activity spans a wide range of species groups and volunteer involvement is extensive. Over 80 national schemes and societies, operating as charities (not for profit organisations providing public benefit), co-ordinate the activity of several thousand individual volunteers. For example, over 20,000 people are currently contributing records of bird sightings towards an Atlas of British Birds.[13] Although birds are the most systematically recorded species group, national recording schemes span many other groups including mammals, plants and a wide range of invertebrate groups. Governmental organisations support this extensive activity, mostly as partners within the National Biodiversity Network (NBN) which acts as an umbrella body for organisations collecting or interpreting biodiversity data in the UK. The NBN, through its internet portal the NBN Gateway has collated, integrated and disseminated over 56 million individual records or species across Britain and Ireland;[14] online databases operated by the BTO for birds provide access to even greater numbers of records, currently more than 150 million. This data has been used to provide evidence of the impact of environmental change on biodiversity such as the impacts of recent climate change,[15] nitrogen enrichment through industrial and agricultural pollution[16] and habitat degradation.[17]

Large collations of volunteer-collected data demonstrate the potential of Big Society monitoring as a barometer of the health of the environment. However, provision of evidence from such monitoring programmes is not cost-free, but rather relies on long-term support in terms of volunteer liaison, data handling, quality assurance, publication and statistical support for measuring trends. For example while specific projects to map the distribution of a whole taxonomic group through an atlas often provides a focus for ongoing species recording; atlas projects often run for a decade or more, beyond the time frame and funding of most research projects. Sustained support for such projects in the United Kingdom has been provided by the British Trust for Ornithology (for birds) and the Biological Records Centre (helping to co-ordinate the activity of national schemes for most other species groups) with co-support from the Joint Nature Conservation Committee (both BTO and the BRC) and the Natural Environmental Research Council (supporting the BRC).

Monitoring atmospheric pollutants

The National Ammonia Monitoring Network (NAMN)[18] is part of the UK Eutrophying and Acidifying atmospheric Pollutants (UKEAP) network which has measured air pollutants at rural sites across the UK over the past two decades on behalf of Department of Environment Food and Rural Affairs. UKEAP sits within the framework of UK pollutant monitoring and contributes to the research effort investigating the flow of chemicals in the environment. With ammonia as a measurand, the network cannot tap into pre-existing individual monitoring organisations. However NAMN has organised and recruited volunteers (Local Site Operators - LSOs) who are an essential part of the network: they collect, replace and return the sampling devices for analysis. The NAMN coordinating bodies employed a number of strategies to create and operate the network successfully with LSOs: the sampling device was designed for easy handling,[19] they run at least one site themselves to provide quality assurance, training and instructions are provided and periodic operator and stakeholder meetings – often through socially oriented events such as a dinner - are arranged to provide knowledge exchange. However, the NAMN requires samples from across the UK and unpaid volunteers do not provide this coverage. To ensure there is adequate coverage, NAMN pays some site operators travelling expenses or an honorarium. Even including this, the use of the LSOs saves Defra an estimated £70,000 pa.

Key requirements for volunteer monitoring

Quality assurance and standardisation of method

Use of the standardised sampling device for the NAMN illustrates part of a key requirement for environmental monitoring:

the measurement process must be calibrated, verifiable, repeatable, and use documented procedures i.e it is quality assured. In some cases these processes may be required to conform to an accepted accreditation status. Use of QA and accreditation to agreed standards means that measurements from differing temporal periods or geographic regions made by different individuals can be compared with confidence; it allows for the back correction of previous analysed samples, the use of the data for modelling and it allows for a change in volunteers without loss of knowledge. There is evidence[20] from wildlife conservation that effective monitoring can be done using a Quality Assurance process. Quality Control to ensure that the documented protocols are being interpreted correctly by those carrying them out is also essential. Without QA and QC, although the quantity of data increases, only a proportion of that is useable.[21] Use of unvalidated data may lead to erroneous results and interpretations. Currently for most environmental monitoring quality assurance is specific to particular tasks, it may be that there is a requirement for an UK wide Environmental Monitoring accreditation (similar to UKAS or ISO laboratory accreditation) that allows end users to be confident that data has come from a monitoring organisation with an accredited process. An example of the use of documented protocols, staff training, quality control and quality assurance is the UK Countryside Survey,[31] carried out by professional surveyors. In 2007 the survey involved interviews and botanical testing for applicants, a 4 week training course, visits from experienced surveyors and data checking early on in the survey (QC) and QA exercises on all aspects of the survey. This survey used paid staff in part due to the importance of high quality data collected according to rigorous field protocols.

Expert and technological limitations

As in any other professional field, there are aspects of environmental monitoring which are beyond the capability of untrained volunteers *e.g.* highly technical processes such as DNA analysis, or identification skills for particular species/habitats. Big Society can still play its part *e.g.* through the collection of samples, or providing access to sites and through very simple protocols across many sites[22] or the use of volunteer experts. A well known example of this is the Open Air Laboratories Network (OPAL) which aims to get over one million people more aware of their open spaces and to participate in monitoring the state of the environment.[23] The Predatory Bird Monitoring Scheme (PBMS) is another example which relies on volunteers to send in dead birds. It receives around 450 samples per annum on which autopsies are carried out to provide a measure of chemical contamination in the natural environment and the impacts of a range of non-chemical threats. The PBMS is a good example of a designed monitoring scheme that takes account of expertise to create the optimum mix of professionals and volunteers to produce cost effective monitoring. However for some monitoring schemes the expertise cannot be separated so easily from the collection and a high degree of biological skills are required. Some species groups *e.g.* birds and butterflies have skilled amateurs who are able to identify species and interested in the whole taxa. Hence the success of schemes like the BTO ones and the Butterfly Monitoring Scheme. Other species groups including plants are more difficult both because of the range and number of types as well as the extent to which they attract interest *e.g.* there is little public interest in bryophytes, lichens, sedges, grasses. Plant recorders tend to prefer rare or attractive species confined to high quality habitats. Monitoring schemes like Countryside Survey which require quantitative recording of all plant species in large numbers of plots within specific 1km squares in areas which are generally of low botanical interest are likely to be of limited appeal to amateur botanists.

In order to ensure high quality data collection, where it is required, the professional environmental community must identify areas where expertise or technological limitations are likely to be a barrier to involvement of volunteers. The process of doing this will enable recognition of areas where improvement of protocols or technical kit may enable greater use of volunteers, as in the NAMN example.

Incomplete monitoring

For some monitoring activities it is of key importance that monitoring is both spatially and temporally representative. For example, Countryside Survey (CS) provides information at a national level, for specific time intervals. CS is a labour intensive survey where multiple measurements are taken across GB 1km squares, some of which are remote and not easily accessible. Failure to collect data of a consistent quality from all sites during the specific survey years would have significant impacts on the statistical validity and representativeness of the data collected. The use of paid trained scientific staff ensures that all data is collected at all squares at the appropriate time. For monitoring schemes exclusively carried out by volunteers incomplete monitoring can take a number of forms:

Geographic – remote and unpopulated areas as well as areas perceived as 'less interesting' will be less well represented in the sample. This can be countered *e.g.* the NAMN pays an honorarium for collection from remote sites.

Temporal – datasets become more valuable with time but discontinuities in data collection can be problematic. Consistent regular monitoring can be particularly useful in situations where evidence is needed fast, *e.g.* In 2010 the Environmental Change Network[24] provided evidence from monitored vegetation plots to the UK Government to determine that chemical deposition from the Icelandic volcanic eruption would not cause health problems for cattle.

Species/Science area – some areas of science attract more volunteers than others. For example bird monitoring is popular and can be coordinated and quality assured[25] largely because there are a large number of expert volunteer bird watchers in the UK (and a comparatively small number of bird species), but the data quality remains subject to geographic and temporal limitations. Conversely, although some plant monitoring is carried out by expert volunteers[26] in general vegetation or soil monitoring attracts smaller numbers of experts and therefore often needs to be carried out by paid experts ensuring high data quality. An example of monitoring which demonstrates the impacts of the use of non-paid *versus* paid experts is a survey of biodiversity on farmland carried out between 2000 and 2003 which included among other taxa, birds and vegetation.[27] Considerable effort was put into recruiting volunteers, providing

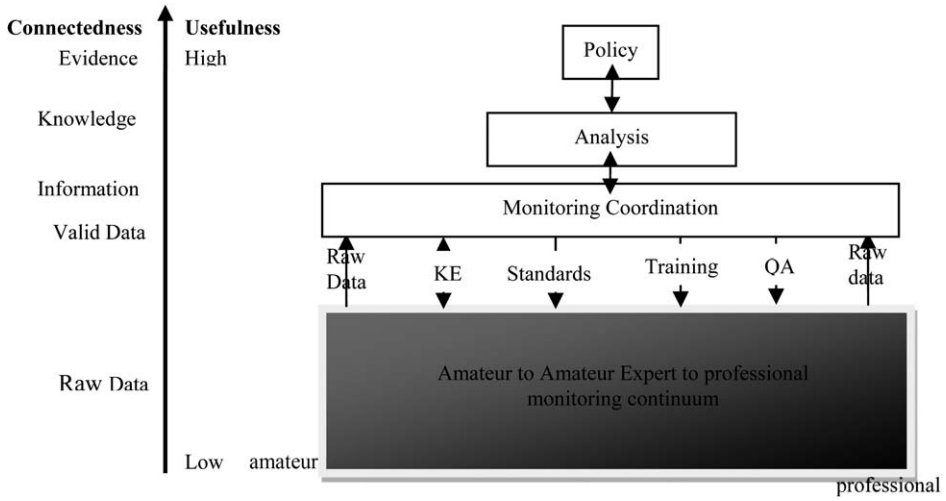

Fig. 1 The interactions required to convert raw data to evidence; illustrating the monitoring as a continuum between expert and amateur monitoring; the need for a coordination group and the interactions therein.

materials and instructing them in bird survey techniques to cover the sample of 89 farms pairs selected for the study, by a paid staff member at the BTO. Ultimately given the distribution of sites and the need for work to be temporally aligned with other survey work on the farms, staff on short-term contracts with the BTO were used to fill gaps where no volunteers could be recruited. In contrast the vegetation aspects of the survey, which required intensive sampling in and around a cereal field on 89 pairs of farms, were covered by four professional staff trained in botany. Whilst staff costs were certainly higher overall for the vegetation aspects of the survey there were staff costs in terms of training and recruitment as well as managing logistics and employing survey staff for the bird surveys. Additionally, datasets were complete for all aspects of the vegetation survey, with all 89 pairs of farms surveyed compared to 61 farm pairs for birds with some missing associated habitat data which bird surveyors had been asked to collect.

Knowledge exchange

A key element of any volunteer monitoring is knowledge exchange. Individuals will be involved in monitoring for a number of reasons that can be summed up through Maslow's hierarchy of needs:[28] Belonging (social interaction)[29] leading to self-esteem (group status) and finally self-actualisation (realising one's own potential). In the examples described above, explicit activities are carried out that allow realisation of these needs *e.g.* the creation of a species atlas or the NAMN dinners. To design appropriate volunteer monitoring schemes this must be accounted for to make the relationship, and the monitoring scheme, work. There must be a two way exchange of information and respect[30] that allows a volunteer to understand that their individual contribution has been recognised and has contributed to the whole. For example with the PBMS an individual who submits a bird to the scheme receives a copy of the autopsy report (acknowledging the contribution) and can see the species analysis on the PBMS website. Without this type of interaction, the volunteers will soon stop providing the raw data. For ecologists working with landowners, whether that is monitoring on their land or actually using them as data providers *e.g.* on management, the importance of feedback cannot be overemphasised and should be incorporated into the design/costs of monitoring.

Coordination

For monitoring exclusively carried out by volunteers an area of key importance is co-ordination. Effective co-ordination representing the interests of the volunteers, the professionals and the end users *e.g.* policymakers, is essential in order to ensure successful monitoring. It is through this approach that a clear vision, strategy and framework can be determined. It overcomes the drawbacks outlined above, and enables useful data to be analysed, modelled and combined as shown by the activities of the BRC.

Fig. 1 illustrates the interactions required to convert raw data to evidence. Coordination sits in the middle and is essential to providing useful data for the analysis and modelling required in order to develop understanding. It is this understanding that provides the evidence to formulate or validate policies. The lower part of the illustration shows the continuum between professional and volunteer monitoring. Research is needed, drawing on social science expertise on successful engagement with volunteers and environmental monitoring expertise to help achieve the optimal balance between professional and volunteer for a particular monitoring scheme.

Conclusion

Environmental monitoring in the UK has to adapt to the current era of austerity and the political driver of 'Big Society'. The current engagement of volunteers in UK monitoring provides valuable data. Any increase in the use of volunteer monitoring needs to build on its successes whilst recognising its constraints. Bodies carrying out environmental monitoring and users of their outputs need to safeguard valuable monitoring time series and highlight where volunteer data collection may be

inappropriate. Where decisions are taken to widen the potential for public engagement in environmental monitoring at local levels careful management needs to be implemented to ensure successful monitoring. Co-ordinating bodies which are inclusive are required to provide an overview of the monitoring and feed validated data into the professional analysts to provide evidence for policymakers. These bodies should encourage systematic, high quality, objective data collection which is consistent within and between areas/countries but aimed at providing information needed for locally relevant concerns.

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