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Where next for macroecology: citizen macroecology?

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symposium summary

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2nd annual symposium of the British Ecological Society's Macroecology Special Interest Group – Sheffield, UK, 10th–11th July 2013

Introduction

Following the success of the first meeting of the British Ecological Society's (BES) Macroecology Special Interest Group in 2012 (see Keith et al. 2012), the second annual meeting of the group took place at the University of Sheffield in July 2013.

The main themes were the 'big data' approach to testing general theory in macroecology, the role of citizen science, and the drafting of a 'manifesto for macroecology'. There was an overt focus on the current limitations of macroecology, centred on a set of five 'provocations' that were put forward early on and returned to repeatedly. These were statements (designed to provoke): (1) that macroecology is now limited by theory, not data availability; (2) that we cannot study natural systems without consideration of human influences; (3) that meaningful predictions of ecosystem-level responses to climate change cannot be generated through modelling, because we can never model every interaction; (4) that functional groups, rather than species, are the meaningful units for macroecological analysis; and (5) that macroecology needs a 'flagship project'. The meeting's keynote speaker was Ethan White (Utah State University, USA), who focused on one potential flagship: the pursuit of a unifying theory. The other talks were a mix of 5-minute presentations by delegates interspersed with a few longer contributions on topics related to collecting and analysing large datasets.

The main point emerging from the discussions and presentations was that, contrary to the first provocation, macroecology is still strongly limited by data availability, especially data with fine-scale coverage over large spatial extents and, ideally, through time. Citizen science frequently arose as a possible avenue for resolving the data deficit. Indeed, macroecology and citizen science inherently have much in common.

Citizen macroecology

Citizen science—the contribution to scientific research by non-specialists—has the potential to enable fine-grained data collection over large spatial extents and through time, beyond what would be feasible by scientists alone, given our limited time and resources (Devictor et al. 2010, Tulloch et al. 2013). We consider much of the ecological and biogeographical research undertaken as 'citizen science' to be macroecology, and argue that macroecology should harness its potential more.

Done well, citizen science promotes public interest in, and awareness of, science. In turn, active public engagement can strengthen the impact of the research (Dickinson et al. 2012). The discussions in Sheffield identified a need for greater public engagement with macroecological research, suggesting that macroecologists would do well to engage with citizen science sooner rather than later.

Below we outline, and then discuss in the wider context, three areas of citizen science representing a selection of the research presented at the Sheffield meeting: (i) developing citizen science projects and engaging the public; (ii) the opportunities and challenges surrounding the use of volunteer-collected data; and (iii) digitising museum collections for macroecology.

Developing Citizen Science Projects

Heather Sugden (University of Newcastle, UK) described a very successful ongoing citizen science project. The Big Sea Survey[1] is a project in which volunteers in the North East of England have filled a large data gap for intertidal species' occurrences along a 150 km stretch of the local coastline. The success of this project stems in part from the flexi-

1 http://www.bigseasurvey.co.uk/, last accessed 21/01/2014

ble nature of the project, specific training and open data.

As part of the Big Sea Survey, volunteers may contribute as much or as little time as they please, meaning that they are less likely to feel pressured and leave the project. Training is initially given on only five species per volunteer so that a high level of accuracy for both presence and absence can be assumed. Data collected are viewable by all volunteers, so that they can see exactly what they are contributing to. Alongside this, it also seems that friendly competition amongst the participating citizen scientists is promoting dedication to the cause. The overall result of this project so far is that there is now a high-quality dataset (as judged by rigorous checking of a sample of the data) consisting of 34,000+ records for this stretch of coastline.

The Big Sea Survey illustrates that the key to a citizen science project's success is often its initial design. The data need to be collected in a methodical way, with accurate metadata available (Bird et al. 2013, Tulloch et al. 2013), and the project needs to be devised in such a way as to adhere to the interests and motivations of participants, therefore encouraging their engagement with the project (see Roy et al. 2012). Finally, results should be fed back to participants as a reward for their work (Silvertown 2009).

Using Citizen Science data

Ethan White's keynote talk demonstrated that volunteer-collected data can be used for testing and refining theory. White argued that a general theory needs to be tested across multiple taxonomic groups and geographic areas; this scope is achievable given the broad spatial- and temporal-scale data available from multiple national monitoring schemes (White et al. 2012). The data used included examples of well-established and controlled citizen science initiatives: the North American Breeding Bird Survey[2], the Christmas Bird Count[3] and the North American Butterfly Count[4].

Louise Barwell (University of Leeds and NERC Centre for Ecology and Hydrology, UK) showed how occupancy–area relationships can be used to downscale species' occupancy, exemplified using dragonfly records from the Biological Records Centre (BRC)[5]. The BRC works with well-established volunteer recording schemes including, but not limited to, the Bat Conservation Trust, the British Trust for Ornithology, and Butterfly Conservation to collate and analyse datasets and improve data quality. The BRC data have been used recently to influence policy decisions in the form of the UK biodiversity species indicators (Defra 2013).

One of the main concerns about using citizen science data is that of quality. Bob O'Hara (Biodiversität und Klima Forschungszentrum, Germany) talked about some of the statistical challenges facing macroecologists, with one such challenge being the way that we deal with sampling procedure and resultant bias. The tendency for citizen science data to have variable levels of quality necessitates techniques to deal with bias (Bird et al. 2013). Careful design can help reduce the biases at the planning stage (Devictor et al. 2010) but is unlikely to fully ameliorate these biases. Estimation of sampling effort (and thus part of the bias) and the use of missing-data models (see Nakagawa and Freckleton 2008 for a discussion) are both potential, but partial, solutions to this issue. Methods specific to issues with citizen science data are being developed (see Bird et al. 2013 for an overview), and further research will ensure their improvement. Bird et al. (2013) discussed and compared some of the statistical techniques available for accounting for sources of error in citizen science data. These include hierarchical models to model sampling processes and mixed-effects models to account for sampling bias. They concluded that emphasis should be placed on good sampling design and careful consideration of model choice based on issues present in the dataset.

Scientific computing skills are important to deal effectively with the large volume of hetero-

2 https://www.pwrc.usgs.gov/bbs/index.cfm, last accessed 21/01/2014
3 https://www.pwrc.usgs.gov/bbs/index.cfm, last accessed 21/01/2014
4 http://www.naba.org/butter_counts.html, last accessed 21/01/2014
5 http://www.brc.ac.uk/, last accessed 21/01/2014

geneous data produced by citizen science. Appropriate training, such as that provided by Software Carpentry[6], will enable macroecologists to more efficiently process and analyse data. Improved scientific computing skills will allow researchers to be more efficient and collaborative, and the resulting science to be more open and reproducible (Wilson et al. 2014).

Crowdsourcing Museum Collections

At the Sheffield meeting, the notion of museums as 'biodiversity hotspots' was put forward by Shai Meiri, who discussed the potential value of museum collections to macroecological research (also see Beck et al. 2012 and Boakes et al. 2010). Underutilisation of museum and herbarium data often results from the fact that they are not digitally available, especially outside of North America, presenting a clear avenue for contributions from citizen scientists through crowdsourcing projects. Such programmes could both speed up the digitisation of records and integrate with technical advances in the training of machine learning algorithms for optical character recognition, for example (Heidorn and Wei 2008). These museum data may include not only more modern specimens but also historical and fossil specimens, which may be useful in reconstructing historical terrestrial and marine biodiversity (e.g. Graham et al. 2004, Lister et al. 2011).

The value of digitising natural history collections data has also been noted in relation to the Global Biodiversity Information Facility (see Berendsohn et al. 2010), and citizen science is one of the ways this could be achieved. Examples of using citizen science in this way are Zooniverse's 'Take Notes from Nature'[7], and the BioBlitz[8] project in the UK. Bioblitz was originally developed as an intensive programme of field surveying in local natural areas, but has recently inspired museums to take a similar approach to cataloguing their natural history collections. Such projects not only contribute towards increasing data availability to scientists but also enhance individuals' education and interest in natural history.

Conclusion

Delegates at the Sheffield meeting outlined a clear data deficit in macroecology. Given suitable methodologies and protocols, citizen science programmes have great potential to reduce this shortfall and, in these days of impact statements, also increase funding opportunities in the discipline. Effective project design is essential in maximising both public engagement and data quality in citizen science. Developing methods to measure and account for bias in the data are important priorities. Robust links with the newly-formed BES Citizen Science Special Interest Group will doubtless be important in these respects.

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6 http://software-carpentry.org/, last accessed 24/02/2014
7 https://www.zooniverse.org/project/notes_from_nature, last accessed 21/01/2014
8 http://www.bnhc.org.uk/home/bioblitz/, last accessed 21/01/2014

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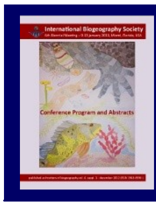

The abstract book of the 6th IBS Biennial Meeting is available at:
http://escholarship.org/uc/item/3kb4c5jr
http://www.biogeography.org/html/Meetings/2013/program.html.