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Careful considerations are required when analysing mammal citizen science data **– a response to Massimino et al.**

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Large-scale citizen science has proved invaluable in the collection of data for ecological monitoring. There are numerous examples of citizen-led data collection initiatives that have highlighted trends in populations for which there would otherwise be a lack of data. However, data collected by citizen scientists have been challenged as being problematic for a variety of mainly methodological reasons, which includes data validation and observer expertise (Johnston et al. 2018). A crucial element in citizen-led initiatives is the input of specialists in interpreting the data, checking for bias and subsampling if required (Callcutt et al. 2018).

Massimino et al. (2018) present maps of changes in mammal distribution and abundance based on spatial modelling of data collected by citizen scientists as part of the Breeding Bird Survey (BBS) in the UK. This survey has informed other citizen led monitoring programmes globally. As the authors correctly highlight, there is still no single, co-ordinated and systematic national-scale initiative to monitor mammals in the UK and a recent systematic assessment has confirmed this data gap (Croft et al. 2017). BBS data, aggregated at national or regional scales, provide some of the best available data on changes in mammal abundances across the UK. However, having worked on surveys of terrestrial mammals in the UK at regional and national scales, we consider that there are a number of significant challenges and biases inherent to such data that were not sufficiently considered in this paper.

The authors indicate that the predictive models for many of the species are a poor fit (Massimino et al. Table 1) yet inference is still drawn rather than being discussed in the context of a valid modelling exercise to establish if a technique accepted for birds is suitable for mammals. No modelling validation is included in the paper and deviance explained is indicative but insufficient. This results in a number of anomalies between the predictive maps presented and the known species' distributions (Mathews et al. 2018). The clearest examples are for mountain and brown hares (*Lepus spp.*) and several species of deer, where the well-reported patterns in their distribution and trends in expansion are not reflected in Massimino et al.'s maps. This suggests that the analysed data are not sufficient to pick up some of the most important changes to these species' distribution. The authors state that they consulted a number of relevant sources such as NBN, the public repository of biological data in the UK, to cross check their distribution maps, but a full, specialist, scrutiny of the outputs of these analyses would almost certainly have identified these large-scale anomalies.

While the anomalies in the distribution data might be rectified by greater specialist input, we would also like to highlight some more fundamental constraints associated with the BBS mammal data, which limit their use in mapping abundance and distribution at the scale which Massimino et al. have done. Detection probabilities of mammals, most of which are nocturnal or crepuscular, are

much lower during daylight hours with implications for data quantity and quality. Furthermore, since habitat use differs substantially between active (night time) and resting (daytime) periods for many species, local and regional differences in the availability of these habitats, which are not accounted for in the authors' models are likely to further bias the spatial patterns observed, especially where the species occur at moderate or low density. The authors' call for distance sampling data to be collected for mammals in the same way BBS surveyors do for birds is welcome, but given the low detection probabilities when surveying nocturnal species in daylight hours, problems with the robustness of the analysis and narrow effective strip width are likely to persist and need to be carefully considered.

Wildlife biologists interested in large-scale mammal monitoring have much to learn from the great successes of the BBS and citizen science initiatives for other taxa. However, the particular challenges posed by surveys for wild mammals mean that the results of citizen science projects seeking to quantify species distribution and abundance in this taxon will continue to suffer major uncertainties. That is not to say that citizen-led efforts do not have an important part to play in collecting data on mammals, but that the data that citizens are able to collect in large-scale initiatives are necessarily limited. The key to maximising the value of any data, including citizen-collected data is to understand their limitations. We feel that, in using data that are subject to many uncertainties to build spatial models, Massimino et al. have stretched these data beyond what they can reasonably tell us and have consequently incorporated significant distribution errors. We urge much more caution and cross-referencing of such datasets. In seeking to fill the major gaps in our monitoring capabilities we should be wary of over-using the imperfect data available to us.

References

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