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Original Articles

An assessment of the state of nature in the United Kingdom: A review of findings, methods and impact

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ABSTRACT

Clear, accessible, objective metrics of species status are critical to communicate the state of biodiversity and to measure progress towards biodiversity targets. However, the population data underpinning current species status metrics is often highly skewed towards particular taxonomic groups such as birds, butterflies and mammals, primarily due to the restricted availability of high quality population data. A synoptic overview of the state of biodiversity requires sampling from a broader range of taxonomic groups. Incorporating data from a wide range of monitoring and analysis methods and considering more than one measure of species status are possible ways to achieve this.

Here, we utilise measures of species' population change and extinction risk to develop three species status metrics, a Categorical Change metric, a Species Index and a Red List metric, and populate them with a wide range of data sources from the UK, covering thousands of species from across taxonomy. The species status metrics reiterate the commonly reported decline in freshwater and terrestrial species' status in the UK in recent decades and give little evidence that this rate of decline has slowed.

The utility of species status metrics is further improved if we can extrapolate beyond the species sampled to infer the status of the community. For the freshwater and terrestrial species status metrics presented here we can do this with some confidence. Nevertheless, despite the range and number of species contributing to the species metrics, significant taxonomic bias remained and we report weighting options that could help control for this.

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The three metrics developed were used in the *State of Nature 2016* report and indications are they reached a large number of audience members. We suggest options to improve the design and communication of these and similar metrics in the future.

1. Introduction

Across society people receive many varied nature conservation messages, ranging from success stories through to warnings about the imminent extinction of species. The frequency, variety and often contradictory nature of these messages may obscure an understanding of the overall state of nature and, importantly, the role of human actions in determining this state. Clear, objective, overarching metrics of the state of the natural environment can provide this understanding, facilitating informed decision making and supporting educational campaigns. This information also allows us to measure our progress towards conservation targets at global (e.g. Convention on Biological Diversity, 2010), European (e.g. Marine Strategy Framework Directive, European Union, 2008) and national scales (JNCC, 2017a).

The UK has some of the longest-running and best-supported biodiversity recording and monitoring in the world, with the majority of data being collected by skilled volunteers. Biological monitoring and recording programmes are well developed for many taxonomic groups (Barlow et al., 2015; Dennis et al., 2013) and these are used to report on species status (Fox et al., 2010), population trends (Holt et al., 2015), and conservation projects (Ellis et al., 2012), either for individual species or taxonomic groups.

Where volunteer-based monitoring of flora and fauna is well-developed, data are strongly skewed towards those groups that are popular to record, relatively easy to identify or accessible to observe, or those especially endangered and requiring close surveillance (UK NEA, 2011). As a result, we are able to assess population trends for only a small percentage of species overall. Recently, analytical techniques for accounting for some of the biases present in opportunistically collected biological records have developed into robust tools for detecting trends in species' status (Isaac et al., 2014; Van Strien et al., 2013). This has enabled data from a much broader taxonomic set to contribute to multispecies metrics (Outhwaite et al., 2018; Van Strien et al., 2016).

A group of the UK's leading wildlife organisations have synthesised data on species status across taxonomy and habitat types, with the ambition of moving closer to a goal of clear, consistent and objective assessment of biodiversity. The findings are published in two '*State of Nature*' reports (Burns et al., 2013; Hayhow et al., 2016). The primary aim of these reports was to develop a robust synthesis of the state of species in the UK, Overseas Territories and Crown Dependencies, making the most of available data, and to increase the level of awareness and understanding by target audiences (policy makers, conservationists, conservation supporters, and the wider public) of the current state of nature and how and why it is changing.

The State of Nature 2016 ('the report' subsequently) brought together recent measures of species status for a far wider range of taxa than had previously been possible, and presented a series of metrics summarising species status and how it has changed over time. Since species monitoring across taxa in the UK is incomplete, the assessment aimed to maximise the sample size based on data availability, rather than on a preselected random sample of species' data. Consequently there was variation between measures of species status in the time period covered, the method of data collection, the aspect of species status measured, and the statistical techniques used to assess trend. It is important therefore, to investigate whether the non-random species sample and the variation in assessment methodology had a significant impact on our results.

In this paper, we:

1. Provide a full description of the species status metrics used to assess the State of Nature and the underpinning biological data used, in order to facilitate their interrogation and reproduction;
2. Subject the metrics of species status to tests of robustness and representativeness of the entire species community and explore methods to control for observed biases;
3. Identify measures to improve the design and communication of the species status metrics and similar studies in the future.

2. Materials and methods

The methods below describe the process used to collate measures of species status and how these were combined into three metrics: 1. A Categorical Change metric, which describes the distribution of species among five population change categories based on their *average annual rate of change* over a *long-term* and a *short-term* period; 2. A Species Index, which charts average species' change over time, and 3. A Red List metric, which presents the proportion of species at risk of extinction from Great Britain. In order to maximise the taxonomic and ecological breadth of the species sample in the Categorical Change metric and the Species Index, we combined information from a diverse range of datasets, treating as equivalent different measures of population change, for instance changes in species abundance, occupancy or distribution. The three metrics use data from the United Kingdom only: the limited data available for the UK Overseas Territories are covered in the Discussion.

2.1. Data collation

We collated as many datasets as possible describing population change of native UK species in order to populate the first two metrics (Table 1; Tables A2–A4). The majority of these datasets were species time-series derived from statistical models, rather than raw counts or observations (Table 1). A small number of datasets consisted of biological records or periodic counts or estimates of species abundance, occupancy or range. For species with more than one dataset available, we gave precedence to assessments of change in abundance, as this is thought to be the most sensitive measure (Chamberlain and Fuller, 2001), and then the most robust dataset, based on the survey method subject to the fewest known biases, and maximising the sample size and time period covered. Each population change dataset contained two or more comparable estimates of species abundance or distribution made between 1960 and the present, had a broad geographical coverage across the species' UK range; the results or the methodology for data collection and/or analysis is published and start and end dates for estimates of status for each species are at least ten years apart. In addition to datasets of species population change, we collated national IUCN Red List assessments.

Assessments of population change in many terrestrial and freshwater species were based on unstructured biological records, meaning records were collected outside a formal monitoring framework. It can be difficult to use datasets of opportunistic records to assess change over time, as recording effort varies spatially and temporally (Hill, 2012; Szabo et al., 2010). Several statistical techniques are available to help account for these biases; here we used a hierarchical Bayesian