Keynote for Global Issues session: How can museum collections contribute to the conservation of global biodiversity in strategic ways?

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Abstract
Global biodiversity faces great threats, brought to light most recently in the IPBES Global Assessment. Global environmental change as a result of habitat alteration, over-exploitation, invasive species, pollution and climate change threaten many species, habitats and natural communities. This presentation will explore how museum collections could be directed towards supporting research for biodiversity conservation in strategic ways, based on a recent project funded by the British Ecological Society.

Introduction

We live in a time of unprecedented environmental change, with climate change, habitat alteration, pollution, invasive species and over-exploitation all contributing to species declines (Millennium Ecosystem Assessment 2005, IPBES 2019). Biodiversity researchers, policy workers, and site and species managers work to stem the tide of declines. Museum collections play a key role, or could play a key role, through supporting biodiversity and nature conservation-related research, management and policy; they also support public education about biodiversity, although that is not the focus of this presentation. This presentation presents some results from a study I ran, with funding from the British Ecological Society in 2018–19, which aimed to develop a strategic approach to using UK museum collections to support biodiversity conservation. There is nothing particularly unique about UK museum collections, so that many of the findings are of wider relevance.

The State of Nature: an ongoing decline

Nature is in decline, and conservation action isn't making sufficient inroads. The 2019 Global Assessment by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) made the following key findings[1]:

A. **Nature and its vital contributions to people, which together embody biodiversity and ecosystem functions and services, are deteriorating worldwide.** While more food, energy and materials than ever before are now being supplied to people in most places, this is increasingly at the expense of nature's ability to provide such contributions in the future and frequently undermines nature's many other contributions, which range from water quality regulation to sense of place… Biodiversity – the diversity within species, between species and of ecosystems – is declining faster than at any time in human history.
B. **Direct and indirect drivers of change have accelerated during the past 50 years.** Changes in land and sea use, direct exploitation, climate change, pollution, and invasive species have had the biggest global impact. These direct drivers result from an array of underlying causes (indirect drivers of change), which are underpinned by societal values, including productin and consumption patterns, human population dynamics, trade, technology and local governance.

[1] https://www.ipbes.net/system/tdf/spm_global_unedited_advance.pdf?file=1&type=node&id=35245

C. **Goals for conserving and sustainably using nature and achieving sustainability cannot be met by current trajectories, and goals for 2030 and beyond my only be achieved through transformative changes across economic, social, political and technological factors.** Most international societal and environmental goals, such as those embodied in the Aichi Biodiversity Targets [for the Convention on Biological Diversity, the Rio Convention] and the 2030 Agenda for Sustainable Development [the Sustainable Development Goals], will not be achieved based on current trajectories. These declines will also undermine other goals, such as those specified in the Paris Agreement and the 2050 Vision for Biodiversity.
D. **Nature can be conserved, restored and used sustainably while simultaneously meeting other global societal goals through urgent and concerted efforts fostering transformative change.** Societal goals – including those for food, water, energy, health and the achievement of human well-being for all, mitigating and adapting to climate change and conserving and sustainably using nature – can be achieved in sustainable pathways through the rapid and improved deployment of existing policy instruments and new initiatives that more effectively enlist individual and collective action for transformative change.

Museums and the conservation of global biodiversity

Museum collections are often associated with taxonomy. However, museum collections support, or can support, the exploration of a much wider range of ecological and environmental topics that have practical applications for biodiversity conservation. Studies of biodiversity, at within-species/population, species and community levels, rely heavily on collections to understand distribution, presence/absence, changes over time, and interspecies interactions and community ecology. Understanding what species live where is a foundation of understanding biodiversity and nature conservation. Even today, historical collections are a basic source of information on the occurrence of species in remote areas, although rapid environmental change may mean that they reveal where species once were, rather than where they still occur. Museum specimens are a major contributor to conservation assessments, such as IUCN 'Red List' assessments, and are an essential tool for work on the Convention on Biological Diversity, and for national and local biodiversity assessments. Specimens enable former assessments of distribution and identification to be reassessed, notably in light of taxonomic changes. Specimens are a source of biomolecules: they are sampled for DNA to explore relationships within and between species, informing decisions on conservation assessment and management, and reintroductions. Morphology, physiology and development can all be explored through collections, and can be related to environmental conditions. As collections are four dimensional, with a time dimension, they enable scientists to explore changes over time, and to study past change.

How can museum collections help support the conservation of global biodiversity in strategic ways?

Researchers, policy workers and site/species managers working to conserve global biodiversity ('biodiversity workers' hereafter) have relatively little contact with museums, and vice versa. This presents a number of problems for museums, researchers, and the conservation of global biodiversity. To help address this situation, BES funded a study in 2018–19 to better understand the perceptions that biodiversity workers and UK museum workers had of the potential of UK natural history collections to support the conservation of global biodiversity. This study helps to begin to build an evidence-based understanding of

how collections could be used and perceptions around their potential use, as well as identifying barriers (real and perceived) to use.

Methods

The study was framed around 'One Hundred Questions of Importance to the Conservation of Global Biodiversity' (Sutherland *et al.* 2009). The aim of that study was to compile a list of 100 questions that, if answered, would have the greatest impact on the conservation of biological diversity worldwide. The questions were developed by a team of representatives of the world's major conservation organisations, professional scientific societies, and universities, and the work was intended to be of use to organisations wishing to support biodiversity research programmes effectively. As museums have unique resources that can potentially contribute to biodiversity conservation, the 100 questions have a high relevance. Sutherland and others' study found that the 100 questions fell into twelve topics. Participants in the present study were asked to complete an online survey which asked which of the twelve topics identified by Sutherland and others they thought UK museum collection were currently used for research, policy or management, or could be used for. UK museum workers were asked to complete a similar, but separate survey.

Results

The study received 454 detailed responses from biodiversity workers, including 224 scientists, 88 biodiversity policy workers, 53 biodiversity data workers, 23 site and species managers, and 66 people working in a combination of these areas. Respondents included many national nodes for the Convention on Biological Diversity, Global Strategy for Plant Conservation and Global Biodiversity Information Facility (GBIF); government ministries; and a wide range of agencies including IUCN, Plantlife, and Flora and Fauna International. Responses were received from 84 countries worldwide. In terms of UK museum workers, detailed responses were received from 133 museum curators and collection managers, from all of the major museums, many medium-sized and small museums, and from all four constituent countries. This study is the largest of its kind.

More than half (58%) of biodiversity workers had given specimens to museums to add to their collections, and 66% of biodiversity workers generated potential specimens in the course of their work. Biodiversity workers were most likely to find out information on resources such as museum collections from websites, notably GBIF and other aggregators. Note, most museum data is not included in GBIF.

In order to make more, or better, use of UK museum collections, they would need:

- Aggregated online catalogues of collections, such as GBIF
- Complete online catalogues of particular collections
- Well-curated and accessible collections
- More specialist staff who can answer enquiries (notably specialist enquiries), and facilitate visits to study collections.

Which of the 12 topics from the '100 Questions' study did biodiversity workers think UK natural history collections supported, or could potentially support?

	No. of biodiversity workers	Currently support	Could support	Could not support
Ecosystem function and services	83	58%	32%	10%
Impact of climate change on biodiversity and ecosystems	82	63%	26%	11%
Impacts of technological change on biodiversity	33	70%	21%	9%
Protected areas and biodiversity	110	66%	25%	9%
Ecosystem management and restoration: impacts on biodiversity	73	62%	25%	14%
Terrestrial ecosystems	125	76%	19%	5%
Marine ecosystems	44	68%	23%	9%
Freshwater ecosystems	46	76%	17%	7%
Species management	89	67%	24%	9%
Nature conservation organisational systems and processes	54	54%	26%	20%
Societal context and change, and its impact on species/habitats	68	62%	29%	9%
Impacts of nature conservation interventions	51	69%	22%	10%

These results show that 80% or more of experts in each topic thought that UK museum collections currently support or could support research, policy and management in those areas. This is a very encouraging result, demonstrating the usefulness, or at least potential usefulness, of collections to support action to address contemporary threats to biodiversity.

(a more detailed analysis is included in the PDF output of the study)

An example: museum collections can support an understanding of a wide range of biological consequences of climate change

Morphology: a major area that museum collections can support, for example changes in body size, shape, coloration, impacts of ocean acidification, annual and seasonal growth.
Genetics: changes in genetic diversity over time, changes in hybridisation and hybrid zones, changes in landscape-scale genetic patterns.
Physiology: disease susceptibility linked to climate change in plants and animals, e.g. the link between climate change and chytrid fungus in amphibians has been explored by studying chytrid presence/absence in historical specimens of amphibians in collections.

Phenology: another major area that museum collections can support, for example timing of migration, flower and seed production, emergence time of insects, from information on specimen labels and examination of specimens.
Population dynamics, e.g. recruitment, age structure, sex ratio, abundance: yet another area museums can support, for example through the understanding of changes in population age structure over time**.**
Distribution, e.g. habitat quantity, range size, range localisation: museums are an irreplaceable resource for understanding the distribution of animals and plants. Changes in distribution over time can often be well-exemplified from collections.
Interspecific relationships, e.g. synchronisation of timing, novel interactions (predation, competition), community composition, changes in paratism and vector-borne disease. Museum collections can help explore e.g. the spread of disease agents over time. Changes in parasitisation of small birds by Cuckoos has been linked to timing mismatches and decline of Cuckoos. Shifts in community composition of birds, crustacea, butterflies and amphibians have all been linked to climate change.
Productivity (biomass, primary productivity): growth at different times can be studied readily from museum collections, and linked to productivity.

Discussion: ensuring the ongoing usefulness of UK natural history collections
The ongoing usefulness of collections is threatened for five main reasons. These are (with suggestions for how to address them):

A. Collections are not as visible or accessible as they could be: faced with enormous numbers of specimens, the task of digitising and networking collections is monumental. *Stronger support for basic care of collections and sharing collections information is needed, within museums and across the museum sector.*
B. Museum funding cuts have meant that there are less natural-history-trained curators in museums than there used to be, and they have wider ranges of responsibilities than previously. *Ensuring collections have appropriate levels of staffing, with skills to facilitate the effective use of collections, should be a key priority for museums and museum funders.*
C. There is relatively little contact between researchers and museums, or between conservation research policy workers and museum policy workers. *Building common purpose between nature conservation and museum sectors should be a priority, to ensure that museum policy development, and associated funding, contribute effectively to the achievement of environmental policies and agendas such as the CBD.*
D. There is no overarching strategy for museum collection development linked to current and developing research agendas, or local or global challenges. *Collections need to continue to be developed to ensure that time series studies can be made, and that specimens are preserved and information curated so that they are useful. This would help support the Sustainable Development Goals, through achieving effective connections between policies, funding, and preservation of natural heritage (both in museums and in the environment).*
E. Collections need to be developed in new ways, to be able to address current and future research questions that would support the conservation and management of biodiversity. *Museum workers need to work in concert with biodiversity workers, to focus collections developments that will help address biodiversity workers' needs.*

Biodiversity workers can benefit greatly from the unique resources offered by museums, and museums can benefit greatly from ensuring their collections and other resources make their maximum impact. A stronger synergy between the two sectors would create significant benefits for biodiversity. It just requires closer integration between the two sectors.

Opportunities:

- post-2020 activities for the Convention of Biological Diversity, towards the 2050 Vision for Biodiversity.
- 2021-30 Decade of Ecosystem Restoration (UNEP and FAO)
- Final decade of Sustainable Development Goals.

Further reading and references:

McGhie, H.A. (2019). Museum collections and biodiversity conservation. (PDF) [includes many useful references]

Dorfman, E (ed) (2017). *The Future of Natural History Museums.* ICOM Advances in Museum Research. Routledge, Abingdon (Oxon).

IPBES (Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services) (2019). Summary for policymakers of the global assessment report on biodiversity and ecosystem services. https://www.ipbes.net/system/tdf/spm_global_unedited_advance.pdf?file=1&type=node&id=35245

McLean, BS *et al.* (2016). Natural history collections-based research: progress, promise, and best practices. *Journal of Mammalogy* 97(1): 287–97.