Impacts of climate change on biodiversity

Carlo Rondinini

UNECE Expert Forum for producers and users of climate change-related statistics, Geneva 3-4 October 2019
Today’s talk

1. Why climate and biodiversity?
2. My involvement with the topic
3. The challenge of indicators of climate change impact on biodiversity
4. Towards indicators of climate change impact on biodiversity
1. Why climate and biodiversity?

Currently climate change is threat #3 to biodiversity...
1. Why climate and biodiversity?

... but is projected to outpace all other threats by 2050
Participation to international bodies

2. My involvement with the topic

IPBES Global Assessment on Biodiversity and Ecosystem Services

Chapter 4. Plausible futures of nature, its contributions to people and their good quality of life

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2. My involvement with the topic

Quantitative analysis of species vulnerability

Assessing species vulnerability to climate change

Michela Pacifici et al.

The effects of climate change on biodiversity are increasingly well documented, and many methods have been developed to assess species’ vulnerability to climate changes, both ongoing and projected in the coming decades. To minimize global biodiversity losses, conservationists need to identify those species that are likely to be most vulnerable to the impacts of climate change. In this Review, we summarize different currencies used for assessing species’ climate change vulnerability. We describe three main approaches used to derive these currencies (correlative, mechanistic and trait-based), and their associated data requirements, spatial and temporal scales of application and modelling methods. We identify strengths and weaknesses of the approaches and highlight the sources of uncertainty inherent in each method that limit projection reliability. Finally, we provide guidance for conservation practitioners in selecting the most appropriate approach(es) for their planning needs to highlight priority areas for further assessments.

Received: 9 May 2017 | Accepted: 4 October 2017
DOI: 10.1111/gcb.13942

A framework for the identification of hotspots of climate change risk for mammals

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Species’ traits influenced their response to recent climate change

Michela Pacifici1*, Piero Visconti2,3, Stuart H. M. Butchart4,5, James E. M. Watson6,7, Francesca M. Cassola1 and Carlo Rondinini1

Although it is widely accepted that future climatic change—if unabated—is likely to have major impacts on biodiversity2,4, few studies have attempted to quantify the number of species whose populations have already been impacted by climate change. Here, we present a framework for assessing three components of climate-related risk for species: vulnerability, exposure and hazard. We used the observed response of species to climate change and a set of intrinsic traits (e.g. warming age) and extrinsic factors (e.g. precipitation seasonality within a species geographic range) to predict, respectively, the change in birds and mammals (Supplementary Table 1). From a literature search, we identified 70 studies covering 120 maternal species and 86 studies relating to 350 bird species whose populations had (or are about to) experience climate change. We explored the influence of species traits on the magnitude of observed change and compared the proportion of species that had experienced a change in current climate conditions, using the observed data on selected intrinsic traits and spatial traits to assess quantitatively which of these are associated with negative responses to climate change. 

Paciﬁci, ... Rondinini 2015. Nature Climate Change
Paciﬁci, ... Rondinini 2017. Nature Climate Change
Paciﬁci, ... Rondinini 2018. Global Change Biology
2. My involvement with the topic

InSiGHTS: Integrated Scenarios of Global Habitat for Terrestrial Species

Socio-economic drivers

- Food crops
- Energy crops
- Livestock
- Forestry
- Climate forcings

Past, present and future climate

GCMs

BIOMOD: ensemble of SDMs

Species’ Range

Area of Habitat (AOH)

Habitat suitability models

Past, present and future land use 5’ resolution

IAMs

Dispersal abilities

Potential distribution

Density = f(body mass, diet, taxonomy, NPP)

Potential population size

Biodiversity indicators

- Food crops
- Energy crops
- Livestock
- Forestry
- Climate forcings

Rondinini & Visconti 2015. Conservation Biology
Visconti, … & Rondinini 2016. Conservation Letters

2. My involvement with the topic
2. My involvement with the topic

Projected biodiversity indicators using InSiGHTS: Red List Index, Living Planet Index
2. My involvement with the topic

Projected biodiversity indicators using InSiGHTS: Area of Habitat

Decline in habitat availability under contrasting scenarios
3. The challenge of indicators of climate change impact on biodiversity

Biodiversity is multidimensional and multiscale
3. The challenge of indicators of climate change impact on biodiversity

Many candidate indicators across scales and dimensions: Essential Biodiversity Variables (EBV)

<table>
<thead>
<tr>
<th>EBV class</th>
<th>EBV examples</th>
<th>Measurement and scalability</th>
<th>Temporal sensitivity</th>
<th>Feasibility</th>
<th>Relevance for CBD targets and indicators (1,9)</th>
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<tbody>
<tr>
<td>Genetic composition</td>
<td>Allelic diversity</td>
<td>Genotypes of selected species (e.g., endangered, domesticated) at representative locations</td>
<td>Generation time</td>
<td>Data available for many species and for several locations, but little global systematic sampling.</td>
<td>Targets: 12, 13. Indicators: Trends in genetic diversity of selected species and of domesticated animals and cultivated plants; RLI.</td>
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<td>Species populations</td>
<td>Abundances and</td>
<td>Counts or presence surveys for groups of species easy to monitor or important for ES, over an extensive network of sites, complemented with incidental data</td>
<td>1 to &gt;10 years</td>
<td>Standardized counts under way for some taxa but geographically restricted. Presence data collected for more taxa. Ongoing data integration efforts (Global Biodiversity Information Facility, Map of Life).</td>
<td>Targets: 4, 5, 6, 7, 8, 9, 10, 11, 12, 14, 15. Indicators: LP; WBI; RLI; population and extinction risk trends of target species, forest specialists in forests under restoration, and species that provide ES; trends in invasive alien species; trends in climatic impacts on populations.</td>
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<td></td>
<td>distributions</td>
<td></td>
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<td>Species traits</td>
<td>Phenology</td>
<td>Timing of leaf coloration by RS, with in situ validation.</td>
<td>1 year</td>
<td>Several ongoing initiatives (Phenological Eyes Network, PhenoCam, etc.)</td>
<td>Targets: 10, 15. Indicators: Trends in extent and rate of shifts of boundaries of vulnerable ecosystems.</td>
</tr>
<tr>
<td>Community composition</td>
<td>Taxonomic diversity</td>
<td>Consistent multitaxa surveys and metagenomics at select locations.</td>
<td>5 to &gt;10 years</td>
<td>Ongoing at intensive monitoring sites (opportunities for expansion). Metagenomics and hyperspectral RS emerging.</td>
<td>Targets: 8, 10, 14. Indicators: Trends in condition and vulnerability of ecosystems; trends in climatic impacts on community composition.</td>
</tr>
<tr>
<td>Ecosystem structure</td>
<td>Habitat structure</td>
<td>RS of cover (or biomass) by height (or depth) globally or regionally.</td>
<td>1 to 5 years</td>
<td>Global terrestrial maps available with RS (e.g., Light Detection and Ranging). Marine and freshwater habitats mapped by combining RS and in situ data.</td>
<td>Targets: 5, 11, 14, 15. Indicators: Extent of forest and forest types; mangrove extent; seagrass extent; extent of habitats that provide carbon storage.</td>
</tr>
</tbody>
</table>
3. The challenge of indicators of climate change impact on biodiversity

EBV are developed by the Global Earth Observation Biodiversity Observation Network

What are EBVs?

EBVs are the abbreviation for Essential Biodiversity Variables. These Essential Biodiversity Variables, defined as the derived measurements required to study, report, and manage biodiversity change, focusing on status and trend in elements of biodiversity. They provide the first level of abstraction between low-level primary observations and high-level indicators of biodiversity.

Criteria for Essential Biodiversity Variables
3. The challenge of indicators of climate change impact on biodiversity

Complex response of biodiversity indicators to change

3. The challenge of indicators of climate change impact on biodiversity

Climate change already impacted most levels and dimensions of biodiversity

- **Organism** (36 processes total)
  - Examples: Genetic diversity, activity rates, body size and shape

- **Population** (28 processes total)
  - Examples: Recruitment, age structure, and abundance, migration, timing of budding, flowering, and spawning

- **Ecosystems**
  - Marine
  - Freshwater
  - Terrestrial
  - Total: 82% of biological processes impacted
  - 25/31, 23/31, 29/32

- **Species** (9 processes total)
  - Examples: Range size and location, habitat quantity and quality

- **Community** (21 processes total)
  - Examples: Biomass and primary productivity, composition, species interactions

Scheffers, ... Rondinini et al. 2016. The broad footprint of climate change from genes to biomes to people. Science 354:aaf7671.
4. Towards indicators of climate change impact on biodiversity

Build on well developed methods to assess species vulnerability and link to existing processes, e.g. GEO BON

- Number / proportion of species threatened by / declining due to climate change
- Fraction of biodiversity indicator (e.g. RLI, LPI, EBV) change attributable to climate change
4. Towards indicators of climate change impact on biodiversity

Draw on abundant literature, e.g. on geographic range shift

- Number / proportion of species shifting distributions due to climate change
- Rate of distributional shift due to climate change
4. Towards indicators of climate change impact on biodiversity

Much need of climate change-related statistics to understand biodiversity responses

Many biodiversity responses to change are observed

BUT...

Attribution of change to climate remains a challenge! e.g. combined effects with other drivers (land use change, invasive species, overexploitation, pollution, ...)

Figure from Oliver and Morecroft 2014. WIREs Climate Change
4. Towards indicators of climate change impact on biodiversity

Much need of climate change-related statistics to disentangle biodiversity responses

• Trends of some drivers are well monitored (e.g. land cover change through remote sensing) while climate data are lower resolution in space and time