Climate change and biodiversity – synergies and challenges
The science perspective

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Climate change <-> biodiversity
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1. Biodiversity
2. Ecosystem functioning
3. Climate change
1. Impact of climate change on biodiversity

IPBES: 1 million species of plants and animals are faced with extinction

1. Impact of climate change on biodiversity

Species decline in the (sub-)tropics

Two different scenarios for species richness estimates based on stacked climate-based species distribution models for the world’s amphibians, birds, and mammals for the year 2080 compared to 1995 assuming a basic dispersal scenario.

www.pnas.org/cgi/doi/10.1073/pnas.1807745115
Climate change is not the only driver of biodiversity loss

Fig. 2 from Diaz, S., Settele, S., Brondizio, E. (2019): Summary for policymakers of the global assessment report on biodiversity and ecosystem services of the IPBES
1. Impact of climate change on biodiversity

What is the bigger threat? Climate change or land use change?

Overlap of threat from climate and land-use change for 2080, assuming a basic dispersal scenario.

CC = Climate
BC = Biofuel cropland
CR = Non-biofuel cropland
PA = Pastures

Fig. S2 from Hof et al. PNAS 115: 13294–13299. www.pnas.org/cgi/doi/10.1073/pnas.1807745115
2. Impact of biodiversity on ecosystem functioning

BEF (Biodiversity-ecosystem functioning) forest experiments worldwide

March 2019: 25 experiments, 1,116,250 trees, 821 ha

http://www.treedivnet.ugent.be/experiments.html

2. Impact of biodiversity on ecosystem functioning

Positive biodiversity – productivity relationships

More species-rich forests accumulate more biomass

Fig. 1 from Huang, Y.Y., Chen, Y.X., …, Bruelheide, H., Ma, K.P., Niklaus, P.A., Schmid, B. (2018): Impacts of species richness on productivity in a large-scale subtropical forest experiment. - Science 362 (6410): 80–83.
DOI: 10.1126/science.aat6405
Biodiversity increases stability in climatically extreme years by increasing resistance, but not resilience.

Fig. 1 from Isbell, F, ….. & Eisenhauer, N. (2015): Biodiversity and the resistance and resilience of ecosystem productivity to climate extremes. - Nature 526: 574-577.
3. Impact of ecosystem functioning on climate change

Two main pathways

**Carbon-climate link**

Biodiversity Increases productivity and soil carbon storage
- \( \Rightarrow \) increased carbon sequestration from the atmosphere

**Surface energy exchange**

Biodiversity decreases albedo (fraction of reflected shortwave radiation)

Biodiversity increases evapotranspiration (sensible heat flux)
via vegetation height, crown shape, leaf size, leaf angle, stomata density, stomata size.
Biodiversity increases evapotranspiration

Australia near Perth; a fence separating shrub vegetation and agriculture

Photograph: courtesy of Axel Kleidon
IPBES: Decline in biodiversity’s contribution to climate

<table>
<thead>
<tr>
<th>Nature’s contribution to people</th>
<th>50-year global trend</th>
<th>Directional trend across regions</th>
<th>Selected indicator</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Habitat creation and maintenance</td>
<td>↓</td>
<td>↓</td>
<td>• Extent of suitable habitat • Biodiversity intactness</td>
</tr>
<tr>
<td>2 Pollination and dispersal of seeds and other propagules</td>
<td>↓</td>
<td>↓</td>
<td>• Pollinator diversity • Extent of natural habitat in agricultural areas</td>
</tr>
<tr>
<td>3 Regulation of air quality</td>
<td>↓</td>
<td>↑</td>
<td>• Retention and prevented emissions of air pollutants by ecosystems</td>
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<tr>
<td>4 Regulation of climate</td>
<td>↑</td>
<td>↑</td>
<td>• Prevented emissions and uptake of greenhouse gases by ecosystems</td>
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<tr>
<td>5 Regulation of ocean acidification</td>
<td>↓</td>
<td>↑</td>
<td>• Capacity to sequester carbon by marine and terrestrial environments</td>
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<tr>
<td>6 Regulation of freshwater quantity, location and timing</td>
<td>↓</td>
<td>↑</td>
<td>• Ecosystem impact on air-surface-ground water partitioning</td>
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<tr>
<td>7 Regulation of freshwater and coastal water quality</td>
<td>↓</td>
<td>↑</td>
<td>• Extent of ecosystems that filter or add constituent components to water</td>
</tr>
<tr>
<td>8 Formation, protection and decontamination of soils and sediments</td>
<td>↓</td>
<td>↑</td>
<td>• Soil organic carbon</td>
</tr>
<tr>
<td>9 Regulation of hazards and extreme events</td>
<td>↓</td>
<td>↑</td>
<td>• Ability of ecosystems to absorb and buffer hazards</td>
</tr>
<tr>
<td>10 Regulation of detrimental organisms and biological processes</td>
<td>↓</td>
<td>↑</td>
<td>• Extent of natural habitat in agricultural areas • Diversity of competent hosts of vector-borne diseases</td>
</tr>
</tbody>
</table>

Global trends in the capacity of nature to sustain contributions to good quality of life from 1970 to the present.

Fig. 1 from Diaz, S., Settele, S., Brondizio, E. (2019): Summary for policymakers of the global assessment report on biodiversity and ecosystem services of the IPBES.
Conclusions

1. Climate change -> biodiversity
   Ample evidence. Models are well established, but depend on co-drivers (such as land use change)

2. Biodiversity -> ecosystem functioning
   Well established relationships at the local scale, but much less is known at the landscape scale and for crop systems.

3. Ecosystem functioning -> climate
   Vegetation effects on climate are well established, but knowledge on the role of species diversity is limited.

State of knowledge
1 > 2 > 3
Acknowledgments

When it is obvious that the goals cannot be reached, don't adjust the goals, adjust the action steps.

Confucius; 551-479 BC