The state of model intercomparisons in (terrestrial) biodiversity science and policy

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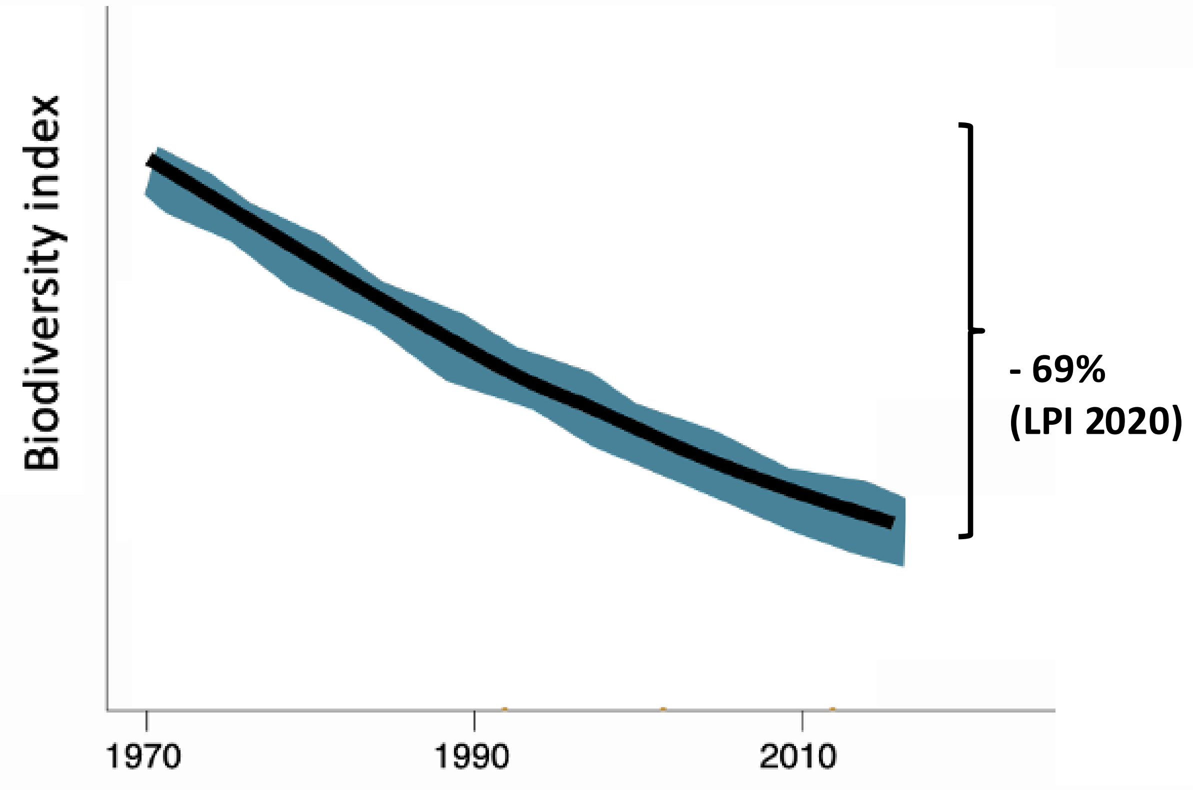
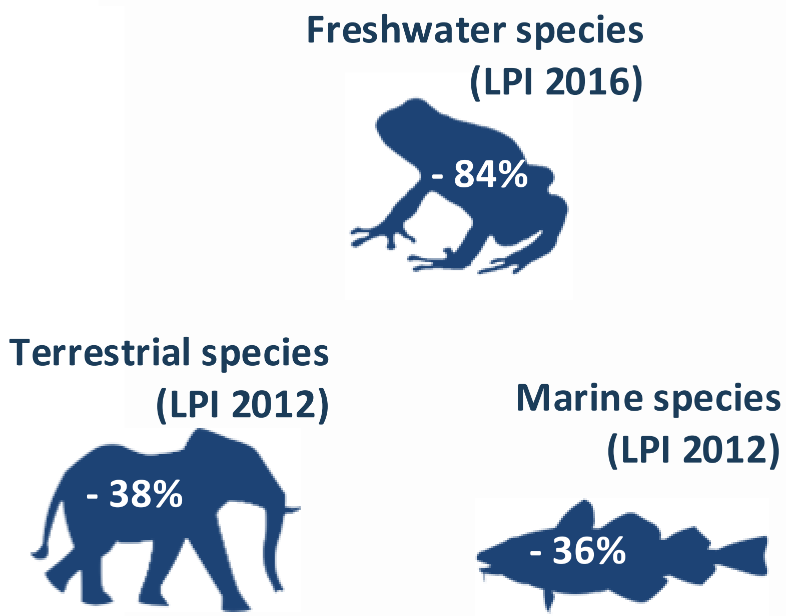
Biodiversity is in crisis

- Human pressures lead to biodiversity loss and redistribution
- Effects on ecosystem functioning, human well-being, and the climate system



Adapted from Mace et al. (2018) Nat Sustain 1: 448-451.

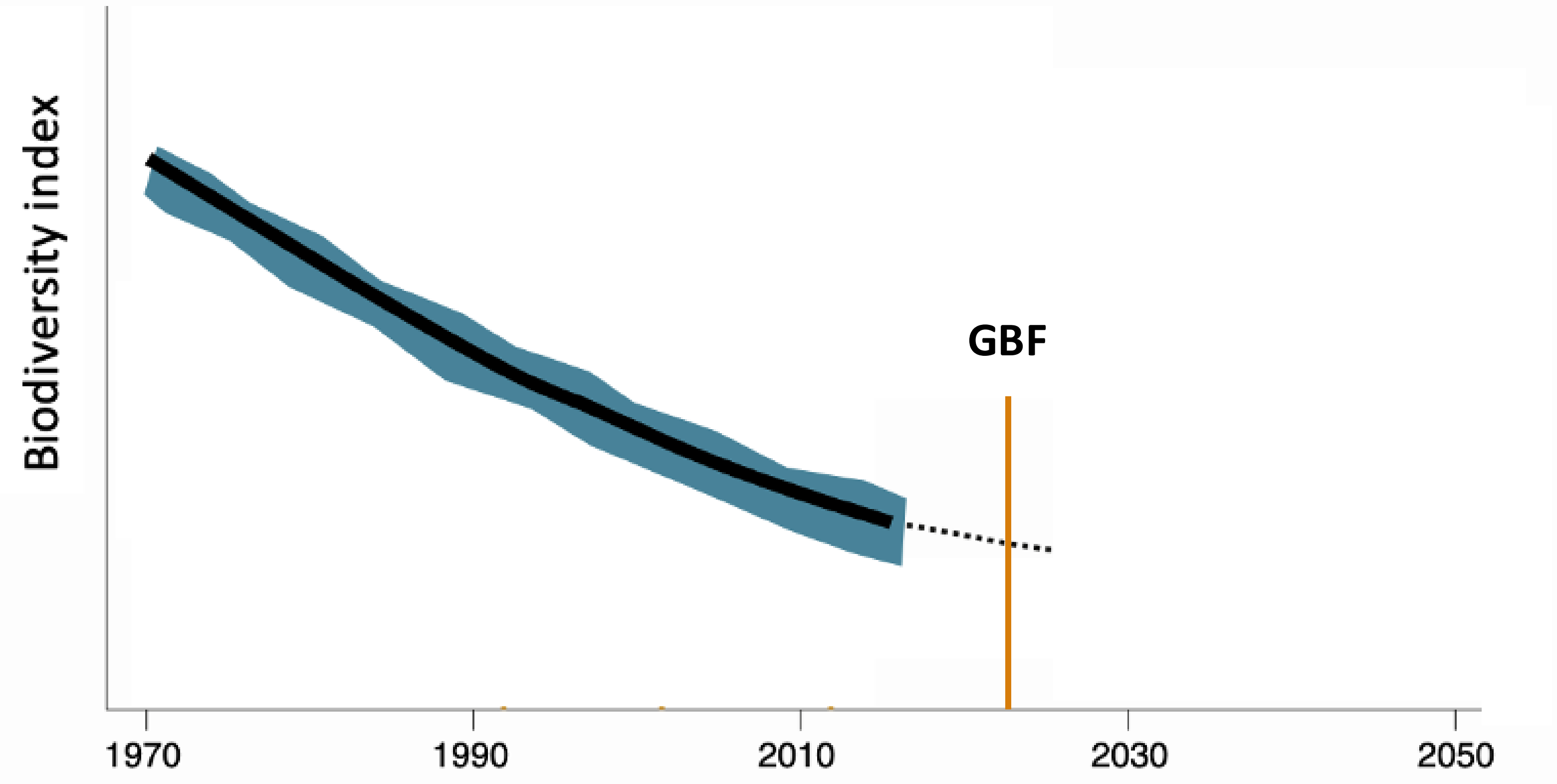


Living Planet Report (2014-2022) WWF.

The Global Biodiversity Framework

Kunming-Montreal Global Biodiversity Framework:

2050 Goals and 2030 Targets



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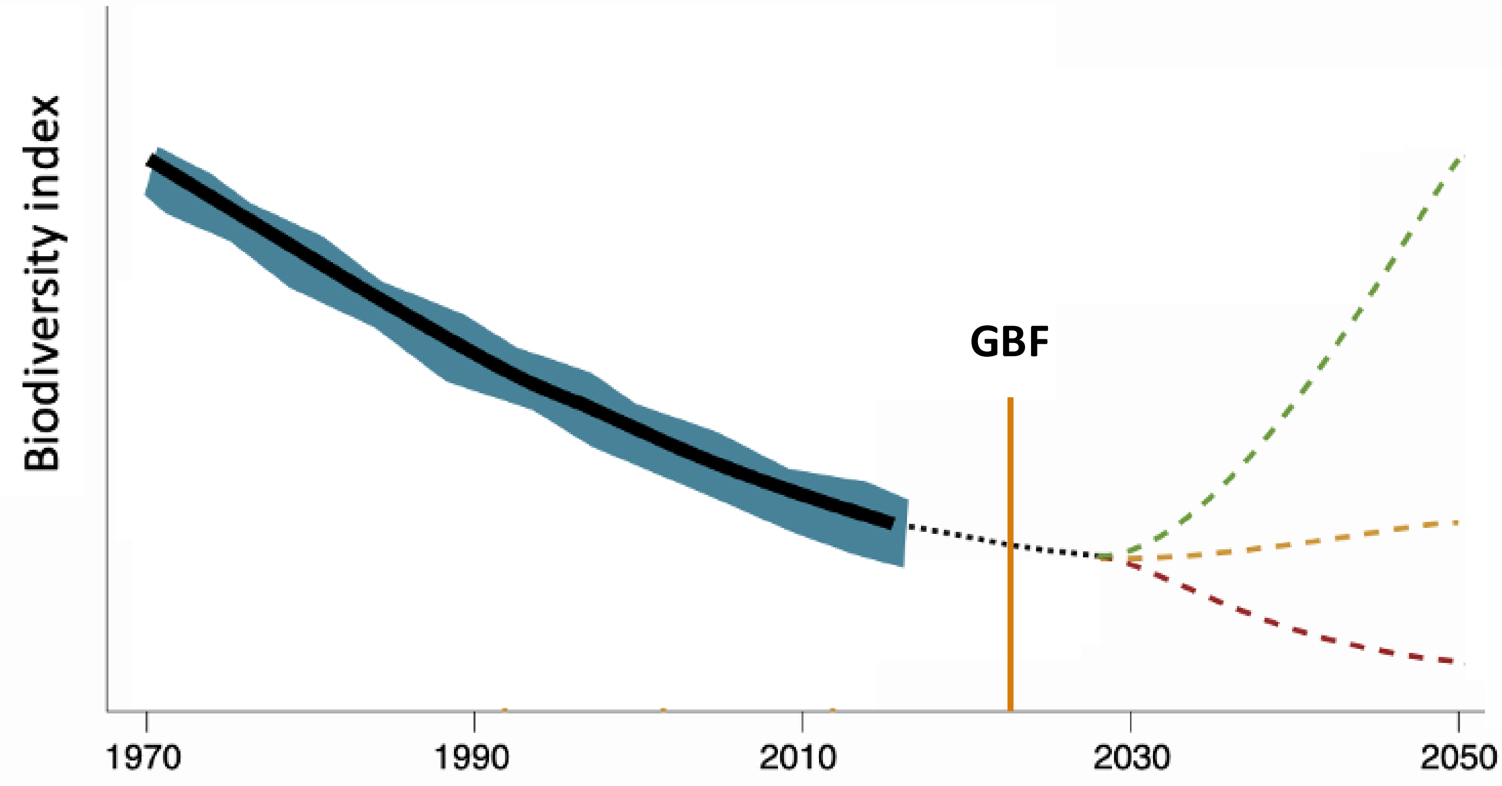

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THE BIODIVERSITY PLAN
For Life on Earth

catalyze, enable and galvanize **policy action globally, regionally and nationally**

The Global Biodiversity Framework

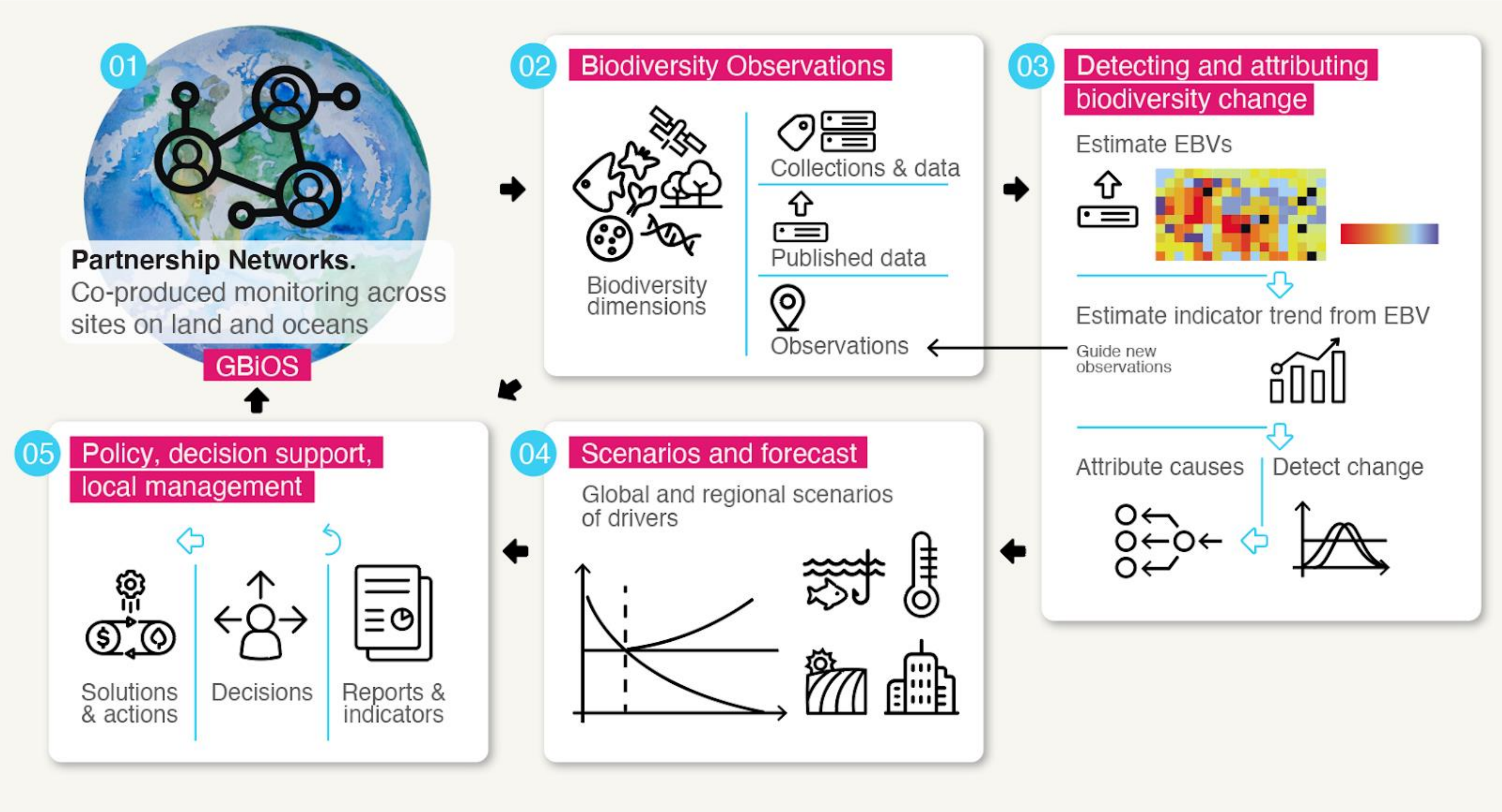
THE BIODIVERSITY PLAN
For Life on Earth

- Conserve 30 by 30
- Restore 30 by 30
- Halt extinction, maintain & restore genetic diversity
- Reduce invasive species introductions - 50 by 30
- Build resilience to climate change
- Capacity building; participation; benefit-sharing

The GBF is likely to fail without improved models of biodiversity

The monitoring-to-mitigation pathway

GEO BON * Strategic Plan 2023-2026



* GEO BON: Group on Earth Observation – Biodiversity Observation Network

The monitoring-to-mitigation pathway

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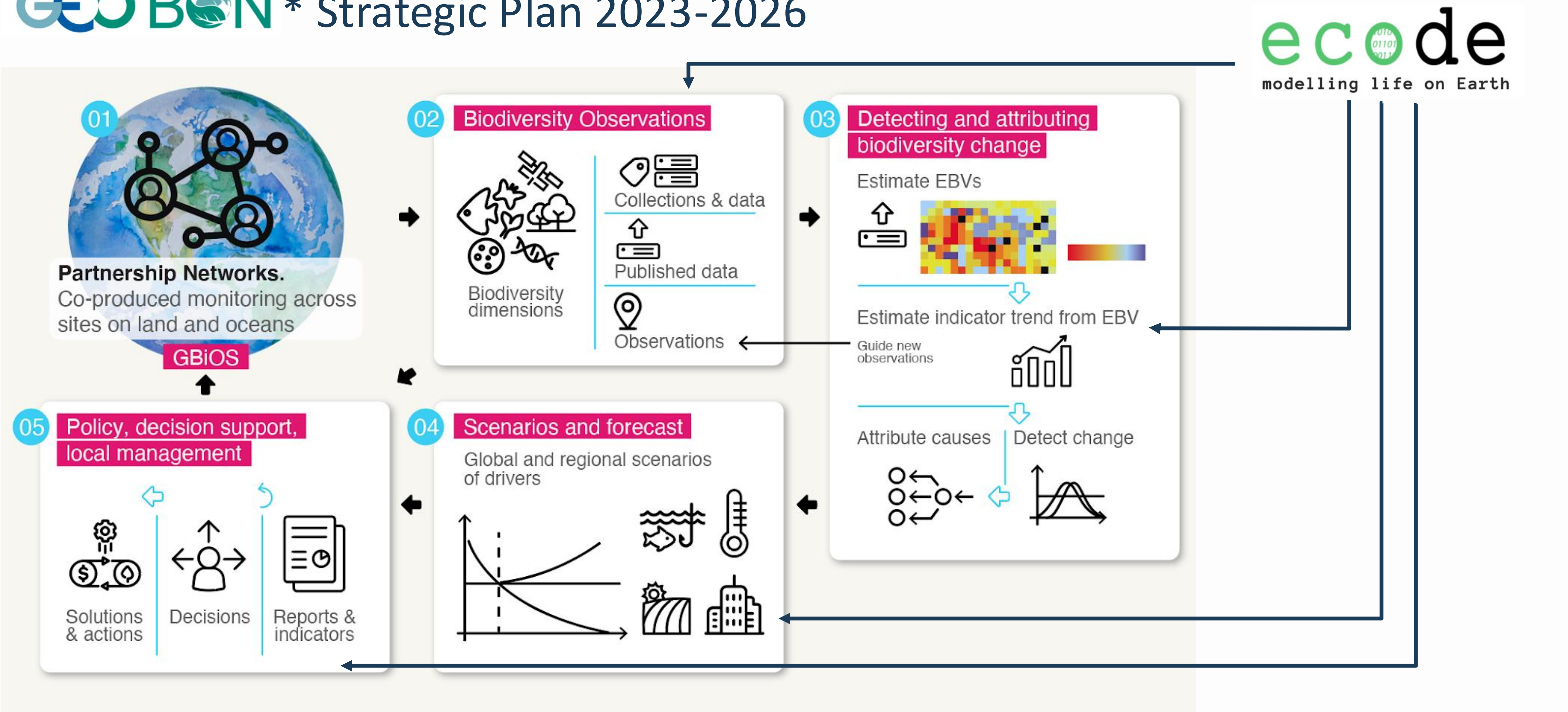

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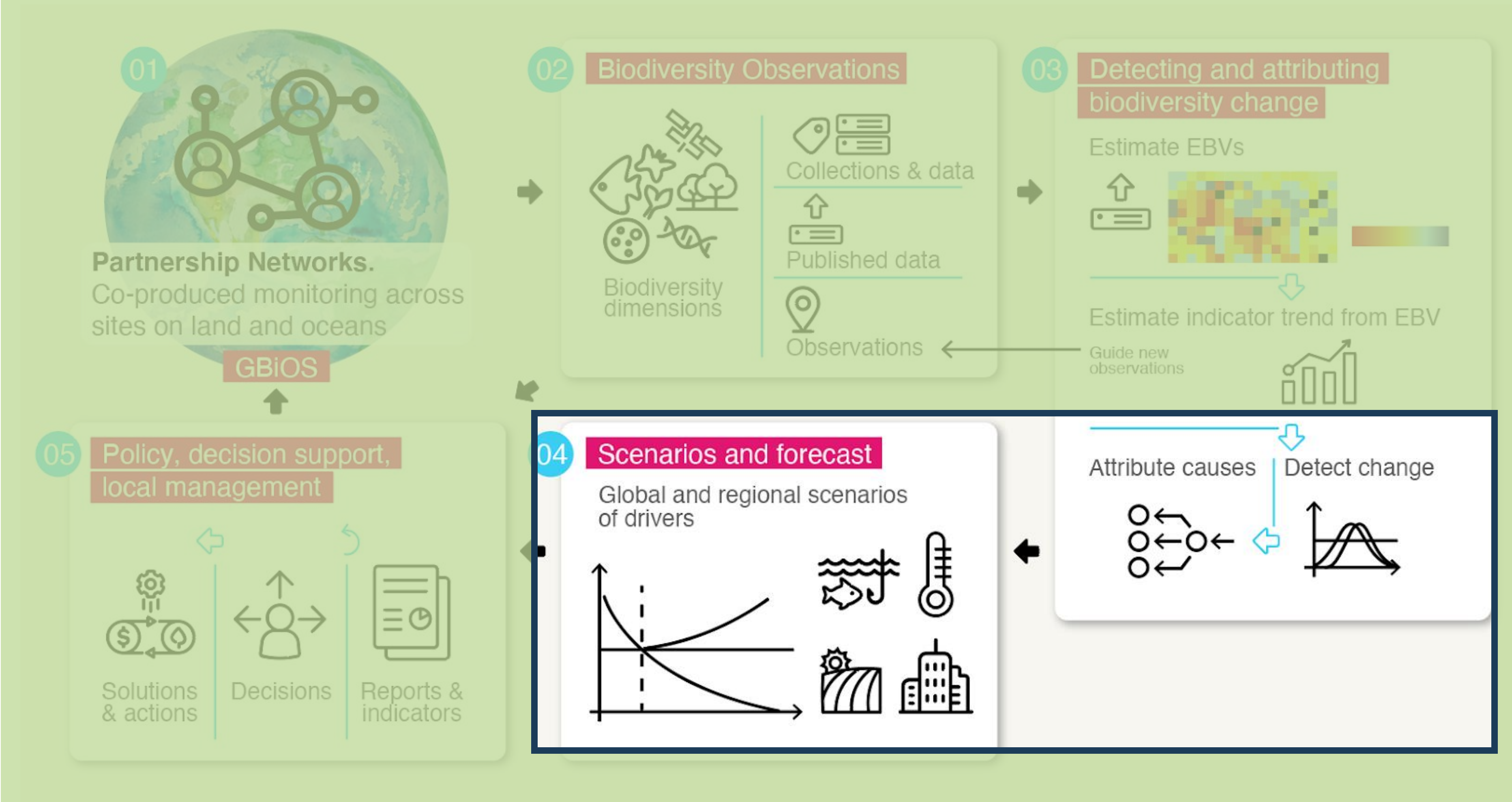

ecode
modelling life on Earth

ISIMIP
Inter-Sectoral Impact Model Intercomparison Project

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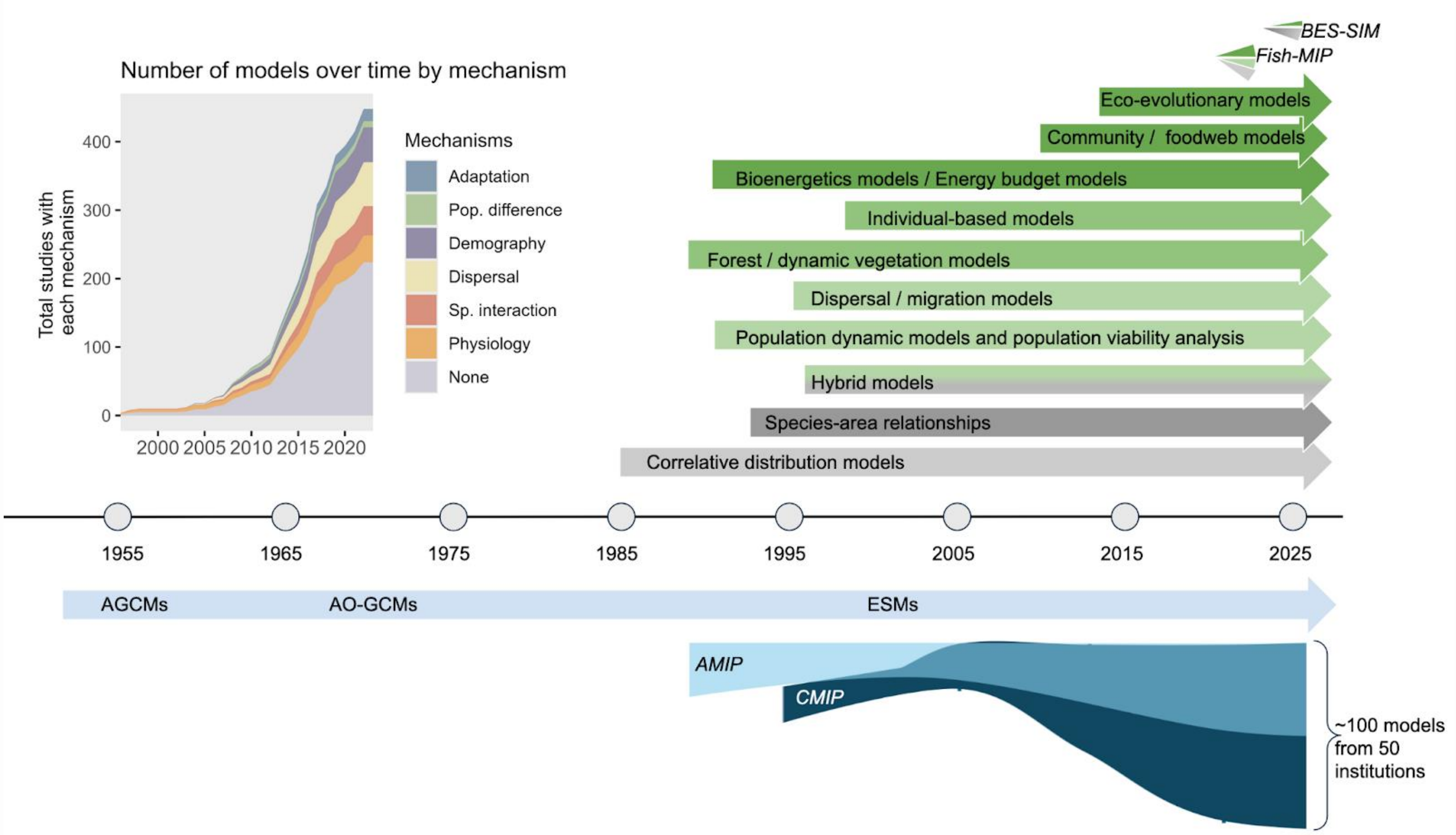
Biodiversity model intercomparison (BMIPs)

Biodiversity model intercomparisons (BMIPs)



Zurell et al. (subm.)

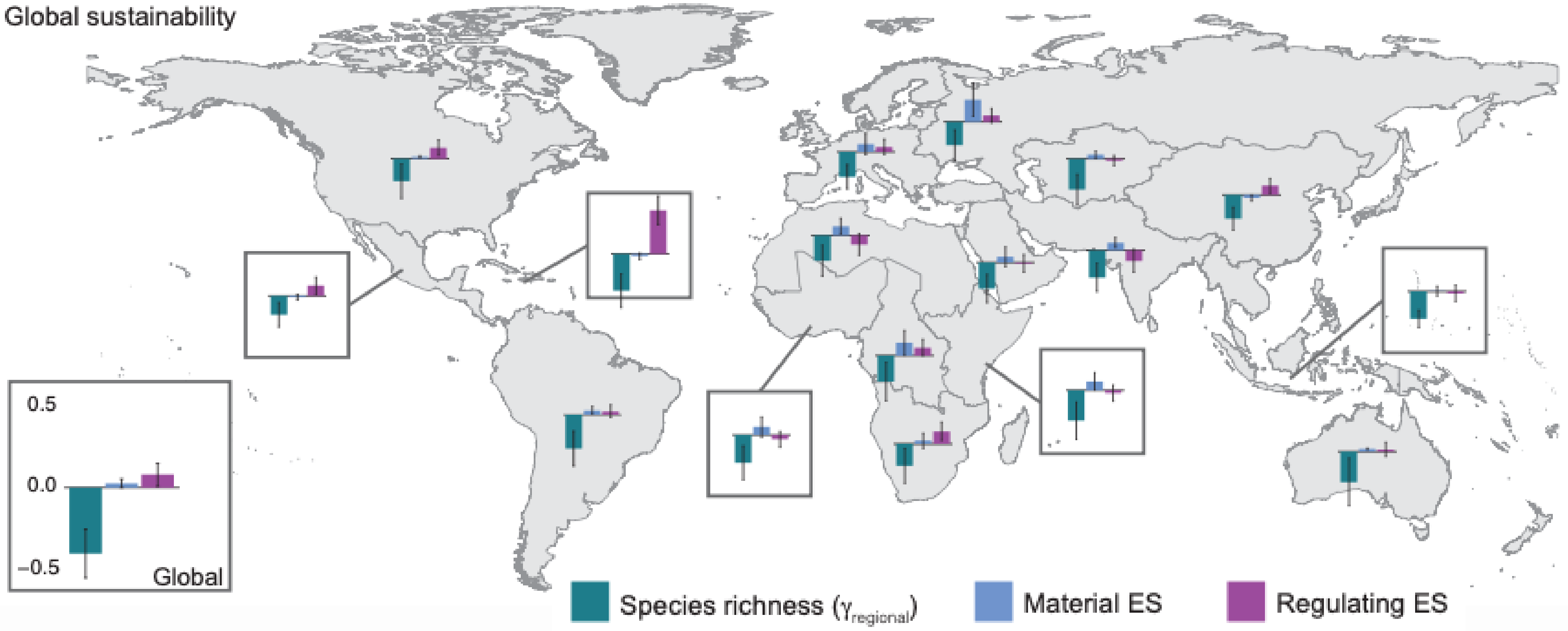
Global, terrestrial BMIP: BES-SIM

RESEARCH ARTICLE | BIODIVERSITY LOSS

Global trends and scenarios for terrestrial biodiversity and ecosystem services from 1900 to 2050

HENRIQUE M. PEREIRA, INÊS S. MARTINS, ISABEL M. D. ROSA, HYEJIN KIM, PAUL LEADLEY, ALEXANDER POPP, DETLEF P. VAN VUUREN, GEORGE HURTT, LUISE QUOSS, [...], AND ROB ALKEMADE

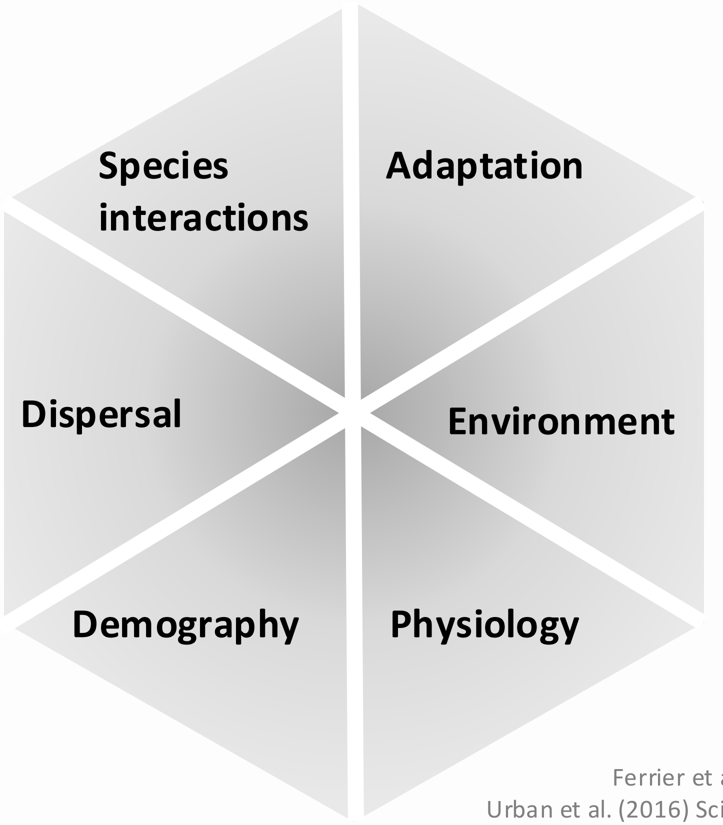
SCIENCE • 25 Apr 2024 • Vol 384, Issue 6694 • pp.



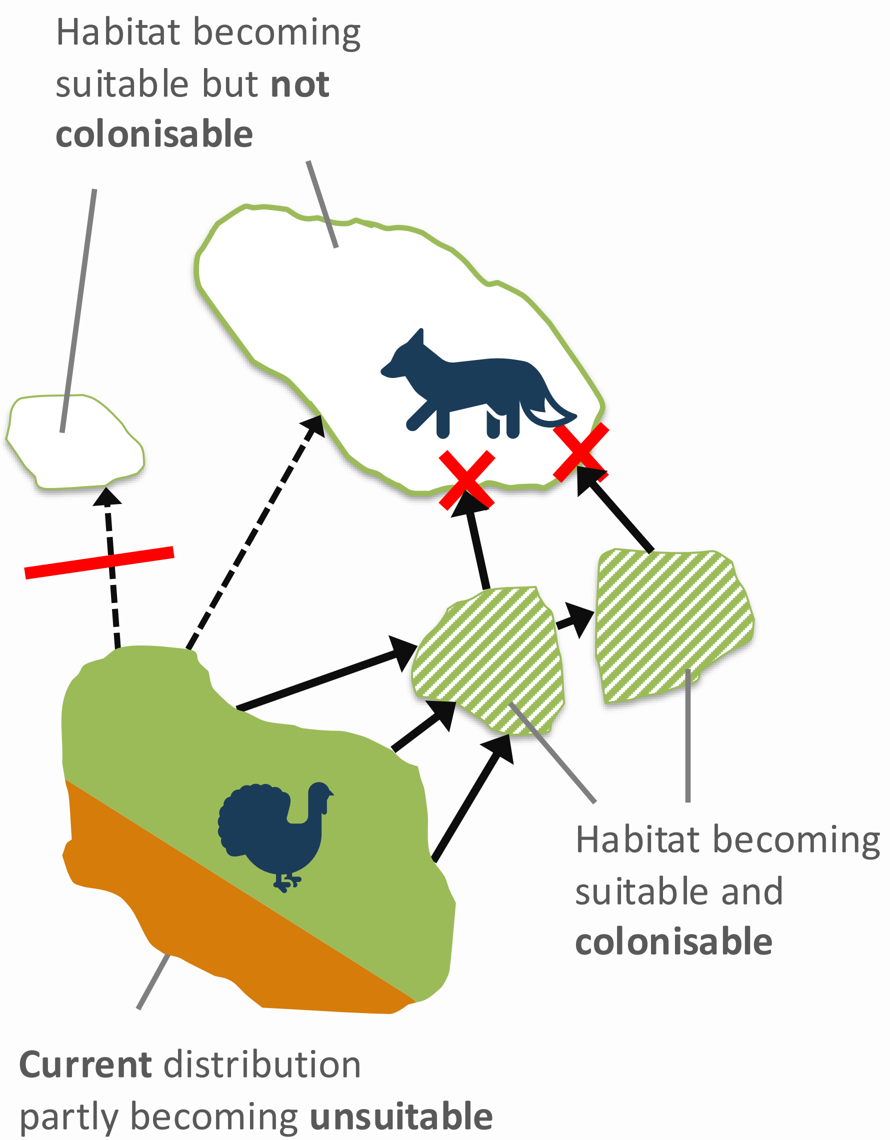
Process-based modelling in BMIPs?

Key mechanisms of biodiversity response

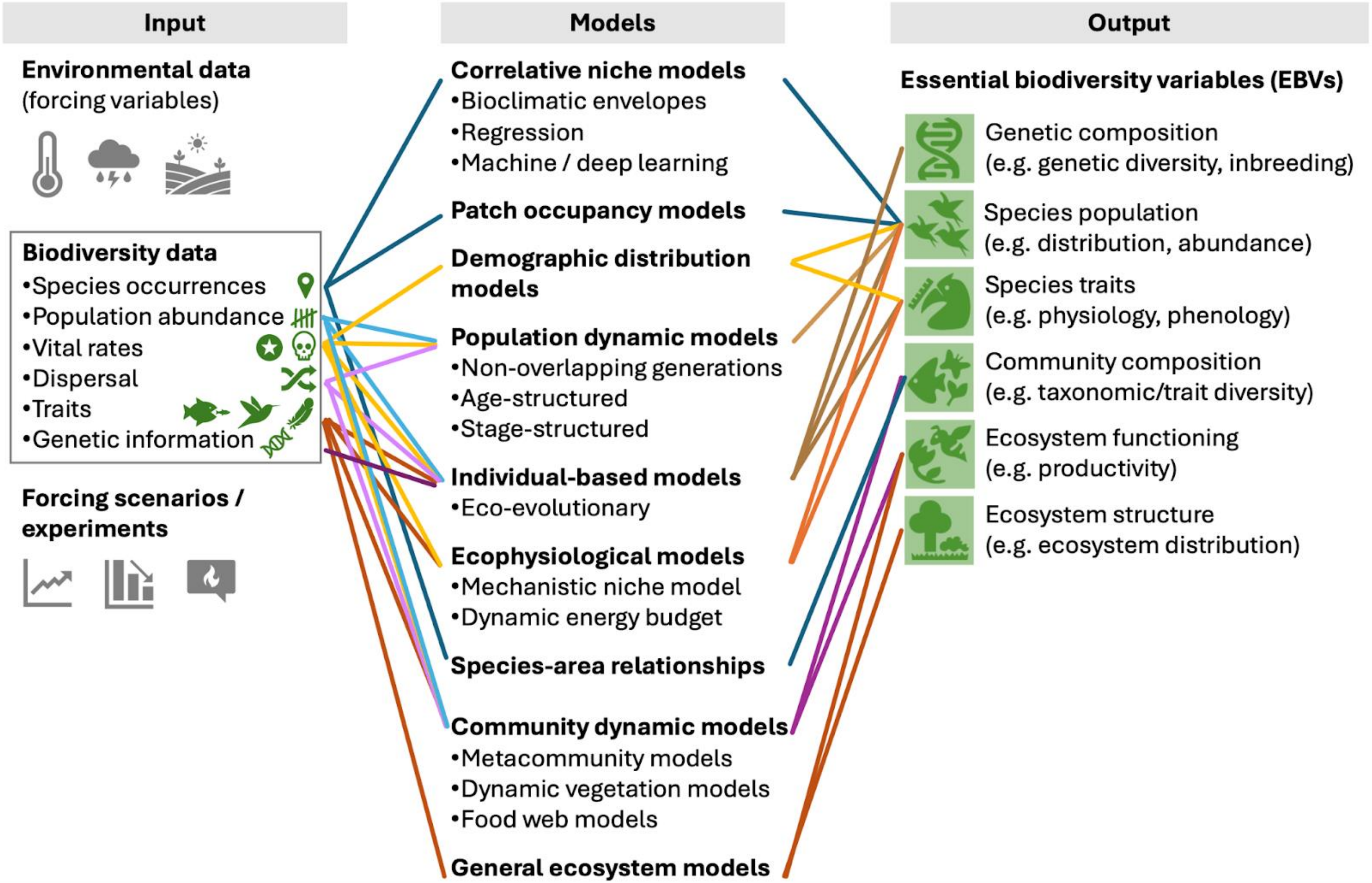
Accurately predicting biodiversity change requires solid representation of underlying processes



Ferrier et al. Eds (2016) IPBES.
Urban et al. (2016) Science 353: aad8466.



Potential models in (terrestrial) BMIPs



Zurell et al. (subm.)

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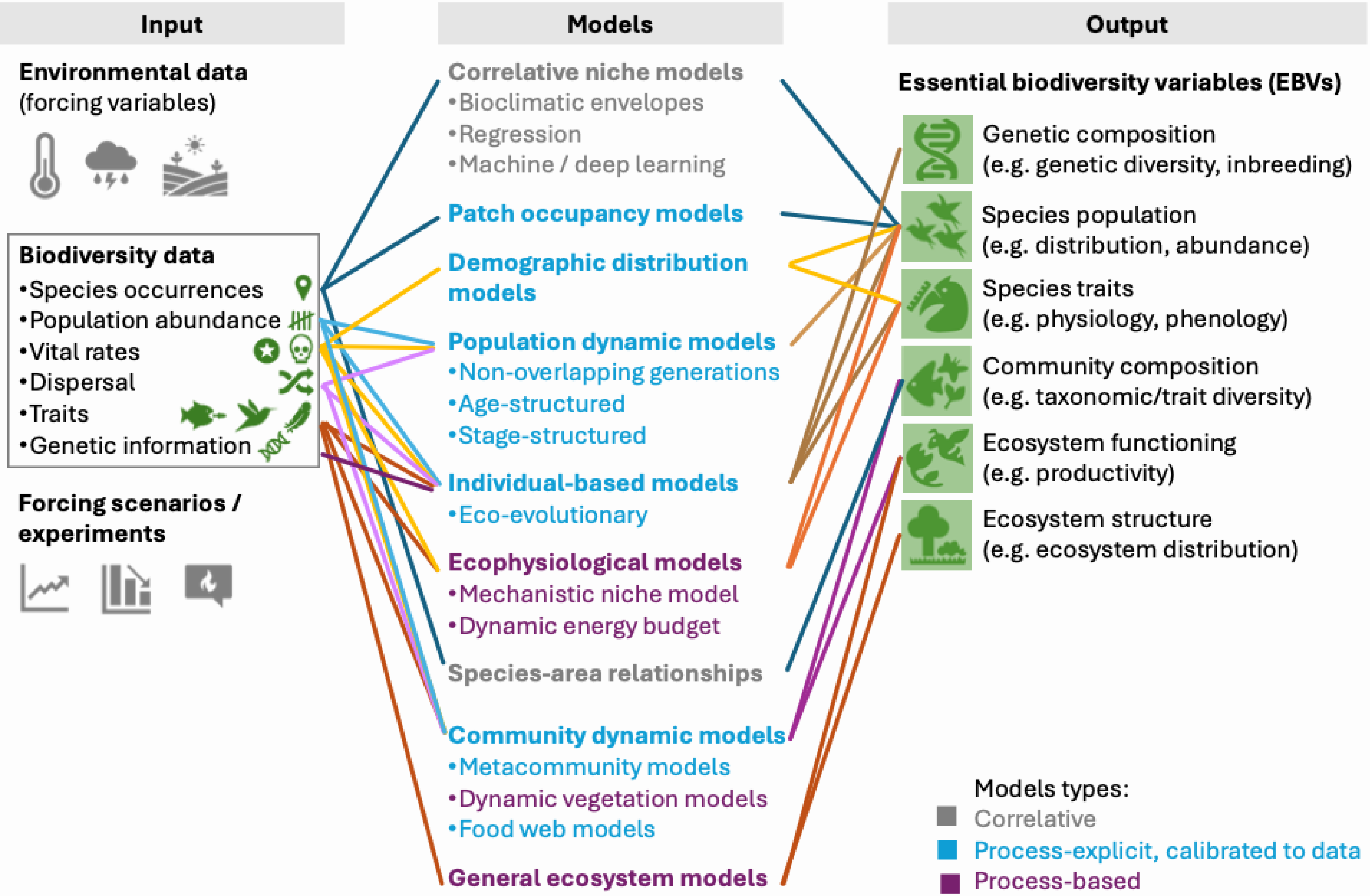

Zurell et al. (subm.)

Biodiversity model intercomparisons (BMIPs)

Challenges:

- Limited data: taxonomic and spatial biases, low availability of historical data
- Technical challenges – calibrating & validating models
- Scale dependence – ecological processes are hierarchical
- Few modelling centres – ecological modellers are dispersed
- …

BMIP - Regional biodiversity model intercomparison

Input
Climate ISIMIP3b Land use / cover ~~LUH2,~~ HILDA+ Biodiversity data Species occurrence / abundance time series, dispersal parameters, demographic parameters, physiological parameters

Example regions/taxa: North American breeding birds, Australian mammals and reptiles, European aquatic invertebrates, Finnish plants

BMIP - Regional biodiversity model intercomparison

Input	Models
Climate ISIMIP3b Land use / cover ~~LUH2,~~ HILDA+ Biodiversity data Species occurrence / abundance time series, dispersal parameters, demographic parameters, physiological parameters	Global SDM (distribution), ADM (abundance) Regional Dynamic occupancy models, integral projection models, spatially explicit population models (RangeShifter, steps, MetaRange, MigClim), EcoPhys

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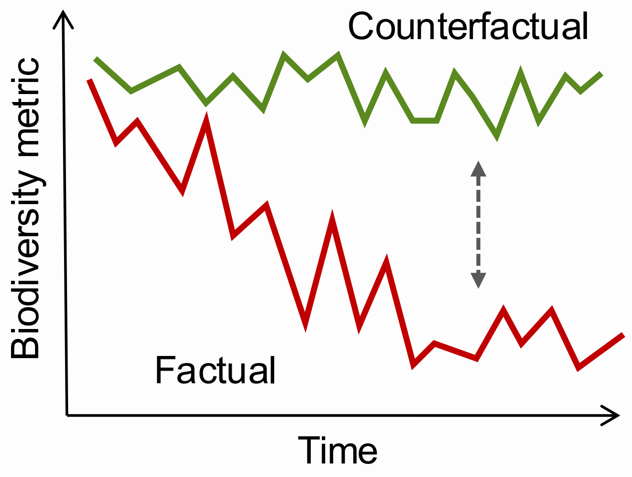
BMIP - Regional biodiversity model intercomparison

Input	Models	Assessments
<u>Climate</u> ISIMIP3b <u>Land use / cover</u> ~~LUH2,~~ HILDA+ <u>Biodiversity data</u> Species occurrence / abundance time series, dispersal parameters, demographic parameters, physiological parameters	<u>Global</u> SDM (distribution), ADM (abundance) <u>Regional</u> Dynamic occupancy models, integral projection models, spatially explicit population models (RangeShifter, steps, MetaRange, MigClim), EcoPhys	a. Model evaluation – spatial and temporal patterns and dynamics • Taxonomic and functional diversity • Attribution to abiotic drivers (climate and land use) and biotic drivers (time-lagged responses) b. Future spatiotemporal predictions considering time lags

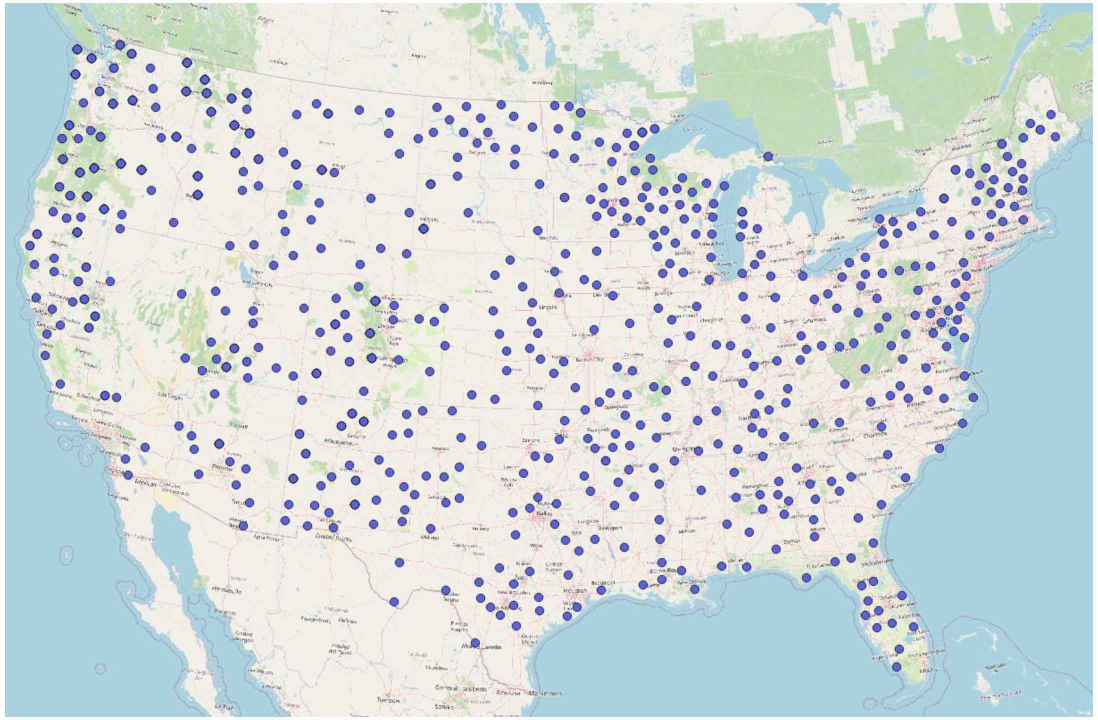
Example regions/taxa: North American breeding birds, Australian mammals and reptiles, European aquatic invertebrates, Finnish plants

Detection & attribution



Dynamic occupancy models

- 25 years: 1995 – 2019
- 539 bird survey routes across the US, 159 species
- 50 km resolution
- ISIMIP climate (GSWP3-W5E5) and land use data (LUH2) => but new counterfactuals relative to 1995
- Spatial and temporal validation



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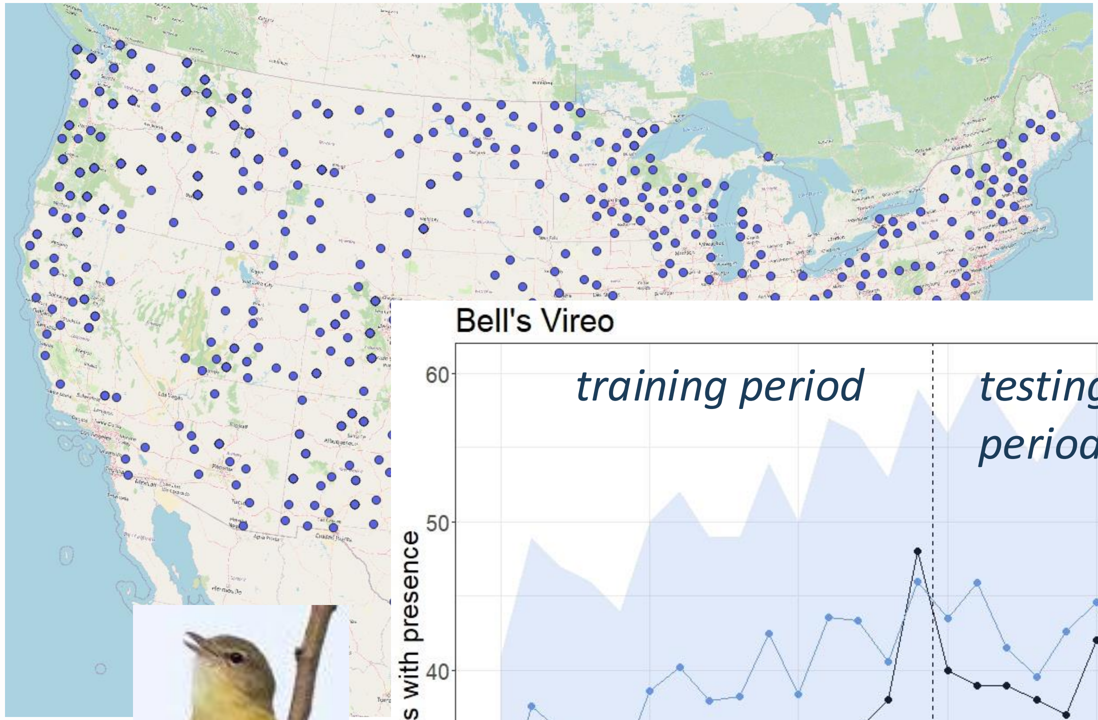

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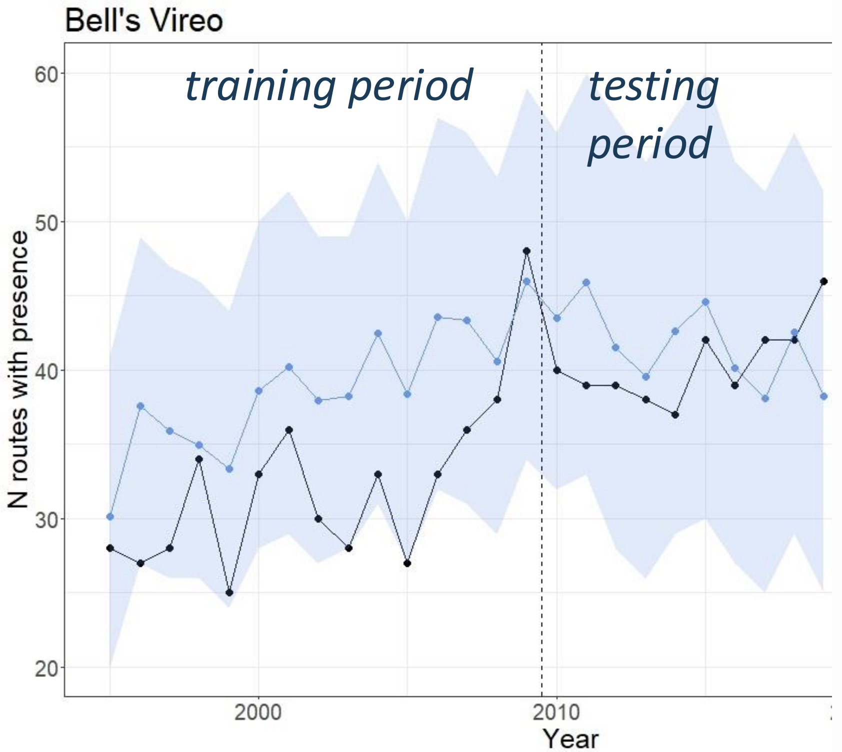
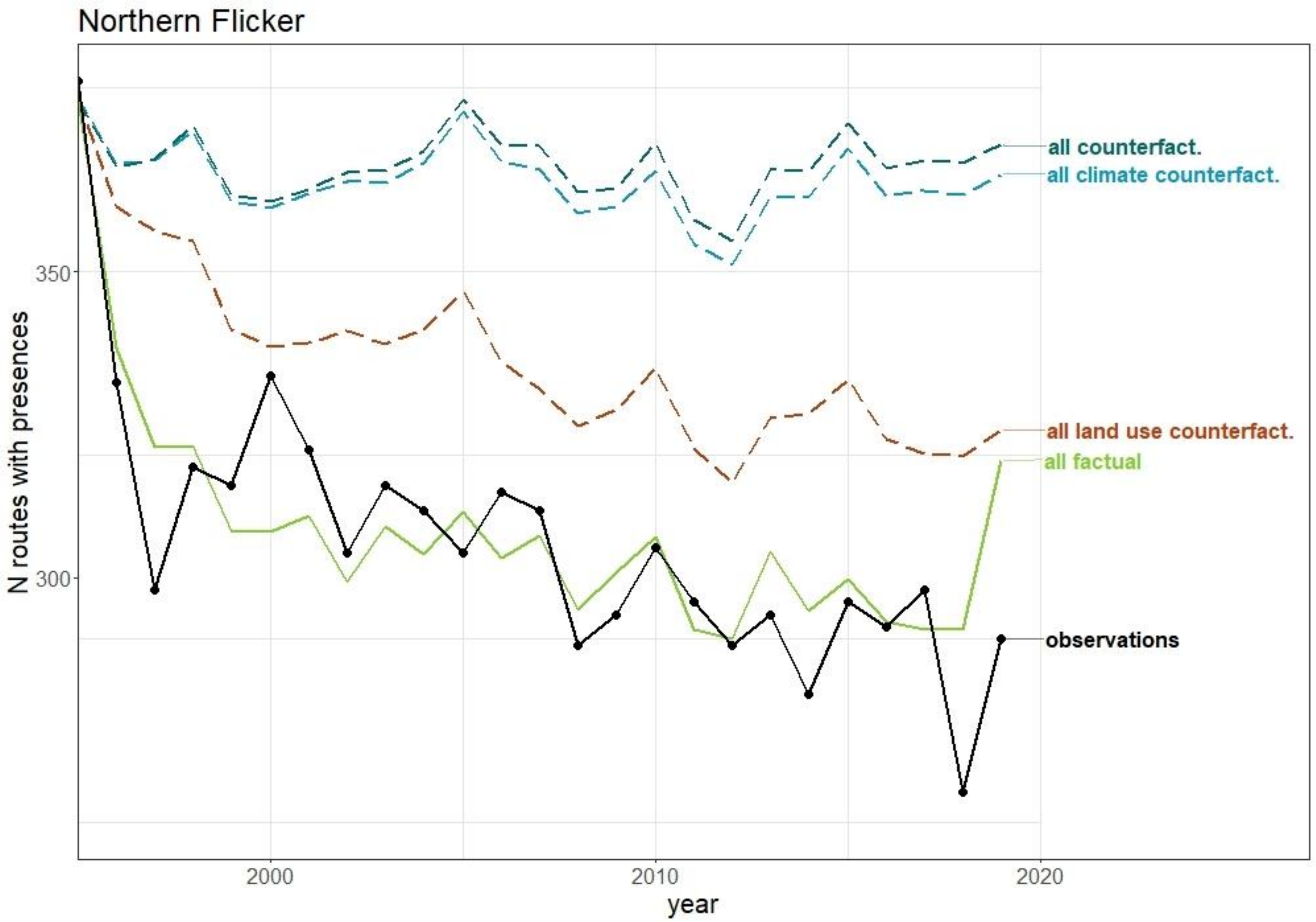


Schifferle et al. (in prep.)

Dynamic occupancy models

- Attribution of occupancy changes to climate and land use change since 1995



© Matthew Plante

Schifferle et al. (in prep.)

BMIP - Regional biodiversity model intercomparison

Input

Climate
ISIMIP3b

Land use / cover
~~LUH2,~~ HILDA+

Biodiversity data
Species occurrence / abundance time series, dispersal parameters, demographic parameters, physiological parameters

Models

Global
SDM (distribution), ADM (abundance)

Regional
Dynamic occupancy models, integral projection models, spatially explicit population models (RangeShifter, steps, MetaRange, MigClim), EcoPhys

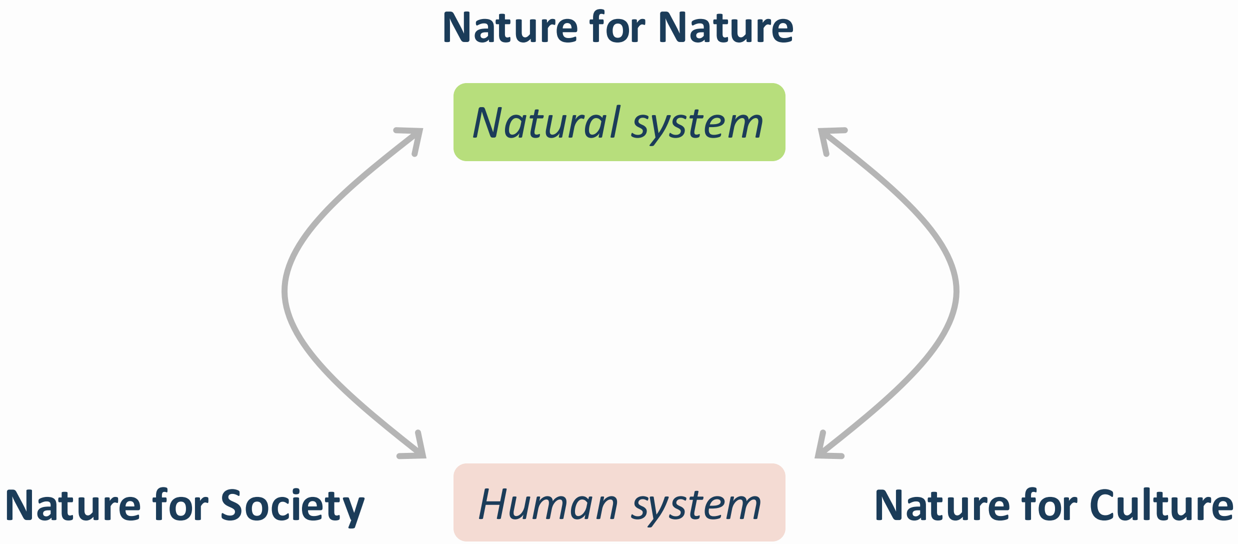
Assessments

a. Model evaluation – spatial and temporal patterns and dynamics
   - Taxonomic and functional diversity
   - Attribution to abiotic drivers (climate and land use) and biotic drivers (time-lagged responses)

b. Future spatiotemporal predictions considering time lags

Example regions/taxa: North American breeding birds, Australian mammals and reptiles, European aquatic invertebrates, Finnish plants

Linking biodiversity and other sectors



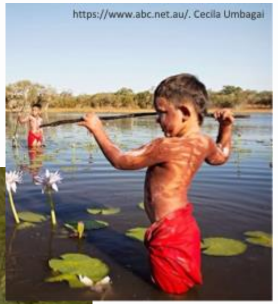
Adapted from Kim et al. (2023) Global Env Change 82: 102681.

Linking biodiversity and other sectors

Intrinsic values: nature has value in and of itself, refer to ethical and moral responsibility

Nature for Nature

Natural system



Nature for Society

Human system

Nature for Culture

Instrumental values: use values (productive and consumptive) and ecosystem services, describe the benefit or purpose for humans

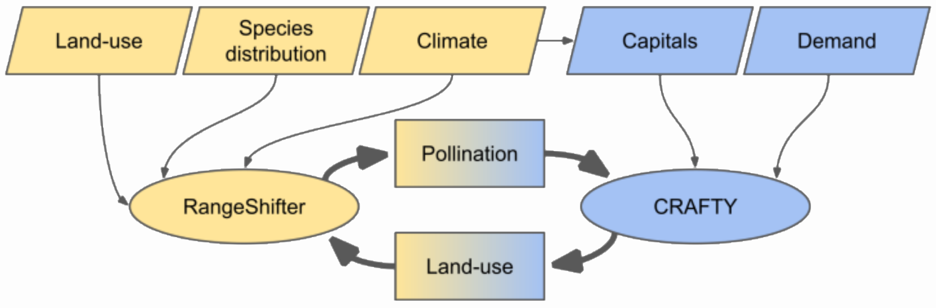
Relational values: refer to the relationship humans have with nature, e.g. cultural identity

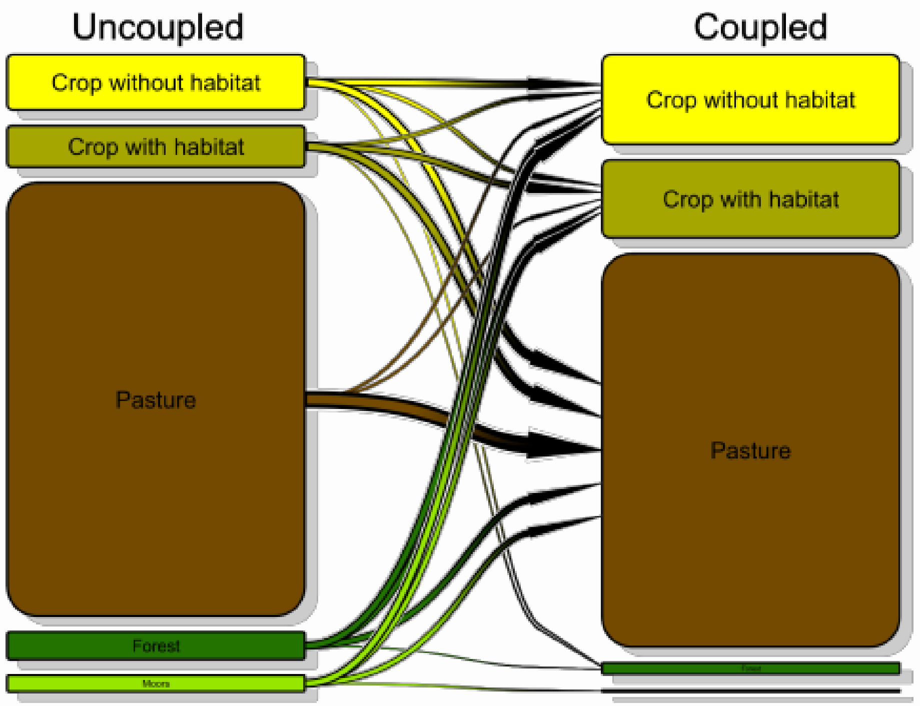
Adapted from Kim et al. (2023) Global Env Change 82: 102681.

Linking biodiversity and other sectors

Examples:

- Feedback between climate change-induced population decrease of pollinators & demand for agricultural land





Urban et al. (2022) BioScience 72: 91-104.

Linking biodiversity and other sectors

Examples:

- Feedback between climate change-induced population decrease of pollinators & demand for agricultural land
- Linking riverine or coastal biodiversity to water quality, flood risk or erosion models to assess ecosystem service provision under climate change, e.g. filtration and flood control
- Feedback between biodiversity and water cycles
- Spatial trade-offs between renewable energy production and biodiversity protection
- Linking disease spread and biodiversity

More funding needed to refine concepts and methods

Thank you!

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