

# **A global biodiversity observing system to unite monitoring and guide action**

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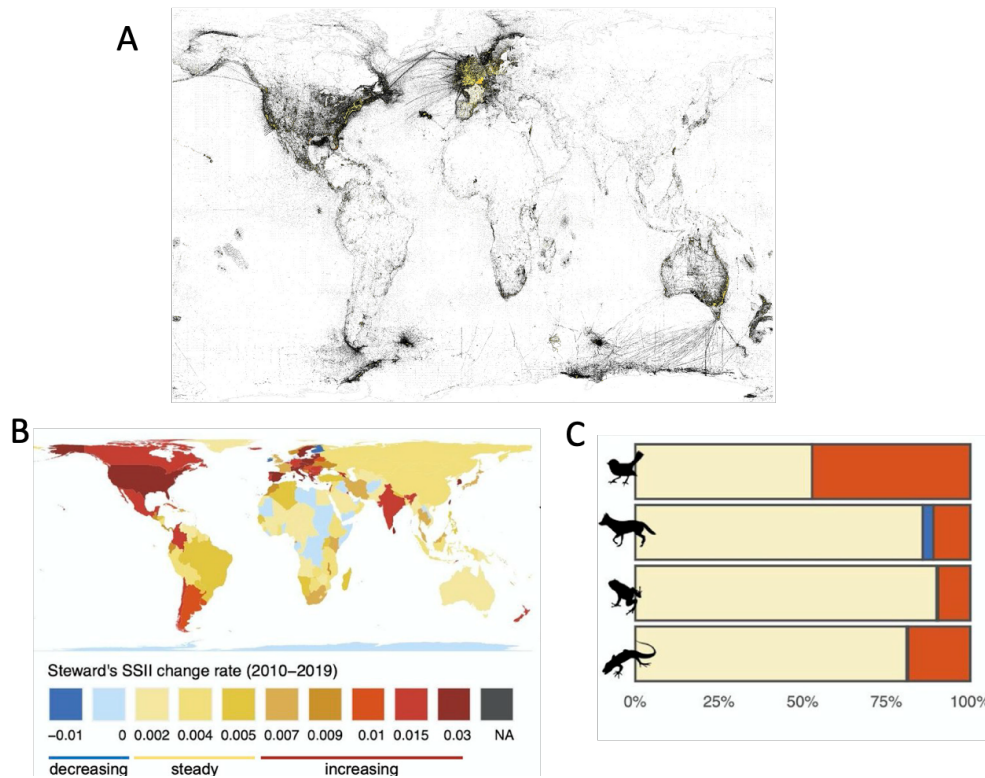
# **A global biodiversity observing system to unite monitoring and guide action**

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## Supplementary Figure and Table



**Supplementary Figure 1:** *The geography of species observations and their use for assessing trends. A) Areas with records in GBIF and OBIS databases. Black dots show locations with 1-50 records. Terrestrial, freshwater, and marine systems are unsampled<sup>1</sup> (based on all databased records; figure from Hughes et al. 2021; see also<sup>2</sup>. B, and C: Trends in biodiversity data coverage by GBIF data 2000-2019 for all ca. 31,000 extant terrestrial vertebrate species. The GEO BON Species Status Information Index (SSII) measures annually how well sampled occurrence data address status and trends in species populations<sup>3</sup>. In warm colors (orange to red) are areas where the collection of taxa occurrence data contributing to monitoring species populations is increasing, and in blue where it is decreasing.*

### Supplementary References for Figure S1

1. Hughes, A. C., et al. *Ecography*, **44**, 1259-1269 (2021).
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**Supplementary Table 1:** Examples of national, regional, or thematic biodiversity observation networks reviewed by GEO BON. Some networks have not yet been endorsed by GEO BON.

Country/region of BON	Biome/EBV/species in focus	Governance/ coordination of biodiversity monitoring
<b>Regional BONs</b>		
Arctic BON <sup>1</sup>	arctic	coordinated by CAFF, supported by Arctic Council and CBMP
Asia-Pacific BON (APBON) <sup>2,3</sup>	WGs covers terrestrial (forest), freshwater, and marine.  boreal, temperate, sub-tropical, tropical / genetic, species, ecosystems / various taxa, phenology, ecosystem functions (e.g., carbon cycle) and services	Established in 2009 at the timing of CBD COP 10 (Nagoya, Japan). Secretariat in the Biodiversity Center of Japan, Ministry of the Environment Japan <a href="http://www.esabii.biodic.go.jp/ap-bon/index.html">http://www.esabii.biodic.go.jp/ap-bon/index.html</a> . Approx. +50 scientists from more than 10 countries and international institutions, universities, national institutions, NGO. Co-chairs (three-year term), Advisory Board (past co-chairs), Management committee, and three working groups. One of Asia-Oceania GEO Task Groups ( <a href="https://aogeo.net/en/">https://aogeo.net/en/</a> ). AP-MBON was launched in 2019 by the Marine group in APBON. Partners: ASEAN Centre for Biodiversity, Asia-Oceania GEO, ILTER East Asia-Pacific regional network.
EuropaBON & European Biodiversity Partnership	various in the Europe, especially EBVs	regional coordination and methodological guidance by EC (top-down) and promoting monitoring across national schemes by ministries of the environment and other national networks (bottom-up) (on-going)
SASSCAL Observation Network (regional: Angola, Namibia, South Africa, Zambia) <sup>4</sup>	Miombo, Savanna, Semi-Desert, Nama Karoo, Succulent Karoo	Network of Angolan, Namibian, Zambian, South African and German researchers and conservationists and paraecologists.
<b>National and sub-regional BONs</b>		
Australia <sup>5,6</sup>	Threatened species data across the taxonomic groups of birds, plants, and mammals; many EBVs by TERN	The Threatened Species Index ( <a href="http://tsx.org.au">tsx.org.au</a> ) was developed by the National Environmental Science Program's Threatened Species Recovery Hub and in collaboration with 42 partners from the Commonwealth Government, all State and Territory governments, several large NGOs and research institutions 2016-2020; since 2021, the TSX has been operated by the Terrestrial Ecosystem Research Network (TERN).
China BON	especially species richness and abundance (birds,	400 universities, research institutes, conservation agencies and civil societies

	reptiles, mammals and butterflies)	
China, Sino BON	ecosystem structure, soils, birds, mammals, insects, invertebrates	coordinated by Chinese Academy of Sciences (CAS)
Colombia BON <sup>7,8,9,10</sup>	tropical, mammals, birds, amphibians, reptiles, plants, fish, insects, piloting EBVs on local scale	coordinated by the Instituto de Investigación de Recursos Biológicos Alexander von Humboldt
Finland FEO <sup>11</sup>	boreal and arctic, ecosystem structure and function, habitats, various taxa	coordinated by Finnish Environment Institute/ ministry of the environment, in cooperation with FinBIF, research institutes and universities
French BON	temperate, mostly terrestrial species surveys (bats, birds, butterflies, snails, plants) but also marine fish; EBV: species population abundance, community composition, demographic traits and phenology	Split between two ministries; coordinated by the National Museum of Natural History (MNHN), the French Office for Biodiversity (OFB) and the National Center for Scientific Research (CNRS), in cooperation with FRB, Sorbonne Univ., CIRAD, Irstea, Ineris, INRA, Ifremer, Montpellier Univ.
Japan BON (JBON) <sup>2</sup>	boreal, temperate, sub-tropical, tropical / genetic, species, ecosystems / various taxa, phenology, ecosystem functions (e.g., carbon cycle) and services  alpine ecosystems, forests, grasslands, Satoyama (traditional landscapes consist of various human dominated ecosystems), lakes, wetlands, marine, coastal/island ecosystems	Established in 2009. Secretariat in National Institute for Environmental Studies, Japan. Network of networks, scientists in research institutions and universities. National component of APBON. Partners: Japan LTER network (JaLTER <a href="http://www.jalter.org/en/">http://www.jalter.org/en/</a> ), JapanFlux, Japan Agency for Marine-Earth Science and Technology) The Monitoring Sites 1000 project cooperated by scientists and voluntary citizens (run by the Ministry of the Environment of Japan)
Nepal	Himalayan ecosystems, endangered species	ILK, local communities, in cooperation with AP BON and international NGOs
New Zealand <sup>12</sup>	temperate (terrestrial)	two national authorities: Department of Conservation (public land), Ministry for the Environment; regional councils (private land); in collaboration with research institutes, universities and Māori landowners (ILK)
Taiwan BON (TaiBON) <sup>13,14,15</sup>	diverse terrestrial and marine taxa (e.g.,	Monitoring: multiple agencies under the Council of Agriculture (terrestrial), Ocean Affairs Council (marine),

	terrestrial vertebrates, marine mammals, moths and butterflies, plants) and tropical/subtropical ecosystems (e.g., forests, mangroves, coral reefs)	Ministry of Economic Affairs (freshwater), and Ministry of the Interior (national parks), with collaboration with research institutes, universities and NGOs. Data integration and exchange: Taiwan Biodiversity Information Alliance, which is an interagency collaborative network for biodiversity data integration and exchange ( <a href="https://www.tbiadata.tw">https://www.tbiadata.tw</a> ) Indicator development and reporting: Forestry Bureau (TaiBON; <a href="https://taibon.tw/en">https://taibon.tw/en</a> )
South Africa BON	Cape Floristic Region(Mediterranean biome); Subtropical grassland and savanna; Temperate grasslands & shrublands; Subtropical broadleaf forest; Temperate broadleaf forest; Desert & xeric shrublands; Mangroves	a multi stakeholder process lead by two national government institutions (SANBI and SAEON); involving over 27 institutions, government, academia, NGO and commercial
Switzerland <sup>16</sup>	Comprehensive species lists, country wide	Federal Office for the Environment (lead) with substantial benefits for new methods. Links to national infrastructures on remote sensing ( <a href="https://ares-observatory.ch/">https://ares-observatory.ch/</a> ) in the make.
<b>Thematic BONs</b>		
MBON (marine) <sup>17,18</sup>	Marine, coastal and oceanic environments, and local to global scales, from microbes to whales; Essential Ocean Variables developed by GOOS from a complementary perspective with EBVs <sup>17</sup>	coordinated by <a href="#">GEO BON</a> , <a href="#">MBON Pole to Pole</a> , <a href="#">U.S.MBON</a> , and MBON secretariats in Europe (AIR Centre), Asia-Pacific (, and the Americas (NOAA IOOS). MBON is a collaboration with the Intergovernmental Oceanographic Commission (IOC) of UNESCO for: a. Implementation through integration of biological and biodiversity observations into the regional alliances of ocean observing networks that constitute the Global Ocean Observing System ( <a href="#">GOOS</a> ) b. Partnership with the Ocean Biogeographic Information System (OBIS) for data and metadata publication, curation and distribution;  Partners: Global Ocean Observing System, Ocean Biogeographic Information System (OBIS), U.S. Integrated Ocean Observing System, U.S. National Marine Sanctuaries, State and federal agencies, and many more
FWBON (freshwater) <sup>19,20</sup>	Rivers, palustrine and lacustrine freshwater, wetlands, subterranean aquatic ecosystems, novel freshwater ecosystems.	With members in over 70 countries in all continents except for Antarctica, FWBON serves as a Freshwater monitoring. Volunteer researcher and practitioner network

	There currently is a greater focus on multinational monitoring programs and Initiatives such as the Circumpolar Freshwater Biodiversity Monitoring Program, and the cross-Amazon Freshwater Fish and Macroinvertebrate monitoring Initiatives.	FWBON members are leading or contributing to many of the Freshwater Biodiversity Monitoring Programs that operate across large Geographic areas and influence the directions of these programs. FWBON is also collaborating with other Global Partners e.g. IUCN Freshwater Species Program and Alliance for Freshwater Life to align different monitoring initiatives towards a global assessment of Freshwater Biodiversity.
Soil BON <sup>21</sup>	Terrestrial ecosystems, from microbes to earthworms, including biodiversity-driven soil functions.	SoilBON has a 2-tier organization, with a international cluster of laboratories that will perform all analysis in a standard and systematic way, and a second extensive group of collaborators that both provide samples and participate from the scientific insights of the network.
OMIC BON	A thematic BON focused on the study of genes, transcripts, proteins, metabolites, and other biomolecules in organisms or environmental materials.	Omics enables biodiversity observation at the molecular scale across environments and geographies. Omic BON will complement thematic BONs focused on environments (Marine BON, Freshwater BON, Soil BON), as well as national and regional BONs. Omic BON will additionally closely work with the GEO BON Genetic Composition Working Group.  Omic BON will be coordinating effort along five major axes: (1) localized omic observatories, (2) networks of observing platforms, (3) data infrastructures, (4) curated and long-term stores of biosamples, and (5) (meta)data standardization bodies.
Coral reefs/GCRMN	coral reefs/global (EBV/EOVs: hard coral cover, algal cover, fish diversity and abundance)	A GCRMN Steering Committee, Host Institution and Global Coordinator mandated under the international Coral Reef Initiative ( <a href="http://www.icriforum.net/gcrmn">www.icriforum.net/gcrmn</a> ). Coordination resources provided by major ICRI members/countries. Coordination through 10 operational regional networks, with resources provided by major ICRI members/countries.
Invasive alien species <sup>22</sup>	The subset of species introduced outside of their native range and with potential or realized negative impacts on biodiversity	National checklist updates supported by GBIF, IUCN SSC ISSG, the CBD CHM and GEO BON, modelled indicators (using EBVs) supported by a GEO BON coordinated partnership

## References of Supplementary Table 1:

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