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Convention on Biological Diversity

GEO BIN Global Conference



MONITORING BIODIVERSITY FOR ACTION

REPORT

11 December 2023



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Foreword

We can now observe the changing state of nature with an array of methods and instruments that can be deployed from the ground, the air, in space, and in the water. This technology and the data it produces must now be used to create knowledge about how biodiversity is changing, how it will change in the future, and what we can do to reverse unsustainable trends. Nearly one year after the United Nations Biodiversity Conference (COP 15), leading experts and stakeholders in the field of biodiversity science came together in Montreal for GEO BON's 2023 Global Conference: "Monitoring Biodiversity for Action" (10 to 13 October 2023).

The event was co-hosted with the United Nations Convention on Biological Diversity (CBD). The main focus of the conference was putting biodiversity monitoring into action, while featuring the latest developments in the knowledge and science needed to monitor biodiversity change around the world in order to guide action towards achieving the targets of the <u>Kunming-Montreal Global</u> <u>Biodiversity Framework (KMGBF) of the CBD</u>.

The 2023 GEO BON Conference was the opportunity to engage scientists, government people, stakeholders and rights holders towards the common goal of protecting biodiversity for current and future generations.

The four-day conference provided:

- Unique insights from plenary presentation, parallel sessions, panel discussions and workshops by world-renowned scientists, policymakers, and conservationists
- Expert insight on the most pressing biodiversity challenges and potential solutions for biodiversity monitoring
- A deep dive into the critical role of linking biodiversity monitoring programmes and initiatives in order to inform policy and actions to combat biodiversity loss.

We would like to express our deep gratitude to the GEO BON community, including the many members that volunteered to organize conference sessions, the student volunteers, and GEO BON's Implementation Committee for their time, expertise, and our sponsors.

This document cannot capture all of the thoughtful discussions and ideas shared among new and old friends in and around the venue, but we hope it reflects the content of the GEO BON 2023 Conference. Readers are invited to refer to the <u>Conference webpage</u> and abstracts for more information. Presentation slides are available at the end of individual abstracts. Recordings are provided where available.

Looking forward to seeing you at the next meeting in Colombia 2025!

Conference Organizing Committee

he conference in numbers



Links:

Conference Webpage:

Conference Recordings (YouTube playlist):

Conference photos by Animesh Ghose (naive.photographie)

BON in a Box:

BON in a Box Introduction video:

https://geobon.org/conf2023

https://www.youtube.com/playlist? list=PLND0FZa0b1hLuBRqVwpdf1fsRomULVtIa

https://photos.app.goo.gl/dVE7GZddmAitCfx7A

https://boninabox.geobon.org/

https://www.youtube.com/watch? v=mLjnjCWwU3w&ab_channel=GEOBON

Opening Ceremony

The Conference was opened by Adriana Radulovici, Executive Secretary of GEO BON. The timing of this year's conference marks GEO BON's fifteenth year in existence, developing Essential Biodiversity Variables (EBVs), Biodiversity Observation Networks (BONs), and collaborating among biodiversity scientists who are working to put biodiversity observation data into practice.

Just last year, policy-makers were in Montreal to negotiate the adoption of the Kunming-Montreal Global Biodiversity Framework (KMGBF) at the fifteenth meeting of the Conference of the Parties to the Convention on Biological Diversity (CBD COP 15). Now GEO BON and the CBD have partnered to organize this conference to help implement the framework through the lens of monitoring biodiversity for action.

Participants received a motivating welcome to share knowledge on monitoring biodiversity with a purpose: informing decisions to protect and use biodiversity sustainably. Additional welcoming messages were provided by the following speakers:

- Otsi'tsaken:ra Charles Patton Elder from the Kanien'keha:ka Community of Kahnawake
- Marc d'Iorio Assistant Deputy Minister of the Science and Technology Branch, Environment and Climate Change Canada
- His Excellency, Carlos Arturo Morales Ambassador of the Republic of Colombia to Canada
- Marie-Andrée Mauger Membre du comité exécutif de la Ville de Montréal, responsable de la transition écologique et de l'environnement et Mairesse de l'arrondissement de Verdun
- David Cooper Acting Executive Secretary, Secretariat of the Convention on Biological Diversity
- María Cecilia Londoño Instituto Humboldt (Colombia) and GEO BON co-Chair
- Andrew Gonzalez McGill University (Canada) and GEO BON co-Chair

Recording available.



Otsi'tsaken:ra Charles Patton



David Cooper



María Cecilia Londoño



Andrew Gonzalez

Keynote

Jillian Campbell, Head of Monitoring, Review and Reporting at the Office of the Secretariat of the United Nations Convention on Biological Diversity (SCBD) presented, "Monitoring the Kunming-Montreal Global Biodiversity Framework." <u>Recording available</u>

Joji Cariño, Senior Policy Advisor for the Forest Peoples Programme presented, "Communitybased Monitoring and Information Systems: Learning from Nature and Cultures at Local to Global Scales."

Recording available









Parallel Sessions

Mainstreaming Biodiversity Monitoring into Policy and Practice



Organizers:

- Alice Hughes (AP-BON, University of Hong Kong)
- Laetitia Navarro (Estación Biológica de Doñana, EBD-CSIC)

Mainstreaming is a key part of effectively reaching biodiversity goals, from the implementation of targets to the monitoring of success. This session discussed the various elements of mainstreaming, from assessing and monitoring biodiversity patterns and communicating them to stakeholders, to helping refine and realise conservation goals and targets.

Session abstracts and slides.

Biodiversity Change Indicators



Organizers:

- María Cecilia Londoño (GEO BON, Instituto Humboldt)
- Melodie McGeoch (La Trobe University)

Biodiversity indicators are needed to put monitoring into action. Indicators are essential to realize the trends in the state of biodiversity and the outcomes of the Kunming-Montreal Global Biodiversity Framework. By progressively improving indicators, we can understand how drivers of biodiversity loss cause biodiversity change. This session discussed particular biodiversity indicators and the additional information and resources needed to use and improve them for effective monitoring.

BON in a Box (INTRO SESSION)





María Cecilia Londoño presenting.

Organizers: Instituto Humboldt

Speakers:

- Andrew Gonzalez (GEO BON, QCBS, McGill University)
- César Gutiérrez Montoya (Instituto Humboldt)
- Jean-Michel Lord (GEO BON Secretariat)
- María Cecilia Londoño (GEO BON, Instituto Humboldt)

The Global Biodiversity Framework calls for a robust monitoring framework designed to support national reporting of progress towards the targets and goals. The monitoring framework uses indicators to track progress that use existing biodiversity data and new data derived from monitoring schemes (e.g. biodiversity observation networks, BONs). Many countries are now planning to increase their monitoring capacity and mobilize existing data to support their NBSAPs and report progress (in 2026) on the targets of the GBF.

To support the process, GEO BON is developing an online platform that will help countries assess the information they have and guide monitoring to improve knowledge of the trends in biodiversity. This platform, called <u>BON in a Box</u>, will allow you to:

- 1. Use a new interactive tool to guide where to monitor biodiversity to improve trend detection and attribution to guide conservation action. This tool will work for existing or planned BONs.
- 2. Work with global and national datasets to create country specific insights.
- 3. Calculate and display Essential Biodiversity Variables (EBVs) and GBF Indicators, using our open platform. The workflows for these calculations will be transparent and reproducible.
- 4. Receive support from GEO BON's large expert community.
- 5. Develop and use models to provide projections of EBVs for areas where data are missing.
- 6. Find ongoing biodiversity monitoring projects and share insights.

The platform can play a key role by fostering collaboration in the worldwide reporting efforts, by sharing information about tools and projects, and by sharing open, generalizable, reproducible and transparent EBV and indicator pipelines. We presented the idea of optimizing sampling using the uncertainty of the variables we want to measure. There was considerable interest in the demonstration and the discussions quickly dove into technical aspects of the pipeline engine. We could clearly see that the community is eager for such open and collaborative tools.

Ecosystem Extent Mapping from Satellite Earth Observations: A Framework for Biodiversity Monitoring



Organizers:

- Jason Duffe (Environment and Climate Change Canada)
- Gary Geller (Jet Propulsion Lab-NASA)
- Yves Crevier (Canadian Space Agency)
- Lucie Viciano (Canadian Space Agency)

Ecosystem extent is a key indicator that reflects the state and health of ecosystems, their biodiversity, and the services biodiversity provides to society. Mapping and monitoring ecosystem extent involves the use of remote sensing technology to assess the distribution and composition of ecosystems and biodiversity. This session highlighted the state-of-the-art Earth Observation (EO) image technologies and algorithm development for ecosystem extent mapping and identified new technologies for biodiversity observations and monitoring to support transformative policy and conservation action including the Global Biodiversity Framework targets and reporting and ecosystem accounting efforts.

Sander Mucher discussed European habitat modelling and mapping with a focus on new technologies, particularly by combining satellite data with AI and deep learning methods. Map quality depended on the reference data used for training though that dependency was more important for some ecosystems than others. Simon Ferrier reviewed his work on the limitations of using only ecosystem extent data as an indicator for forest ecosystems. Including other information, particularly integrity, connectivity, and plant-species composition profoundly changed the understanding of the state of the ecosystem, indicating that component and complementary indicators should also be used. Victor H. Gutierrez Velez discussed the value of using continuous variables as inputs to ecosystem classification methods. Seamus Lombardo explained how public-private partnerships can improve geometric accuracy to better delineate ecosystem edges and facilitate tracking change. Roger Sayre looked at how changes in climate and land use would change ecosystem distribution of the World Terrestrial Ecosystems. Valeria Mobilia provided an overview of the OBAMA-NEXT project for monitoring marine biodiversity. Finally, Neeti Neeti discussed the important of EO time series for mapping vegetation in India and relating this to drivers of change.

Community-Based Monitoring and Traditional Knowledge



Speakers Uzma Saeed (centre) with colleagues in the Chitral Valley, Pakistan and Naneng Setiasih.

Organizer:

• Eren Turak (FWBON)

The interests, knowledge and capabilities of local communities can be powerful drivers of transformative change. This session showcased examples of how these elements helped to understand local change in biodiversity and guided conservation actions. It contained presentations from Burkina Faso, Indonesia, Pakistan, USA and Canada (2) all of which demonstrated that the needs, interests, knowledge and capabilities of local communities can be powerful drivers of transformative change. There were, however, major differences between the different case studies presented in this session. In the examples from Burkina Faso, Pakistan and Indonesia, a very strong and direct connection was made between the livelihoods and material well-being of communities and biodiversity outcomes. In all three cases provisioning and regulating ecosystem services were highlighted as important actual or potential drivers of biodiversity monitoring and management. Also, in these cases studies, the information systems used for collecting data were shaped by the specific needs of the users, enabling the data to directly support actions. In contrast, for the case studies from Canada and USA, participation was not explicitly linked to livelihoods, no specific ecosystem service was identified as a driver and the information systems used (in iNaturalist, eBird) were well-established, and general-purpose data collection systems based in the USA were not shaped or influenced by community interests and needs.

After the presentations, there was a lively panel discussion focusing on two questions:

- 1. How can Traditional and local knowledge and skills and resources contribute to achieving broader biodiversity goals?
- 2. How can we create stronger connections within GEOBON to support these monitoring initiatives?

This discussion continued on a WhatsApp group formed to connect presenters and the audience. The most important message emerging from this discussion was that there was a big need for support and resources for training, education, communication and engagement and that the various networks with GEO BON and their collective knowledge could not only greatly strengthen community-based monitoring efforts but also learn and benefit from them.

Recording available.

Detection and Attribution of Biodiversity Change



Brian Leung presenting.

Organizers:

- Andrew Gonzalez (GEO BON, QCBS, McGill University)
- Brian Leung (McGill University)

This well-attended session focused on the detection and attribution of biodiversity change. The talks covered a range of topics relating to different steps required to achieve high confidence in trend detection and causal attribution for different dimensions of biodiversity. Some talks focused on how information stemming from monitoring can support decisions for conservation and policy action.

The session began with an overview of the detection and attribution framework and gave a perspective on how the different talks relate to the framework. The talk by Kuzmich addressed the power of remote sensing time series (e.g. airborne laser scanning data, ALS) to assess changes in habitat quality, quantity, and configuration of bird species that can be used to update habitat models (e.g. occupancy models) for trend prediction. Habitat models developed with multiple years of ALS data had higher accuracy and greater transferability over time. The talk by Zhang focused on how to detect trends in population abundance and species composition that account for observer (personalized) biases stemming from different sources including cultural, taxonomic, and sensorial biases. Disentangling the effects of personalized bias from other sources of biases in biodiversity estimation and conservation will be crucial for reducing uncertainty in the observation step of the detection and attribution framework.

Other talks assessed data-related biases in well-known datasets for population abundance (i.e., Living Planet Database). Trend uncertainty was the key topic: for example, uncertainty from various sources hinders our ability to assess improvements in well-known indicators such as the Living Planet Index (LPI). Hebert showed for the LPI, that measurement and process uncertainty consistently pull the index below the expected true trend. Leung presented a risk framework that addressed large uncertainty in population trends worldwide. It considered the probability and magnitude of decline and assessed statistical power to detect future trends. Given that uncertainty is pervasive in biodiversity trend assessments, society needs to decide the acceptable risks of biodiversity loss. These talks motivated the need for a global biodiversity observing system.

Other talks focused on decision support. The talk by Bennett offered a simplified framework to assess when information from monitoring is valuable to conservation and management decisions. The framework provides guidance that is easily replicable and defensible and can be applied where the evidential basis for monitoring decisions is sparse. Talk by Urbach focused on the trends and targets for mountain biodiversity that made the case (using data from Switzerland) that assessments require interpretation at subnational scales if spatially variable outcomes for different mountain ecosystems are to be interpreted meaningfully. The closing talk by Patterson described a monitoring program in national parks in Canada that focuses on assessing trends in ecological integrity. The five-year trend indicated that 79% of ecosystems were stable or improving across 42 parks and reserves. This program provides the knowledge needed to prioritize actions to recover and protect ecological integrity in national parks and reserves.

We are at the beginning of the effort to standardize the flows of information from monitoring needed to conduct trend detection and causal attribution for decision support. No talk covered both aspects, so we have a big opportunity to move this knowledge gap forward.

Session abstracts and slides.

CEC BCIN Global Biodiversity Conference SEA Ecosystem Accounting and Biodiversity

SEEA Ecosystem Accounting and Biodiversity

Organizers:

- Marc Paganini (European Space Agency -ESA)
- Francois Soulard (Statistics Canada)

In 2021, the UN Statistical Commission adopted the System of Environmental-Economic Accounting Ecosystem Accounting (SEEA EA) as a new international statistical standard for monitoring changes in ecosystem stocks (ecosystem extent and condition) and flows of ecosystem services, and their linkages to the economy. SEEA EA provides a measurement framework underpinning the development of the GBF monitoring framework and its headline indicators. The SEEA EA implementation strategy highlights the importance of scaling up implementation in countries using Earth Observation in combination with in-situ data. This session presented some best practices and discussed the challenges of compiling national ecosystem accounts, including biodiversity.

Workshops

What Role for Community-Based Monitoring and Information Systems (CBMIS) in Biodiversity Monitoring?



Organizers:

- Joji Cariño (Forest Peoples Programme)
- Maurizio Farhan Ferrari (Forest Peoples Programme)

CBD COP-15 invites Parties and relevant organizations to support community-based monitoring and information systems (CBMIS) and citizen science and their contributions to the implementation of the monitoring framework for the Kunming-Montreal Global Biodiversity Framework. This workshop included:

- 1. Sharing and discussing CBMIS approaches, practices and tools, including through case studies on biodiversity monitoring by indigenous peoples and local communities;
- 2. An interactive session addressing questions on methodological and practical ways in which data and information generated at the local level can interact with national and global systems and databases (including GEO-BON), thereby contributing to monitoring the implementation of the Kunming-Montreal Global Biodiversity Framework.

Ocean Vision AI: Tools for Visual Marine Biodiversity Monitoring



Organizers:

- Genevieve Patterson (Climate Change AI)
- Henry Ruhl (Central and Northern California Ocean Observing System)
- Eric Orenstein (Monterey Bay Aquarium Research Institute)

The Global Biodiversity Framework mandates that we monitor marine environments, regions that are notoriously difficult to observe. Challenges related to imaging workflows and data management only increase the obstacles faced by many marine researchers. Ocean Vision AI (OVAI), an initiative spearheaded by the Monterey Bay Aquarium Research Institute, offers marine scientists two tools to help fill the gaps in their data analysis pipelines: OVAI's FathomNet database and the OVAI Portal. This hands-on session demonstrated to participants how they can collaboratively label data, tune machine learning models, and deploy their custom AI on new imagery.

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Tracking a Moving Target: Testing and Benchmarking Indicators of Biodiversity Change





Participants working on their grids during the workshop.

Organizers:

- Laura Pollock (McGill University)
- Katherine Hebert (McGill University)
- Dirk Nikolaus Karger (Swiss Federal Research Institute, WSL)
- Brian Leung (McGill University)
- Walter Jetz (Yale University)

How well do biodiversity change indicators capture real world change across time and space? How sensitive are existing indicators to changes at local, regional, or global scales? Are some indicators best-suited to capture short-term or long-term changes? Which indicators are sensitive to conservation actions (e.g. is it likely the indicator improves with substantial conservation efforts)?

This workshop sought a wide pool of participants (from indicator experts to users) to help us identify major gaps in existing indicators that will serve as the basis of developing a standard protocol for testing indicators. Participants worked through a range of scenarios of biodiversity change. The results will be summarized and disseminated during the conference, with a platform for feedback.

One of the space-time grids from the workshop, showing how a short list of indicators cover rapid habitat conversion over the short (4 years or less) to long term (50+ years), at local, subnational, and national scales under the (idyllic!) assumption that we have all the data we need.



Panels

Productive Alternatives by Chiquitano Women in the Bolivia Chiquitania



Speakers:

- Silvia Pasabare, president of the Monte Verde Indigenous Association of Women Non-Timber Producers
- Nancy Paine, CACIQUE Monte Verde
- Patricia Patiño, Executive Director APCOB (Apoyo al Campesino Indígena del Oriente Boliviano)

This panel showcased examples of sustainable use of non-timber products in the Bolivian Chiquitano dry forest with results in habitat preservation and positive changes in gender roles.

Biodiversity Monitoring in Canada: Regional Governance and Partnerships in Action



Speakers:

Monica Kohler presenting.

- Monica Kohler (Operations Director, Alberta Biodiversity Monitoring Institute/University of Alberta)
- David Roberts (Science Centre Co-Director, Alberta Biodiversity Monitoring Institute/Innotech Alberta)
- Anouk Simard (Québec Government, Ministère de l'Environnement, de la Lutte contre les changements climatiques, de la Faune et des Parcs (MELCCFP))

This session brought together different sub-national monitoring programs with the aim to promote knowledge exchange, collaboration, and showcase the importance of partnerships in biodiversity monitoring and reporting. The speakers discussed how effective governance structures can steer successful programs and the role partnerships play in mobilizing large-scale, regional biodiversity monitoring programs. The speakers shared their experiences and highlighted case studies from their regional Canadian biodiversity monitoring program.

From Data to Action: The Role of the Global Ecosystems Atlas in Science-Based Conservation



Organizers:

• Sara Venturini (GEO Secretariat)

Speakers:

- Yana Gevorgyan (GEO Secretariat)
- Jillian Campbell (Convention on Biological Diversity CBD)
- Andrew Gonzalez (GEO BON, QCBS, McGill University)
- James D'Ath (Taskforce on Nature-related Financial Disclosures TNFD)
- Emily Darling (Wildlife Conservation Society WCS)
- Marc Paganini (European Space Agency ESA)

GEO is forging this project as a collaborative public-private initiative by a multi-stakeholder coalition to bring together the many good efforts taken by different groups and organizations and build a globally recognised approach and tool for ecosystems extent mapping and monitoring for effective assessment of nature's loss/gain with transparency and coherency. The Atlas has the endorsement and support from the CBD, UNFCCC, UNCCD, Ramsar Convention secretariats, and galvanized the interest of the main public and private data and technology providers, and science-based conservation organizations in a coalition.

Insights from a Collaborative National-Scale and Long-term Genomic Monitoring Strategy of an Iconic Model Species-at-risk





Micheline Manseau presenting.

Speakers:

- Marc D'Iorio (Assistant Deputy Minister, Science and Technology, Environment and Climate Change Canada, Gatineau, Quebec, Canada)
- Paul Wilson (Professor, Biology Department, Trent University, Peterborough, Ontario, Canada; Organizer)
- David Johns (Senior Species at Risk Biologist, Alberta Environment and Protected Areas, Grande Prairie, Alberta, Canada)
- Rachel Boone (Environmental Specialist, Manitoba Hydro, Winnipeg, Manitoba, Canada)
- Leon Andrew (Dene Elder and Research Coordinator, Sahtu Renewable Resources Board, Norman Wells, Northwest Territories, Canada)
- Rebecca Taylor (Research Scientist, Science and Technology, Environment and Climate Change Canada, Ottawa, Ontario, Canada)
- Micheline Manseau (Research Scientist, Science and Technology, Environment and Climate Change Canada, Ottawa, Ontario, Canada; Organizer)

The development of best practices and new technologies for monitoring can benefit from "lessons learned" from existing long-term programs. Here, we will introduce a large-scale collaborative project, spanning 20-years and the systematic sampling of 40,000 non-invasively collected caribou fecal samples, which produced a range of demographic and diversity parameters of importance to Recovery Planning. Our panel will consist of the Co-Principal Investigators of this framework with associated partners representing academia; government; Indigenous communities; and the private sector. The panel will reflect on the history and expansion of the collaborative network, what has been accomplished, benefits and challenges, and future opportunities.

Recording available.

Networking Knowledge: Linking Technology and Collaboration for Environmental Change Monitoring Across North America



Moderator:

• Georgina O'Farrill (Commission for Environmental Cooperation)

Speakers:

- Mariam Latofski (Local Environmental Observer (LEO) Network)
- Dominique Croteau (Commission for Environmental Cooperation)
- Henry Reges (Community Collaborative Rain, Hail and Snow Network (CocoRaHS) US National Coordinator (TBC)
- Andrew Gonzalez (GEO BON, QCBS, McGill University)
- Orlando Cabrera (Commission for Environmental Cooperation)

Collaborative networks can help identify shared environmental priorities and ensure knowledge sharing and tool development to support decision making. This session demonstrated the value of technology-based environmental networks, e.g., GEO BON that improves the acquisition, coordination and delivery of biodiversity observations; the LEO Network that facilitates sharing of unusual environmental events; CocoRaHS, a community-based precipitation network that documents on-the-ground conditions that are affected by precipitation; and the CEC's North American Atlas that combines and harmonizes geospatial data with a regional perspective on environmental issues. This session facilitated a regional discussion to identify key joint priorities and knowledge gaps.

Recording available.

Monitoring Biodiversity from Space: Using Remote Sensing to Inform Biodiversity Science and Conservation



Organizers:

- Peter Kalmus (NASA/JPL)
- Kyla M. Dahlin (Michigan State University)
- Gary Geller (NASA/JPL)
- Fabian Schneider (NASA/JPL)

Speakers:

- Kyla M. Dahlin (Professor, Michigan State University Department of Geography, Environment, & Spatial Sciences)
- Victor H. Gutierrez-Velez (Associate Professor, Department of Geography and Urban Studies, Temple University)
- Jeannine Cavender-Bares (Distinguished McKnight University Professor, Department of Ecology, Evolution and Behavior, University of Minnesota)
- Maria J. Santos (Associate Professor at the Department of Geography at the University of Zurich)

Remote sensing has long played an important role in biodiversity monitoring, albeit with limitations in resolution and coverage. Looking forward, new imaging spectroscopy, thermal, lidar and radar missions are poised to revolutionize biodiversity monitoring from space by providing repeated, high-resolution global measurements of ecosystem diversity, structure and function. NASA's SBG, NISAR, and numerous other missions to be launched in this decade, led by agencies around the world, will provide a smorgasbord of global remote sensing products. This session asked how to make best use of the torrent of data that will soon be streaming in from space to monitor and understand biodiversity, and how and why it is changing.

The panel discussed the future of biodiversity monitoring since capabilities are rapidly increasing our capacities by addressing the question: What excites you most, and why? Some exciting opportunities ahead include the new data provided by imaging spectroscopy, an unprecedented understanding of plant form and function, and contributions of monitoring (plant) biodiversity and as proxy (as habitat) for other taxonomic groups. The accessibility and capacity to deal with this data is still a question to be solved both in terms of data structure to collect, archive and distribute this data, training and know-how to process and achieve analysis-ready data, and how to distribute it in a fair and just way with special attention to the areas that hold most global biodiversity.

Questions were opened to the audience, leading to interesting discussion. There were questions about ecosystem extent, connectivity, and what could be the contribution of imaging spectroscopy. The panel commented that this would be moving beyond area-based estimates towards a greater understanding of the functional perspective on these topics.

Cocktail Reception

GEO BON welcomed all participants to the Montreal Science Centre for an evening of snacks and networking. Funding and support were provided by <u>Montreal International</u>.









Keynote

Jeannine Cavender-Bares, Distinguished McKnight University Professor and of the University of Minnesota presented, "Integrating Earth Observations with Biodiversity Science to Address Global Targets."

Recording available



Parallel Sessions

From Biodiversity Data to Species Population EBVs, Indicators and Decision Support



Organizers:

- Walter Jetz (Yale University)
- Melodie McGeoch (LaTrobe University)

In the run-up to the Kunming-Montreal Biodiversity Framework the biodiversity monitoring and modelling community delivered a range of methodologies, pilot demonstrations, and global information products to link from biodiversity data to Essential Biodiversity Variables (EBVs) and formal UN CBD indicators. A next phase has begun to translate these into effective tools for target tracking and decision support by CBD parties, NGOs, industry, and other stakeholders. This session featured activities for making this important link for species distributions and abundances.



Advances in Biodiversity Modeling from Monitoring to Mitigation

Organizers:

- Mark Urban (University of Connecticut)
- Greta Bocedi (University of Aberdeen)
- Damaris Zurell (University of Potsdam)

Time is running out to limit further devastating losses of biodiversity and nature's contributions to humans. Global biodiversity monitoring networks are rapidly improving our ability to observe and understand patterns of biodiversity change worldwide. Preventing biodiversity loss requires theoretical and conceptual tools that synthesize incoming data, estimate uncertainties, improve data collection, detect trends, attribute trends to drivers, project future changes under differing socioeconomic scenarios and compare results, and design efficient mitigation strategies. In short, modeling is now needed more than ever to translate data into action. A new working group and knowledge-to-action hub are being launched within GEO BON to address these needs. This session explored recent advances in biodiversity modeling, including challenges and opportunities for integration and expansion, incorporation of mechanisms, accurate error propagation, scaling across space, time, and diversity, and new opportunities through artificial intelligence.

Our symposium introduced **EcoCode** while covering the advancements in modeling through two oral sessions and posters. We learned about recent advances in biodiversity modeling, including challenges and opportunities for integration and expansion, incorporation of mechanisms, more accurate procedures for accounting for spatial and temporal non-stationarity and sampling effort in biodiversity change detection, incorporating random structure for scaling across space, time, and phylogenetics, novel model-based biodiversity and ecosystem indicators, and new opportunities to improve results through artificial intelligence. Based on the accepted abstracts, we observed three general trends in these advancements:

- 1. Improvements of models for sampling, indices, and detection and attribution;
- 2. Inclusion of more mechanistic information into models; and
- 3. The application of artificial intelligence.

We are currently scoping a GEO BON Science Brief that summarizes how modeling can play a role in assisting countries in meeting the targets of the Convention on Biological Diversity.

Global Analyses and Macrogenetic Theories to Quantify and Monitor Genetic Diversity for the Global Biodiversity Framework



Organizer:

• Moi Exposito-Alonso (Stanford University)

The 2022 Kunming-Montreal Global Biodiversity Framework established for the first-time protection of genetic diversity of species globally.

However, we still lack accurate estimates of genetic diversity loss across many species or predictive frameworks that can use indicators for monitoring. This session brought together researchers addressing questions such as: how much genetic diversity species across countries have lost through large macrogenetic meta-analyses, theoretical tools to understand and predict long-term losses, practical scalable approaches of genetic diversity recovery, and policy narratives to combine indicators with existing data and models. This knowledge is critical to enabling the scalability of genetic diversity protection targets and goals.

Session abstracts and slides.



Importance of Earth Observation to Monitor and Assess the Drivers of Biodiversity Changes

Organizers:

- Marc Paganini (European Space Agency -ESA)
- Clement Albergel (European Space Agency ESA)

The GBF stresses that nature can be conserved, restored and used sustainably if the drivers of changes (changes in land and sea use, overexploitation of natural resources, climate change, pollution and invasive alien species) and their underlying causes are properly addressed. The compounding effects of biodiversity stressors are likely to exacerbate the degradation of nature, as already seen in vulnerable ecosystems. The monitoring of these drivers is an essential component of the detection and attribution of biodiversity changes. The session showcased and reviewed best practice examples in the use of Earth Observations for monitoring the drivers of biodiversity changes.

<u>Recording available.</u> <u>Session abstracts and slides.</u>

Innovative Approaches to Monitoring, Documenting, and Communicating Change in Freshwater Biodiversity



Organizers:

- Luiz Silva (ETH Zurich)
- Jennifer Lento (Canadian Rivers Institute and University of New Brunswick)
- Thilina Surasinghe (Bridgewater State University)
- Eren Turak (FWBON)

This session highlighted innovative approaches to freshwater biodiversity monitoring worldwide, showcasing solutions to challenges encountered at various stages of the data cycle, from primary observations to assessment and transformative actions. Topics covered included advances in technology (e.g., AI, automated instrumentation, remote sensing), approaches in data management; addressing gaps in taxonomic and ecological research; improvements in data mobilization; increasing the freshwater focus in biodiversity assessments and initiatives; optimizing workflows from primary data to essential biodiversity variables across ecological hierarchies; supporting multiple knowledge systems in freshwater biodiversity monitoring (e.g., Traditional Ecological Knowledge and Indigenous methodologies); and improving the detection and attribution of freshwater biodiversity change resulting from multiple drivers, offering insights into how these changes can be monitored and mitigated.

The 17 presentations in this session collectively addressed four main questions that are important to FWBONs global agenda for documenting and analyzing freshwater biodiversity change. Many of the presentations addressed two or more of these questions. The first question was about how to use previously (or currently) collected primary data to measure multiple essential biodiversity variables and detect biodiversity change in a way that explicitly supports the implementation of the Kunming-Montreal Global Biodiversity Framework and Sustainable Development Goals. Most presentations at the session addressed this question to some degree. The second question, addressed by almost half of the presentations, was about geographic, thematic and taxonomic gaps and how to fill these innovatively and efficiently. The third question, specifically addressed in three of the presentations, was about indicator frameworks at national and global scales. The fourth question, also addressed by three presentations, was about specific management interventions i.e. environmental flows, and ecological restoration of wetlands.

Collectively the work presented in the session supports the development workflows from primary observations to essential biodiversity variables and then to indicators. This work also informs how EBVs and indicators might guide specific management interventions across a wide range of inland aquatic ecosystem types. The session showed that there is a clear need to create stronger connections between the multiple streams of work presented there and that FWBON can play an important role in achieving this. One of the agreed next steps was to support the further development and publication of some of the ideas presented in the session.

Climate Change as a Driver of Biodiversity and Ecosystem Change – Novel Uses of Satellite Remote Sensing



Group photo (left to right): Clement Albergel (session co-organizer), Sylvia Wood, Isabelle Helfenstein, Roberto Chávez, Leila Yousefizadeh Naeni, and Sophie Hebden (session co-organizer).

Organizers:

- Clement Albergel (European Space Agency ESA)
- Sophie Hebden (European Space Agency ESA/Future Earth)

Satellite observations play an important role in biodiversity and ecosystem monitoring, complementing other observations to characterise changes and their drivers. The impact of climate change on biodiversity, the capacity of species to adapt, the resilience of ecosystems, thresholds to irreversible changes, and the contribution of ecosystems to climate feedbacks - e.g., via impacts on carbon cycling - are urgent, policy-relevant research topics to which satellite observations can contribute. In the context of the definitions of the Essential Climate Variables and Essential Biodiversity Variables, this session featured novel demonstrations of satellite-derived products for research and development feasibility and contributions to understanding these interactions and impacts.

Speakers presented on remote sensing of vegetation phenology and Chile's expanding phenological monitoring system combining phenocams and satellite observations; an AI-based methodology for mapping lichens for caribou forage north of Quebec, upscaling from centimeters (with uav imagery) to tens of metres (with satellite imagery); a study using upscaled functional diversity index mapping over Swiss forest landscapes to investigate drought response, finding a positive relationship with functional richness and evenness; a risk analysis of Canadian cities' urban canopy under climate change, modelling tree resilience and ecosystem service provision. The European Space Agency (ESA) plans to launch a call in 2024 for several new projects under the <u>Climate Change Initiative</u> program that will contribute to improving our understanding of climate-biodiversity interactions.

<u>Recording available.</u> <u>Session abstracts and slides.</u>

From Insight to Action: Mapping Europe's Biodiversity Initiatives and Their Path Towards 2030 Ambitions





Nestor Fernandez presenting.

Organizers:

- Miguel Fernandez (iDiv, B-Cubed, NaturaConnect, EuropaBON)
- Nestor Fernandez (iDiv, NaturaConnect, EuropaBON)
- Quentin Groom (Meise Botanic Garden, B-Cubed)
- Tim Hirsch (GBIF)
- Junker Jessica (iDiv, EuropaBON)
- Andrew Rodrigues (GBIF, B-Cubed)
- Petteri Vihervaara (SYKE, Biodiversa+)
- Piero Visconti (IIASA, NaturaConnect)

This session explored the implementation of the Europa Biodiversity Observation Network, including topics on sampling design, open data infrastructures, protected area monitoring, and data intelligence. The focus of this session was on the utilization of Essential Biodiversity Variables workflows and data-driven scenario planning through platforms like <u>EuropaBON</u>, <u>GBIF</u>, <u>NaturaConnect</u>, <u>Biodiversa+</u>, and <u>B-Cubed</u>. By connecting different initiatives along the data value-chain, our goal is to support transformative policy and conservation action in Europe. This session concluded with a panel discussion to share knowledge on halting and reversing biodiversity change, as well as EuropaBON's societal contributions within an international context.

Workshops

AI/ML Applied to the Problem of Species Distribution Models: An Introduction to the Julia Programming Language



Organizers:

• Timothée Poisot (Université de Montréal)

The Julia programming language offers both high performance and ease of writing. This session demonstrated how Julia can be used to deal with biodiversity data, as well as environmental predictors, to enable scalable pipelines for data analysis. A particular focus was how the language can blend data management with machine learning (ML), using a variety of state-of-the-art packages. Throughout this workshop, participants produced species distribution models from openly available data, performed validation, and visualization, as well as range forecasting under climate change scenarios.

Participants discussed the opportunities that explainable machine learning (xML) represents for the construction and interpretation of species distribution models. The field of applied ML has been making significant progress in the past few years, and the biodiversity community would stand to gain much from using them. By producing models that are more interpretable, we will increase the trust in our predictions, and have a larger impact. Benefiting from the collective expertise of the GEOBON community was thrilling; the workshop ended in a series of informal discussions about additional data sources, different ways to think about the models, and ways to visually present the output of these approaches. One outcome of the workshop will be a review paper on the potential uses (and research priorities) for the use of explainable ML in the context of species distribution models (SDMs) to predict the impacts of climate change, currently being drafted by a few workshop attendees.

Building a Multidimensional Biodiversity Index



Organizers:

- Andrea Baquero (United Nations Environment Programme World Conservation Monitoring Centre, UNEP WCMC)
- Ana Rodrigues (United Nations Environment Programme World Conservation Monitoring Centre, UNEP WCMC)
- Neil Burgess (United Nations Environment Programme World Conservation Monitoring Centre, UNEP WCMC)

Pilot Partners:

- South Africa: South African National Biodiversity Institute (SANBI)
- Vietnam: WWF Viet Nam
- Colombia: Instituto de Investigación de Recursos Biológicos Alexander von Humboldt
- Switzerland: Sanu Future Learning AG and the Swiss Academy of Sciences (SCNAT), Swiss Biodiversity Forum

The Multidimensional Biodiversity Index (MBI) is a policy-focused index that aims to monitor the status of biodiversity and its contributions to people in an easy-to-communicate manner. The index incorporates ecological and socio-economic perspectives on biodiversity to support policy decisions and ensure that ecological integrity, human wellbeing, and sustainable development priorities are considered. The conceptual framework of the MBI was published in 2021 and is now being piloted in Europe, Africa, Asia, and Latin America through an inclusive, co-designed process, involving decision-makers, experts, and relevant stakeholders. The diverse circumstances of the pilot countries in terms of data availability and stakeholder needs will test the utility of the MBI in national and global biodiversity reporting settings.

This workshop showcased four country pilots championing this research initiative lead by <u>UNEP-</u><u>WCMC</u> on developing MBI. The range of methods and approaches being employed, as well as the challenges in regards to data mobilization, accessibility, and implementation opportunities through mechanisms such as the <u>CBD</u> or <u>IPBES</u> were discussed.

Attendees discussed the challenges related to possible methodological approaches for the MBI and its potential alignment with the GBF by addressing a set of prepared questions. From these discussions, the organizers gathered valuable feedback that will be incorporated into the development of the index. The overarching insight was the need to construct an index that communicates progress over time for biodiversity assessments, using an in-country methodology to enhance governance ownership and adaptability to local conditions. The workshop feedback was shared and discussed in the MBI project's Community of Practice, which includes teams from all pilot countries in the project.

At the conference, the organizers were able to connect with different groups, including Ad Hoc Technical Expert Group (AHTEG) members on Indicators for the Kunming-Montreal Global Biodiversity Framework. They are exploring opportunities to collaborate on adding relevant indicators/proxies to the MBI.

From Raw Heterogeneous Biodiversity Data to Operational Indicators Based on Essential Variables





Workshop organizer Yvan La Bras presenting.

Organizers:

- Yvan Le Bras (National Museum of Natural History, MNHN)
- Olivier Norvez (The French Foundation for Biodiversity Research, FRB, & National Museum of Natural History, MNHN)
- FrenchBON community (Pôle National de Données de Biodiversité, PNDB, and Data Terra teams)

The added value in terms of services and tools of the Pôle National de Données de Biodiversité (**PNDB**) and Data Terra communities is to offer standardized analytical workflows through virtual research environments (VRE), from raw data standardized by metadata (e.g. ecological metadata language, ISO 19115) to indicators. The data will come from various observatories and/or observation structures (citizen science, environmental DNA or remote sensing platforms etc.). Thus, to fully understand the framework "biodiversity, ecosystem functioning and essential variables (EOVs, EBVs, ECVs)", these VREs will build an integrated framework through a continuum ranging from the land to the deep ocean via the coast.

Following this, and based on the EBVs, the French BON, is developing an integrated framework for 1) extracting EBV information from raw data using Ecological Metadata Language, 2) running reproducible ecological analysis through open-access workflows, and 3) producing biodiversity indicators thanks to the Galaxy-Ecology collaborative platform. This case study focused on i) advancing conceptual developments related to EBVs, such as the complementarities between essential variables (EOVs, EBVs, ECVs) and Pressure-State-Response frameworks or the improvement of the research/expertise interface, ii) implementing essential variables for and with various communities (scientific research, expertise and policy makers), and iii) operationalizing EVs based on existing technologies (EML, Galaxy-Ecology).

This workshop covered virtual research environments (VRE), raw data, standardized by metadata, ecological metadata language, integrated framework, EBV, reproducible ecological analysis, openaccess workflows, biodiversity indicators, Galaxy-Ecology. Discussions among participants ranged from fine techniques to more high-level aspects, with great interest for training, creating linkages with BON in a Box. Participants appreciated the format and content of the workshop, particularly anchoring the information on concrete data and source codes

For more information on the developments, insights, tools and resources available, the organizers shared the following:

- Presentation slides
- EBVOSC project
- Galaxy-Ecology
- Galaxy-Ecology Training material
- French BON web page



Workshop organizer Coline Royaux presents.

Towards the Mobilization and Integration of Historical Biodiversity Observations





Organizers Miguel Clavero and Laetitia Navarro present their workshop.

Organizers:

- Laetitia M. Navarro (Estación Biológica de Doñana, EBD-CSIC)
- Catalina Munteanu (University of Freiburg)
- Adam Spitzig (Harvard University)
- Duarte Viana (Estación Biológica de Doñana, EBD-CSIC)
- Miguel Clavero (Estación Biológica de Doñana, EBD-CSIC)

Understanding historical species and ecosystem distributions is crucial for disentangling humanenvironment interactions and establishing conservation baselines. While <u>EBVs</u> play a key role in biodiversity change detection, they are primarily derived from recent time series. Meanwhile, the data for developing "historical EBVs", going back centuries, often remains hidden in historical written sources and natural archives. This workshop aimed to identify (1) sources of historical material within the BONs, (2) existing efforts and repositories to mobilize the historical data and (3) approaches and bottlenecks in the integration of sparse data across EBV classes. This will also be key for future conservation applications.

The workshop was attended by 20 to 30 participants. After a brief introduction to the potential of both cultural and natural archives to extract historical biodiversity observations, the participants provided input with suggestions of potential sources of information, ranging from general types of sources that could be mined to actual datasets already mobilized. An important part of the discussion addressed Indigenous and Local Knowledge as a key source of historical information and the associated considerations for data sovereignty and fair ways to approach and understand this type of information. Another important point is that while there was an expected bias towards Canada, the examples given by the participants of the workshop are overall global in scope. The participants later gave examples of approaches to integrate, or combine, different sources of historical information. The outputs of the session will be integrated with those of another workshop organized earlier in 2023 by the same team. Some of the participants also indicated their interest in continuing the discussion around the identification, mobilization and integration of historical observations beyond the conference.

Recording available.

Using Ecoacoustics to Scale Up Biodiversity Monitoring and Conservation



Carly Batist presents during the ecoacoustics workshop.

Organizers:

- Marconi Campos-Cerqueira (Rainforest Connection)
- Carly Batist (Rainforest Connection)

The rapid and dangerous decline of fauna worldwide requires creative solutions to improve biodiversity monitoring. Ecoacoustics has greatly improved our ability to monitor biodiversity efficiently across time and space. Continuous survey data—such as those yielded by ecoacoustic monitoring—are essential for informing conservation efforts. This introductory workshop guided participants through an example acoustic monitoring workflow, from sampling design to deployment and analysis.

This workshop introduced participants to a passive acoustic monitoring (PAM) workflow, from sampling design to deployment to analysis. The organizers presented several case studies from their work at **Rainforest Connection** to illustrate the many ways ecoacoustics can be used for conservation. They discussed the technology involved, both on the hardware and software side, and provided a demo of the free, no-code **Arbimon** platform. Arbimon consists of a user-friendly interface that can be used to upload and store unlimited audio recordings, visualize and annotate spectrograms, develop species identification models, conduct soundscape analyses, and summarize results through interactive dashboards. Anyone interested in getting started with Arbimon can access the support documents (available at <u>https://support.rfcx.org/</u>).

Poster Session

Participants had the opportunity to discuss research and monitoring initiatives across all topics. Electronic posters (e-posters) can be viewed on the conference platform.

Link to **<u>e-posters</u>** where available.









Keynote

Paul Hebert, Director of Centre for Biodiversity Genomics at the University of Guelph, presented "A mission for planetary biodiversity."

Recording available



Parallel Sessions

Tools and Models for Biodiversity Monitoring



Organizers:

- Simon Ferrier (CSIRO Environment)
- Katie Millette (GEO BON Secretariat)
- Ruben Valbuena (Swedish University of Agricultural Sciences)

The ability to measure and predict biodiversity trends is essential for biodiversity conservation. This session focused on the development and use of new tools and algorithms to improve our ability to monitor species and ecosystems.

This session covered national monitoring protocols implemented by the Australian Government, to new workflows and new data challenges in predicting biodiversity changes using artificial intelligence and non-invasive monitoring tools like acoustic tools. In tool development for biodiversity data, it is important that data management is easy to carry-out, sometimes reverting to familiar ways of organizing data, like spreadsheets, rather than complex schema. After the presentations, the speakers and audience engaged in a discussion on the uptake of the use of biodiversity monitoring tools. A key point that was highlighted was the importance of continuous user engagement; a tool must be built for a purpose, with the users, otherwise it is not likely to be used. The audience discussed challenges of tools that emerge as a result of short-term projects that lose funding and maintenance priorities.

Biodiversity Monitoring in Aquatic Ecosystems to Support a Whole Society Approach to Transformative Change



Organizers:

- Frank Muller-Karger (University of South Florida)
- Eren Turak (FWBON)
- Joana Soares (Atlantic International Research Centre)

This session brought together members of the Fresh Water Biodiversity Observation Network (FWBON) and the Marine Biodiversity Observation Network (MBON) to explore how biodiversity monitoring capabilities and approaches in marine and inland waters can be aligned with terrestrial approaches to track biodiversity change. Topics included:

- 1. The role of thematic biodiversity observation networks (FWBON and MBON) and existing programs (GBIF, OBIS, etc.) in building the Global Biodiversity Observation System (GBiOS) and measuring ecosystem services with a special focus on food, energy, and water;
- 2.Linking the frameworks of Essential Variables (Essential Ocean Variables, Essential Climate Variables, and Essential Biodiversity Variables) and Biotic Condition Indicators of the SEEA Ecosystem Accounting framework;
- 3. Benefits and feasibility of aligning biodiversity indicator dashboards for communicating biodiversity change in marine and inland waters;
- 4. Opportunities and challenges for community-based monitoring and integration of Traditional Ecological Knowledge in aquatic realms; and
- 5. Priorities for further indicator development to support national needs and international agreements such as the Kunming-Montreal GBF, the Sustainable Development Goals, and the UNFCCC Paris Agreement.

There is an urgency to synergize aquatic approaches to biodiversity monitoring and data collection and to better connect the community globally and across freshwater and marine domains. In fresh water, coastal and open ocean environments, important direct drivers of biodiversity loss (fishing, land and sea use, pollution) augment the impacts of climate change. Measuring the extent of inland, coastal, and marine biodiversity to characterize habitats and biodiversity is a management priority for nations around the world. Nations are faced with addressing the goals and targets of the Kunming-Montreal GBF, and this requires baselines and measuring progress against them. Yet, nationally and regionally accepted protocols for freshwater biodiversity monitoring and ecological status assessment are rare.

Key challenges still encompass limited awareness and understanding, restricted access to advanced technologies, capacity-building gaps, and financial constraints.

The structure provided by GEO BON to link different national and thematic BONs helps to address requirements for biodiversity information in the land-ocean-atmosphere continuum to address multiple societal needs. A major effort underway is to integrate biology and ecosystems observations with physical and biological observing systems across the continuum. There is also progress in better coordinating across the limnology community and wetlands observing strategies. The Global Ocean Observing System (GOOS) provides a framework for the design and implementation of ocean observing systems for marine life via a series of Essential Ocean Variables (EOVs). These EOVs, spanning physical, biogeochemical and marine life observations, provide the foundation for the Essential Biodiversity Variables. There is a recognition that habitats such as drainage ditches, estuaries of all sizes, and wetlands play important roles in delivering ecosystem services and need to be integrated into these observing frameworks. Many of these areas are important for food, human health, and developing and managing Blue Carbon.

New methods, such as Underwater Hyperspectral Imaging, environmental DNA, acoustics, animal tracking and remote sensing are emerging for assessing biodiversity and ecological status of shallow and deep aquatic ecosystems.

Session abstracts and slides.

Remote Sensing for Biodiversity Monitoring



Organizers:

- Simon Ferrier (CSIRO Environment)
- Ruben Valbuena (Swedish University of Agricultural Sciences)

Advances in remote sensing are continuing to open exciting new opportunities to monitor change in biodiversity and essential biodiversity variables across vast geographic extents. This session showcased cutting-edge examples of the many ways in which new satellite and airborne sensors are now being used to measure a growing array of structural, functional and compositional attributes of ecosystems across a wide range of spatial scales.

Session abstracts and slides.

GEO BON Global Conference 2023 REPORT —

Monitoring Ecosystem Services: Where Do We Stand and How Do We Move Forward?



Flavio Affinito presenting.

Organizers:

- Agnes Vari (McGill University)
- Flavio Affinito (McGill University)
- Ana Sofia Vaz (CIBIO)
- Nuria Pistón (University of Granada; Federal University of Rio de Janeiro)

Most monitoring and reporting activities focus on biodiversity, with ecosystem services (ES) mentioned alongside it. Existing frameworks are often less specific about measuring and monitoring ES. This is particularly true for the linkages between biodiversity and the social dimensions of ES (e.g., socio-cultural values, knowledge systems), all of them fundamental for appropriate action from multiple stakeholders in line with the Convention on Biological Diversity.

This session featured contributions on how to advance ES monitoring, including the definition of indicators, the standardization and harmonization of data and concepts, and the integration of ES into wider sustainability reporting frameworks and agendas, among others. It covered a wide range of topics: the role of earth observations in ecosystem services mapping, the positive impact of indigenous-led conservation in promoting ecosystem services, how a One Health approach can protect ecosystem services and human health, a complete data driven project focused on monitoring mountain ecosystem services and the potential for using standardized essential ecosystem service variables to report on ecosystem services change from local to national scales. These exciting talks led to a workshop session where participants discussed the current frameworks for studying ecosystem services and what dimensions of ecosystem services are missing from them. These table conversations resulted in valuable insights for the working group going forward and we expect they will contribute to upcoming collaborations across the network.

Omic BON - Opportunities and Challenges in Biomolecular Observing



Moderator:

• Margaret Hunter (Genetic Composition Working Group)

Panelists:

- Katrina Exter (EMBRC)
- Lori Phillips (AAFC)
- Tim Hirsch (GBIF)
- Sujeevan Ratnasingham (BOLD)
- Chris Meyer (MarineGEO, OBON, Omic BON)
- Raïssa Meyer (GSC-TDWG, OBON, Omic BON)

This panel introduced Omic BON–GEO BON's first thematic BON focused on an observational technique: omics. Omic BON is a collaborative effort between national, regional, and global observing systems, standards and best practices organizations, and data and sample management infrastructures for omics.

The discussion focused on opportunities of integrating omics technologies into biodiversity monitoring efforts, as well as the challenges that come along with that, such as the need for standardization and interoperability across different observing systems and data infrastructures. The panel provided a forum for participants to learn more about the Omic BON initiative and its partners, its goals and values, and how to get involved.

Recording available.

Standardized eDNA-Based Biodiversity Monitoring to Inform Environmental Stewardship Programs





Mehrdad Hajibabaei presenting.

Organizers:

- Mehrdad Hajibabaei (University of Guelph)
- John Darling (US EPA)
- Florian Leese (University Duisburg-Essen)
- Kelly Goodwin (NOAA)
- Kristian Meissner (Finnish Environment Institute)
- Toshifumi Minamoto (Kobe University)

Environmental DNA approaches are well-established for both targeted and taxonomically broad biodiversity characterization, however they are not yet widely applied beyond proof-of-concepts or pilot studies. To support large-scale and long-term environmental stewardship, especially as we face a climate emergency and biodiversity decline, we need standardized and robust eDNA workflows. This session brought together leading experts in multidisciplinary programs that have developed and utilized eDNA for real-world applications within current regulatory regimes or for forward-looking environmental stewardship programs. Speakers demonstrated challenges and opportunities for applying eDNA as a routine measure of biodiversity in varied environmental settings.

<u>Recording available.</u> <u>Session abstracts and slides.</u>

GEO BON Global Conference 2023 REPORT

Biodiversity Monitoring in Canada: Coordinating Genomics Across Initiatives in Canada and Worldwide - A Call for Action





The Genome Canada team.

Biodiversity experts from academia, government and non-profit groups were invited to a sponsored working meeting organized by <u>Genome Canada</u> and the six regional Genome Centres (<u>Genome Alberta</u>, <u>Genome Atlantic</u>, <u>Genome British Colombia</u>, <u>Genome Prairie</u>, <u>Genome Québec</u>, <u>Ontario Genomics</u>). During the event, participants were invited to share their insights on four key topics surrounding biodiversity monitoring:

- Stakeholder and rights holder engagement
- Standardizing tools for biodiversity monitoring
- Data management, integration, and access
- Coordinating approaches across Canada

Several main themes emerged from the event's discussion. First, the importance of trust, whether it pertains to trust in data through standardized methods or proper documentation, or trust between partners when working with industry, government, or communities. Another recurring sentiment was the importance of finding a "good enough" solution to many of the present challenges and being careful not to be distracted by the search for a perfect option. Finally, specific principles and objectives were identified, including the need for investment in a foundational omics data infrastructure solution for Canada, and ensuring that results are transparent, reproducible, and comparable across research initiatives. The insights, requests, and recommendations gathered from this workshop have increased the Canadian Genomics Enterprise's understanding of key challenges facing the use of genomics in the biodiversity monitoring space. They will be vital to help shape and inform future funding programming targeted towards convening and coordination efforts, and monitoring research and innovation, all of which will better position Canadian researchers and conservationists to realize long-term benefits and enhance the impact from their work.

Panel

Genomic Translation: Adoption and Use of Genomic Tools and Technologies to Monitor Biodiversity



Speakers:

- Valérie Langlois (Full Professor, Eau Terre Environnement Research Centre, INRS)
- Jennifer Sunday (Assistant Professor, Department of Biology, McGill)
- Jean-Christophe Guay (Environmental Advisor, Hydro-Québec)
- Claude Robert (Full Professor, Université Laval)
- Joëlle Taillon (General Director of Wildlife and Habitat Management, MELCCFP)

Discoveries in academic research can lead to new tools or technologies for the study and surveillance of biodiversity, but the transfer of technology from the laboratory to the field comes with a unique set of challenges. It is important that support for academic research include resources for the implementation of new technologies into real-world use by industries, governments, or private partners.

The panel brought together researchers studying environmental DNA (eDNA) and their respective end users from three research projects funded by the Canadian Genomics Enterprise. The end users present were from private industry and government (both provincial and federal). The panellists discussed the factors that contribute to the success of their collaborations and perspectives from end users on the use of genomics for biodiversity monitoring.

There was a consensus from participants on the advantages provided by eDNA-based tools in terms of speed and reliability. Although there remains work to be done regarding education and training, it was clear from the discussions that genomics-based techniques for biodiversity monitoring provide significant advantages and are sure to become more common. Researchers and end users also shared their thoughts on the barriers to effective knowledge and technology transfer and highlighted the usefulness of regular and clear communication between parties. The importance of designing research projects with end users in mind was also brought up as a key contributor to success as it ensures early exchanges and drives the adoption of new innovative practices or technologies.

Recording available.

Workshops

Using Map of Life Tools to Derive Biodiversity Indicators and Decision-Support Products



Tamara Rudic of the Map of Life team presents at the workshop.

Organizers:

- Alex Killion (Yale Center for Biodiversity and Global Change)
- Kevin Winner (Yale Center for Biodiversity and Global Change)
- John Wilshire (Yale Center for Biodiversity and Global Change)
- Kalkidan Chefira (Yale Center for Biodiversity and Global Change)
- Tamara Rudic (Yale Center for Biodiversity and Global Change)
- Walter Jetz (Yale Center for Biodiversity and Global Change, Scientific Chair of the E.O. Wilson Biodiversity Foundation)

The Map of Life offers an array of EBV-supported metrics, maps, and decision-support tools that link to a range of CBD indicators. Indicators include the Species Habitat Index, Species Protection Index, Species Information Index, and metrics supporting the assessment of Invasive Alien Species spread, addressing CBD Goals A and Targets 1, 3, 4, 6, 8, and 21.

This workshop explored the many tools and data available on **MOL.org**, emphasizing the specieslevel approach of the website and engaged with attendees to envision new community approaches to accessing and using global biodiversity data. In the workshop, we explored the <u>Species page</u>, which displays various spatial biodiversity data for a species; our <u>high-resolution species</u> <u>distribution modeling efforts</u>; the <u>Indicators page</u>, which reports trends in the Species Habitat, Protection, and Information Indices for all countries; and the new <u>Regions page</u>, which generates biodiversity expectations for any region of interest in the world. Some of the important feedback we heard from workshop attendees is developing an API to allow users easier access to MOL data/products and compiling user stories detailing how Map of Life is being used to support science and conservation. We are planning to incorporate this feedback soon.

BON in a Box





Jean-Michel Lord presenting.

Organizers:

- Jean-Michel Lord (GEO BON Secretariat)
- Guillaume Larocque (Quebec Centre for Biodiversity Science)
- Victor Julio Rincón Parra (Humboldt Institute)

The Global Biodiversity Framework calls for a robust monitoring framework designed to support national reporting of progress towards the targets and goals. The monitoring framework uses indicators to track progress that use existing biodiversity data and new data derived from monitoring schemes (e.g. biodiversity observation networks, BONs). To support the process, GEO BON is developing an online platform that will help countries assess the information they have and guide monitoring to improve knowledge of the trends in biodiversity. Among other things, this platform called "BON in a Box" will calculate and display Essential Biodiversity Variables (EBVs) and GBF Indicators based on transparent and reproducible workflows. It allows scientists to share validated work for others to use it more easily.

But now: How can I share my work through BON in a Box? What are the benefits?

This workshop covered key concepts, technical elements such as the customization of pipelines and the integration of scripts, as well as resources available. Attendees were expected to be familiar with BON in a Box, either from attending the BON in a Box Intro Session on Tuesday or viewing the <u>intro webinar</u> (~45 min) recording.

Attendees learned how to run, edit and create EBV and indicator pipelines in BON in a Box. Key concepts and the benefits of the approach were covered, followed by several step-by-step walkthroughs. We ran and modified a pipeline, integrated a small script by writing a description file and adding a few lines to read the inputs from a Json file and wrote the outputs to a Json file. The floor was opened for questions and the contact information of those interested to collaborate with BON in a Box in the future were collected.

Half-Earth Day

In partnership with the **E.O. Wilson Biodiversity Foundation**, GEO BON hosted the organization's annual **Half-Earth Day**® as part of Thursday's global conference program.

This afternoon-long event brought together people from around the world and across disciplines to share their unique perspectives on how to achieve the goal of <u>Half-Earth</u> and ensure the health of the planet for future generations.

Half-Earth Day 2023 at the GEO BON conference focused on how we can link information to action, fostering a conversation on how we can use the best available science to support communities in their understanding and stewardship of biodiversity, and to connect and empower community and stakeholder insights to ensure successful conservation outcomes.



<u>Paula J. Ehrlich</u>, President & CEO, E.O. Wilson Biodiversity Foundation, Co-Founder <u>Half-Earth</u> Project



PANEL: Safeguarding species in a changing world: From Knowledge To Action



Louie Psihoyos, Oscar-winning filmmaker, Executive Director, Oceanic Preservation Society (OPS), National Geographic Photographer, & Founder of Projecting Change



<u>Sam Hunter</u>, Natural Resources Monitor, Weenusk First Nation



The Black Bear Singers, a pow wow drum group from the Atikamekw community of Manawan.



<u>Wade Davis</u>, Professor of Anthropology and the BC Leadership Chair in Cultures and Ecosystems at Risk at the University of British Columbia

Early Career & Student Mixer

Students and early career researchers were invited to <u>Thomson House</u>, McGill's Post-Graduate Students' Society for an evening of trivia and socializing. Support and prizes kindly provided by the <u>Quebec Centre for Biodiversity Science</u>.









Keynote

Emily Darling, Director of Coral Reef Conservation and the Wildlife Conservation Society presented, "Connecting a Global Network of Coral Reef Field Data"

Recording available.



Parallel Sessions

Tools and Models to Understand Biodiversity and Carbon Benefits in Data-Limited Landscapes for Decision Support



Organizers:

- Karen Richardson (Parks Canada)
- Jason Duffe (Environment and Climate Change Canada)

Parks Canada and <u>Environment and Climate Change Canada</u> are working with Indigenous, academic, NGO and government partners to assess biodiversity and the extent and quantity of carbon stocks and fluxes in wetland, peatland, coastal, and marine ecosystems in the Hudson-James Bay Lowlands where decisions on protection and development are pending. Many national and international tools and models have been developed to aid in evaluation and prioritization of biodiversity and carbon conservation and other co-benefits. This session presented case studies that demonstrate implementation of applicable prioritization models to large, data limited landscapes for decision support.

Session abstracts and slides.

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Al for Insect Monitoring



Group photo (left to right): Timm Haucke, Owen Martin, Grace Skinner, Marc Bélisle, Zahra Gharaee, David Rolnick and Maxim Larrivée (session co-organizers).

Organizers:

- David Rolnick (McGill University)
- Maxim Larrivée (Montreal Insectarium)
- Tom August (UK Centre for Ecology & Hydrology)

As global insect populations collapse, there is an urgent need for data on species abundances and distributions. However, the diversity of insects and scarcity of experts for many taxa can make traditional data-gathering challenging. Recent developments in artificial intelligence (AI) present opportunities for scalable insect monitoring, including via automated camera traps, eDNA analysis, and annotation of citizen science data. This session explored how AI is being used in insect monitoring from the perspectives of both ecology and computer science.

The session focused on the ongoing advancements in insect monitoring scaled by AI, particularly deep learning and computer vision, to monitor various insect groups. The session witnessed ten invited speakers from multiple countries, institutions, and backgrounds in ecology and computer science. The talks showcased new insect camera traps for monitoring nocturnal and diurnal pollinator insects, lessons learned from early-stage deployments of automated insect monitoring systems, machine learning workflows to automatically process the large amount of data generated by the insect camera traps, building an extensive insect database using DNA barcoding and RGB imaging, statistical solutions for dealing with uncertainty associated with AI models and various environmental variables, and automated distance estimation for modelling animal population density. The work has been carried out in multiple locations in North America, Europe and India. The speakers emphasized the importance of standardization of monitoring techniques, open access data and models, and the need for cross-disciplinary collaboration. The lack of labelled data for most insect groups to train AI models was the common challenge raised by most speakers. The audience followed up with questions about the sampling bias of such systems, using more advanced AI models such as vision transformers and vision language models, monitoring other insect taxa through the moth camera traps, and the challenges associated with deploying these systems from temperate to tropical conditions.

Linking Biodiversity Monitoring Networks to Assess Biodiversity Change Across Scales



Organizers:

- European Biodiversity Partnership (Biodiversa+)
- AP BON
- GEO BON Secretariat

This session presented key questions that arise from a bottom-up approach of monitoring biodiversity, and how to connect currently running monitoring programs to national, regional and international objectives.

Our session gathered 13 presentations covering overviews of national, regional and thematic biodiversity monitoring networks across the globe. The first part included four talks on European Biodiversity Partnership (Biodiversa+), Asia-Pacific BON, Colombian Biotablero, and Finnish Ecosystem Observatory. The second part included four talks on Marine BON of East and South-East Asia, biodiversity monitoring of the province of Québec, an Oceania BON, and Arctic BON (CBMP). The third part included five talks on Marine BON, implementing EBV grammar in real world biodiversity monitoring, influence of EBV framework for biodiversity and ecosystem service monitoring, EBVs facilitating international cooperation and harmonisation, and EBV operationalization pilot to GBiOS from FrenchBON.

Issues of governance, data and information infrastructure, protocols and indicators, and development of their capabilities through the networks were discussed, and speakers emphasized how **Essential Biodiversity Variables** can be combined with observations from monitoring networks to make inferences about biodiversity change at various levels. The talks gave an excellent overview of the ongoing biodiversity monitoring activities across the scales and different biomes with many good examples that can provide benchmarking for new and emerging BONs.

The EBV concept should be actively used to harmonize results from the biodiversity monitoring schemes. It was noted that clarity in the roles of various BONs (national, regional, thematic) would benefit the network. Supporting the establishment of the new BONs will be essential, particularly as they are framed as the foundation of <u>GBiOS</u> in the future. This is necessary also to strengthen the data and knowledge basis for the GBF and reporting on the indicators of the GBF monitoring framework.

Recording available. Session abstracts and slides.

Mainstreaming and Communicating Biodiversity Monitoring Across Society



Organizers:

- Cornelia Krug (University of Zürich, bioDISCOVERY)
- Alice Hughes (AP-BON, University of Hong Kong)
- Laetitia Navarro (Estación Biológica de Doñana, EBD-CSIC)

The Kunming-Montreal Global Biodiversity Framework (GBF) takes a "whole of society" approach, relying on action of sectors of society to achieve its goals and targets. In this session, speakers shared their experiences and lessons learnt in engaging a diverse set of stakeholders in implementing biodiversity monitoring and raising awareness of biodiversity. Key to reaching the goals and targets of the GBF is creating partnerships between academia and sectors of society.

Understanding the needs of stakeholders such as cities or business, co-producing appropriate monitoring frameworks and tools as well as building capacity are the foundation for successful monitoring of biodiversity impacts, and raising awareness of biodiversity and recognising the interlinkages between human well-being and nature. Detecting and understanding biases in monitoring and data collection assist in redressing inequities and support equitable decision-making.

New technological advances and tools such as Large Language Models provide opportunities to improve monitoring and data analysis, and can support sectors in monitoring their biodiversity impacts. Examples of networks spanning academia, sectors and society that were presented in the session are **Biodiversité Québec** and the **Campus Biodiversity Network**.

Standardized eDNA-Based Biodiversity Monitoring to Inform Environmental Stewardship Programs



Organizers:

- Mehrdad Hajibabaei (University of Guelph)
- John Darling (US EPA)
- Florian Leese (University Duisburg-Essen)
- Kelly Goodwin (NOAA)
- Kristian Meissner (Finnish Environment Institute)
- Toshifumi Minamoto (Kobe University)

Environmental DNA approaches are well-established for both targeted and taxonomically broad biodiversity characterization, however they are not yet widely applied beyond proof-of-concepts or pilot studies. To support large-scale and long-term environmental stewardship, especially as we face a climate emergency and biodiversity decline, we need standardized and robust eDNA workflows. This session brought together leading experts in multidisciplinary programs that have developed and utilized eDNA for real-world applications within current regulatory regimes or for forward-looking environmental stewardship programs. It demonstrated challenges and opportunities for applying eDNA as a routine measure of biodiversity in varied environmental settings.

Session abstracts and slides.

Innovative use of Earth Observation Products in Support of Nature Finance



Organizers:

- Francesca Elisa Leonelli (European Space Agency ESA)
- Christophe Christiaen (Oxford Sustainable Finance Group, University of Oxford; UK Centre for Greening Finance and Investment)

The global biodiversity loss poses a crucial development issue and states the urgency of a financial system with winning policies in terms of both biodiversity and economic outcomes. Satellite-based products provide crucial information to quantify dependencies and impacts on nature of supply chains and can be integrated into operational reporting practices and financial decision-making. Developing standard procedures to assess and monitor physical and transition risks, transparently define bio-debits/credits, effectively integrate nature-based solutions in financial systems are some key challenges where satellite assets can highly contribute. This session featured innovative demonstrations of satellite assets for nature finance metrics and management and concluded with a panel discussion among the speakers and organizers.

Session abstracts and slides.

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Ten Years of Essential Biodiversity Variables: How Are We Calculating Them?



María Helena Olaya-Rodríguez presenting during the session.

Organizers:

- María Helena Olaya-Rodríguez (Instituto de Investigación de Recursos Biológicos Alexander von Humboldt)
- Lina María Sánchez-Clavijo (Instituto de Investigación de Recursos Biológicos Alexander von Humboldt)
- Víctor Rincón (Instituto de Investigación de Recursos Biológicos Alexander von Humboldt)
- María Camila Díaz (Instituto de Investigación de Recursos Biológicos Alexander von Humboldt)
- Juan Carlos Rey (Instituto de Investigación de Recursos Biológicos Alexander von Humboldt)

The concept of Essential Biodiversity Variables (**EBV**) was first published about 10 years ago. Since then, several projects, initiatives and methodologies have been developed to measure and monitor EBV at different scales. This session presented and initiated a discussion on protocols and standards to work on EBVs collaboratively, and identify elements that are needed to make EBVs accessible for the global community interested in biodiversity monitoring.

A large focus of this session was on learning about the different methodologies that have been developed in different countries to calculate essential biodiversity variables (EBVs) across biodiversity classes. The session began with a general review of the original EVB concept proposed by **Pereira and collaborators in 2013**, and continued with presentations that covered studies at the genetic level (poster presentation), the integration and processing of biodiversity data to calculate variables associated with populations and areas of occurrence and distribution of species, also going through the conceptualization of new variables, such as the essential mountain biodiversity variables, and finally sharing tools such as the <u>Galaxy platform</u> to share workflows for the calculation of EBV under FAIR standards. The general conclusion of the session is that there are already many robust methodologies for calculating EBVs, in fact, that it is necessary to ensure all groups are aware of the advances in these methodologies and to share them throughout the network so as not only to prevent duplicate efforts, but to ensure that the EBVs capture the attributes of biodiversity in a comparable and interoperable way for the reporting of indicators at national and international level.

Unlocking eDNA as a Biodiversity Monitoring and Conservation Tool in Tropical Landscapes



Organizers:

- Alexandre Aleixo (Instituto Tecnológico Vale ITV)
- Valéria Tavares (Instituto Tecnológico Vale ITV)

In tropical areas, biodiversity monitoring through environmental DNA is still in its infancy. The number and scope of eDNA studies in the tropics is constrained by the high monetary and computational costs of sequencing and analyzing genomic data, plus the lack of complete genetic references, integrated local germplasm banks, and trained personnel in each country. This session evaluated the contribution of eDNA to monitoring studies of megadiverse biotas and delivered a roadmap to remove impediments preventing the common use of this technique in tropical landscapes.

Biomolecular Approaches for Global Biodiversity Observation



Organizers:

- GEO BON Omic BON and Genetic Composition Working Group
- Margaret Hunter (U.S. Geological Survey)
- Raissa Meyer (Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research)
- Anna MacDonald (Australian Antarctic Division)
- Neil Davies (Gump South Pacific Research Station, University of California Berkeley)
- Pier Luigi Buttigieg (Helmholtz Metadata Collaboration, Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research)
- Kathleen Pitz (Monterey Bay Aquarium Research Institute)

This minisymposium discussed the integration of biomolecular tools in global biodiversity monitoring across space and time. Biomolecular approaches include the observation of DNA, environmental DNA (eDNA), proteins, lipids and other metabolites. The symposium discussed applications from within- species genetic diversity to tracking the distribution of organisms across ecosystems. Presented topics spanned data collection, analysis, and management, to standards, indicators, and the translation of biomolecular data to inform policy and management. The organized aimed to promote 'omics' and genetic composition observation initiatives to advance the mainstream integration of biomolecular tools and augment biodiversity observations across the GEO BON community.

Fireside Chat

What is the best way to predict the future of biodiversity?



Organizers:

- Mark Urban (University of Connecticut, Center of Biological Risk, EcoCode)
- Greta Bocedi (University of Aberdeen, EcoCode)
- Damaris Zurell (University of Potsdam, EcoCode)

We generally agree on the need to make more accurate projections about future biodiversity patterns, but arguments abound about how best to do that. This informal discussion covered how to apply diverse models to improve biodiversity projections rapidly. Discussion questions included:

- 1.Is there a way to overcome the diversity-complexity divide, whereby we can make lots of predictions using simple models or a few predictions with complex models?
- 2. When and where are correlative approaches sufficient for making predictions and when are more mechanistic approaches needed?
- 3. How can we scale between regional dynamic models to global ecosystem assessment models, or should we?
- 4.Can recent advances in AI provide useful tools that could be leveraged for biodiversity projections and management?
- 5. What are the current barriers to making better predictions, and how can they be overcome?

We were pleasantly surprised by the strong attendance at the conference's only fireside chat. Although we had developed questions in advance, we started by opening up the discussion to questions from the audience and the conversation followed naturally until the end. We discussed the best ways to perform modeling and the various tradeoffs involved. We also discussed how the modeling community could best serve the global monitoring and conservation community which included activities that ranged from building better models to providing support to countries and direction to the Convention on Biological Diversity. When asked how hypothetical financial support for modeling could be spent, the audience was split on whether it should be spent on better monitoring and validation data (including personnel) versus improving models. Our next step is to host an all-hands modeling online workshop to define EcoCode sub-working groups and define our broader mission.

Closing Ceremony

The conference closed with a panel discussion among old and new GEO BON members. Our cochairs, Maria-Cecilia and Andy, led the discussion with the panelists on what they learned and appreciated most during the week-long conference, how they see themselves as GEO BON members, what they think a Global Biodiversity Observing System (<u>GBiOS</u>) could mean for the biodiversity observing community, and what challenges should the network make a point of focus.

Panelists:

- Belma Kalamujić Stroil (University of Sarajevo-Institute for Genetic Engineering and Biotechnology)
- Alice Hughes (University of Hong Kong; AP BON)
- Damaris Zurell (University of Potsdam; EcoCode)
- Eren Turak (FWBON)
- Gary Geller (JPL-NASA)
- Mailyn Gonzalez (Humboldt Institute)



Following the panel discussion, Katie Millette polled the audience on their experience at the conference and the best way to stay connected as a network. Results of the poll are below.











Student awards for best poster and presentation were presented by Najet Guefradj, on behalf of the Quebec Centre for Biodiversity Science (<u>QCBS</u>).



Group photo (left to right): Isaac Eckert, Najet Guefradj, Flavio Affinito, Owen Martin, Antoine Caron-Guay, Neha Acharya-Patel, Kristy Mualim.

Closing remarks by Erie Tamale, on behalf of the <u>Secretariat of the Convention on Biological</u> <u>Diversity</u>, were made with a call to action for each of us to support our national processes, and to help government officials do their job better in defining their national monitoring systems.



Erie Tamale speaking.

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We are pleased to announce that the next GEO BON Conference will be in Colombia, in 2025.

On behalf of the GEO BON network, we are grateful to Adriana Radulovici for her intense work as Executive Secretary. We wish her all the best in her new position and look forward to strengthening future connections and involving all voices in the global effort to monitoring biodiversity.

Thank you to our sponsors, speakers, participants and volunteers. See you in Colombia in 2025!

Recording available.



Sponsors

A special big **THANK YOU** goes to these organizations for their contribution to the success of the GEO BON Global Conference 2023 "Monitoring Biodiversity for Action":





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