*SNIS Project – Research Plan*

# Unblocking the flow of biodiversity data for multi-stakeholder environmental sustainability management: Research plan

***Project duration**:* 2 years

***Swiss institution:*** University of Lausanne

***Main partner institutions:*** University of St Gallen; Centre for African Wetlands, University of Ghana; Humboldt Biological Resources Research Institute.


**Project Summary**

Governments, businesses and civil society require biodiversity data to facilitate informed decision-making on environmental management and conservation. However, biodiversity data are fragmented, challenging to collect or access, difficult to use, and rarely available to decision makers in appropriate formats. Challenges include lack of capacity and the absence of appropriate tools for identifying indicators and for collecting, analysing and interpreting data. Causal factors include taxonomic and geographic data biases, differences in spatial scales, and governance issues such as willingness to share information, especially in risk-averse governments and businesses.

Solutions proposed to unblock the flow of biodiversity data across stakeholder groups include the development of science-policy fora and capacity building. However, few studies have linked data solutions to user needs and there is no comprehensive, openly available tool for supporting biodiversity data use. We will therefore bring together experts from conservation biology and business sustainability management to explore biodiversity data user needs across sectors and identify the reasons behind blockages to data flow and access. We will then use our research results to work with Information Technology and data connectivity experts to develop a user-friendly, open-access decision support tool to help stakeholders find the standards, guidelines, tools, methods and data they need.

The project will enhance and complement global efforts by international organisations like IUCN and GEOBON to share and publicise data sources and to make existing tools and data freely available to the managers who need them. This will ultimately help mainstream biodiversity data into decision-making and halt biodiversity loss.


## 1. Background and Context

Biodiversity is declining (IPBES, 2019; Secretariat of the Convention on Biological Diversity 2020). Effective action to reverse current trends requires effective, data-driven decision-making and adaptive management. To that end, many stakeholders require data on the state of species and habitats, the pressures they face, the benefits accrued from ecosystem services, and their management and policy responses, to facilitate informed decision-making on conservation, natural resource management, and sustainability (Stephenson et al., 2015, 2017ab, 2020; Addison et al., 2020; Stephenson & Carbone, 2021). Governments need data, for example, to develop environmental legislation and policies, manage resources across industries (e.g. agriculture, fisheries, mining), and deliver multilateral environment agreements (Stephenson et al., 2017a,b, 2020). Businesses need biodiversity information to attain sustainability targets, monitor and report their environmental impacts, and manage risk (Walls et al., 2012, 2020; Walls & Berrone, 2017; Chiu & Walls, 2019; Addison et al., 2020; Stephenson & Carbone, 2021; Salaiz et al., in press). Conservation NGOs need data to prioritize actions, monitor outcomes and impacts, and apply adaptive management (Young et al., 2014b; McKinnon et al., 2015; Stephenson et al., 2015). Most actors also need data to demonstrate contributions to global goals and policy processes, such as the Sustainable

Development Goals (UN, 2021) and the post-2020 Global Biodiversity Framework of the Convention on Biological Diversity (Convention on Biological Diversity, 2020).

Biodiversity monitoring is therefore an essential element of environmental management, providing data for informed decision-making. However, it is often inadequate. Data are frequently scattered, fragmented, of poor quality, and rarely available in the right format at the right time (Nesshover et al., 2016; Kissling et al., 2018; Stephenson et al., 2017a,b; Stephenson, 2019; Hochkirch et al., 2020; Stephenson & Stengel, 2020). Consequently, government reporting on biodiversity often lacks data (Walpole et al, 2009; Bubb, 2013) and few companies report on biodiversity (Overbeek et al., 2013; Stephenson & Carbone, 2021). Conservation NGOs also struggle to collect and use data to monitor their impacts on biodiversity (Stephenson et al., 2015).

**2. Review of Existing Research**

A number of challenges have been identified that prevent the use of biodiversity data in decision-making. These include a lack of capacity and tools for identifying indicators and collecting, analysing and interpreting data (Stephenson et al., 2017a, 2020; Addison et al., 2020; Hochkirch et al., 2020; Stephenson, 2020). Advances in technological tools, such as remote sensing and environmental DNA (Taberlet et al., 2018; Zinger et al., 2019; Stephenson, 2020), have also left many actors behind. Biodiversity monitoring schemes and databases have taxonomic and geographic biases and data access limitations (Amano et al., 2016; McRae et al., 2017; Troudet et al., 2017; Fabian et al., 2019; Stephenson & Stengel, 2020; Moussy et al., 2021;), and many institutions fail to follow data management best practices (Wilkinson et al., 2016). Variability in the spatial and temporal resolution of data, a lack of willingness to share information, and the failure to link risks and dependencies to actions, also affect governments and businesses (Walls et al., 2012; Whiteman et al., 2013; Bansal & DesJardins, 2015; Stephenson et al., 2017a). Therefore, many stakeholders, from government departments to businesses, struggle to identify appropriate indicators for monitoring biodiversity, sources of existing data they can use, and the relevant monitoring tools for collecting their own data (Addison et al., 2020; Stephenson, 2020; Stephenson & Stengel, 2020; Stephenson et al., 2020). So how can these blockages be addressed and data made more freely available to inform decision-making and enhance conservation impact and environmental sustainability?

Solutions proposed so far to unblock the flow of biodiversity data often focus on developing science-policy fora to enhance knowledge transfer between data users and providers (Young et al., 2014a; Stephenson et al., 2017a,b), and building stakeholders' capacity to collect, use and share data in easy-to-interpret formats (Tittensor et al., 2014; Stephenson et al., 2015, 2017a,b, 2020; Stephenson, 2019; Stephenson & Carbone, 2021). However, few concrete solutions have been proposed to meet identified user needs (Stephenson et al., 2017b; Fabian et al., 2019). Various platforms exist for accessing or mapping data (Wilkinson et al., 2016; Stephenson & Stengel, 2020), and some efforts have been made to collect tools for certain sectors (e.g. Lammerant et al., 2019; GEOBON, 2021), but many potential users (especially those in the corporate sector; Stephenson & Carbone, 2021) still do not know which tools to use or where to find the data they need. What can be done to link existing tools with user needs?

Decision support tools or decision support systems are sometimes proposed as means to improve conservation delivery (Hoare, 2001; Kühl et al., 2008; Hedges et al., 2012; Strindberg & O'Brien, 2012; Reynolds et al., 2014) as a means of helping people assess available information and work through options to decide on the best course of action. While there is no comprehensive, openly available tool for supporting the use of biodiversity data, existing tools and data could in theory be linked to user needs if the tools and the needs are properly mapped and linked through a suitable portal. Few conservation practitioners read scientific literature to search for data (Pullin et al., 2004; Fabian et al., 2019); and few business scholars influence sustainability practices (Ergene et al., 2020). But many people are receptive to specialized reputable websites offering support online (Fabian et al., 2019).

Factors influencing the uptake of decision support tools in conservation include appropriate alignment with relevant policies and their usefulness even when some data are missing (Gibson et al., 2017). This further underlines the importance of aligning tools and data with stakeholder needs, especially if linked to meeting policy obligations. It also underlines the importance of ensuring that the tool deals with questions that may have no clear answer or have no clear solution; for example, what to do when the user wants to access data but that data currently do not exist - as is the case, for example, with global data sets for law enforcement and prosecutions, and conservation education and training (Stephenson & Stengel, 2020). There is therefore a compelling argument for bringing together the empirical and theoretical perspectives on data access and use and finding solutions linked to user needs and policies.

We therefore propose to bring together experts from multiple disciplines to explore biodiversity data user needs globally and in three sample countries. We will use diverse approaches to identify the reasons behind blockages to data access and then use the results to support stakeholders in finding solutions. The main output will be an online tool that, through a stepwise series of questions, will guide users towards data, tools, standards, guidelines and methods. Additional bespoke recommendations and policy briefs will be produced for specific stakeholder groups as necessary.

The project builds on and complements relevant work currently being led by the implementing partners:

- The IUCN SSC Species Monitoring Specialist Group has identified current global biodiversity data sources (Stephenson & Stengel, 2020) and monitoring projects (Moussy et al., 2021) and some of the tools available specifically for the corporate sector to monitor biodiversity performance (Stephenson & Carbone, 2021)
- The Chair for Sustainability Management at the Institute for Economy and the Environment, University of St. Gallen, conducts research on environmental governance. To date, most of that research has focused on environmental performance typically measured via ESG ratings or greenhouse gas emissions (Walls et al., 2012; Walls & Berrone, 2017). This project would build and expand on that work by focusing specifically on biodiversity performance, a new frontier in business sustainability research.
- GEOBON (2021) is cataloguing monitoring tools in its "BON in the Box" database and is starting a project with Microsoft to further enhance data availability.
- The Humboldt Institute and the Centre for African Wetlands, University of Ghana are developing monitoring protocols for biodiversity in different habitat types in their respective regions.

**3. Research questions**

Our project sets out to test the assumption made by Stephenson & Stengel (2020) that "*if the conservation, science and business communities could make a greater effort to share and publicise data sources and make existing tools and data freely available for the managers who most need them, we might be able to mainstream biodiversity data into decision-making and ultimately stop biodiversity loss*".

Our ***project goal*** is: To assess the biodiversity data needs of international organizations, governments, civil society and business, to understand blockages to data flow and capacity development, and to produce a decision support tool to help enhance access to the methods and data necessary to facilitate monitoring and informed decision-making for conservation and sustainability.

Our main ***research questions*** are:

- What are the biodiversity data needs of international organizations, governments, civil society and business?
- What factors curtail biodiversity monitoring and data access?

- What solutions are needed to unblock the flow of biodiversity data and enhance its use in decision-making and how can an online decision support tool help?

We argue that in-depth analyses of user needs for biodiversity data could be mapped against existing tools, data sources and sources of technical support and advice to develop a framework that facilitates the mainstreaming of data into decision-making. Our working hypothesis is that a simple decision support system could be developed that, by walking data users through a logical, stepwise series of questions, could lead them to the precise information they need to solve their biodiversity monitoring problem (e.g. an indicator, a monitoring method, a monitoring protocol, a data source, a source of advice, target setting, etc.).

The project will be based on two theoretical frameworks. The first, focused on governmental and non-governmental conservation agencies and developed by Stephenson et al. (2017a; Figure 1), suggests the enabling conditions for data use include data availability and usability, and the willingness and capacity to use data. We will test empirically if the precise blockages proposed in the framework can be quantified by each main stakeholder group and then addressed through a web-based IT solution.

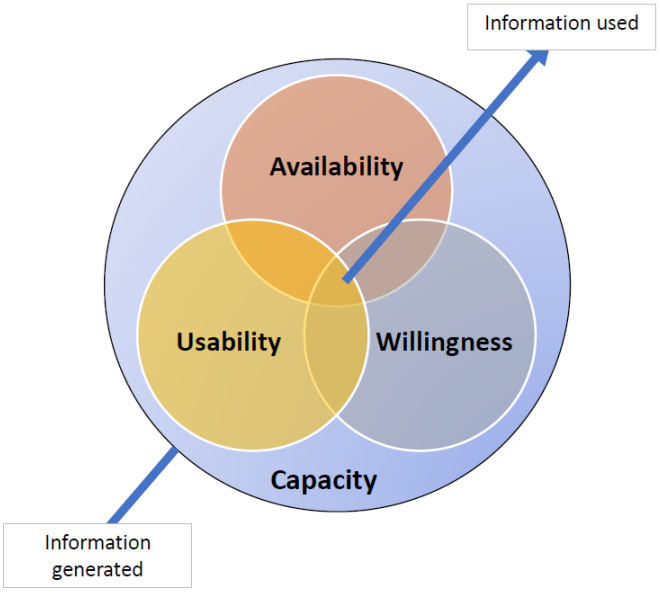


**Figure 1.** Enabling conditions for use of biodiversity data in decision-making (based on Stephenson et al., 2017a).

Secondly, for the business-specific context, we will consider the Mitigation Hierarchy, a model often used to govern biodiversity impact and avoid, reduce, restore and regenerate nature (Mitchell, 1997; Figure 2). The application of this model requires data on biodiversity states and pressures, as well as company responses. The model is also the foundational concept for two key frameworks that companies can draw on to monitor, govern, and control their biodiversity footprint, namely the Natural Capital Protocol (NCP) and the Science-Based Targets for Nature (SBTN) initiative (Natural Capital Coalition, 2016; Science-Based Targets Network, 2020). Both frameworks and their associated guidelines, as well as the broader IUCN guidelines for monitoring business biodiversity performance (Stephenson & Carbone, 2021), require companies to measure biodiversity, using relevant, rigorous, and consistent information that is material and replicable which then guides target setting and actions to reduce their impact on biodiversity. We will assess how companies use the NCP, SBTN and IUCN guidelines to measure biodiversity and make decisions to reduce biodiversity impact to determine biodiversity data needs. We will then compare and contrast these needs and challenges with those identified for other stakeholders in the public and civil society sectors.

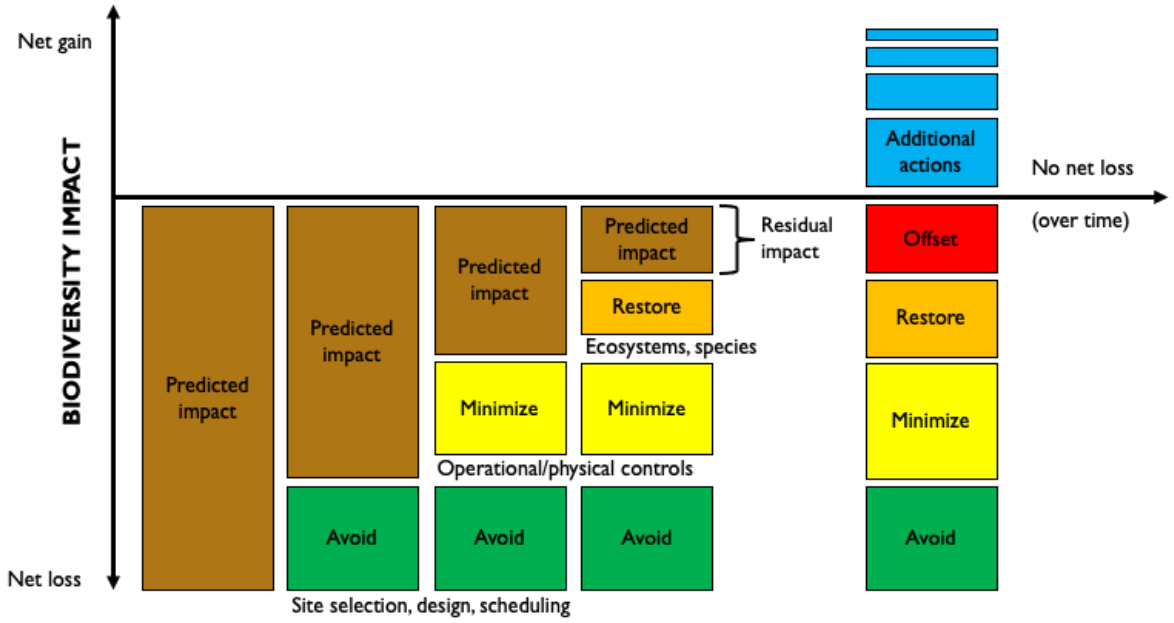


**Figure 2.** Mitigation Hierarchy – from measuring to mitigating biodiversity impact (based on Mitchell, 1997).

## 4. Approach and Methodology

The project will adopt a multi-disciplinary approach, tackling issues around biodiversity data use in conservation biology and business sustainability, and exploring web-based information technology solutions. The university departments involved reflect the project's diversity, focusing on conservation biology, business management and IT.

During three defined phases, the project will employ several research methods including:

- Systematic literature review
- Online questionnaire surveys
- Case study analysis
- Content analysis
- Panel data regression analysis.

***Phase 1: Identify data user needs/constraints***

***Step 1a. Conduct a systematic literature review*** to identify the biodiversity data required by governments, international organizations (IOs), civil society and the private sector and blockages to data access, from national levels to global policy processes, such as the Sustainable Development Goals and the post-2020 Global Biodiversity Framework. The review will include systematic content analysis of grey literature such as (business sustainability reports, disclosure platforms, government reports to CBD, NGO reports, etc.).

> ***Systematic literature review.*** A systematic literature review is a structured, thorough, and transparent process by which researchers take steps to review relevant scholarly and sometimes grey literature in order to identify prior scholarly work that is relevant to answering a particular research question or a particular methodology (Adams et al., 2017; Aguinis et al., 2020). It involves a process of setting the scope of the review and then identifying and screening literature and disclosing the criteria used for searching and screening (Hiebl, 2021). The literature is then read and categorized to aggregate, integrate, interpret, and explain as a way of synthesizing how scholars understand the field of study and identify where knowledge gaps may exist (Rousseau et al., 2008). For our study, we plan to search academic and grey literature on biodiversity measures and governance by using ISI

Web of Science, SCOPUS and GoogleScholar to identify relevant publications that exist using keyword searches (e.g. terms like “nature”, “ecology”, “biodiversity” combined with terms like “monitoring”, “measures”, “commensuration”, “reporting” etc.). Articles will be collected and categorized according to key topics and publications outlets. We will then assess if any should be excluded and establish relevant exclusion criteria where necessary. The next step will be to read the articles thoroughly and categorize the content which will then be integrated and interpreted to gain insight into the current state of biodiversity data and measurement, and how organizations use such data in decision making processes. We will then develop recommendations on how best to synthesize the insights from the literature to develop a biodiversity data framework and (governance) decision making tool.

***Content analysis.*** We plan to use content analysis (Holsti, 1969; Miles & Huberman, 1994) of documents uncovered during the literature review, such as national biodiversity reports, corporate sustainability reports and corporate disclosures to the Carbon Disclosure Project (which asks companies questions on their biodiversity footprint). The content analysis will be conducted in two stages (sensu Arndt & Bigelow, 2000). In the first stage, text, pictures, captions and other information from reports is coded close to the text, with increasing levels of abstraction in an iterative process to categorize the biodiversity data topics that emerge (Glaser & Strauss, 1967; Miles & Huberman, 1994). In the second stage, the topics from the coding will be reconciled with the scholarly literature (based on the systematic review discussed above), to identify what types of biodiversity data stakeholders most commonly collect, measure and report, and the specific challenges and solutions companies have found for biodiversity data and measurement, as well as governance decision-making processes.

***Step 1b. Conduct an online questionnaire survey*** of a random selection of stakeholders worldwide, including government departments, IOs, NGOs and businesses. The survey will identify what sort of data are needed, how often, in what format and for what purposes, what gaps and challenges exist, and what help is needed. Survey data will be disaggregated by type of biodiversity data use, organization, habitats and species affected, as well as by the gender, origin and age of respondents.

***Online questionnaire surveys.*** Questionnaire surveys are an often-used tool in conservation biology for assessing people’s opinions about key biodiversity topics (e.g. Chen et al., 2019; Danovaro et al., 2020; Mair et al., 2021). Such surveys are a form of expert elicitation, a tool used to develop estimates unknown or uncertain quantities based on careful assessment of the knowledge and beliefs of experts about those quantities (Morgan, 2014), and used especially when data are sparse or lacking (Meyer & Booker, 2001). This approach is considered more practical than structured interviews or focal groups during the current health situation and will cover efficiently a larger number of potential respondents. The project team will develop questions that help fill the gaps in understanding identified in the literature review as to the data needs and challenges experienced by stakeholders and the reasons people identify for those challenges. It will be checked for internal reliability and convergent/discriminant validity, social desirability, and common method biases, The majority of questions will request a quantifiable answer (a numerical value or ranking) to allow statistical analyses of the results. Participants will be chosen from people identified in the literature review from each main stakeholder group (government, IO, civil society, business).

***Step 1c. Conduct a large-sample analysis*** to understand data needs and relationships. This will involve connecting biodiversity data and linking it to stakeholders’ organizational data (e.g. financial, governance) and identifying implications for conservation monitoring, environmental risk management, and decision-making. At the same time, we will map existing monitoring tools, standards, data sources and guidelines to assess what is available.

***Panel data regression analysis.*** To uncover the effectiveness of current biodiversity data usage (by businesses in particular), we will use a panel data regression analysis. Our sample

will focus on the largest companies in sectors that directly affect biodiversity loss such as agriculture and agri-commodities, mining/extraction, and forestry products over a ten-year period from 2010 to 2020. Using the content analysis of the CDP data (see above), we will create several measures of biodiversity data and governance, based on the results of our literature review and case study insights. We will additionally work with Spatial Research Systems to collect key biodiversity indicators of organizations based on where their plants and facilities are located, to use as a measure of "biodiversity performance". We will also collect basic organizational data such as financial information from Compustat and information on organizational leaders using BoardEx as control variables. Our aim is to build a panel data set using these multiple sources of data to test whether different governance techniques of biodiversity have differential effects on the overall improvement of an organization's biodiversity performance. We will likely end up with an unbalanced panel sample; observations will be dropped if data is missing, and the relationships will be tested using panel data econometric techniques (e.g. fixed or random effects regression). Independent variables will be lagged by one year to help address endogeneity and reverse causality bias. Year and industry fixed effects will be included in the regression (e.g. Walls et al., 2012).

***Step 1d. Conduct "deep dive" case studies***, using literature reviews and semi-structured individual and focus group interviews, to identify the causes and effects of different data access challenges in:

- At least three multi-national companies, from among those already working with PJ Stephenson and Judith Walls (e.g. Alcoa, Boskalis, Enel, Johnson & Johnson, Lafarge/Holcim, Nespresso, Syngenta)
- At least three IOs and international NGOs, from among those PJ Stephenson has worked with or is currently collaborating with (e.g. CI, GWC, UN Environment, WWF), as well as GEOBON and IUCN
- Government departments and NGO communities in team members' countries: Colombia, Ghana, and Switzerland. Site visits (if the health situation allows) will also allow an evaluation of current methods and practices for data collection.

***Case study analysis***. Case study research typically seeks to understand a field of study from the ground up (Glaser & Strauss, 1967) by understanding the dynamics within single settings (Eisenhardt, 1989). Case study research uses a comparative method by identifying theoretically determined 'cases' (e.g. organizations) to compare and contrast how organizations manage a particular topic. The selecting of cases is done through theoretical sampling or a specific population, followed by designing protocols for investigation and then entering the field to collect data (Eisenhardt, 1989). Data can be collected in multiple ways such as interviews with individual members of organizations, archival data (e.g. reports, emails), personal observations in the field, questionnaires, and so on. Evidence may be qualitative and/or quantitative. Typically, multiple methods are used to triangulate the findings. The data are then analysed within-case and/or cross-case to identify patterns and provide insights into the study topic (Eisenhardt, 1989; Yin, 1984). Data analysis can include a process of tabulating and visualizing patterns (Miles & Huberman, 1984). For our research, we plan to select cases of organizations in Colombia, Ghana and Switzerland that actively collect data on biodiversity and that use data to govern, monitor, and control their biodiversity impact and/or make decisions on biodiversity. Data will be collected using archival sources, interviews and site visits. Interviews will be semi-structured and open-ended to allow interviewees ample room to express themselves (Alvesson, 2003). Interviews will be transcribed and coded via an iterative process of inductive and deductive coding that moves beyond initial impressions and across several stages (Glaser & Strauss, 1967; Holsti, 1969; Miles & Huberman, 1994). Data will be analysed to understand what challenges organizations face in collecting biodiversity data and using it for decision making, as well as ways in which organizations have overcome those challenges.

***Step 1e. Synthesize results and conduct statistical analyses*** to identify relationships and correlations between factors affecting data availability. Depending on data type and distribution, tests used are

likely to include Pearson's correlation, Wilcoxon and Kruskall-Wallace tests, ANOVA models, and econometric techniques, such as panel data regression and multi-level modelling.

***Phase 2: Develop a decision support tool***

***Step 2a. Hold a workshop*** to convene project partners and a representative selection of stakeholders to assess project results and develop the functional specifications for a decision support tool. Particpants from large NGOs and IOs will be asked to cover their own travel costs as an in-kind contribution to the project.

***Step 2b. Develop a web-based decision support tool*** for guiding stakeholders to data, tools, methods and support, and to test it with project partners. UNIL IT expertise will be supported by teams in St Gallen, Humboldt and GEOBON.

***Phase 3: Produce and disseminate results and lessons***

***Step 3a. Produce papers and disseminate results*** (see Dissemination Strategy). Key outputs will include papers for peer-reviewed scientific journals defining factors affecting stakeholders' data and capacity needs, the design of the decision support tool, key resources available for stakeholders and recommendations on gaps to be filled. Reports for different data users will also be produced to offer bespoke guidance (e.g. this might include a summary of guidance on identifying tools and data for a particular business sector, such as extractives). Results will also be shared through open online webinars, training webinars, and calls with key partners and stakeholders. A targeted social media campaign by project partners will also be implemented and results posted on institutional websites.

**5. Project organization and team roles**

This project will be implemented by a diversity of partners working in close collaboration with data users from IOs, governments, civil society and business. Implementing partners will include:

- Research institutions: universities of Ghana, Lausanne and St Gallen; Humboldt Biological Resources Research Institute
- International organizations (IOs): GEOBON (Group on Earth Observations Biodiversity Observation Network), IUCN (International Union for Conservation of Nature)
- NGOs: Centre for African Wetlands.

User groups whose needs will be surveyed and met, and examples of organizations that will be invited to become associate project members, include:

- Research institutions: UNEP-WCMC (United Nations Environment Programme – World Conservation Monitoring Centre), Zoological Society of London,
- Government agencies: government departments in Colombia, Ghana and Switzerland
- International organizations: UN Development Programme (UNDP), World Business Council for Sustainable Development (WBCSD).
- NGOs: Conservation International, Re:wild (formerly Global Wildlife Conservation), Wildlife Conservation Society, WWF
- Companies: Alcoa, Boskalis, Enel, Johnson & Johnson, Lafarge/Holcim, Nespresso, Syngenta, Spatial Research Systems.

A representative group of these partners will be invited to attend the project workshop and help design the decision support tool. They will also be offered opportunities to co-author papers. (Note that the principal team members have personal contacts and existing working relationships with all of the agencies listed in the user groups.)

A selection of potential associate partners have provided support letters for the project:

- **Re:wild**: an international conservation NGO based in the US

- **United Nations Environment Programme – World Conservation Monitoring Centre**: a research organization and global leader in biodiversity data management based in the UK
- **World Business Council for Sustainable Development**: an international CEO-led organization of over 200 leading businesses working on sustainability issues, with its headquarters in Geneva.

The project will be managed by a steering committee comprised of the coordinator and principal team members or their delegates. The committee will meet quarterly to plan and share updates. Members working together on specific research tasks will meet more frequently as required.

The division of labour throughout the project is explained below.

| Team member | Main roles |
|---|---|
| Coordinator<br>Dr Luca Fumagalli<br>University of Lausanne | Oversight and coordination; chair steering committee quarterly meetings<br>Supervise UNIL post-doctoral researchers in Conservation Biology (PM1)<br>Host workshop<br>Foster links to other UNIL departments and to Swiss organizations<br>Contribute to scientific papers<br>Disseminate results at relevant meetings and conferences |
| Co-cordinator & Principal Member 1<br>Dr Peter J. Stephenson<br>IUCN SSC Species Monitoring Specialist Group &<br>University of Lausanne | Lead project researcher and co-coordinator<br>Support for oversight and co-ordination<br>Foster links to relevant IUCN and IUCN SSC projects and to relevant IO, NGO, government and business partners<br>Conduct literature review and online survey of stakeholders<br>Design case studies<br>Conduct case studies: multinational businesses; NGOs; IOs<br>Conduct data analyses<br>Participate in UNIL-hosted workshop to share results and develop specifications for decision support tool<br>Contribute to scientific papers<br>Disseminate results at relevant meetings and conferences |
| Principal Member 2<br>Professor Judith L. Walls<br>University of St Gallen | Supervise St Gallen post-doctoral researcher (PM5)<br>Conduct literature review and online survey of stakeholders<br>Design case studies<br>Oversee case studies: multinational businesses; government departments and NGOs in Switzerland<br>Oversee data analyses<br>Participate in UNIL-hosted workshop to share results and develop specifications for decision support tool<br>Contribute to scientific papers<br>Disseminate results at relevant meetings and conferences |
| Principal Member 3<br>Professor Yaa Ntiamoa-Baidu<br>Centre for African Wetlands,<br>University of Ghana | Supervise UG post-doctoral researcher (PM6)<br>Oversee case studies: government departments and NGOs in Ghana<br>Oversee data analyses<br>Participate in UNIL-hosted workshop to share results and develop specifications for decision support tool<br>Contribute to scientific papers<br>Disseminate results at relevant meetings and conferences |
| Principal Member 4 | Supervise Humboldt post-doctoral researcher (PM7)<br>Foster links to relevant GEOBON initiatives |

| Team member | Main roles |
|---|---|
| Dr María Cecilia Londoño Murcia<br>Instituto de Investigación de Recursos Biológicos Alexander von Humboldt & GEOBON | Oversee case studies: IOs; government departments and NGOs in Colombia<br>Oversee data analyses<br>Participate in UNIL-hosted workshop to share results and develop specifications for decision support tool<br>Contribute to scientific papers<br>Disseminate results at relevant meetings and conferences |

**6. Timetable and milestones** (final version)

| Activities | Leads | Project Milestones | 2021 | | 2022 | | | | | | | | | | | | 2023 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | N | D | J | F | M | A | M | J | J | A | S | O | N | D | J | F | M | A | M | J | J | A | S | O |
| ***Project management*** | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Recruit post docs | JW/MCL/YNB | | | | x | x | x | x | x | | | | | | | | | | | | | | | | | |
| Supervise post doc in HSG | JW | | | | | | | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | |
| Supervise post docs in Humboldt and UG | MC/YNB | | | | | | | | | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | |
| Organise Steering Committee online co-ordination meetings | LF/PJS | | x | | x | | | x | | | x | | | x | | | x | | | x | | | x | | | x |
| ***Phase 1: Identify data user needs & constraints*** | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Conduct literature review & online survey | PJS/JW | List of preliminary user data needs by 31 July 2022 | x | x | x | x | x | x | x | | | | | | | | | | | | | | | | | |
| Connect/analyse data; prepare initial papers; | PJS/JW | | | | | | | x | x | x | | | | | | | | | | | | | | | | |
| Design case studies | PJS/JW/MCL/YNB | Understanding of factors affecting data access by 1 May 2023 | | | | | | | | | | | | | | | | | | | | | | | | |
| Case studies: | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Multi-national businesses | PJS/JW | | | | | | | | | | x | x | x | x | x | x | x | x | | | | | | | | |
| International NGOs and IOs | PJS/MCL | | | | | | | | | | x | x | x | x | x | x | x | x | | | | | | | | |
| Government departments & NGO communities in: | | | | | | | | | | | x | x | x | x | x | x | x | x | | | | | | | | |
| Colombia | MCL | | | | | | | | | | x | x | x | x | x | x | x | x | | | | | | | | |
| Ghana | YNB | | | | | | | | | | x | x | x | x | x | x | x | x | | | | | | | | |
| Switzerland | PJS/JW | | | | | | | | | | x | x | x | x | x | x | x | x | | | | | | | | |
| Synthesize results; conduct data analyses; finalize communications & dissemination plan | Project team | | | | | | | | | | | | | | | | | x | x | x | | | | | | |
| ***Phase 2: Develop a decision support tool*** | | | | | | | | | | | | | | | | | | | | | | | | | | |
| UNIL-hosted workshop to share lessons and develop ideas for decision support system | LF/PJS | Results shared & validated and specifications for decision support tool developed by 30 April 2023 | | | | | | | | | | | | | | | | | | x | | | | | | |

| Activities | Leads | Project Milestones | 2021 | | 2022 | | | | | | | | | | | | 2023 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | N | D | J | F | M | A | M | J | J | A | S | O | N | D | J | F | M | A | M | J | J | A | S | O |
| Develop web-based decision support tool | PJS with IT teams | Beta version of support tool developed by 31 October 2023 | | | | | | | | | | | | | | | | | | | x | x | x | x | x | x |
| ***Phase 3: Produce and disseminate results and lessons*** | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Produce papers & stakeholder reports | Project team | At least 2 journal articles submitted and at least 3 presentations given by 31 October 2023 | | | | | | | | | | | | | | | | x | x | x | x | x | x | x | x | x |
| Webinars to share results/tool | Project team | | | | | | | | | | | | | | | | | | | | | | | | x | x |
| Presentations at international meetings and conferences (e.g. ICCB 2023; WCC 2024; GEOBON Open Science conference; IUCN SSC Leaders Meeting; SwissBiz4Nature forum) | PJS and others as opportunities arise | | | | | | | | | | | | | | x | x | x | x | x | x | x | x | x | x | x | x |

## 7. Expected results

We will identify the biodiversity data required by multiple stakeholders locally and globally and factors affecting access, and propose solutions. A decision support tool is a practical advancement that will allow stakeholders to identify indicators, data sources, data collection tools and advice relevant to them.

The results of this research will have implications for governance, planning, monitoring, reporting, disclosure, sustainability and decision-making across multiple stakeholders managing, conserving and restoring biodiversity. The project will contribute to academic fields of study such as conservation biology and business sustainability management scholarship. In conservation biology, the results will help frame data access and management in the context of local and global planning, practice and policy needs. This will lead to improvements in the monitoring of pressures, impacts and project delivery, and more informed natural resource management policy-making. In business sustainability, we expect to contribute to the field of corporate governance and sustainability, specifically by expanding the focus of environmental performance outcomes that have typically captured only greenhouse gas emissions or environmental ratings to develop appropriate biodiversity performance measures. In addition, we contribute to the micro-foundations literature of corporate sustainability in understanding how and why managers make decisions around biodiversity.

The findings of this study will have broad policy implications by helping stakeholders monitor and report on their contributions to the post-2020 Global Biodiversity Framework of the Convention on Biological Diversity and the Sustainable Development Goals, as well as multilateral environment agreement commitments (e.g. Convention on Migratory Species; Convention on Trade in Endangered Species of Wild Fauna and Flora). For many companies, data use also meets key legal obligations (such as the requirements imposed by various EU directives and national laws requiring environmental impact assessments for developments in most sectors) or contributes to company sustainability policies and governance. Furthermore, the increasing regulations on non-financial disclosure (such as the European Union's non-financial reporting directive 2014/95/EU) are putting more pressure on businesses to identify credible indicators for their biodiversity performance that can be shared publicly (Stephenson & Carbone, 2021). The policy context should therefore create a suitable enabling condition for our project's outputs.

The project will therefore strive to bring together the empirical and theoretical perspectives on biodiversity data access and use and find solutions linked to user needs and policies. This will improve the availability of data and monitoring tools and ultimately enhance conservation, natural resource management and sustainability.

## 8. Dissemination strategy

**i. Purpose:** Ensure project lessons are shared with academics studying the same issues to advance the science behind biodiversity monitoring and with data users who may benefit from our findings and the decision support tool.

**ii. Key messages:**

- What factors affect the availability of biodiversity data to key users
- What indicators, data, tools, standards and guidelines are available to meet monitoring needs of different users
- What people can do to address their data needs
- How to access our decision support tool and find relevant data, tools and support

**iii. Target audiences:**

- Academics working in relevant fields (business science, conservation biology, etc.)
- Data users in governments, IOs, NGOs, businesses
- General public (especially on the value of citizen science to fill gaps)

**iv. Methods and approaches**

***Scientific papers***

Key project outputs will include papers targeting peer-reviewed scientific journals that define factors affecting data availability and use, stakeholders' data and capacity needs, governance and decision-making processes around biodiversity, the design of the decision support tool, key resources available for stakeholders and recommendations on gaps to be filled. The papers will also link results to ongoing global policy processes, such as the Sustainable Development Goals and the post-2020 global biodiversity framework.

Relevant journals that will be targeted for project results include: Biological Conservation, Business & Society, Conservation Biology, Conservation Letters; Environmental Science & Policy, Leadership Quarterly, Organization & Environment, Leadership Quarterly, PLoS ONE, Strategic Organization, Strategic Management Journal, etc. The papers will be complemented by dissemination across more general media outlets (e.g. The Conversation, Medium). Where possible, open access journals will be favoured, with costs covered by the principal partners' institutions. All papers will be archived in the UNIL institutional repository, SERVAL.

The team will also submit papers for presentation at various relevant conferences that maximise dissemination not only to the science community but also other data stakeholders, such as governments, IOs, NGOs and businesses. Examples of such conferences include the 2023 Academy of Management Annual Meeting (Organizations and Natural Environment division), the 2023 Alliance for Research on Corporate Sustainability, the 2023 International Congress for Conservation Biology, the 2024 Group of Organizations and the Natural Environment conference, the 2024 IUCN World Conservation Congress and GEOBON Open Science conferences,). Some presentations will be recorded for further sharing on institutional websites.

***Data sharing***

The data collected during this project will be made publicly available, by publishing alongside the scientific papers (usually as supporting or supplementary material) and by posting on institutional websites (see https://www.speciesmonitoring.org/data-sources.html for an example of the type of sharing planned). The use of other data sharing platforms such as Dryad Digital Repository, FigShare, and Zenodo will also be explored.

***Policy and advocacy***

Results and the decision support tool will be shared through a series of meetings and webinars, some targeting national governmental and non-governmental collaborators in Colombia, Ghana and Switzerland, others open to a global audience. The team will also present at key policy-related conferences, such as technical meetings of multilateral environment agreements. Various fora on business and biodiversity will also be targeted (e.g. the EU Business & Biodiversity Platform, SwissBiz4Nature). Reports and policy briefs for different data users will be produced to offer bespoke guidance (which might include a summary of guidance on identifying tools and data for a particular business sector, such as extractives).

***Public engagement with science***

A series of webinars that specifically target the general public interested in nature and science will be held to promote the need for data-driven decision-making and to demonstrate opportunities for their involvement, such as through citizen science monitoring schemes. Recordings will be shared online through platforms such as YouTube.

***Training***

Online training on how to use the decision support tool will be made available to all interested data users.

***Social media***

A targeted social media campaign by project partners (focused on Twitter and LinkedIn) will also be implemented and results posted on institutional websites.

**v. Developing a plan**

A communications and dissemination plan will be developed during the first year of project implementation as the precise products and outputs are confirmed based on project findings and user needs. This will map out and refine the products to disseminate, the target audience and the methods of communication, and produce a final timeline.

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