Project "*Cooperation on Biodiversity Data Management for Species and Ecosystem Assessments*"

1) Detail the activities implemented during the project.

Activity 1: The first activity implemented was to inform the directives of the participating institution the signature of the agreement between the Humboldt Institute and the Secretariat of the CBD and the official start of the project. A letter was sent by email by the end of May with this information and an invitation to participate in a first online meeting to start planning the agenda and expected outcomes, organization and facilitation of the three workshops planned with the following objectives:

   (i)   Establish a network of code developers and to agree software architecture for species assessment tool;

   (ii)   Facilitate technical exchange and capacity strengthening on criteria and tools for assessment and dissemination of information useful for management process regarding endangered and exotic species; and

   (iii) Develop a flexible methodology for ecosystem integrity assessment in megadiverse countries and advance on a pilot case study.

Considering the different subjects of interest and participants involved, during June one meeting was scheduled to discuss the subject of endangered and exotic species, and other for the subject of ecosystem integrity assessment. Biodiversity informatics were considered in both meeting, as this a cross-cutting subject. Additional online meetings were scheduled in July to revise the proposed agenda and define the participants that would attend representing each institution.

Although initially it was proposed to organize the three workshop during the same week to promote the exchange between subjects, this was not possible considering the availability of participants. Therefore, the workshop related to endangered and exotic species occurred between the 21st and 24th of August and the workshop related to ecosystem integrity assessments between the 27th and 31st of August. Biodiversity informatics were discussed during both workshops.

Annexes:
   - Annex A1_1 Letters of invitation
   - Annex A1_2 Planning meetings
   - Annex A1_3 Agenda workshops

Activity 2: The workshops were attended by 32 participants from four countries (Colombia, México, South Africa and Brazil), and for each institution, with the exception of Rio de Janeiro Botanical Garden, there were representatives of the three subjects of interest identified in the proposal: data management of endangered and exotic species, ecosystem integrity assessments and biodiversity informatics. Although most of the participants flew to Bogota to attend the workshop, some researchers participated online in specific sessions.

The participation of the four institutions and the diverse profiles of the participants, which included biologist as well as mathematicians and system engineers, allowed to establish collaborative networks of researchers in the following subjects:

- Data interoperability and data processing times for the assessment of ecosystems and species
- Criteria and tools for assessment and dissemination of information for endangered and exotic species
- Methodological incorporation of species taxonomic and functional information into ecosystem integrity indices

Detail information regarding the establishment for the network is exposed in the Output: Biodiversity Informatics Network.

In terms of standard software architecture for collaborative system development, the presentations and discussion that took place in the workshops showed that the four institutions were making considerable progress in the first steps required for the assessment of species, consolidation and validation of data, however, with the exception of Brazil, there was less progress in systems that allowed the recording and publication of assessments of extinction risk and invasiveness. The needs of countries for a system with this objective was confirmed and there is a fertile ground in terms of conceptual basis, tool development and technical team for a collaborative developments.

Detail information regarding the standard software architecture is exposed in the Output: Architecture species assessment system and in the annexes:

-Annex A2_1 Report workshop species
-Annex A2_2 Report workshop ecosystems
-Annex A2_3 List of participants
-Annex A2_4 Service orders (travel, lodging and meals arrangements)

Activity 3: Based on the workshop on Ecosystem Assessment we develop Develop a flexible methodology for ecosystem integrity assessment in megadiverse countries. The methodology was developed by Mexico, adjusted during the workshop and tested during Activity 4 using Colombia as the pilot case study. All algorithms used to implement the methodology in the test countries are available through GitHub.

Further detail and results of this activity can be found in the output: Concept Ecosystem Integrity in Megadiverse Countries.

Activity 4: Between September 3 and September 29, the Humboldt and Conabio teams were in constant communication in order to finished the pilot case study for the implementation of ecosystem integrity assessment. The activities and results of activity 4 can be found in the output: Concept Ecosystem Integrity in Megadiverse Countries.

Activity 5: During the ecosystem assessment workshop a first idea of a follow-up project was discuss. This project idea was build ones the Ecosystem integrity Methodology was adapted and the challenges of this methodologies were identify. The proposal for the project

aims to develop solutions for those challenges, focusing primarily in the integration of species information into the measurements and in enhancing the interoperability of the current research infrastructures. The proposal of the project was submitted on October 8th to a National Geographic and Microsoft Call "Artificial Intelligence for Earth Innovation Grant".

-AnnexA5_NatGeo AI Cal submission.

2) What are the main outcomes of the project? How these results impact the state of the biodiversity? How this project generated social and economic benefits? Please annex any written relevant document.

The main outcome of the project was the technical exchange and capacity strengthening that took place, which allowed to identify priorities common to the participating institutions and potential collaborations to address them.

On of these priorities is the need to provide reports in short-term and considering the best quality information available regarding progress in the achievement of Aichi target 9, 12 and 19. All the institutions that participated are producing information relevant about their species and ecosystems and national biodiversity system have been established to manage and store this information. However there is a lag to translate this data in outcomes that can be easily consulted by environmental authorities and the general public, and answer more efficiently questions such as: how many species are endangered? where are they? what is their level of protection? what are the priority areas to control and monitor invasive species?

All participants institutions are moving forward in the development of routines and tools that allow better interoperability between different types of data, such as occurrence records of species of conservation priority and spatial data of ecosystems and environmental data, together with automatization of analysis to answer this questions. Sharing this routines and tools provides economic benefits to the participants institutions by optimizing the investment of resources.

The face to face interactions between participants promoted the building of personal relationships between the researchers that will facilitate the writing of proposals, for example for undertaking a collaborative approach to system development. In this regard, representatives of the Humboldt Institute and SANBI had a meeting after the workshop to evaluate the alternative scenarios to collaborate in the development of an extinction risk system, with the participation of researcher of the teams of biodiversity informatics and conservation biology.

On the other hand, the project allowed participants to share the practices that have produced the higher impact on the conservation of species, including the production of maps for regional environmental authorities and prioritization exercises, which can be applied by other countries and if required remote advice can be provided. This analysis do not occur often between institution with similar roles in CBD countries, and surely can have a positive impact on the medium-term on the state of biodiversity.

3) What has been the role of the National Focal Points of the CBD of the different Parties involved in the project?

The National Focal Points of the Parties involved in the project did not participate directly in the activities undertaken. In the case of Colombia, representatives of the Ministry of Environment were invited to one of the workshop but could not attend.

The representatives of the different departments related to international cooperation of the different institutions are aware of this cooperation project. This is important because they are the link from the different institutions into the National Focal Points. The final version of the report will be socialized with the representatives of the International Cooperation offices of the different institutions highlighting the opportunities for cooperation and the advances made in the ongoing process that the different institutions have.

We will discuss with this representatives how to transfer this information into the National Focal Points.

4) Describe how the project enhanced the Technical and Scientific Cooperation (TSC) between the Parties and organizations involved in the project.

Regarding invasive species after the identification of progress on different topics, the institutional delegates identified strategies to move forward to accomplish the targets including possible future collaborations on the different strengths and challenges.

From the threatened species perspective future collaborations to discuss common challenges and how to deal with this for risk analysis platforms or developments.

For the Ecosystem Assessment topics, there was a very strong enhancement of the researchers that participated in this project. In general perspectives this project was an exercise of co-creating knowledge between the participants, in that sense everyone learned something from the others. Specifically there are two products derived from this project that enhance the technical and scientific cooperation between the parties:

1-A flexible methodology of Ecological Assessment is developed and the script to run the methodology is publicly available in GitHub at https://github.com/jequihua/bnecology. We hope we can continue our cooperation in this topic and that the method and ways to implement it are each time more complete, available for other parties and easy to use.
2-The MadMex Antares 3 system was installed in the web server and this project impose the need to adapt its implementation so that other countries could use it. MadMex is a powerful land cover classification system that works in a megadiverse country as Mexico, adapting it so that other countries can use it is a big technical success.

5) Which activity or approach efficiently succeeded to foster sustained TSC and why?

Considering the time lapse of the project, it is not possible to evaluate if sustained TSC is occuring. The leaders of the project at Humboldt have allocated the available time after the workshops to write the final report of the project, and will maintain the follow-up of the agreements reached in the events.

However, during the workshop, participants were asked to identify according to their experience the limitations to continue collaborations with other institutions after similar events and these were mentioned: changes in personnel, collaborations representing additional work and limited time, collaboration without specific resources assigned to the products that are committed are some of the limitations. These limitations can be considered to implement the strategies to foster sustained TSC.

The building of the network Coders4Conservation is probably the activity that will result in a continue cooperation process, it is important to maintain the activity in the network. The proof of concept of the ecosystem Integrity methodology will be a living document for the following months, and we hope to generate a scientific publication from it.

The activity to develop a proposal was a good activity that force us to think in a concrete project. We hope we can have the grant were we submitted it, otherwise the proposal is ready to be adjusted for new funding opportunities.

6) Which activities or approaches would be done differently, now that you have experienced them, and why?

During the planning of the agenda of the workshop focused on biodiversity informatics and management of invasives and threatened species, we realized that the possible areas of discussion were diverse and numerous, considering the different profiles that we were interested to involve. Although there was an effort to reduce as much as possible the themes included, the final agenda was still rich in themes and time for drafting proposals was affected and some specific areas of interest could not approached in detailed, for example analysis and discussions regarding exotic species with higher risk at a national level and how to categorize these species with a differential management.

7) How this project could be pursued to maintain or scale up the positive results obtained?

One strategy to scale up the positive results is to share the major results in relevant instances, such as a CBD bulletin or event. Also if there is the opportunity, we can share our results with the new generation of project that BioBridge will be supporting, in that sense new project can start from our results and continue enhancing them. Ones BioBridge initiative has clear the results obtain in this project can offer them to parties that are looking for support in related topics.

A second strategy is to accomplish the task and commitments agreed in the workshop by the different institutions and seek for resources in the case of those priorities that require funding.

8) How this project could be replicated in another region?

The project involved the participation of countries from three major regions, South and Central America and Africa, and institutions with considerable progress in the subjects of interest and similar challenges. With this in mind, the project could be replicated by two different means: that participant countries transfer the results and invite pair of other

biodiversity institutes in their region to participate in the established networks or by identify institutions with similar profile as those involved in other regions, such as Europe or Asia.

Many of the participants of the workshops are active members of regional or global networks, shearing this results through those networks will be a way in which other regions can get interest in replicating them. For example the Ecosystem Integrity Methodology and workflow can be presented as an example for the integration of essential biodiversity variables within the Bon Development working group of GEOBON.

Also the BioBridge initiative could facilitate the matchmaking with other countries of other regions for the replication of the project.

9) Describe the in-kind contribution of the different stakeholders involved in the project and how this type of contribution could be increased in future projects.

The Humboldt Institute provided in-kind contribution to the project in terms of the time allocated by three leader researchers and an administrative assistant to the following activities: contact participants and organize preliminary meetings, construct agenda, manage invitations and logistics procedures for the event, and follow-up and final reports. In addition, the workshops took place in the offices of the Humboldt Institute in Bogota without charge. The other participant institutions also provided in-kind contributions in terms of the time devoted by researchers to participate in online meetings and to travel to Colombia to attend the event. Especially CONABIO gave a high in-kind contribution by transferring their current Ecosystem Integrity and Land Cover Classification methods to the workshop participants, and after the workshop they still work for one more month to adapt their methods for other countries.

The culture of open data and open knowledge is a key factor for this type of cooperation project to succeed. It will be desirable that open access tools and platforms, such as the ones used in this project, are implemented by different stakeholders so that their in-kind contributions increase.

10) If the project included a participation of major groups like business, subnational and local authorities, NGOs, youth, women, indigenous peoples and local communities, what would be your advices to engage efficiently this specific group?

The project was envisaged as a technical meeting, so no activities were considered to engage other type of stakeholders.

11) Propose a summary of the project in 250 words to be published on the Bio-Bridge web portal.

The project involved a technical exchange between biodiversity institutions of four megadiverse countries in the following subjects: management of threatened and invasive species, biodiversity informatics and ecosystem integrity assessment. Bio-Bridge resources were used to organize two workshops in Bogota addressing the subjects of interest. The profile of the participants of these events was diverse, including biologist, geographers,

mathematicians and system engineers; which allowed the group to address issues that require the collaborative work of the different disciplines and share the present and future project of independent teams inside the institutions involved. One of the main results of the project is the establishment of "Coders4conservation" network, we invite you to join the network by contacting us through https://coders4conservation.slack.com

12) Any other lessons learned to share with the Bio-Bridge team?

This project was very useful for maintaining the cooperation process between Mexico, Colombia, South Africa and Brazil. Thanks to this project specific products as the Ecosystem Integrity methodology and the adaptation of the MadMex Antares3 system where possible.

WORKSHOP REPORT "*SPECIES AND BIODIVERSITY INFORMATICS*"
Sede Venado de Oro, Instituto Alexander von Humboldt, Bogotá D.C
21-24 August 2018

INTRODUCTION

A series of challenges related to information and data management for the assessment of biodiversity state have been identified by parties of the Convention of Biological Diversity (CBD) as a result of exchange workshops between the Humboldt Institute (Colombia), the National Commission for the Knowledge and Use of Biodiversity - CONABIO (Mexico), the South African Biodiversity Institute - SANBI (South Africa) and the Rio de Janeiro Botanical Garden - JBRJ (Brazil). Solving these challenges would allow countries to produce more robust and on time information for reporting Aichi targets and SDG goals.

The project "*Cooperation on Biodiversity Data Management for Species and Ecosystem Assessments*", funded by the Biobridge Initiative of the CBD, aims to promote cooperation between Colombia, Brazil, Mexico and South Africa to improve management of biodiversity data to assess species and ecosystem and produce information relevant for policy and decision-making. With this purpose, a series of workshops were organized in August 2018 to build a collaborative network of researchers in the following subjects: 1) data interoperability and data processing times for the assessment of ecosystems and species, 2) standard software architecture for system collaborative development, 3) criteria and tools for assessment and dissemination of information for endangered and exotic species, and 4) methodological incorporation of species taxonomic and functional information into ecosystem integrity indices.

The first workshop organized in the framework of this project took place on the week of the 21-24th of August of 2018 in the main office of the Humboldt Institute in Bogotá. This workshop focused on the first three subjects of interest mentioned previously and included

the participation of 21 participants representing five institutions and four countries. During the four days, a mixture of session types were scheduled, including plenary presentations, open discussions with all participants and discussions in smaller thematic groups. This allowed all participants to interact with pairs in other institutions and to contribute to the specific and general agreements resulting in each session.

DAY 1 - CONTEXT AND OVERVIEW OF BIODIVERSITY INFORMATICS

On the first day of the workshop, the morning session started with a welcoming message from researchers of the Humboldt Institute and presentation of all participants. Following, the organizers of the event gave a series of short presentations to socialize the objectives and expected results, provide a general context of the workshop in relation to the Strategic Plan of Biodiversity of the CBD and present progress and needs identified to achieve the Aichi targets 9, 12 and 19, to which the subjects of the workshop contribute directly (Fig. 1).
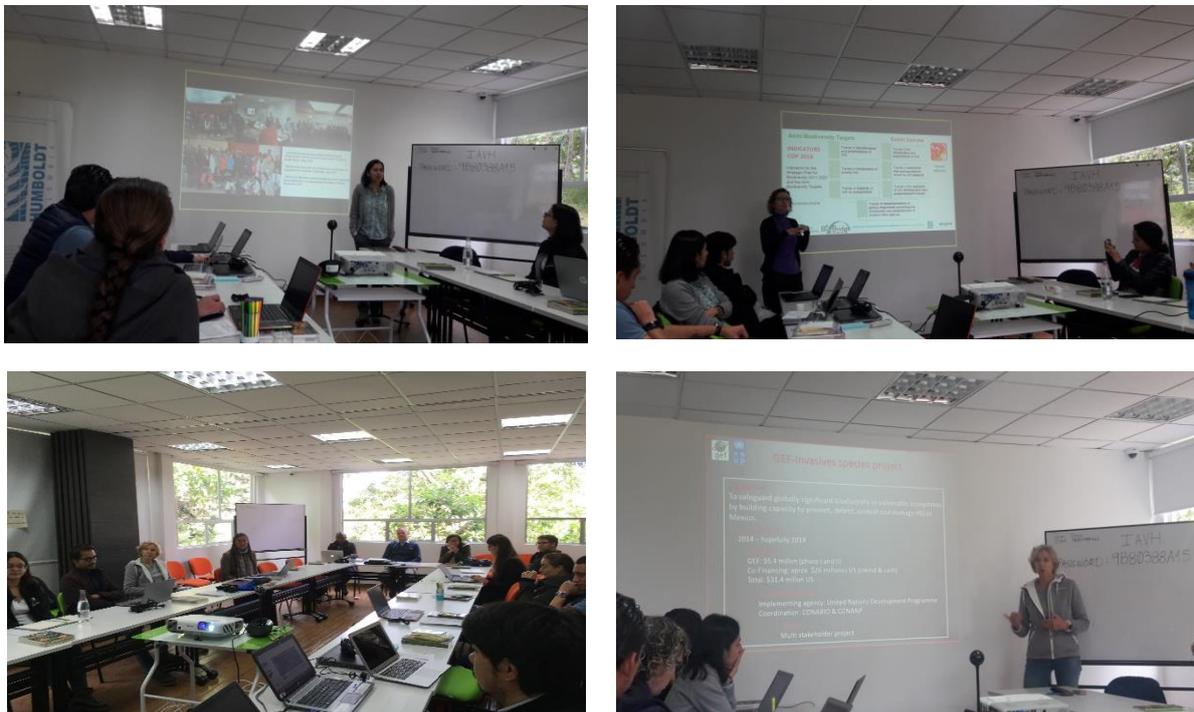

Figure 1. Participants in the morning session on the 21 of August.

The last presentation of this session was conducted by Georgia Born-Schmidt, researcher of the UNEP and associated to Conabio (Fig. 1), who presented the current status of a GEF project conducted in Mexico with the aim of improving national capacities to manage invasive exotic species by means of implementing national strategies. This presentation was a great example of the different challenges that institutions face to adequately record and manage information at the species level and use it to generate actions and collaborate with the public and private sector.

This session was closed with a short time for participants to answer three questions: what is you role at the institution (data provider, data engineer, data analyst, manager?), what would you like to obtain at the end of the workshop? and if you have participated in similar initiatives before, what are the main limitation for inter-institutional collaboration to succeed?

The afternoon session considered a 30 min presentations of each participant institution, with the exception of Brazil, to provide a general overview of current status at the institutional level in terms of biodiversity data engineering and software development. In general terms, all participant countries have developed a National Biodiversity System that manages species and spatial data, which in the case of South Africa and Mexico is administered by the national biodiversity institute, whereas in Colombia is a inter-institutional initiative hosted by the Humboldt Institute. The amount of species level information managed is enormous and the sources and quality of data diverse, so there is a great need to optimize workflows to run geographical and taxonomic validations and integrate different types of data.

SANBI has started a two year project to articulate the independent services that currently provides through its webpage and develop an architecture and aggregated database, and at present the engineer team is interviewing the technical team to generate a detailed diagnosis of needs and desired outputs. Conabio, on the other hand, showed considerable progress in achieving a single occurrence database, which can be consulted through different services and at present they're developing new tools that allow more robust analysis and queries of the data, and interoperability with other databases (e.g. national biodiversity monitoring system). The Humboldt Institute presented the institutional data infrastructure, which storages all the biological and geographical data produced by the Institute and makes it available to be published in the National Biodiversity System or for institutional analysis for which new tools have developed, such as species distribution models and a board of indicators and other information useful for decision-making. All institutions agreed on the need of personnel, developments and infrastructure to answer more efficiently the requests from the public and civil sector in relation to biodiversity data in specific geographical areas (Fig. 2).

	Process		
Type of data	**Storage/ Publication**	**Validation**	**Analysis**
Taxonomic authorities		Tools	Interoperability
	Tools		
Occurrence data		Record changes	Queries
	Integration		
		Interoperability	
Profiles of species			
Geographic data			

<------------Infrastructure needs (storage, analysis)------------>

Figure 2. Synthesis of main issues discussed

DAY 2 - SPECIES ASSESSMENT

The second day of the workshop was focused on the processes that each Institution follows to assess the extinction risk or invasiveness of a species, including the consolidation of data and the publication of results and use in multi taxonomic analysis.

The morning session was dedicated to threatened species and all institutions exposed their efforts to increase the number of species and taxonomic groups assessed, with a significant progress observed in South Africa, where they have achieved comprehensive assessments of several taxonomic groups (Fig. 3). This country also showed the need to develop tools to manage more efficiently the information produced, considering the several sources, and to record the contribution from experts. Despite this limitations, South Africa has been able to produce outputs useful for decision making such as indicators of protection level, gap analysis and land use screening tools. Colombia showed progress in the wide adoption of standards to digitize information about species, in the assessment of different taxonomic groups involving the networks of specialists in the country and in the generation of preliminary analysis of prioritization, causes of extinction risk and protection level; however there is need to increase strategically and in the short term the number of assessed species. Finally, Mexico showed that the country adopted a national normative for the assessment of the conservation status of species, which together with the scarce information available for many species has limited the percentage of species assessed using this methodology. Under this panorama, Conabio is testing other methods that include Bayesian analysis and remote sensing with positive results. In addittion, Mexico is working on prioritization exercises suchs as the Areas of Zero Extinction, using information no only of threatened species but also endemisms.
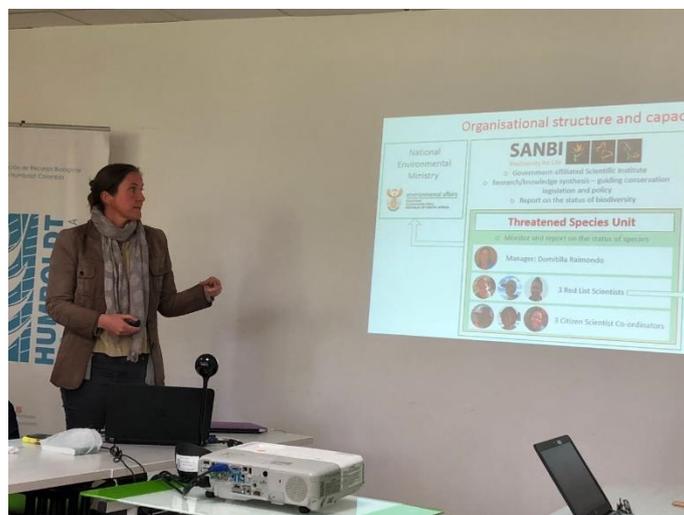

Figura 3. Presentation from Lize von Staden, representative of Sanbi, related to threatened species data and assessments

Workflow to assess risk extinction of species

Integration of data --->   Biological collections (data sharing agreements)
Personal or institutional data sets (data sharing agreements)
Citizen science (more than occurrences)
Standardization and templates for species profiles (challenge to upload information to national biodiversity systems)

Validation --->   Automated algorithms to flag records with errors
Contribution from experts (example solution BioModelos)
Challenge to record changes in databases
Interoperability with other types of information (e.g geographic, taxonomic)

Assessments --->   Need of an application-system to record and publish assessments results.

Analysis --->   Protection level
Prioritization - gap analysis, AZE - including species of importance at the national level, no only threatened
Interactions - relationships between species

Report --->   Dashboard for queries in specific geographic areas
Functional requirement of strategic queries - What kind of questions will be answered?

Fig. 4. Synthesis of main issues discussed about methods, criteria and tools for threatened species

In the afternoon session, each country presented advances regarding the concepts, methodologies, strategies for consolidation and management of information related to invasive species, including adopted systems by the countries for risk analysis of species and their classification according to their potential for causing impacts for native biodiversity. Mexico has important advances in management and publication of information associated to risk analysis, and South Africa has advances in organisation of specific working groups, citizen science, systems of early identification, eradication of emerging invasive species and generation of detailed information of species, including evidence of impacts caused by species of economic importance. South Africa also underlined the importance of programs for eradication of species (aquatic mainly) that have created job opportunities for local communities (Fig. 5). In Colombia, there has been progress in the consolidation of detailed species information, with special emphasis in exotic fauna, which have been important to conduct preliminary analysis of pathways associated to introduction, dispersion and establishment of exotic species.
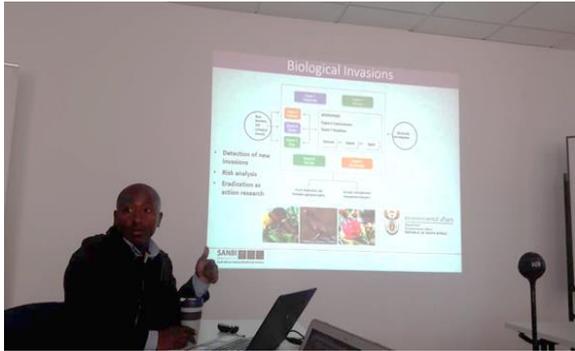
Figure 5. Presentation from Sebataolo Rahlao, representative of Sanbi, related to invasive species data and assessments (22 of August)

Once the presentations were finished, participants discussed the common challenges and identified areas of interest and opportunities to strengthen channels for sharing information across countries related to the classification of exotic species and the results of invasiveness analysis (Fig. 6).

Workflow to assess invasion risk of species

Integration and validation of data --->	Standards for species and pathways Criteria for quality of information Catalogues of exotic species Citizen science
Interoperability (Informatics)	Automated algorithms to identify errors associated to multiple data sources Interoperability with other type of information (e.g geographic, taxonomic)
Assessments --->	Need of a risk analysis tool for rapid assessments and early detection of exotic species
Analysis and Report--->	Impacts Climate change BioModelos Indicators Reports

Fig. 6. Synthesis of main issues discussed about methods, criteria and tools for invasive species

DAY 3 - SPECIES MANAGEMENT AND BIOINFORMATICS

The third of the workshop participants were divided in two groups: one focused in species management and other in bioinformatics. The management group started the morning session with presentations of each institution related to the tools and strategies implemented to make species information incident in decision making. In all countries a legal act is published by the environmental authority with the national list of threatened species, which is supported by additional biodiversity related legislation. However, the impact of this normative depends on the implementation of several strategies and making information available to different actors at the regional and local scale, as the national biodiversity institutions are usually not responsible for conducting local and control actions. With this purpose, all

countries have a strong institutional network involved in different levels in the management of threatened species. For example, South Africa delivers for regional authorities detailed distribution maps of species of conservation priority, who are also involved in the assessment process, which has promoted a strong collaboration with SANBI. Other instruments useful to trigger actions are the action plans aimed to taxonomic or thematic groups or charismatic species, for which Colombia showed several examples, but can be limited by resources available for their implementation and achievement and are especially recommended for useful species.

Legislation --->	Provides an official context for the work of the research institutions and authorities and can leverage funds. Takes time and it is not required to implement all the identified strategies.
Prioritization analysis --->	Conservation objects should include threatened species but also non threatened species of national importance and species with restricted distribution. Analysis require the support of national authorities and research institutes to have an approval by other actors.
Capacity training for actors that implement actions at the local level --->	Involve local authorities and actors in assessment processes (familiarize with the process and use the information) Support civil conservation initiatives
Action Plans --->	Recommended only for groups of species that cannot be conserved only by applying a landscape approach Tools required to follow-up the number of actions and resources invested (e.g. PREVIENE developed in México)
Articulation with public and private sectors--->	Demonstrate value of information produced by identifying information useful for the public and private sector. This should consider support from the offices in each institution in charge of communication and marketing (mainstream).

Fig. 7. Synthesis of main strategies identified for management of conservation priority species

On the afternoon session, the group exchanged the different strategies and information regarding biological invasions (invasive species) including national strategies and legal acts as well as the articulated and joint efforts with different stakeholders (private sectors and citizens) and challenges and priorities on a country level. South Africa showed major progress on species control thanks to the government's substantial economic resources and also the academia and stakeholders cooperation, which have allowed the development of projects that provide the technical support on invasive species impacts and implementation of the following actions (Biological Invasion Policy and Legislation Development):

- Estimation of richness of exotic species in the country, not abundance.
- Monitoring introduction of species in airports.
- Analyze the number of permits, including permits issued for restricted activities.
- Permits issued for intended use: trade, conveying, possession, import, research.

- License system integrated for monitoring permits and control.

On México, Conabio showed also progress thanks to a GEF project and Conabio's efforts to strengthen articulation with different economic sectors such as aquaculture and highlighted the lessons learned during this process. Finally Colombia emphasize the institutional articulation within the environmental sector on the development of a invasive species act as well as the risk assessment protocols and also the challenges regarding the management of exotic species of economic importance. After this exchange, participants identified common areas of interest as well as challenges.

On the other hand, the bioinformatics working group revised with detailed the tools developed and the workflows implemented by each institution to consolidate and validate biodiversity data (Fig. 8). In addition, the group created a collaborative network of developers and data analysts, identified the interest of each participants, identified the tools that can be shared in the network and agreed the channel and communication mechanisms for the network.

Figure 8. Working group focused on biodiversity informatics (23 of August).

DAY 4 - WORKING GROUPS (THREATENED AND INVASIVE SPECIES AND BIODIVERSITY INFORMATICS)

Last day of the workshop the group was splitted into three working groups in order to discuss and identified future common interests and specific proposals, taking into consideration the potential areas of collaboration identified in previous working sessions (Fig. 9). For each potential area of collaboration participants were asked to draft a proposal that considered stakeholders, expected outcomes and timeline for implementation, as well as human resources and financial capacity required. The afternoon session included a time to identified and prioritize proposal on each working groups and a plenary to socialize each group priorities and closing remarks

DATA MANAGEMENT	Network of data engineering and development teams (share algorithms. workflows, tools)
ASSESSMENTS	Platform for extinction risk assessment Participation of authorities and local actors in assessments Standardized information of invasibility assessments
ANALYSIS	Prioritization exercises (microendemics - restricted distribution, AZE, gap analysis) Level of protection (estimations of population data) Pathways and vectors of invasibility
INCIDENCE	Dashboard for biodiversity queries in specific geographical polygons (species, ecosystems) Identify relevant questions to approach public and

Figure 9. Areas of potential collaboration identified during the first three days of the workshop.

THREATENED SPECIES PRIORITY PROPOSALS

I. Training in assessments methodologies

Strengthen capacities in countries by organizing training sessions in available tools to assess the extinction risk of species more efficiently with limited data and using the methodology and criteria of the UICN.

Needs: a) resources for training (identify calls and other funding opportunities), and b) making sure that the data required for the analysis is available for the trainings.

II. Citizen science

The data collected by citizens is an important source of information about the distribution and populations of species. However, the quality of data can be highly improved by implementing protocols to record information and providing training and supporting material for the identification of invasive and threatened species. South Africa has considerable experience in implementing this projects and could advise other countries to implement pilot projects.

Needs: a) identify biological groups and social contexts where pilot projects can be implemented in Colombia and México, b) resources for collaborative proposals (identify calls and other funding opportunities).

III. Collaborative development of a national platform for risk extinction assessments

South Africa and Colombia have common needs to developed an online tool-platform to record and publish extinction risk assessments and in both countries there are people

actively working in this initiative, so there is an interest in joining human and financial resources in a collaborative development.

Some of the common needs for this tool are the following:
- The main objective of the tool is to record and publish the results of the assessments of all taxonomic groups
- Flexibility in the incorporation of different sources of information and types of data, which can vary between countries and taxonomic groups
- The outputs of the tool should include the possibility to export data in a format compatible with the UICN Species Information System (SIS export), which would allow to share the information at the international level. The outputs should also include common queries by environmental authorities and the general public and the publication of species profiles.
- The platform should consider different types of users, including experts with editing rights linked to the assessment of taxonomic or thematic groups of species and the general public.

Following steps:
- Establish an agreement of collaboration to start discussions of common ground between countries.
- The Humboldt Institute will socialize discussions with other institutions that participate in a official national committee of threatened species to request institutional and financial support.
- Directives of SANBI and the Humboldt Institute will meet next week in South Africa and potentially discuss this collaboration.

IV. Prioritization analysis

Conducting regional and national analysis to identify areas of importance for the conservation of species have shown to be a successful strategy to transfer relevant information to environmental authorities and decision makers. These analysis should consider not only threatened species at the global level but also species of national importance such as endemics and of restricted distribution. There is an opportunity to share the experiences with this initiatives between countries by means of training sessions or sharing documentation.

A message identified for the post-2020 discussion is that countries require resources to have prioritization analysis of biodiversity at the country level, and by the oficial institutions, considering that international exercise are useful but don't have a local impact.

Some of the examples presented by the countries are the following:

-        Alliance for Zero Extinction sites. The methodology is been adapted in Conabio to include in the analysis endemic species of restricted distribution and areas of biological and socio-economic importance. In addition, environmental authorities and local actors will be involved in the process and the outputs will include information at the state level.

-        Analysis to identify areas for the expansion of national parks and other protection figures in South Africa. This analysis consider the information available of occurrence of

threatened species and socio economic data that allows to consider the cost-benefit of conserving the areas.

- Distribution maps of highly restricted range species available for environmental authorities. This initiative of SANBI includes a list of species with an extent of occurrence lower than 10 km^2, specially plants, and for which a transforming event in the area would have as a consequence the extinction of the species.

- Areas of importance for freshwater species. The Humboldt Institute has constructed a methodology to identify areas of high conservation value for threatened freshwater species of mammals, reptiles, birds, crabs and mollusks. The initial analyses were conducted independently for each group and at present the team is working on a integrative approach.

The analyses presented also provide information to estimate the protection level of threatened species, one of the specific indicator of the Aichi target 12. In this aspect, México mentioned progress assessing the protection level of species in the official normative, while South Africa showed significant advances that not only assess species presence in the protected areas systems but also use estimates of populations to grade different levels of protection per species and taxonomic groups and differences between political regions.

VII. Online tool to allow queries related to biodiversity information portal by authorities and general public (transfer technologies between countries).

All the participating institutions showed the needs to develop a tool that allows authorities and general public to solve common queries that at present are taking a considerable amount of time of researchers to answer. Some of this common queries include number of total species, invasive and of conservation importance by political limits and polygons. This tools would also allow environmental authorities to validate the information provided for companies in the Environmental Impact Studies.

Needs: a) resources that fund collaborative developments (identify calls and other funding opportunities).

INVASIVE SPECIES PRIORITIES PROPOSALS

I. Proposals for Species Profiles

Idea: Pilot case to share information of invasive species common between countries, taking as an starting point the GISD database ([Global Invasive Species Database)](#).

Rationale: Taking into account that the three countries could implement management actions for common exotic species, it is convenient to find a mechanism to share general information related to the invasiveness risk of these species (biology and ecology).

Species profiles data set - Where and what kind of information the countries have available at present.
Mexico (MX): Enciclovida (http://enciclovida.mx/), 300 species listed

Colombia (CO): SiB Colombia (https://sibcolombia.net/), 100 high risk exotic species approx. but not listed nationally or officially declared as invasive.

South Africa (SA): species profiles (https://www.sanbi.org/resources/), 2033 exotic, 561 listed

Mechanisms/strategies to consolidate information :

1. Species profiles with general species information to share between countries as a phase I.
2. Specific site or repository with information on Risk Analysis.
3. Citizen science.
4. Capacity building between countries

ACTIVITIES	RESPONSIBLES
1. Consolidate a list with global databases related to invasive species. Includes a repository with this information.	Ana I. González (MX), Maria Piedad (CO), Sebataolo R. (SA). Date: september 14th
2. Standards for RA and species profiles. Include and exchange learning on how is the structure of databases.	Ana I.González, (MX), Maria Piedad (CO), Sebataolo R. (SA).
3. Framework to share and exchange information and Risk analysis already done.	Ana I.González, (MX), Maria Piedad (CO), Sebataolo R. (SA).
4. Interface (API) to store shared information	Ana I. González, Raúl Sierra and Carlos Alonso (MX), Daniel López and Lina García (CO), Sebataolo + 1 (SA).
Outcome: Paper on risk analysis tools, differences and similarities between countries. Recommendations, link to indicators related to Aichi target 9.	Georgia Born (MX), Maria P. Baptiste (CO), Sebataolo R. (SA).

II. CBD Indicators and information that we need. Analysis and try to influence after 2020. (Step 2 for 2019)

Rationale: Each country has made progress in reporting national indicators, as a contribution to global commitments. However, the management of the information, the standards and methodologies applied are different. The countries seek to advance in the development of a joint proposal of indicators that give response to the same priorities and information at the national level, oriented to meet the Aichi target 9.

ACTIVITIES	RESPONSIBLES
1. Consolidation on what info each country are including for national indicators	Ana I. González y Georgia Born (MX), Sebataolo R. (SA), Maria P. Baptiste and Lina García (CO).
2. Modeling distribution of invasive species on	Lina García, Elkin Noguera and Susana

	climate change and land use change scenarios (Working meeting). Specific outcomes.	Rodríguez (CO), Ana I. Gonzalez, Georgia Born and Raúl Sierra, Sebataolo R. (SA). The information from Mexico will be available in October (Georgia).
	3. Outcome: Analysis on common issues and recommendations for post 2020.	Ana I. González and Georgia Born (MX), Sebataolo R. (SA) , Maria P. Baptiste (CO)

III. How to approach strategic sectors?

Implement successful strategies shared by Conabio, by means of capacity building for Colombia and South Africa.

IV. Pathways analysis CO, Mx and SA. Meeting and exchange. (Step 1 for 2019)

ACTIVITIES	RESPONSIBLES
1. Exchange of experiences of CO, Mx, SA, and potentially Brazil related to detailed pathways analysis	Ana Isabel González (MX), Sebataolo R. (SA), Maria Piedad and Lina García (CO)
2. Comparative analysis, knowledge sharing. Spreadsheet with metrics of the three countries and different components	Sebataolo R. (SA), Maria Piedad and Lina García (CO), Georgia Bonn and Ana Isabel (MX)
3. Prioritization and Risk Analysis for pathways: which species, areas and several species	Sebataolo R. (SA), Maria Piedad and Lina García (CO), Georgia Bonn and Ana Isabel (MX).
4. Modify tool or adopt one for AR pathways including CDB categories and prioritization	Raúl Sierra (MX), Maria Piedad Baptiste, Daniel López and Lina García (CO).

V. Monitoring system and invasive species.

Work together on a proposal for monitoring indicators. For example, the Geobon indicators.

VI. Bilateral exchange at three levels (SA, CO, MX).

The main interest is to strengthen skills related to the collection and integration of data on invasive species:
CO to SA: invasiveness risk and pathways analysis.
SA to MX: virtual training for managers, certified by Conabio (Sebataolo and Ana Isabel González).

VII. Funding proposals:

Seek for funding opportunities that facilitate a continued process between countries. For example: GIZ, GEF small or medium, CDB Biobridge, GCF Global Climate Fund (climate change adaptation).

LIST OF PARTICIPANTS

Name - Institution	Email
• María Piedad Baptiste. Instituto Alexander von Humboldt	mpbaptiste@humboldt.org.co
• María Cecilia Londoño. Instituto Alexander von Humboldt	mlondono@humboldt.org.co
• Lina Marcela García. Instituto Alexander von Humboldt	lgarcia@humboldt.org.co
• Carolina Castellanos Castro. Instituto Alexander von Humboldt	ccastellanos@humboldt.org.co
• Daniel López. Instituto Alexander von Humboldt	dlopez@humboldt.org.co
• Erika Suarez. Instituto Alexander von Humboldt	esuarez@humboldt.org.co
• Ángela Devia. Instituto Alexander von Humboldt	adevia@humboldt.org.co
• Alejandro Moreno. Instituto Alexander von Humboldt	umoreno@humboldt.org.co
• Helena Olaya. Instituto Alexander von Humboldt. BioModelos	molaya@humboldt.org.co
• Elkin Noguera. Instituto Alexander von Humboldt. BioModelos	enoguera@humboldt.org.co
• Edgar Saavedra. Conabio	esaavedra@conabio.gob.mx
• Raúl Sierra. Conabio	raul.sierra@conabio.gob.mx
• Carlos Alonso. Conabio	carlos.alonso@conabio.gob.mx
• Esther Quintero. Conabio	esther.quintero@conabio.gob.mx
• Ana Isabel Gonzalez. Conabio	agonzalez@conabio.gob.mx
• Georgia Born-Schmidt. PNUD - Conabio	gborn@conabio.gob.mx
• Lize von Staden. SANBI	L.vonStaden@sanbi.org.za
• Sebataolo Rahlao. SANBI	S.Rahlao@sanbi.org.za
• Gert Conradie. SANBI - Compass Informatics	gconradie@compass.ie
• Eduardo Dalcin. Rio de Janeiro Botanical Garden (JBRJ)	edalcin@jbrj.org

WORKSHOP REPORT "ECOSYSTEM ASSESSMENT"
Sede Venado de Oro, Instituto Alexander von Humboldt, Bogotá D.C
27-31 August 2018

Figure 1. Participants of the Ecosystem Assessment workshop
during the walking tour in the Venado de Oro headquarters.

The project "*Cooperation on Biodiversity Data Management for Species and Ecosystem Assessments*", funded by the Biobridge Initiative of the CBD, aims to promote cooperation between Colombia, Brazil, Mexico and South Africa to improve management of biodiversity data to assess species and ecosystem and produce information relevant for policy and decision-making. With this purpose, a series of workshops were organized in August 2018 to build a collaborative network of researchers in the following subjects: 1) data interoperability and data processing times for the assessment of ecosystems and species, 2) standard software architecture for system collaborative development, 3) criteria and tools for assessment and dissemination of information for endangered and exotic species, and 4) methodological incorporation of species taxonomic and functional information into ecosystem integrity indices.

The second workshop organized in the framework of this project took place on the week of the 27-31st of August of 2018 in the main office of the Humboldt Institute in Bogotá. This workshop focused on the assessment of ecosystems, in particular the discussion of methodological approximations to measure Ecosystem Integrity (EI) . During the first day of the workshop plenary presentations were given by the participants related to the approaches used to assess EI. During the next four days a mixture of discussion sessions and working sessions allowed all participants to interact with pairs in other institutions and to contribute to the specific products resulting from this workshop.

The specific aims of the workshop were:

- Develop a conceptual and methodological framework for EI assessment.

- Develop a document with the methodological details
- Proof the methodology in at least two countries
- Engage in the established network "coders4conservation"
- Develop a project proposal for further funding.

Day 1

After the general introductions and welcomes, we started a series of presentation to make sure everyone has the same context and get to know the work of everyone.

Morning presentations:

- Jose Manuel Ochoa gives an introduction to the Von Humboldt Institute and also to the program of biodiversity monitoring and assessment.
- María Cecilia Londoño presents the state of the art for Ecosystem Integrity including: the complexity for its operationalization but also its convenience as a boundary (science-policy) interface object, the different framework used for its conceptual development and the current ways to measure it.
- Lina Estupiñan presents the Earth Data cube from the ESA, she explains how in Colombia it is use for trend analysis of variables derived from MODIS, and how this data cube aims to be used in understanding the relations between biosphere and atmosphere. The data cube does not pretend to have a high spatial resolution but a high temporal resolution. Coding for processing the data can be written using R, python or Julia.
- Daniel Lopez presents the developments and challenges of biodiversity infromatic infrastructure. He focus on the open source politics of Humboldt Institute and in the current developments. He also presents the network "coders4conservation" and invites the workshop participants to join it.
- Maria Cecilia presents a very short summary of the advances that Mexico, Brazil, South Africa and Colombia has for the ecosystem assessment.
- Loic and Erick presents the MadMex system version Antares 3. They explain that this system uses other data cube, the Open Data Cube from NASA and CSIRO.
- Julián presents the methodology for Ecosystem Integrity assessment based on Bayesian Networks.

Afternoon discussion:

- Iván presents an exercise based on seasonality and time series using MODIS data for the product Leaf area index, and its logic behind EI.

Final review of agenda

-Maria C drows a Venn diagram (Figure 2) representing the three discussion groups for the next four days: Informatics, Conceptual and Analysis group. Using this diagram the key issues to be discuss in the workshop were identified in order to successfully achieve the workshop aims. Based on their our interest participants chose the topic in which they were going to work.
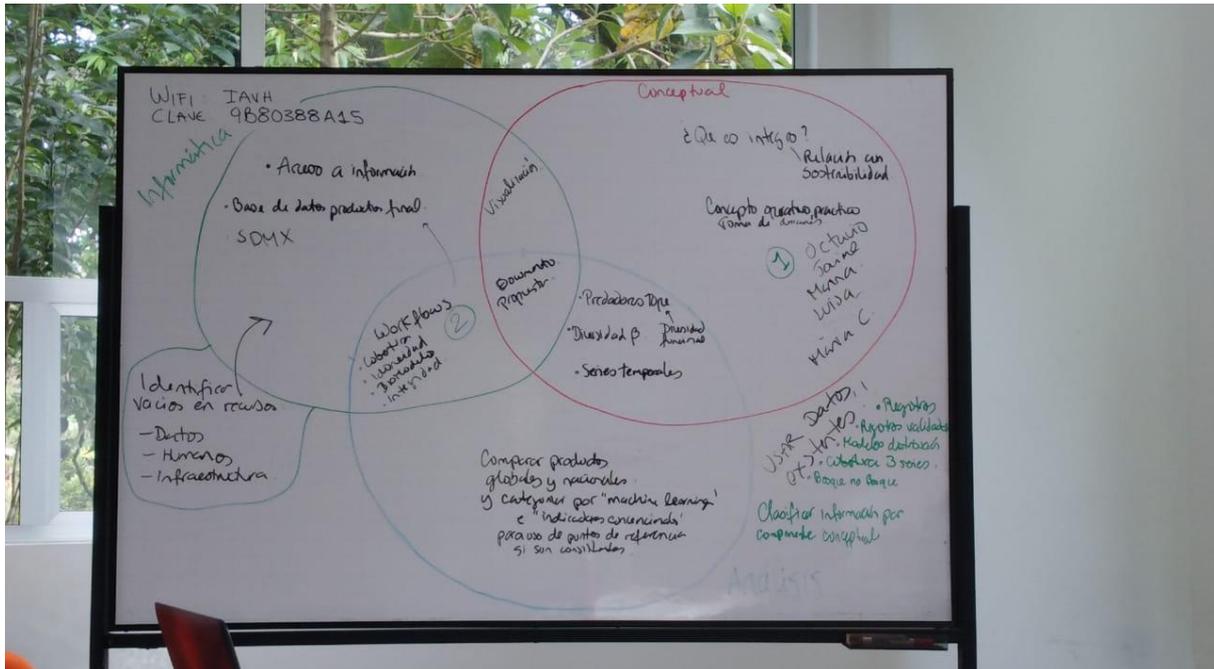
Figure 2. Themes and topics to be discuss over the workshop.

A series of questions were identified to guide the development of the proof of concept document, also a discussion arise about the tipping points of EI and its use in effectivity of protected areas were Mexico has already use it. Pilot case study was also discuss and define for a central region in Colombia.

-How can we use a common conceptual framework that can be operative in its measurements? Proposal of a conceptual framework based on Mexico Ecosystem Integrity model, maybe complement it by including: top predators, beta diversity, temporal series.

-How can the existing workflows be integrated?

-What are the resources and capacities that has to be developed in order to have a more robust measurement of ecosystem integrity?

Flexible methodology:
-What are the components of ecological integrity that megadiverse countries can measure based on their capacities?

Day 2.

Participants spit into two groups. Group number 1 discuss the conceptual framework for EI assessment, and defined general needs and the other group worked on the pilot case study, specifically they start preparing the test data (Table 1).

 Table 1. General needs for calculation EI and way to address them.

Issues to further develop for EI assessment	Product to be deliver	Requirements for achieving it.
Include in the workflow monitoring tools, especially from automated recording devices (ARD).	Species records, identified to trophic guild.	Integrate existing species data management system to the results from existing software for sp identification. Incorporate into species management systems information about trophic guild so that it can be related to the identification process.
Develop functional diversity (FD) indices derived from the species records identified to trophic guild.	FD indices layer.	Adapt an existing functional diversity measurements to the data available and integrate it into the EI workflow by representing FD spatially in a map.
Incorporate expert criteria layer and field work data (mainly from permanent plots data) to develop a layer with calibration points for EI, were these points are a reference for ecosystem condition.	Calibration data layer.	Development of an instrument (eg. Software platform) to compile expert criteria. Development of a method to integrate calibration data from monitoring and expert criteria.
Operationalization of the *Workflow* for the calculation of the EI.	APIs or other informatics developments, and data and metadata standards definitions.	Implement tools (informatics developments and standards) such that the workflow can be automatized to the higher level as possible.

Explore additional methods from Artificial Intelligence (AI) to calculate the EI, (we are just using Bayesian networks, we would like to contrast results to other AI methods)	Alternative methodologies based on AI for EI calculation and results compare with current method.	Try different AI methods for EI calculation, apply test for effectivity, efficiency and sensitivity.

A general table (Table 2) was designed so that through the next days of the workshops the groups could fill it as their discussions progressed. The aim of the table was to document the advances in variables development that each country had for the general assessment of ecosystems.

Table 2. Existing variables/workflows/tools for calculating EI.

Variable	Tools	Modelling	Technique	Data input	Scale/ resolution
MEXICO					
Coverage	Antares	Supervised	Random forest	Rapid eye, Landsat, Sentinel 2	5m, 30m
Structure (vegetation)	Script (Julián)	Regression		NFI, topography, weather	250m, 1000m
Contextual				Holdridge life zones, altura, DEM	1km
COLOMBIA					
Coverage				CLC (Corine Land Cover)	
Tree density					30m

Biotic regions	Biomod elos		SDM + expert opinion	Weather records	1km
Contextual				Ecosystem s (2007)	1:500,000
Validated species distribution models	Biomod elos		SDM + expert opinion	Weather records	Square kilometer
Connectivity					
Function	Time series analysis (scripts: Iván y Jaime) - > Functio nal diversity			FPAR, GPP, LAI, LST, NDVI, TRMM, MODIS	250m
Disturbance				Human footprint, distance to roads	

During the rest of the day, the two groups work independently, one group work on discussing the conceptual issues of EI and other group on developing the pilot exercise. A share document in google drive was used so that each group could document their advances. This document correspond to output: Concept ecosystem integrity megadiverse countries.

Day 3.

The morning session started by each group shearing a summary of their activities with all the participants.

A plenary discussion was taken regarding global biodiversity indicators, BIP indicators related with EI were review and comment and also the results from the Biodiversity Habitat Index and the Protected Biodiversity Index developed by CSIRO were explore for Mexico and Colombia. The comments of CSIRO indicators were share through email with Tom Harwood, researcher from CSIRO. We hope that a collaboration with CSIRO can be established in order to better implement global indicators at national scales.

During the afternoon a group continue working of the pilot case and other in the discussions for incorporating functional dimensions into the EI indicator. The discussion for the second group centre in the incorporation of fauna functional diversity and interactions (predator-prey, pollination or dispersion) into the EI measurement. The following resources were highlighted as potential for integrating species interactions:

Interaction Webs Database: http://www.nceas.ucsb.edu/interactionweb/
Food webs: http://vlado.fmf.uni-lj.si/pub/networks/data/bio/foodweb/foodweb.htm
Flower visitors: http://www.illinoiswildflowers.info/ (or http://www.flowervisitors.info/)
Neotropical frugivorous: http://www.cria.org.br/neofrug/
Global Biotic Interactions - GLOBI: https://www.globalbioticinteractions.org/
Bat ecological interactions: https://www.batplant.org

Day 4.

In the morning results from the independent group sessions were shared with all the participants. Carolina Catellanos who coordinated the species assessment workshop during the week before to our workshop, gave a presentation of the results. A general discussion was taken on how to more efficiently share data and products between the countries. A general proposal for the organization data and information derived from this workshops in shared drive folders was establish (Table 3).

Table 3. Proposal for the structure of shared drive folders with data and information derived from this collaboration, based on A guide to reproducible code in ecology and evolution. British Ecological Society 2017. Link: britishecologicalsociety.org/publications/guides-to.

Name	Description
data	All input data and metadata
doc	Project's manuscript
figs	Figures generated by the analysis
output	Any type of intermediate or output files
cleaned-data	Data sets curated and ready for use
scripts	Function definitions

reports	Documentation for the analysis or report on results

In the afternoon one group continue working on the pilot case and the other started to work on the draft of a project proposal. For the proposal project a NatGeo & Microsoft call was open, so the group decided to work on it: https://www.nationalgeographic.org/grants/grant-opportunities/ai-earth-innovation/

Day 5.

In the morning the groups shared their results from the day before. The project proposal was review in detail and adjustment were done based on comments from all the participants.

A closing session was done by assigning task to participants in order to finish the proposal and to finish the pilot case.

In the afternoon we did a walking tour in the forest reserve adjacent to the Humboldt headquarters.

ANNEX A2_2. LIST OF PARTICIPANTS

Name - Institution	Email
• María Piedad Baptiste. Instituto Alexander von Humboldt	mpbaptiste@humboldt.org.co
• María Cecilia Londoño. Instituto Alexander von Humboldt	mlondono@humboldt.org.co
• Lina Marcela García. Instituto Alexander von Humboldt	lgarcia@humboldt.org.co
• Carolina Castellanos Castro. Instituto Alexander von Humboldt	ccastellanos@humboldt.org.co
• Daniel López. Instituto Alexander von Humboldt	dlopez@humboldt.org.co
• Erika Suarez. Instituto Alexander von Humboldt	esuarez@humboldt.org.co
• Ángela Devia. Instituto Alexander von Humboldt	adevia@humboldt.org.co
• Alejandro Moreno. Instituto Alexander von Humboldt	umoreno@humboldt.org.co
• Helena Olaya. Instituto Alexander von Humboldt. BioModelos	molaya@humboldt.org.co
• Elkin Noguera. Instituto Alexander von Humboldt. BioModelos	enoguera@humboldt.org.co
• Edgar Saavedra. Conabio	esaavedra@conabio.gob.mx
• Raúl Sierra. Conabio	raul.sierra@conabio.gob.mx
• Carlos Alonso. Conabio	carlos.alonso@conabio.gob.mx
• Esther Quintero. Conabio	esther.quintero@conabio.gob.mx
• Ana Isabel Gonzalez. Conabio	agonzalez@conabio.gob.mx
• Georgia Born-Schmidt. PNUD - Conabio	gborn@conabio.gob.mx
• Lize von Staden. SANBI	L.vonStaden@sanbi.org.za
• Sebataolo Rahlao. SANBI	S.Rahlao@sanbi.org.za
• Gert Conradie. SANBI - Compass Informatics	gconradie@compass.ie
• Eduardo Dalcin. Rio de Janeiro Botanical Garden (JBRJ)	edalcin@jbrj.org
• Octavio Pérez Maqueo. Conabio	octavio.maqueo@inecol.mx
• Iván González. Conabio Instituto Alexander von Humboldt.	igonzalez@humboldt.org.co
• Mariana Munguia. Conabio	mariana.munguia@conabio.gob.mx
• Julian Equihua. Conabio	jequihua@conabio.gob.mx
• Erick Palacios Moreno. Conabio	epalacios@conabio.gob.mx
• Loic Dutrieux	ldutrieux@conabio.gob.mx
• Miguel Hidalgo Reyes. INECOL	miguel.hidalgo@inecol.mx
• Maria Isabel Arce. Instituto Alexander von Humboldt	marce@humboldt.org.co
• Richard Rios Patiño. Instituto Alexander von Humboldt	rrios@humboldt.org.co
• Jaime Burbano. Instituto Alexander von Humboldt	jburbano@humboldt.org.co
• Jose Manuel Ochoa. Instituto Alexander von Humboldt	jochoa@humboldt.org.co
• Luisa Fernanda Lievano. UFG - Universidade Federal de Goiás (Brasil)	luisafer.lievano@gmail.com