

# Remote Sensing for Conservation and Biodiversity

Cindy Schmidt, Amber McCullum

January 24, 2019

# Course Structure

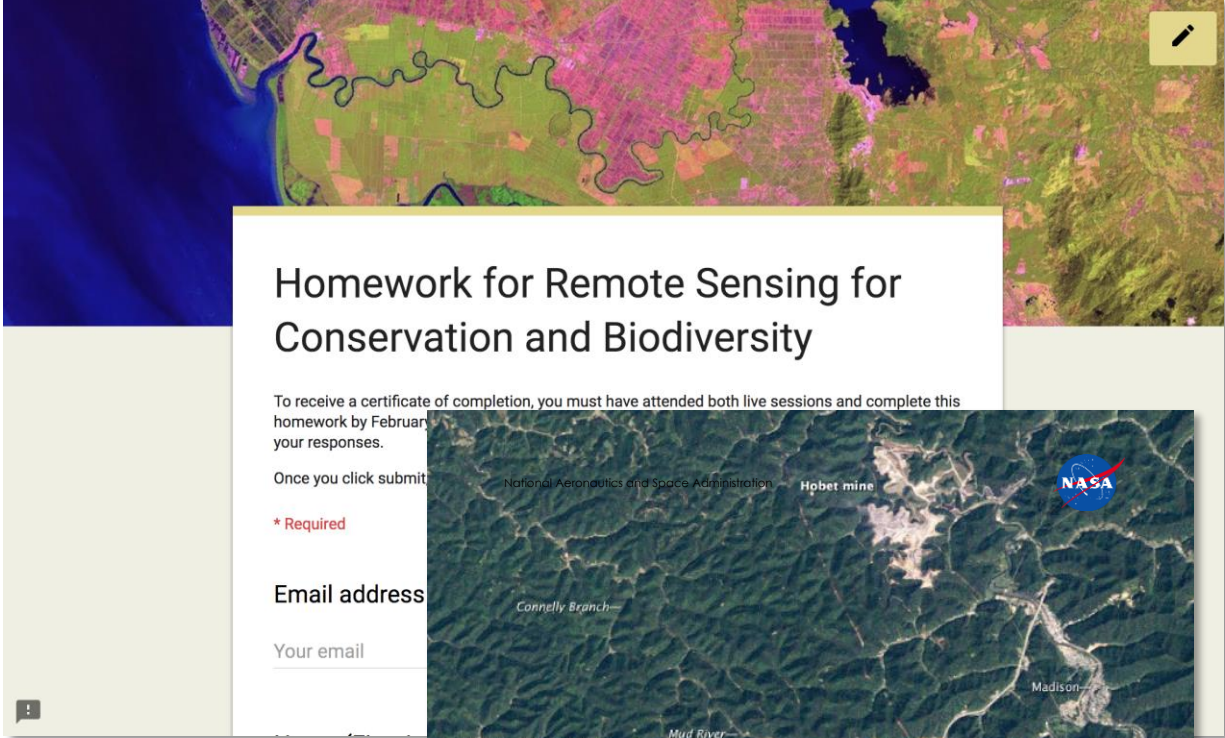
- Two, one-hour sessions on Jan. 22 and Jan. 24, 2019
- The same content will be presented at two different times each day:
  - Session A: 10:00-11:00 EDT (UTC-5)
  - Session B: 18:00-19:00 EDT (UTC-5)
  - **Please only sign up for and attend one session per week**
- Webinar recordings, PowerPoint presentations, and the homework assignment can be found after each session at:
  - <https://arset.gsfc.nasa.gov/land/webinars/conservation-biodiversity-2018>
- Q&A: Following each lecture and/or by email
  - [cynthia.l.schmidt@nasa.gov](mailto:cynthia.l.schmidt@nasa.gov), or
  - [amberjean.mccullum@nasa.gov](mailto:amberjean.mccullum@nasa.gov)





# Homework and Certificates

- Homework
  - One homework assignment
  - Answers must be submitted via Google Forms
- Certificate of Completion:
  - Attend both live webinars
  - Complete the homework assignment by the deadline (access from ARSET website)
    - **HW Deadline: February 7<sup>th</sup>, 2019**
  - You will receive certificates approximately two months after the completion of the course from:  
[marines.martins@ssaihq.com](mailto:marines.martins@ssaihq.com)



**Homework for Remote Sensing for Conservation and Biodiversity**

To receive a certificate of completion, you must have attended both live sessions and complete this homework by February 7<sup>th</sup>, 2019. Submit your responses.

Once you click submit

**\* Required**

Email address

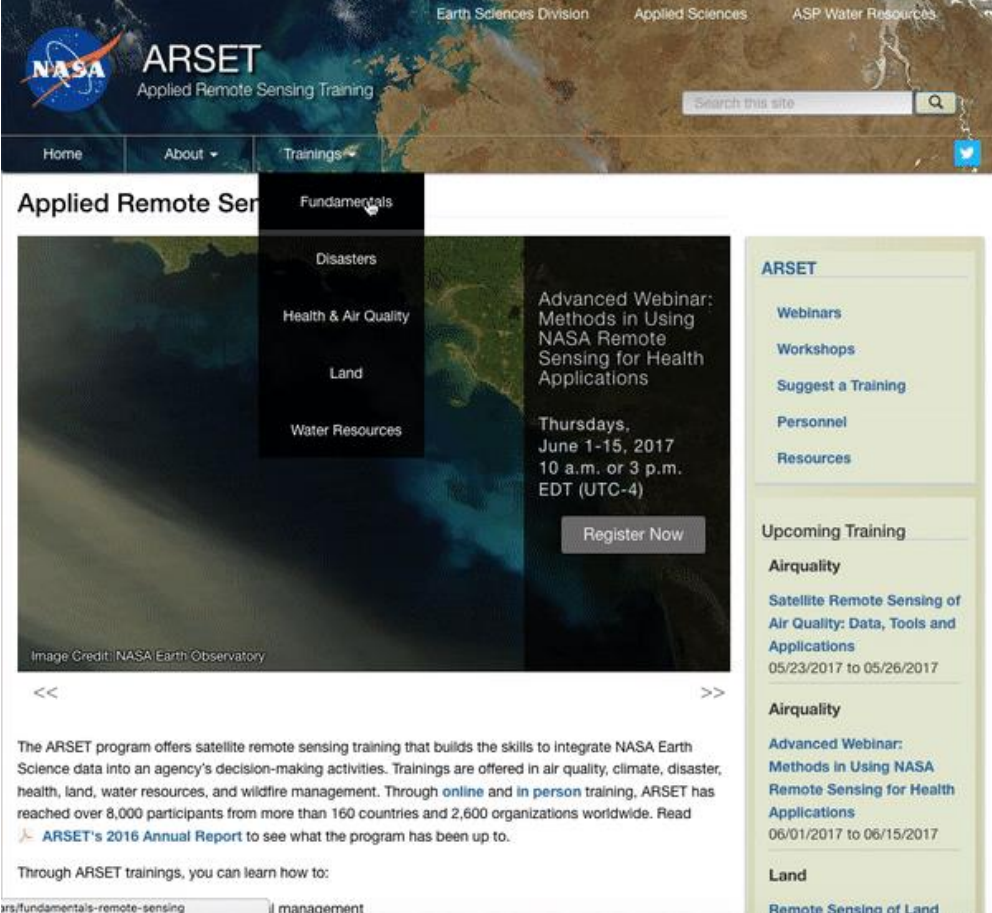
Your email

NASA's Applied Remote Sensing Training Program (ARSET) presents a certificate of completion to Amber McCullum for completing:  
**Advanced Webinar: Change Detection for Land Cover Mapping**  
September 28 – October 5, 2018  
Trainers: Cindy Schmidt, Amber McCullum



# Prerequisite

ARSET Webinar *Introduction to Remote Sensing* or equivalent knowledge

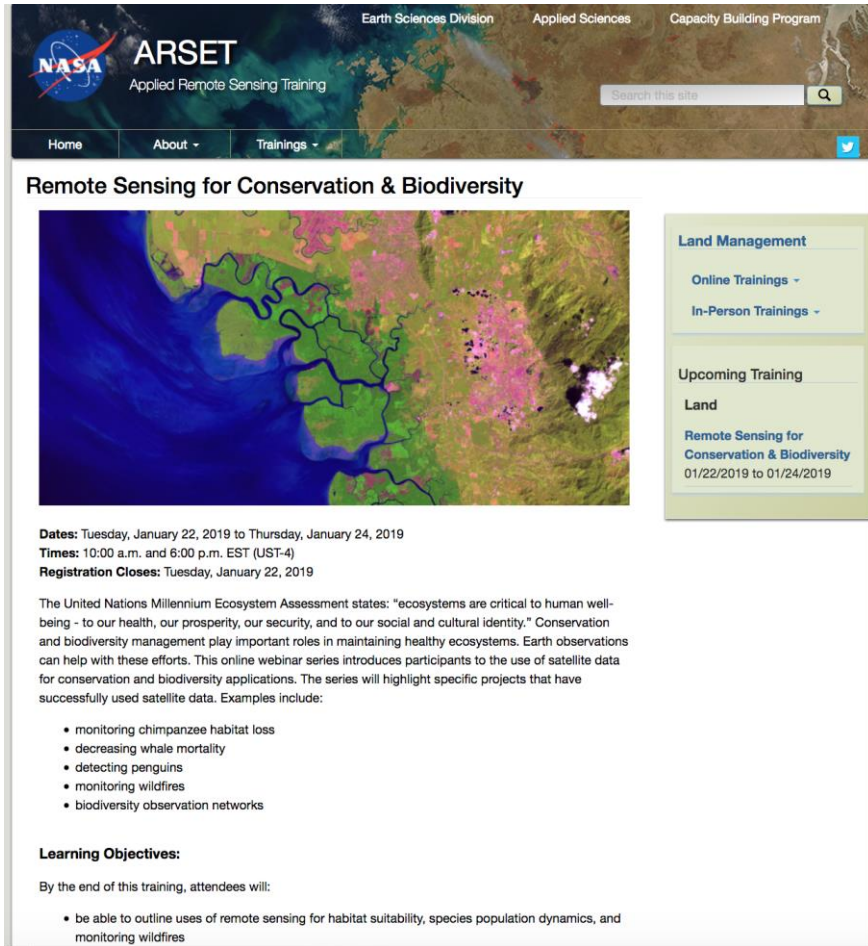


The screenshot shows the NASA ARSET website. The header includes the NASA logo, 'ARSET Applied Remote Sensing Training', and navigation links for 'Earth Sciences Division', 'Applied Sciences', and 'ASP Water Resources'. A search bar is present. The main content area features a large banner for an 'Advanced Webinar: Methods in Using NASA Remote Sensing for Health Applications' scheduled for Thursdays, June 1-15, 2017, from 10 a.m. to 3 p.m. EDT (UTC-4). A 'Register Now' button is visible. A sidebar on the right lists 'ARSET' resources: Webinars, Workshops, Suggest a Training, Personnel, and Resources. Below this, 'Upcoming Training' is listed, including 'Airquality' with a sub-entry for 'Satellite Remote Sensing of Air Quality: Data, Tools and Applications' (05/23/2017 to 05/26/2017) and another 'Airquality' entry for 'Advanced Webinar: Methods in Using NASA Remote Sensing for Health Applications' (06/01/2017 to 06/15/2017). A 'Land' section is also partially visible. The main text below the banner describes the ARSET program's focus on satellite remote sensing training for various applications like air quality, climate, disaster, health, land, water resources, and wildfire management. It mentions that ARSET has reached over 8,000 participants from more than 160 countries and 2,600 organizations worldwide. A link to 'ARSET's 2016 Annual Report' is provided. The bottom of the page shows a URL: 'rs/fundamentals-remote-sensing' and a partial link to 'management'.



# Accessing Course Materials

<https://arset.gsfc.nasa.gov/land/webinars/conservation-biodiversity-2018>



The screenshot shows the ARSET (Applied Remote Sensing Training) website. The header includes the NASA logo, 'ARSET Applied Remote Sensing Training', and navigation links for 'Home', 'About', and 'Trainings'. The main content area features a satellite image of a river delta with a color-coded overlay. To the right, there are navigation menus for 'Land Management' (Online and In-Person Trainings) and 'Upcoming Training' (Land). The course details for 'Remote Sensing for Conservation & Biodiversity' are listed below the image.

**Remote Sensing for Conservation & Biodiversity**

**Dates:** Tuesday, January 22, 2019 to Thursday, January 24, 2019  
**Times:** 10:00 a.m. and 6:00 p.m. EST (UST-4)  
**Registration Closes:** Tuesday, January 22, 2019

The United Nations Millennium Ecosystem Assessment states: "ecosystems are critical to human well-being - to our health, our prosperity, our security, and to our social and cultural identity." Conservation and biodiversity management play important roles in maintaining healthy ecosystems. Earth observations can help with these efforts. This online webinar series introduces participants to the use of satellite data for conservation and biodiversity applications. The series will highlight specific projects that have successfully used satellite data. Examples include:

- monitoring chimpanzee habitat loss
- decreasing whale mortality
- detecting penguins
- monitoring wildfires
- biodiversity observation networks

**Learning Objectives:**

By the end of this training, attendees will:

- be able to outline uses of remote sensing for habitat suitability, species population dynamics, and monitoring wildfires

## Course Format:

- Two, one hour sessions
- The same session will be broadcast at both times, both in English

## Prerequisites:

*Fundamentals of Remote Sensing* or equivalent knowledge

If you do not complete the prerequisite, you may not be adequately prepared for the pace of the training

## Audience:

This training is designed for individuals and organizations interested in using satellite imagery for conservation and biodiversity.

## Registration Information:

There is no cost for the webinar, but you must register to attend the sessions. Both sessions will be held in English. So that we can accommodate as many people as possible, **please only register for one session.**

- [Register for Session A: 10:00-11:00 EST \(UTC-4\)](#) »
- [Register for Session B: 18:00-19:00 EST \(UTC-4\)](#) »

## Course Agenda:

[Agenda.pdf](#)

### Session One: Remote Sensing for Conservation

January 22, 2019

This session will focus on remote sensing for habitat suitability, species population dynamics, and monitoring wildfires.

### Session Two: Remote Sensing for Biodiversity

January 24, 2019

This session will focus on the Group on Earth Observations Biodiversity Observation Network (GEOBON), Marine Biodiversity Observation Network (MBON), and essential biodiversity variables.

**Application Area:** [Land](#)

**Available Languages:** [English](#)

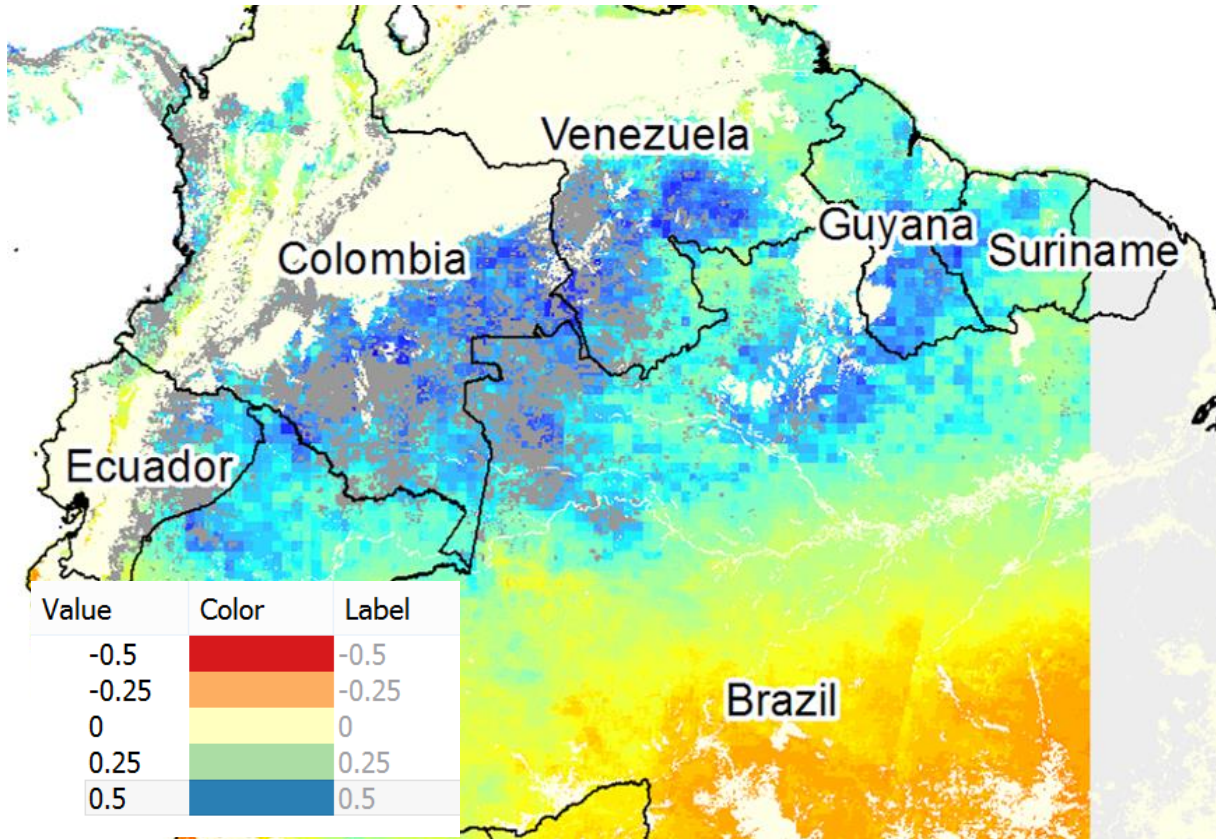
**Instruments/Missions:** [VIIRS](#), [Terra](#), [Landsat](#), [Aqua](#), [NPP](#), [MODIS](#), [Aqua](#)

**Keywords:** [Conservation](#), [Land-Cover and Land-Use Change \(LCLUC\)](#), [Satellite Imagery](#), [Tools](#)





# Course Outline



Session 1: Remote Sensing for Conservation



Session 2: Remote Sensing for Biodiversity



# Agenda

- Global Biodiversity
- Group on Earth Observations (GEO)
- GEO Biodiversity Observation Networks (GEO BON)
  - Regional and Thematic BONs
  - BON in a Box
  - Essential Biodiversity Variables
- GEO BON project examples
- Marine BON project examples
- Summary

The screenshot shows the BioModelos website. At the top, there is a navigation bar with links for INICIO, MODELOS, GRUPOS, INGRESAR, and REGISTRARSE. Below the navigation bar is a search bar with the text "Consulta una especie por su nombre científico" and a magnifying glass icon. To the left of the search bar is a link "Ir a la versión anterior" and to the right is "Búsqueda avanzada". Below the search bar are three buttons: "MODELOS", "CONTRIBUYE", and "PUBLICA". The main content area features a section titled "MEJORES MODELOS CON EL APOYO DE EXPERTOS" with seven circular icons representing different animal groups. Each icon has a percentage of models with expert support: MAMÍFEROS (492 total, 443 models, 90%), AVES (1921 total, 1821 models, 95%), REPTILES (537 total, 507 models, 94%), ANFIBIOS (803 total, 783 models, 97%), PECES (1435 total, 1391 models, 96.9%), INVERTEBRADOS (19312 total, 18612 models, 96.4%), and PLANTAS (22840 total, 22340 models, 97.8%).

Grupo	Total	Modelos con Apoyo de Expertos	Porcentaje
MAMÍFEROS	492	443	90%
AVES	1921	1821	95%
REPTILES	537	507	94%
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PECES	1435	1391	96.9%
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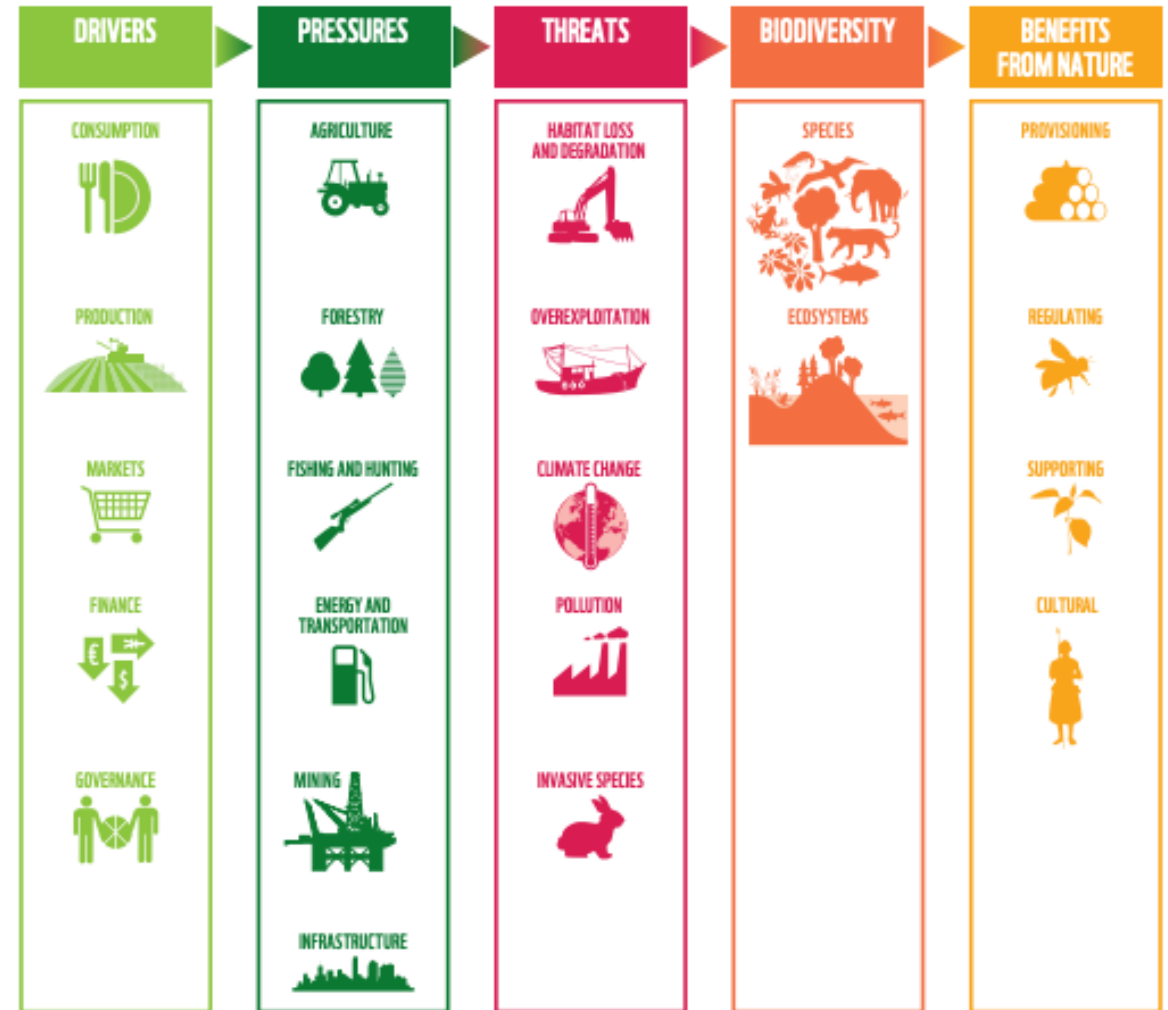


# Global Biodiversity



# Global Biodiversity

- Biodiversity supports the functioning of ecosystems, human economies and public health
- Unfortunately biodiversity is being lost at an alarming rate:
  - ~11,000 to 58,000 species lost annually (Dirzo et al. 2014)
  - Current rates of extinction are about 1000 times the background rate (Pimm et al. 2014)
  - Living Planet Index: Overall decline of 60% in the population sizes of vertebrates between 1970 and 2014 (Living Planet Report 2018)



Source: Living Planet Report 2018, World Wildlife Fund



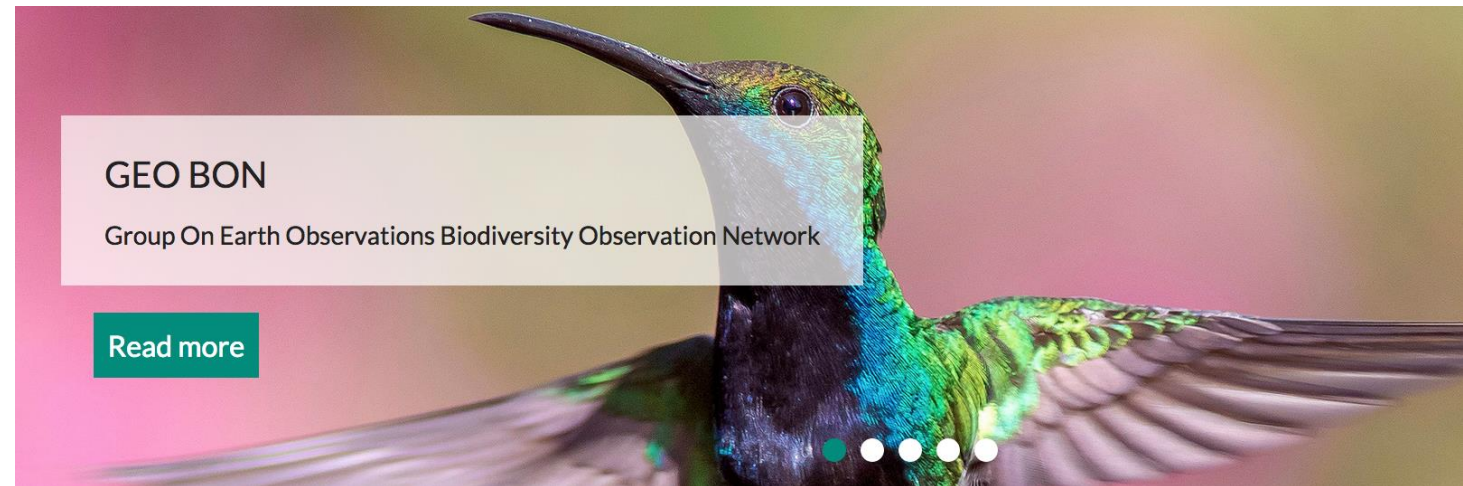
# Global Biodiversity Monitoring

- Convention on Biological Diversity (CBD)
- Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES)
- Global Biodiversity Information Facility (GBIF)
- International Union for Conservation of Nature (IUCN)
- Group on Earth Observations Biodiversity Observation Network (GEO BON)



Convention on  
Biological Diversity

<https://www.cbd.int/>



<https://geobon.org>





# Convention on Biological Diversity (CBD)

- Established Dec. 1993
- Objectives:
  - Conservation of biological diversity
  - Sustainable use of the components of biological diversity
  - Fair and equitable sharing of the benefits arising out of the utilization of genetic resources
- Strategic Plan for Biodiversity 2011-2020
  - Overarching framework on biodiversity
  - Aichi biodiversity targets
  - National Biodiversity Strategies and Action Plans (NBSAPs)
- More information: <https://cbd.int/>



# Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES)

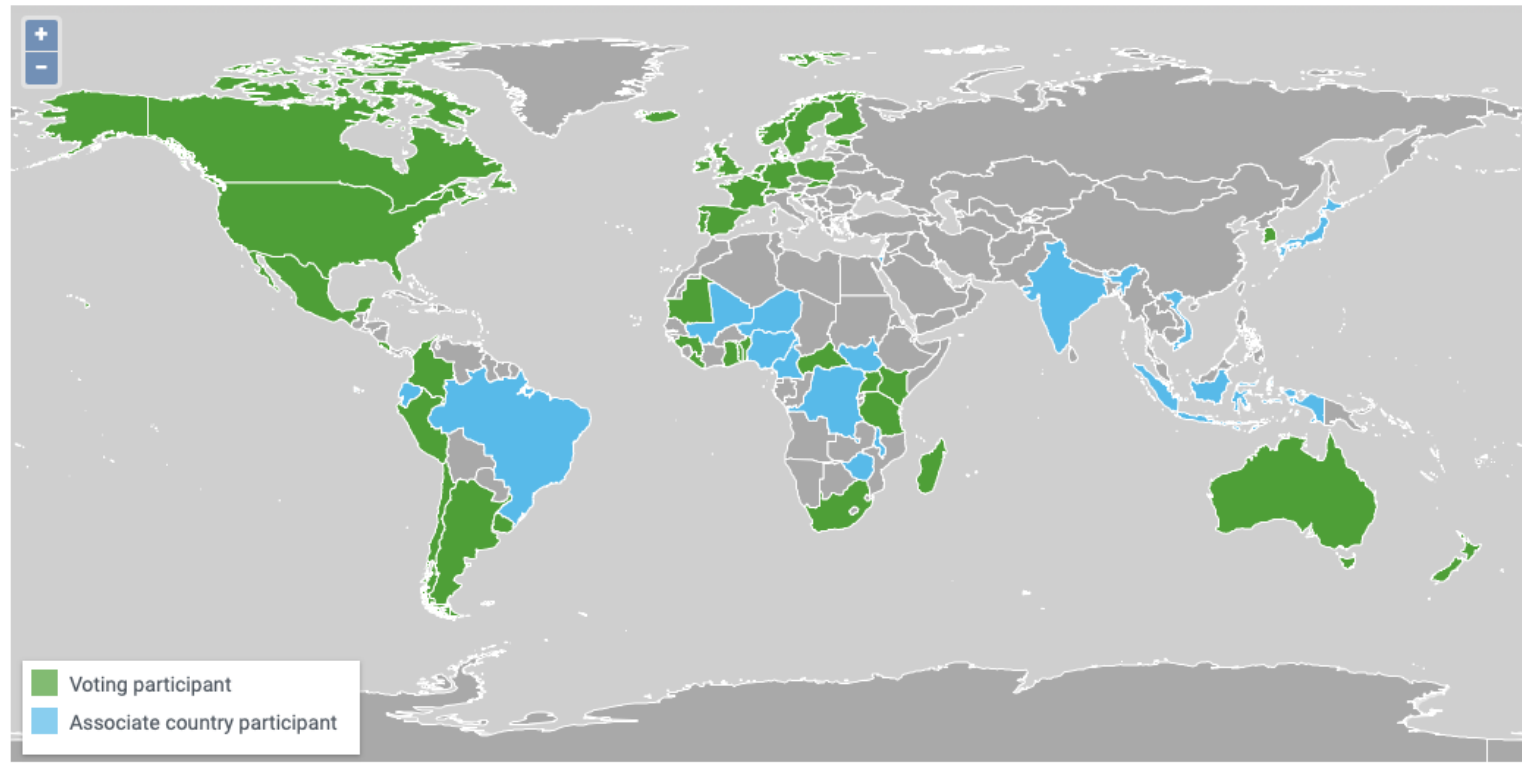
- Established 2012
- Provides policymakers with objective scientific assessments about the state of knowledge regarding the planet's biodiversity, ecosystems and the benefits they provide to people, as well as the tools and methods to protect and sustainably use them.
- Currently 128 member states
- Work grouped into 4 areas:
  - Assessments on specific themes and methodological issues
  - Policy support
  - Building capacity and knowledge
  - Communications and outreach
- More information: <https://www.ipbes.net/>





# Global Biodiversity Information Facility (GBIF)

- Provides open access to biodiversity and species data
- Hundreds of millions of species occurrence data
- More information: <https://www.gbif.org>



Network of participating countries



# International Union for the Conservation of Nature (IUCN)

- Red List of Threatened Species
- Red List of Ecosystems
- World Database on Key Biodiversity Areas – hosted by Bird Life International and IUCN
  - Criteria defined in the IUCN Global Standard for the Identification of Key Biodiversity Areas
  - Criteria are clustered into 5 categories:
    - Threatened biodiversity
    - Geographically restricted biodiversity
    - Ecological integrity
    - Biological processes
    - Irreplaceability
  - For more information (and access to data): [www.keybiodiversityareas.org/](http://www.keybiodiversityareas.org/)







Group on Earth Observations Biodiversity  
Observation Network (GEO BON)

# Group on Earth Observations (GEO)



<https://www.earthobservations.org>

- Intergovernmental organization working to improve the availability, access and use of Earth observations for the benefit of society
- Supports the UN 2030 Agenda for Sustainable Development, the Paris Climate Agreement and the Sendai Framework for Disaster Risk Reduction
- 105 member countries; 127 participating organizations
- 8 societal benefit areas:

Biodiversity and Ecosystem Sustainability  
Disaster Resilience  
Energy and Mineral Resources Management  
Food Security and Sustainable Agriculture

Public Health Surveillance  
Sustainable Urban Development  
Infrastructure and Transportation Management  
Water Resources Management





# GEO Biodiversity Observation Network (BON)

- Represents Biodiversity and Ecosystem Sustainability societal benefit area from GEO
- Based on Convention on Biological Diversity (CBD) Strategic Plan for 2011-2020: “by 2050 biodiversity is valued, conserved, restored and wisely used, maintaining ecosystem services, sustaining a healthy planet and delivering benefits essential for all people”
- GEO BON was developed to coordinate large-scale biodiversity monitoring – a Global Observation Network to meet the CBD goals



<https://geobon.org>





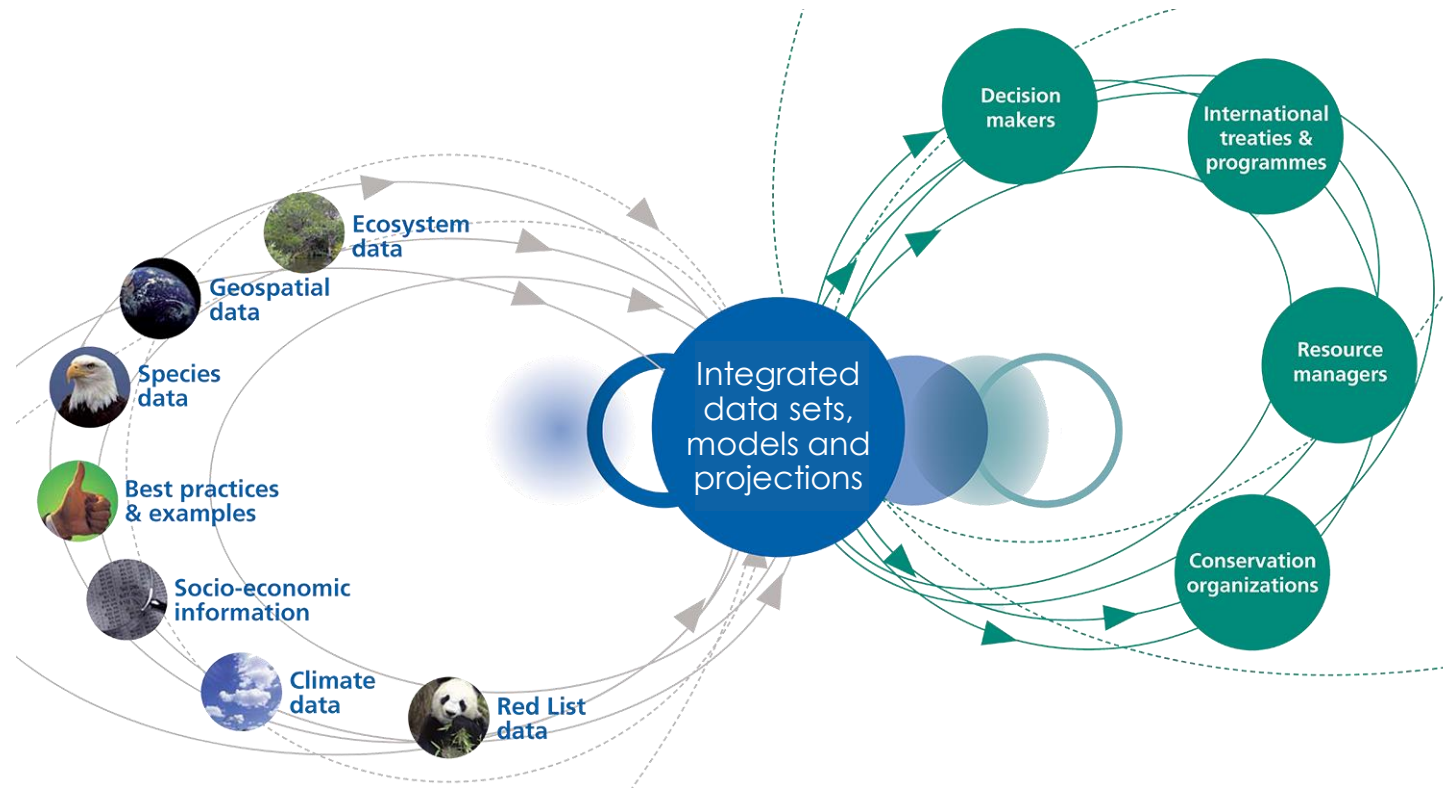
# The GEO BON approach in a nutshell

## Mission:

Improve the **acquisition, coordination** and **delivery** of biodiversity observations and related services to users, including decision makers and scientists.

## Vision:

A **global biodiversity observation network** that contributes to effective **management policies** for the world's biodiversity and ecosystem services.



**GEO BON**

<https://geobon.org>



# GEO BON: A network of networks

- Volunteer-based
- Long-term
- Openness
- Small secretariat
- Biodiversity monitoring



# The two pillars of GEO BON

**Developing a standard and flexible framework for biodiversity observations**

**Supporting the development of Biodiversity Observation Networks**



**Producing Policy Relevant Outputs**

**GEO BON**

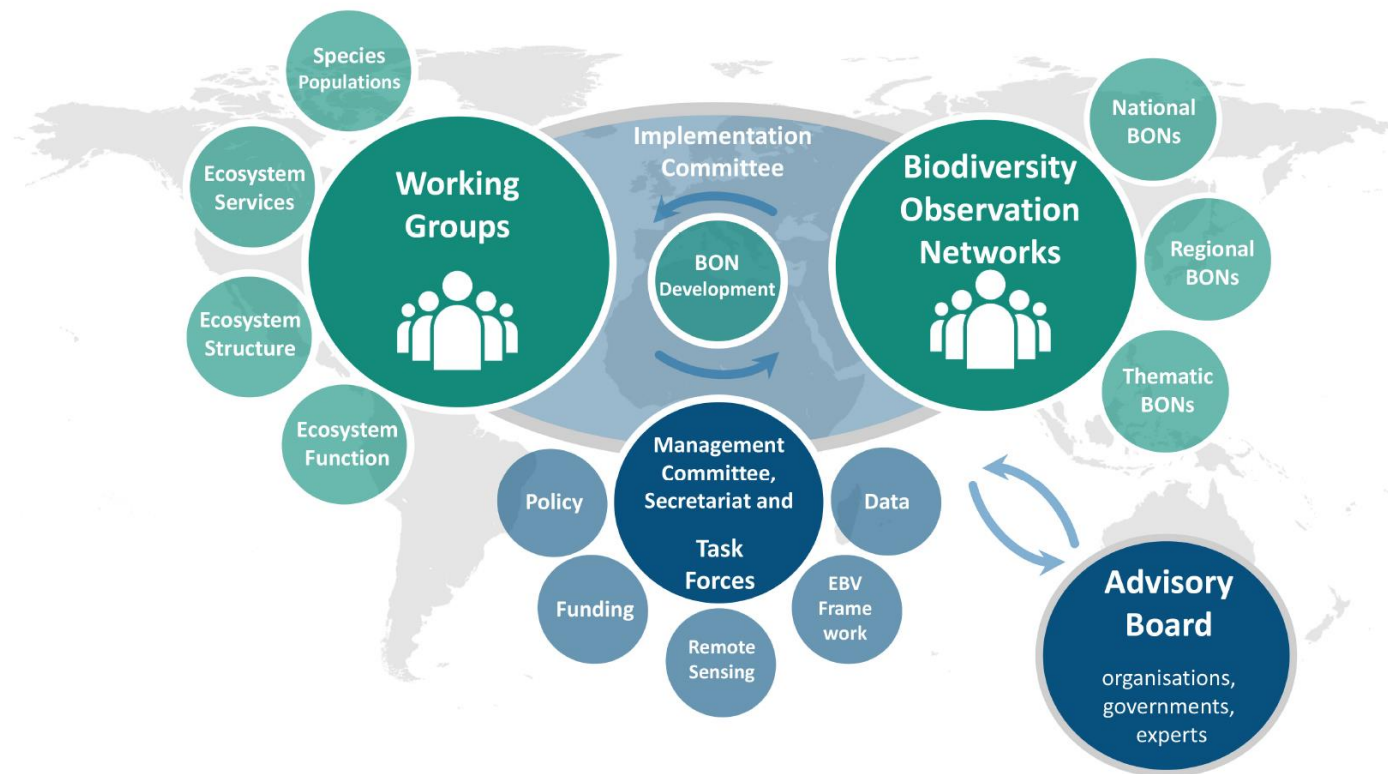
<https://geobon.org>





# GEO BON Elements

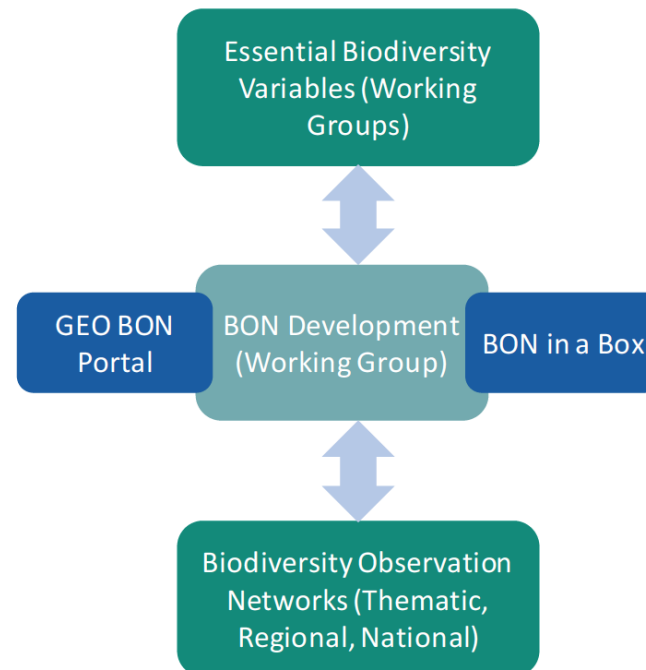
- National BONs
  - China, Colombia and France
- Regional BONs
  - Circumpolar Biodiversity Monitoring Program (Arctic BON)
  - Asia-Pacific BON
- Thematic BONs
  - Marine BON (MBON)
  - Freshwater BON (FBON)
- BON in a Box
  - Online toolkit for facilitating the start up of enhancement of national or regional BONs
  - Regional pilot: Neotropics
    - Developed by the Humboldt Institute of Colombia



# Essential Biodiversity Variables

**Essential Biodiversity Variables** are a minimum set of measurements, complementary to one another, that can capture major dimensions of biodiversity change.

- *Biological and policy relevance*
- *Sensitive to change*
- *Biological, state variables*
- *Generalizable across realms*
- *Scalable*
- **Feasible**

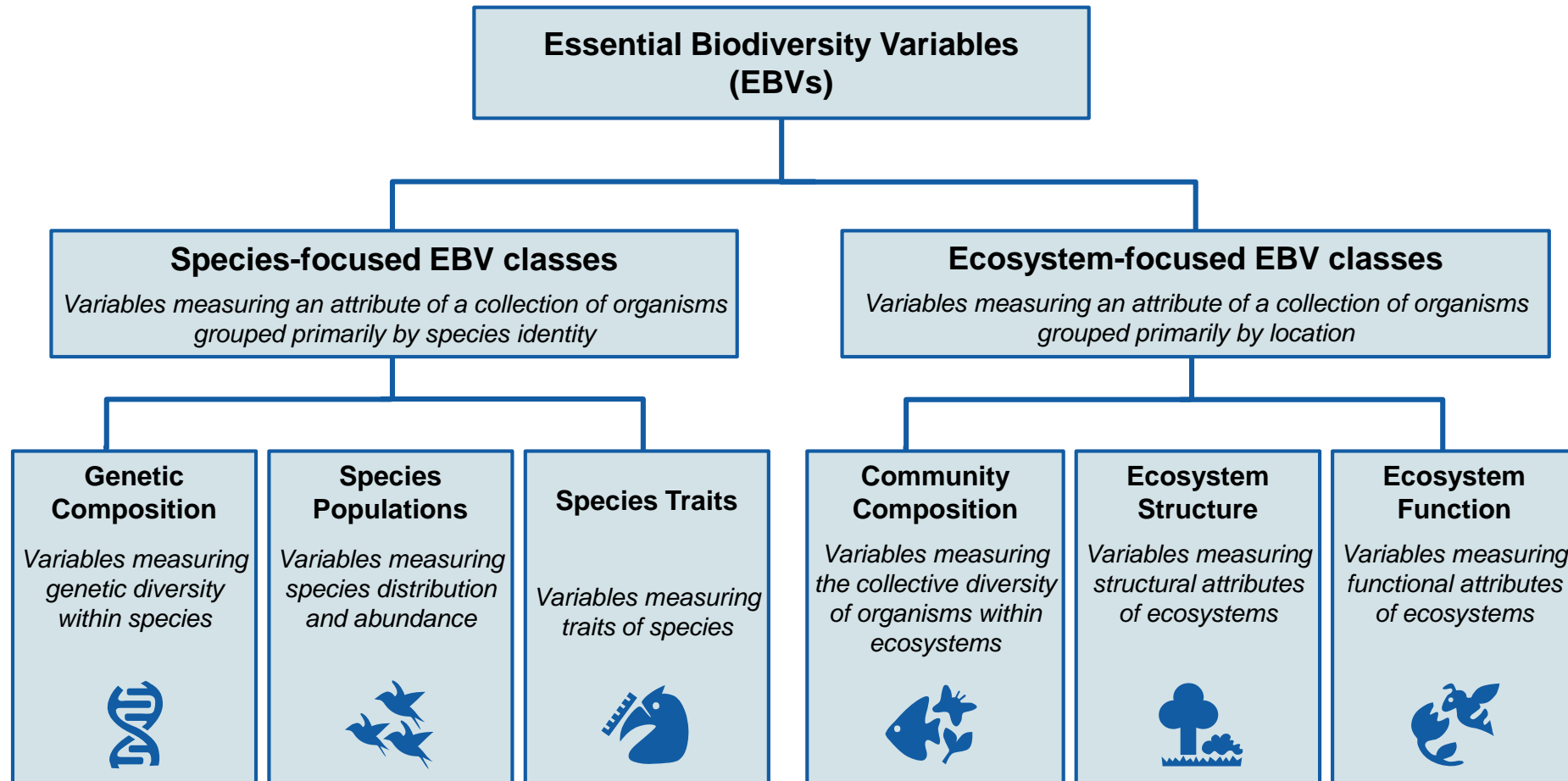


    
UNEP/CBD/SBSTTA/17/INF/7



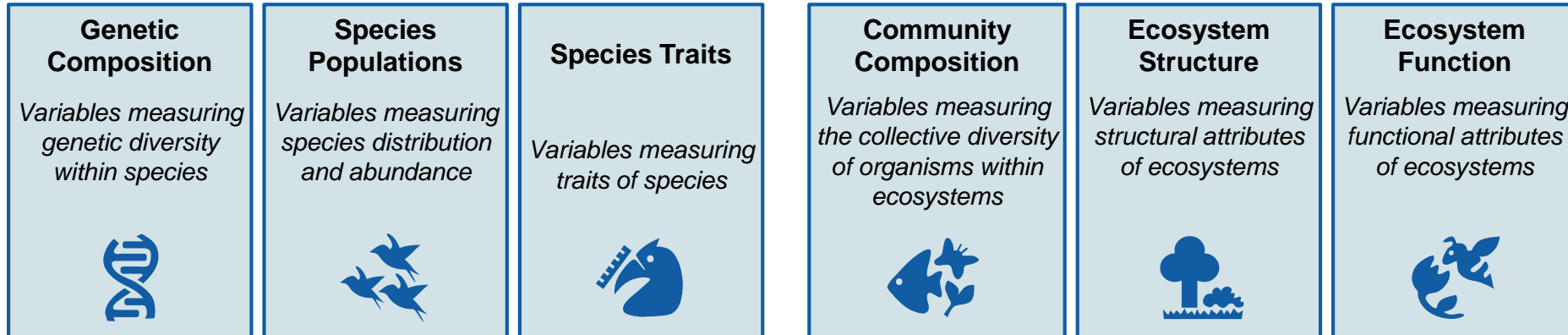
# Essential Biodiversity Variables:

Complementary species-centered and ecosystem-centered perspectives





# Essential Biodiversity Variables: A working list

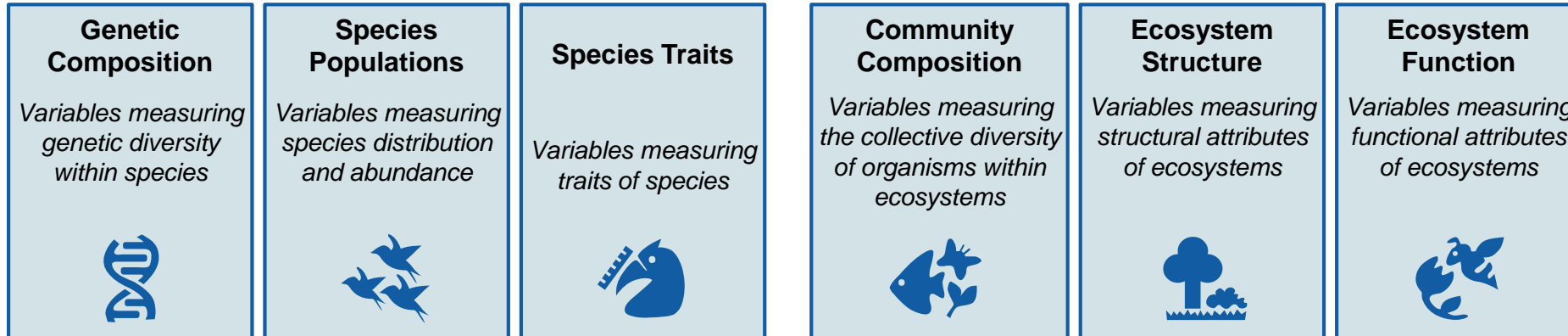


Genetic composition	Co-ancestry
	Allelic diversity
	Population genetic differentiation
	Breed and variety diversity
Species populations	Species distribution
	Population abundance
	Population structure by age/size class
Species traits	Phenology
	Body mass

Community composition	Taxonomic diversity
	Species interactions
Ecosystem function	Net primary productivity
	Secondary productivity
	Nutrient retention
	Disturbance regime
Ecosystem structure	Habitat structure
	Ecosystem extent and fragmentation
	Ecosystem composition by functional type



# Essential Biodiversity Variables: A working list



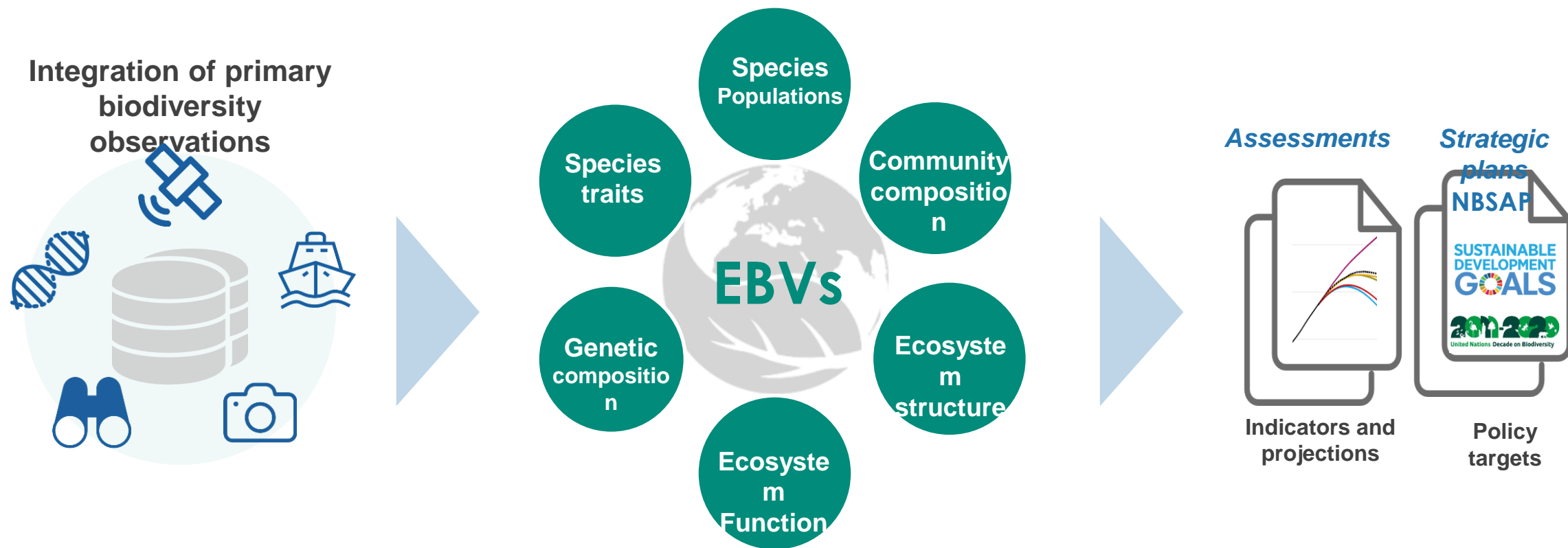
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## Satellite Earth observations



# EBVs: from observations to integration to indicators



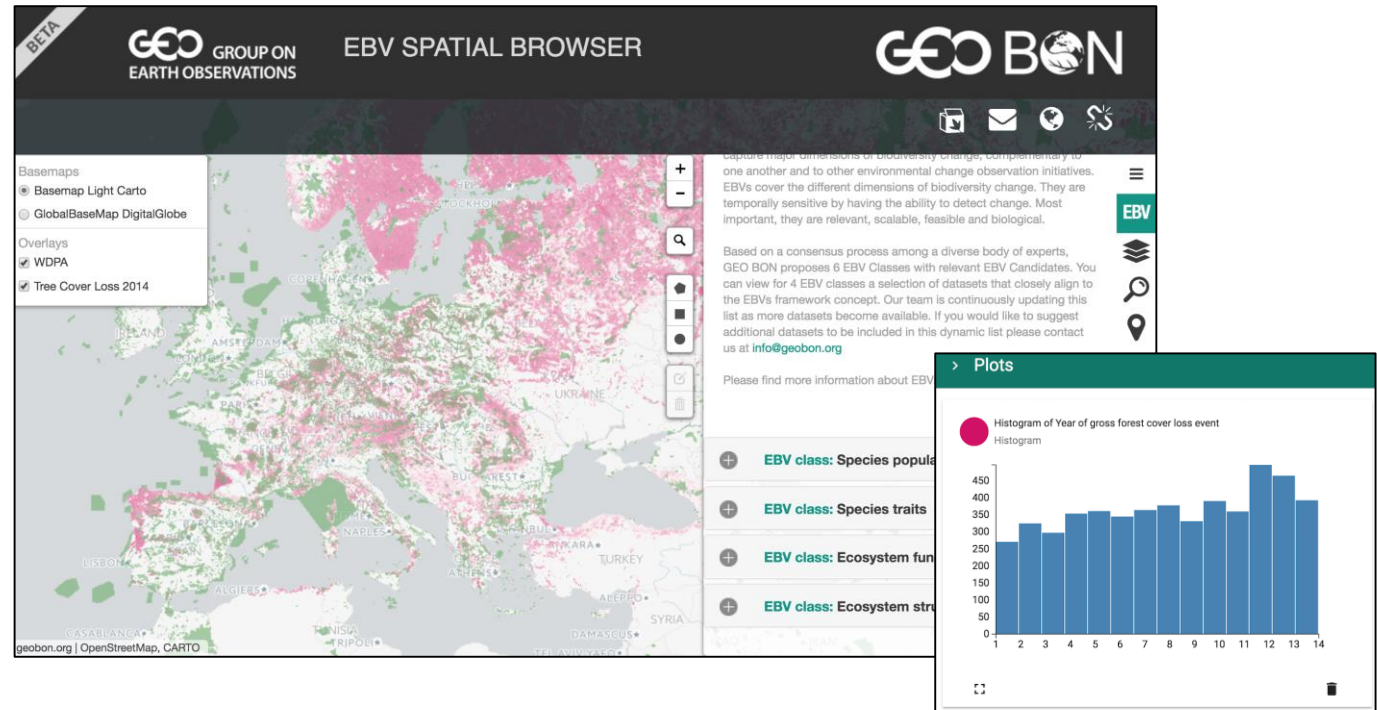
Navarro et. al. (2017) COSUST





# Bringing it all together: EBV Data Portal

EBV	Metric	Name	Conceptual definition	Spatial Scope	Temporal Scope	Taxonomic Scope	Access
POPULATION ABUNDANCES	Population occupancy	Wildlife Picture Index	The TEAM Wildlife Picture Index (WPI) consists of occupancy time series coming for more than 250 species and approximately 500	Global, 120-180 km2	2007-2016, yearly	Mammals & birds	Download metadata Download data
	Population abundances	eBird	eBird engages volunteers via the Internet and mobile apps to collect bird observations in the form of checklists. The checklists contain	Global, 3 km	1900-, yearly	Birds	Download data
	Population abundances	Living Planet Index	The Living Planet Index (LPI) tracks trends in a large number of populations of species. The data used in constructing the Index are	Global, point data	1970-2015, yearly	Animals	Download metadata Download data
SPECIES POPULATIONS	Population abundances	North American Breeding Bird Survey	The North American Breeding Bird Survey (BBS), a survey that has been conducted for more than 45 years across much of North	North America, transects of 29.4 km	1966-2014, yearly	Birds	Download metadata Download data



INDEXING

VISUALIZING

ANALYZING /  
SUMMARIZING

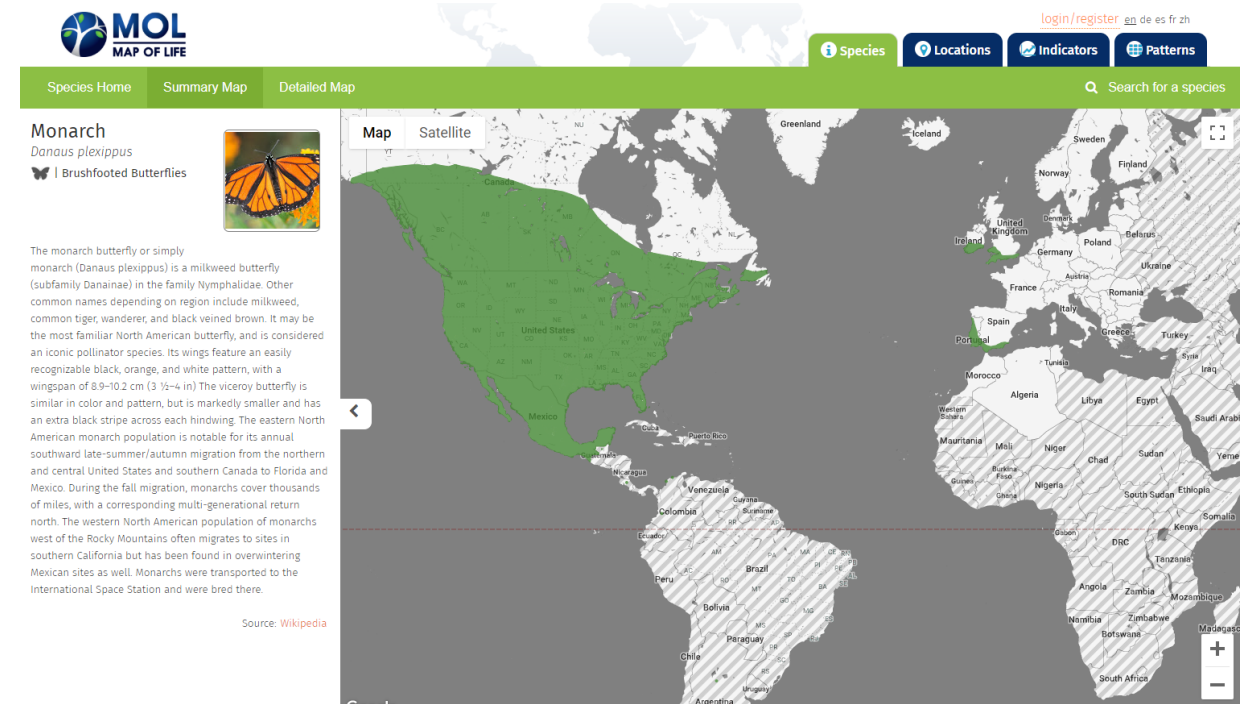
<https://vat.gfbio.org/geobon-cop/#/>



# Project: Developing Remote Sensing-Supported Species Distribution and Species Abundance EBVs

PI: Walter Jetz, Yale University

- Map of Life will be used as modeling and web-infrastructure by
  - Advancing the use of inventory datasets such as camera trapping and plant plot survey data
  - Combining with broadly available incidental point records
- Will improve existing modeling methods for assessing population change using remote sensing data
- Will deliver a range of spatial and spatio-temporal EBV products for select species in North America (birds, mammals), South Africa (Proteas), and globally (select terrestrial vertebrates) including some select invasive species.



<https://mol.org/>

MOL assembles species distribution data from providers like IUCN, WWF, GBIF and others

Jetz, W., McPherson, J. M., and Guralnick, R. P. (2012). Integrating biodiversity distribution knowledge: toward a global map of life. *Trends in Ecology and Evolution* 27:151-159. [DOI:10.1016/j.tree.2011.09.007](https://doi.org/10.1016/j.tree.2011.09.007)







## GEO BON Projects: Colombia



# Supporting Biodiversity Change Indicator Calculations in Colombia

PI: Mary Blair, American Museum of Natural History

- Goal: To expand the open-source species distribution modeling software, *Wallace*, as a tool for BON in a Box
- Will connect Wallace with BioModelos, a Colombian BON web application
- Will develop training materials and user guides



<http://biomodelos.Humboldt.org.co>



# Supporting Biodiversity Change Indicator Calculations in Colombia

PI: Mary Blair, American Museum of Natural History

- EBV: Species distribution
- Open source software will match in-situ observations of a species' occurrence to remote sensing products (i.e. MODIS)
  - Will refine species distribution model predictions and estimate species' current range
- Open source software will also aggregate distribution model predictions for individual species to calculate biodiversity change indicators
  - Extent of occurrence
  - Percent suitable land cover
  - Mean human footprint
  - Protected area coverage



# Integrating Earth Observations for Decision-making on Biodiversity Management in Colombia

PI: Victor Gutierrez-Velez, Temple University

- Developing a decision support system to strengthen the BON in Colombia
- Will target four strategic ecosystems for assessing change and degradation:
  - Paramos, wetlands, savannas, lowland forests
- Will develop tools for:
  - Change assessment
  - Identifying priority areas for conservation
- Have developed an R package forestChange to help measure EBVs

Satellite imagery used in the project

Sensor	Product (s)
MODIS	NPP, GPP, Vegetation Indices, LAI, Thermal anomalies
Landsat	Forest cover and change (Hansen et al. 2013); Land cover
Sentinel 1	Land cover
Sentinel 2 and ALOS-PALSAR	Land cover





# Quantifying Forest Vertical Structure in Colombia

PI: Patrick Jantz, Northern Arizona University

- Developing a habitat structure EBV using Lidar imagery
- Will use spaceborne Lidar imagery from Global Ecosystem Dynamics Investigation (GEDI)
  - 25m diameter spatial resolution
  - Launched December 4, 2018
  - Allows mapping of forest canopy heights, canopy three-dimensional structure, above-ground biomass and surface topography

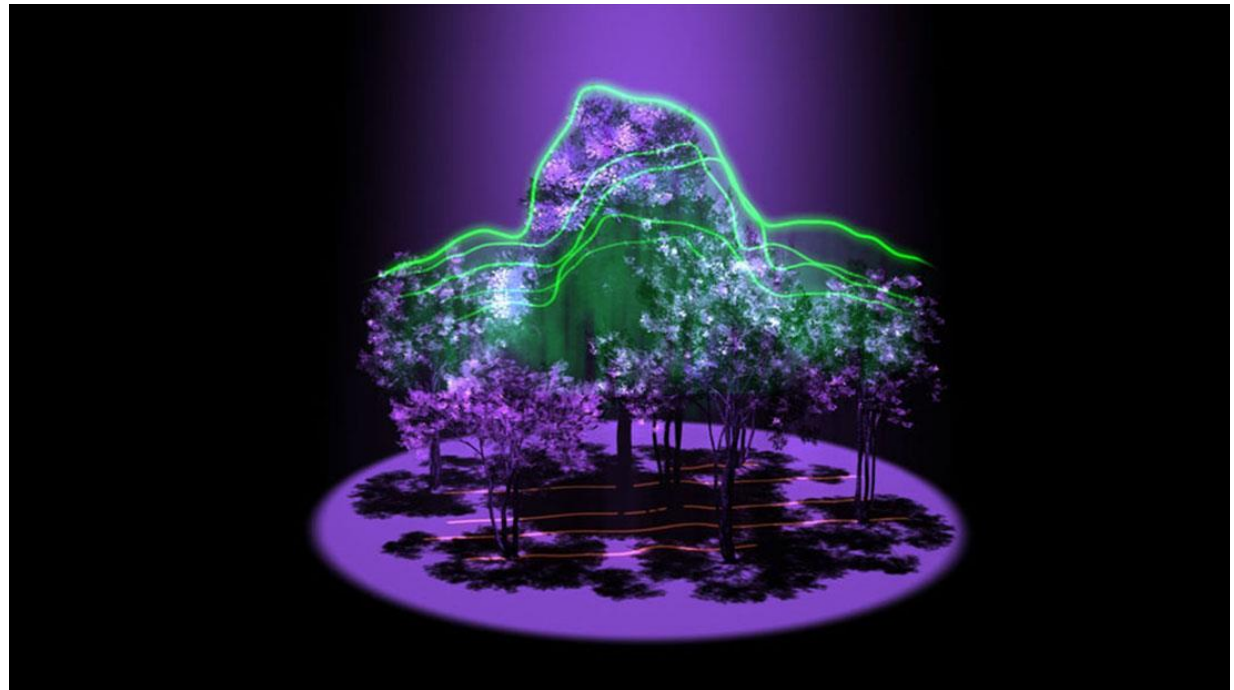


Image credit: <https://www.nasa.gov/feature/goddard/nasa-goddard-technology-helps-fight-forest-pests>





Marine BON



# Marine BON (MBON)

- Established in 2016 to use the EBV concept in the marine realm
- Goal: “Coordinate, promote and augment the capabilities of present and future national and international observing systems to characterize and monitor diversity of marine life at the genetic, species and ecosystem levels using a broad array of in situ and remote sensing observations”
- Defined Essential Ocean Variables (EOVs)
- US MBON projects:
  - Arctic
  - Santa Barbara Channel Islands Sanctuaries
  - For more information: [www.marinebon.org](http://www.marinebon.org)
- International/Global MBON projects
  - Pole to Pole
  - Dynamic seascapes

Mueller-Karger, F.E. et al. (2018) Advancing Marine Biological Observations and Data Requirements of the Complementary Essential Ocean Variables (EOVs) and Essential Biodiversity Variables (EBVs)





# Essential Ocean Variables (EOVs)

- Developed through the Global Ocean Observing System (GOOS)
- MBON is collaborating with GOOS, the Ocean Biogeographic Information System (OBIS) and the Integrated Marine Biosphere Research (IMBeR) project to ensure EBVs and EOVs are complementary.
- For more information:
  - [www.iobis.org](http://www.iobis.org)
  - [www.ioos.noaa.gov](http://www.ioos.noaa.gov)
  - [www.goosocean.org](http://www.goosocean.org)
  - [www.marinebon.org](http://www.marinebon.org)



Global Ocean Observing System (GOOS)  
Essential Ocean Variables (EOVs)

PHYSICS	BIOGEOCHEMISTRY	BIOLOGY AND ECOSYSTEMS
Sea state	Oxygen	Phytoplankton biomass and diversity
Ocean surface stress	Nutrients	Zooplankton biomass and diversity
Sea ice	Inorganic carbon	Fish abundance and distribution
Sea surface height	Transient tracers	Marine turtles, birds, mammals abundance and distribution
Sea surface temperature	Particulate matter	Hard coral cover and composition
Subsurface temperature	Nitrous oxide	Seagrass cover
Surface currents	Stable carbon isotopes	Macroalgal canopy cover
Subsurface currents	Dissolved organic carbon	Mangrove cover
Sea surface salinity	Ocean colour ( <i>Spec Sheet under development</i> )	Microbe biomass and diversity (*emerging)
Subsurface salinity		Benthic invertebrate abundance and distribution (*emerging)
Ocean surface heat flux		

Source: [www.goosocean.org](http://www.goosocean.org)





Marine BON projects



# Pole to Pole MBON of the Americas

PI: Enrique Montes, University of South Florida

- Facilitates the integration of biological and environmental data for countries along the Pacific and Atlantic coasts of the Americas
- Network of cooperating research institutions, marine laboratories, parks and reserves
- Develops and documents best practices associated with marine biodiversity and observations
- Enhances coordination of data collection

Geographic Scope

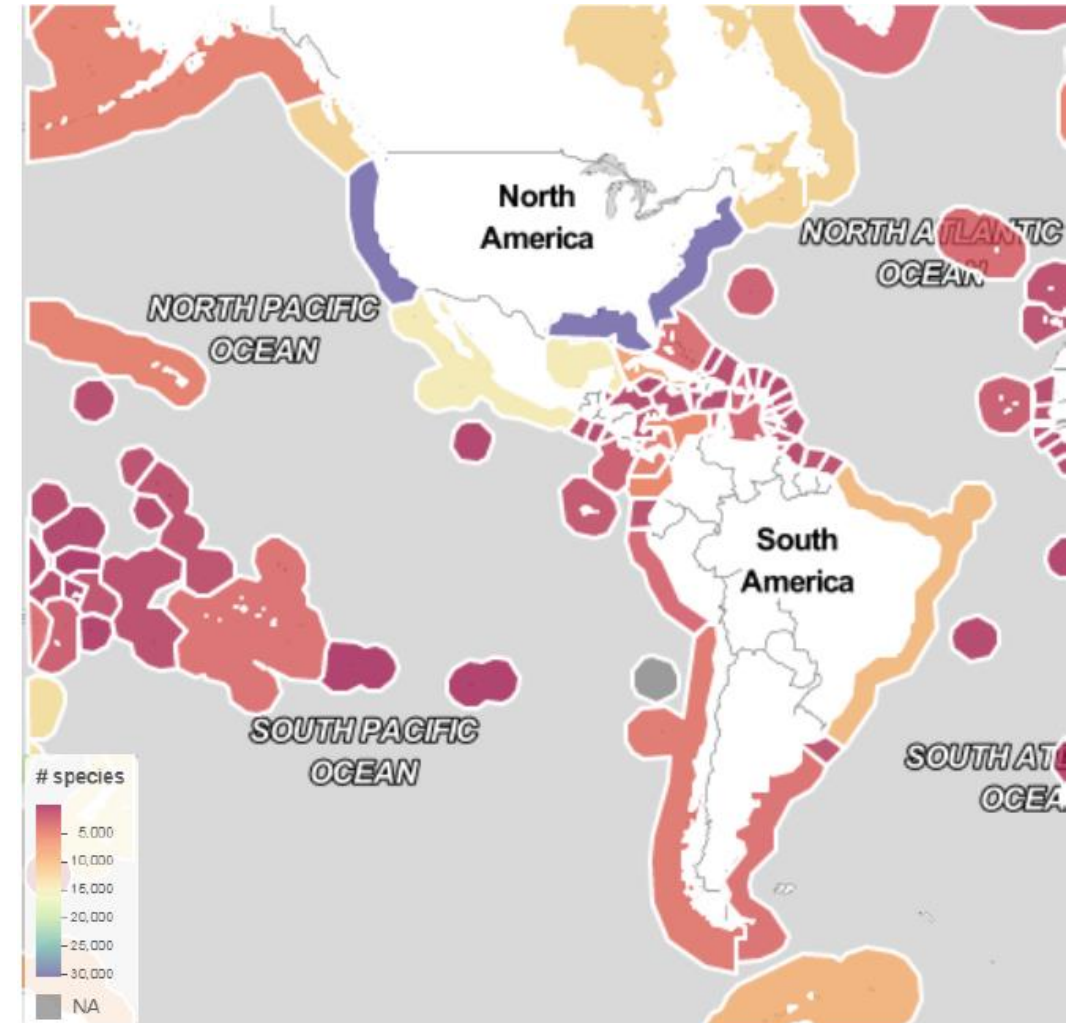


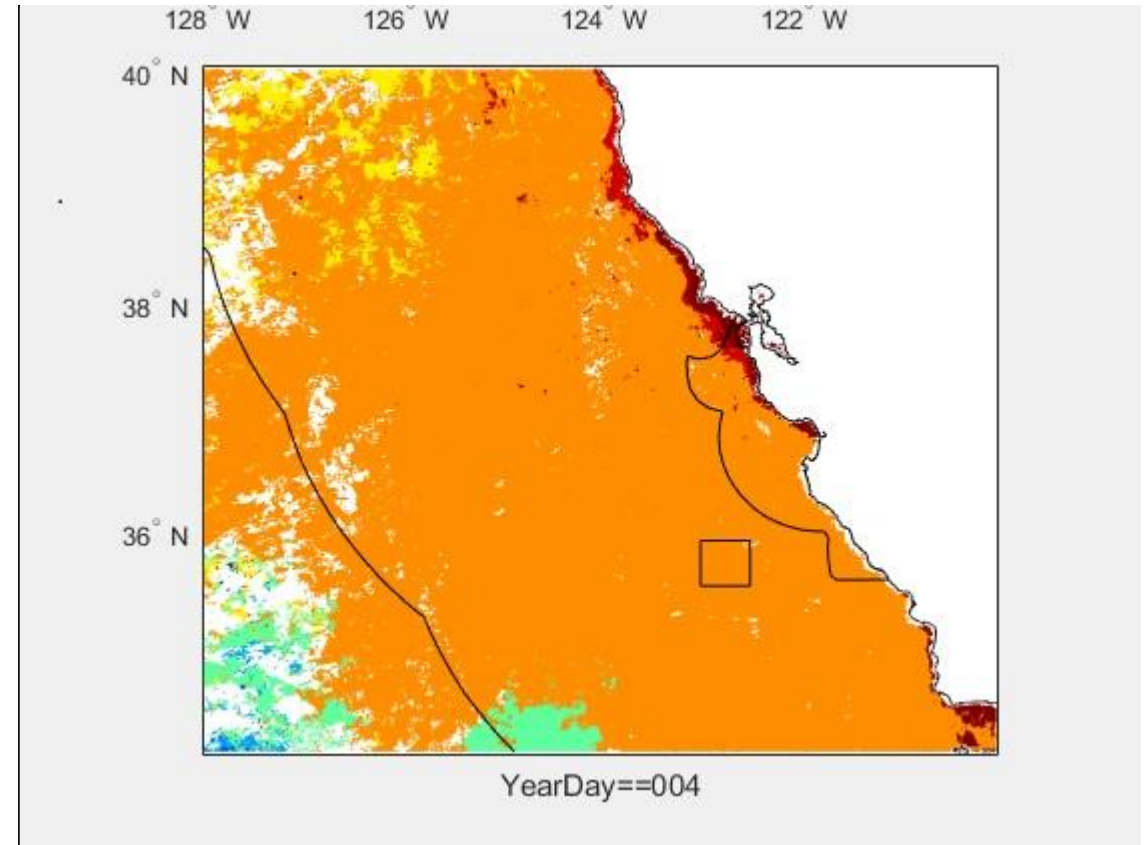
Image credit: Enrique Montes



# Dynamic Seascapes

PI: Maria Kavanaugh, Oregon State University

- Developing a common biogeographic framework that characterizes the variability of ocean dynamics in time and space
- Will serve as the basis for scaling local observations of biodiversity to regional responses to climate.
- Results include a global seascape classification scheme using ocean color, winds, temperature, sea surface height and sea ice from satellite imagery.



Monterey Bay Seascapes

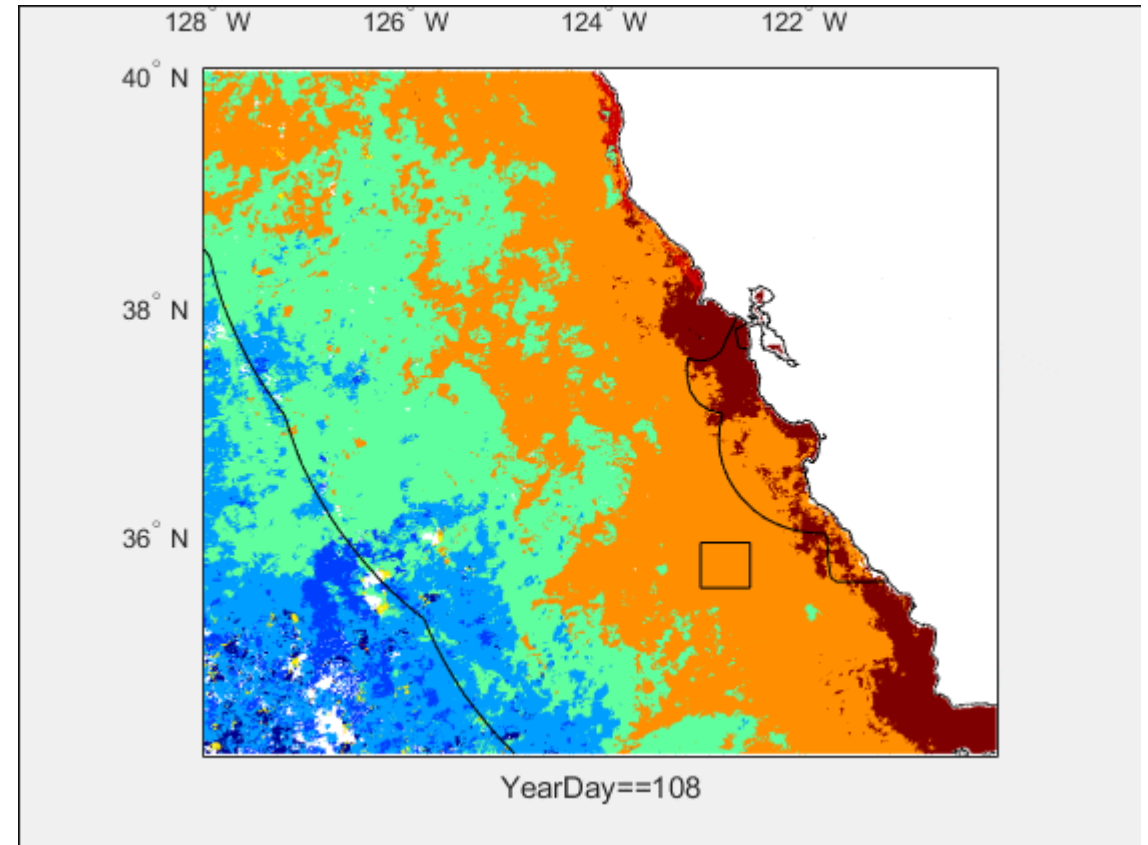




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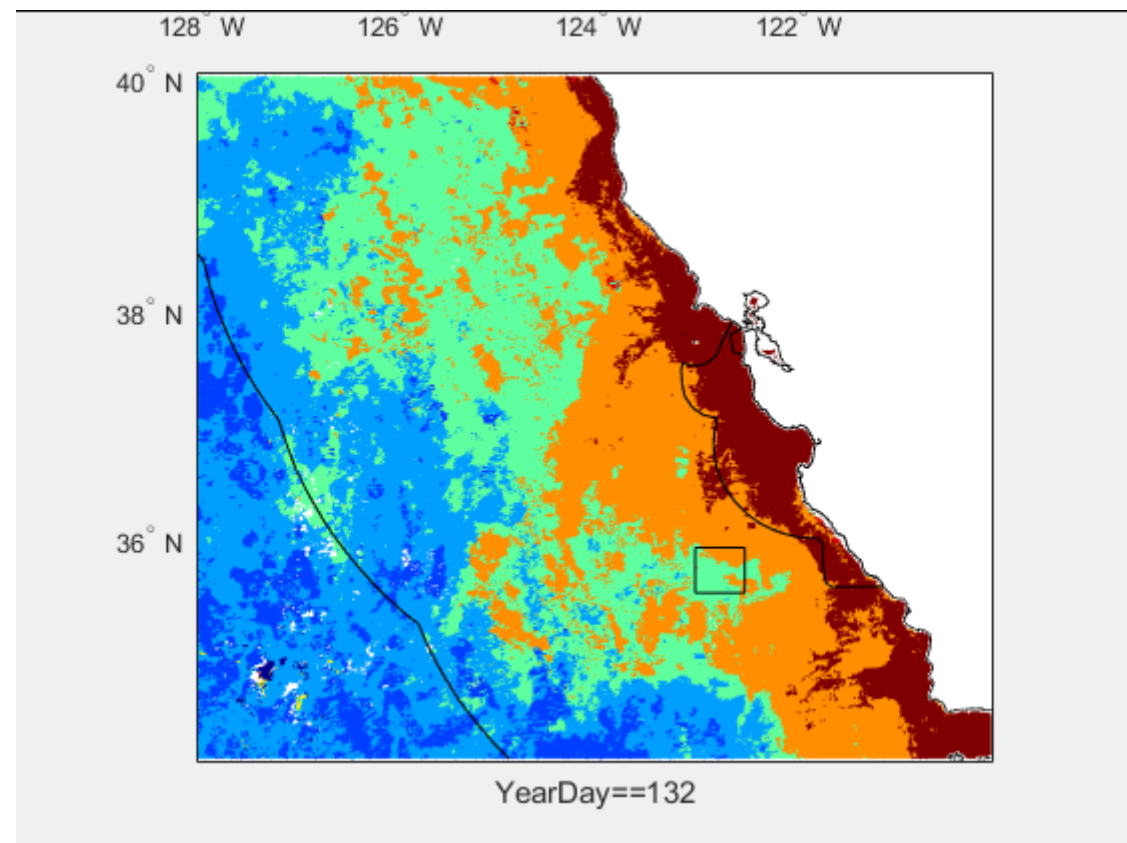
Monterey Bay Seascapes



# Dynamic Seascapes

PI: Maria Kavanaugh, Oregon State University

- Developing a common biogeographic framework that characterizes the variability of ocean dynamics in time and space
- Will serve as the basis for scaling local observations of biodiversity to regional responses to climate.
- Results include a global seascape classification scheme using ocean color, winds, temperature, sea surface height and sea ice from satellite imagery.



Monterey Bay Seascapes



# Summary

- Global biodiversity monitoring efforts:
  - Convention on Biological Diversity
  - Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES)
  - Global Biodiversity Information Facility
  - IUCN
  - Group on Earth Observations Biodiversity Observation Network (GEO BON)
- GEO BON is using satellite remote sensing to measure Essential Biodiversity Variables (EBVs)
- Marine BON is coordinating EBVs and EOVs
- Stay tuned for more to come on BON in a Box tools!





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