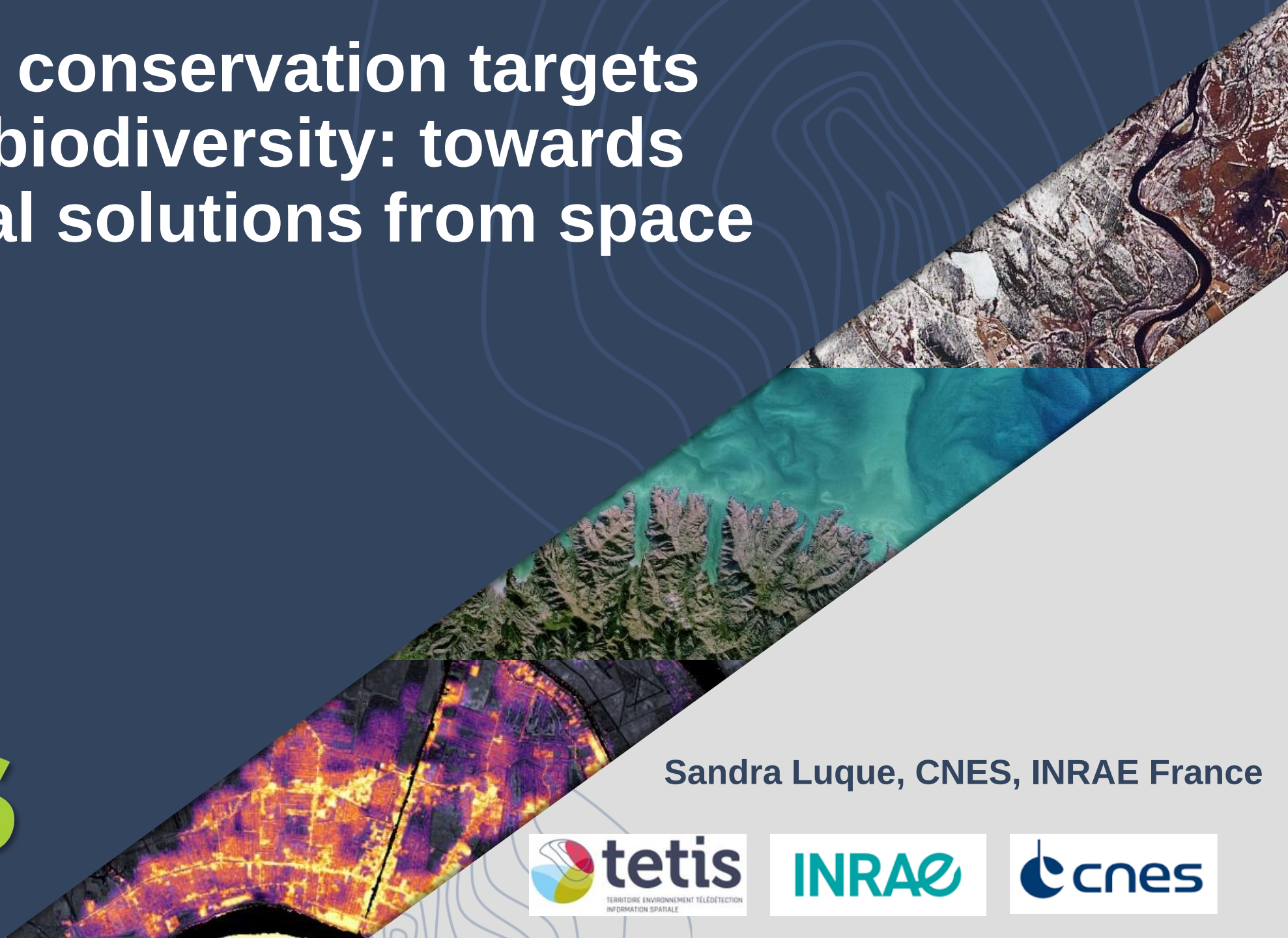
Improving conservation targets for forest biodiversity: towards operational solutions from space



Sandra Luque, CNES, INRAE France

CEOS Committee on Earth Observation Satellites

tetis TERRITOIRE ENVIRONNEMENT TÉLÉDÉTECTION INFORMATION SPATIALE

INRAE

cnes

Cop 15 à Kunming

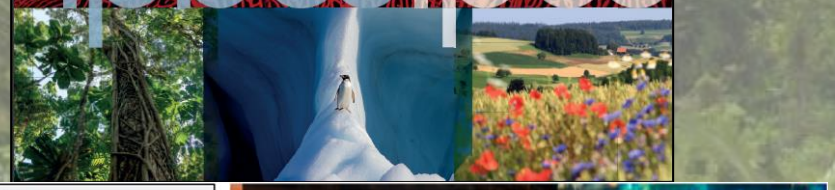
Le monde 11/09/2021

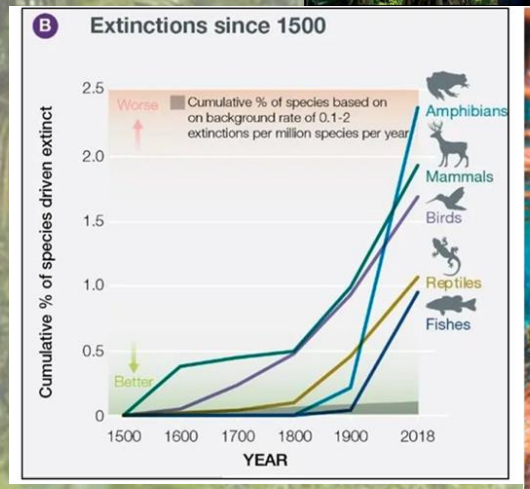
Biodiversity loss risks ‘ecological meltdown’

Humans exploiting and destroying nature on unprecedented scale – report

2021

ipbes ipcc



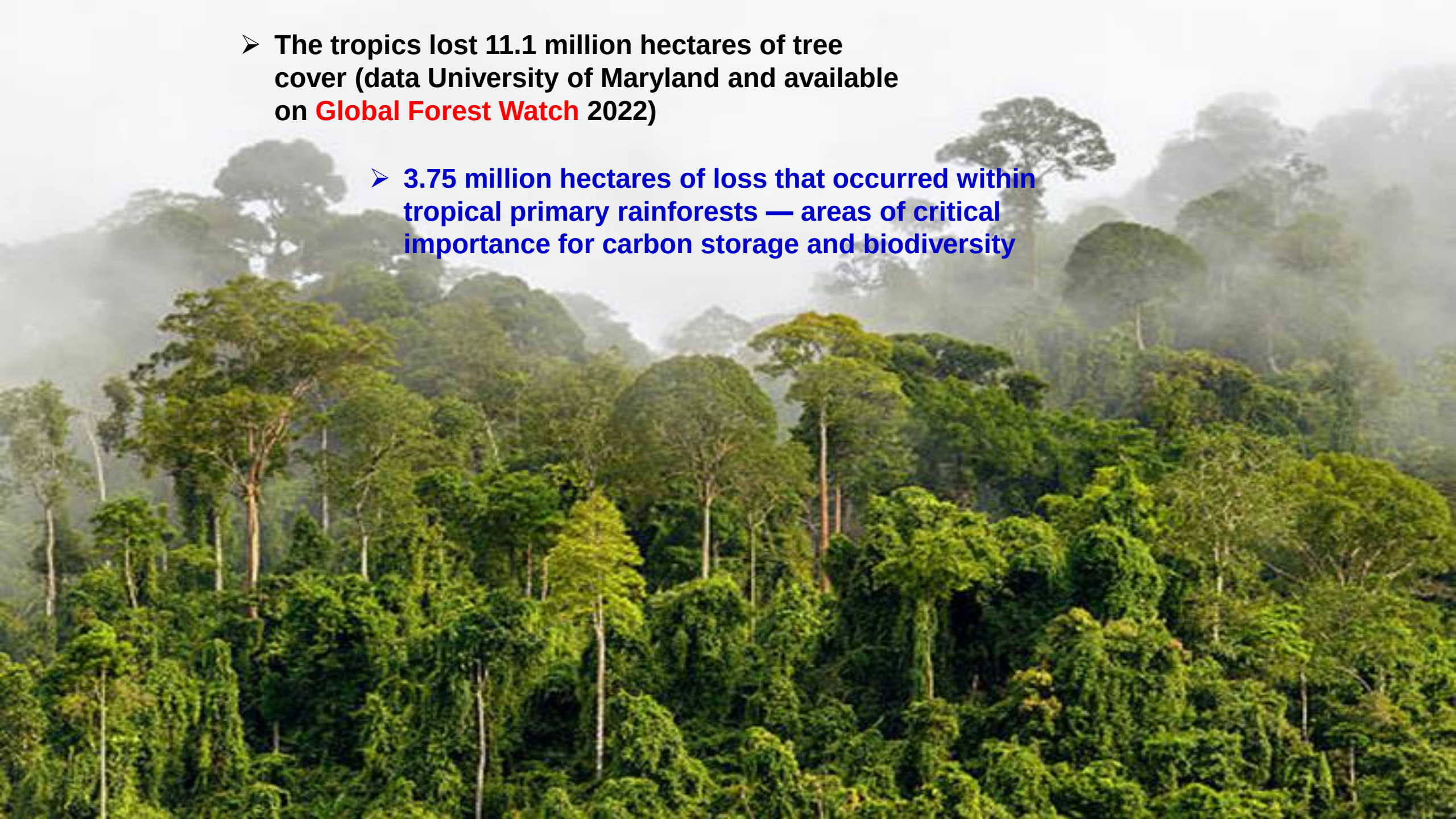


Global biodiversity loss is on the rise (IPBES 2019)

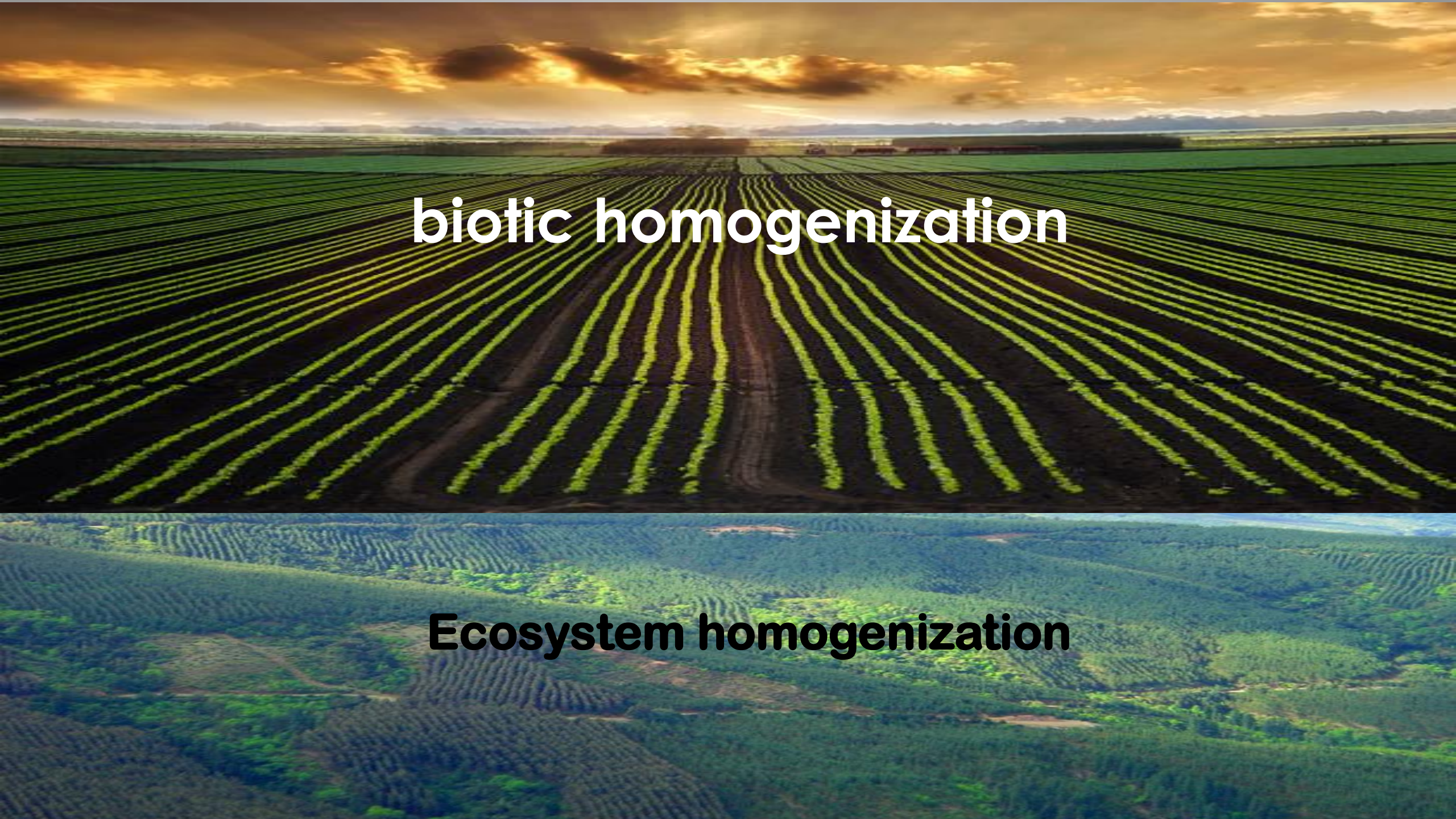
LIVING PLANET REPORT 2020

BENDING THE CURVE OF BIODIVERSITY LOSS

The latest in WWF’s flagship research series, the Living Planet Report, shows that our planet’s wildlife populations have now plummeted by 68% since 1970

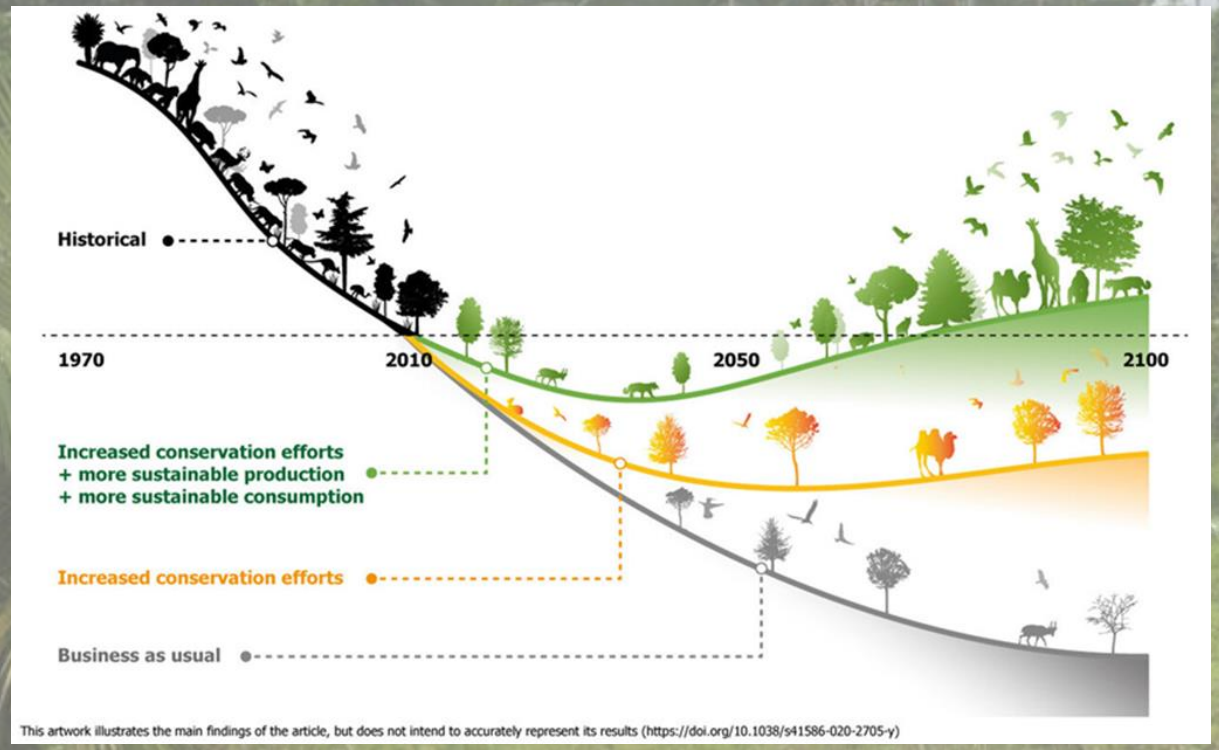


- **The tropics lost 11.1 million hectares of tree cover (data University of Maryland and available on Global Forest Watch 2022)**
  - **3.75 million hectares of loss that occurred within tropical primary rainforests — areas of critical importance for carbon storage and biodiversity**


biotic homogenization
Ecosystem homogenization

Convention on Biological Diversity

COP15: Nations Adopt Four Goals, 23 Targets for 2030 In Landmark UN Biodiversity Agreement



By 2030: Protect 30% of Earth's lands, oceans, coastal areas, inland waters; Reduce by $500 billion annual harmful government subsidies; Cut food waste in half

Outcomes of the CBD COP 15

Adoption of the Kunming-Montreal Global Biodiversity Framework (GBF)

2050 Vision

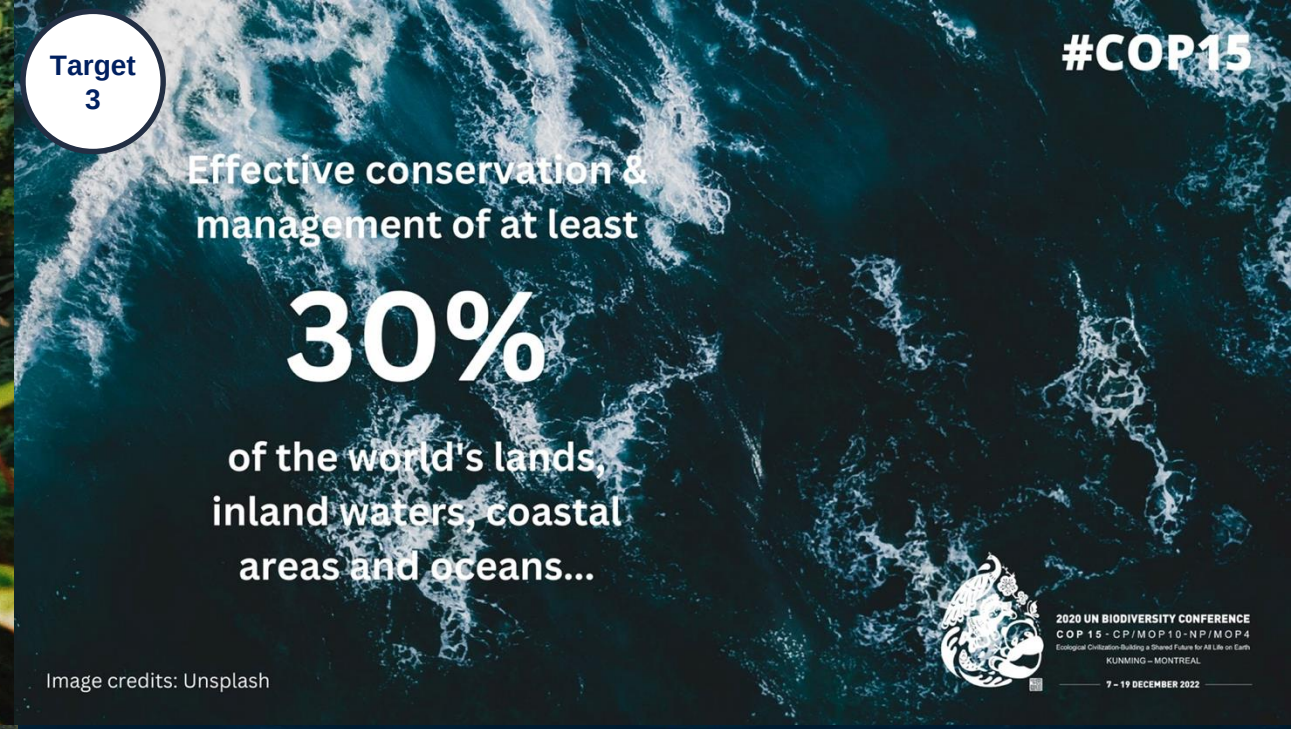
"by 2050, biodiversity is valued, conserved, restored and wisely used, maintaining ecosystem services, sustaining a healthy planet and delivering benefits essential for all people"

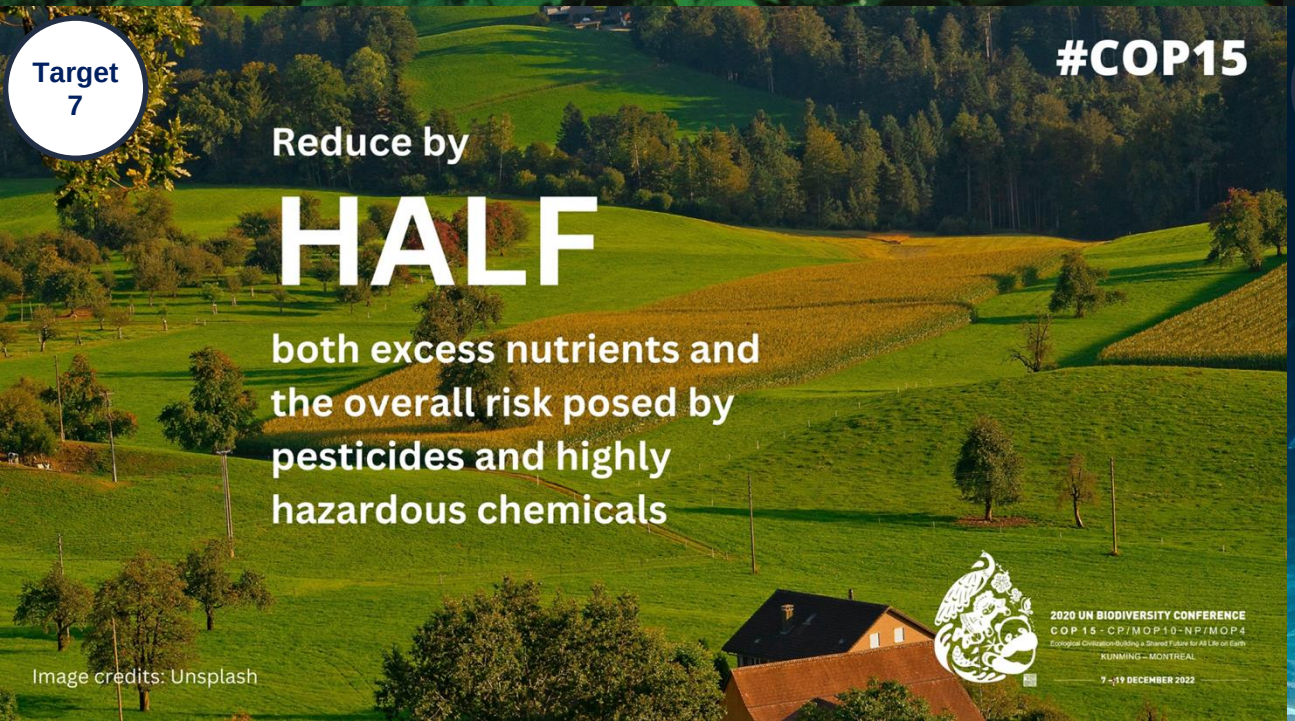
GBF Mission for 2030

"To take urgent action to halt and reverse biodiversity loss to put nature on a path to recovery for the benefit of people and planet by conserving and sustainably using biodiversity and by ensuring the fair and equitable sharing of benefits from the use of genetic resources, while providing the necessary means of implementation".

- 4 overarching long-term Goals for 2050
- 23 targets for 2030
- GBF Monitoring Framework
- Resource Mobilisation


Target 1
#COP15
Reduce to near
ZERO
the loss of areas of high biodiversity importance, including ecosystems of high ecological integrity
2020 UN BIODIVERSITY CONFERENCE
COP 15 - CP/MOP10-NP/MOP4
KUNMING – MONTREAL
7 – 19 DECEMBER 2022
Image credits: Unsplash


Target 3
#COP15
Effective conservation & management of at least
30%
of the world's lands, inland waters, coastal areas and oceans...
2020 UN BIODIVERSITY CONFERENCE
COP 15 - CP/MOP10-NP/MOP4
KUNMING – MONTREAL
7 – 19 DECEMBER 2022
Image credits: Unsplash


Target 7
#COP15
Reduce by
HALF
both excess nutrients and the overall risk posed by pesticides and highly hazardous chemicals
2020 UN BIODIVERSITY CONFERENCE
COP 15 - CP/MOP10-NP/MOP4
KUNMING – MONTREAL
7 – 19 DECEMBER 2022
Image credits: Unsplash


Target 4
#COP15
Have restoration completed or underway on atleast
30%
of degraded terrestrial, inland waters, & coastal & marine ecosystems
2020 UN BIODIVERSITY CONFERENCE
COP 15 - CP/MOP10-NP/MOP4
KUNMING – MONTREAL
7 – 19 DECEMBER 2022
Image credits: Unsplash

GBF Mission in cooperation with other conventions and international organizations

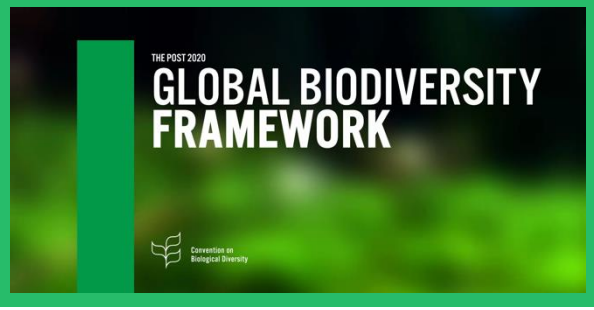
UN Convention to Combat Desertification (UNCCD)

UNCCD 2018-2030 Strategic Framework

Strategic Objective 1: to improve the conditions of ecosystems

Convention on Biological Diversity (CBD)

Post 2020 Global Biodiversity Framework (GBF) and its monitoring framework



UN Framework Convention on Climate Change (UNFCCC)

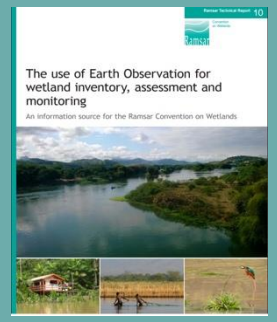
UNFCCC Paris Agreement

Glasgow Climate Pact

Ramsar Convention on Wetlands

Ramsar Strategic Plan (2016 – 2024)

Conservation and wise use of all wetlands



UN SEEA Ecosystem Accounting

International standard on Ecosystem Accounting that regulates the production of statistical accounts on ecosystem extent, condition and services, underpinning the development of monitoring frameworks of other MEAs.

Sustainable Development Goals (SDGs)

SDG Target 6.6
Protect and restore water-related ecosystems

SDG Target 14.2
Sustainably manage and protect marine and coastal ecosystems

SDG Target 15.1
Ensure conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems.

Global Policy Goals and Biodiversity Targets

UNITED NATIONS DECADE ON ECOSYSTEM RESTORATION 2021-2030

RESTORE OUR FUTURE
BONN CHALLENGE

- Emerging and ambitious policy targets are being proposed to address the impact of biodiversity loss and climate change

Convention on Biological Diversity

- Scientific evidence can underpin environmental policies

Task Team on Ecosystem Extent

https://ceos.org/ Committee on Earth Observation Satellites

Understanding ecological systems at a global or regional scale is a complex problem, requiring the integration of a wide variety of different sources, types of data and interdisciplinary expertise

why ecosystem extent is important

The **extent of an ecosystem** is important because it influences the health and stability of the ecosystem and the services it provides to humans and other organisms

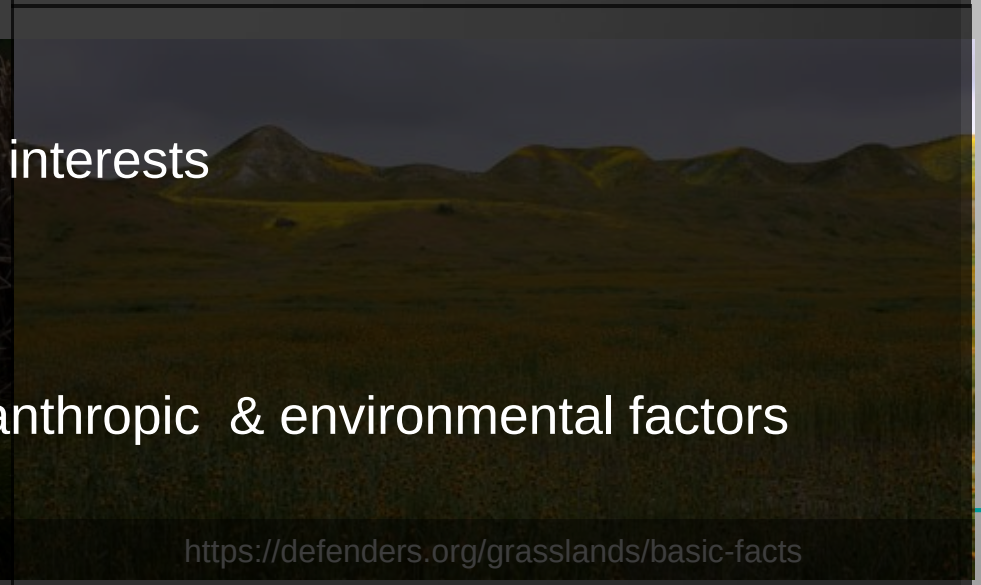
1. **Biodiversity**: Larger ecosystems typically support more diverse plant and animal species. A larger ecosystem can provide a greater variety of habitats, which allows for a wider range of species to coexist.
2. **Climate regulation**: Ecosystems play a critical role in regulating the Earth's climate by absorbing and storing carbon dioxide and other greenhouse gases. A larger ecosystem can sequester more carbon, which helps to mitigate the impacts of climate change.
3. **Water quality**: Ecosystems can help to filter and purify water, making it safer for human consumption and supporting aquatic life. A larger ecosystem can provide more filtration and improve water quality.
4. **Human well-being**: Ecosystems provide a range of benefits to humans, including food, medicine, recreation, and cultural value. A larger ecosystem can provide more of these benefits and contribute to the well-being of local communities.

Diversity of ecosystems

https://www.istockphoto.com/

Les Ecologistes de l'Euziere

http://www.doc.govt.nz/nature/habitats/wetlands/



https://defenders.org/grasslands/basic-facts

Multiple interests

- Mapping biological diversity
- Mapping functional diversity
- Studying evolution of diversity with anthropic & environmental factors
- …

Measuring Forest Biodiversity Status and Changes Globally

Samantha L. L. Hill[1,2*†], Andy Arnell[1†], Calum Maney[1], Stuart H. M. Butchart[3,4], Craig Hilton-Taylor[5], Carolyn Ciciarelli[6], Crystal Davis[6], Eric Dinerstein[7], Andy Purvis[2,8] and Neil D. Burgess[1,4,9]

[1] UN Environment World Conservation Monitoring Centre (UNEP-WCMC), Cambridge, United Kingdom, [2] Department of Life Sciences, The Natural History Museum, London, United Kingdom, [3] BirdLife International, The David Attenborough Building, Cambridge, United Kingdom, [4] Department of Zoology, University of Cambridge, Cambridge, United Kingdom, [5] IUCN Global Species Programme, Cambridge, United Kingdom, [6] WRI, Washington, DC, United States, [7] RESOLVE, Washington, DC, United States, [8] Department of Life Sciences, Imperial College London, Ascot, United Kingdom, [9] CMEC, University of Copenhagen, Copenhagen, Denmark

Hill et al, Frontiers in Forests and Global Conservation 2019

Review

How Can Remote Sensing Help Monitor Tropical Moist Forest Degradation?—A Systematic Review

Chloé Dupuis *, Philippe Lejeune, Adrien Michez and Adeline Fayolle

TERRA Teaching and Research Centre (Forest is Life), Gembloux Agro-Bio Tech, University of Liege, Passage des Déportés n°2 5030 Gembloux, Belgium; p.lejeune@uliege.be (P.L.); adrien.michez@uliege.be (A.M.); adeline.fayolle@uliege.be (A.F.)
* Correspondence: chloe.dupuis@uliege.be

Dupuis et al, Remote Sensing 2020

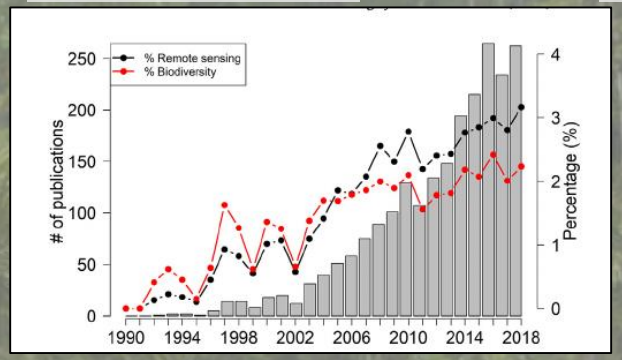
ELSEVIER

Ecological Informatics
Volume 61, March 2021, 101195

From local spectral species to global spectral communities: A benchmark for ecosystem diversity estimate by remote sensing

Duccio Rocchini [a, b], Nicole Salvatori [c, d], Carl Beierkuhnlein [e], Alessandro Chiarucci [a], Florian de Boissieu [f], Michael Förster [g], Carol X. Garzon-Lopez [h], Thomas W. Gillespie [i], Heidi C. Hauffe [j], Kate S. He [k], Birgit Kleinschmit [g], Jonathan Lenoir [l], Marco Malavasi [b], Vítězslav Moudrý [b], Harini Nagendra [m], Davnah Payne [n], Petra Šímová [b], Michele Torresani [o, q] ... Jean-Baptiste Féret [f]

Rocchini et al, Ecological Informatics 2021

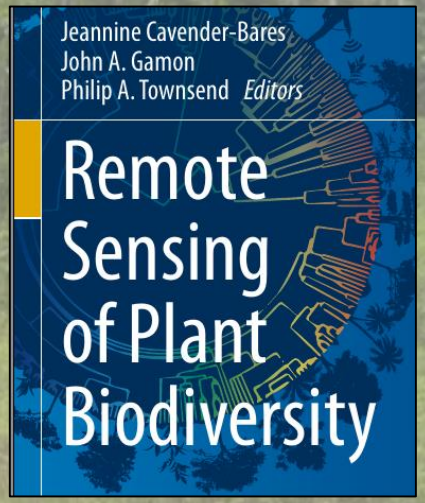


Remote sensing of terrestrial plant biodiversity

Ran Wang[a,*], John A. Gamon[a,b,c]

[a] Department of Earth and Atmospheric Sciences, University of Alberta, Edmonton, AB T6G 2E3, Canada
[b] Department of Biological Sciences, University of Alberta, Edmonton, AB T6G 2E9, Canada
[c] School of Natural Resources, University of Nebraska-Lincoln, Lincoln, NE 68583, USA

Wang and Gamon, Remote Sensing of the Environment 2019



Cavender-Bares et al, Springer 2020

Applied Vegetation Science
Conservation, restoration and survey of plant communities
IAVS

SPECIAL FEATURE: REMOTE SENSING | Open Access

Which optical traits enable an estimation of tree species diversity based on the Spectral Variation Hypothesis?

Michele Torresani, Hannes Feilhauer, Duccio Rocchini, Jean-Baptiste Féret, Marc Zebisch, Giustino Tonon

First published: 29 April 2021 | https://doi.org/10.1111/avsc.12586

Torresani et al, Applied Vegetation Science 2021

Contents lists available at ScienceDirect
Remote Sensing of Environment
journal homepage: www.elsevier.com/locate/rse

On the use of binary partition trees for the tree crown segmentation of tropical rainforest hyperspectral images

G. Tochon [a,b,*], J.B. Féret [b,c], S. Valero [c], R.E. Martin [b], D.E. Knapp [b], P. Salembier [d], J. Chanussot [a,e], G.P. Asner [b]

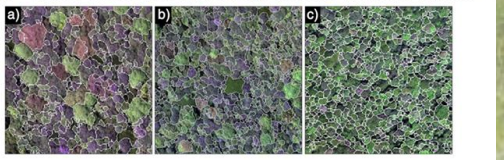


Fig. 10. Visual results obtained when using mean shift clustering, PC selection without PC # 1 and size threshold of 1200 for Hawaii (a, b) and 150 for Panama (c).

Remote Sensing in Ecology and Conservation
Open Access
ZSL LET'S WORK FOR WILDLIFE

REVIEW

Satellite remote sensing to monitor species diversity: potential and pitfalls

Duccio Rocchini[1], Doreen S. Boyd[2], Jean-Baptiste Féret[3], Giles M. Foody[2], Kate S. He[4], Angela Lausch[5], Harini Nagendra[6], Martin Wegmann[7] & Nathalie Pettorelli[8]

Biodiversity monitoring is critical to understand how to mitigate mass extinction

- Biodiversity is multidimensional
- There is no unique indicator to describe or monitor biodiversity

→Group on Earth Observations Biodiversity Observation Network (GEO BON) aims at improving the availability of biodiversity change data to decision makers and scientists in support of policy

GEO BON

A global system of harmonized observations is needed to inform scientists and policy-makers.

ECOLOGY

Essential Biodiversity Variables

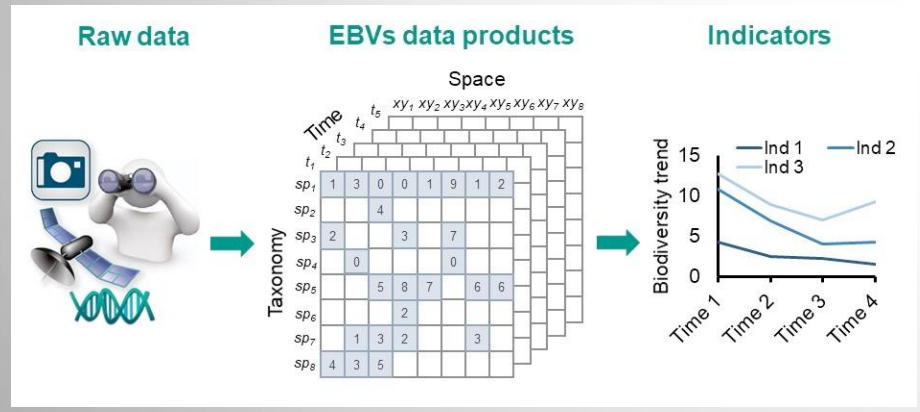
H. M. Pereira,[1*†] S. Ferrier,[2] M. Walters,[3] G. N. Geller,[4] R. H. G. Jongman,[5] R. J. Scholes,[3] M. W. Bruford,[6] N. Brummitt,[7] S. H. M. Butchart,[8] A. C. Cardoso,[9] N. C. Coops,[10] E. Dulloo,[11] D. P. Faith,[12] J. Freyhof,[13] R. D. Gregory,[14] C. Heip,[15] R. Höft,[16] G. Hurtt,[17] W. Jetz,[18] D. S. Karp,[19] M. A. McGeoch,[20] D. Obura,[21] Y. Onoda,[22] N. Pettorelli,[23] B. Reyers,[24] R. Sayre,[25] J. P. W. Scharlemann,[26,27] S. N. Stuart,[28] E. Turak,[29] M. Walpole,[26] M. Wegmann[30]

Pereira *et al.*, *Science*, 339(277-278), 2013.

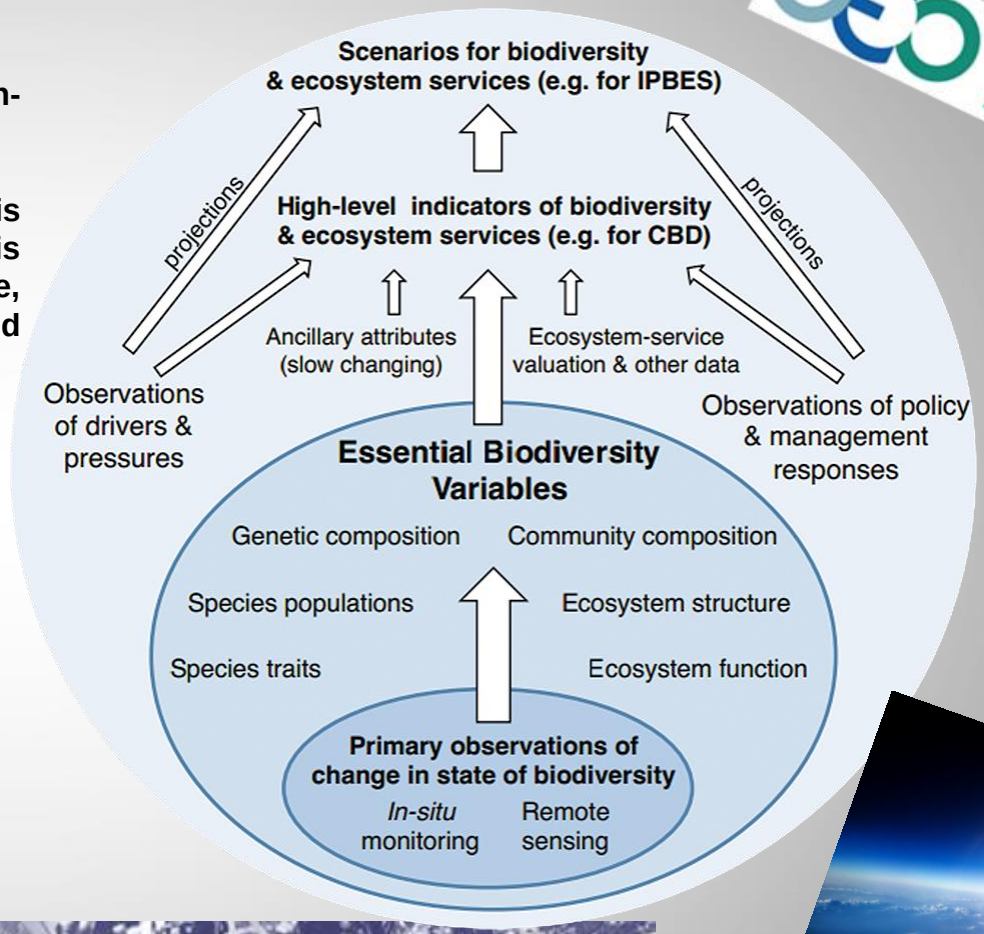
How can we reliably measure and monitor the state of biodiversity at various spatial scales?

Integrated efforts are needed to consolidate data from in-situ and remote sensing.

The concept of essential biodiversity variables (EBVs) is currently gaining momentum as a framework to address this research and operational need in order to prioritize, integrate, and consolidate biodiversity observations and monitoring programs worldwide.



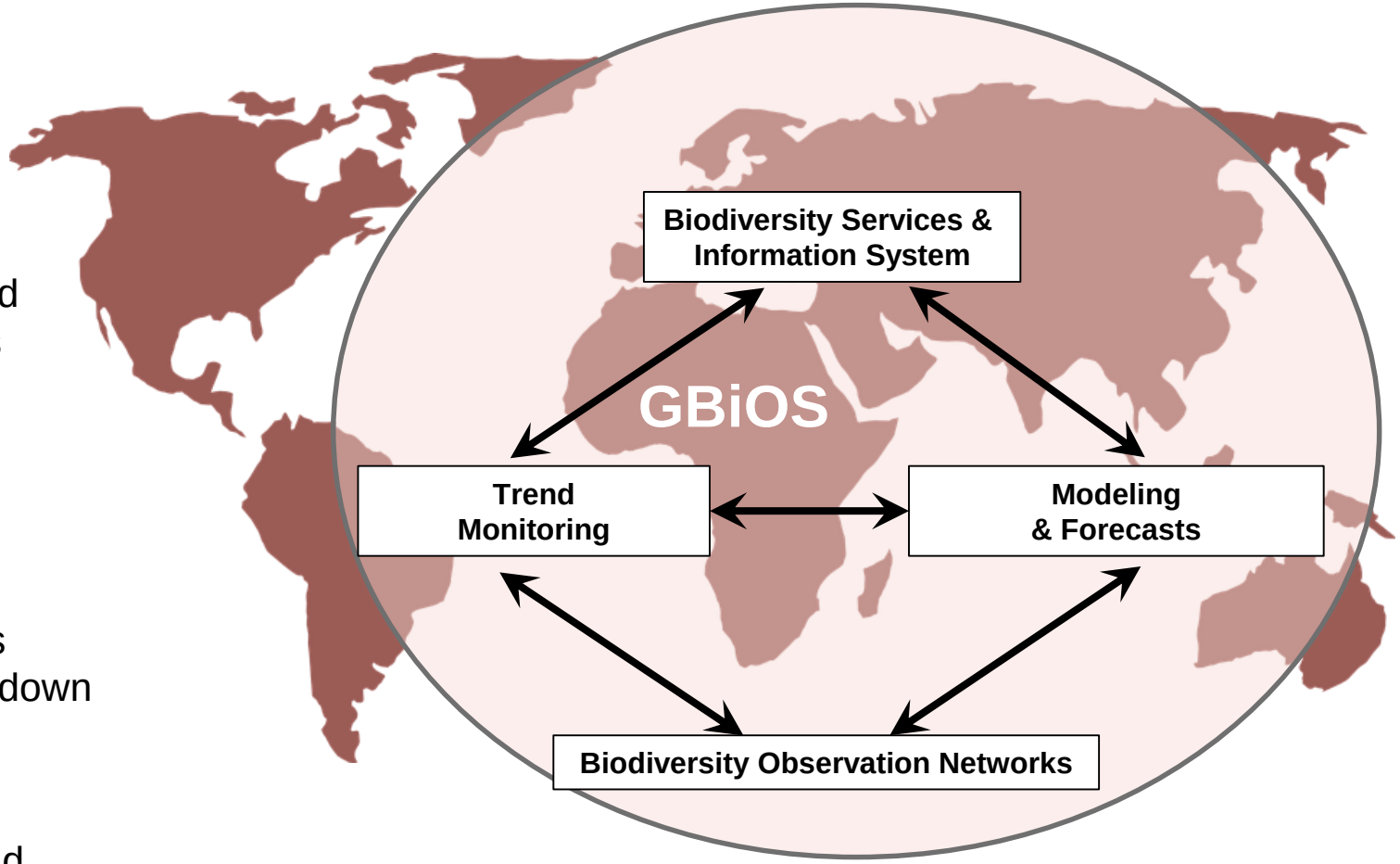
https://www.biomac.org/research/themes/7/global_biodiversity_change.html



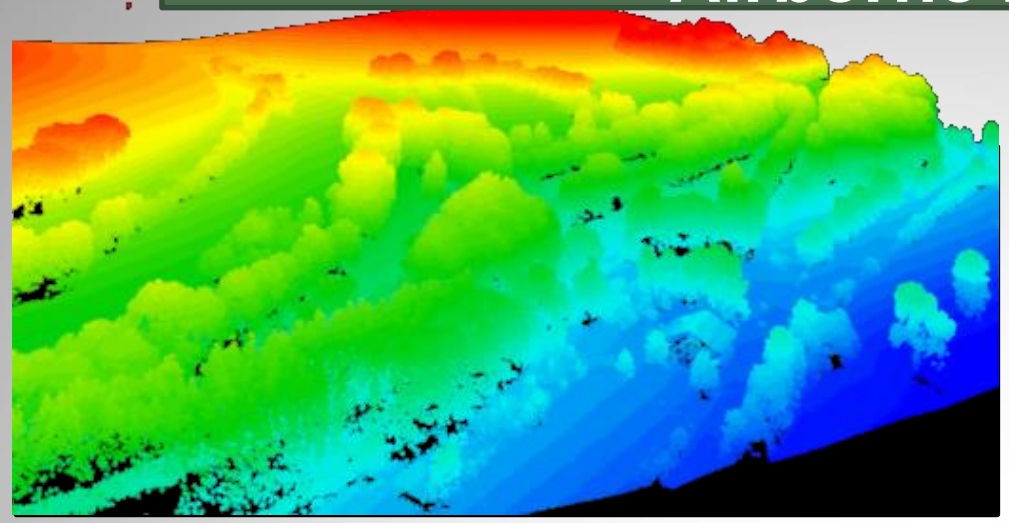
Global Biodiversity Observation System (GBiOS) led by GEO BON

A GBiOS will address four critical issues

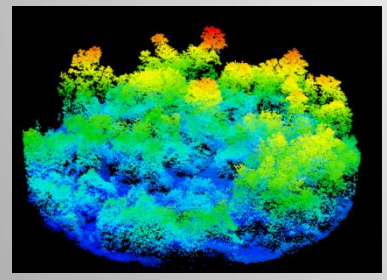
1. Systematic biodiversity monitoring designed to fill gaps and assess outcomes of actions
2. Federate ‘actors’ and ‘users’ in the monitoring community
3. Network scaling: capacity and technologies transform translation of knowledge up and down social and ecological scales
4. Supporting fit-for-purpose data to global and regional biodiversity models and assessments



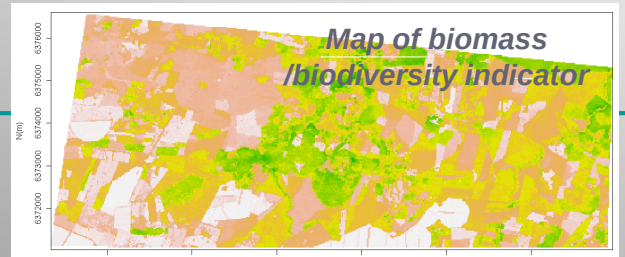
Landscape or stand structure with Airborne Lidar



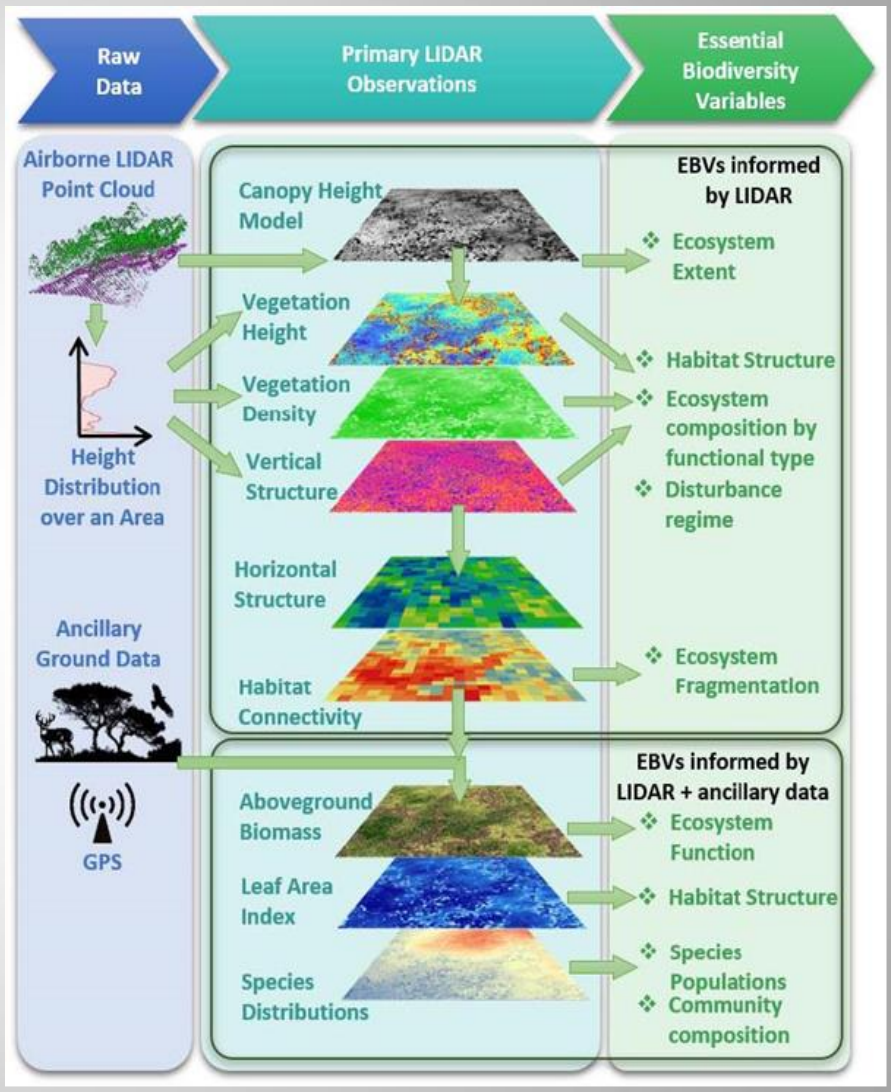
Calibration / Validation plots



Model

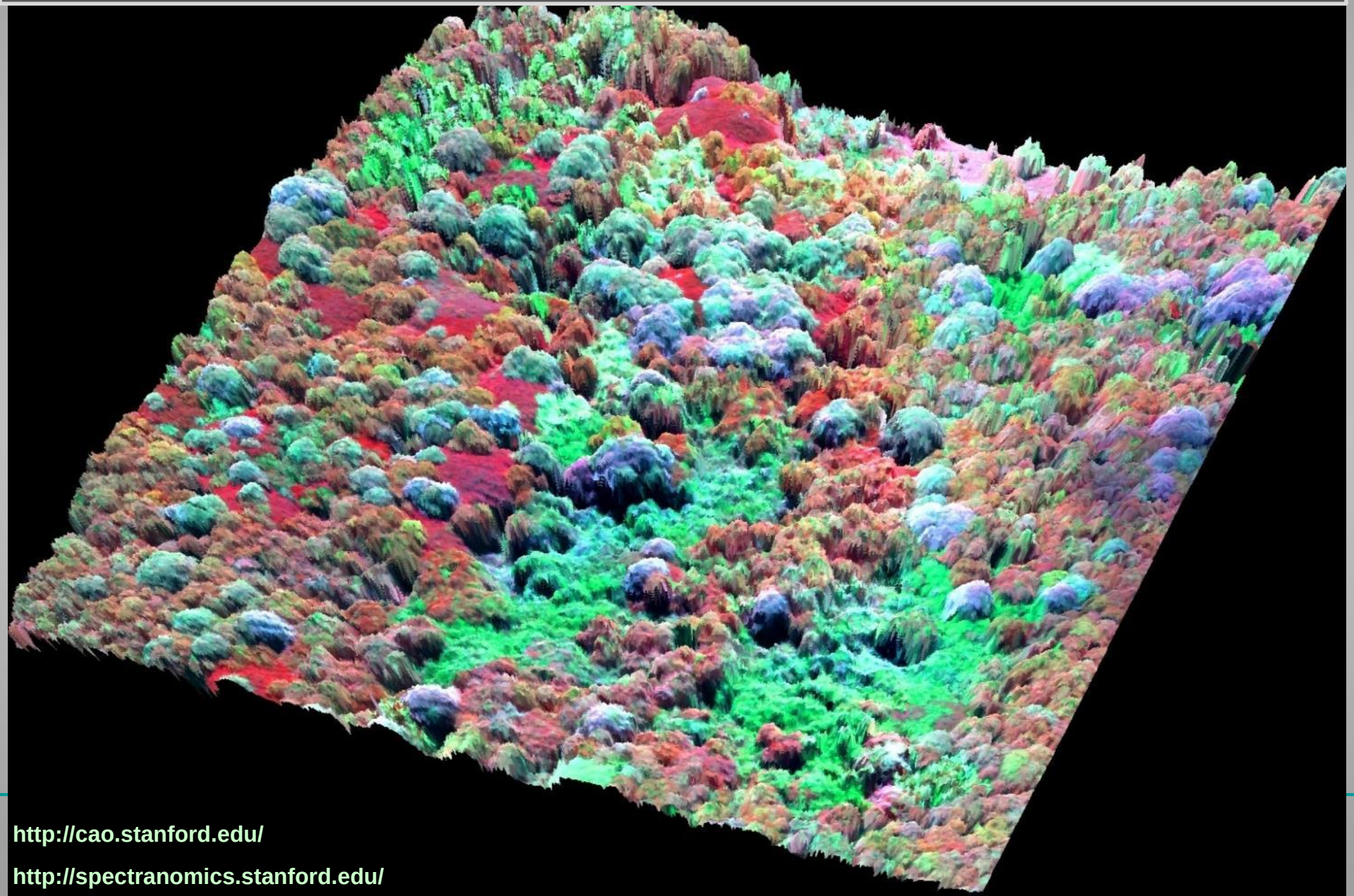


From Sylvie Durrieu



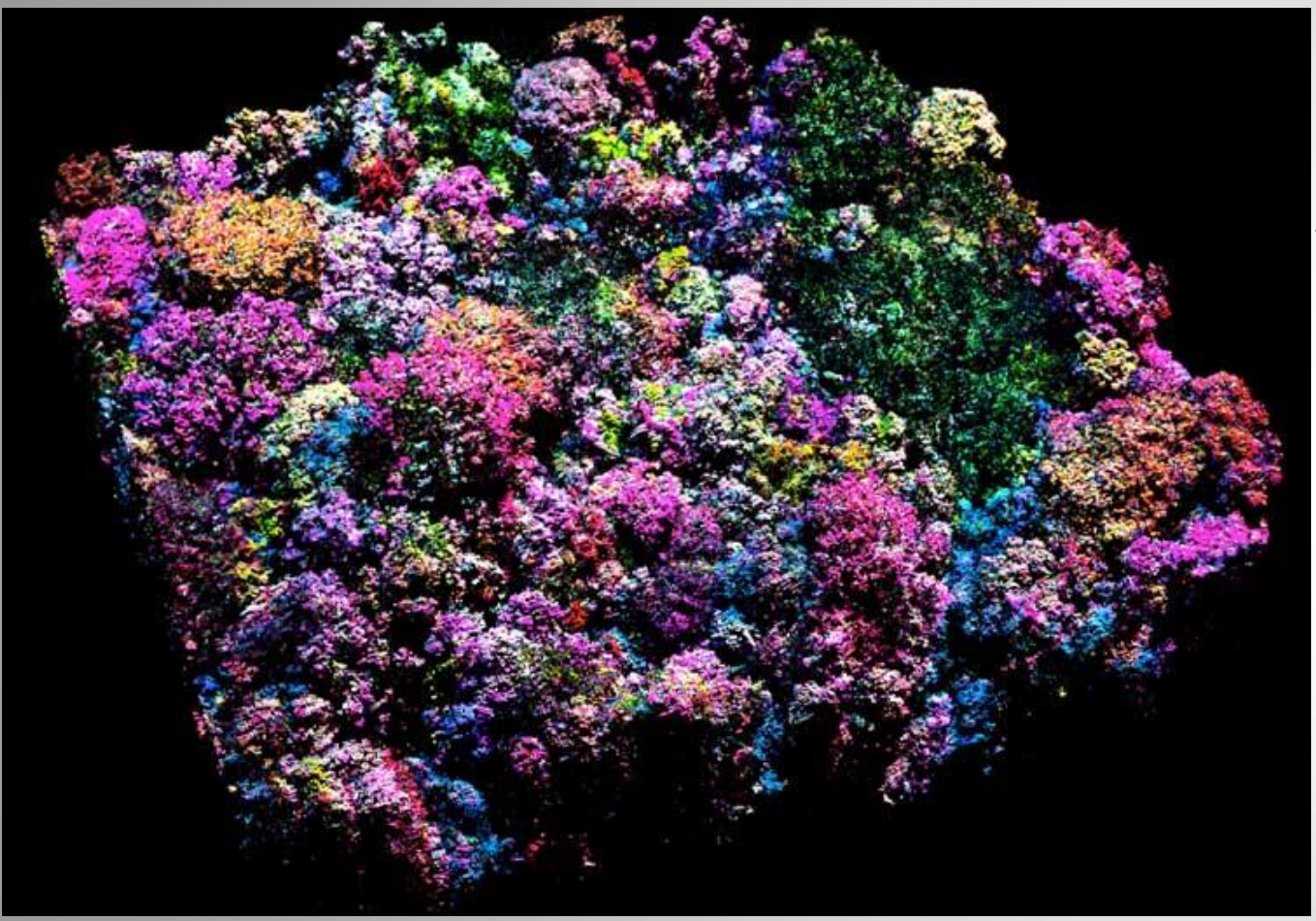
Pathways for EBVs informed by LIDAR

Diversity of sensors: combining imaging spectroscopy with LiDAR…



http://cao.stanford.edu/

http://spectranomics.stanford.edu/



Asner et al. 2017

Spectral Variability Hypothesis

variability in reflectance or "**spectral variability**" of an area is an expression of spatial ecosystem heterogeneity and therefore related to plant diversity

Diversity metrics

Alpha diversity – local richness
Beta diversity – turnover in species composition

Feret, J.; Boissieu, F. BiodivMapR: An r Package for A- and B-diversity Mapping Using Remotely Sensed Images. Methods Ecol. Evol. ***2020***

Rocchini, D.; Luque, S.; Pettorelli, N.et al. Measuring Diversity by Remote Sensing: A Challenge for Biodiversity Monitoring. Methods Ecol. Evol. 2018

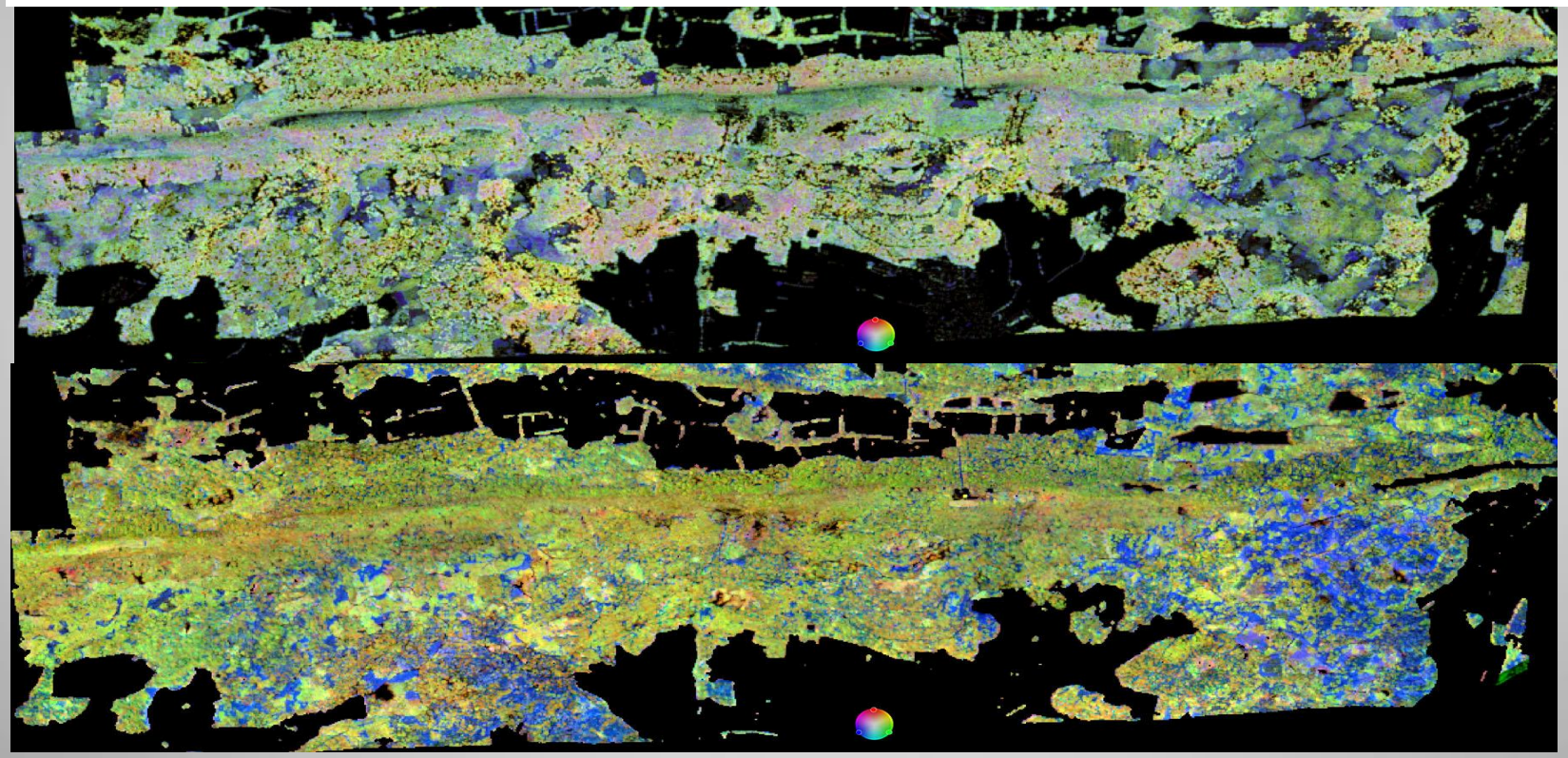
nature COMMUNICATIONS

ARTICLE

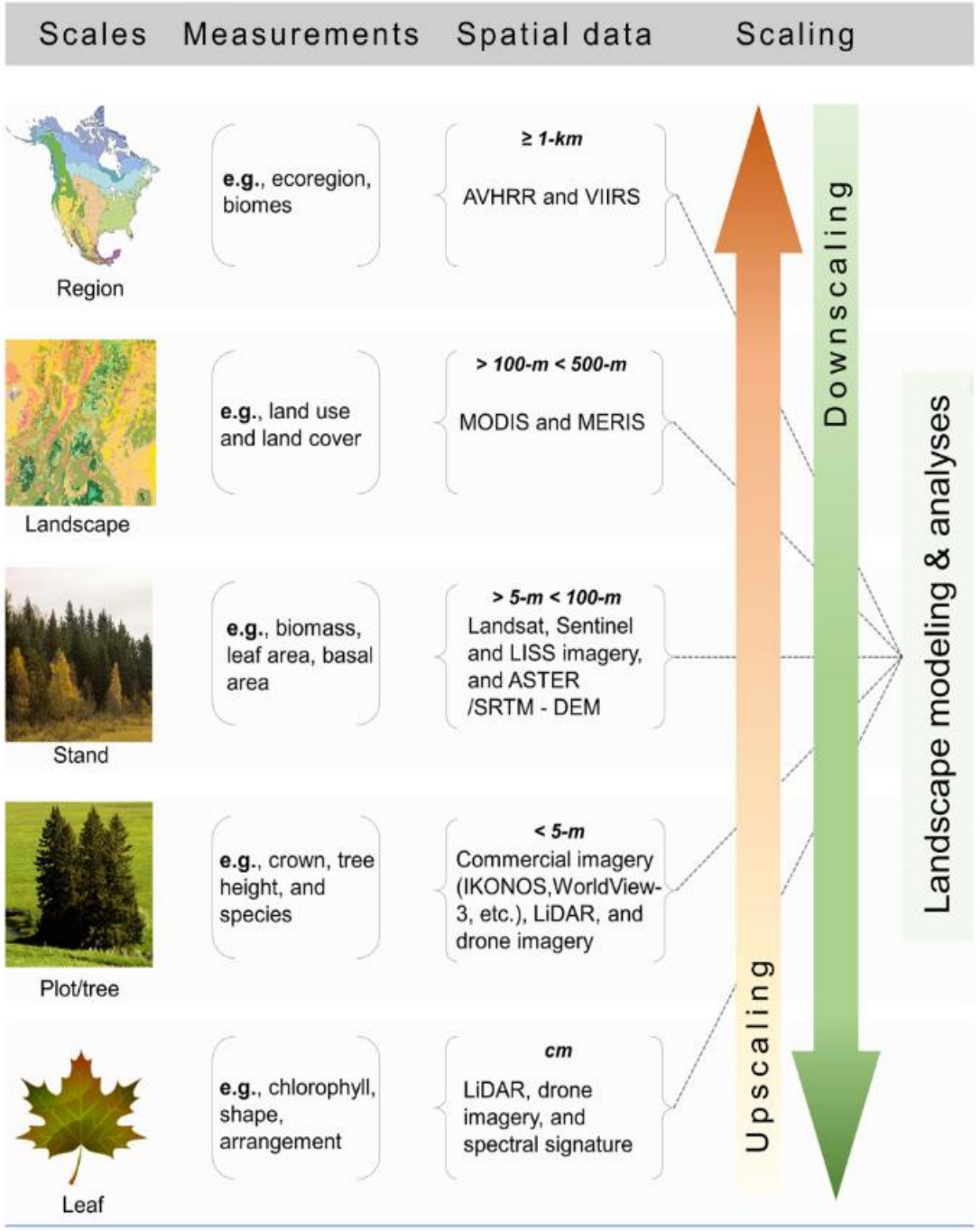
DOI: 10.1038/s41467-017-01530-3 OPEN

Mapping functional diversity from remotely sensed morphological and physiological forest traits

Fabian D. Schneider [1], Felix Morsdorf [1], Bernhard Schmid [2], Owen L. Petchey [2], Andreas Hueni [1], David S. Schimel [3] & Michael E. Schaepman [1]



Spatial composition of morphological and physiological forest traits. RGB colour composites of morphological traits (upper panel) plotted as abundance-scaled plant area index (PAI, blue), canopy height (CH, red) and foliage height diversity (FHD, green), and physiological traits (lower panel) plotted as abundance-scaled equivalent water thickness (EWT, blue), carotenoids (CAR, red) and chlorophyll (CHL, green) (2017)



A schematic of upscaling and downscaling with examples of feature scales, typical imagery and data types for representation, and common metrics extracted from the data (from Markham et al. Landscape Ecology 2023)

EETF Demonstrator Objective

Demonstrate the use of EO

for ecosystem extent mapping and monitoring

US Fish and Wildlife Service

Hudson's Bay Lowlands

- Focus: Map and monitor wetlands
  - Partner: ECCC
  - Ongoing, staffed
- Transition between boreal forest and arctic tundra
- Lots of peat
- Drivers include carbon reporting requirements
- 5 basic classes, 11 detailed classes

Parks Canada

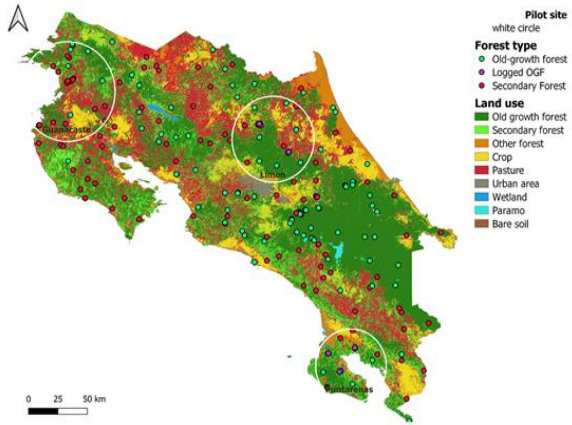
Great Western Woodlands

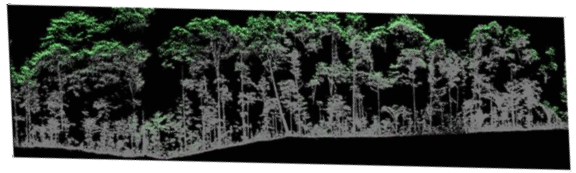
- Largest remaining area of temperate woodlands on Earth
  - Significant biodiversity and cultural values
  - Pressure from climate change and land-use intensification
  - Ecosystem extent maps needed to guide planning and management
- CSIRO postdoc position for three years
  - Collaboration: CSIRO, Dept of Biod & Conservation Attractions (DBCA), Uni Bristol
- Key questions
  - Can the delineation of vegetation types be improved with multi-wavelength SAR?
  - Can stand age be reliably mapped from multi-sensor satellite imagery?
  - Can historic stand growth rates be derived from time-series imagery?

EASI OPEN DATA CUBE

Tropical Forests – Costa Rica

- *Costa Rica* accounts for only 0.03 percent of the earth's surface. However it contains nearly 6 percent of the world's *biodiversity*
- Objectives
  - Assess conservation potential of secondary forests in human-modified landscape
  - Compare conservation potential of intact and disturbed forests
    - CNES/INRAE Data Analyst /ecologist position for 12 M (just hired)
    - Develop data cube for analyzing biodiversity data and trends
- Key questions
  - How to operationalize forest ecosystem extent mapping
  - How to assess conservation potential of secondary forests using multi-sensor satellite imagery?
  - How to assess secondary forests using α and β diversity predicted directly and indirectly from spectral information?





Summary

- EO is underutilized for biodiversity applications
- EO is recognised as an important source of information for the implementation of the Global Biodiversity Framework, in particular to detect changes in biodiversity globally and in a consistent way.
- Ecosystem Extent is a key product needed by a wide range of organizations
- Advancing technology and both current and forthcoming missions have the potential to greatly improve existing products to extend biodiversity capabilities
- Operational methods & tools to be linked to policies for improvement of public awareness and cost-effective management of biodiversity

Thank you


Mediterranean ecosystems:
Characterizing openness of vegetati
Alpine ecosystems:
Mapping habitats based on floristic inventory
Tropical ecosystems:
Mapping taxonomic diversity & species communities