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# Improving biodiversity monitoring coupling remote sensing and biodiversity data

Sandra Luque

► **To cite this version:**

Sandra Luque. Improving biodiversity monitoring coupling remote sensing and biodiversity data. INTECOL 2022, International Ecological Association, Aug 2022, Geneve, Switzerland. hal-03798313

**HAL Id: hal-03798313**

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Submitted on 5 Oct 2022

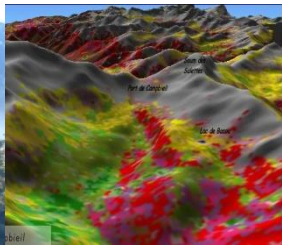
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## IMPROVING BIODIVERSITY MONITORING COUPLING REMOTE SENSING AND BIODIVERSITY DATA

Sandra Luque

**INRAE** National Research Institute on Agriculture, Food & the Environment,  
**Unit TETIS** *Land, environment, remote sensing and spatial information, Montpellier France*



Cop 15 à Kunming

Le monde  
11/09/2021

Biodiversity loss  
risks 'ecological  
meltdown'

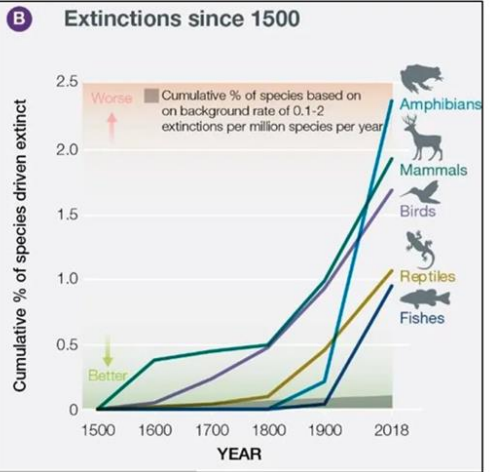


Humans exploiting and destroying  
nature on unprecedented scale - report



▲ Mass soybean harvesting in Cuijia Village, Brazil. Intensive agriculture has contributed to the collapse of some animal populations. Photograph: AFP/WWF

2021



# 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

Global biodiversity loss is on the rise (IPBES 2019)

"All the News  
That's Fit to Print"

# The New York Times

Late Edition

Today, clouds and sunshine, afternoon showers or thunderstorms, high 74. **Tonight**, cloudy, showers, 53. **Tomorrow**, partly sunny, cooler, high 66. Weather map, Page B16.

VOL. CLXVIII ... No. 58,320

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NEW YORK, TUESDAY, MAY 7, 2019

\$3.00

Wildlife Facing  
Extinction Risk  
All Over Globe



U.S. ADVISERS SAY  
CHINA IS RENEGING

IPBES  
GLOBAL  
ASSESSMENT  
SUMMARY FOR  
POLICYMAKERS  
(PDF)



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

Media Release

[\(Cliquez ici pour le texte en Français\)](#)

- Summary for Policymakers, photos, 'B-roll', other media resources: [bit.ly/IPBESReport](http://bit.ly/IPBESReport)
- Media launch webcast live from #IPBES7 (Paris, France): [bit.ly/IPBESWebcast](http://bit.ly/IPBESWebcast) starts at 1p.m. (Paris time – CEST) / 7 a.m. (US EDT) / noon (London – BST)
- For interviews: [media@ipbes.net](mailto:media@ipbes.net) or French: +33 62520-0281 English: +1-416-878-8712 or +1- 415-290-5516 or +49- 176-2538-2223 (After 7 May: +49-152-3830-0667)

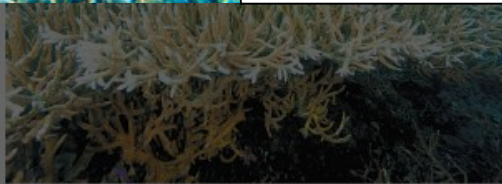
Nature's Dangerous Decline 'Unprecedented'  
Species Extinction Rates 'Accelerating'

Current global response insufficient;  
'Transformative changes' needed to restore and protect nature;  
Opposition from vested interests can be overcome for public good

Most comprehensive assessment of its kind;  
1,000,000 species threatened with extinction

in biodiversity across the globe and the dangers that creates for human civilization. A summary of its findings, which was approved by representatives from the United States and 131 other countries, was released Monday in Paris. The full report is set to be published this year.

Its conclusions are stark. In most major land habitats, from



more significant concessions from Beijing.

Mr. Trump, angry that China is retreating from its commitments just as the sides appeared to be nearing a deal and confident the American economy can handle a continuation of the trade war, will increase tariffs on \$200 billion worth of Chinese goods on Friday morning, his top advisers said.

CLOCKWISE FROM TOP LEFT: TONY KARUMBA/AGENCE FRANCE PRESSE ... GETTY IMAGES; BRUNO KELLY/REUTERS; SORIN ANDRUSCU/AFP ... GETTY IMAGES; JURGEN FREUND/NPL/INDIGO PICTURES



Convention on Biological Diversity

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

## Global Policy Goals and Biodiversity Targets

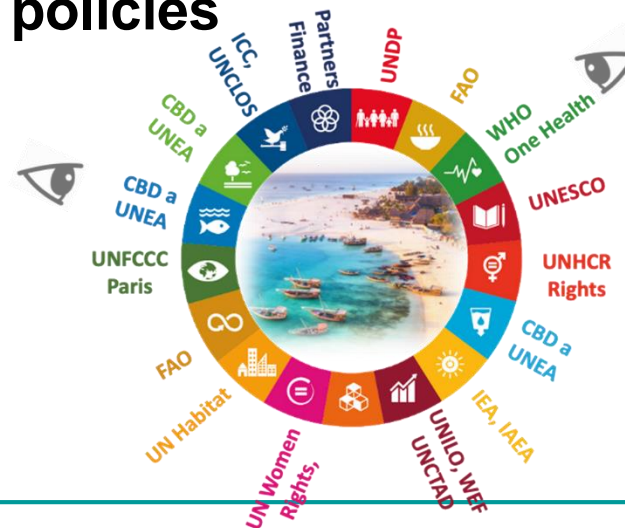


Scientific evidence can underpin environmental policies



UNITED NATIONS DECADE ON ECOSYSTEM RESTORATION 2021-2030

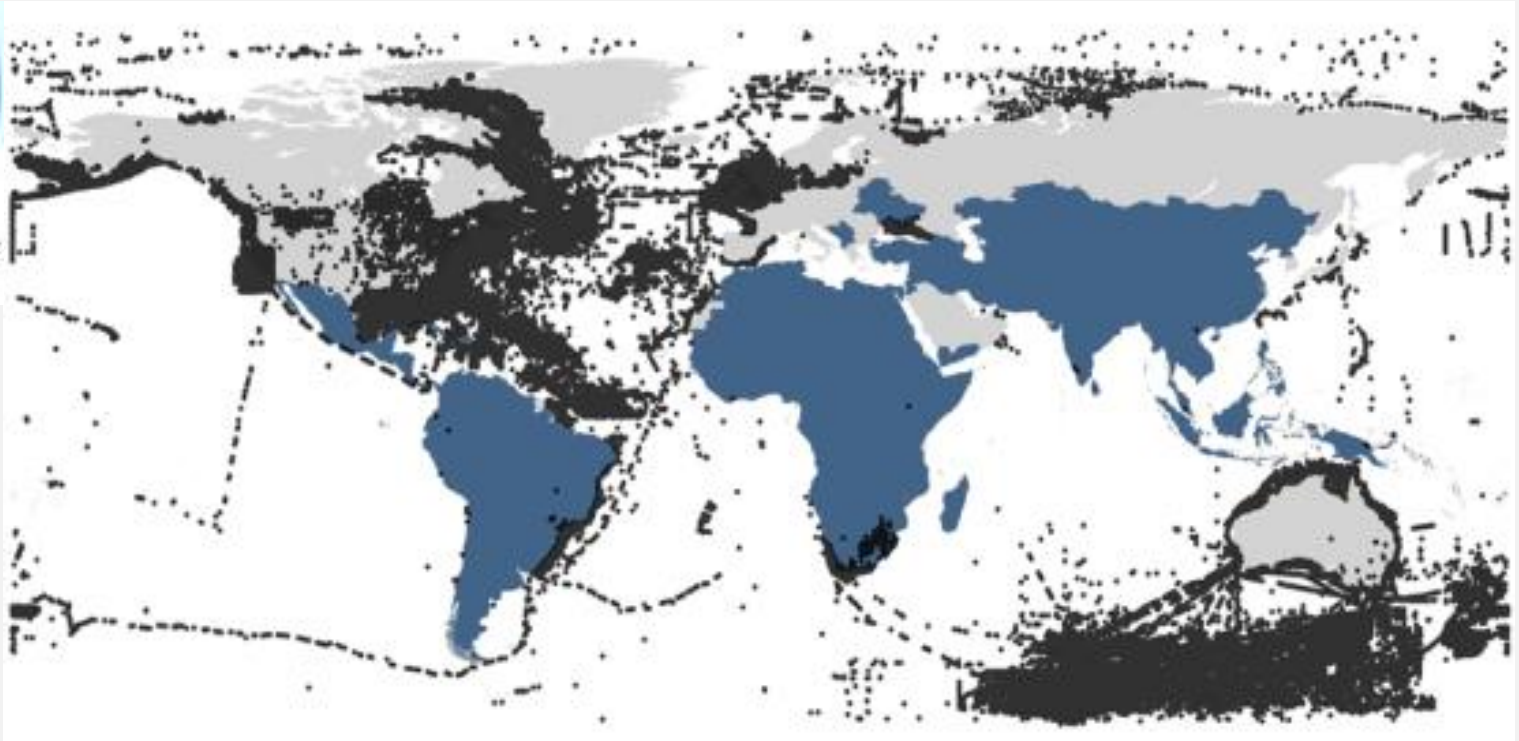
RESTORE OUR FUTURE BONN CHALLENGE



# BIG DATA to answer conservation needs



University of  
St Andrews



**BioTIME database contains c. 12 million records, nearly 50,000 species and 124 unique years from locations across the globe (black dots) (600 thousand distinct geographic locations and is representative of over 20 biomes, occurring over 6 different climatic zones)**

**BioTIME follows the guiding principles of FAIR data (Findable, Accessible, Interoperable, Reusable).**

**Coupling temporal big data with spatio-temporal remote sensing data to study biotic homogenization and patterns of change across gradients of anthropogenic pressures**

# What do we know about biodiversity?



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Species

Locations

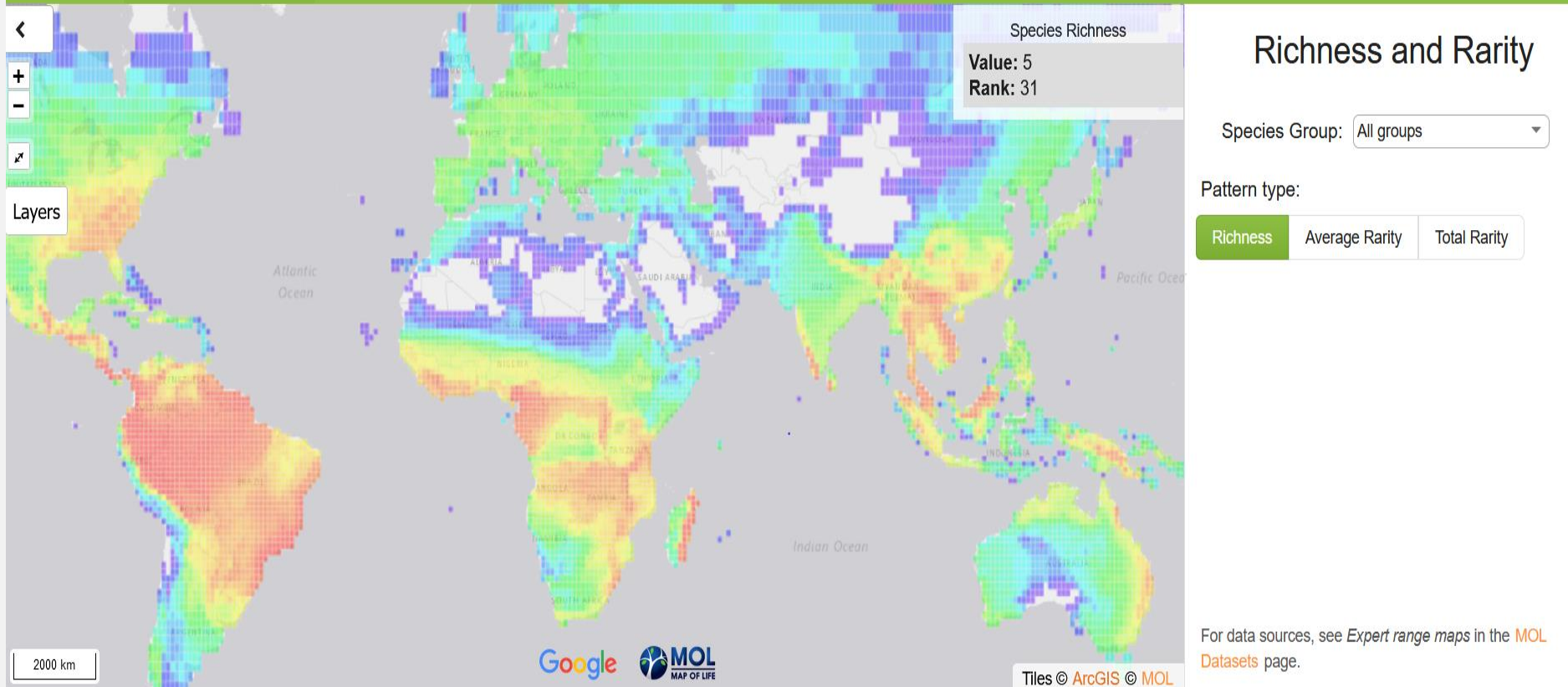
Indicators

Patterns

Overview

Richness and Rarity

Background



**Several latest studies working with large global database of different nature, -have been contesting- that such loss is actually occurring in particular at local scales in nature (Vellend et al 2013, Dornelas et al 2014 ; Elahi et al. 2015; Newbold et al 2015). Nevertheless, land-use change due to human pressures is recognized as the main driver of global biodiversity degradation – still the relative impact on species turnover ( $\beta$ -diversity) across multiple spatial scales remains unclear**

DOWNLOAD AS TSV

## GBIF Backbone Taxonomy

Checklist dataset

The GBIF Backbone Taxonomy is a single, synthetic management classification with the goal of covering all names GBIF is dealing with. It's the taxonomic backbone that allows GBIF to integrate...

Published by GBIF Secretariat

6 783 300 records 77 citations

## Catalogue of Life Checklist

Checklist dataset

The Catalogue of Life is an assembly of expert-based global species checklists with the aim to build a comprehensive catalogue of all known species of organisms on Earth. Continuous progress is made t...

Published by The Catalogue of Life Partnership

4 675 779 records 7 citations

## NCBI Taxonomy

Checklist dataset

The NCBI taxonomy database is not a primary source for taxonomic or phylogenetic information. Furthermore, the database does not follow a single taxonomic treatise but rather attempts to incorporate p...

Published by National Center for Biotechnology Information (NCBI)

3 348 623 records 2 citations



➤ **The tropics lost 11.1 million hectares of tree cover in 2021 (new data from the 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**



**Landscape homogenization**

## Measuring Forest Biodiversity Status and Changes Globally

Samantha L. L. Hill<sup>1,2\*</sup>, Andy Arnell<sup>1\*</sup>, Calum Maney<sup>1</sup>, Stuart H. M. Butchart<sup>1,3</sup>, Craig Hilton-Taylor<sup>1</sup>, Carolyn Cicciarelli<sup>4</sup>, Crystal Davis<sup>5</sup>, Eric Dinerstein<sup>1</sup>, Andy Purvis<sup>1</sup> and Neil D. Burgess<sup>1,4,6</sup>

<sup>1</sup> UN Environment World Conservation Monitoring Centre (UNEP-WCMC), Cambridge, United Kingdom, <sup>2</sup> Department of Science, The Natural History Museum, London, United Kingdom, <sup>3</sup> BirdLife International, The David Attenborough Centre for Nature Conservation, Cambridge, United Kingdom, <sup>4</sup> Department of Zoology, University of Cambridge, Cambridge, United Kingdom, <sup>5</sup> Species Programme, Cambridge, United Kingdom, <sup>6</sup> WRI, Washington, DC, United States, <sup>7</sup> RESOLVE, Washington, United States, <sup>8</sup> Department of Life Sciences, Imperial College London, Ascot, United Kingdom, <sup>9</sup> CIMEC, 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<sup>\*</sup>, Philippe Lejeune<sup>①</sup>, Adrien Michez<sup>①</sup> and Adeline Fayolle<sup>①</sup>

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



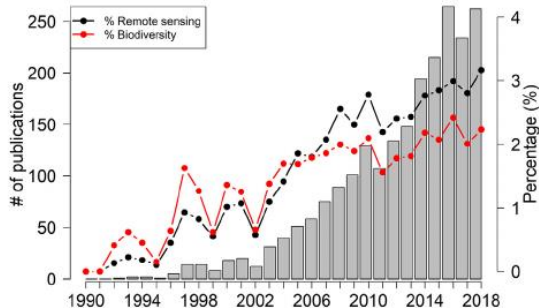
Ecological Informatics  
Volume 61, March 2021, 101195



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

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

## Rocchini et al, Ecological Informatics 2021



## Remote sensing of terrestrial plant biodiversity

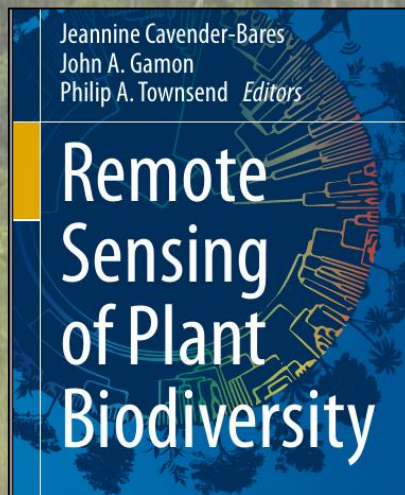
Ran Wang<sup>a,\*</sup>, John A. Gamon<sup>a,b,c</sup>

<sup>a</sup> Department of Earth and Atmospheric Sciences, University of Alberta, Edmonton, AB T6G 2E3, Canada

<sup>b</sup> Department of Biological Sciences, University of Alberta, Edmonton, AB T6G 2E9, Canada

<sup>c</sup> 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



SPECIAL FEATURE: REMOTE SENSING | [Open Access](#) | [CC](#) | [i](#)

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

Michele Torresani ✉, Hannes Fellhauer, Duccio Rocchini, Jean-Baptiste Féret, Marc Zebisch, Giustino Toton

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

## Torresani et al, Applied Vegetation Science 2021

# 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



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

ECOLOGY

## Essential Biodiversity Variables

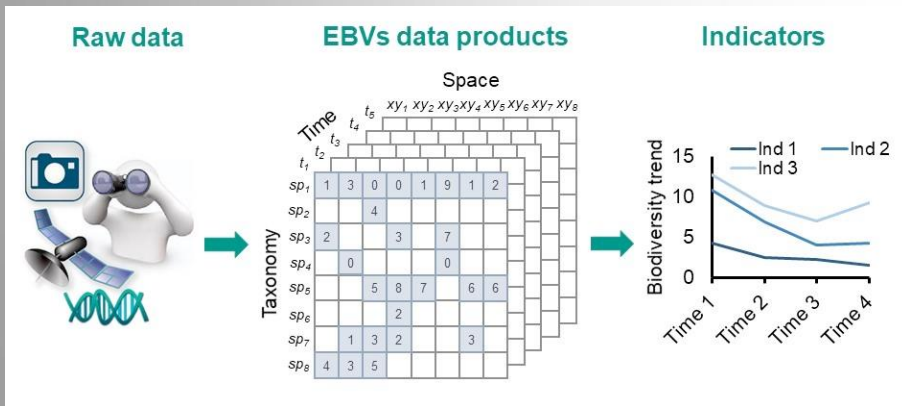
H. M. Pereira,<sup>1\*</sup> S. Ferrier,<sup>2</sup> M. Walters,<sup>3</sup> G. N. Geller,<sup>4</sup> R. H. G. Jongman,<sup>5</sup> R. J. Scholes,<sup>3</sup> M. W. Bruford,<sup>6</sup> N. Brummitt,<sup>7</sup> S. H. M. Butchart,<sup>8</sup> A. C. Cardoso,<sup>9</sup> N. C. Coops,<sup>10</sup> E. Dulloo,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

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

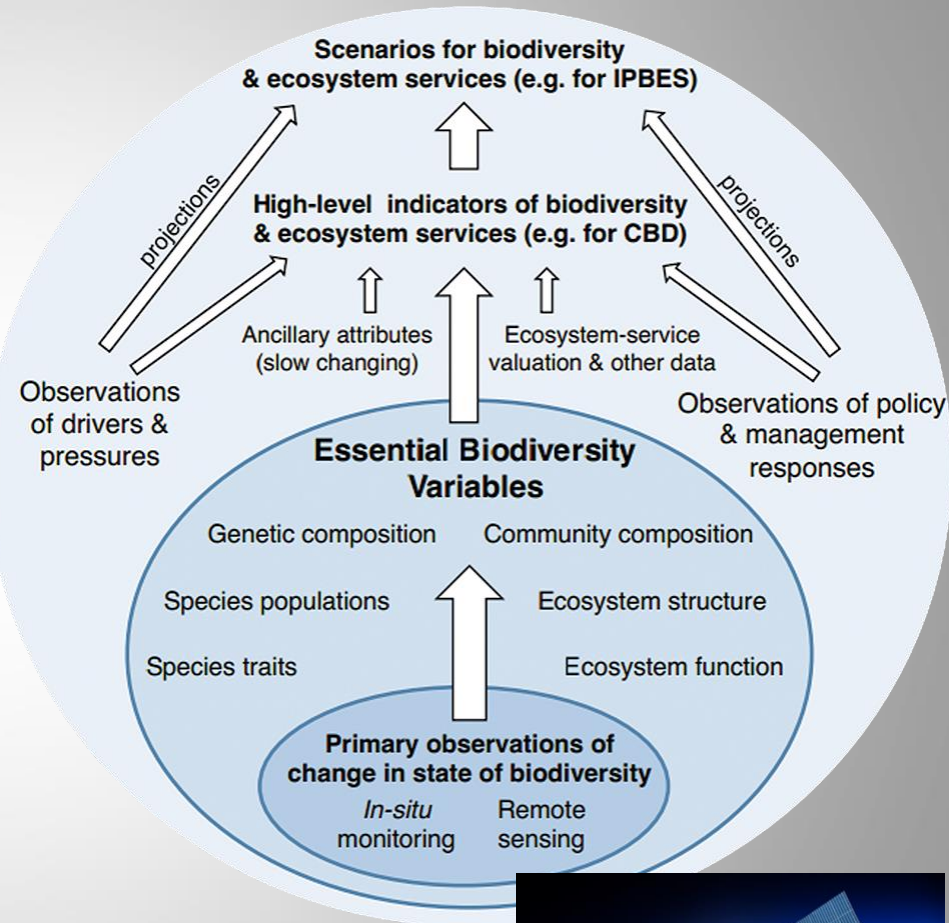
# How can we reliably measure and monitor the state of biodiversity at various spatial scales?

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



# Remote sensing as a key data source for biodiversity monitoring

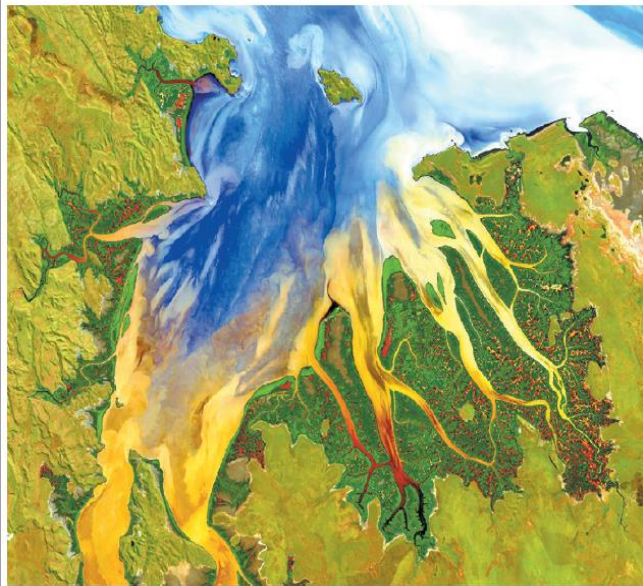
Earth observation appropriate to provide information for the monitoring of biodiversity

‘RS enabled EBVs’

- Regional / global monitoring
- Cost effective
- Coupling with global modeling tools
- Combined with *in situ* observation networks



Very active domain of research, boosted by increased RS data availability (including LandSat & Copernicus)



Estuary sediment and vegetation patterns in Australia, captured by NASA's Landsat 8 satellite in 2013.

Agree on biodiversity metrics to track from space

Ecologists and space agencies must forge a global monitoring strategy, say **Andrew K. Skidmore**, **Nathalie Pettorelli** and colleagues.

**Skidmore et al. 2015, Nature, 523(7561)**

# Operationalization Biodiversity mapping with satellite data

Received: 22 September 2017 | Accepted: 11 November 2017  
DOI: 10.1111/2041-210X.12941

IMPROVING BIODIVERSITY MONITORING  
USING SATELLITE REMOTE SENSING

Methods in Ecology and Evolution

Remote Sensing in Ecology and Conservation

Open Access

ZSL  
LET'S WORK  
FOR WILDLIFE

## Measuring $\beta$ -diversity by remote sensing: A challenge for biodiversity monitoring

Duccio Rocchini<sup>1,2,3</sup> | Sandra Luque<sup>4</sup> | Nathalie Pettorelli<sup>5</sup> | Lucy Bastin<sup>6</sup> | Daniel Doktor<sup>7</sup> | Nicolò Faedi<sup>3,8</sup> | Hannes Feilhauer<sup>9</sup> | Jean-Baptiste Féret<sup>4</sup> | Giles M. Foody<sup>10</sup> | Yoni Gavish<sup>11</sup> | Sergio Godinho<sup>12</sup> | William E. Kunin<sup>13</sup> | Angela Lausch<sup>7</sup> | Pedro J. Leitão<sup>14,15</sup> | Matteo Marcantonio<sup>16</sup> | Markus Neteler<sup>17</sup> | Carlo Ricotta<sup>18</sup> | Sebastian Schmidlein<sup>19</sup> | Petteri Vihervaara<sup>20</sup> | Martin Wegmann<sup>21</sup> | Harini Nagendra<sup>22</sup>

REVIEW

## Satellite remote sensing to monitor species diversity: potential and pitfalls

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



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ScienceDirect

Remote Sensing of Environment 111 (2007) 423–434

Remote Sensing  
of  
Environment

[www.elsevier.com/locate/rse](http://www.elsevier.com/locate/rse)

Short Communication

## Measuring Rao's Q diversity index from remote sensing: An open source solution

Duccio Rocchini<sup>a,\*,1</sup>, Matteo Marcantonio<sup>a,b,1</sup>, Carlo Ricotta<sup>c</sup>

## Effects of spatial and spectral resolution in estimating ecosystem $\alpha$ -diversity by satellite imagery

Duccio Rocchini \*



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Remote Sensing of Environment

journal homepage: [www.elsevier.com/locate/rse](http://www.elsevier.com/locate/rse)



remote sensing



Article

## Realistic Forest Stand Reconstruction from Terrestrial LiDAR for Radiative Transfer Modelling

Kim Calders<sup>1,2,3,\*</sup>, Niall Origo<sup>1,2</sup>, Andrew Burt<sup>2</sup>, Mathias Disney<sup>2,4</sup>, Joanne Nightingale<sup>1</sup>, Pasi Raunonen<sup>5</sup>, Markku Åkerblom<sup>5</sup>, Yadvinder Malhi<sup>6</sup> and Philip Lewis<sup>2,4</sup>

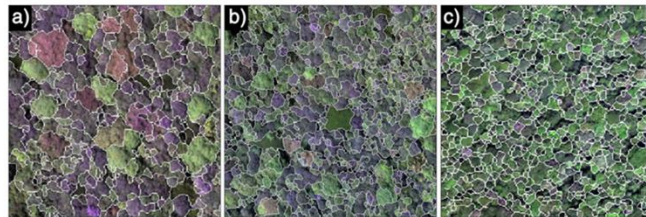


Fig. 10. Visual results obtained when using mean shift clustering, PC selection without PC # 1 and size threshold of 1200 for Hawaii (a, b) and 150 for Panama (c).



A satellite remote sensing map showing various land use patterns in different colors (green, purple, brown, orange). A magnifying glass is positioned over a specific area on the left side of the map, highlighting a cluster of buildings and roads. The text 'VIENT DE PARAITRE' is written inside the magnifying glass.

VIENT DE  
PARAITRE

Methods in  
Ecology and  
Evolution

NUMÉRO SPÉCIAL DE 'METHODS IN ECOLOGY AND EVOLUTION'

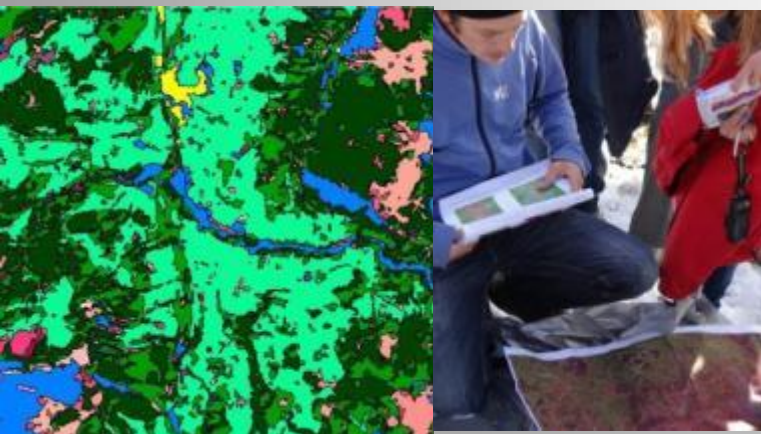
# Improving Biodiversity Monitoring Using Satellite Remote Sensing

Improving biodiversity monitoring using satellite remote sensing to provide solutions towards the 2030 conservation targets  
Sandra Luque | Nathalie Pettorelli | Petteri Vihervaara | Martin Wegmann. (2018)



# Over-arching research goals

- ❑ Innovation & technology for improved biodiversity monitoring coupling in situ data & RS
- ❑ Other types of data should be considered for application of methods for diversity mapping based on spectral heterogeneity
- ❑ Operational methods & tools to be linked to policies for improvement of public awareness and cost-effective management of biodiversity
- ❑ Using a mixture of remote sensing and field based data requires ecologists and remote sensing experts to collaborate closely to make the best use of the newest remote sensing capabilities and modelling approaches

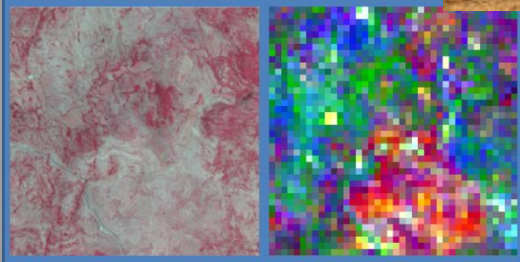


# Thank you

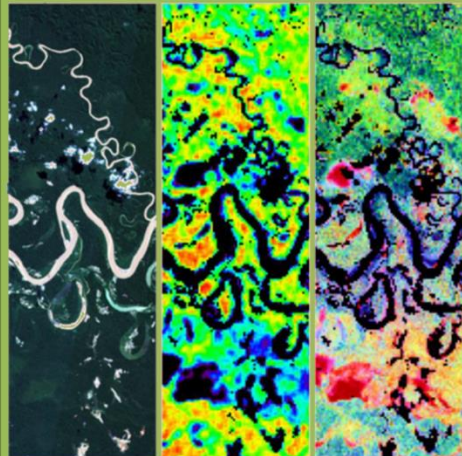
Jean Baptiste Féret, Eric Chraïbi, Maxime Lenormand,  
Samuel Alleaume



*Mediterranean ecosystems:*  
Characterizing openness of vegetation



*Tropical ecosystems:*  
Mapping taxonomic diversity & species communities



*Alpine ecosystems:*  
Mapping habitats based on floristic inventory

