Biodiversity from space

Opportunities for advancing monitoring with satellite remote sensing

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Workshop on "E-shape solutions: Earth Observation for biodiversity and water management", 14 February 2023, 11:00-11:20, the Hague

Introducing

Joris Timmermans

- Expert on (joint) optical, thermal and microwave RS
- ITC, Utwente, UCL, Leiden University, University of Amsterdam, Lifewatch

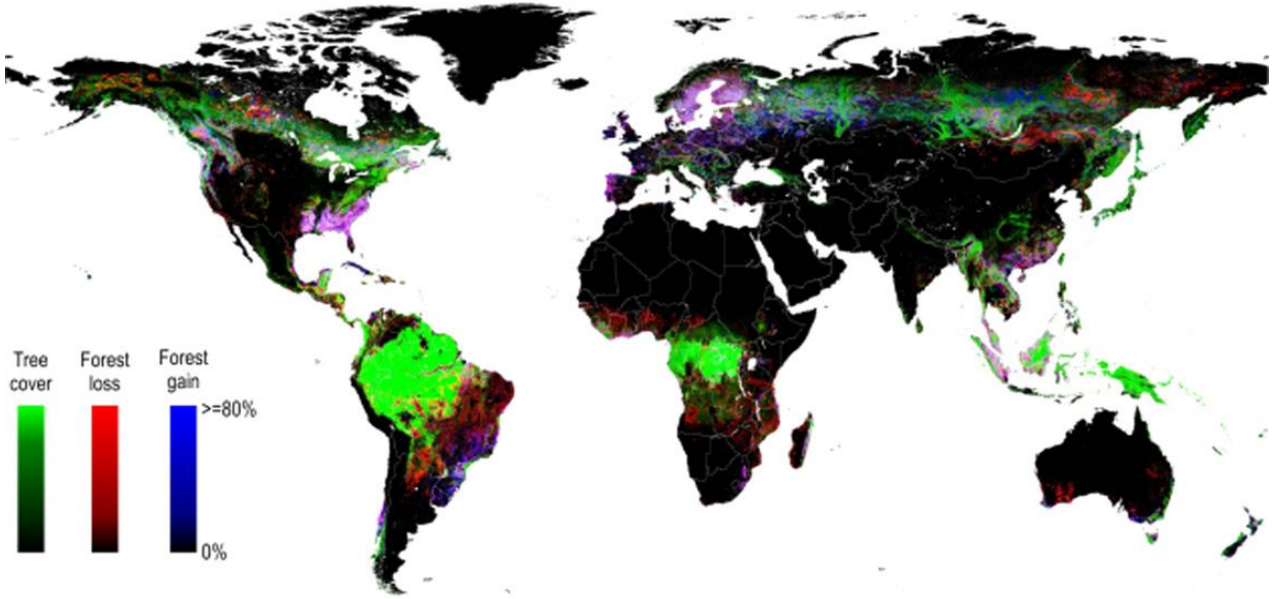
LifeWatch

- Tackle constraints affecting biodiversity research
  - Pressing need for increasingly diverse data
  - Larger and more advanced models
  - Open data and open science clouds
- Facilitate ecological policy making
  - Co-design new workflows

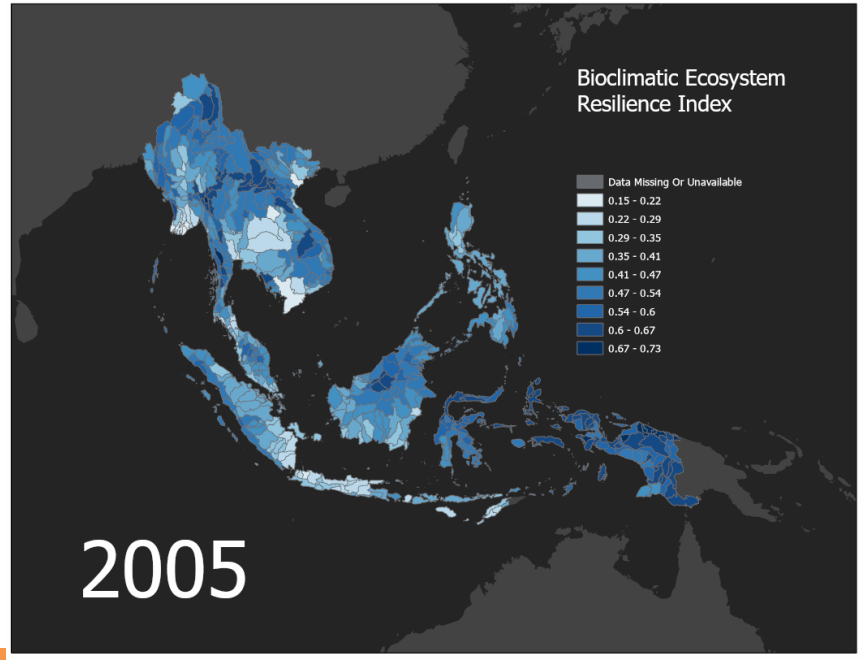
https://www.lifewatch.eu/

Potential of satellite remote sensing

Global Forest Cover product (Hansen et al., 2013)



Bioclimatic Ecosystem Resilience Index (Ferrier et al, 2020).



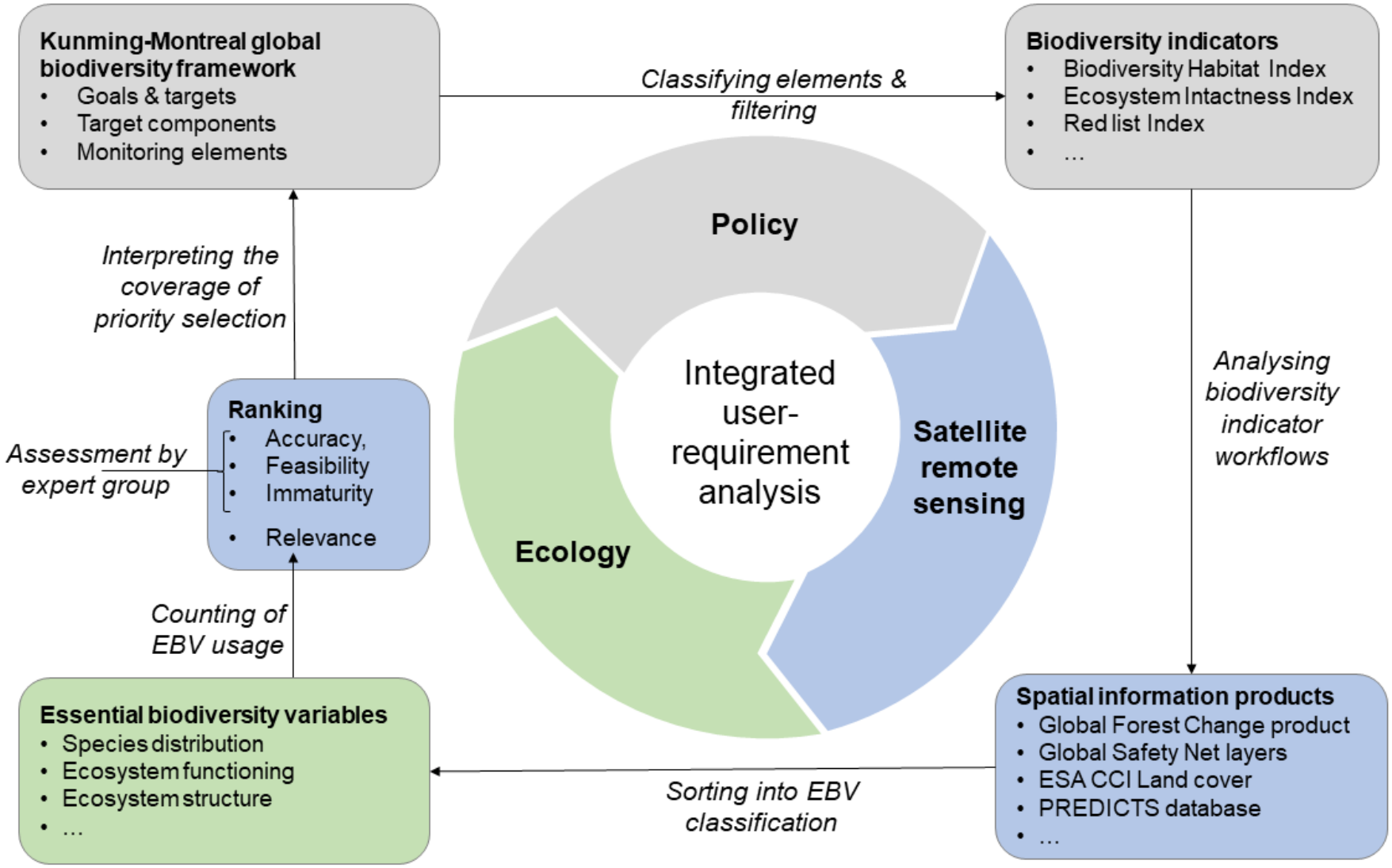
To repeat such a success story, advancements in RS need to guided with requirements of ecologists and policy makers

Opportunity

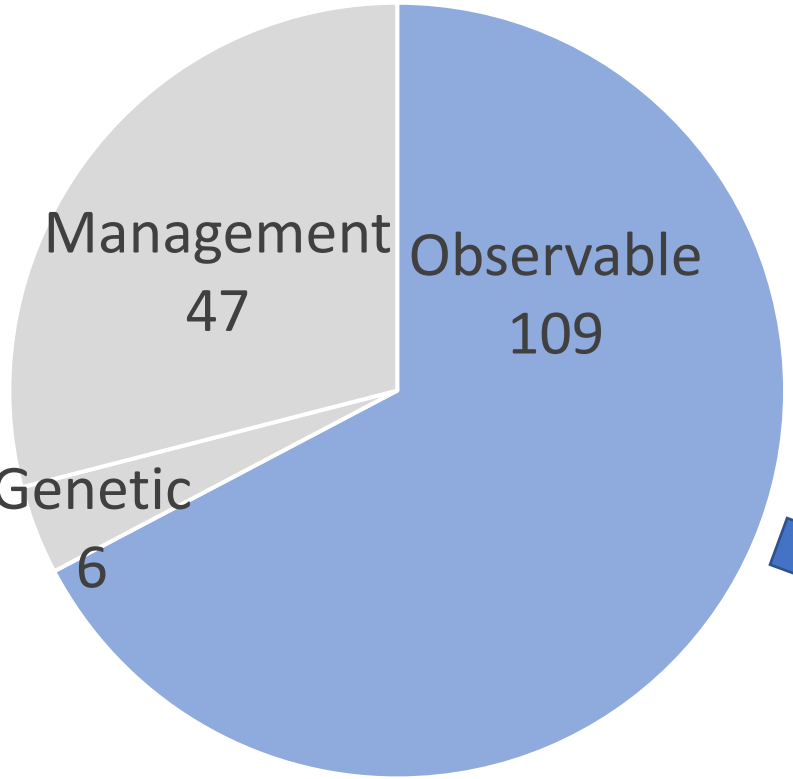
- Kunming-Montreal global biodiversity framework (GBF) (CBD,2022)
  - 2019 August : 0th draft
  - 2021 July: 1st draft
  - 2022 December: finalized at COP15

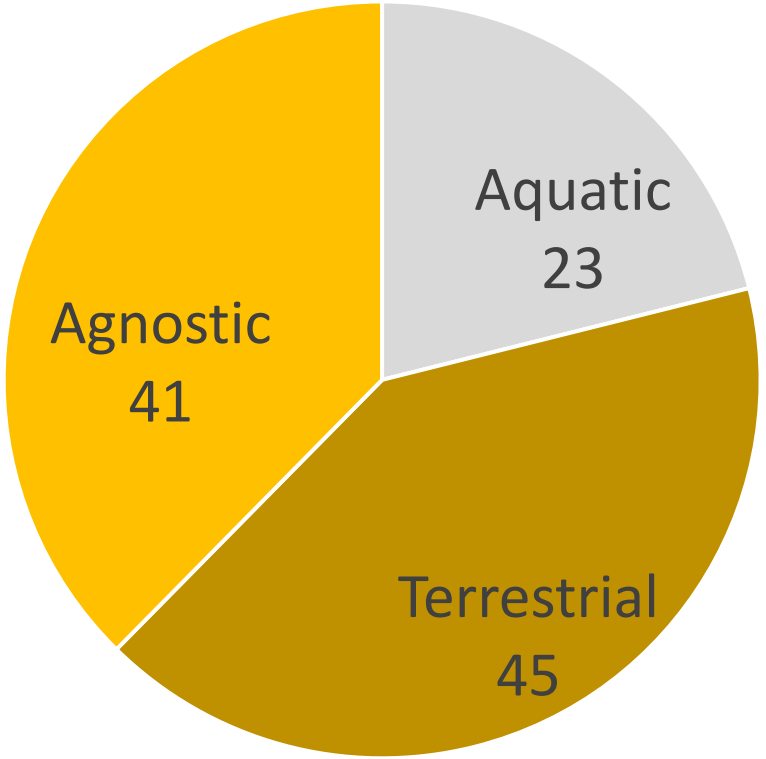
  - SMART
    - 4 Long term goals for 2050, with corresponding
    - 23 targets to assess progress in 2030
    - 371 usages of biodiversity indicators

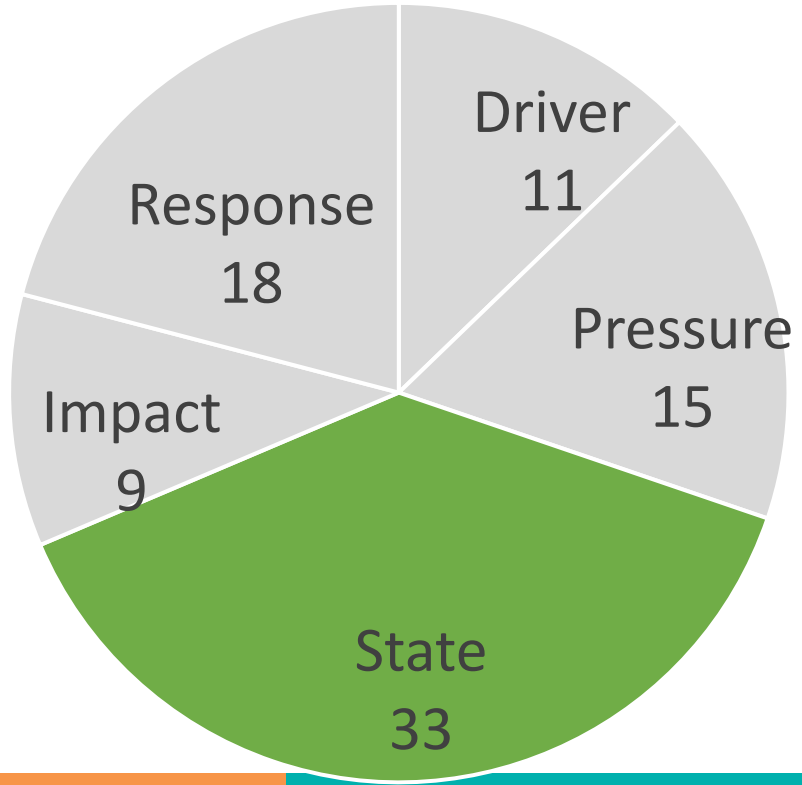
To quantify the opportunities



Analysing GBF monitoring elements







Identified goals and targets

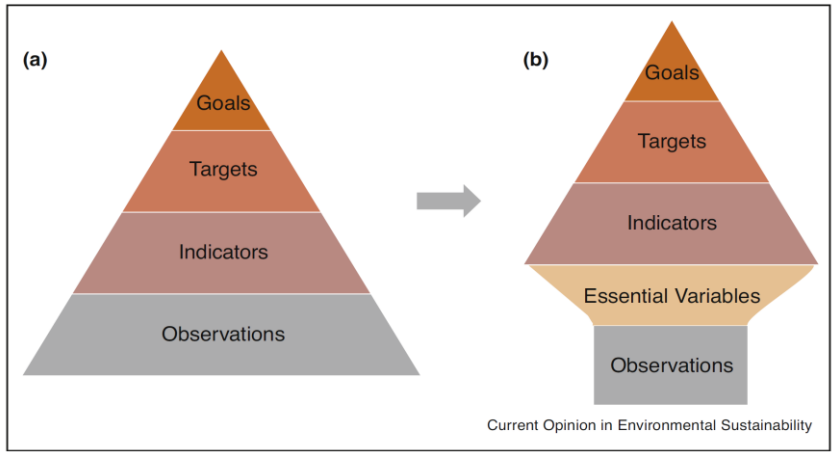
Goal description	Target description
Goal A: Reduce threats	T01. Bring the loss of areas of high biodiversity importance close to zero by 2030.
	T02. Ensure that >30% of degraded ecosystems are under effective restoration by 2030
	T03. Enable that >30 percent of areas are made into protected areas or other effective area-based conservation measures by 2030
	T06. Reduce the impacts of invasive alien species on biodiversity and ecosystem services by 2030
	T08. Minimize the impact of climate change and ocean acidification on biodiversity by 2030
Goal B: Meet peoples needs	T10. Ensure that areas under agriculture, aquaculture, fisheries and forestry are managed sustainably.
	T11. Restore, maintain and enhance nature's contributions to people.

To track progress of these goals/targets, we find 86 usages of 57 unique biodiversity indicators, of which 35 provided enough information for a workflow analysis

Products used by biodiversity indicators

- Large number (88) and heterogeneity of geospatial data products

Essential Biodiversity Variables (EBV) are a set of the derived measurements required to report on biodiversity change, ***which help prioritize specific products by defining a minimum essential set to capture major dimensions*** *of biodiversity change (Pereira et al., 2013)*



ID	Variable name (as used in the biodiversity indicator workflows)	Indicator number	EBV classification	Spatial information products	Citation / responsible organisation
1	Above ground biomass	1	Primary productivity	SDG 15.2.1	(FAO, 2020a)
2	Agricultural land cover	22	Ecosystem distribution	Data from national reports	FAO
3	Beta diversity	6,25	Taxonomic/phylogenetic diversity	PREDICTS database	(Hoskins et al., 2020)
4	Beta diversity	16	Taxonomic/phylogenetic diversity	Global Safety Net layers	(Dinerstein et al., 2020)
5	Biodiversity hotspots	16	Species distributions	Global Safety Net layers	(Dinerstein et al., 2020)
6	Bird population	35	Species distributions	Data from national surveys (Common Birds Census, the Breeding Bird Survey, the Wetland Bird Survey)	BTO, USGS, JNCC, RSPB, WWT
7	Ecoregions	31	Ecosystem distribution	SRTM & ASTER DEM data	(Abrams et al., 2020)
8	Ecosystem quality	10, 16	Live cover fraction	Human Footprint Index	(Venter et al., 2016)
9	Energy balance	14	Primary productivity	MCD43 MOD11 MCD12Q MYD13A3	(Schaaf, C., Wang, 2015), (Wan, 1999), (Sulla-Menashe and Friedl, 2018) (Didan, 2015)
10	Forest area	4	Live cover fraction	Data from the forest management certification	(FAO, 2020a)
11	Forest areas under sustainable management	19	Live cover fraction	Data from the forest management certification	(FAO, 2020a)
12	Forested area and characteristics	3, 5, 6, 12, 33, 34	Live cover fraction	Global Forest Change product	(Hansen et al., 2013)
13	Fractional cover	31	Live cover fraction	LUH2 - fractional cover product	(Hurtt et al., 2020)
14	Soil composition	8	Primary productivity	GSOC Map	(FAO, 2020b)
15	Soil types	8	Primary productivity	Harmonized World Soil Database	FAO
17	Important bird & biodiversity areas	24,	Ecosystem distribution	protected areas key biodiversity areas	(UNEP-WCMC, 2019)
18	Intact large mammal assemblages	16	Community abundance	Global Safety Net layers	(Morrison et al., 2007)
19	Introduced and invasive species	20	Ecosystem distribution	Data from GRIIS	(Pagad, 2018)
20	IUCN range rarity sites	16	Species distributions	Global Safety Net layers	(Hill et al., 2019)
21	IUCN threatened species sites	16	Species distributions	Global Safety Net layers	(Hill et al., 2019)
22	Key biodiversity areas	16	Ecosystem distribution	WDPA	Birdlife international
23	Land cover	13, 18	Live cover fraction	Landcover CCI	ESA (ESA, 2017)
24	Land cover	32	Ecosystem distribution	Landsat 5, Landsat 7 and Landsat 8	NASA
25	Land cover	6	Ecosystem distribution	CLC product	MCD12Q (Tuanmu and Jetz, 2014)
26	Land cover change	14	Ecosystem distribution	Global Forest Change product	(Hansen et al., 2013)
27	Land productivity degradation	14	Ecosystem disturbances	MYD13A3	(Didan, 2015)
28	Land use	6, 31	Ecosystem distribution	LUH2 - land use product	(Hurtt et al., 2020, 2011)
29	Land use	7, 34	Ecosystem distribution	Internal data products	(Hoskins et al., 2016)
30	Land use intensity	7, 34	Ecosystem distribution	Internal data products	(Newbold et al., 2016)
31	Land use / cover (change)	26, 32	Ecosystem distribution	MCD12Q1	(Sulla-Menashe and Friedl, 2018)
32	Land use / cover (change)	25	Ecosystem distribution	Data from WDPA	UNEP-WCMC
33	Last of the wild in each ecoregion	16	Species distributions	Global Safety Net layers	(Plumptre et al., 2019)
34	Local terrestrial diversity	7, 33	Taxonomic/phylogenetic diversity	PREDICTS database	(Hudson et al., 2014)
35	Mountain location	18	Ecosystem distribution	SRTM DEM	(Sayre et al., 2020)
36	Natural (biological) hazards	15	Ecosystem disturbances	Fire and Drought Risk maps	(NESDIS NOAA, 2013)
37	Population	32	Species distributions	Rate of Decline, Range & Occurrence data	MOL
38	Population density	7	Live cover fraction	Data from GRUMP	(NASA Socioeconomic Data and Applications Center (SEDAC), 2016)
39	Potential connectivity	13	Ecosystem distribution	Connectivity data	(Laestadius et al., 2011)
40	Effects of ~agriculture on biodiversity	13	Ecosystem disturbances	Data on agriculture	USGS
41	Effects of deforestation on biodiversity	13	Ecosystem disturbances	Global Forest Change product	(Hansen et al., 2013)
42	Rare plant species	16	Species distributions	Global Safety Net layers	(Enquist et al., 2019)
43	Small-range vertebrate sites	16	Species distributions	Global Safety Net layers	(Pimm et al., 2018)
44	Species geographic distributions	31	Species distributions	MOL/GBIF records	MOL (Map of Life)
45	Species occurrence	5, 6, 25	Species distributions	MOL/GBIF records	(Hoskins et al., 2020)
46	Temperature condition	15	Primary productivity	Brightness temperature (...)	(NESDIS NOAA, 2013)
47	Threatened species	24, 29, ,	Species distributions	Red List	IUCN
48	Tropical primary forest land cover	3	Ecosystem distribution	Tropical primary forest land cover	(Turubanova et al., 2018)
49	Gridded cell covered by primary vegetation	15	Primary productivity	MODIS vegetation condition maps	(NESDIS NOAA, 2013)
50	Vegetation cover	5, 25	Live cover fraction	MODIS vegetation continuous fields	MOD44B (DiMiceli et al., 2017)
51	Vegetation coverage	15	Live cover fraction	Vegetation Health maps	(NESDIS NOAA, 2013)
52	Vegetation greenness	15	Ecosystem phenology	no noise NDVI maps	(NESDIS NOAA, 2013)
53	Soil Emission potentials	8	Primary productivity	WISE30Sec grids	ISRIC (Batjes, 2016)

Essential Biodiversity Variables

Genetic composition

- Genetic diversity
- Genetic differentiation
- Effective population size
- Inbreading

Species Populations

- Species Distribution
- Species abundances

Species traits

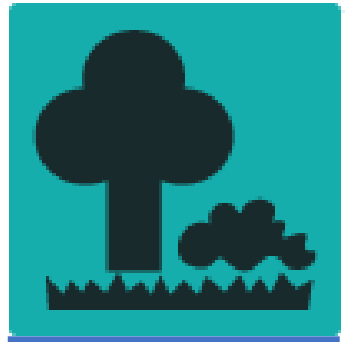
- Morphology
- Physiology
- Phenology
- Movement
- Reproduction

Community composition

- Community abundance
- Taxonomic diversity
- Trait diversity
- Interaction diversity

Ecosystem functioning

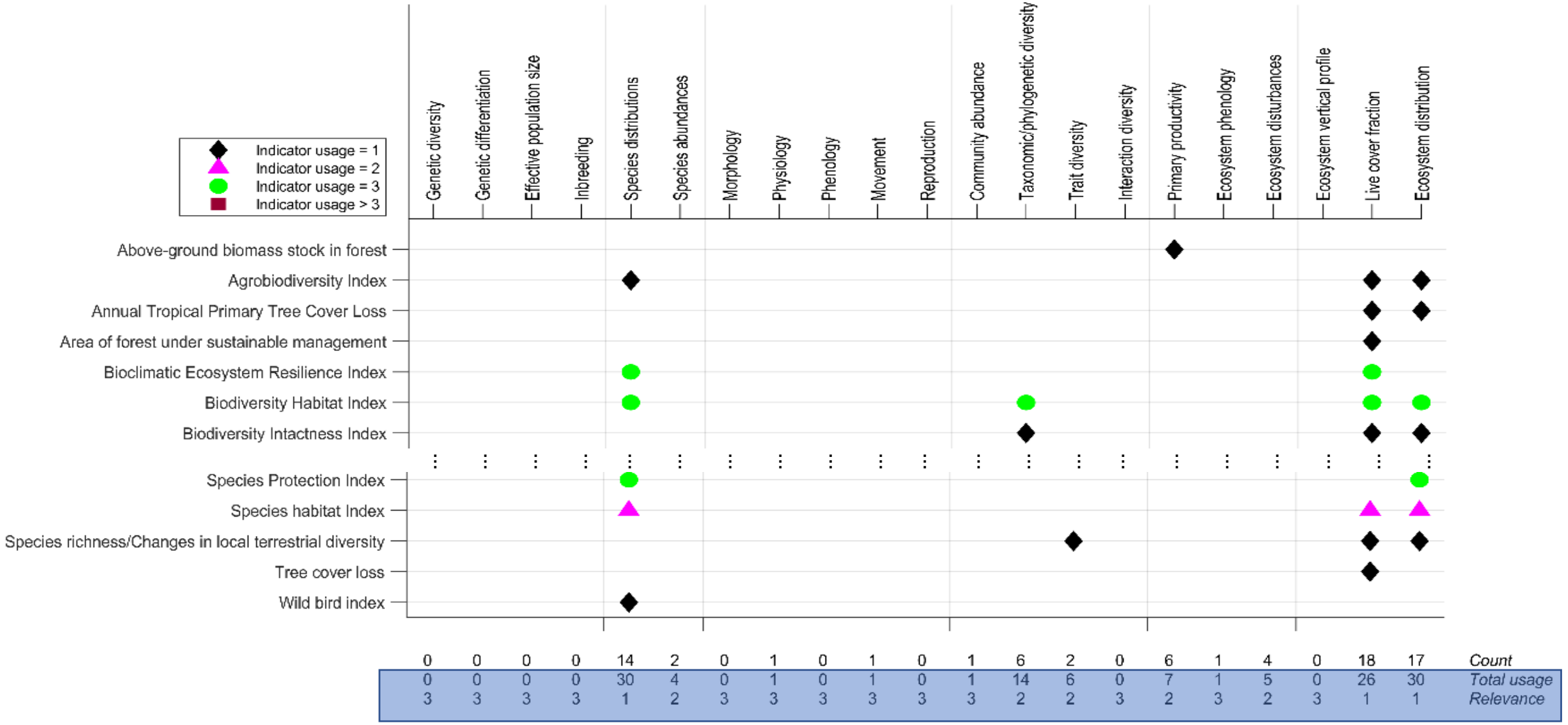
- Primary Productivity
- Ecosystem phenology
- Ecosystem disturbances



Ecosystem structure

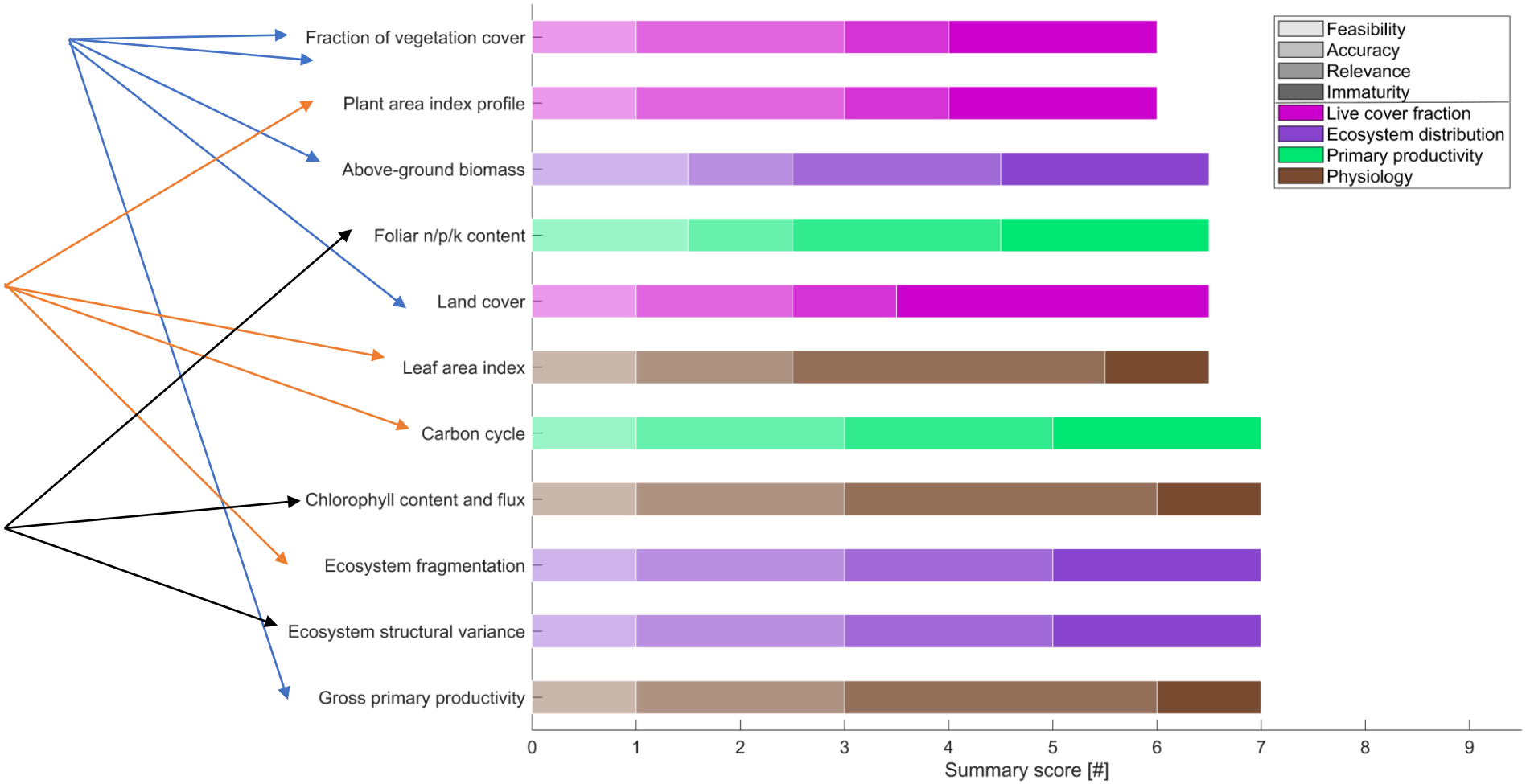
- Ecosystem Distribution
- Live cover fraction
- Ecosystem Verticale Profile

Essential Biodiversity Variable usage



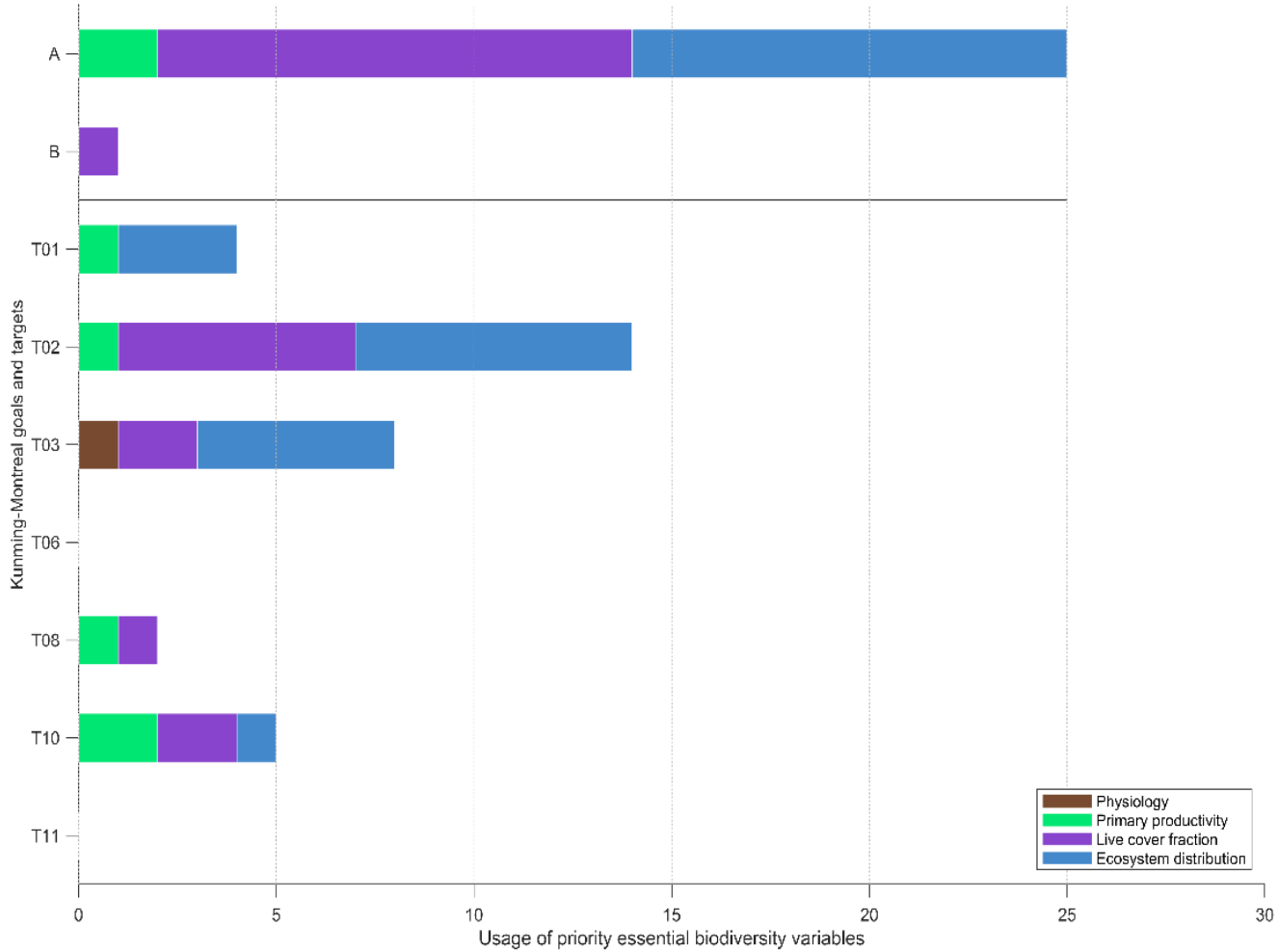
Criteria Ranking of SRS products

- Already used
- Proxies used
- Not used yet



Priority coverage in Kunming-Montreal GBF

- Wide of goals and targets
  - Target 6 (invasive species)
  - Target 11 (ecosystem services)



RS Development opportunities

Ecosystem distribution	Live cover fraction	Species physiological traits
• 17x used: CLC, MODIS, terrestrial ecoregions of the world • Shortcoming: single variable (land cover/use) but with high heterogeneity of data source • Opportunity: Harmonized products with higher resolutions	• 18x used: ESA CCI fractional cover, Percentage of cropland, Proportion of forested area • Shortcoming: Diverse (ECV) products with to coarse classifications • Opportunity: New SRS products to be developed through co-design/co-production approach.	• 0x used: possibly because high immaturity. • Opportunity: Merge multiple satellite remote sensing observations together to joint retrieve physiological traits (from multi-spectral sensors) and within pixel (plant) species abundance from high resolution (drone) observations.

Conclusion

- The Kunmin-Montreal global biodiversity framework offers significant opportunities to combat biodiversity change
- Satellite remote sensing provides a huge potential for tracking the progress of the Kunmin-Montreal GBF.
  - Out of 371 biodiversity indicators, we focus on 57 that track the state of terrestrial biodiversity. 35 mature indicators were analysed to use in total 88 geospatial information products, though very heterogeneously and with better products to be developed.
- By quantifying their relevance as Essential Biodiversity Variables we were able to create a priority list of SRS products
  - Fraction of vegetation cover, Plant area index, Above-ground biomass, Foliar N/P/K content, Land cover, Leaf area index, Carbon cycle, Chlorophyll content and flux, Ecosystem fragmentation, Ecosystem structural variance, Gross primary productivity
  - Spread over 4 EBVs: ecosystem distribution, Live cover fraction, primary productivity and Species Physiological traits.
- Development of each of these SRS EBVs contains specific challenges
  - Improvement of current products by better collaboration between policy-makers, ecologist and SRS specialists through co-design and co-production
  - Development of new satellite remote sensing products that utilize multi-sensor techniques.

Thank you!

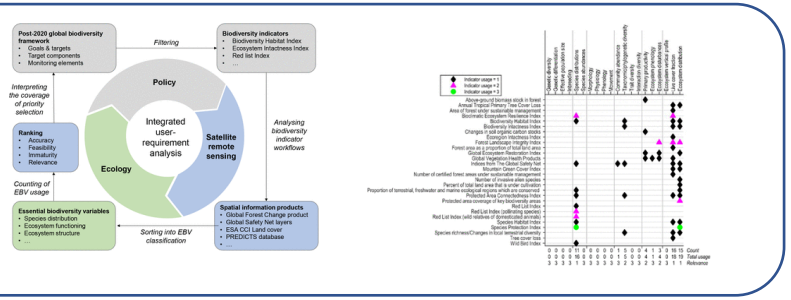
Cold Spring Harbor Laboratory

bioRxiv

THE PREPRINT SERVER FOR BIOLOGY

Preprint of initial research

Scientific opportunities for developing essential biodiversity variables from satellite remote sensing in the context of the post-2020 global biodiversity framework

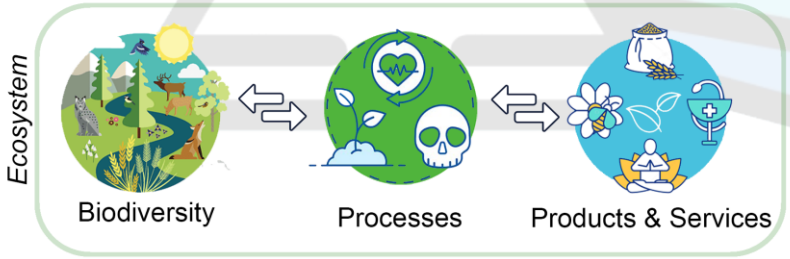


MDPI

remote sensing

Call for Papers for Special Issue in Remote Sensing on

Earth Observation Application in Biodiversity Monitoring



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