From GENES to ECOSYSTEMS:
Meeting the needs for biodiversity knowledge

Building Capacities in Countries to Map and Monitor Ecosystem Distribution

Session hosted by

GEO esa vito

CALI, Colombia – October 28, 2024, 16:45 – 18:00

AI2 GEO GEO BON Group on Earth Observations Biodiversity Observation Network esri MAXAR

COP16 COLOMBIA Paz con la Naturaleza

Building Capacities in Countries to Map and Monitor Ecosystem Distribution

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GROUP ON EARTH OBSERVATIONS

GLOBAL ECOSYSTEMS ATLAS

MAPPING THE WORLD'S ECOSYSTEMS FOR ACTION: The Global Ecosystems Atlas

Associate Professor Nicholas Murray
Global Ecology Lab, James Cook University
Science Lead, Global Ecosystems Atlas

Challenges of ecosystems data availability and use

Existing data on the world's ecosystems are **inconsistent, incomplete, or scattered.**

We lack information about the distribution of **more than half of the world's ecosystems.**

Many countries don't have **the necessary spatial data about ecosystems** for policy, planning, and monitoring to **conserve, manage and sustainably use** biodiversity.

Countries lack **opportunities and support to utilize advanced approaches** for ecosystem mapping.

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#MapEcosystems

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GLOBAL ECOSYSTEMS ATLAS

The first **comprehensive, harmonised, open resource** on **the extent** of all the world's ecosystems

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A Global Biodiversity Framework (GBF)-**driven knowledge resource**

Will support **global level ecosystem assessments, stock-take, prioritization and action** with consistency, comparability and coherence.

The Global Ecosystems Atlas: Mapping ecosystems for action

#MapEcosystems

Will **streamline national reporting** on ecosystem-related indicators of the GBF and **strengthen implementation of NBSAPs.**

Will enable development and implementation of national actions and **policies to scale up conservation, restoration, and the sustainable use and management of ecosystems**.

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GLOBAL ECOSYSTEMS ATLAS

Supported by UN

Conventions

United Nations Convention to Combat Desertification

Convention on Biological Diversity

United Nations Framework Convention on Climate Change

Resilience Frontiers

Ramsar Convention on Wetlands

Funded by

UN environment programme

Department for Environment Food & Rural Affairs

Our Partners

IUCN

GBIF

TNFD Taskforce on Nature-related Financial Disclosures

esri

planet.

NATURE POSITIVE INITIATIVE

Ai2

THE UNIVERSITY OF MELBOURNE

JCU

UNSW SYDNEY

Centre for Ecosystem Science

System of Environmental Economic Accounting

GEO BON Group on Earth Observations Biodiversity Observation Network

UN environment

WCMC

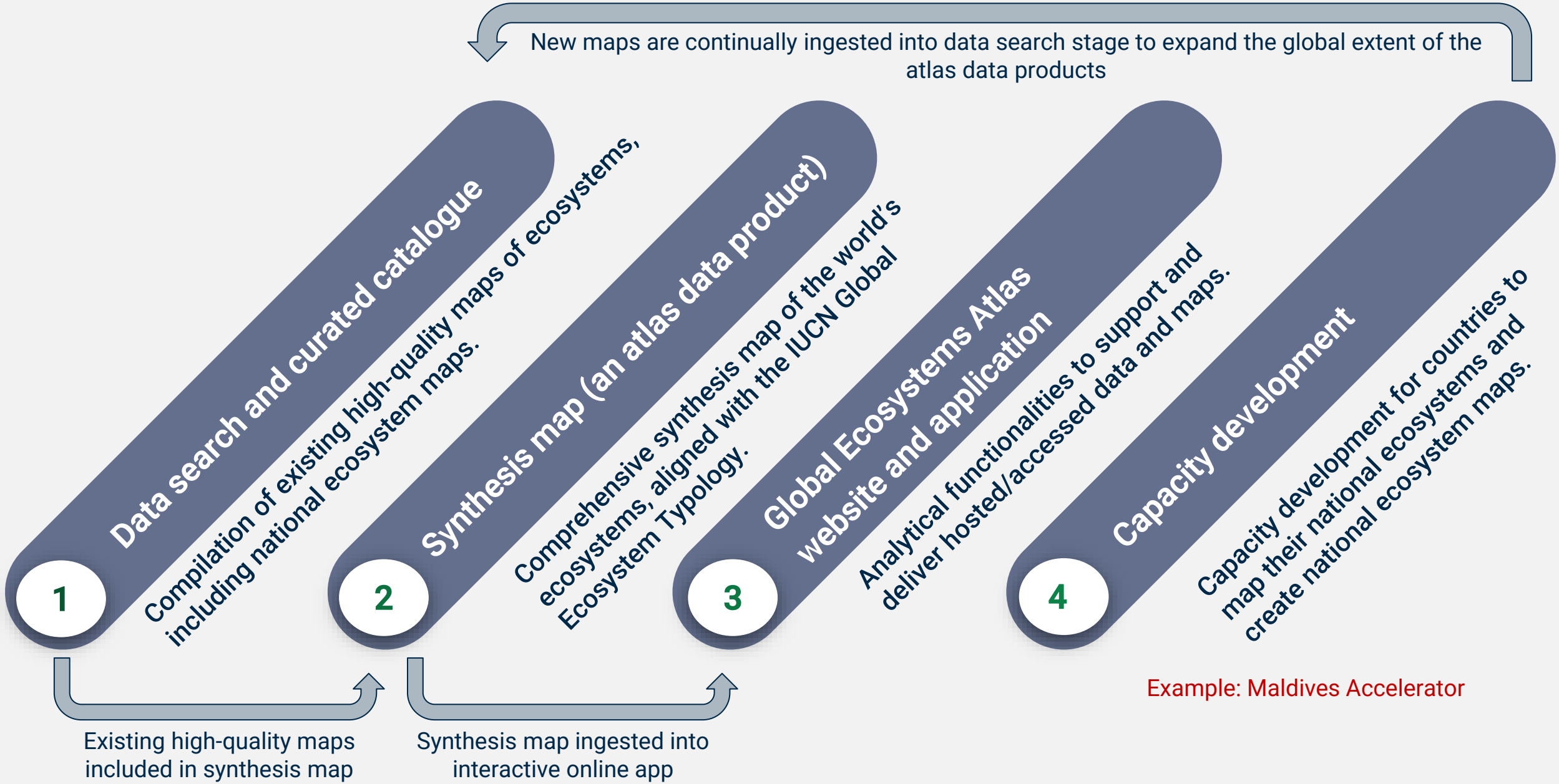
Villars Institute

USGS science for a changing world

walderwyss

HOW WILL WE BUILD THE ATLAS AND HOW CAN YOU GET INVOLVED?

Atlas development approach



Example: Maldives Accelerator

How did we build the proof-of-concept?

- 45 datasets in the Atlas synthesis map, including national or sub-national datasets from 13 countries

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- 2691 individual map classes have been cross-walked to ecosystem functional groups in the Global Ecosystem Typology

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- Live links back to source dataset and national mapping groups

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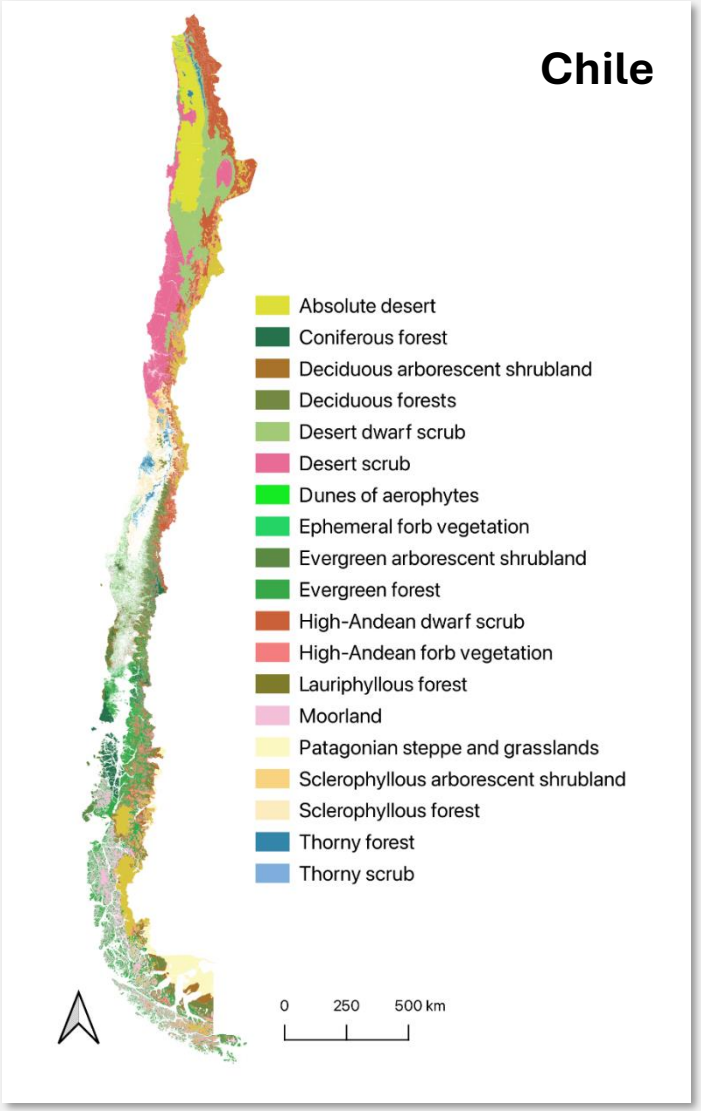
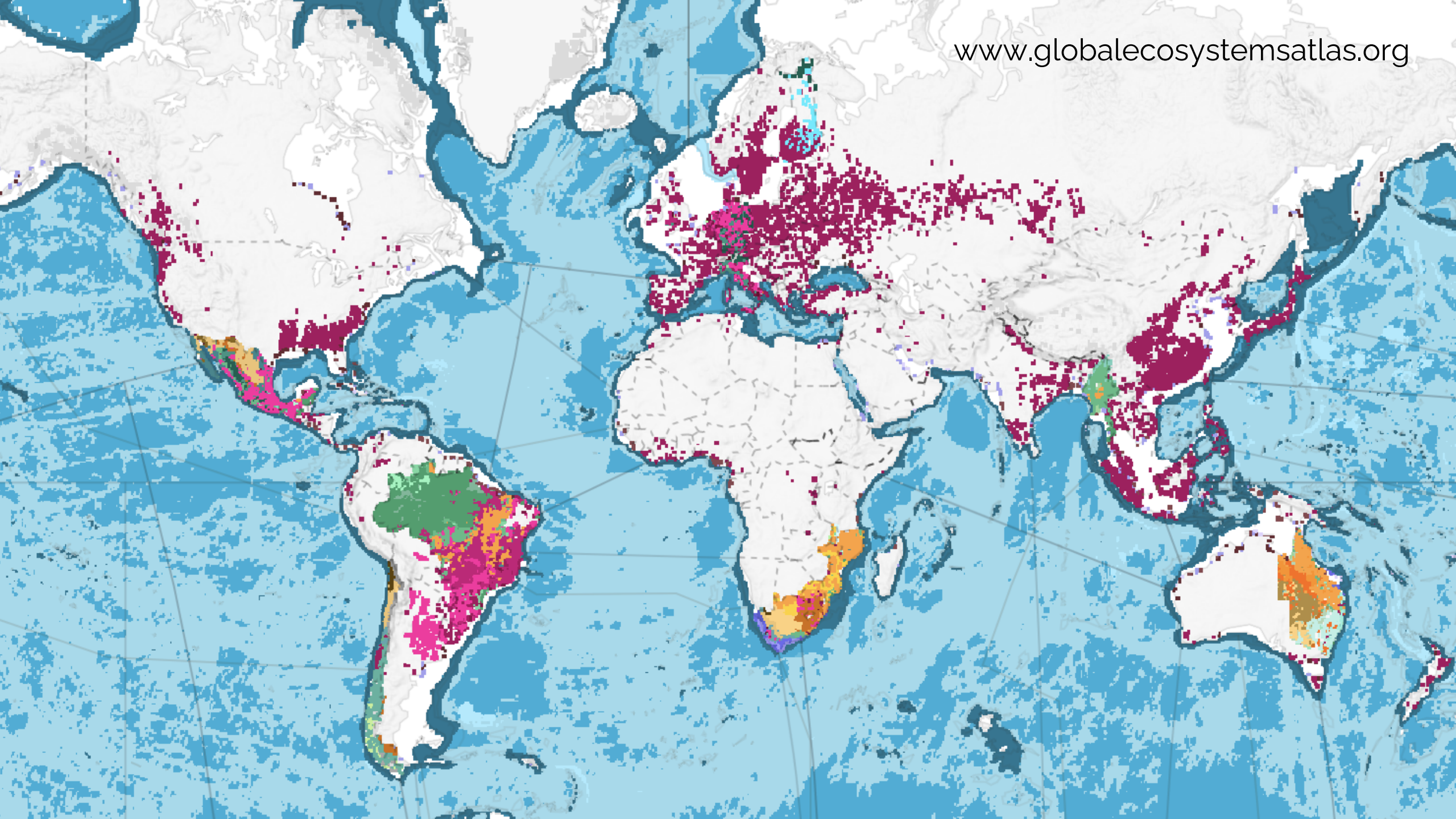
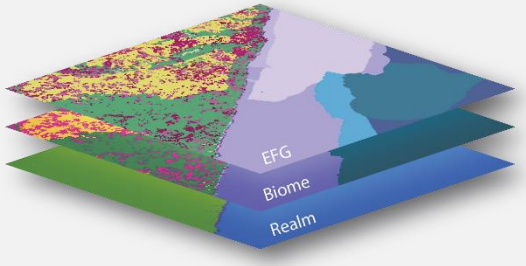
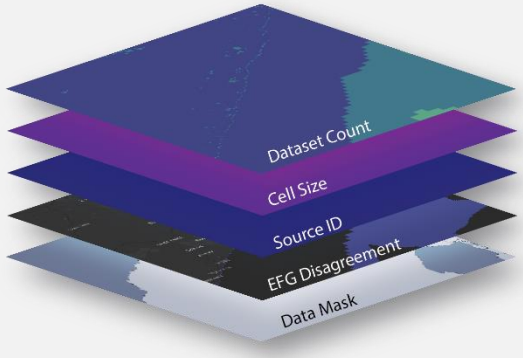
- Mostly via outreach to map developers. Includes: National departments and agencies, NGOs, and research institutions

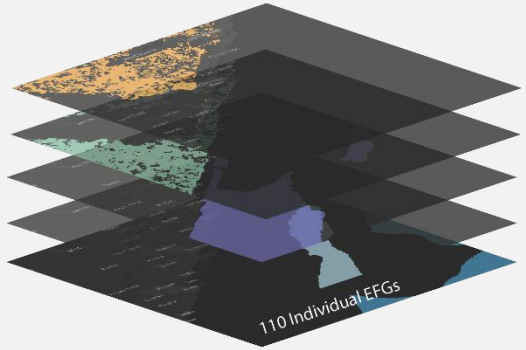



www.globalecosystemsatlas.org

Data details



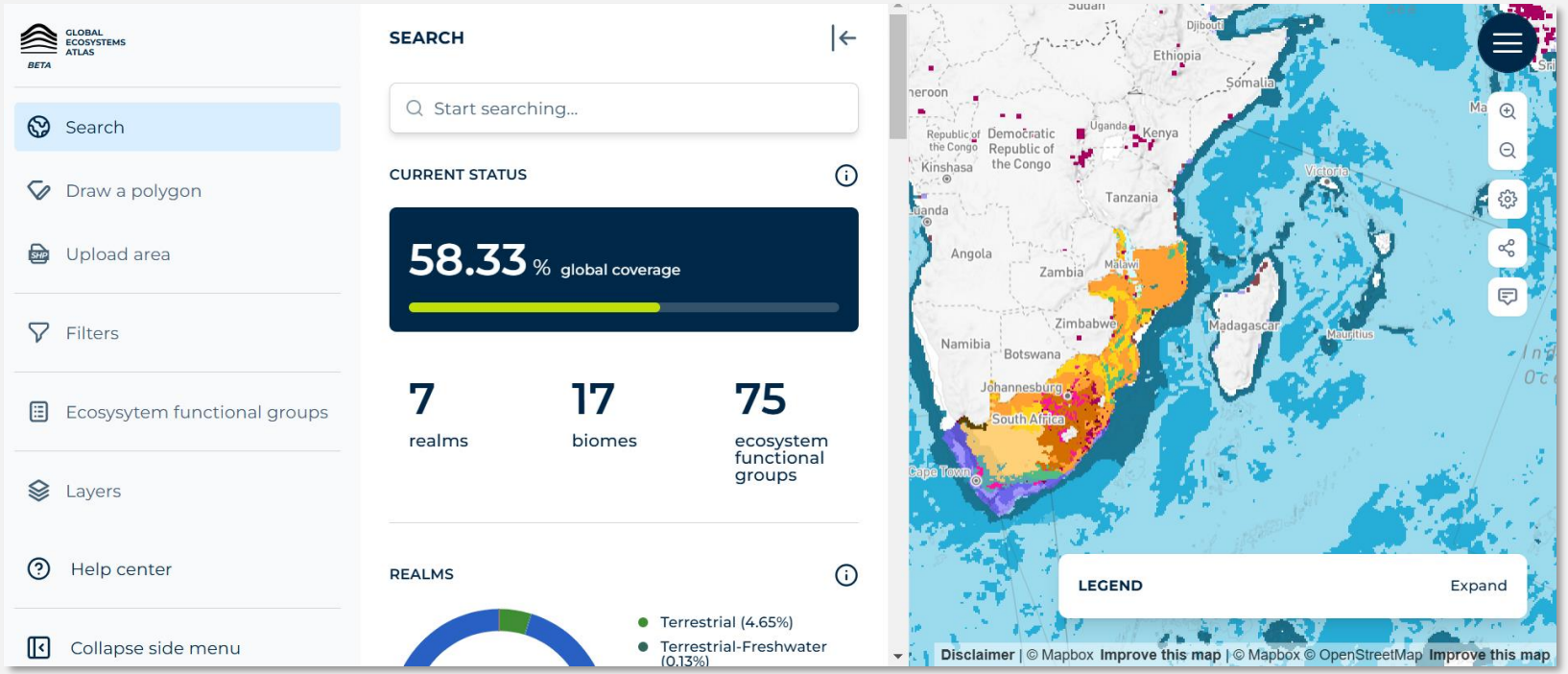




- 100-m global Cloud-optimized raster dataset developed from ingesting high-quality ecosystem maps
- Synthesis data:
  - 3 data layers representing ecosystem functional groups, biomes
- QA data:
  - 5 data layers relating to data quality and context
- Individual ecosystem data layers:
  - 110 binary data layers representing each ecosystem functional group

The Atlas web platform

www.globalecosystemsatlas.org



Web platform

- Data access
- Analytical tools
- Contextual data

Direct access

- Download Atlas data products
- Open access code base and data
- Analysis tutorials

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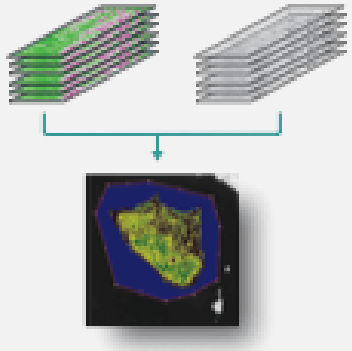
How will the Atlas develop new maps?

Technology + AI and ML models + Training datasets

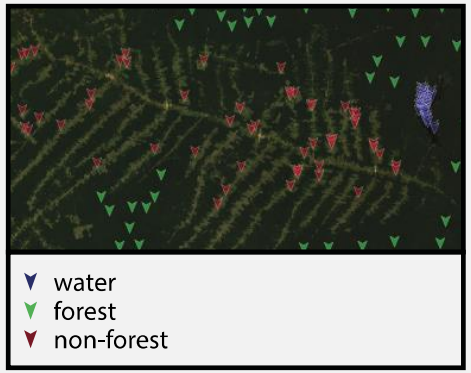
Using cutting edge technology

- Capitalising on earth observations for advancing knowledge of ecosystem distributions



New ecosystem distribution models

- New generation approaches for developing high-resolution ecosystem maps



Open access training and validation data for ecosystems

- Providing the foundations to support ecosystem mapping efforts into the future

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GLOBAL ECOSYSTEMS ATLAS

Timeline

Delivery of a Prototype by CBD COP16

A prototype featuring a harmonized map of select ecosystem types across specific geographic areas will be delivered through a proof-of-concept web application.

October 2024

Ecosystem Mapping in the Maldives with EO and AI

Pilot underway to develop a new foundational model to accelerate mapping of ecosystems in the Maldives.
Initial results presented at CBD COP16.

Supporting Further Development of National Ecosystem Maps

The Atlas data, open training data sets and AI tools will enable development of national ecosystem maps worldwide.

Launch the Global Ecosystem Synthesis Map

The global synthesis map is a data product representing the distribution of all ecosystems on Earth.

December 2026


GLOBAL
ECOSYSTEMS
ATLAS
GEO
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Introducing the WEED toolbox

Bruno Smets

On behalf of the ESA and the consortium

VITO, BC3, IIASA, IDIV,

supported by DHI, JCU, Ecounting, U-Bonn

Gaps and Needs

- We require ecosystem maps to be generated more frequently.
- For this, it is important to produce periodic information on the various co-variables.
- Since the last map, there have been conceptual and methodological developments that we need to adopt to generate more robust and useful information for decision-making.
- We need to implement classification systems that enable comparisons of the state of the country's ecosystems with those of other nations
- We need methods or classification systems that can generate information from national to local scales.
- We need methods or classification systems that can be used in various fields, such as measuring the conservation status of ecosystems and mapping ecosystem services

What We Expect from the WEED - ESA Project

- Contribute to the development of methods and tools that enhance our understanding of the extent and dynamics of ecosystems in Colombia and other countries.
- Facilitate knowledge transfer to enable the adoption of recent conceptual and methodological advancements.
- Develop tools that can address multiple needs, including assessing the state of ecosystems, understanding the benefits ecosystems provide to society, setting conservation priorities, and identifying the habitats of various species.
- We hope that the tools being developed will help measure the indicators used to assess progress toward international agreements
- Ensure that the tools are easily accessible, user-friendly, and robust enough to be applied across different scales.

Programmatic context

Global-Applicable **Toolbox**

Project Objectives

World Ecosystem Extent Dynamics (WEED)

The objective is to **develop** and **demonstrate**,
with some **Champion Users**,
globally applicable and **scalable EO-integrated** solutions
for **mapping the extent** and distribution of terrestrial, freshwater and coastal (up to the intertidal zones) ecosystems
and monitoring their **changes in extent**,
with country demonstrations in European and global contexts.

KO: 2 September 2024 | Duration: 24 months | World-series

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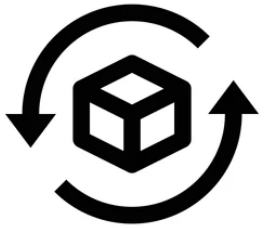
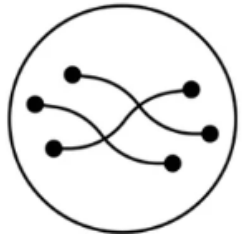
The outputs of the toolbox



- Ecosystem **characteristics open data-cube**
  (EO data + non-EO data 300+ layers -> abiotic, biotic)

- Ecosystem **Extent map**, incl. uncertainty layer
  (multi-scale, terrestrial/freshwater/coastal)



- Ecosystem **Dynamics**
  (consistent changes over time)

- **Indicators** for policy support
  (GBF A.2, SEEA EA, Ramsar)

Example: Biotic (flora habitat) data cube

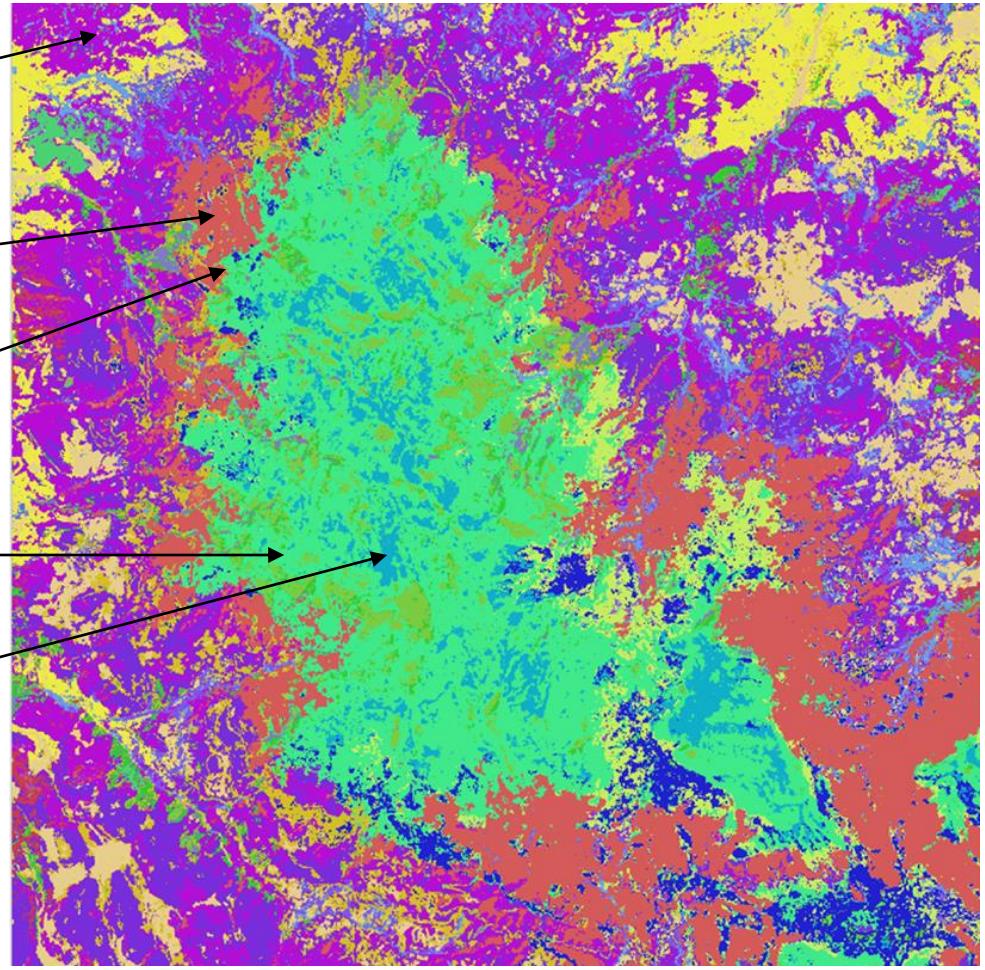
Mediterranean evergreen Quercus forest (Greece)

Mediterranean mountain *Abies* forest (Greece)

Mediterranean closely grazed dry grassland

Eastern Mediterranean mountain hedgehog-heath

Balkan and Anatolian oromediterranean dry grassland

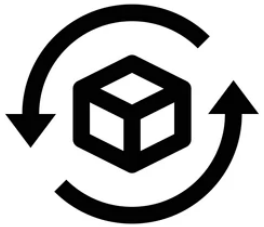


Greece Pelopponese
Credits: PEOPLE-EA project

Machine Learning

Optical EO + Radar EO + Lidar EO + Physical Properties

The outputs of the toolbox



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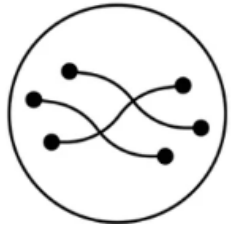

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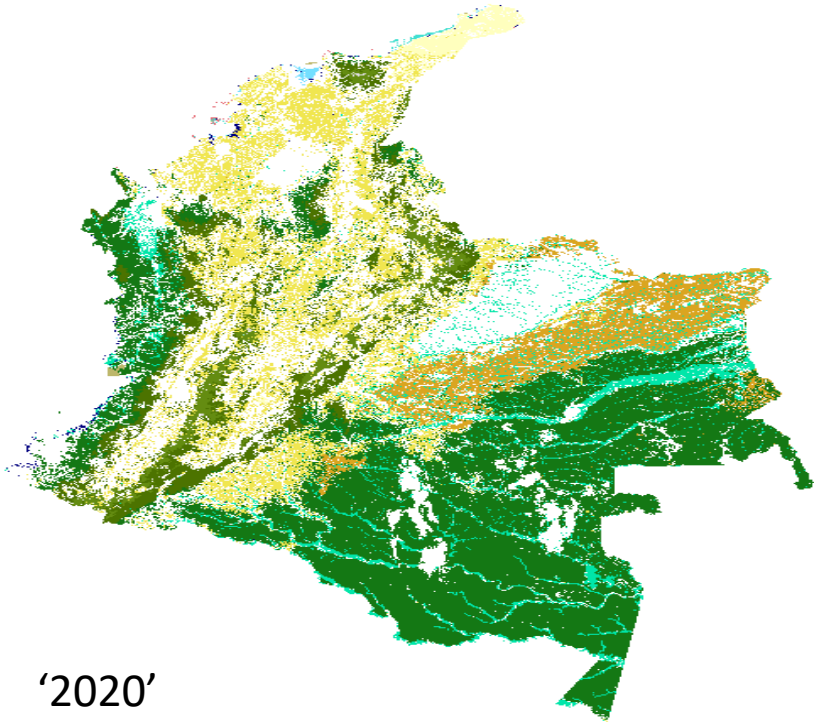
Example : IUCN GET extent map



‘2020’

- CoastalRiverDelta
- FreezethawFreshwaterLake
- IceSheetGlacierPerennialSnowfield
- PermanentlyOpenRiverineEstuaryBay
- PhoticCoralReef
- PyricTussockSavanna
- SeagrassMeadow
- SownPastureField
- SubtidalSandBed
- ThornyDesertSemidesert
- TropicalAlpineGrasslandShrubland
- TropicalFloodedForestPeatForest
- TropicalSubtropicalLowlandRainforest
- TropicalSubtropicalMontaneRainforest

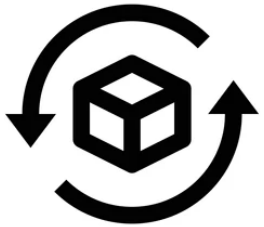
Credits: ARIES4SEEA

Crosswalked

- Land cover 2020
- Ecosystem Continental map 2011

In collaboration with experts

The outputs of the toolbox



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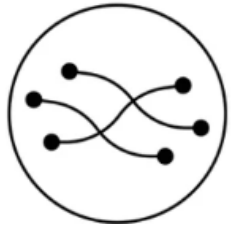

- Ecosystem **Dynamics**
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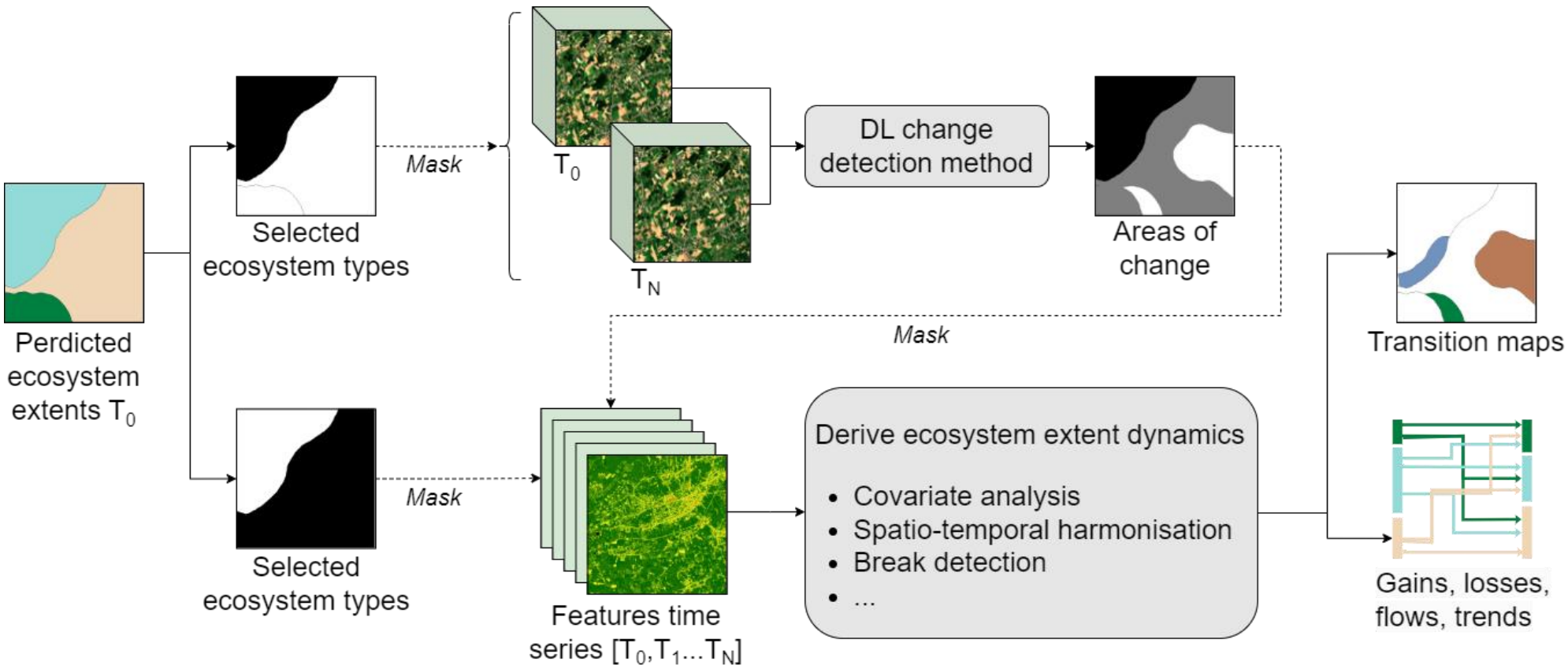
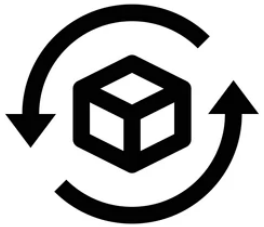
- **Indicators** for policy support
  (GBF A.2, SEEA EA, Ramsar)

Change detection workflow

Combine deep learning techniques with domain knowledge (covariates time series)



The outputs of the toolbox



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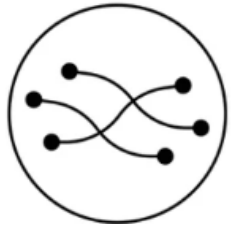
- Ecosystem **Extent map**, incl. uncertainty layer
  (multi-scale, terrestrial/freshwater/coastal incl. intertidal)



- Ecosystem **Dynamics**
  (consistent changes over time)

- **Indicators** for policy support
  (GBF A.2, SEEA Extent Account, Ramsar)

Example : Extent account Peloponnese

value	Ecosystem Type	Opening area (ha)	Additions	Reductions	Net changes	Closing area 2020 V3_1 (ha)	Share of closing area
0	outside accounting area						
1	Settlements and other artificial areas					156,141	3.17%
2	Cropland					1,499,487	30.47%
3	Grassland					773,421	15.72%
4	Forest and woodland					2,108,915	42.86%
5	Heathland and shrub						
6	Sparsely vegetated ecosystems						
7	Inland wetlands						
8	Rivers and Canals						
9	Lakes and reservoirs						
10	Marine inlets and transitional waters						
11	Coastal beaches, dunes, and wetlands						
12	Marine ecosystems						
	Total Ecosystem Accounting Area						

value	Ecosystem Type	Opening area (ha)	Additions	Reductions	Net changes	Closing area (ha)	Share of closing area
0	outside accounting area					1321837	
4	*Forest and woodland - Totals*					*2,108,915*	*42.86%*
4.0	*Unallocated L2*					*305,258*	*6.20%*
4.1	*Broadleaved deciduous forest - Subtotals*					*1,065,434*	*21.65%*
4.1.0	*Unallocated L3*					0	*0.00%*
4.1.1	Riparian forest and woodland					*8,795*	*0.18%*
4.1.2	Broadleaved swamp woodland on non-acid and acid peat					*205*	*0.00%*
4.1.3	Fagus dominated forest					*762,934*	*15.50%*
4.1.4	Submediterranean and Mediterranean thermophilous deciduous forest					*293,500*	*5.96%*
4.1.5	Acidophilous [Quercus]- dominated woodland					-	*0.00%*
4.1.6	Temperate and boreal and Southern European Betula and *Populus tremula* forest on mineral soils					-	*0.00%*
4.1.7	Other broadleaved deciduous forest, excluding highly-modified plantations					-	*0.00%*
4.1.8	Highly modified broadleaved deciduous forests including stands of non-native trees species that have long been established in European ecosystems stands					-	*0.00%*
4.2	*Coniferous forests - Subtotals*					*311,248*	*6.32%*
4.3	*Broadleaved evergreen forest - Subtotals*					*226,453*	*4.60%*
4.4	*Mixed forests - Subtotals*					*200,522*	*4.07%*
4.5	*Transitional forest - Subtotals*					-	
4.6	*Plantations - Subtotals*					-	

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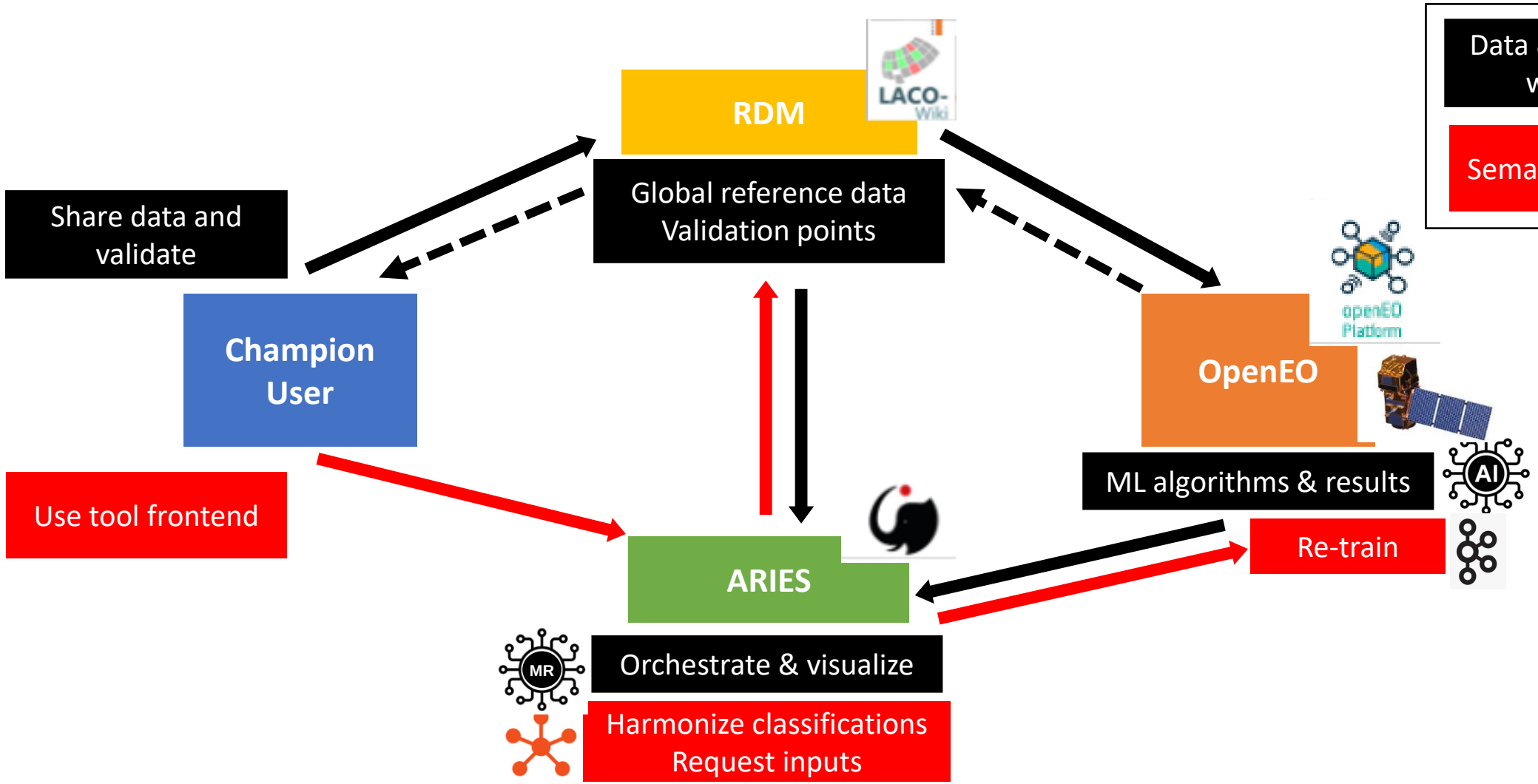
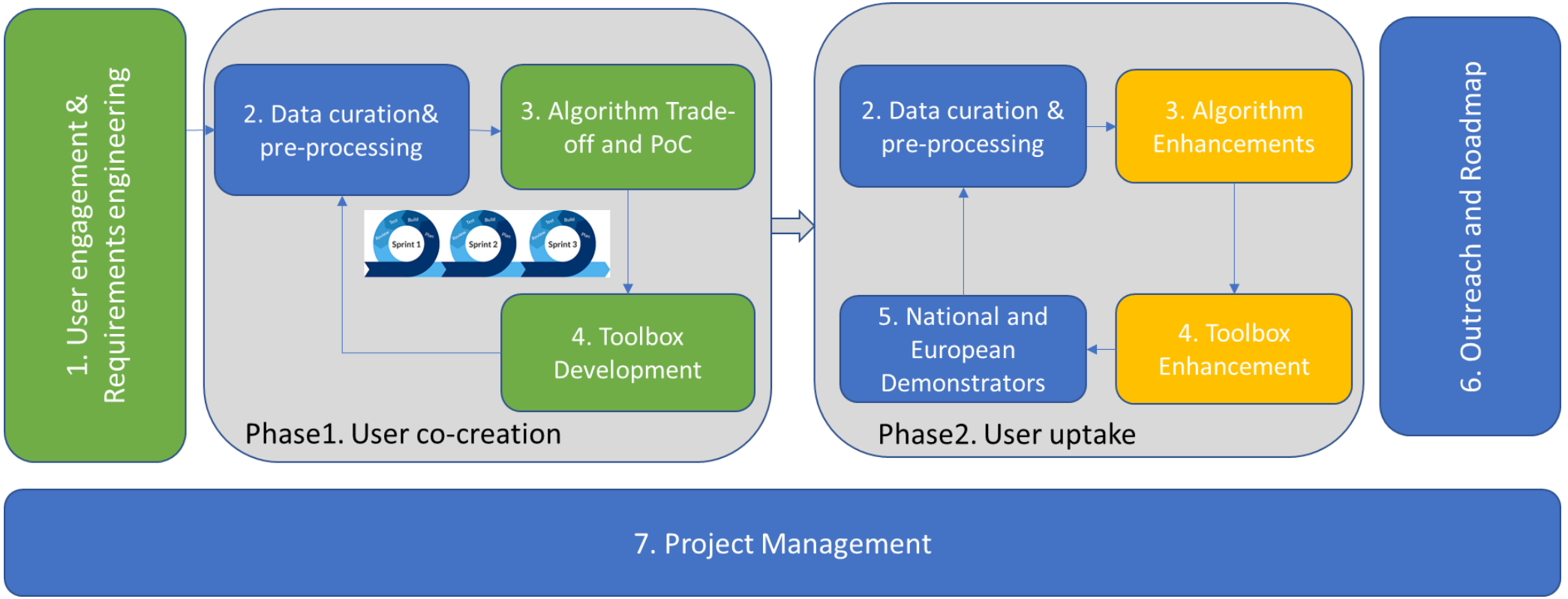
Credits: PEOPLE-EA project

Our open toolbox solution



2 Phases


1. User engagement & Requirements engineering
2. Data curation& pre-processing
3. Algorithm Trade-off and PoC
Sprint 1
Sprint 2
Sprint 3
4. Toolbox Development
Phase1. User co-creation
2. Data curation & pre-processing
3. Algorithm Enhancements
5. National and European Demonstrators
4. Toolbox Enhancement
Phase2. User uptake
6. Outreach and Roadmap
7. Project Management

Timeline

First Alpha version of toolbox

Proof-of-Concept

System generates ecosystem extent maps in zones from champion users (Colombia, Vietnam, South-Africa, Norway, CzechR, Greece)

February 2025

Toolbox improvements, co-creation

Pilot maps

Sub-national maps from champion users

Additional test zones optimized to cover all EFG (coastal, wetlands, ...), includes dynamics

Beta version of toolbox ready

Ready for validation

Able to generate ecosystem extent maps (EU, GET, Ramsar typologies) for 6 champion users + additional 5 (data poor) countries at national scale, incl. Dynamics + indicators.

December 2025

1.0 version of toolbox ready for global deploy

Ready for public launch

Validated for 11 countries. EU continental available. Able to generate ecosystem extent maps across any country at globe.

October 2026

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Take-away message

#1

- An ***innovative toolbox*** for ecosystem mapping & dynamics

#2

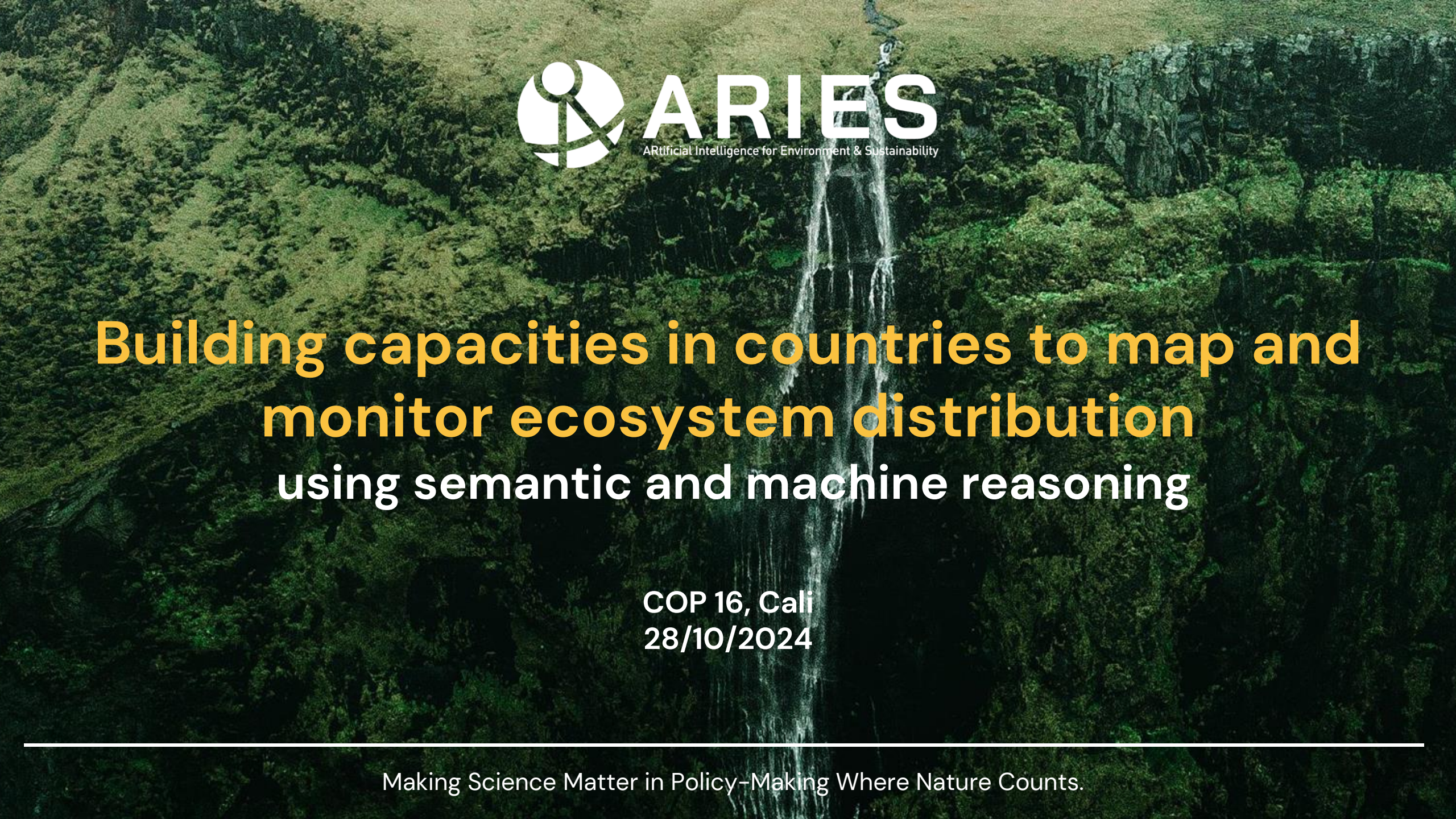
- **Multi**-EO, Multi-modal (incl. non-EO), Multi-scale, Multi-typology (L3/L4+)
- **State-of-art** algorithms, **context aware** and self-learning (expert controlled)
- Feedback cycle on in-situ samples (suspicious & gaps), uncertainties

#3

- **Co-creation** approach
- **FAIR** principles, decentralized approach (e.g. Copernicus LAC)
- National agencies generate their maps (capacity building)

#4

- A **DIY** toolbox to support multiple initiatives (e.g. GEO-Atlas)



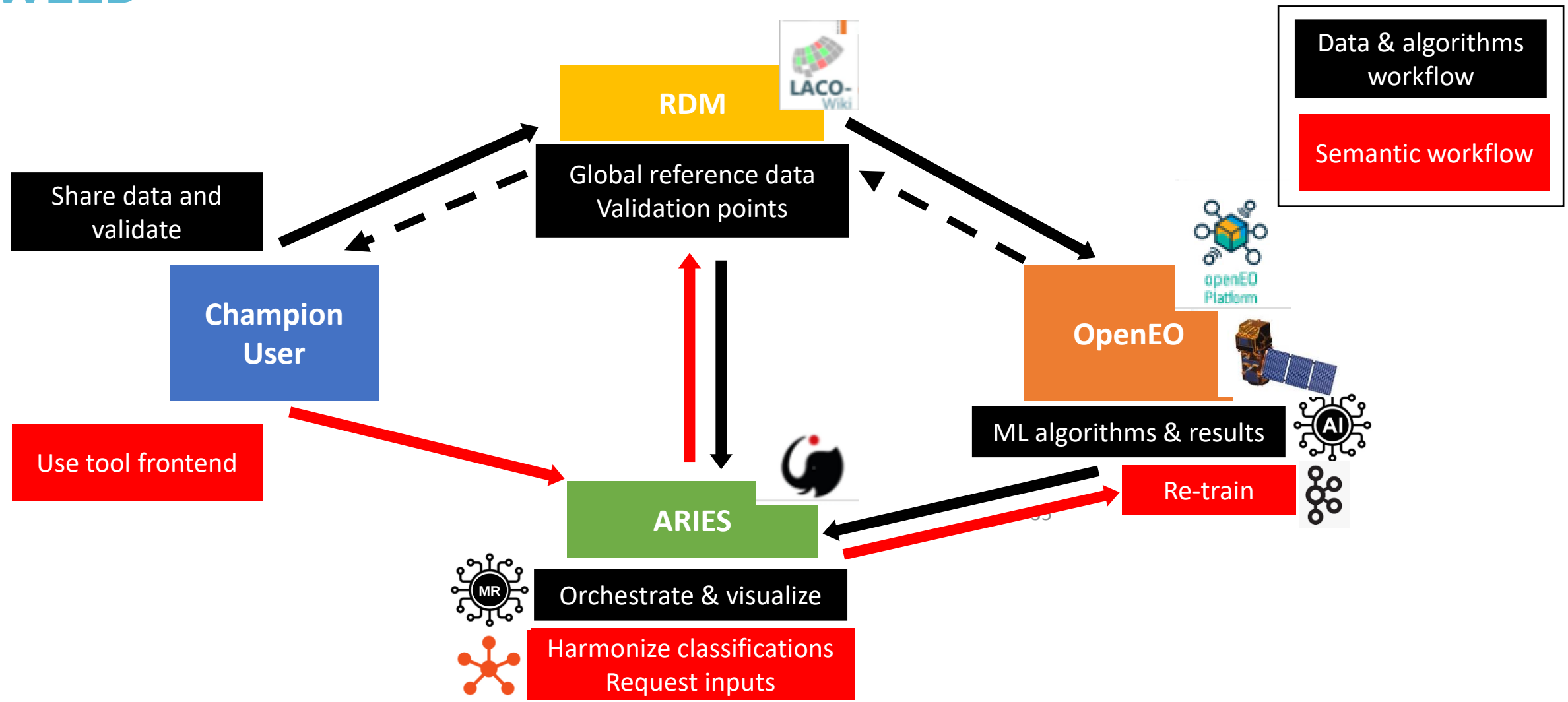
Building capacities in countries to map and monitor ecosystem distribution

using semantic and machine reasoning

COP 16, Cali
28/10/2024

Making Science Matter in Policy-Making Where Nature Counts.

WEED


Data & algorithms workflow
Semantic workflow
RDM
Global reference data
Validation points
Share data and validate
Champion User
Use tool frontend
OpenEO
openEO Platform
ML algorithms & results
Re-train
AI
ARIES
MR
Orchestrate & visualize
Harmonize classifications
Request inputs

Context-awareness of the workflows

#1 All inputs in the system are curated and validated, **restricted** and **prioritized** by human experts to the context(s) in which they apply

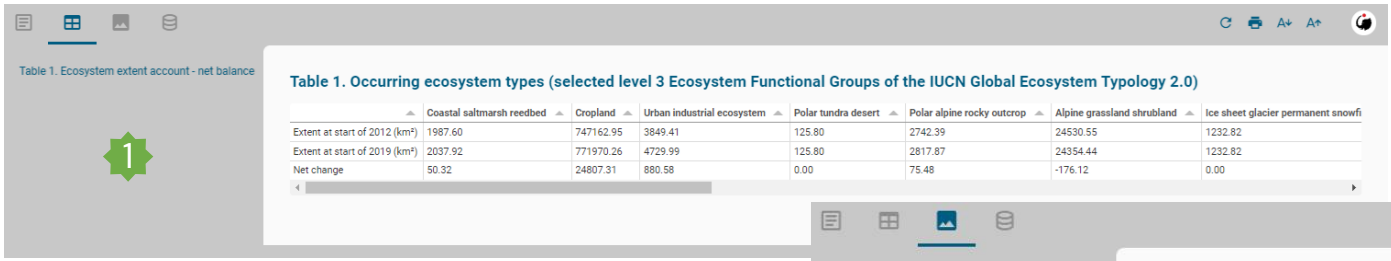
#2 To solve a particular problem, the system always define its **context** and builds a strategy reasoning with the information **available** (**scale, spatial and temporal coverage** under analysis)

#3 **Local and specialized** information can **take priority** over generic information (i.e. national data can be prioritized over global dataset)

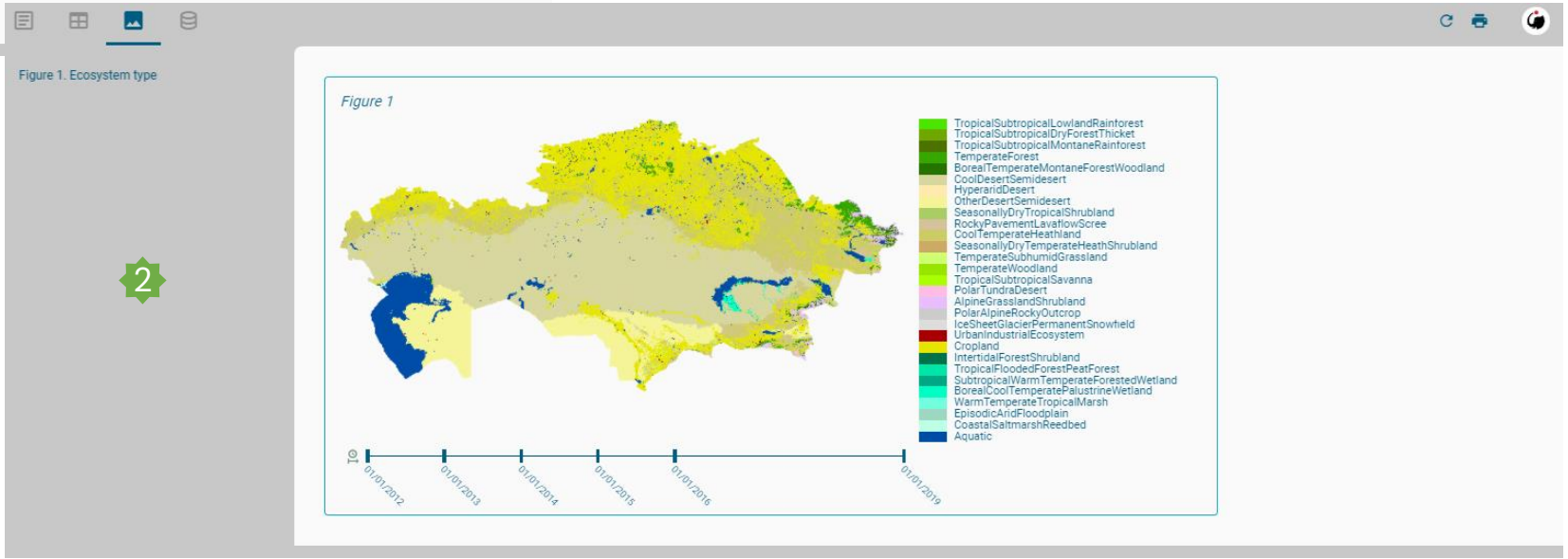
#4 The ability to **accommodate** the modeling strategy to the available information, makes it useful (for different reasons) for **data-rich and data-poor** countries alike

What will outputs be like?

#1 A combination of statistical and spatial analysis summarized in **Tables(1)** and **Maps(2)**.

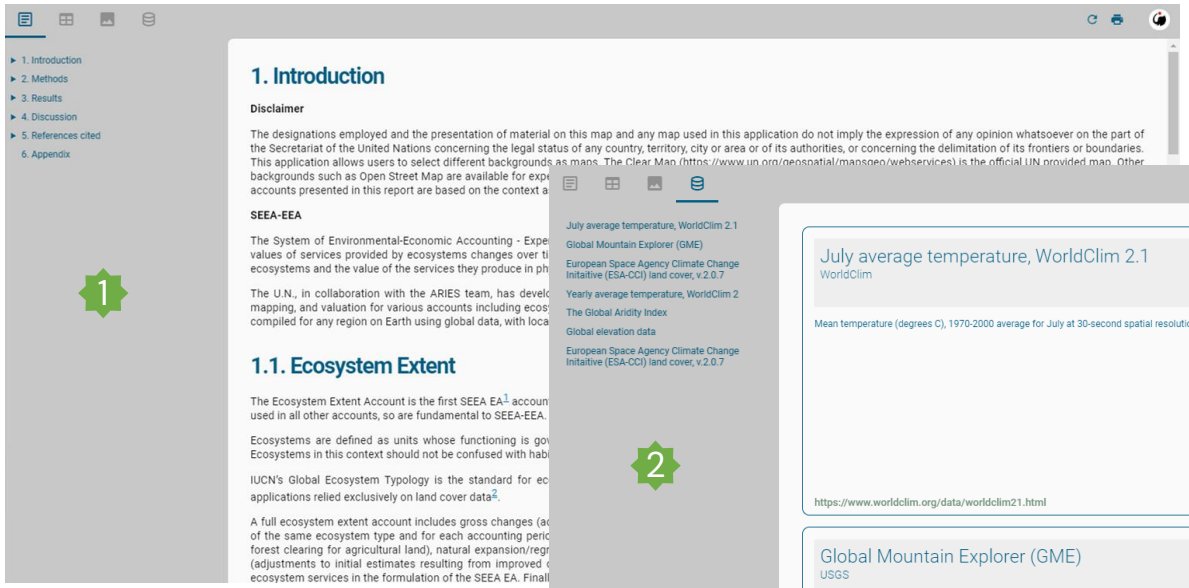


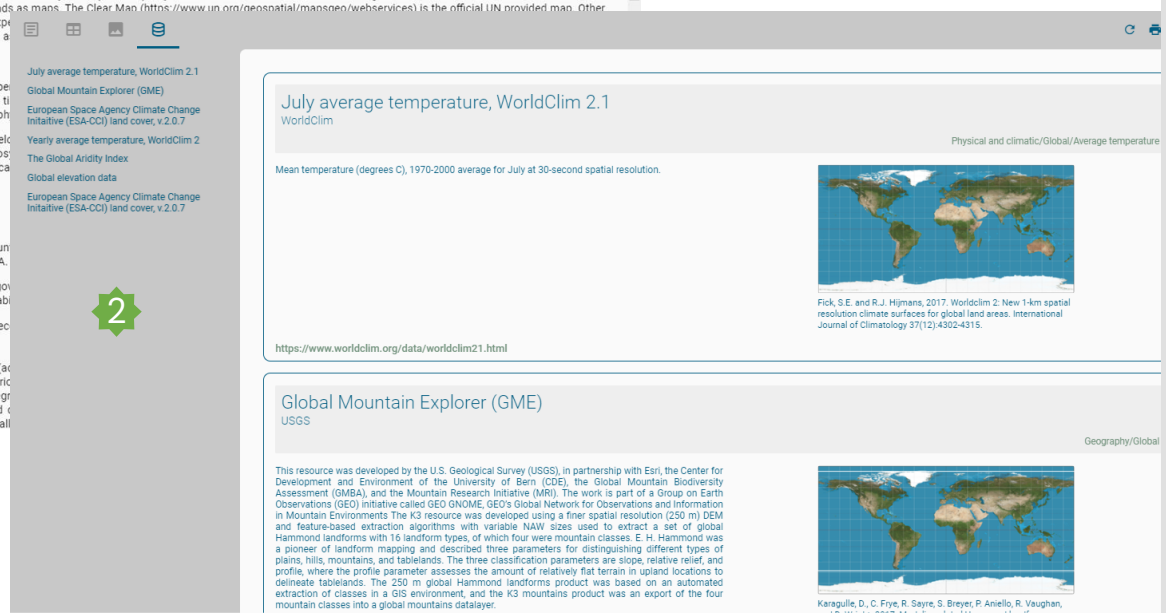
	Coastal saltmarsh reedbed	Cropland	Urban industrial ecosystem	Polar tundra desert	Polar alpine rocky outcrop	Alpine grassland shrubland	Ice sheet glacier permanent snowfi
Extent at start of 2012 (km²)	1987.60	747162.95	3849.41	125.80	2742.39	24530.55	1232.82
Extent at start of 2019 (km²)	2037.92	771970.26	4729.99	125.80	2817.87	24354.44	1232.82
Net change	50.32	24807.31	880.58	0.00	75.48	-176.12	0.00

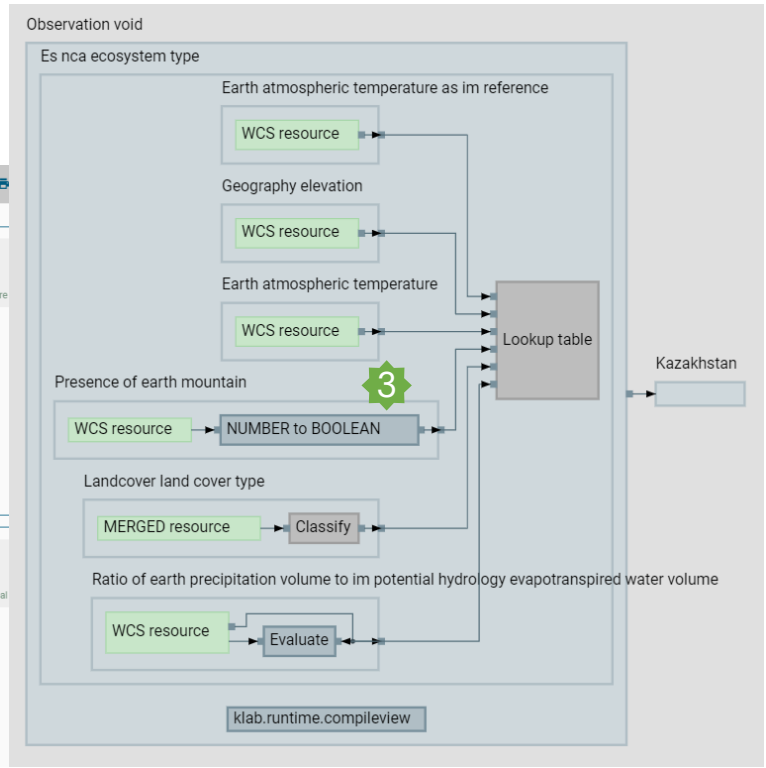


What will outputs be like?

#2 Full transparency for replicability and traceability through **Reports(1)**, a **Resource Section(2)** & a **Dataflow Diagram(3)**.

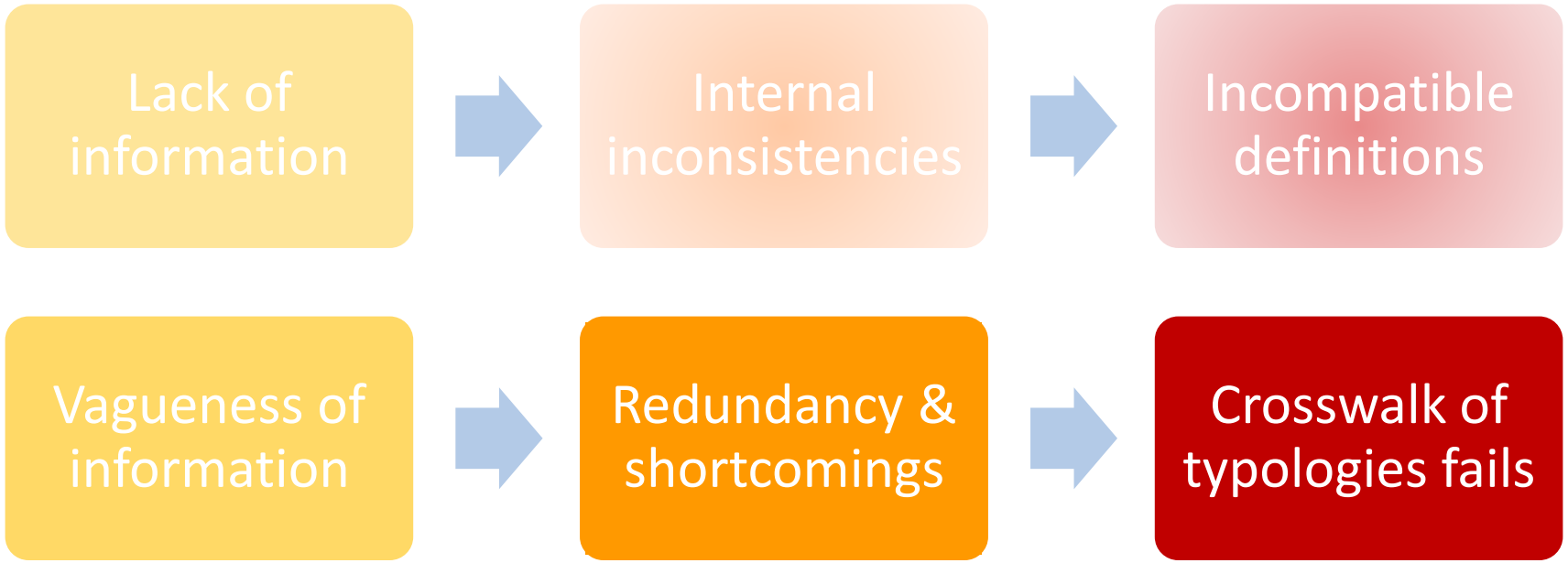






When crosswalk of typologies fails

In certain circumstances, cross-walking classes across different classifications is not possible



Main flaws of a classification

Incompatible definitions of ecosystem typologies are the result of:

#1 Classification(s) defined on a **specific "perspective/scale"** (geographic and temporal coverage, BSU, technology available) - *emphasis is on what is "visible" given the goals, sensors and methods known at the time of development*

#2 Categories can be **vague** or expressed unclearly preventing their **re-use across classifications**

#3 Classification often contains **multiple semantic dimensions** that need to be identified and orthogonalized

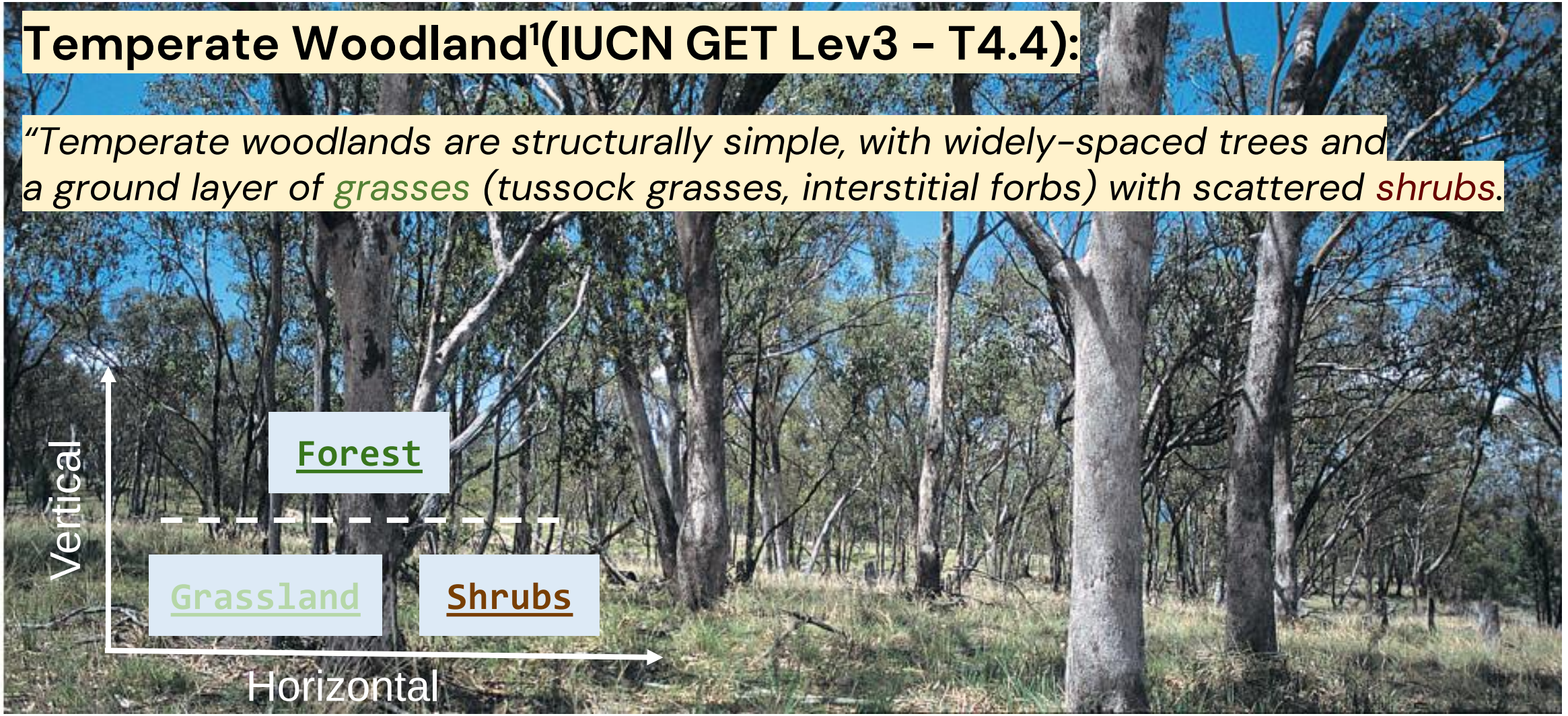
How can semantic mediation help?

- Identifies the **configurations** (spatial and temporal layering of ecological dimensions) involved in each class
- Identifying the **semantic** of the identities involved for the ecological elements into precise logical axioms
- **Navigate vague information** using fuzzy logic to mediate semi-quantitative distributional criteria

How does it work in practice?

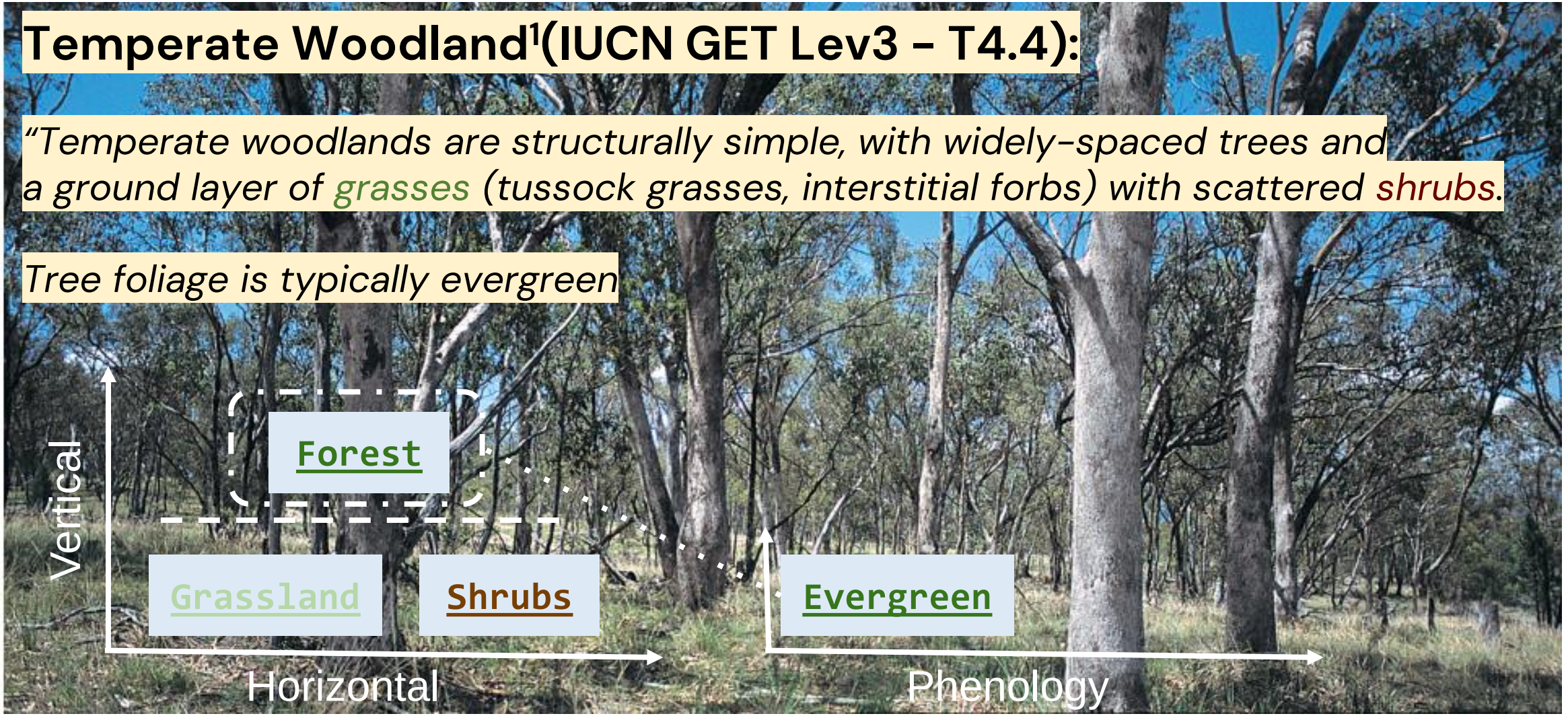
1: https://global-ecosystems.org/explore/groups/T4.4
2: referred to as tree cover

How does it work in practice?



1: https://global-ecosystems.org/explore/groups/T4.4

How does it work in practice?



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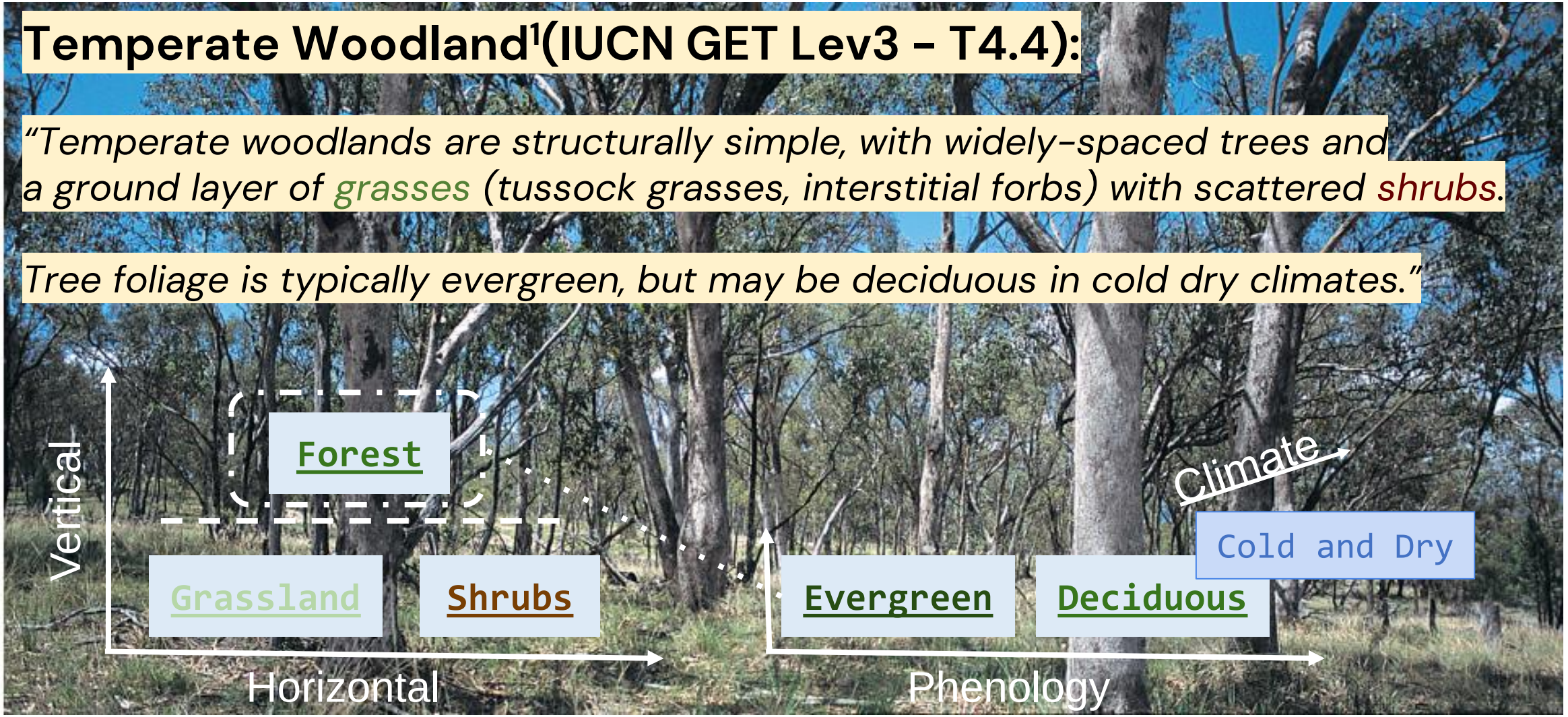
How does it work in practice?



1: https://global-ecosystems.org/explore/groups/T4.4

How does it work in practice?

```
identity IUCNGET:TemperateWoodland
equals PATTERN.EARTHCOVER:“
      physical:VerticalCover(
                  +++physical:HorizontalCover(++GBIF:9613389,
                                        +GBIF:5370389 OR +GBIF:5370389,
                  +physical:HorizontalCover(GBIF:6745223),
            physical:VerticalCover(
                  +ecology:EvergreenForest OR
                  +ecology:DecidousForest where (climate:Cold and climate:Dry))
)";
```

Tussock Grassland

ForbPlant#1
ForbPlant#2

Deciduous Forest in a cold and dry climate

Shrub

How does it work in practice?

```
identity IUCNGET:TemperateWoodland
equals PATTERN.EARTHCOVER:“
      physical:VerticalCover(
            +++physical:HorizontalCover(++GBIF:9613389,
                  +GBIF:5370389 OR +GBIF:5370389,
            +physical:HorizontalCover(GBIF:6745223),
         physical:VerticalCover(
            +ecology:EvergreenForest OR
            +ecology:DecidousForest where (climate:ColdDry))
 )";
```

Tussock Grassland

ForbPlant#1
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Deciduous Forest in a cold and dry climate

Shrub

Fuzzy logic

to mediate semi-quantitative description

Take-away messages

#1 State-of-the-art technology **(machine reasoning)** to allow easy access to best scientific knowledge to all countries, independently of their starting point

#2 Collaborative approach, relying on validation from countries themselves and ecologists and scientists

#3 In such an integrated intelligent system, the **benefits are multiplicative** as any information is reapplied when appropriate (more exposed and further validated)

#4 This project will provide high-quality inputs for compiling many other frameworks, such as (1) Ecosystem Condition, (2) Services, (3) GBF framework, (4) SDG indicators and Physical risk estimates being developed in parallel

PANEL DISCUSSION

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Muchas Gracias!

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