Living Earth – an integrated EO-based approach for Land Degradation assessment

Gregory Giuliani & Audrey Lambiel
[University of Geneva]

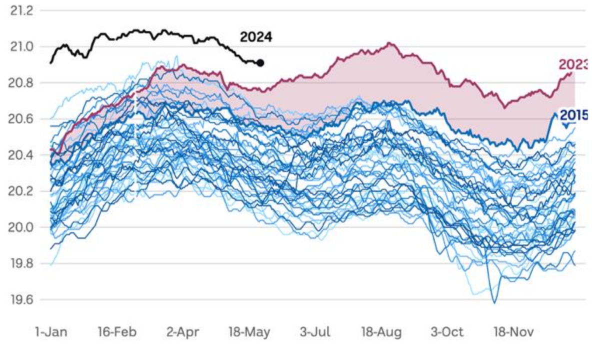
MONALISA

Courtesy: R.Lucas

Towards Global Recovery of Ecosystems and Environments

Reasoning

Our planet's land, water and atmosphere are rapidly changing, with this particularly evident in the time-series of environmental data, including that provided through Earth observations.



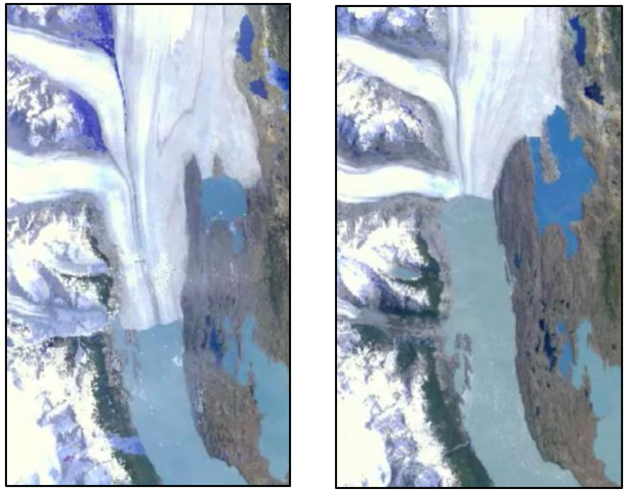
Each of these lines shows the daily global sea surface temperature across a year from 1979.

Source: C3S Climate Data Store / Get the data

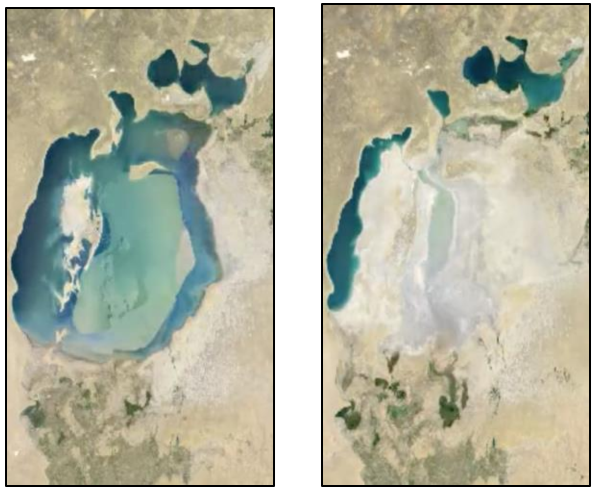
We need understandable, viable and accessible solutions for planning our future, informed by the past and utilising predictions where appropriate.

The solution needs to be relevant from local to global scales to allow full engagement in addressing the climate and biodiversity emergencies.

Living Earth is one such approach that may contribute to our requirements.



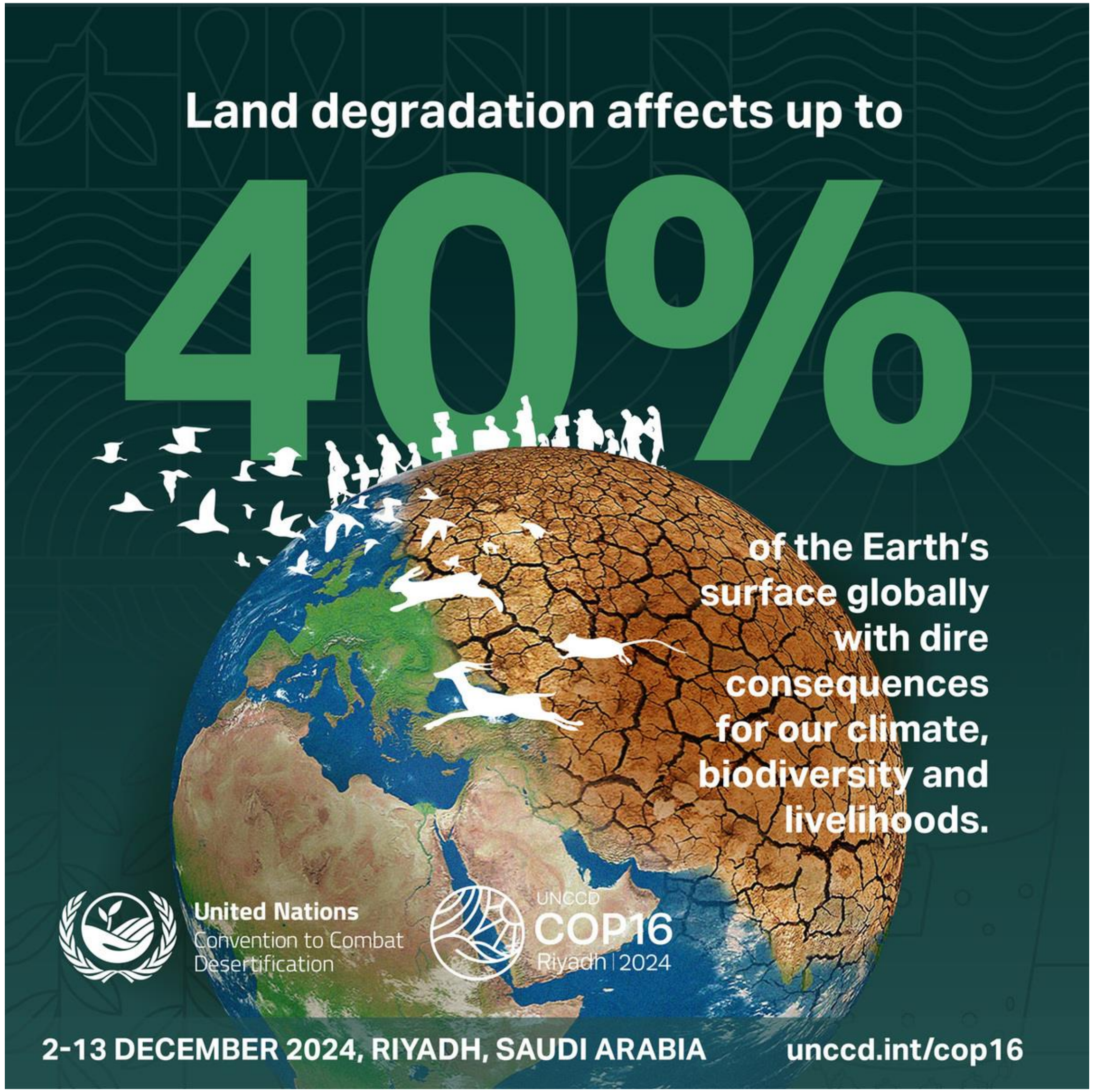
Glacier retreat
Patagonia (From 1985)



Retreat of the Aral Sea,
(From 1985)

Land Degradation – a global issue

To halt, prevent, and reverse degradation, achieving a land-degradation-neutral world, humanity needs to restore 1.5 billion hectares of degraded land by 2030.



Land Degradation – Many causes & effects

Understanding Land Degradation: Causes and Effects

Soil Erosion

Implement contour farming to reduce soil erosion rates effectively.

Deforestation

Promote reforestation initiatives to restore tree cover in degraded areas.

Overgrazing

Establish rotational grazing practices to improve pasture health and productivity.

Pollution

Implement sustainable farming practices to minimize agricultural runoff and pollutants.

Urbanization

Encourage green infrastructure to mitigate urban land impact on natural habitats.

Climate Change

Develop adaptive land management practices to improve resilience against climate impacts.

Mining Activities

Reclaim mined land using native vegetation and responsible mining techniques.

Water Scarcity

Adopt water conservation practices to enhance soil moisture retention and usage.

Land Degradation – Many challenges for monitoring and assessment

1. Data Availability and Quality

- **Sparse ground data**: Many regions, particularly in developing countries, lack reliable and consistent ground-based data.
- **Temporal gaps**: Infrequent monitoring limits the ability to detect trends or sudden changes.
- **Spatial resolution**: Satellite data may not be detailed enough for local assessments, especially in heterogeneous landscapes.

2. Methodological Inconsistencies

- **Lack of standardization**: Different countries or organizations use varying definitions and indicators of land degradation (MEDALUS, SDG15.3.1, …) > show different aspects of LD
- **Complexity of indicators**: Assessments often require integrating multiple biophysical and socio-economic indicators (e.g., soil erosion, vegetation cover, productivity, land use change), which can be difficult to measure accurately and combine meaningfully.
- **Scalability**: Methods that work at the plot level may not scale well to regional or global levels.

3. Integration of Different Data Sources

- **Incompatibility**: Remote sensing, field surveys, and socio-economic data often differ in scale, format, and quality.
- **Data fusion**: Combining multiple datasets in a coherent and analytically sound way remains technically demanding.

Land Degradation – Many challenges for monitoring and assessment

4. Dynamic and Multifactorial Nature of Degradation

- **Complex causality**: Degradation is influenced by climate, land management, policy, and socio-economic factors, making attribution difficult.
- **Thresholds and reversibility**: Identifying tipping points beyond which land degradation becomes irreversible is challenging.
- **Lag effects**: Impacts of land degradation may take years to become visible, making real-time assessment difficult.

5. Monitoring Degradation vs. Land Use Change

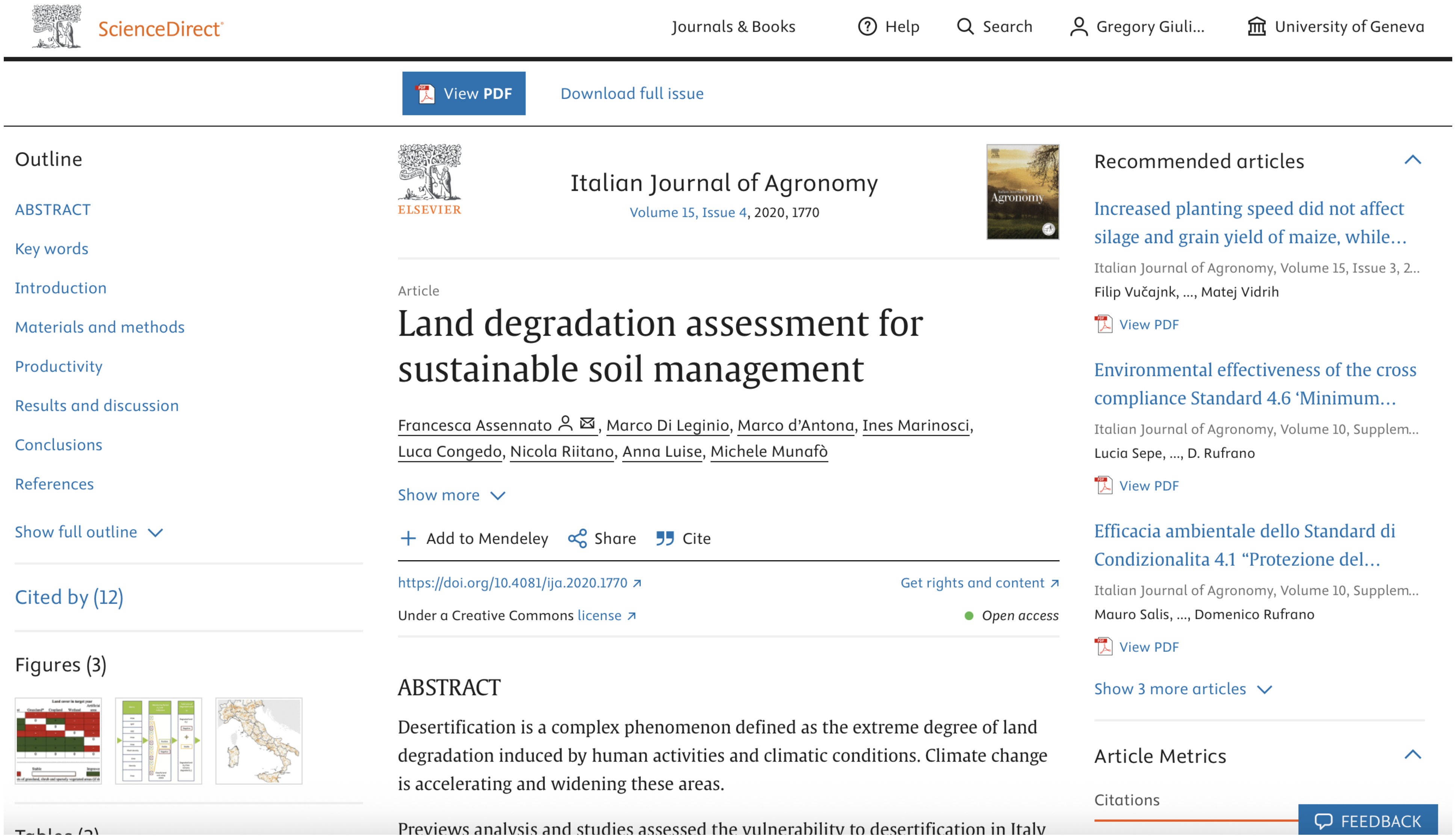
- **Confounding factors**: Land use change (e.g., urbanization or reforestation) can obscure degradation signals.
- **Misclassification**: Areas may be marked as degraded due to land use changes that are actually sustainable or beneficial

6. Socio-Economic and Institutional Barriers

- **Weak institutional capacity**: Inadequate technical and financial resources to implement monitoring programs, especially in low-income regions.
- **Policy disconnect**: Monitoring efforts may not be linked to land use planning or policy decisions.
- **Stakeholder engagement**: Local land users are often not involved in monitoring, leading to poor data validation and limited buy-in.

Assennato et al. (2020)…

…There is still the need for some technical improvement of LDN indicators to obtain an accurate land degradation picture, integrating also climate data as well as a better representation of physical and chemical phenomena.



ScienceDirect Journals & Books Help Search Gregory Giuli... University of Geneva

View PDF Download full issue

Outline

ABSTRACT
Key words
Introduction
Materials and methods
Productivity
Results and discussion
Conclusions
References
Show full outline

Cited by (12)

Figures (3)

Tables (2)

ELSEVIER
Italian Journal of Agronomy
Volume 15, Issue 4, 2020, 1770

Article

Land degradation assessment for sustainable soil management

Francesca Assennato, Marco Di Leginio, Marco d'Antona, Ines Marinosci, Luca Congedo, Nicola Riitano, Anna Luise, Michele Munafò

Show more

Add to Mendeley Share Cite

https://doi.org/10.4081/ija.2020.1770 Get rights and content

ABSTRACT

Desertification is a complex phenomenon defined as the extreme degree of land degradation induced by human activities and climatic conditions. Climate change is accelerating and widening these areas.

Previews analysis and studies assessed the vulnerability to desertification in Italy

Recommended articles

Increased planting speed did not affect silage and grain yield of maize, while…
Italian Journal of Agronomy, Volume 15, Issue 3, 2...
Filip Vučajnk, ..., Matej Vidrih
View PDF

Environmental effectiveness of the cross compliance Standard 4.6 'Minimum…
Italian Journal of Agronomy, Volume 10, Supplem...
Lucia Sepe, ..., D. Rufrano
View PDF

Efficacia ambientale dello Standard di Condizionalita 4.1 "Protezione del…
Italian Journal of Agronomy, Volume 10, Supplem...
Mauro Salis, ..., Domenico Rufrano
View PDF

Show 3 more articles

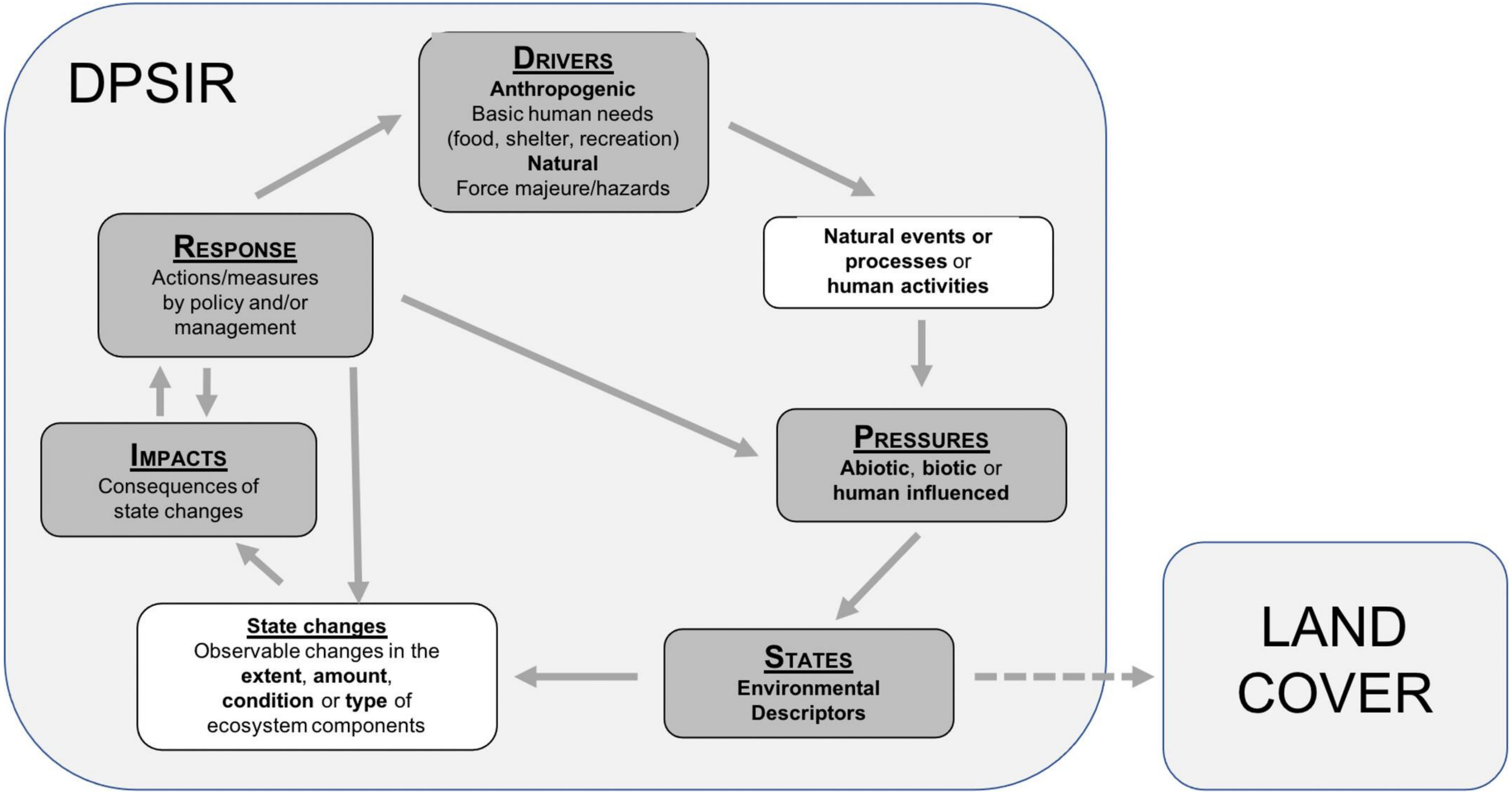
Article Metrics

Citations

FEEDBACK

How to move from systems that show states/impacts…

…to an integrated system to identify DPSIR & predict future landscapes?



Lucas et al. (2022)

Assumption…

…LD is (mostly) reflected in Land Cover change

Food and Agriculture Organization of the United Nations

Google Search on fao.org

FAO elearning Academy

About the Academy | What we do | Courses | Certification | Webinars | Repository | Partners | Help and support | You are not logged in. (Log in) Register

Using land-cover information to monitor progress on Sustainable Development Goal 15

CERTIFIED COURSE

Share Tweet Share E-mail

This course seeks to provide a basic understanding of land-cover data and its use for monitoring progress towards the achievement of international agreed goals, such as Sustainable Development Goal (SDG) 15, with a practical focus on its Indicators 15.3.1 (proportion of land that is degraded over total land area) and 15.4.2 (including its subindicators: Mountain Green Cover Index and Proportion of degraded mountain land).

Released in: MARCH 2024

3 h of learning

THEMATIC AREA: Forests and landscape restoration; Sustainable Development Goal indicators

This course is available in Spanish; French

Can we develop an integrated-consistent-standarized-scalable monitoring and assessment system for Land Degradation?

Living Earth…

…is a *standardized* framework designed to provide consistent, flexible, and scalable classification of land cover data across various spatial and temporal scales.

…developed to support environmental monitoring, land management, and sustainable development initiatives

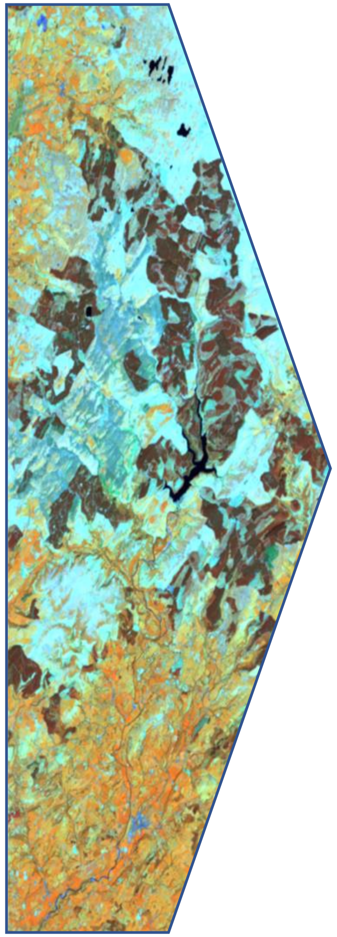
...its modular structure accommodates diverse ecological and anthropogenic features, enabling users to *harmonize* local and global datasets.

Living Earth – Concept and Approach

DIGITAL INFRASTRUCTURE (BASED ON THE OPEN DATA CUBE)

Earth Observation Data

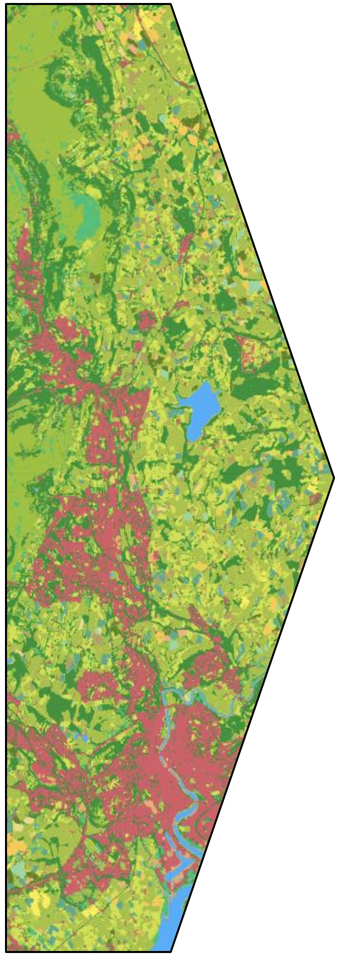
Acquisition and Processing to an Analysis Ready Format



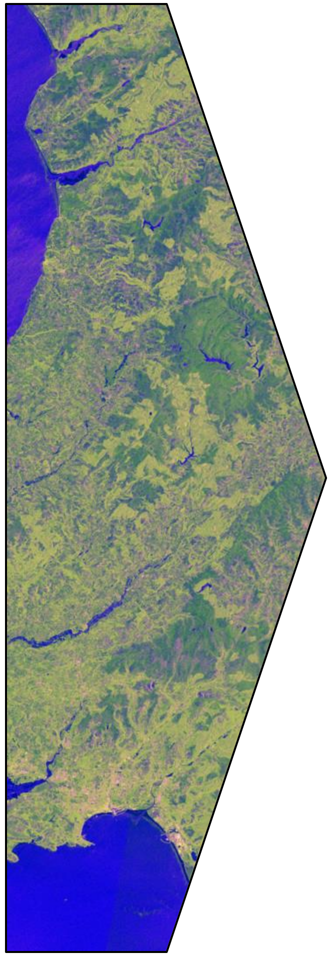
Environmental Descriptors

Classifications of land cover and habitats

Historical and near real time



Evidence-based change



Future Landscapes

Delivery

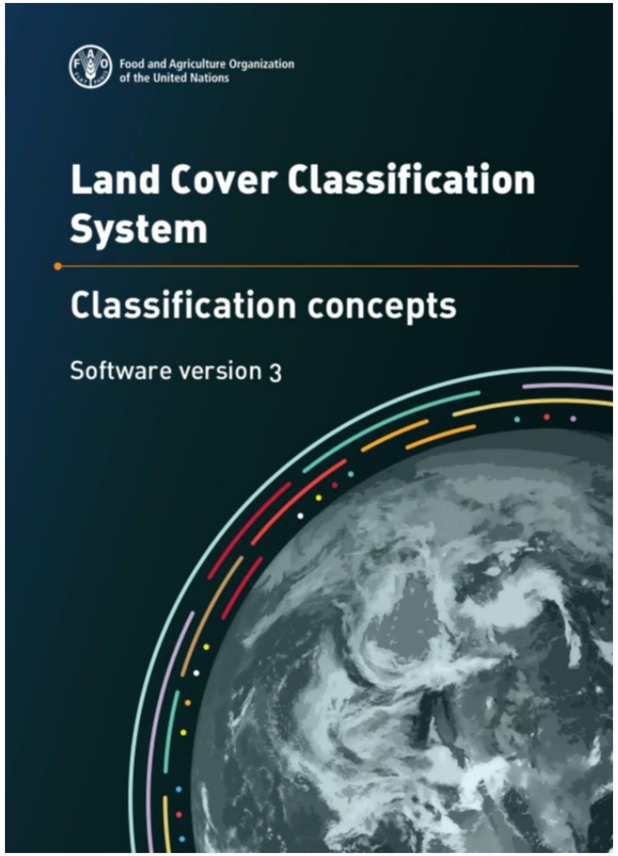
Policy, Economy, Environment and Society

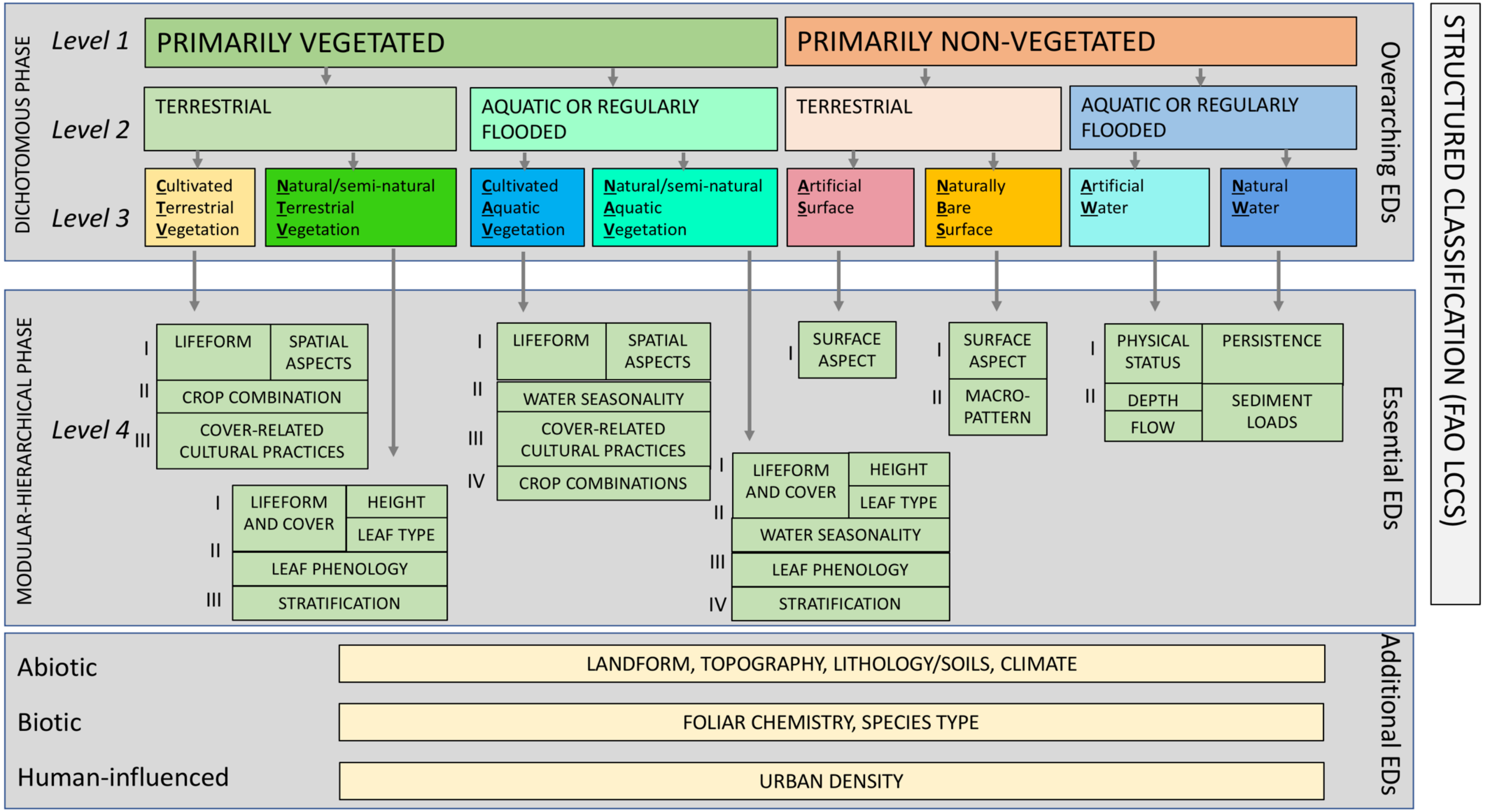
Calibration and Validation

ENGAGEMENT (E.G. ACADEMIA, GOVERNMENTS, RESEARCH AND SPACE AGENCIES, NGOS, LANDHOLDERS)

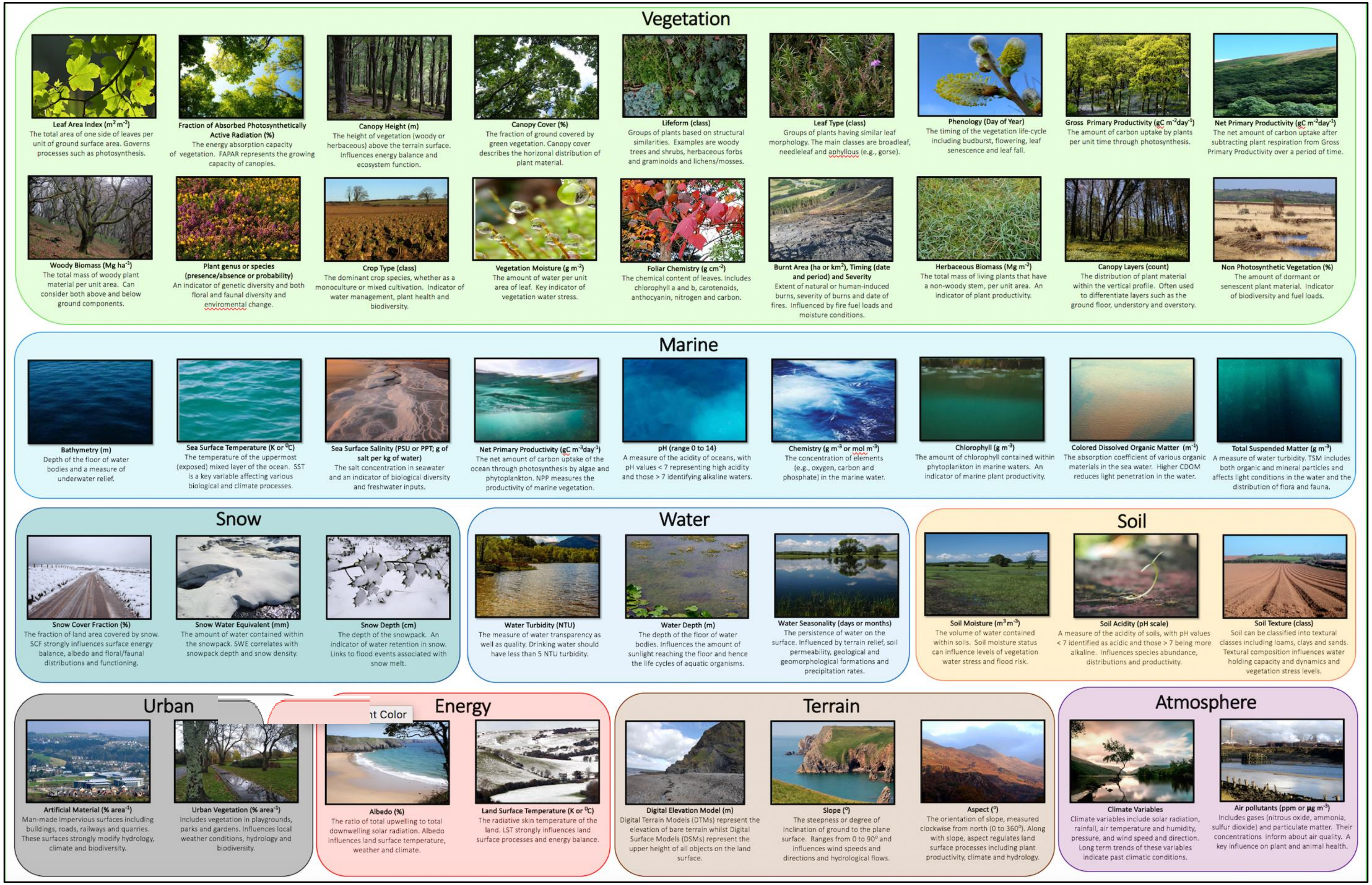
Classification of land cover

Living Earth uniquely constructs land cover classes from environmental descriptors (EDs) retrieved or classified primarily from EO data and according to the Food and Agriculture Organisation (FAO) Land Cover Classification System (LCCS).





Environmental Descriptors: Categorical or continuous



Defined Categories

CROP TYPE

The crop type is the type of plants cultivated in the fields during the main growing season. The crop type can be, for example, maize, potatoes, etc. The type of crops is important for various applications such as hydrological modelling, plant health, crop science, environment monitoring, biodiversity safeguard, etc. Indeed, the type of plants directly...

READ MORE

Defined units

WOODY BIOMASS

Woody biomass is defined as the total mass of living plant material per woody area. Aboveground biomass plays a key role in the carbon cycle and climate processes. It can be measured through direct or indirect in situ sampling (see here) or estimated through satellite/airborne sensors. Typically, biomass in woody areas ranges between 0 (poorly...

READ MORE

Environmental Descriptors: Categorical or continuous

Broad description (Level 3)

- 'Natural' Terrestrial Vegetation

More detail (Level 4)

- Woody shrub
- Canopy cover (40-65 %)
- Canopy height (0.5 m)
- Broadleaved
- Evergreen
- No second layer
- Not waterlogged

Additional information

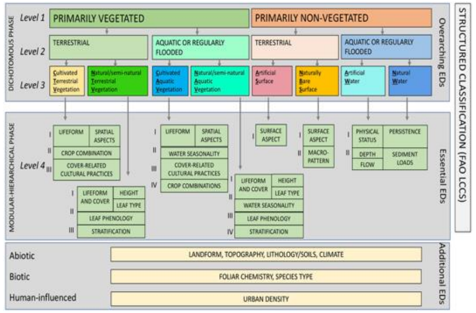
- Above ground biomass (10 kg)
- Canopy cover (55.5 %)
- Species A

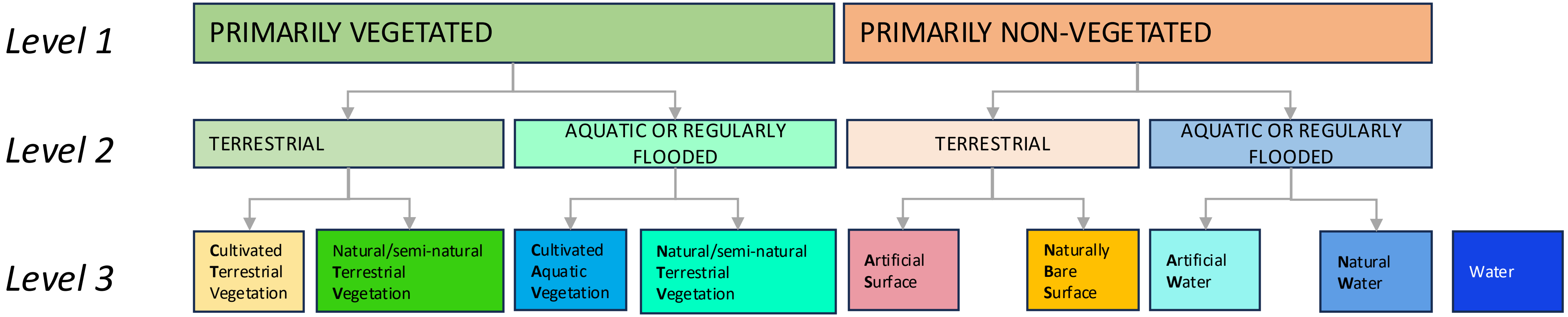
If defined units or categories are used, then the descriptors and overall description are completely scalable in space and time.

Constructing Land Cover Maps

Overarching Environmental Descriptors

Make the undercoat



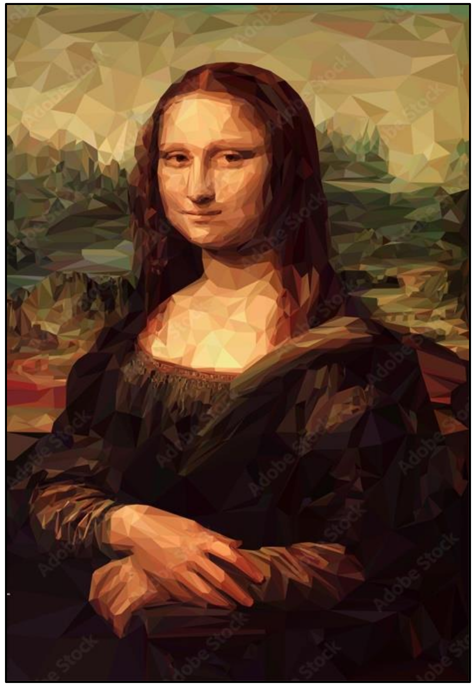


Overarching Environmental Descriptors

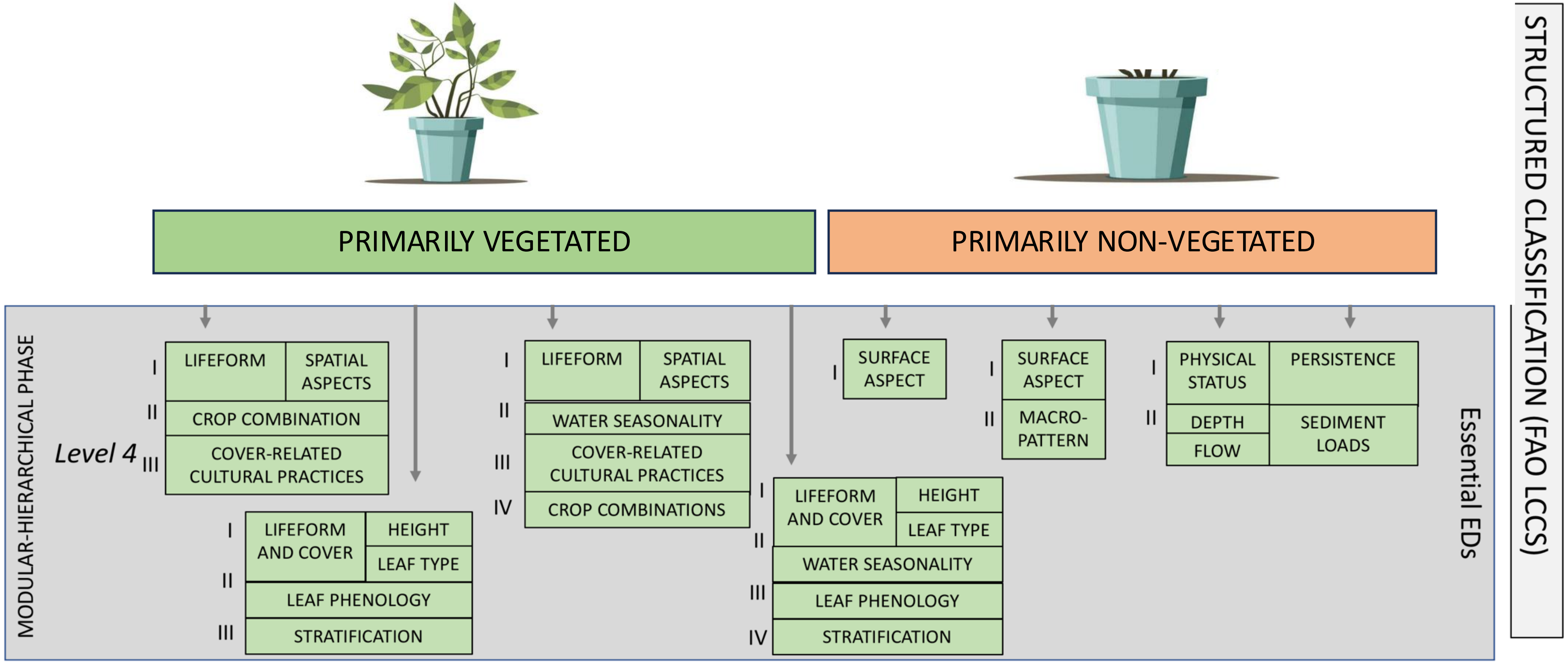
Constructing Land Cover Maps

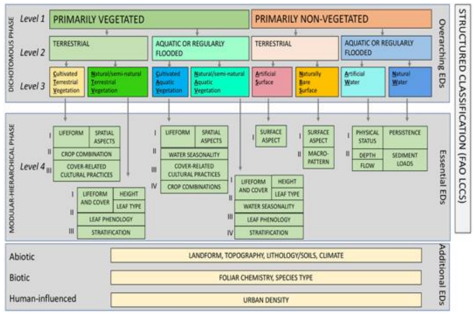
Essential Environmental Descriptors

Needed to fully construct the FAO LCCS



Add in detail





A12

CODE	Lifeform
A1	Woody
A2	Herbaceous
A3	Trees
A4	Shrubs
A5	Forbs
A6	Graminoids
A7	Lichens/Mosses

CODE	Canopy cover
A10	Closed (> 65 %)
A12	Open (40-65 %)
A13	Open (15 to 40 %)
A15	Sparse (4 to 15 %)
A16	Scatt3ered (1 to 4 %)

CODE	Canopy height
B5	> 14 m
B6	7 to 14 m
B7	5 to 7 m
B8	2 to 5 m
B9	0.5 to 2 m
B10	< 0.5 m

CODE	Leaf type
D1	Broad-leaved
D2	Needle-leaved
D3	Aphyllous

CODE	Leaf phenology
E1	Evergreen
E2	Deciduous
E3	Mixed
E5	Mixed (Forbs, graminoids)

CODE	Stratification
F1	Second layer absent
F2	Second layer present

CODE	Water seasonality
C1	Water > 3 months, semi(-permanent
C2	Water < 3 months (temporary or seasonal)
C3	Waterlogged
C4	Water < 3 months (persistent all day)
C5	Water > 3 months (with daily variations)

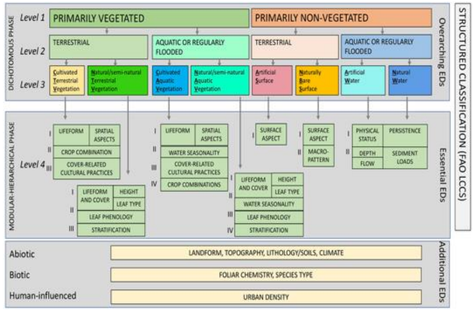
A12 . A4 . A12 . B10 . D1 . E1 . F1

Shrub, open (40> 65 %) canopy cover, short (< 0.5 m), broadleaved evergreen with no second layer

Constructing Land Cover Maps

Additional Environmental Descriptors

Put in the frame and other finishing touches



PRIMARILY VEGETATED

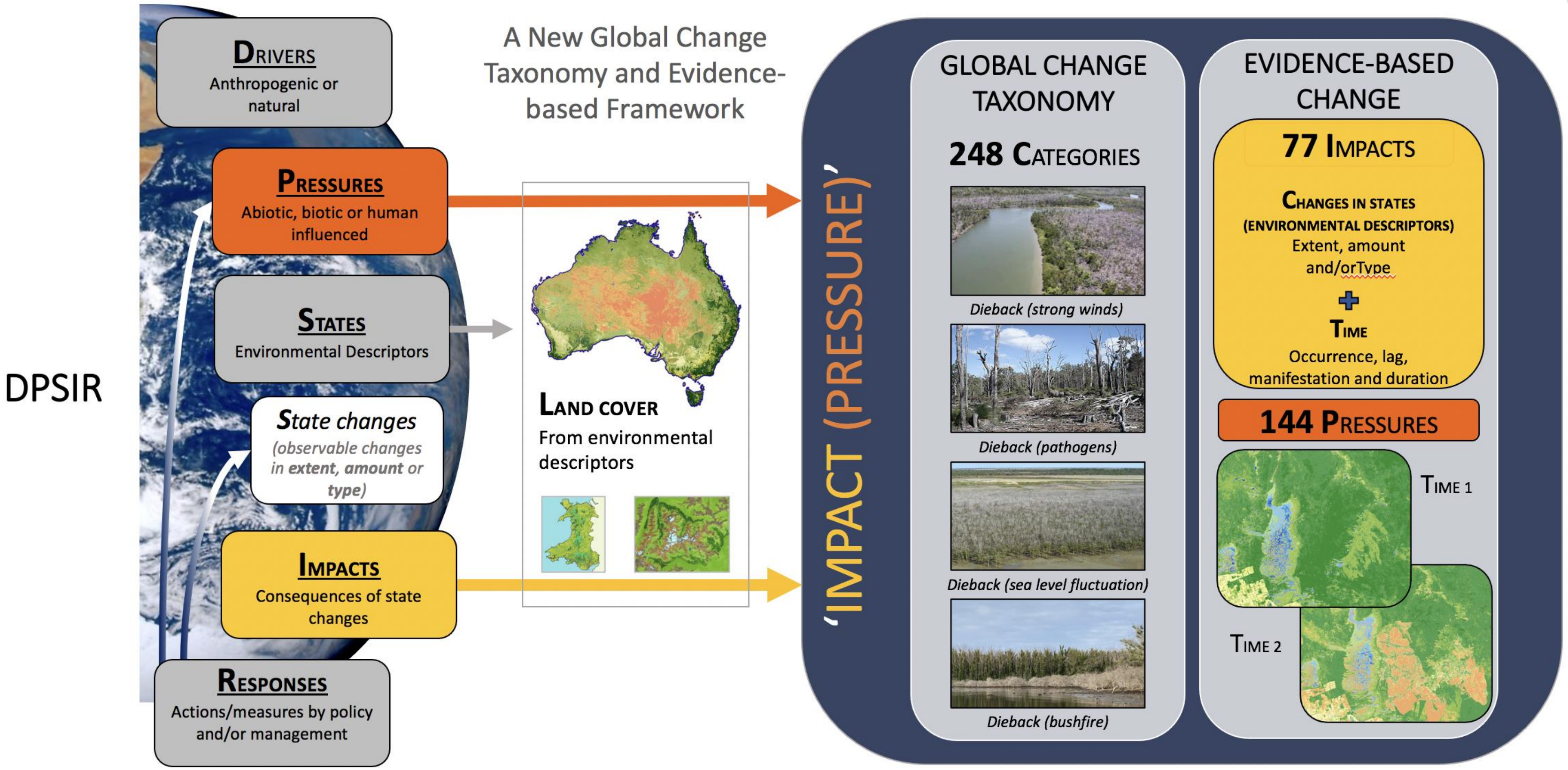
PRIMARILY NON-VEGETATED

Additional EDs

Abiotic	LANDFORM, TOPOGRAPHY, LITHOLOGY/SOILS, CLIMATE
Biotic	FOLIAR CHEMISTRY, SPECIES TYPE
Human-influenced	URBAN DENSITY

Evidence-Based Change Framework (EBCF)

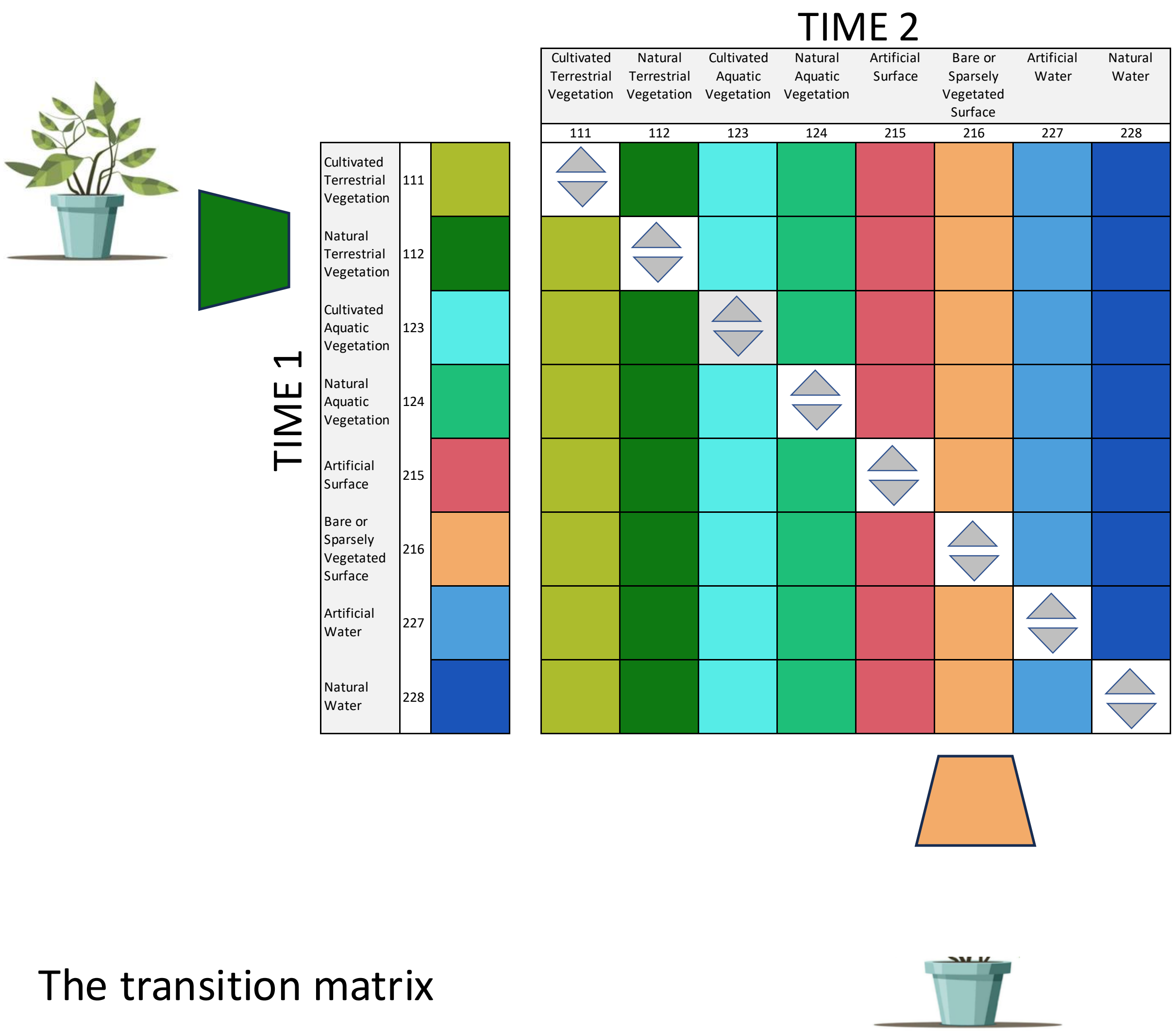
Living Earth partners developed Evidence-Based Change Framework with this building on the Driver-Pressure-State-Impacts-Response (DPSIR) framework and a Global Change Taxonomy. Currently, **77** impact and **144** pressure terms are defined, forming **246** combined 'impact(pressure)' classes. The use of EDs with pre-defined units and codes ensures scalability of the *Living Earth* approach across space and time.



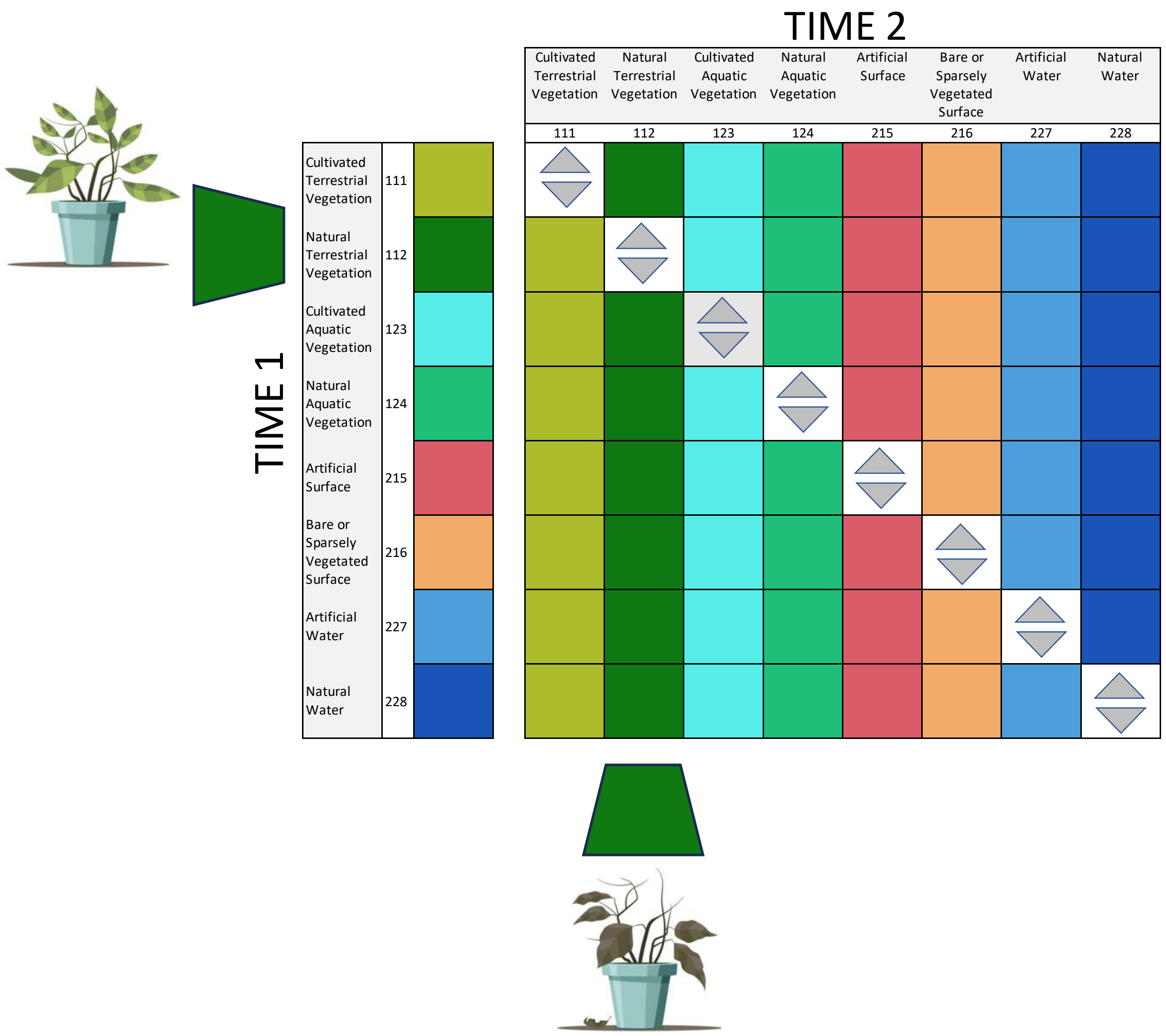
Comparisons of LCCS maps and contributing EDs between time-separated periods allows evidence for change impacts to be gathered and linked to driving pressures to ascertain causes and consequences.

Observed change - comparing OEDs (Level 3)

CONVERSION
(Off-diagonals)

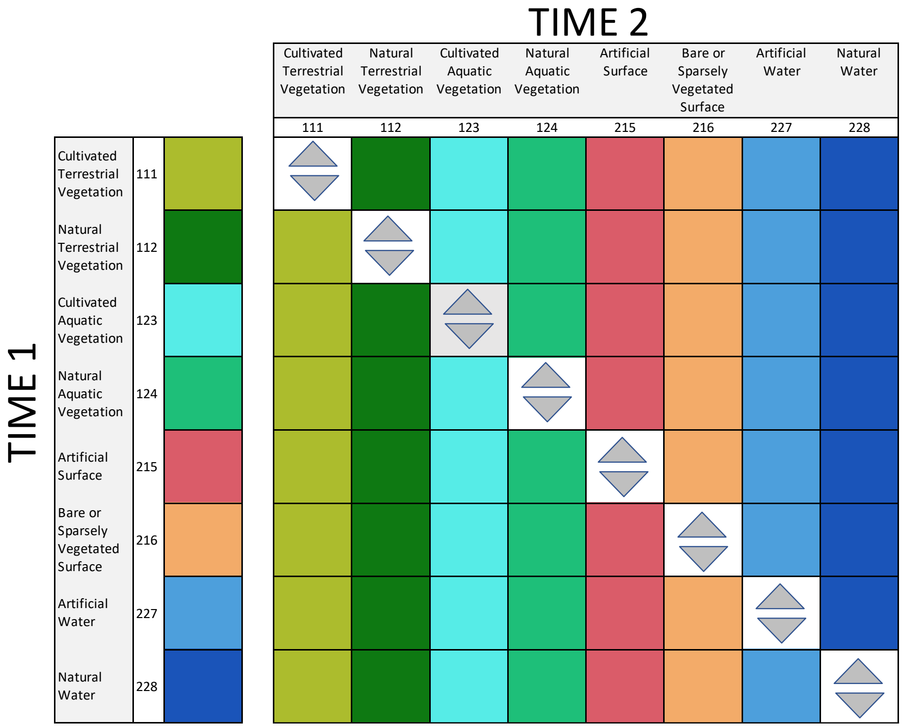


MODIFICATION
(on-diagonals)



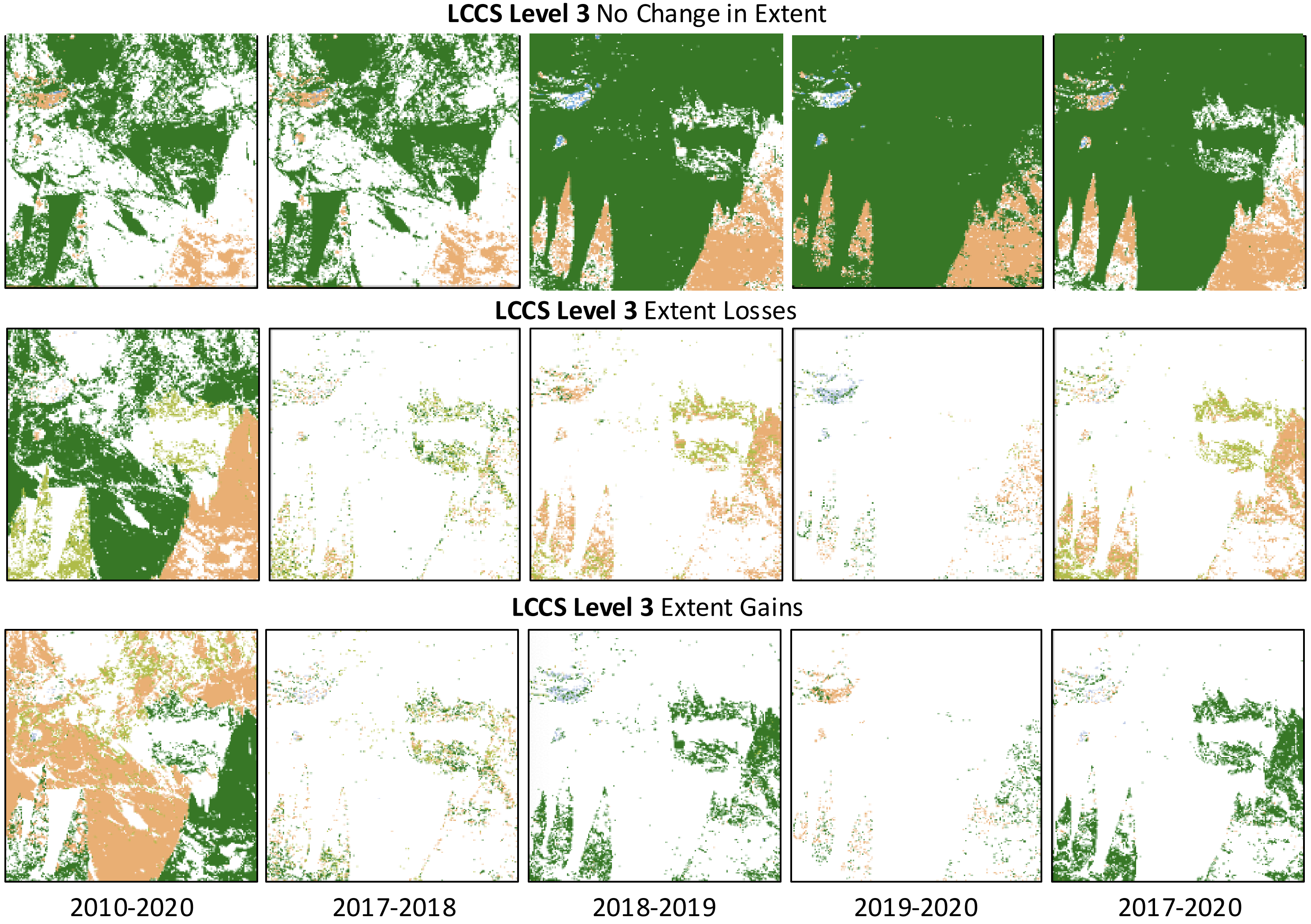
The transition matrix

Observed Change



Digital Earth AUSTRALIA

Modifications and conversions at LCCS Level 3



Evidence for impacts

Cultivated Terrestrial Vegetation	Natural Terrestrial Vegetation	Cultivated Aquatic Vegetation	Natural Aquatic Vegetation	Artificial Surface	Bare or Sparsely Vegetated Surface	Artificial Water	Natural Water
111	112	123	124	215	216	227	228

Evidence for each of the 77 impacts is gathered by comparing the environmental descriptors used to construct and describe the land cover maps between any two time-separated periods.

Vegetation dieback	Vegetation damage	Vegetation amount (reduction)	Vegetation amount (gain)	Vegetation extent (gain)
Level 3: 111=Cultivated Terrestrial Veg., 112=(Semi-)Natural Terrestrial Veg., 123=Cultivated Aquatic Veg., 112=(Semi-)Natural Veg., 215=Naturally Bare Surface, 216=Artificial Surface, 227=Artificial Water, 228=Natural Water				
CTV to CTV CAV to CAV | NTV to NTV NAV to NAV	CTV to CTV CAV to CAV | NTV to NTV NAV to NAV	CTV to CTV CAV to CAV | NTV to NTV NAV to NAV	CTV to CTV CAV to CAV | NTV to NTV NAV to NAV	NBS to CTV, NTV, CAV or NAV AV to to CTV, NTV, CAV or NAV | AS to to CTV, NTV, CAV or NAV NW to to CTV, NTV, CAV or NAV
A: Lifeform: A1 = Woody, A2 = Herbaceous, [*A3 = Trees, A4 = Shrubs, A5 = Forbs, A6 = Graminoids, A7 = Lichens/Mosses, A8 = Lichens, A9 = Mosses*]				
Remains woody | Remains herb.	Remains woody | Remains herb.	Remains woody | Remains herb.	Remains woody | Woody to herb. | Remains herb.	Becomes woody | Becomes herb.
A: Canopy cover: A10 = Closed (> 65 %), A12 = Open (40-65 %), A13 = Open (15 to 40 %), A15 = Sparse (4 to 15 %) and A16 = Scatt3ered (1 to 4 %)				
Decrease in canopy cover	Decrease in canopy cover	Decrease in canopy cover	Increase in canopy cover	Increase in canopy cover
B: Canopy height: B5= > 14 m, B6 = 7 to 14 m, B7 = 5 to 7 m, B8 = 2 to 5 m, B9 = 0.5 to 2 m, B10 = < 0.5 m				
Decrease in forest height	Decrease in forest height	Decrease in forest height	Increase in forest height	Increase in forest height
D: Leaf type: D1 = Broad-leaved, D2 = Needle-leaved[*D3 = Aphyllous*]				
Remains BLeaf | Remains NLeaf	Remains BLeaf | Remains NLeaf	Remains BLeaf | Remains NLeaf	Remains BLeaf | Remains NLeaf | Bleaf to NLeaf | Nleaf to BLeaf	Becomes BLeaf | Becomes NLeaf
E: Phenology: E1 = Evergreen, E2 = Deciduous = 2 [*E3 = Mixed, E5 = Mixed (Forbs, graminoids or grasses)*]				
Remains evergreen | Remains deciduous	Remains evergreen | Remains deciduous	Remains evergreen | Remains deciduous	Remains evergreen | Deciduous to evergreen | Remains deciduous	Becomes evergreen | Becomes deciduous
Canopy cover (Range 0-100 %): Loss = -1, Gain = 1, no quantifiable change = 0; uncertainty can be included (continuous variable).				
Decrease in canopy cover	Decrease in canopy cover	Decrease in canopy cover	Increase in canopy cover	Increase in canopy cover
AG Biomass (Range 0 - > 500 Mg ha^{-1}): Loss = -1, Gain = 1, no quantifiable change = 0; uncertainty can be included.				
No change or decrease in AGB	Decrease in AGB	Decrease in AGB	Increase in AGB	Increase in AGB

Identifying and evidencing pressures

Each of the 77 impacts is linked to a number of driving pressures (144 in total)

Vegetation dieback

- Anchoring
- Cold snap
- Drought
- Heatwave
- Increased wind
- Non-insect herbivory (natural)
- Pathogens
- Pollution
- Prolonged inundation
- Prolonged snow cover
- Sea level fluctuation
- Soil salinisation
- Water salinization*

Vegetation extent (loss)

- Bushfire
- Deforestation
- Drought
- Excess rain
- Farmland abandonment
- Land reclamation
- Sea defence construction
- Strong winds
- Vegetation clearance
- Wave action*

Vegetation amount (reduction)

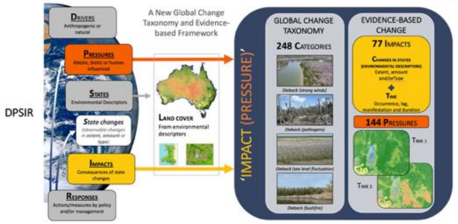
- Bushfire
- Coppicing
- Decreased nutrient supply in soil
- Farmland abandonment
- Fuelwood collection
- Harvesting
- Insect herbivory
- Mowing
- Non-insect herbivory (natural)
- Overgrazing (natural)
- Overgrazing (stock)
- Pesticide application
- Sedimentation
- Selective logging
- Stubble burn
- Thinning*

Vegetation amount (gain)

- Afforestation
- Bushfire recovery
- Ecological restoration
- Encroachment
- Farmland abandonment
- Fertilizer application
- Growth
- Reduced or cessation of grazing
- Reforestation (natural)
- Reforestation (plantations)
- Regrowth
- Removal of herbivores
- Revegetation
- Thinning
- Urban greening
- Vegetation thickening*

Vegetation extent (gain)

- Afforestation
- Colonisation
- Wave action
- Ecological restoration
- Greenspace construction
- Mine site rehabilitation
- Planting
- Rehabilitation
- Revegetation
- Snowmelt*



Recap

Environmental descriptors used to construct land cover classes

Defined units or categories

Broad description

'Cultivated' Terrestrial Vegetation

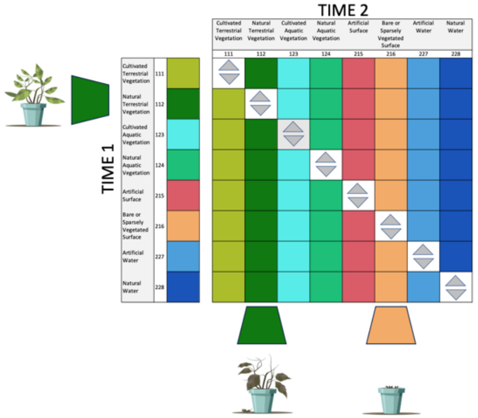
More detail

- Woody shrub
- Canopy cover (40-65 %)
- Canopy height (0.5 m)
- Broadleaved
- Evergreen
- No second layer
- Not waterlogged

Additional information

- Above ground biomass (10 kg)
- Canopy cover (55.5 %)
- Species A

I: Observed change



Modification (on-diagonal)

Conversion (off diagonal)

NATURAL TERRESTRIAL VEGETATION
Trees closed canopy (> 65 %) tall (>14 m) broadleaved evergreen with an understory; canopy cover of 72 (± 5) %, above ground biomass of 170 (± 15) Mg ha^{-1}, dominated by European beech (*Fagus sylvatica*)
A12. A3.A10.B5.D2.E2.F1
-72 (± 5). 170 (± 15).676

NATURAL TERRESTRIAL VEGETATION
Trees closed canopy (< 10 %) tall (< 2m) broadleaved evergreen with no understory; canopy cover of 50 (± 10) %, above ground biomass of 15 (± 5) Mg ha^{-1}, dominated by Birch (*Betula pendula*)
A12.A3.A15.B8.D2.E2.F2
- 50 (± 10). 15 (± 5) .144

II: Evidence for impacts

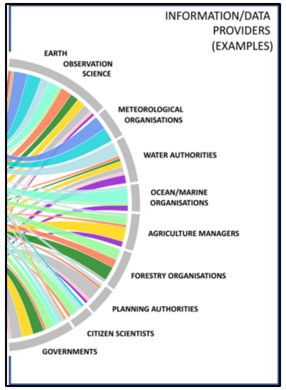
Gathering through time-series comparison of environmental descriptors

Vegetation dieback
Level 3:
CTV to CTV | NTV to NTV
CAV to CAV | NAV to NAV
A: Lifeform:
Remains woody | Remains herb.
A: Canopy cover
Decrease in canopy cover
B: Canopy height:
Decrease in forest height
D: Leaf type:
Remains BLeaf | Remains NLeaf
E: Phenology
Remains evergreen | Remains deciduous
Canopy cover (Range 0-100 %):
Decrease in canopy cover
AG Biomass (Range 0 - > 500 Mg ha^{-1}
No change or decrease in AGB

III: Identifying and evidencing pressures

- Anchoring
- Cold snap
- Drought
- Heatwave
- Increased wind
- Non-insect herbivory (natural)
- Pathogens
- Pollution
- Prolonged inundation
- Prolonged snow cover
- Sea level fluctuation
- Soil salinisation
- Water salinization*

Different pressures linked to impacts



Sources of pressure data

IV: Linking impacts with pressures

Sequential and/or simultaneous

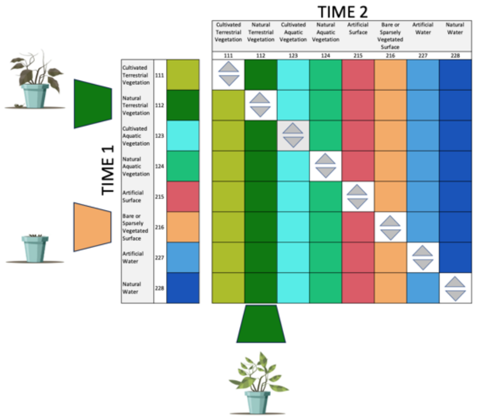
Vegetation extent (gain) (Colonization)
Veg. amount (gain) (Growth) | **Veg. species change** (Succession)
Vegetation dieback (Pathogens)
Veg. amount (gain) (Growth) | **Veg. species change** (Succession)

Impact (pressure)

V: Future landscapes

Visioning

Designing landscapes



Planning Actions

Colonization > **Vegetation extent (gain)**
Growth > **Veg. amount (gain)** | Succession > **Veg. species change**
Avoid Pathogens ~ **Vegetation dieback**
Growth > **Veg. amount (gain)** | Succession > **Veg. species change**

Pressure > Impact

Big Earth Data ›
Volume 5, 2021 - Issue 3: Big Data in Support of the Sustainable Development Goals (Part A): A celebration of the establishment of the International Research Center of Big Data for Sustainable Development Goals (CBAS)

Original Research Article

Living Earth: Implementing national standardised land cover classification systems for Earth Observation in support of sustainable development

Christopher J. Owers, Richard M. Lucas, Daniel Clewley, Carole Planque, Suvarna Punalekar, Belle Tissott,
...show all

Pages 368-390 | Received 15 Apr 2021, Accepted 17 Jun 2021, Published online: 28 Jul 2021

Cite this article https://doi.org/10.1080/20964471.2021.1948179 Check for updates

In this article

ABSTRACT

Earth Observation (EO) has been recognised as a key data source for supporting the United Nations Sustainable Development Goals (SDGs). Advances in data availability and analytical capabilities have provided a wide range of users access to global coverage analysis-ready data (ARD). However, ARD does not provide the information required by national agencies tasked with coordinating the implementation of SDGs. Reliable, standardised, scalable mapping of land cover and its change over time and space facilitates informed decision making, providing cohesive methods for target setting and reporting of SDGs. The aim of this study was to implement a global framework for classifying land cover. The Food and Agriculture Organisation's Land Cover Classification System (FAO LCCS) provides a global land cover taxonomy suitable to comprehensively support SDG target setting and reporting. We present a fully implemented FAO LCCS optimised for EO data; *Living Earth*, an open-source software package that can be readily applied using existing national EO infrastructure and satellite data. We resolve several semantic challenges of LCCS for consistent EO implementation, including modifications to environmental descriptors, inter-dependency within the modular-hierarchical framework, and increased flexibility associated with limited data availability. To ensure easy adoption of *Living Earth* for SDG reporting, we identified key environmental

Global Change Biology

RESEARCH ARTICLE | Open Access

A globally relevant change taxonomy and evidence-based change framework for land monitoring

Richard M. Lucas, Sophia German, Graciela Metternicht, Rebecca K. Schmidt, Christopher J. Owers, Suzanne M. Prober, Anna E. Richards, Sally Tetreault-Campbell, Kristen J. Williams ... See all authors

First published: 01 September 2022 | https://doi.org/10.1111/gcb.16346 | Citations: 3

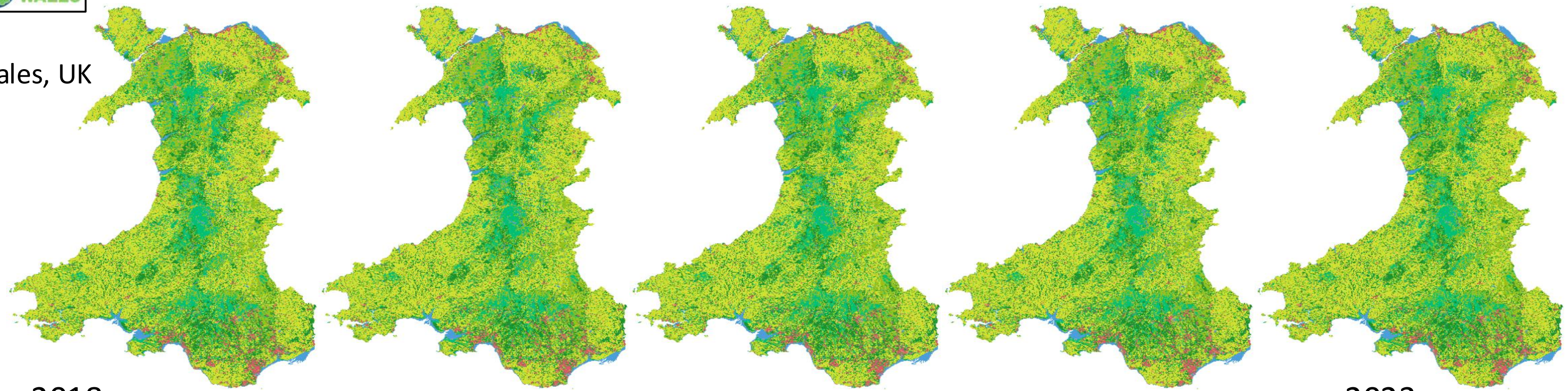
Abstract

A globally relevant and standardized taxonomy and framework for consistently describing land cover change based on evidence is presented, which makes use of structured land cover taxonomies and is underpinned by the Driver-Pressure-State-Impact-Response (DPSIR) framework. The Global Change Taxonomy currently lists 246 classes based on the notation 'impact (pressure)', with this encompassing the consequence of observed change and associated reason(s), and uses scale-independent terms that factor in time. Evidence for different impacts is gathered through temporal comparison (e.g., days, decades apart) of land cover classes constructed and described from Environmental Descriptors (EDs; state indicators) with pre-defined measurement units (e.g., m, %) or categories (e.g., species type). Evidence for pressures, whether abiotic, biotic or human-influenced, is similarly accumulated, but EDs often differ from those used to determine impacts. Each impact and pressure term is defined separately, allowing flexible combination into 'impact (pressure)' categories, and all are listed in an openly accessible glossary to ensure consistent use and common understanding. The taxonomy and framework are globally relevant and can reference EDs quantified on the ground, retrieved/classified remotely (from ground-based, airborne or spaceborne sensors) or predicted through modelling. By providing capacity to more consistently describe change processes—including land degradation, desertification and ecosystem restoration—the overall framework addresses a wide and diverse range of local to international needs including those relevant to policy, socioeconomics and land management. Actions in response to impacts and pressures and monitoring towards targets are also supported to assist future planning, including impact mitigation actions.

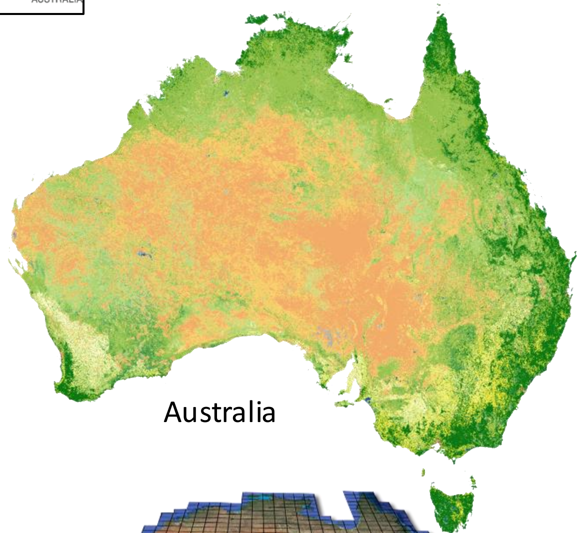
Living Earth - in Action

Living Earth has been developed for local to national implementation, including through the newly established Welsh Data Cube, Geoscience Australia's Digital Earth Australia, the Swiss Data Cube and CSIRO's EASI.

Wales, UK

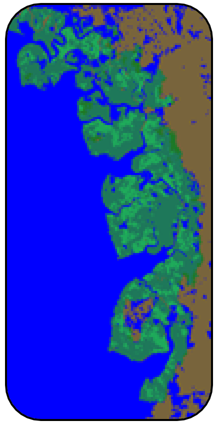


2018 2023

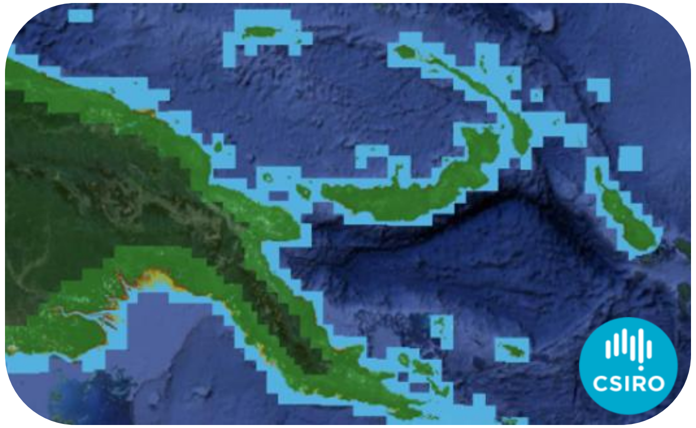


Australia

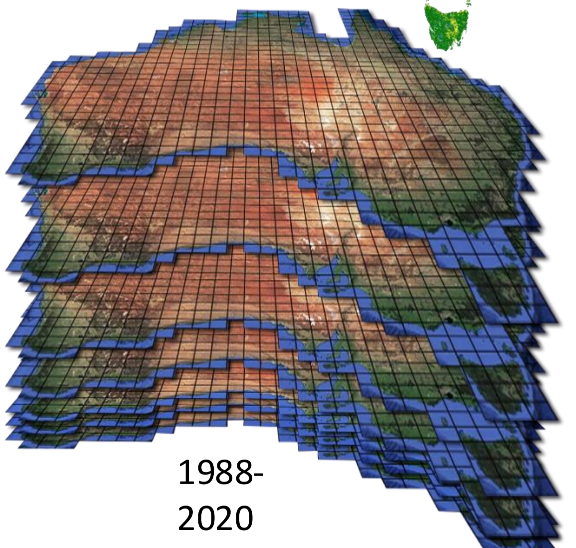
Switzerland



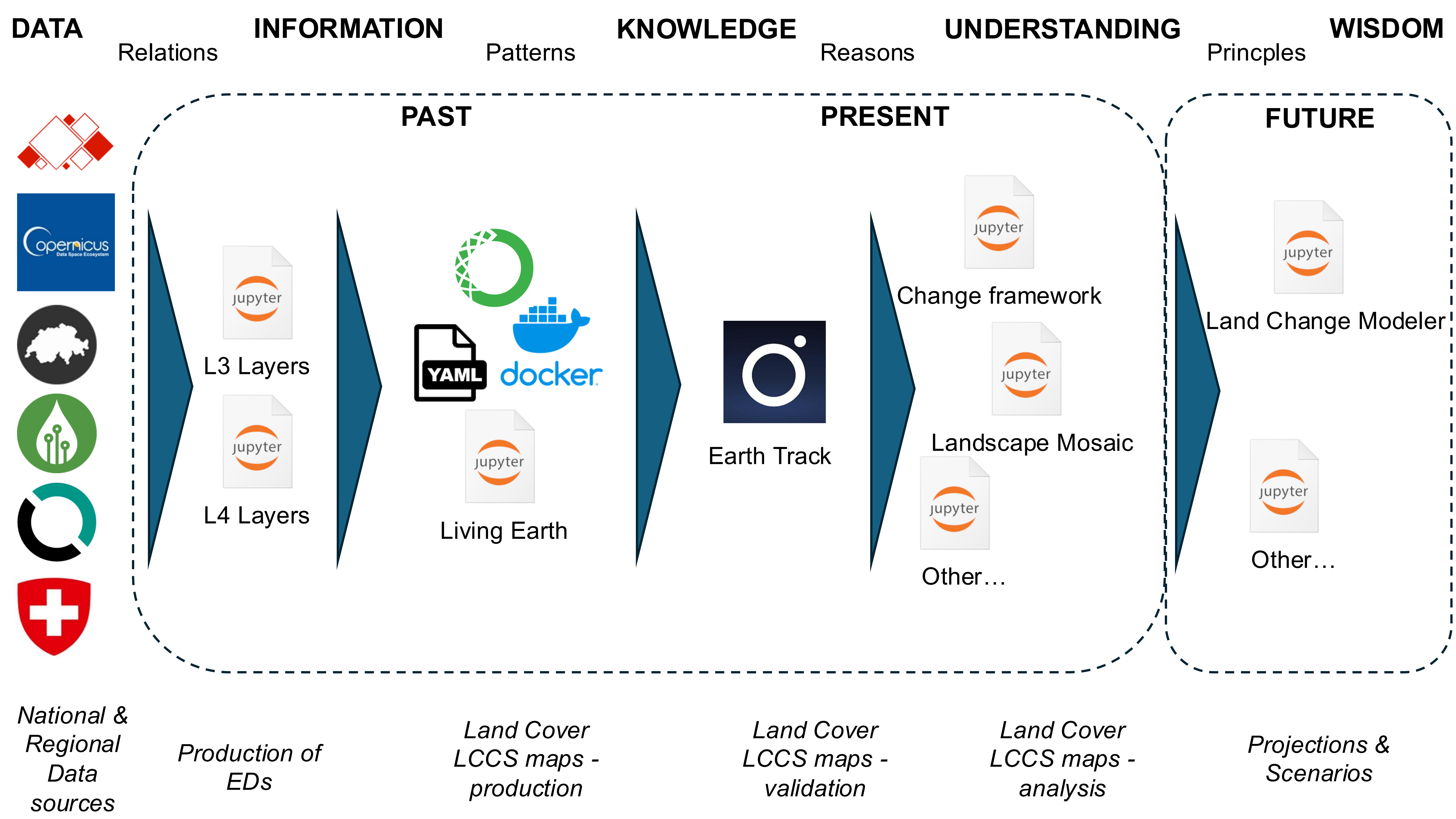
Malaysia



Papua New Guinea

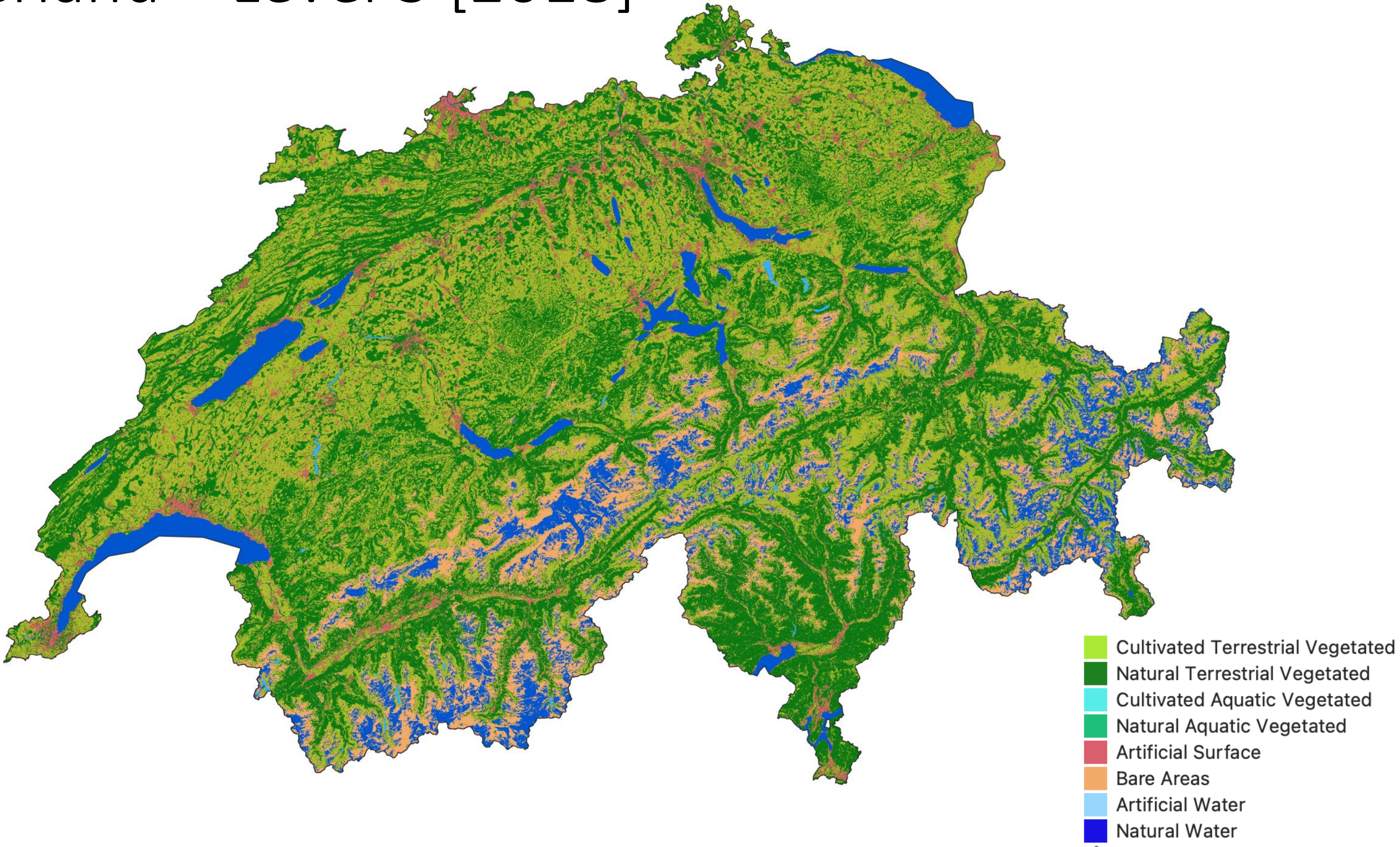


1988-
2020

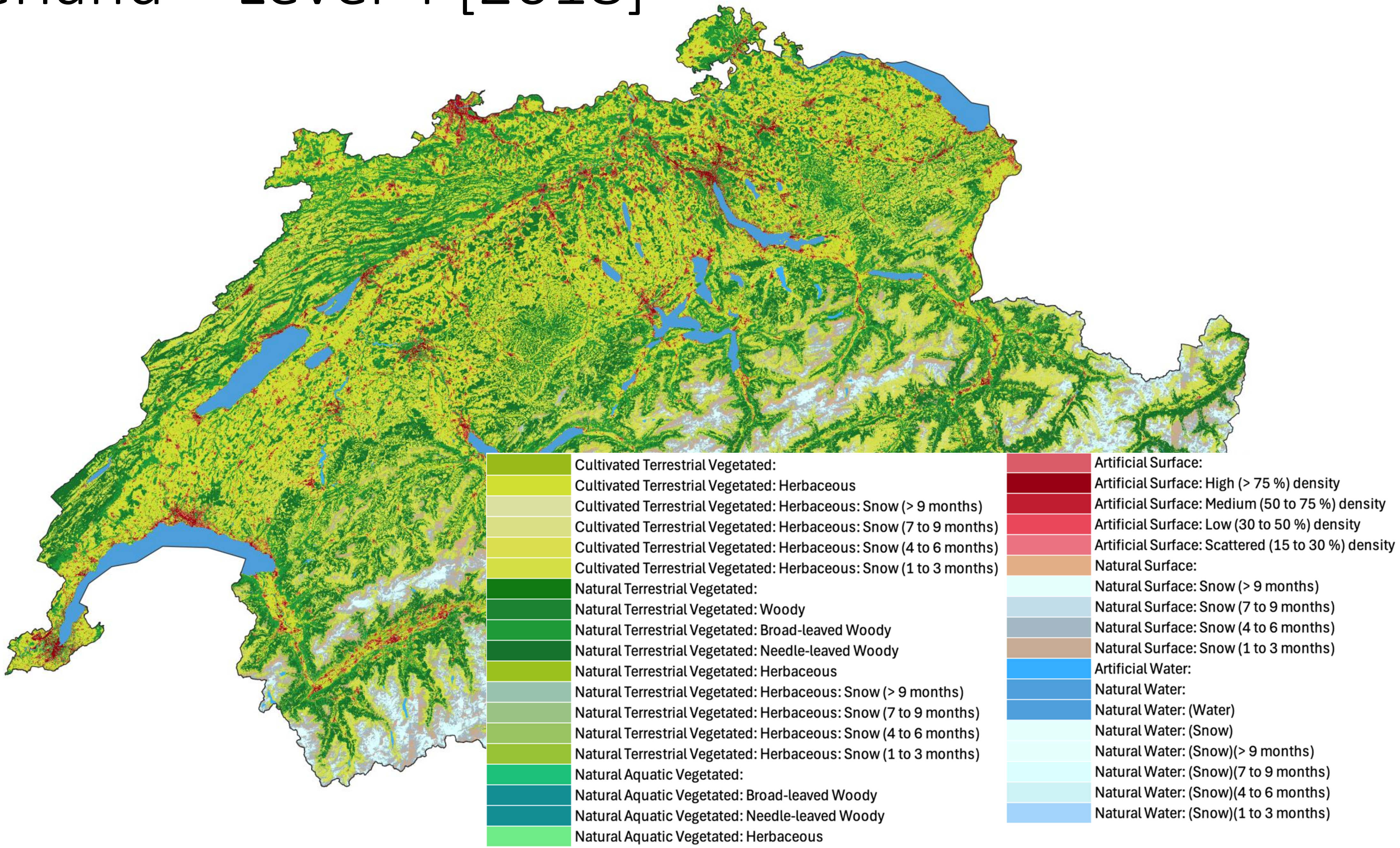


DATA
Relations
INFORMATION
Patterns
KNOWLEDGE
Reasons
UNDERSTANDING
Princples
WISDOM
PAST
PRESENT
FUTURE
L3 Layers
L4 Layers
YAML
docker
Living Earth
Earth Track
Change framework
Landscape Mosaic
Other…
Land Change Modeler
Other…
National & Regional Data sources
Production of EDs
Land Cover LCCS maps - production
Land Cover LCCS maps - validation
Land Cover LCCS maps - analysis
Projections & Scenarios

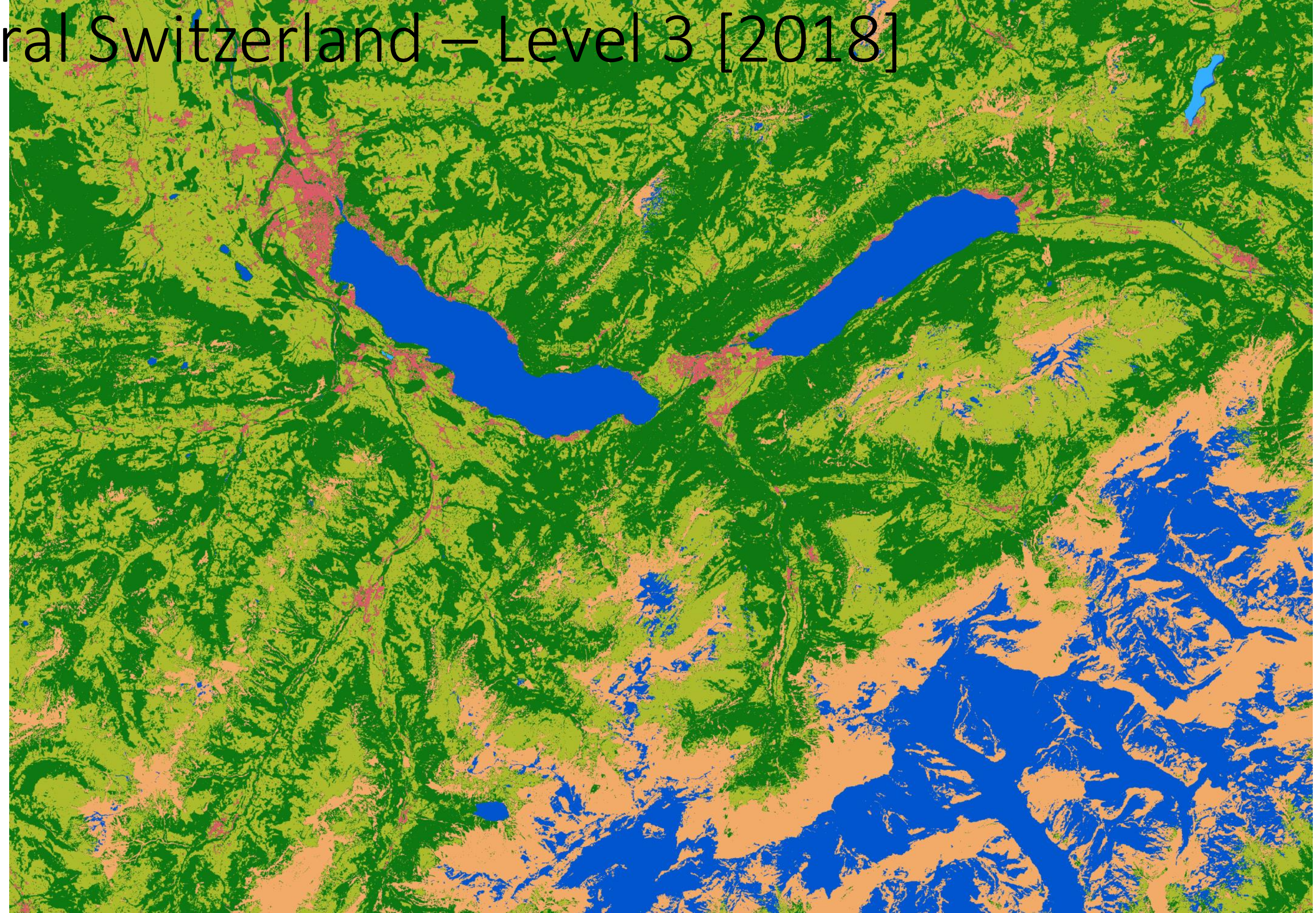
Switzerland – Level 3 [2018]



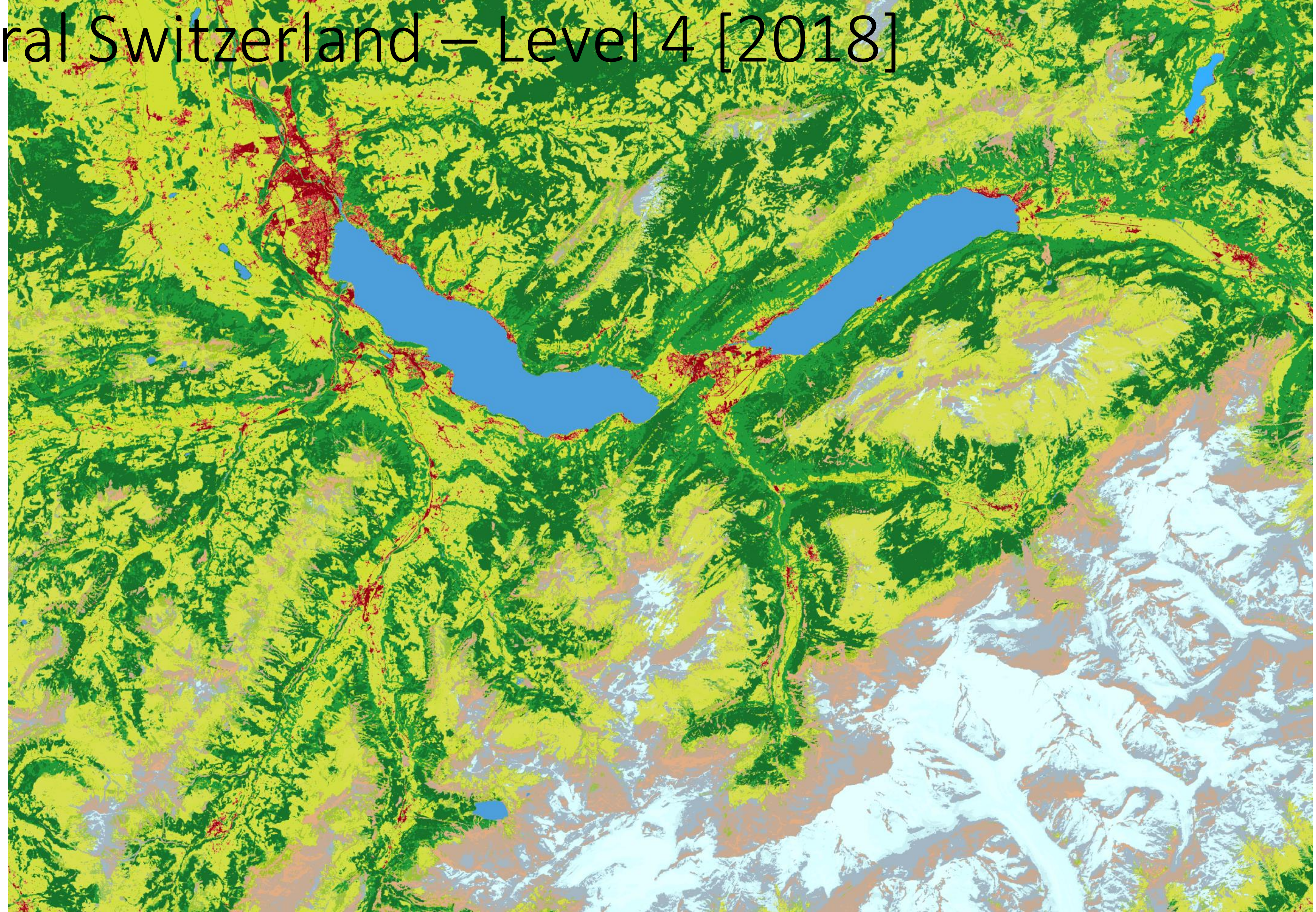
Switzerland – Level 4 [2018]



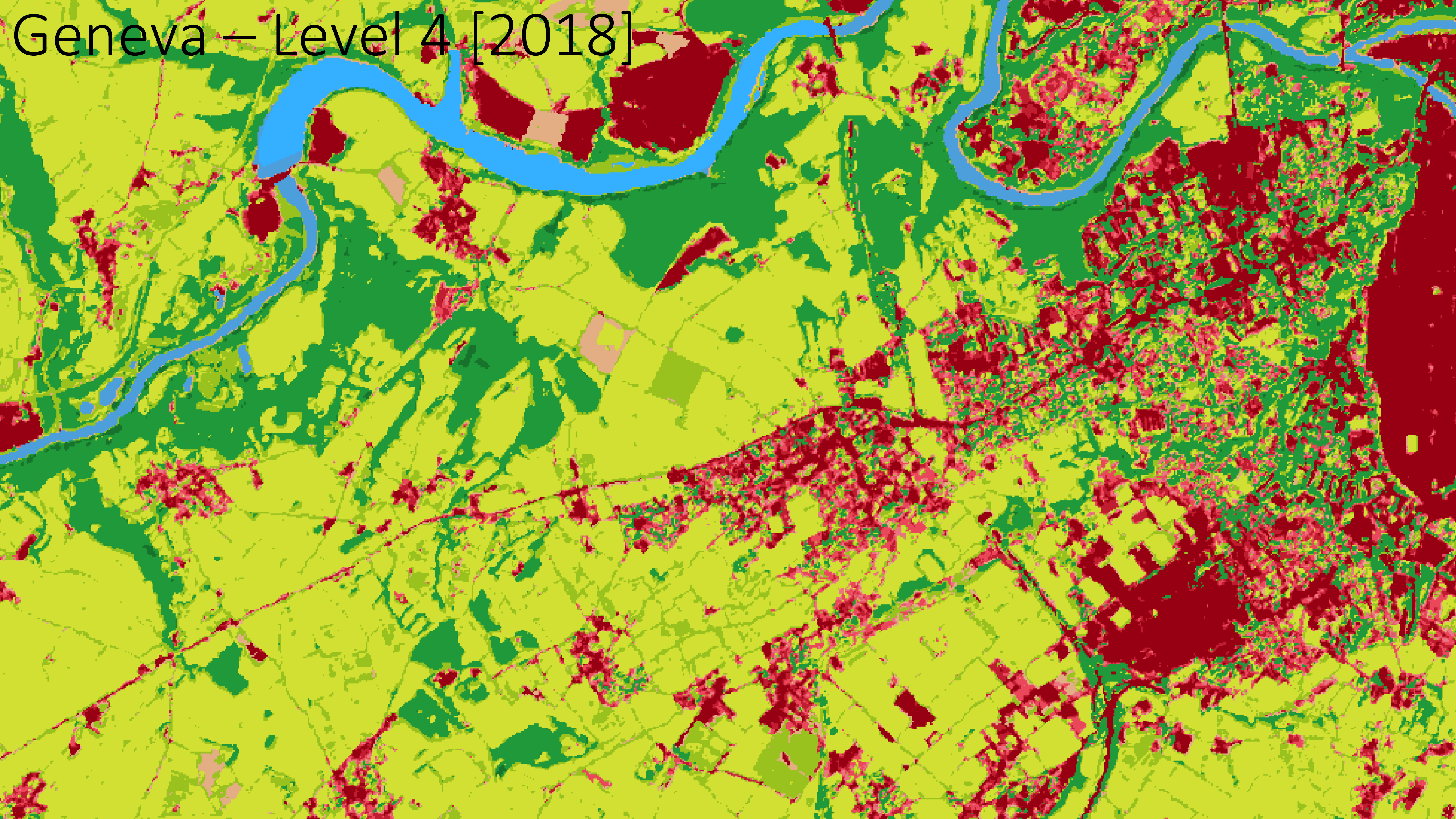
Central Switzerland – Level 3 [2018]



Central Switzerland – Level 4 [2018]



Geneva – Level 4 [2018]

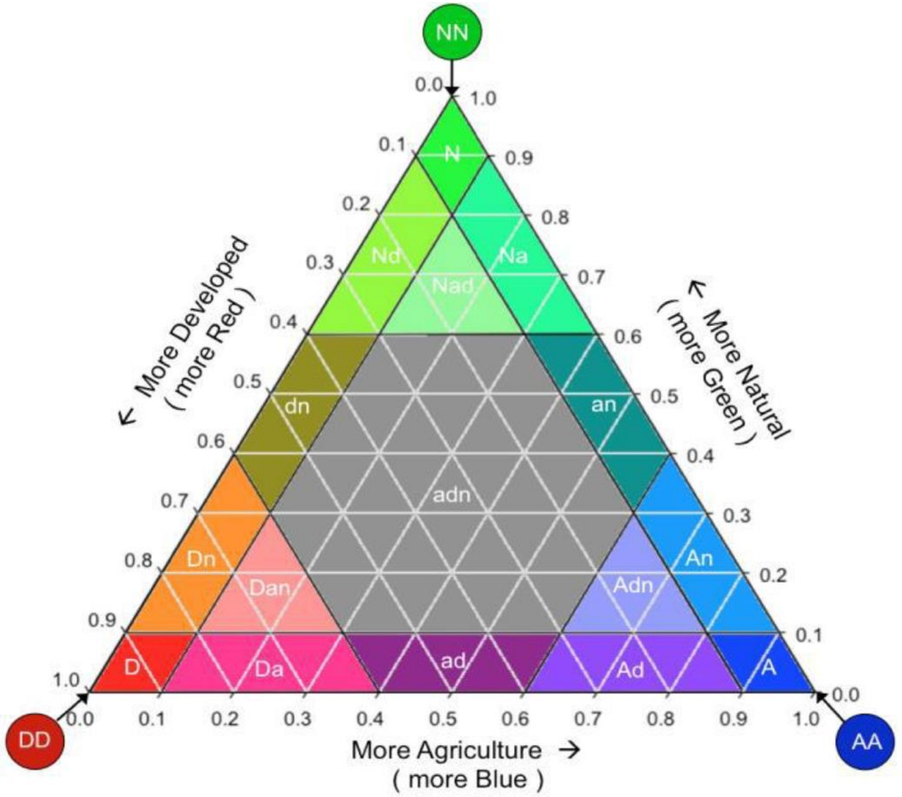


Landscape Mosaic Model

More than 90% of the earth's land surface has experienced some human impact. As human populations continue to expand and migrate, they alter the earth's landscapes. Natural processes and human activities spatially interact to produce an ever-changing mosaic.

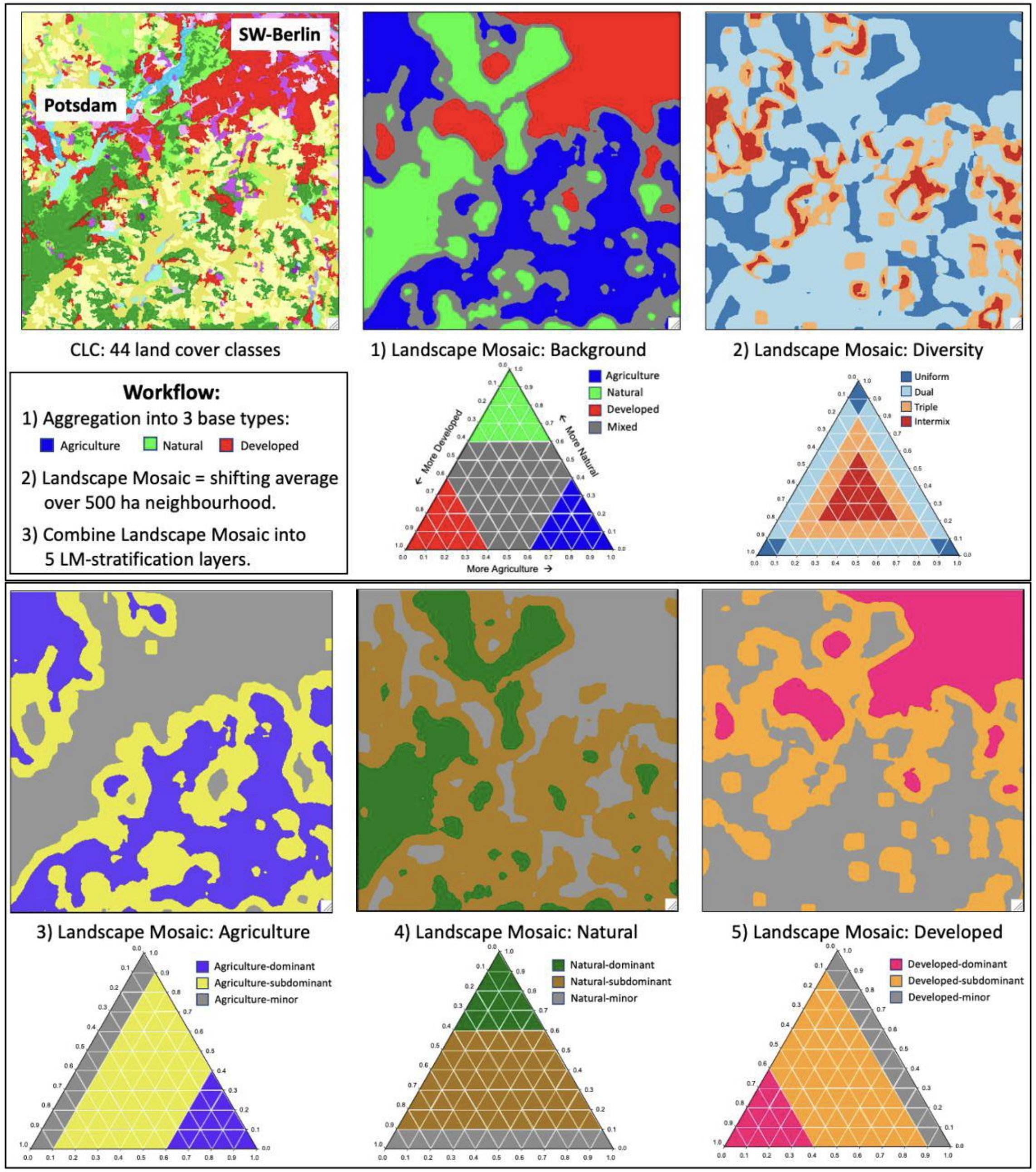
The Landscape Mosaic model quantifies and maps the spatial juxtaposition of different land uses. It provides a landscape perspective of anthropic threats posed by agriculture and urban development, and the spatial-temporal shifting of the landscape mosaic indicates landscapes where anthropic intensity has changed.

The Landscape Mosaic is a tri-polar classification of a location accounting for the relative contributions of three prevalent land cover types, i.e., Agriculture, Natural, Developed in the window surrounding that location. The classification model is designed to identify anthropogenic activity (land cover classes falling in the categories Agriculture and Developed) in relation to natural land cover



Value [byte] - Class Name	Color	RGB
0 – Missing		255/255/255
1 – A		000/000/255
2 – D		255/000/000
3 – N		000/255/000
4 – Ad		128/000/255
5 – An		000/128/255
6 – Dn		255/128/000
7 – Da		255/000/128
8 – Na		000/255/128
9 – Nd		128/255/000
10 – Adn		128/128/255
11 – Dan		255/128/128
12 – Nad		128/255/128
13 – ad		128/000/128
14 – an		000/128/128
15 – dn		128/128/000
16 – adn		128/128/128
17 – NN		000/191/000
18 – AA		000/000/191
19 – DD		191/000/000

Landscape Mosaic Model



Landscape Mosaic Model

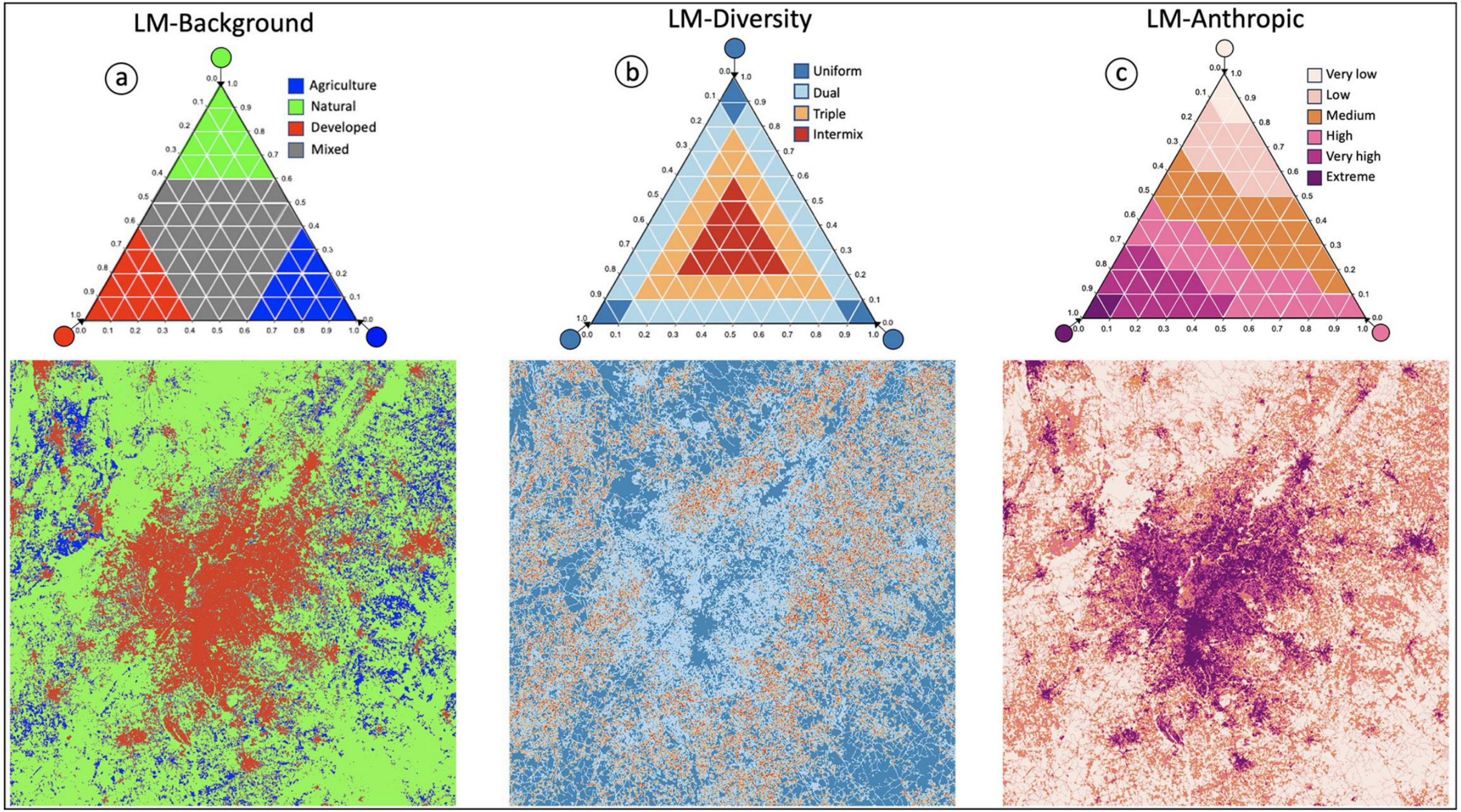
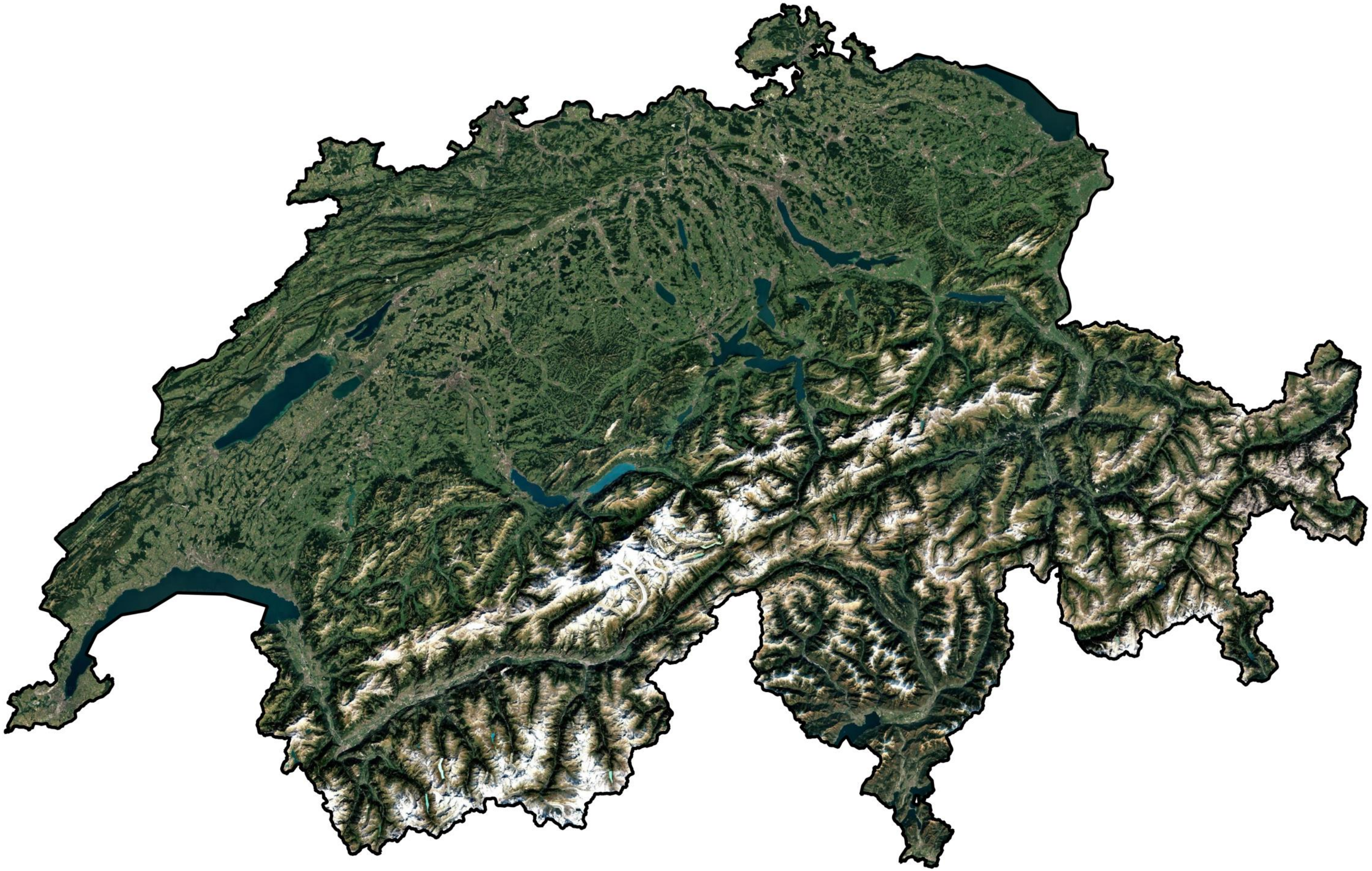


Fig 3. LM around Atlanta for the year 2021 using a moving window size of 13 pixels. Showing the 103-class LM map and applying different color tables to highlight dominant background land cover (a), degree of diversity (b), or anthropic intensity (c).

https://doi.org/10.1371/journal.pone.0304215.g003

Vogt P, Wickham J, Barredo JI, Riitters K (2024) Revisiting the Landscape Mosaic model. PLoS ONE 19(5): e0304215. https://doi.org/10.1371/journal.pone.0304215

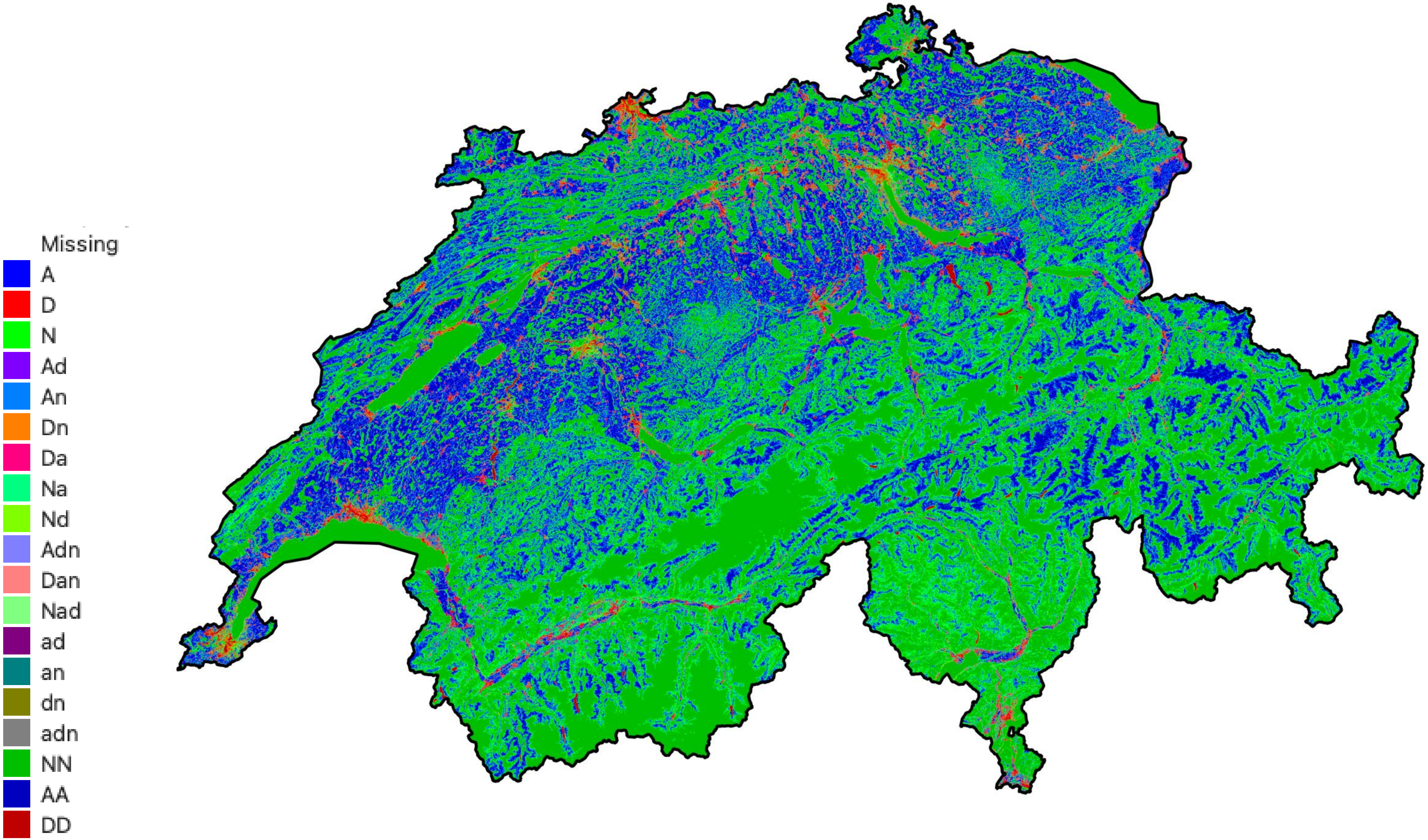
Switzerland – Sentinel-2



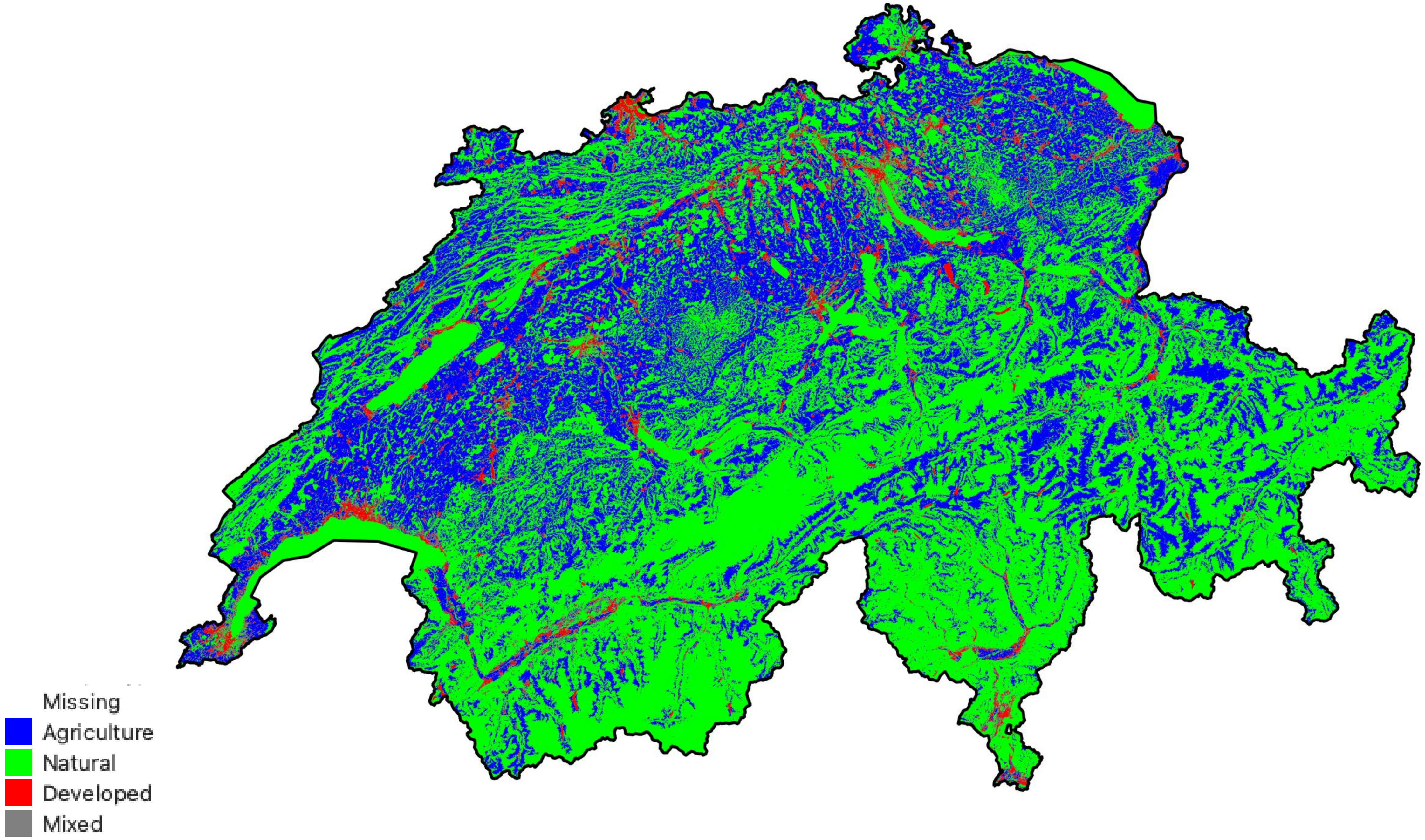
Land Cover


Cultivated Terrestrial Vegetated
Natural Terrestrial Vegetated
Cultivated Aquatic Vegetated
Natural Aquatic Vegetated
Artificial Surface
Bare Areas
Artificial Water
Natural Water

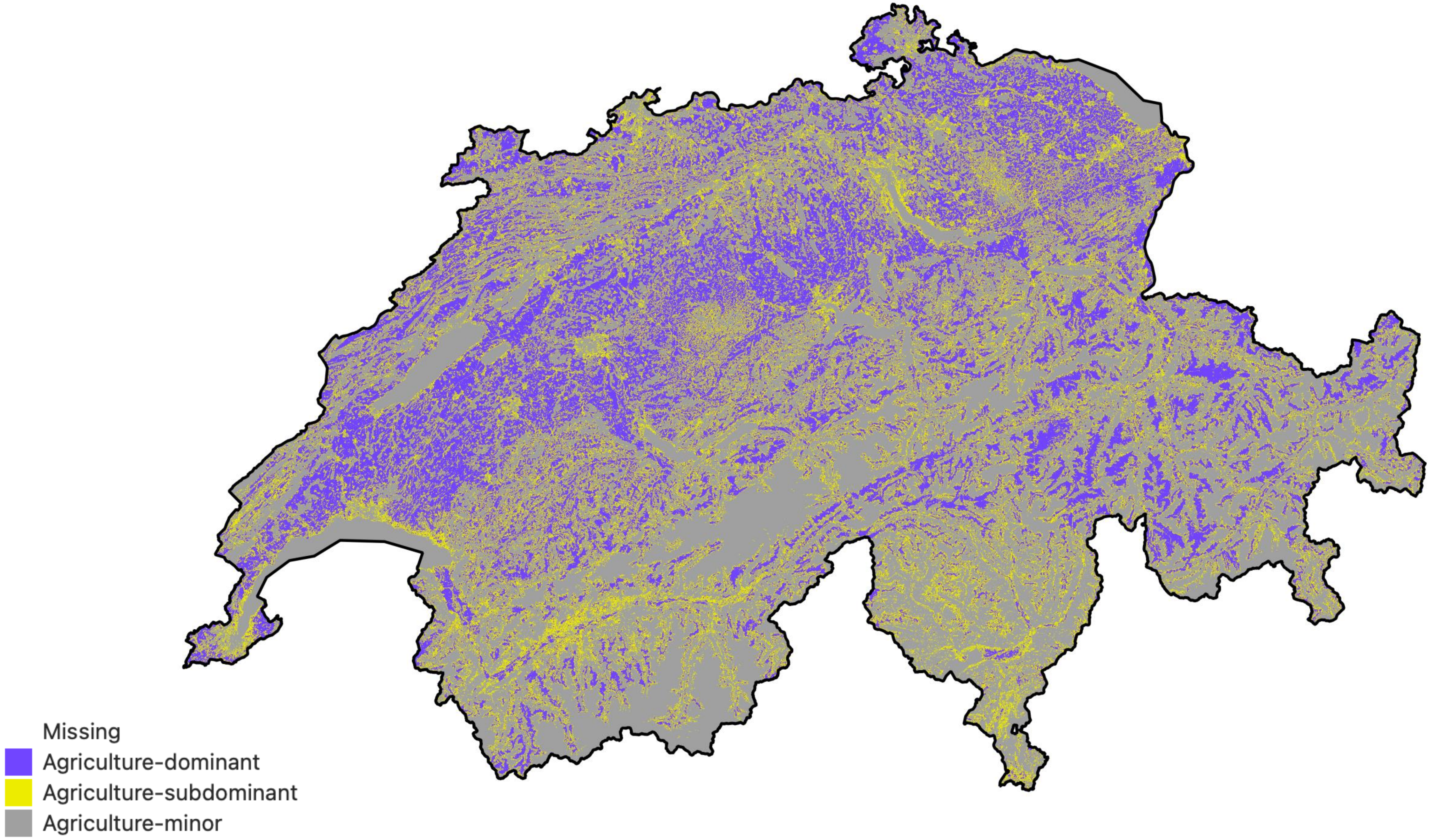
LM - 19 classes



LM - Background



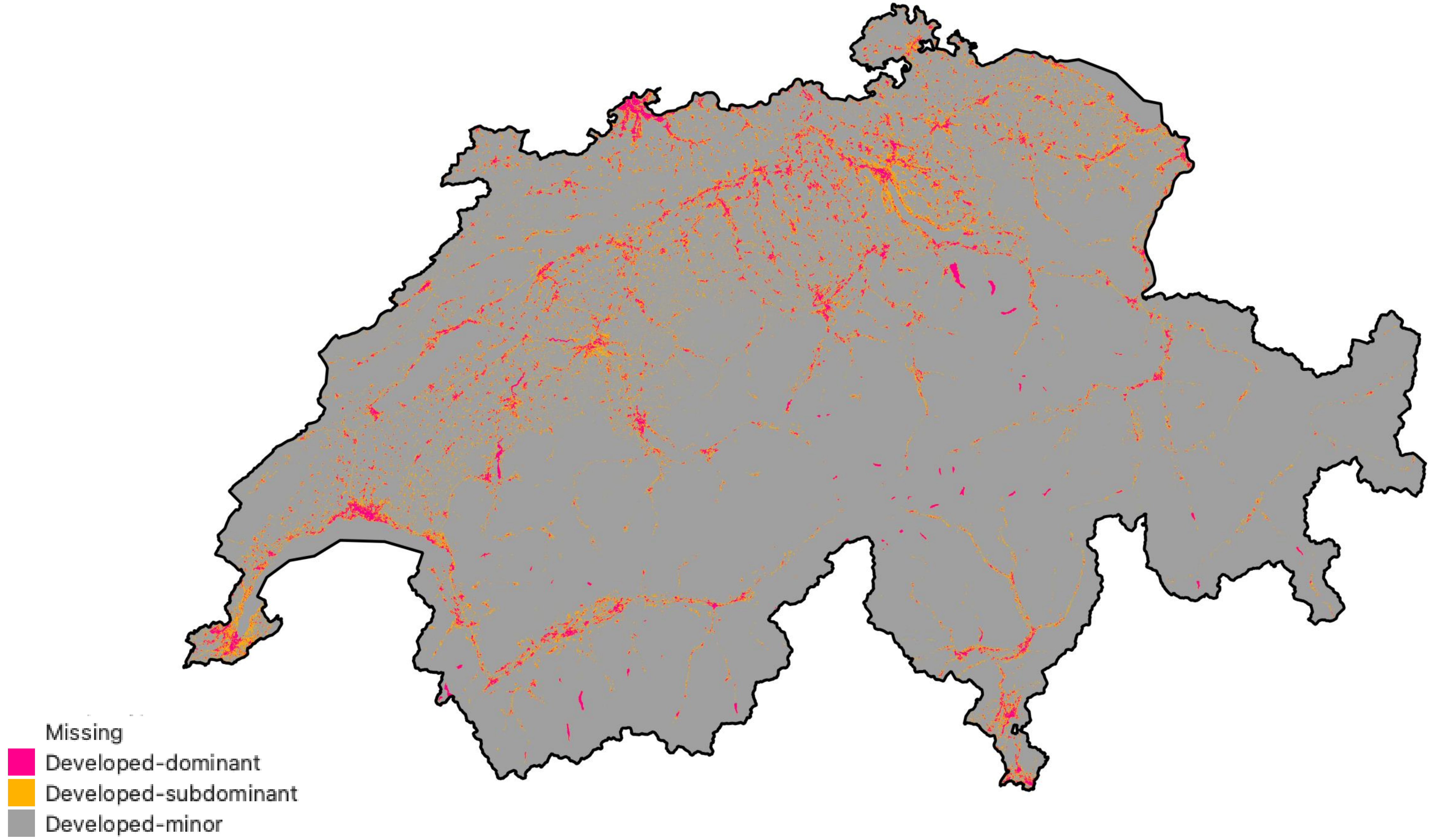
LM - Agriculture



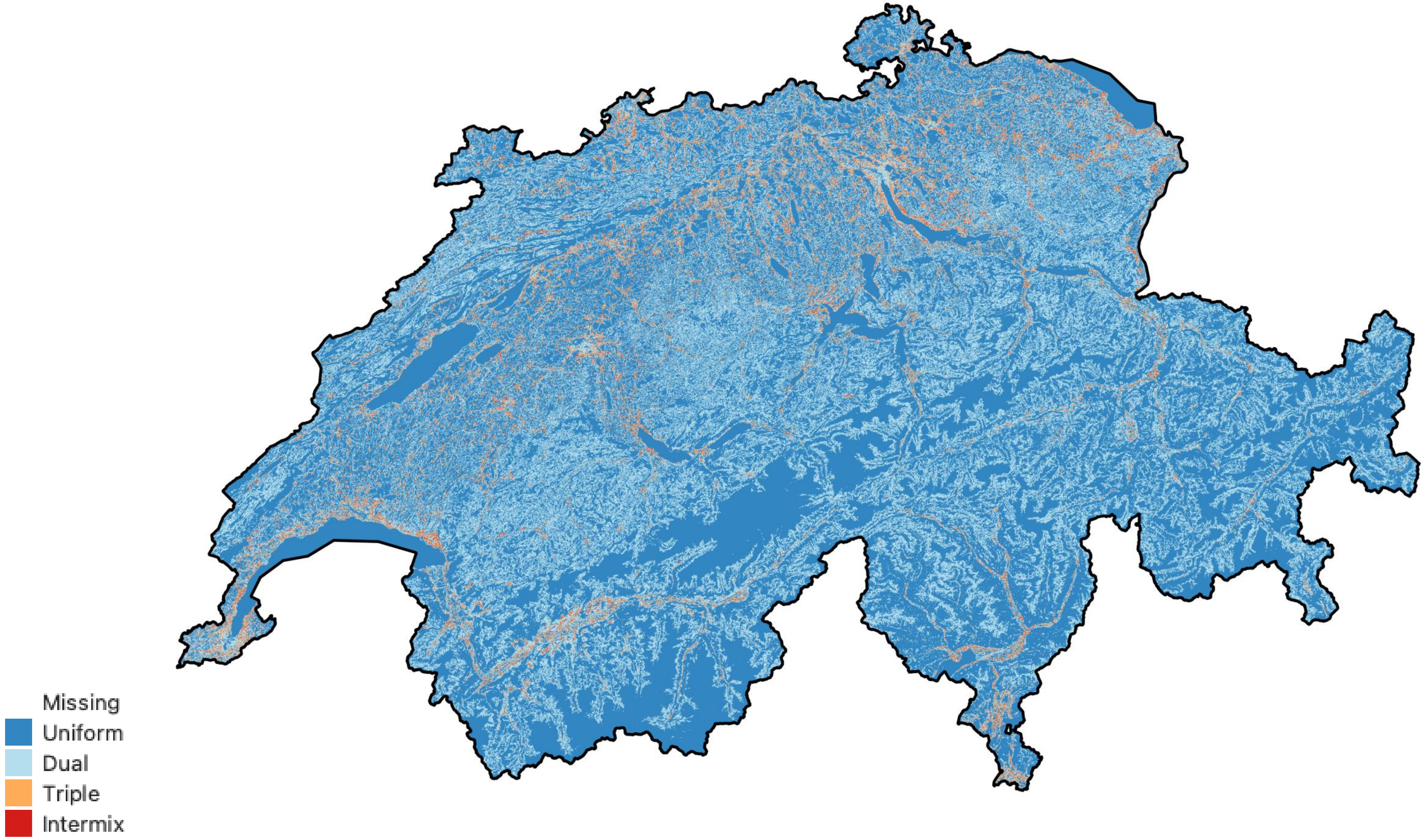
LM - Natural


Missing
Natural-dominant
Natural-subdominant
Natural-minor

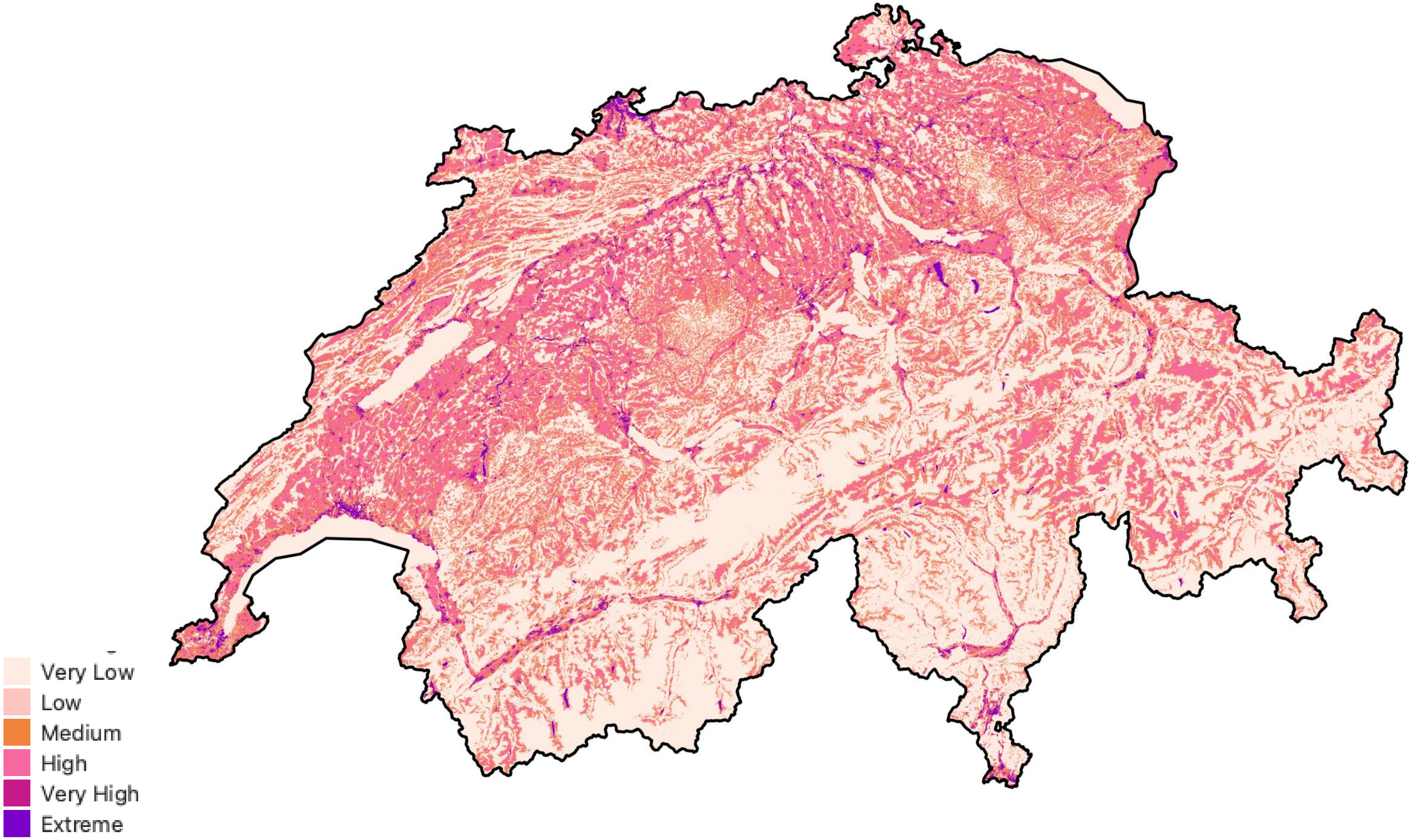
LM - Developed



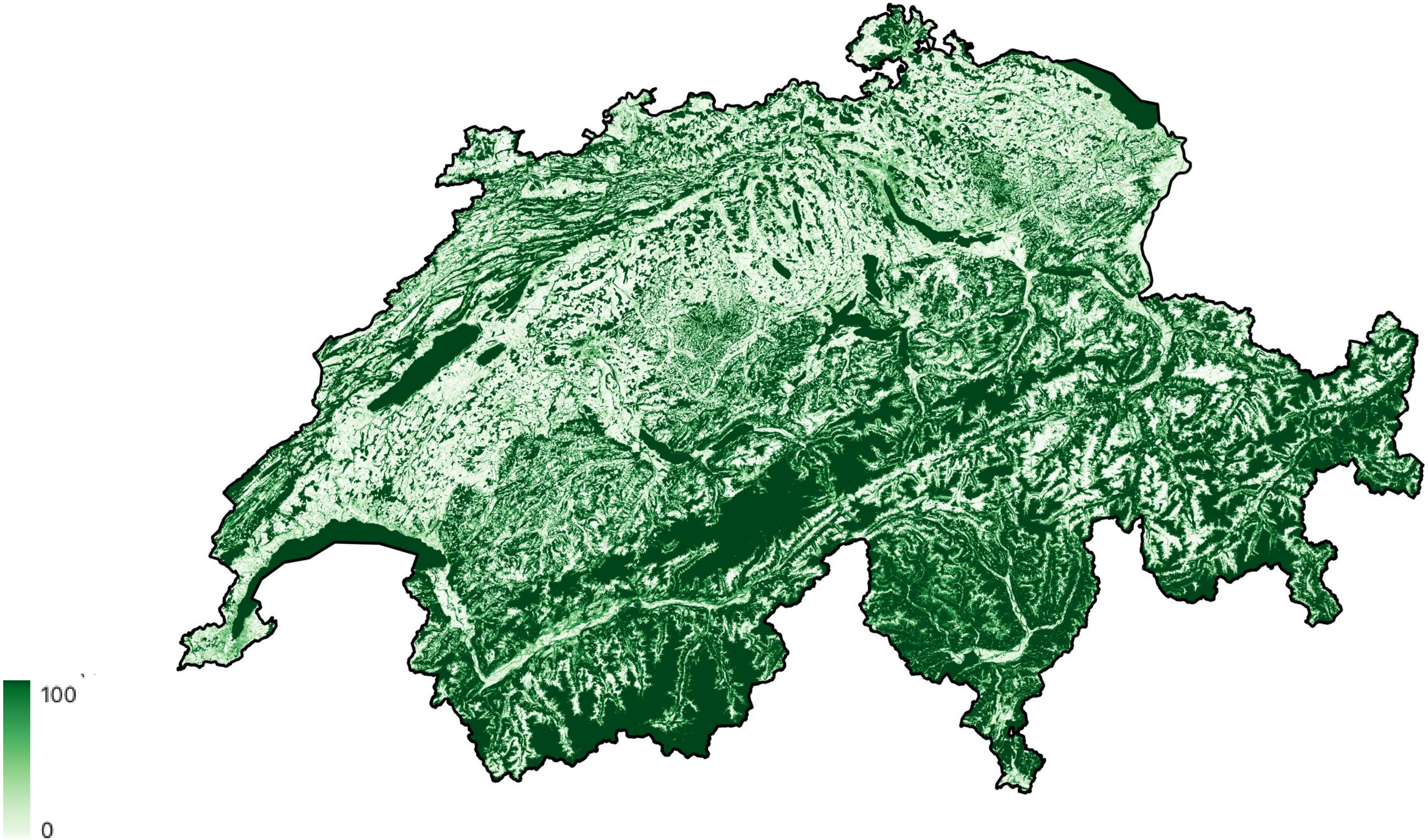
LM - Diversity



LM – Anthropic Intensity



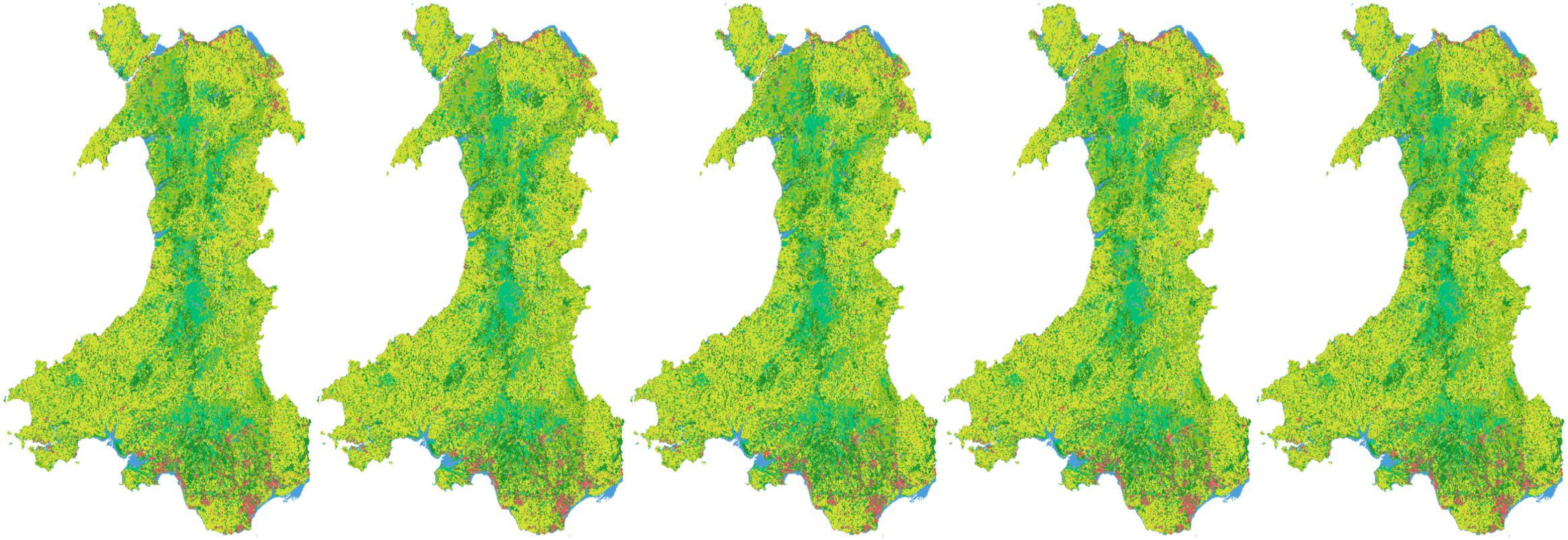
LM - Naturality



How can we benefit from Living Earth in MONALISA?

Produce consistent time-series of Land Cover…

…a request from case study in T4.1



Most of ESAI/SDG layers & soil attributes are EDs…

…L3 = Land Cover & L4 = Land Degradation attributes

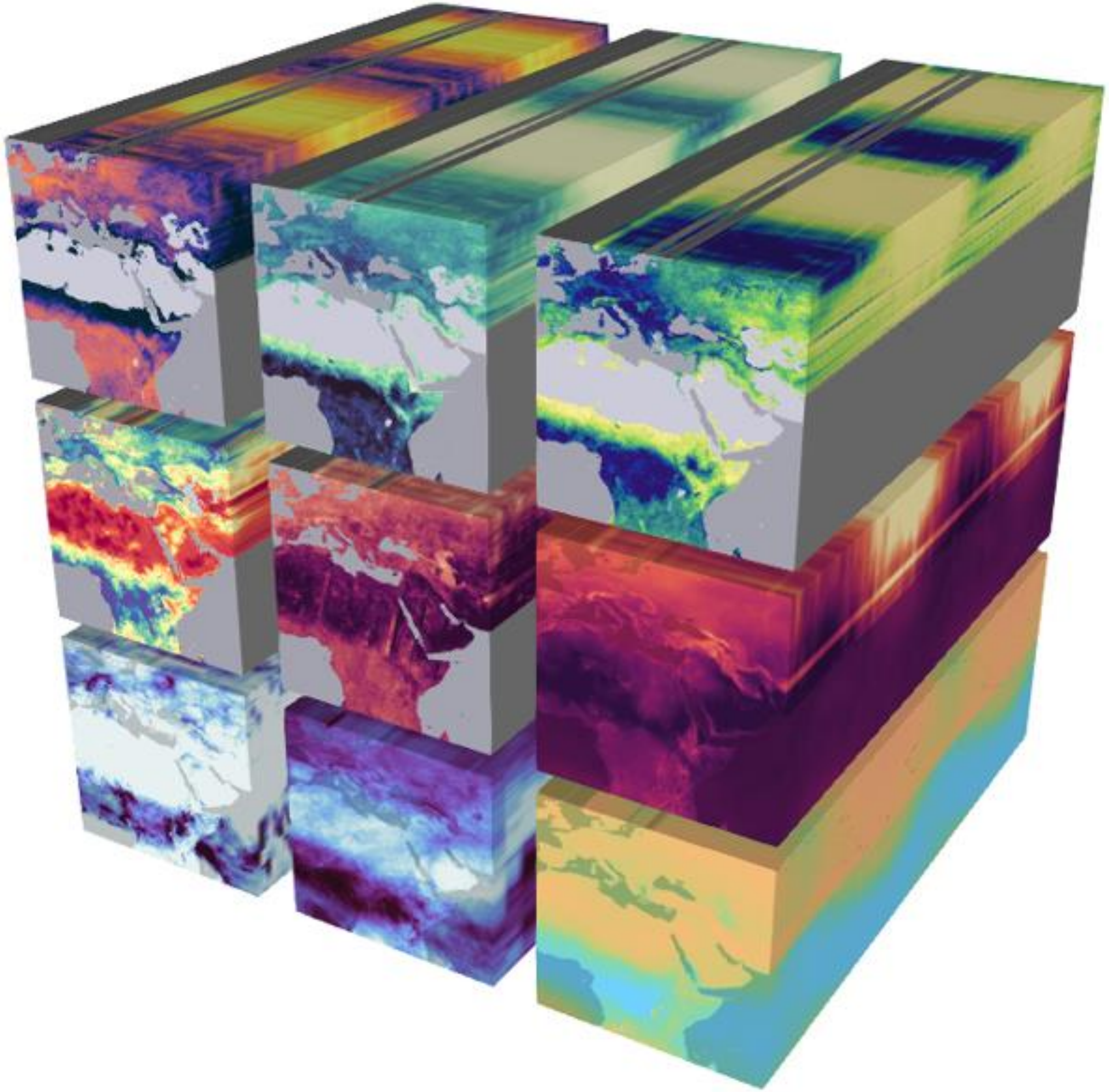
…we already started to map attributes (ESAI/SDG/soil) [Audrey, Thomas, Antonio]

…we could integrate most of data already produced/used in MONALISA

ESAI	LCCS4	Potential dataset	Variable name	Description	Region	Value type	Unit	Comments/Required modification in nootbook	Format	Link
Rainfall	rainfall_cqi_cat_l4d_esai	CHELSA V2.1 (current)	bio12	Accumulated precipitation amount over 1 year	Global	Continuous	kg m-2 (mm)		GeoTIFF	https://www.envidat.ch/dataset/chelsa-climatologies/resource/ee935f48-b3da-432d-961d-f815289e476f
Aridity index	aridityidx_cqi_cat_l4d_esai	Global-AI_PET_v3	ai_v3_yr	Aridity index annual average	Global	Continuous	unitless	Values are *10000 in dataset	GeoTIFF	https://figshare.com/ndownloader/files/34377245
Rainfall erosivitiy	raineros_cqi_cat_l4d_esai	GloREDa	R_FINAL	Annual data for the R-factor, taking into account the scaling	Global	Continuous	MJ mm ha-1 h-1 yr-1		GeoTIFF	https://esdac.jrc.ec.europa.eu/content/gloreda#tabs-0-description=0
		ESDAC Rainfall erosivity	R_Factor	Index about capacity of rainfalls to erode	Europe	Continuous	MJ mm ha-1 h-1 yr-1		GeoTIFF	https://esdac.jrc.ec.europa.eu/content/rainfall-erosivity-european-union-and-switzerland
Wind speed	windspd_cqi_cat_l4d_esai	Global Wind Atlas 3.0	WIND-SPEED 10m	Wind speed at 10m/50m hi	Global	Continuous	m/s	Either define new categories for wind speed at 10m or choose the 50m above surface dataset to align with Remus paper	GeoTIFF	https://globalwindatlas.info/api/gis/global/wind-speed/10; https://globalwindatlas.info/api/gis/global/wind-speed/50
Parent materials	parentmat_sqi_cat_l4a_esai	European Soil database v2	PARMADO	Lithology. Dominant parent material of the STU	Europe	Categorical	code	Reclassify classes if internal function in .py file not possible	GeoTIFF	https://esdac.jrc.ec.europa.eu/content/european-soil-database-v2-raster-library-1kmx1km
Rock fragment	rockfrag_sqi_cat_l4d_esai	SoilGrids250m 2.0	cfvo	Coarse fragments volumetric in ‰ at 6 standard depths	Global	Continous	‰	Determine which depth to use or average for all depths	GeoTIFF	https://data.isric.org/geonetwork/srv/eng/catalog.search#/metadata/713396f8-1687-11ea-a7c0-a0481ca9e724
Soil depth	soildepth_sqi_cat_l4a_esai	European Soil database v2	DR	Depth to rock	Europe	Categorical	code	Reclassify classes if internal function in .py file not possible	GeoTIFF	https://esdac.jrc.ec.europa.eu/content/european-soil-database-v2-raster-library-1kmx1km
Soil texture	soiltex_sqi_cat_l4a_esai	SoilGrids250m 2.0	sand; silt; clay	% of granulometric classes at 6 standard depths	Global	Continuous	mass fraction in %	Need to 1. combining all 3 layers, 2. determining % of each component (sand, silt, clay) and 3. defining USDA class of texture. Either select the best depth or calculate the average of all depths	GeoTIFF	https://data.isric.org/geonetwork/srv/eng/catalog.search#/metadata/713396fa-1687-11ea-a7c0-a0481ca9e724 ; https://data.isric.org/geonetwork/srv/eng/catalog.search#/me
Doil drainage	soildrain_sqi_cat_l4a_esai	HYSOGs250m	HYSOGs250m	soil runoff potential	Global	Categorical	code	Reclassify classes if internal function in .py file not possible	GeoTIFF	https://daac.ornl.gov/SOILS/guides/Global_Hydrologic_Soil_Group.html#:~:text=Hydrologic%20soil%20groups%20A%2C%20B,60%20cm%20of%20the%20surface
Soil salinity	soilsal_sqi_cat_l4d_esai	SoilGrids250m 2.0	Global Soil Salinity	Salinity of soil	Global	Categorical	code	Maybe easier to use but less precise	GeoTIFF	https://data.isric.org/geonetwork/srv/eng/catalog.search#/metadata/c59d0162-a258-4210-af80-777d7929c512
		Harmonized World Soil Da	EC	Electrical conductivity	Global	Continous	dS/m	Based on WISE30sec. Maybe better to disaggragate soil salinity and alkalinity in 3 different classes "Electrical conductivity", "cation exchance capacity" and "pH of H2O in soil" and then use relationship between these 3 parameter to determine levels of degradation risk	GeoTIFF	https://data.isric.org/geonetwork/srv/eng/catalog.search#/metadata/54aebf11-ec73-4ff8-bf6c-ecff4b0725ea
Soil alkalinity	soilalk_sqi_cat_l4d_esai	SoilGrids250m 2.0	phh2o	Water pH in soil at 6 differe	Global	Continous	unitless	Values are multiplied by a 10 factor. See comment for soil salinity	GeoTIFF	https://data.isric.org/geonetwork/srv/eng/catalog.search#/metadata/713396fd-1687-11ea-a7c0-a0481ca9e724
Fire risk	firerisk_vqi_cat_l4a_esai	CORINE land cover	clc2018	land cover category	Europe	Categorical	code	Reclassify classes if internal function in .py file not possible	GeoTIFF	https://land.copernicus.eu/en/products/corine-land-cover/clc2018
Erosion protection	erosprot_vqi_cat_l4a_esai	CORINE land cover	clc2018	land cover category	Europe	Categorical	code	Reclassify classes if internal function in .py file not possible	GeoTIFF	https://land.copernicus.eu/en/products/corine-land-cover/clc2018
Vegetation cover	canopyco_veg_cat_l4d_esai	Copernicus NDVI	to choose	NDVI (several choice regarding period range or update)	Europe to Global	Continuous	unitless	Convert netCDF to GeoTiff ?	netCDF	https://land.copernicus.eu/en/products/vegetation

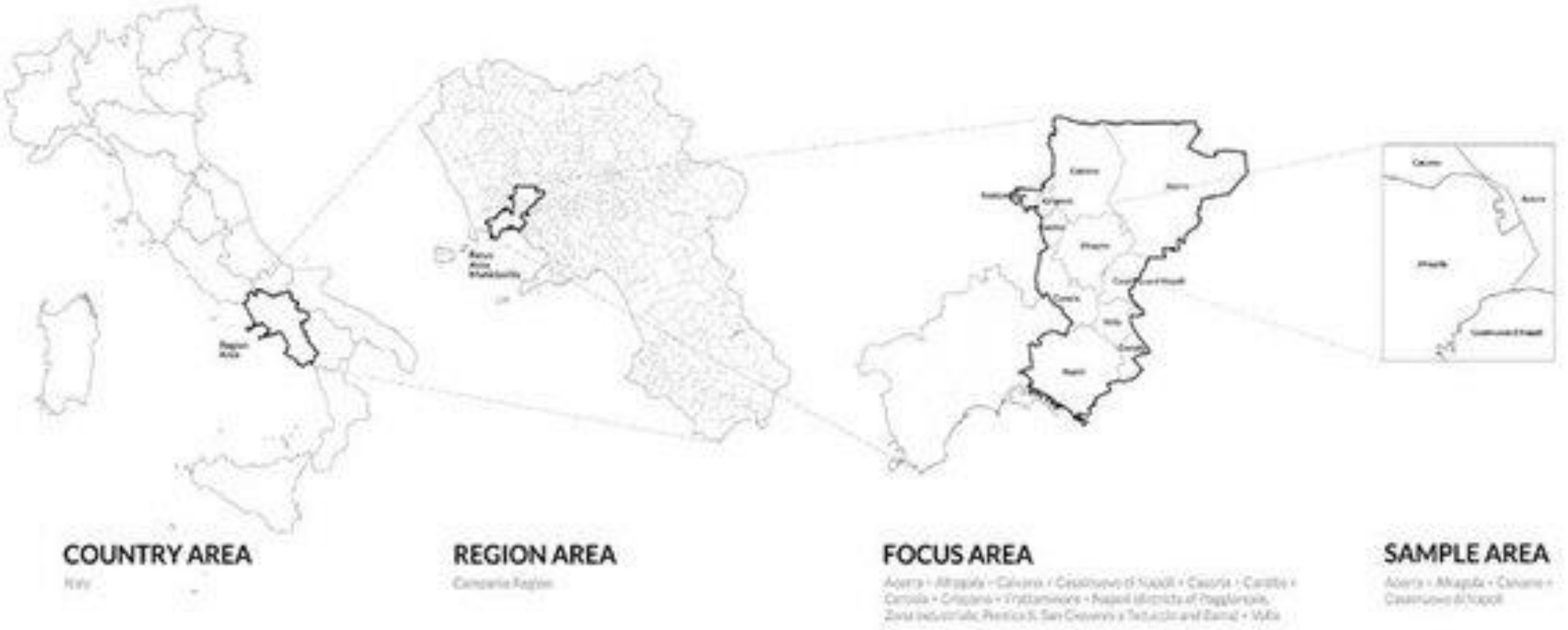
Stack of key layers for LD monitoring and assessment…

…explore the different/multiple dimensions of LD (LDCube)



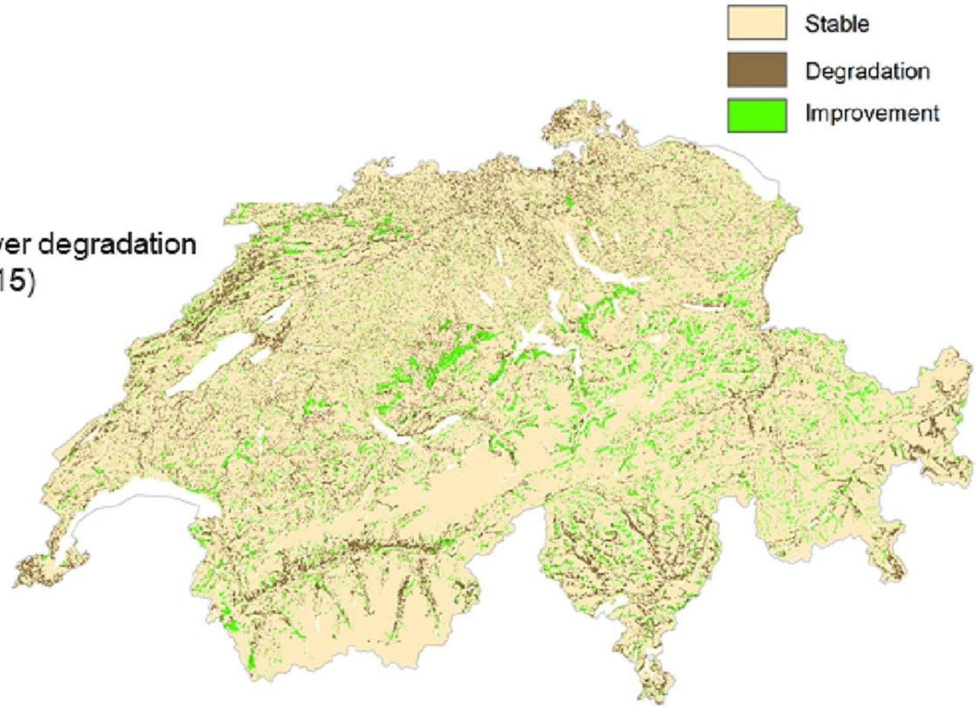
Enable multi-scale analysis…

…local to regional data integration



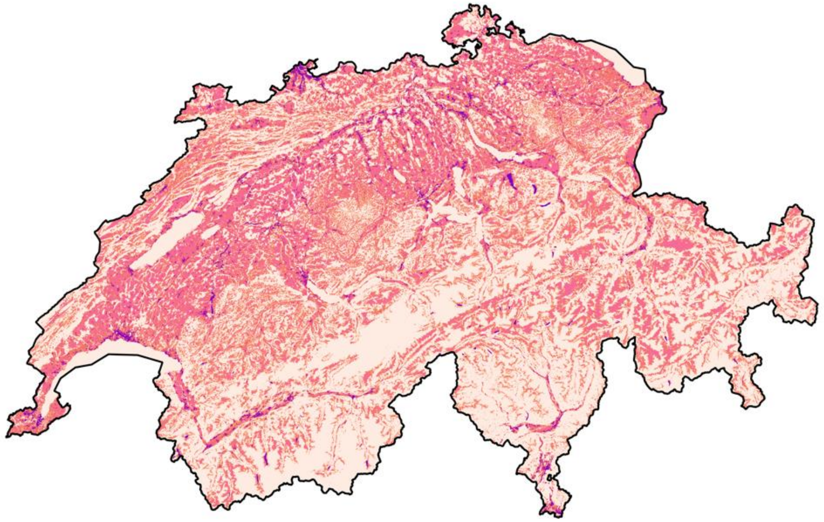
Landscape Mosaic to identify drivers…

…natural vs anthropic

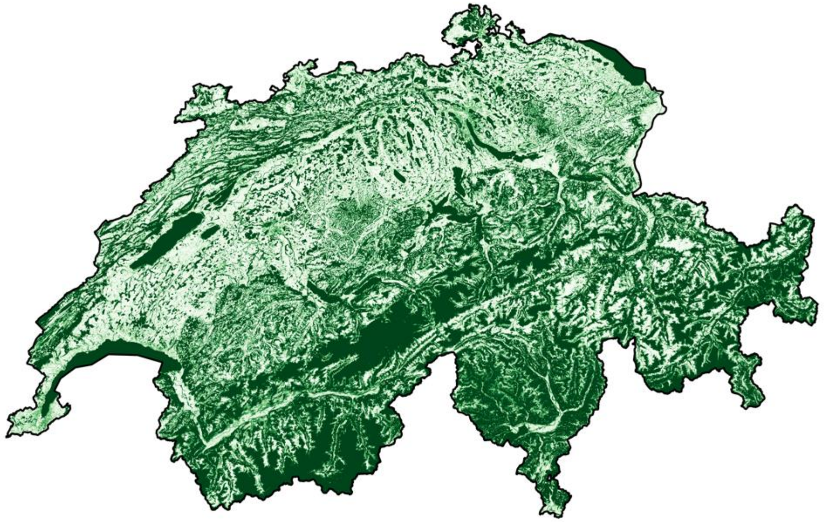


b) Land cover degradation (2000 – 2015)

Bär et al. (2023)



Anthropic intensity



Naturality

Define impacts/pressures specific to LD …

…and integrate them in the Evidence-Based Change Framework

Identifying and evidencing pressures

Each of the 77 impacts is linked to a number of driving pressures (144 in total)

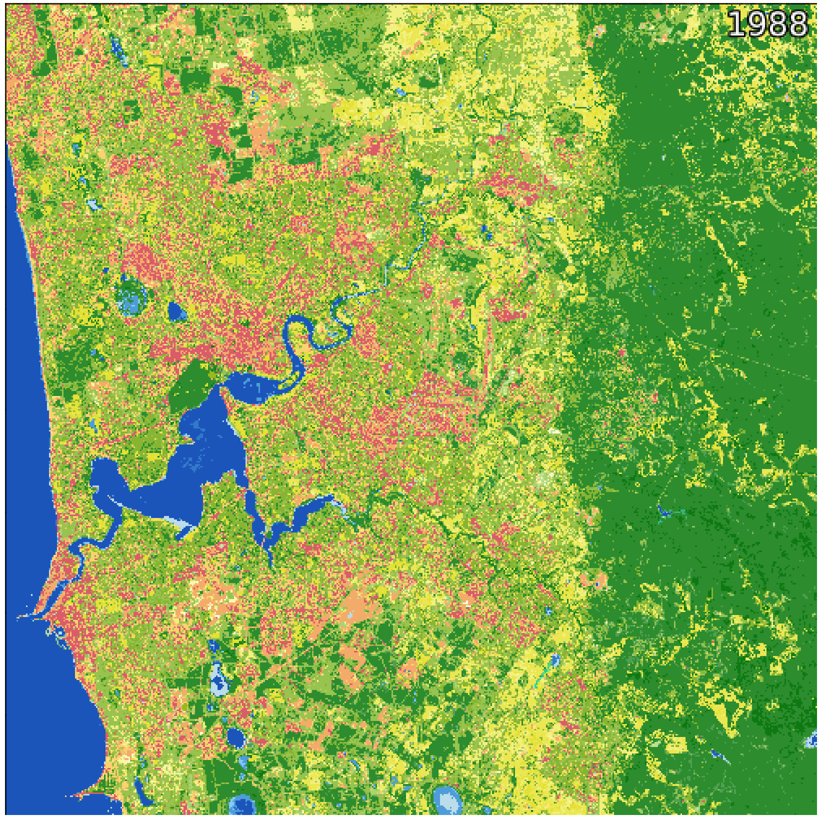
Vegetation dieback	Vegetation extent (loss)	Vegetation amount (reduction)	Vegetation amount (gain)	Vegetation extent (gain)
				
Anchoring	Bushfire	Bushfire	Afforestation	Afforestation
Cold snap	Deforestation	Coppicing	Bushfire recovery	Colonisation
Drought	Drought	Decreased nutrient supply in soil	Ecological restoration	Wave action
Heatwave	Excess rain	Farmland abandonment	Encroachment	Ecological restoration
Increased wind	Farmland abandonment	Fuelwood collection	Farmland abandonment	Greenspace construction
Non-insect herbivory (natural)	Land reclamation	Harvesting	Fertilizer application	Mine site rehabilitation
Pathogens	Sea defence construction	Insect herbivory	Growth	Planting
Pollution	Strong winds	Mowing	Reduced or cessation of grazing	Rehabilitation
Prolonged inundation	Vegetation clearance	Non-insect herbivory (natural)	Reforestation (natural)	Revegetation
Prolonged snow cover	Wave action*	Overgrazing (natural)	Reforestation (plantations)	Snowmelt*
Sea level fluctuation		Overgrazing (stock)	Regrowth	
Soil salinisation		Pesticide application	Removal of herbivores	
Water salinization*		Sedimentation	Revegetation	
		Selective logging	Thinning	
		Stubble burn	Urban greening	
		Thinning*	Vegetation thickening*	

Depending on data availability…

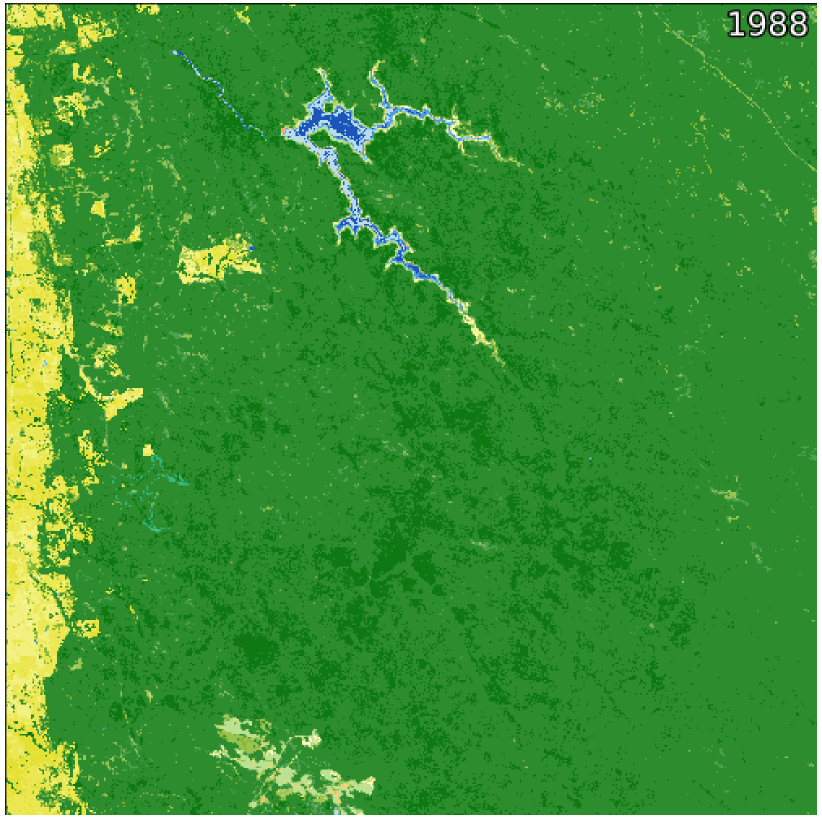
…enabling time-series analysis

…a step towards a dynamic LD monitoring and assessment system

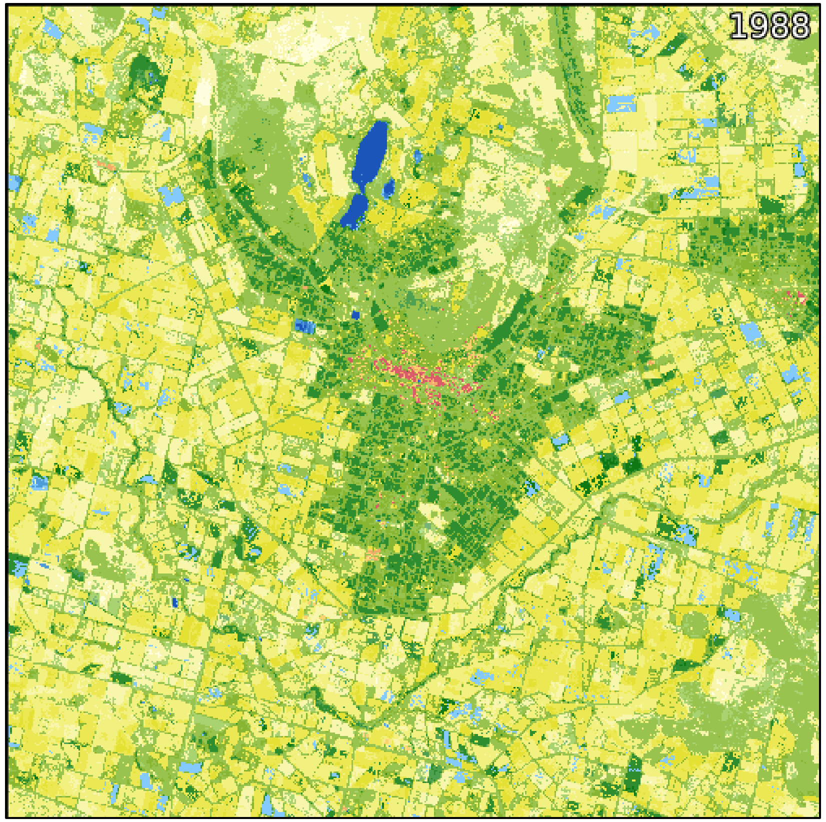
Urban expansion (Perth, Australia)



Mine dynamics (Western Australia)

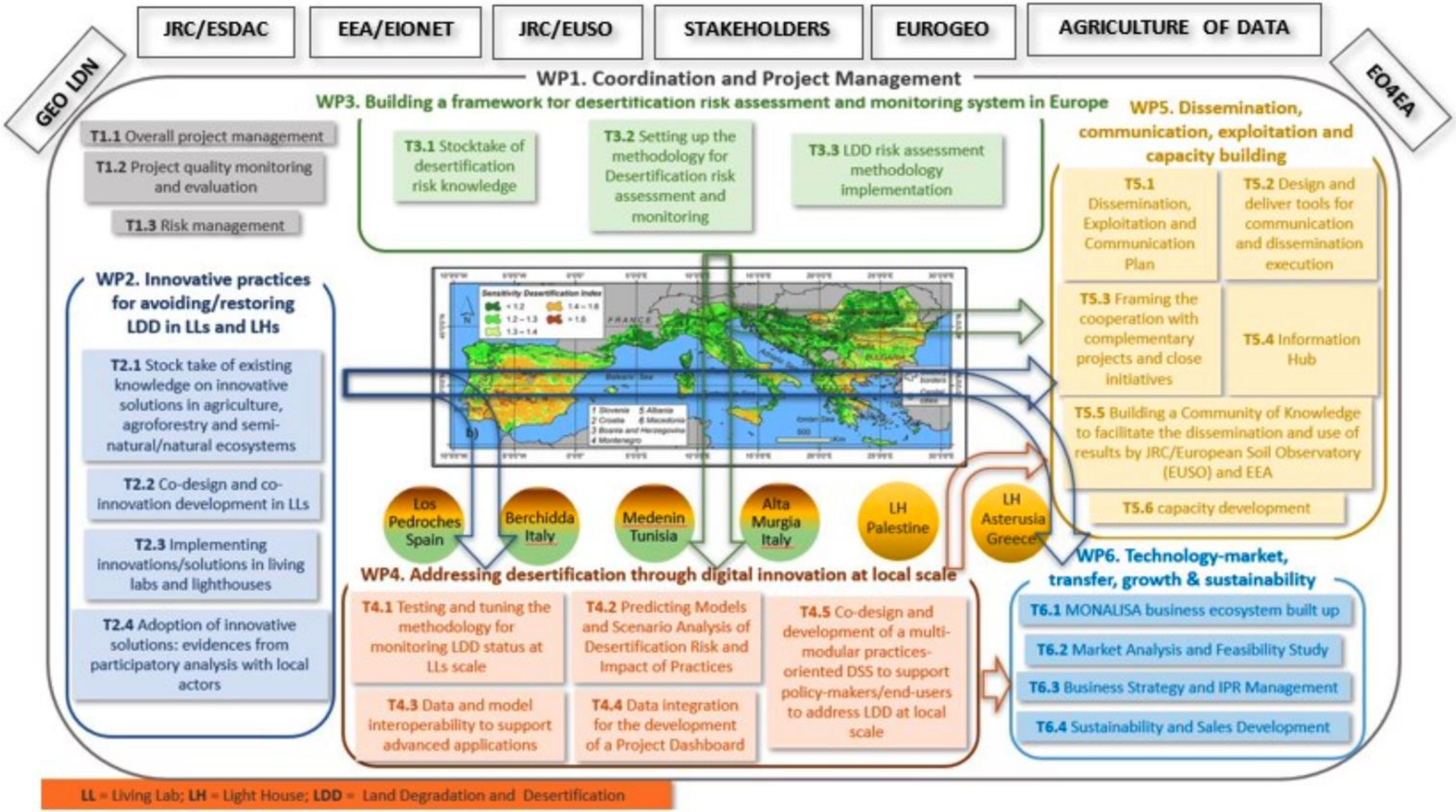


Crop dynamics (Murray Darling Basin)



Effective links between WPs…

…especially WP2-3-4



Nostradamus & LandShift…

…Living Earth in a Box

OPEN DATA CUBE

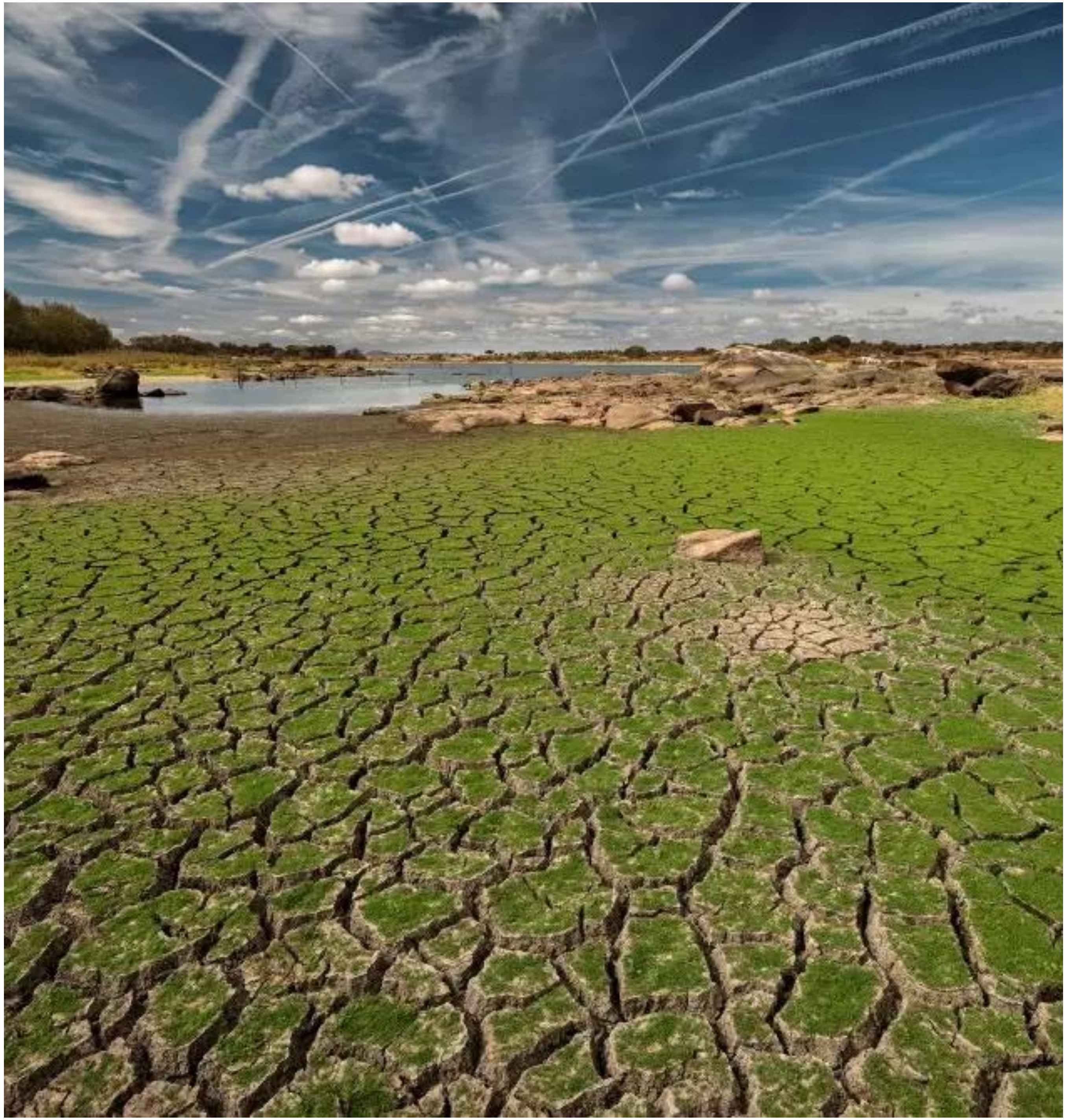
+

LIVING EARTH

Perspectives and next steps…

…in MONALISA for Living Earth for LD

> Define soil attributes to be integrated
> Define impacts/pressures specific to LD
> Magnitude/Severity of LD
> Uncertainty
> Ecosystems Multi-functionality
> LDN targets
> Any other ideas?



Collaborate & co-create together!

gregory.giuliani@unige.ch
gregory.giuliani@unepgrid.ch
http://www.unige.ch/envirospace/people/giuliani/