Consiglio Nazionale delle Ricerche

IRCRES

ISTITUTO di RICERCA sulla CRESCITA ECONOMICA SOSTENIBILE
RESEARCH INSTITUTE on SUSTAINABLE ECONOMIC GROWTH

Interdisciplinary research in Critical Zone studies: Integrating socioeconomic and natural approaches to study the impact of Land Use Change in the Italian Alps

Sella L., Rota F. S., Ragazzi E., Adamo M.P.,
Scartazza A., Pennisi M.

ERSA Congress, 31 August 2023
S22 – Spatial dimension of climate change

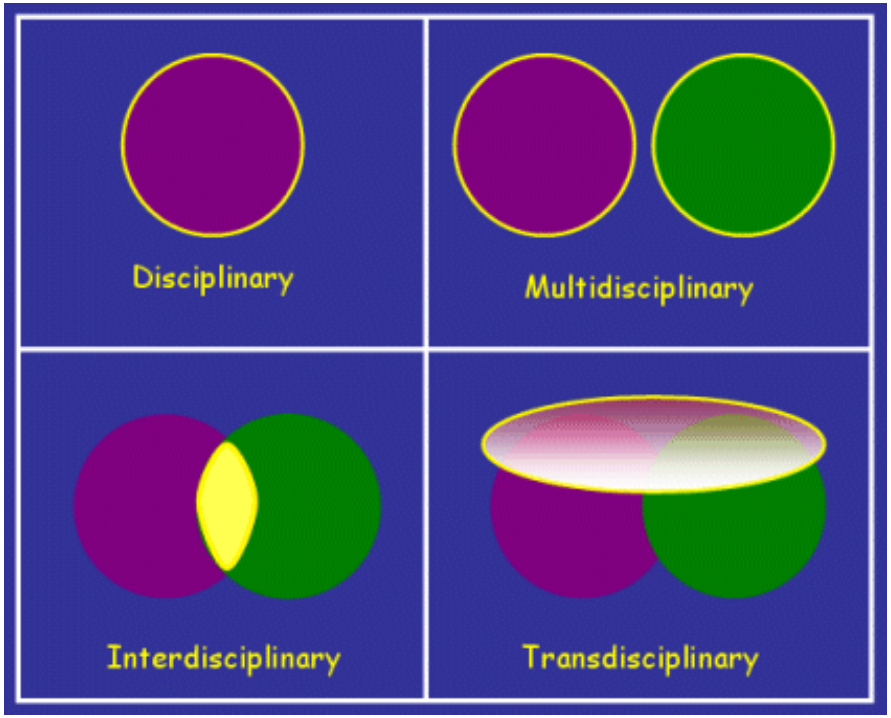
ABRESO
Abandonment & Rebound of land use: Societal views

MOTIVATION

- "We live in a **complex world** and at a challenging time" (US President Obama, July 16th 2014): many **social and ecological challenges**, including climate change
- Policymakers need considerable knowledge from **several disciplines** and the capacity to integrate them into a **holistic framework**
- Need for **interdisciplinary and transdisciplinary approaches**: breaking down the methodological and epistemological boundaries (Stock and Burton, 2011)
- **Global sustainability studies** deal with complex real-world challenges (e.g., climate change) by combining research on ecological and social issues (Luks and Siebenhüner, 2007) → **genuine interdisciplinarity?**

MULTI-/INTER-/TRANS- DISCIPLINARITY

- **Disciplinary**: Epistemologies, assumptions, knowledge, skills, methods within the boundary of a discipline
- **Multidisciplinary**: Using the knowledge/understanding of more than one discipline
- **Interdisciplinary**: Using the epistemologies/methods of one discipline within another
- **Transdisciplinary**: Focus on an issue both within and beyond discipline boundaries with the possibility of new perspectives in collaboration with stakeholders/society



(Source) Holistic Education Network: http://www.hent.org/transdisciplinary.htm

CHALLENGES OF INTER-DISCIPLINARITY

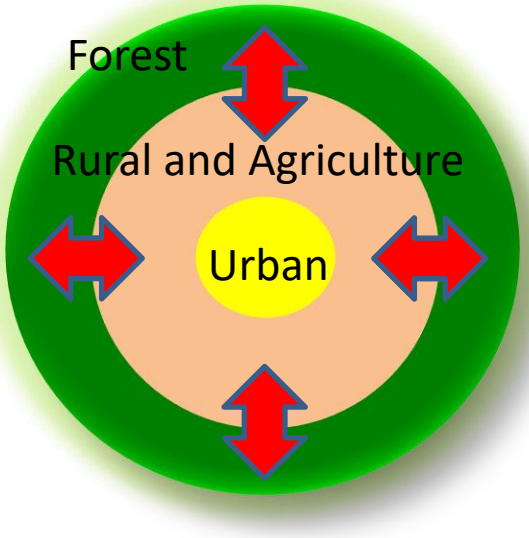
- **Shared terminology** and lexical understanding (François, 2006; Bracken and Oughton, 2006)
- Multi-disciplinarity does not imply inter-/trans- disciplinarity: researchers tend to collaborate exclusively **inside their disciplinary boundaries** (Li Vigni, 2020)
- Interdisciplinarity is seldom the researchers' main aim: rather, it is a **tool** to fulfil a given research objective
- Some **preconditions**: intellectual curiosity, collaborative and open attitude, propensity to establish new relationships, researchers' friendship and trust (MacMynowski, 2007; Buller, 2009)
- **Lack of** (Stock and Burton, 2011):
  - Training in integrated research
  - Academic recognition of interdisciplinary research
  - High-level journals to publish in
  - A college of peers to discuss the research approach itself

Project title:

ABRESO

Abandonment and rebound: Societal views on landscape- and land-use change

(2021-2023, Project leader: Prof. Timothy White, The Pennsylvania State University, USA)



Socio-economic dynamics

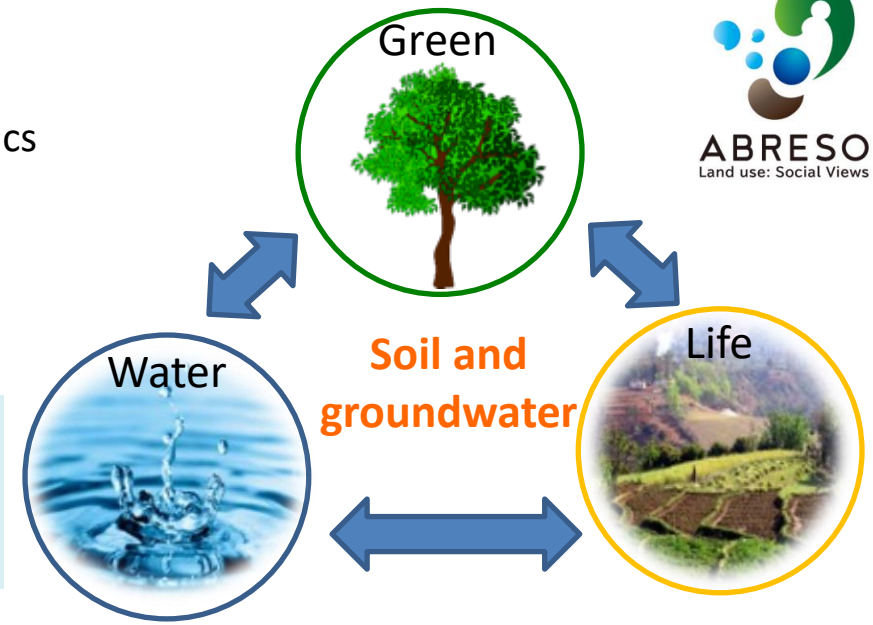
↓

Land use change

↓

Resource use

Impact to **sustainability of soil and water**



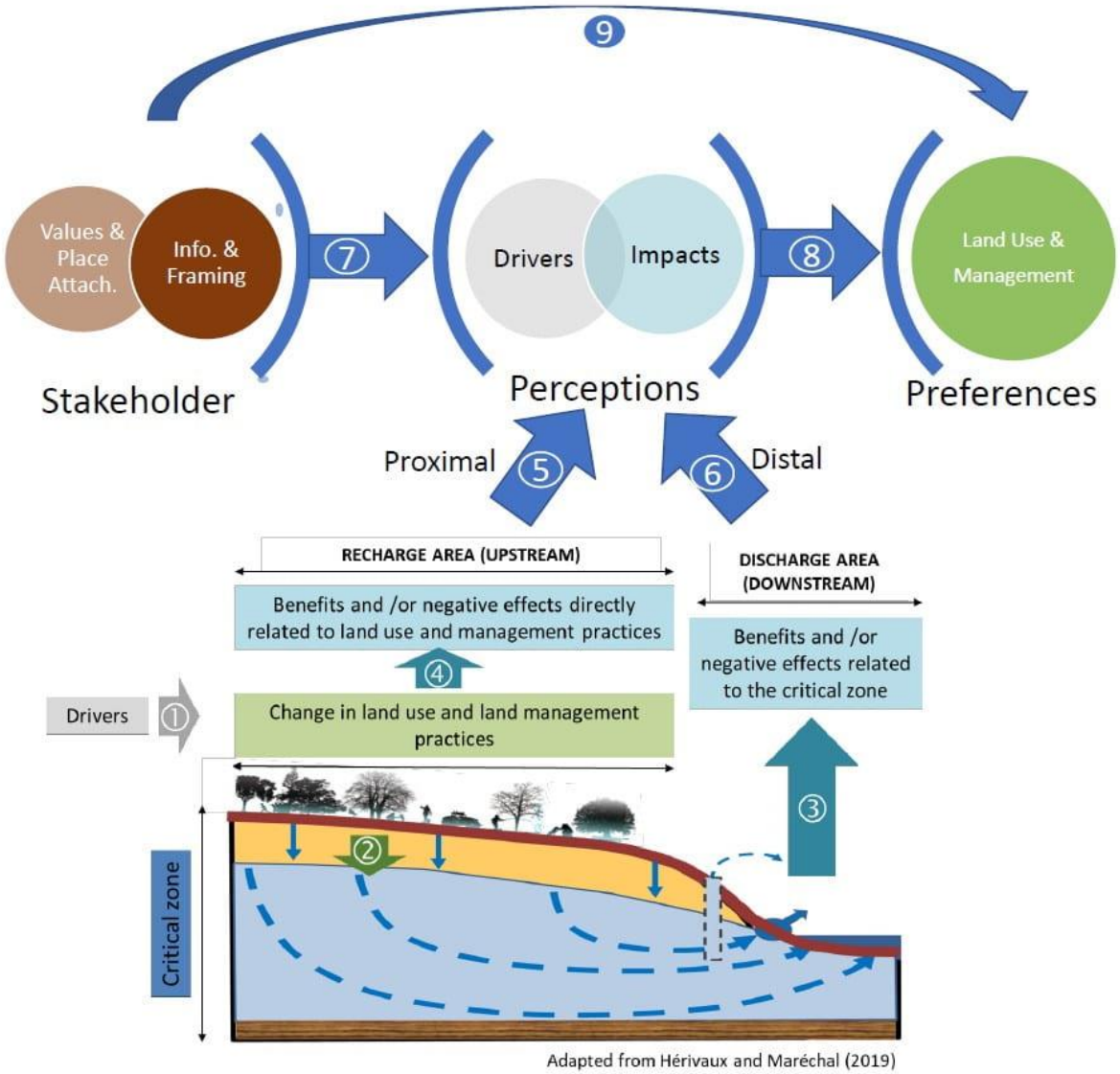
ABRESO
Land use: Social Views

Overarching questions:

- ✓ What are the **key attributes of abandonment or land use change** that drive changes in **soil health and water quality** across the globe?
- ✓ What are the **central attributes of social circumstances** that lead to land abandonment and land use change and what are the ultimate effects on soil health and water quality?

- ☐ International project among USA, Japan, Italy, France and Taiwan
- ☐ Interdisciplinary approaches between natural and social sciences
- ☐ Collaboration with multiple stakeholders

ABRESO CONCEPTUAL FRAMEWORK



Adapted from Hérivaux and Maréchal (2019)

RQ1 - DRIVERS: *What are the environmental, economic and social drivers of land use change?* ***(Arrow 1)***

RQ2 – UNDERLYING MECHANISMS: *What underlying mechanism explain the spatial and temporary patterns in environmental quality of soil and water that are altered by different land management patterns? (**Arrow 2**)*

RQ3 - STAKEHOLDER PERCEPTIONS AND PREFERENCES: *Does understanding stakeholders and their perceptions of land use change help explain and facilitate the development of sustainable land management? (**Arrows 5 to 9**)*

***RQ4 SCENARIOS**: What are the possible future pathways of CZ structure and functions and their impacts on humans and nature under different scenarios of landscape/watershed management (**Arrows 3 & 4**).*

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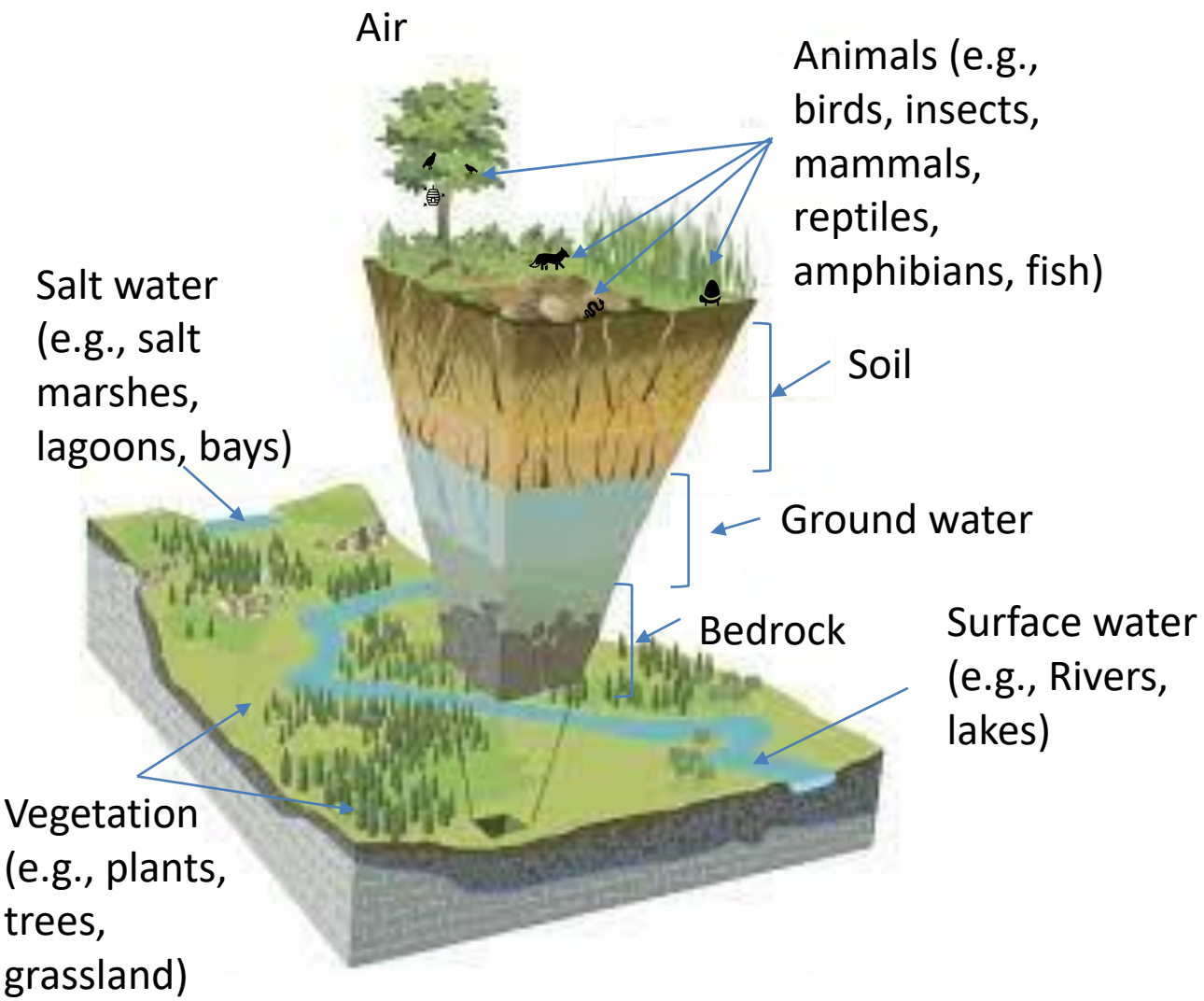
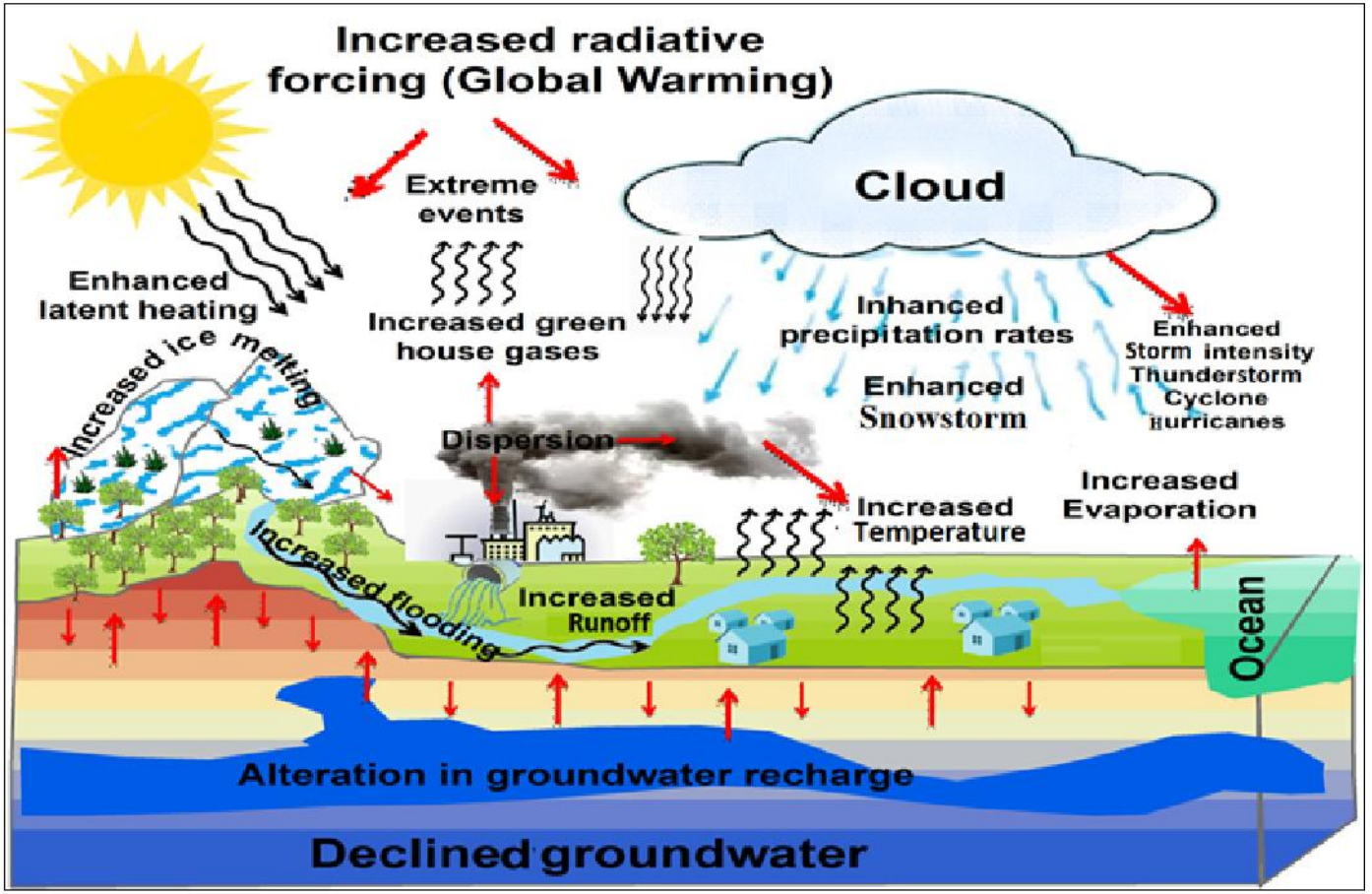
Land use: Social Views

THE CRITICAL ZONE FRAMEWORK



The CZ represents the **fragile skin of the planet** that extends from the top of the vegetation to the lower limits of groundwater, where **rocks, soil, atmospheric gases, meteoric water, and living organisms interact** to provide the **primary habitat for terrestrial life** (Brantley *et al.*, 2007).

CRITICAL ZONE & CLIMATE CHANGE



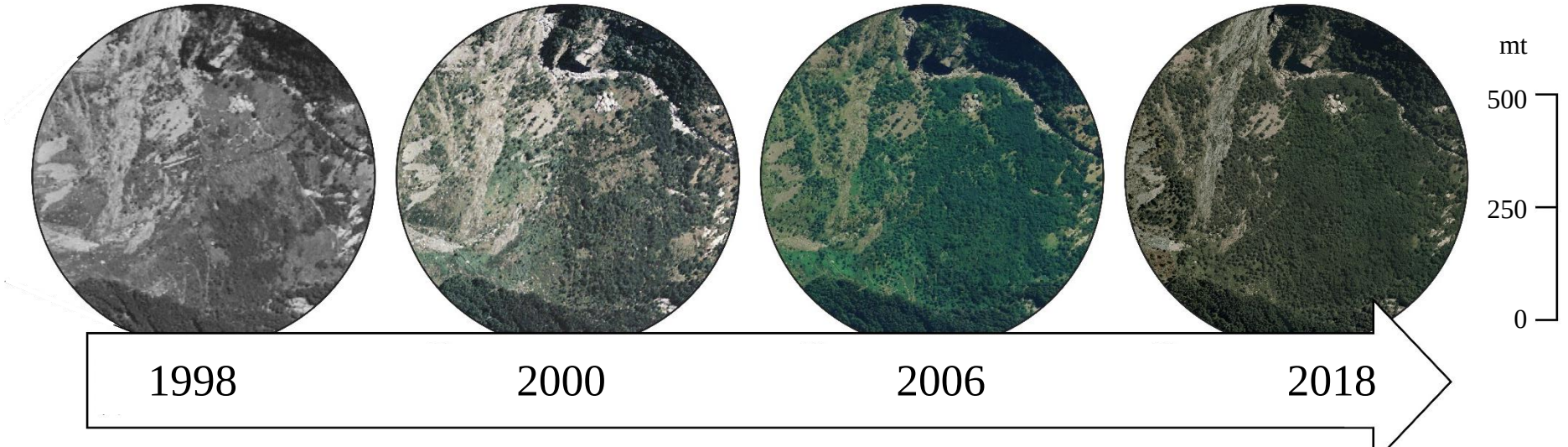
From Singh & Kumar (2018)

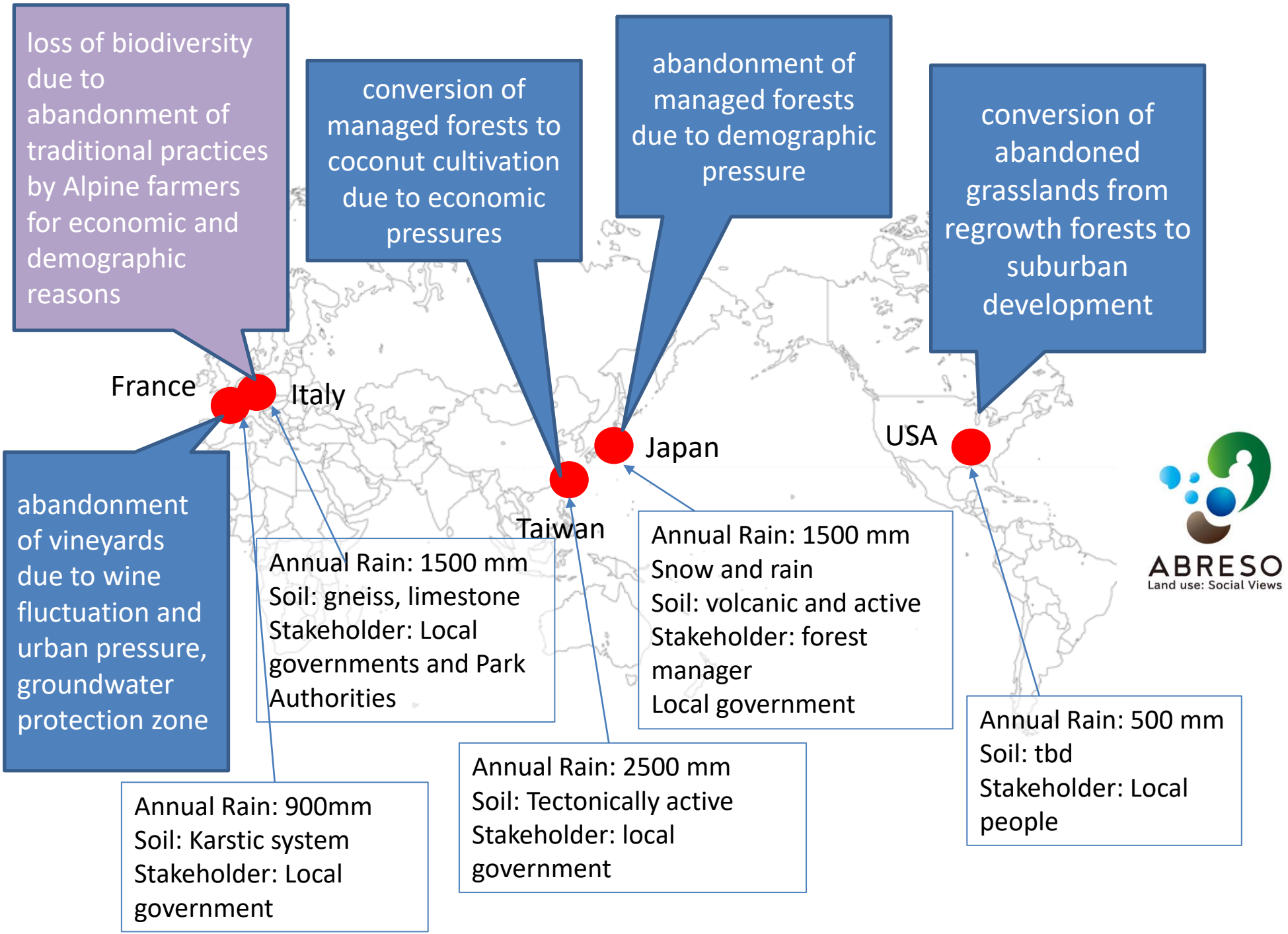
An **integrated approach between scientists of different disciplines**, including biologists, soil scientists, hydrogeologists, geologists, is mandatory to deal with the complex CZ modifications induced by LUC and CC (Chorover *et al.*, 2007; Wymore *et al.*, 2017)

LAND USE CHANGE IN THE CZ

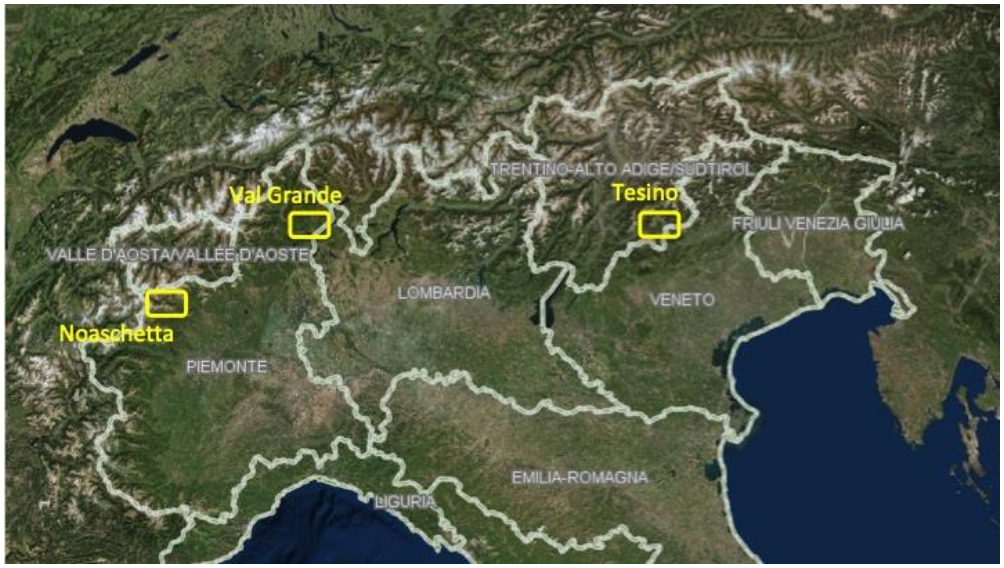
Land use change (LUC) refers to the **alteration of the purpose/utilization of a particular portion of land**, which can have **significant environmental, social, and economic implications** (Lucas et al., 2022)

improving the **understanding of the bidirectional dynamics** between LUC and the CZ is crucial to enhance **sustainable land and water management strategies** (François, 2006; Kajikawa et al., 2007; Kajikawa, 2008; Tress et al., 2007)




loss of biodiversity due to abandonment of traditional practices by Alpine farmers for economic and demographic reasons
conversion of managed forests to coconut cultivation due to economic pressures
abandonment of managed forests due to demographic pressure
conversion of abandoned grasslands from regrowth forests to suburban development
France
Italy
Taiwan
Japan
USA
abandonment of vineyards due to wine fluctuation and urban pressure, groundwater protection zone
Annual Rain: 1500 mm
Soil: gneiss, limestone
Stakeholder: Local governments and Park Authorities
Annual Rain: 1500 mm
Snow and rain
Soil: volcanic and active
Stakeholder: forest manager
Local government
Annual Rain: 500 mm
Soil: tbd
Stakeholder: Local people
Annual Rain: 900mm
Soil: Karstic system
Stakeholder: Local government
Annual Rain: 2500 mm
Soil: Tectonically active
Stakeholder: local government
ABRESO
Land use: Social Views

THE ITALIAN CASE STUDY



LUC produces changes in vegetation (land cover) that alter landscape as well as CZ processes and services

Municipality	Elevation (m above sea)	Area (km^2)	Pop 2021 (inhab.)	Pop 2001 (inhab.)	Density 2021 (inhab/ km^2)	Pop. Var 2001-21 (%)	Age 2021 (%)
Noasca	min: 825; max: 4.030	78,1	106	202	1,4	-47,5	0-14 (3,8%) 15-64 (52,8%) 65 and over (43,4%)
Cossogno	min: 267; max: 2.183	40,3	651	537	16,2	+21,2	0-14 (12,9%) 15-64 (64,2%) 65 and over (22,9%)
Castello Tesino	min: 317; max: 2.847	113,0	1.182	1.445	10,5	-18,2	0-14 (7,9%) 15-64 (58,9%) 65 and over (33,2%)
Cinte Tesino	min: 350; max: 2.419	30,0	352	407	11,7	-13,5	0-14 (10,2%) 15-64 (52,2%) 65 and over (30,6%)
Pieve Tesino	min: 722; max: 2.825	69,0	647	775	9,4	-16,5	0-14 (10,5%) 15-64 (58,3%) 65 and over (31,2%)

DRIVERS OF LUC IN THE ITALIAN ALPS

Socio-economic

Market dynamics
Industrialization in periurban area
Tourism, local products
Demographic dynamics
Depopulation, Ageing
Cultural views (perception of ESD)

Environmental

Climate change (snow cover, vegetated period, instability of terraces)
Soil/water (fertility, carbon sequestration, access to water)
Bio-ecological (ticks, wolves, biodiversity)

- ✓ Abandonment of alpine ecosystem and landscape
- ✓ Abandonment of traditional agro-pastoral activities
- ✓ Unmanaged forest encroachment
- ✓ Re-population during the turistic season

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Land use: Social Views

Land use change

Climate changes

- Biodiversity

- C sequestration capacity (from C fluxes, net primary productivity and soil organic C content)
- Soil fertility, aggregates stability, soil erosion

- Nutrients and their stable isotope composition in plants and soil
- Water quality (nitrates)

ALPINE ECOSYSTEM MONITORING

Effects of local warming and duration of snow cover on growing season length and productivity

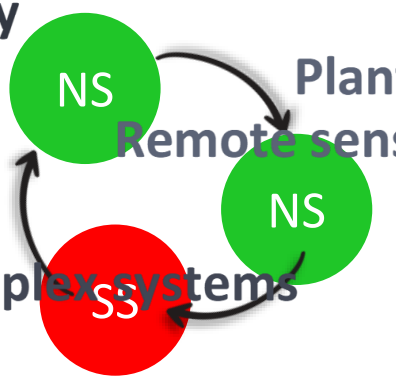
adjustment of the grazing regime

Effects of water availability on plant response and productivity

INTEGRATION OF DISCIPLINES

NS-SS COOPERATION

Soil biochemistry
Environmental geochemistry
Sedimentology



Plant physiology
Remote sensing algorithms
Phenology

Economics of complex systems
Policy evaluation
Territorial analysis and planning

ONE AIM
DIFFERENT:

- OBJECTS
- METHODS
- SPATIAL AND TEMPORAL SCALES
- MEANINGS
- WORDINGS
- VALUES, VISIONS
- TARGET GROUPS

- When dealing with territorial/regional analysis, the **ecological dimension** of the local system is mostly neglected in Social Sciences (SS). Why?
- As the CZ framework shows, Natural Sciences (**NS**) produce very punctual, **spatially circumscribed data** on the functioning of the territorial system; instead, **SS** research has an **areal and regional approach**.

How to integrate Natural Science (NS) data, models and knowledge into Social Science (SS) research? And vice-versa

INTEGRATION OF DATA SOURCES

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NATURAL SCIENCES NS

Assessing the effects of land-use changes in Alpine sites on **plant biodiversity**, **carbon sequestration** and **nutrient cycling**

FIELD MEASUREMENTS

REMOTE SENSING (SATELLITE)

STAKEHOLDERS

National Parks

Municipalities

Promotion offices

Associations

SS SOCIAL SCIENCES

Mixed methods research

- Social context (economic, demographic trends)
- Review of local land use policies, land and water protection practices
- Collection historical photos of land use
- Literature review of social science contributions to CZ analysis

Qualitative Data

Semi-structured interviews to stakeholders (e.g., farmers, natural scientists, local government officials) aimed at investigating:

- Perceptions of land use change
- Drivers and evidences of land use change, services and disservices
- Management strategies and policies

Quantitative data

- Survey
- Questionnaires/interviews with stakeholders

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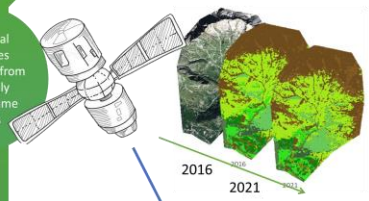
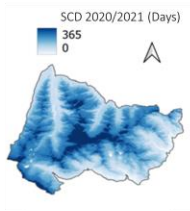
CO-CREATION OF RQs AND DATA SOURCES

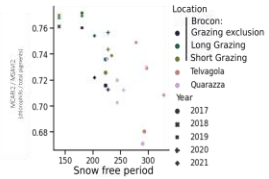
OBSERVED (NS)	PERCEIVED (SS)
LAND USE CHANGE	
Remote sensing – land cover maps and temporal changes from the 1990s on **Ground truth** – plant biodiversity and bio-geochemical cycles	Web-based survey (sites' oversampling) In-depth interviews to local stakeholders Analysis of socio-economic secondary data
SNOW COVER and GRAZING SEASON	
Remote sensing – Snow cover monitoring (extent and duration); extraction of time series of spectral indices for vegetation and soil analysis **Ground truth** – variation on water discharge	Web-based survey (sites) In-depth interviews to shepherds Are shepherds aware of the snow cover effects on - the grazing season (start, duration)? - the phenology and quality of grazing? - water availability?
BIODIVERSITY AND LAND USE (abandonment, grazing, overgrazing)	
Remote sensing – soil organic carbon, primary productivity extraction **Ground truth** – carbon and nitrogen cycling, plant physiology, phenology and biodiversity	In-depth interviews to shepherds Are shepherds aware of the effect of grazing on - biodiversity? - carbon and nitrogen cycles?
LANDSCAPE TRANSITIONS (FOREST ↔ PASTURE)	
Orthophotos, satellite imagery, ground truth	In-depth interviews to local stakeholders Analysis of territorial forest management plans

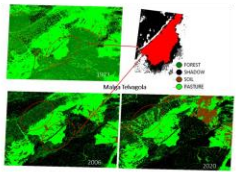
OBSERVED

Essential variables extracted from remotely sensed time series



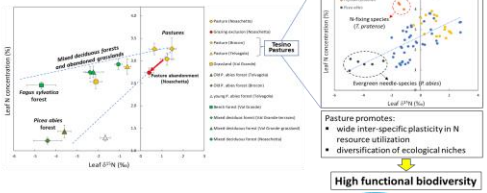


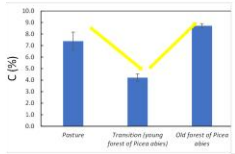


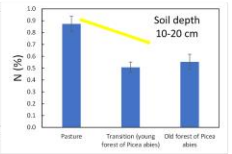


Land Cover Change — Snow Cover Duration — Grazing pressure **and chlorophyll** — Forest↔Pasture Transition

Plant functional biodiversity — Soil Carbon & Nitrogen concentration







Field surveys to collect ground truth data

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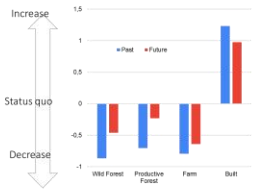
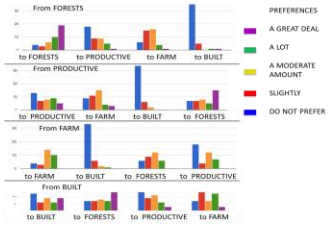
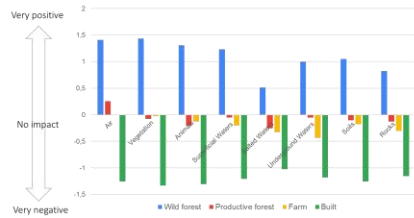






Past and expected LU change — LU change preferences — LU impact on CZ components

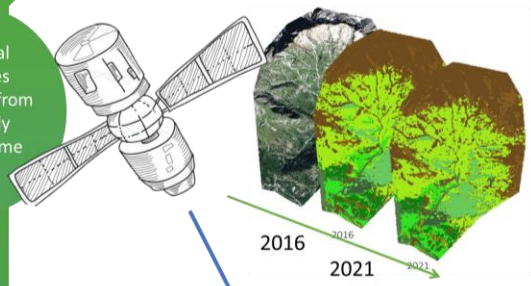
Surveys and cooperation with stakeholders

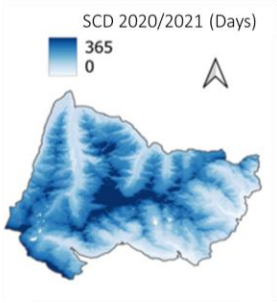
PNGP — P. ValGrande — Club Alpino Italiano — UNCEM — Noasca — Castello Tesino — Pieve T. — Cinte T. — Cossogno

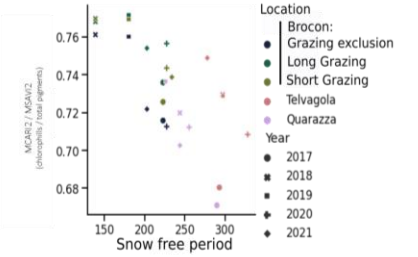
TERRITORIAL AND LOCAL POLICIES

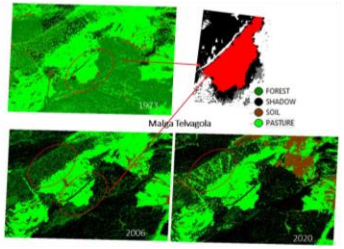
Essential variables extracted from remotely sensed time series

OBSERVED









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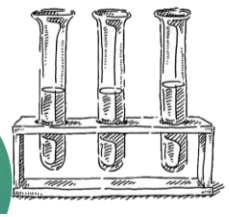
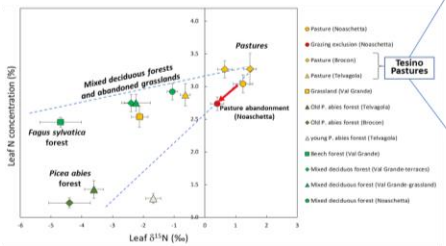
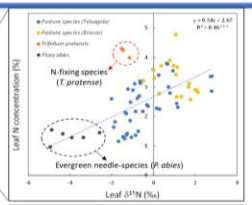
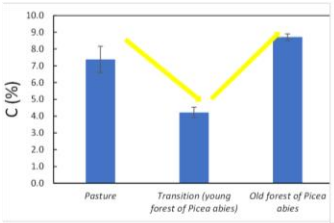


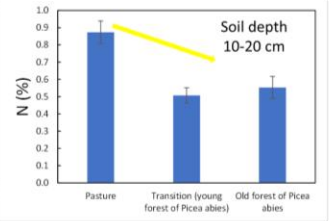




Pasture promotes:
- wide inter-specific plasticity in N resource utilization
- diversification of ecological niches

High functional biodiversity





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TERRITORIAL AND LOCAL POLICY

data

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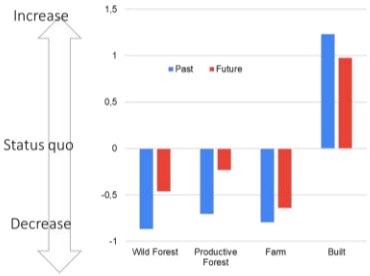

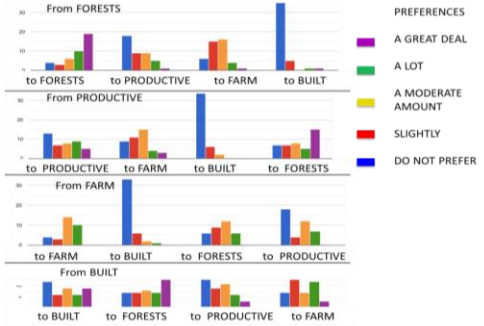

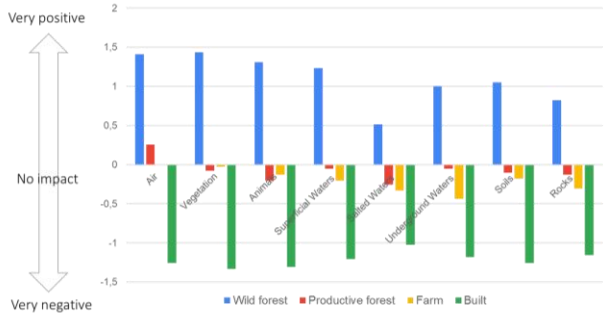

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PARCO NAZIONALE GRAN PARADISO

PARCO NAZIONALE ValGrande

CLUB ALPINO ITALIANO

UNCEM

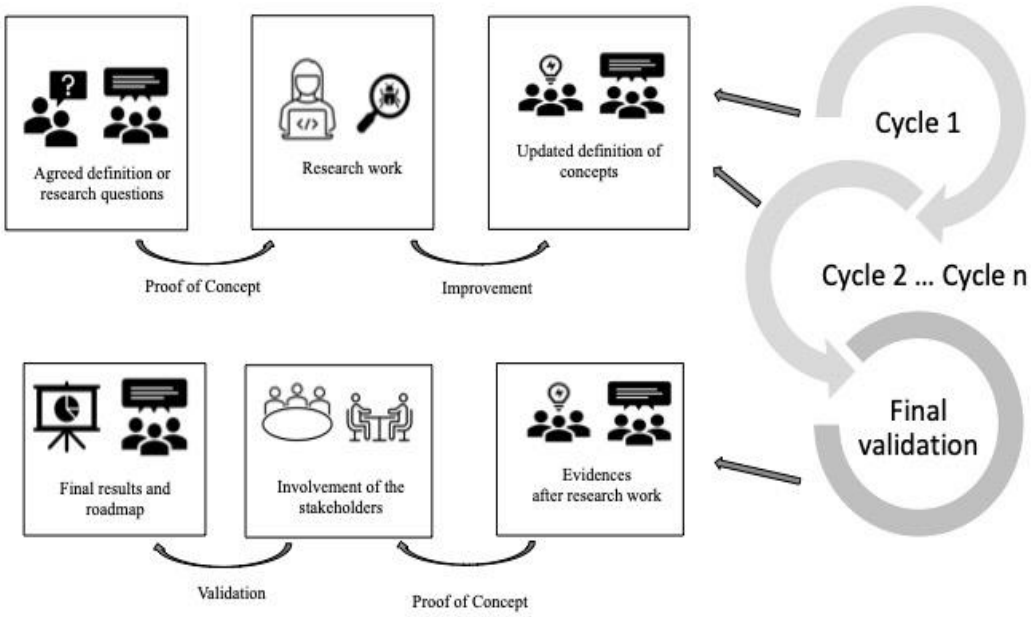
PRO LOCO NOASCA

SOME «CONCLUDING» REMARKS

- The research project is **still ongoing**, no results can be presented today
- This research framework is intended to understand whether local **stakeholders do perceive LUCs and their impacts** on the CZ elements **consistently** with respect to the CZ dynamics that emerge from the NS
- This is fundamental to explain **how the social ecosystem influences the human-nature interaction** that emerges from the land and water **management practices and policies**
- In addition, we are investigating the determinants of **heterogeneity** in stakeholders' LUC preferences in terms of nature perception and place identity
- This research goes beyond interdisciplinarity, embracing the realm of **trans-disciplinarity**: brand-new involvement of two relevant stakeholders (CAI, Iren)

KNOWLEDGE CO-CREATION PROCESS

- A **cyclical iterative process** is needed to build the common ground the researchers need to overcome their disciplinary boundaries
- The need of **checkpoints** to revise and improve is not self-evident: once a new piece of knowledge is agreed (e.g., term/concept, research question, approach, preliminary result), this must be validated through its application



- Each cycle includes an **agreement on a piece of knowledge, then a proof of concept** based on research work in the various disciplines, and **finally an updated release of the piece of knowledge**. The final step of this iterative process will be the involvement of **non-scientific stakeholders**

Consiglio Nazionale delle Ricerche

THE ITALIAN TEAM

ABRESO
Land use: Social Views

Istituto di Geoscienze e Georisorse, sedi Pisa e Pavia

Istituto di Ricerca sugli Ecosistemi Terrestri

Istituto sull'Inquinamento Atmosferico

Istituto di Ricerca sulla Crescita Economica Sostenibile

Dipartimento Scienze della Terra, Università di Pavia

NATURAL SCIENCE & SOCIAL SCIENCE

sedimentology
phenology
environmental geochemistry
economics of complex systems
policy evaluation
soil biochemistry
remote sensing algoritms
PLANT PHYSIOLOGY
economic geography
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RESEARCH INSTITUTE on SUSTAINABLE ECONOMIC GROWTH

Thank you

https://abreso.psu.edu/overview/italy/

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ABRESO
Abandonment & Rebound of land use: Societal views