Expert meeting on Ecosystem Accounting

EEA, UNSD and the World Bank

Copenhagen 11-13 May 2011

Land classification for ecosystem accounting

Jean-Louis Weber

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European Environment Agency
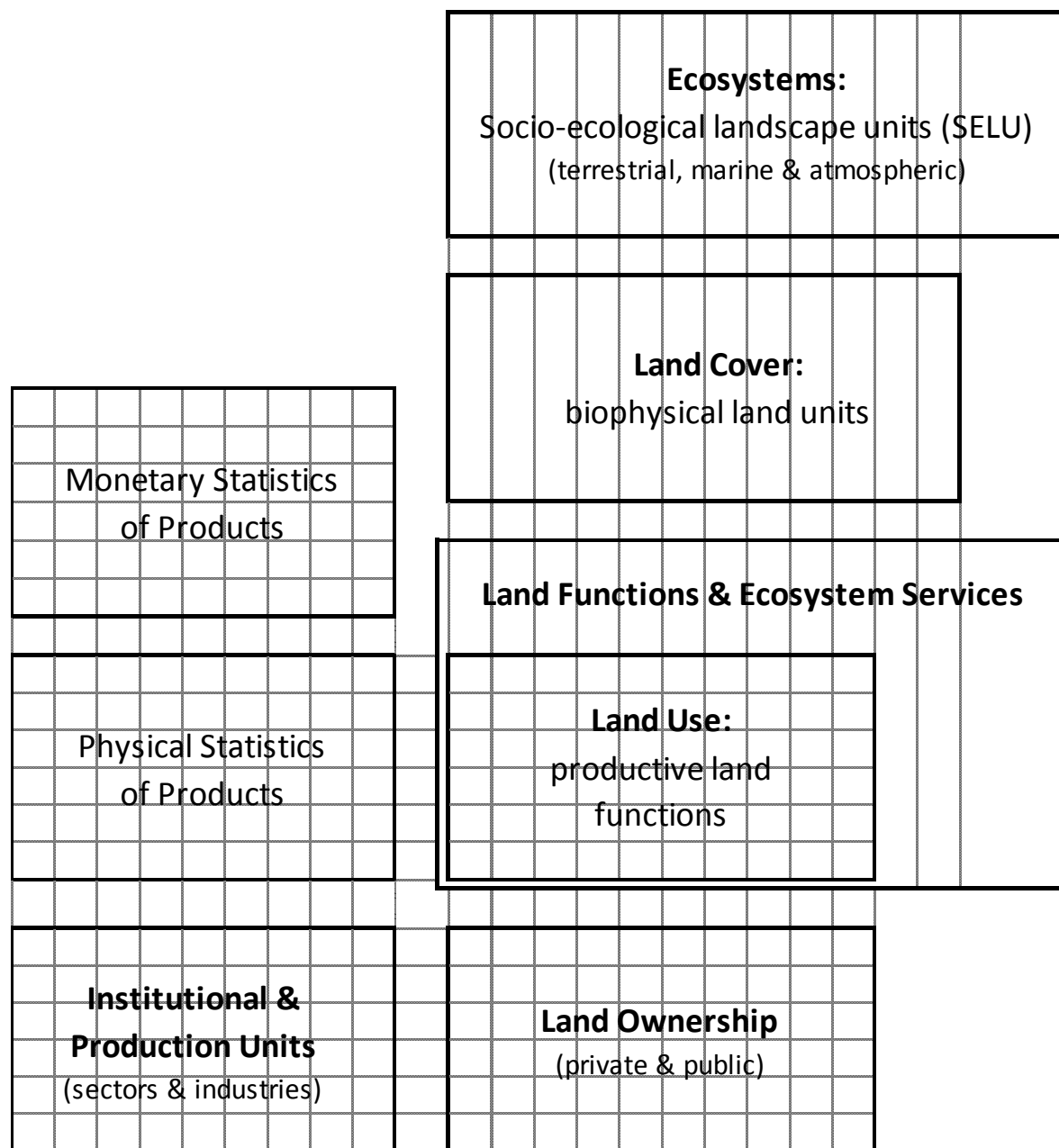
jean-louis.weber@eea.europa.eu

Spatial distribution of ecosystems, assets, functions and uses is paramount for assessing impacts and measuring degradation

Land cover types	1.1 Food	1.2 Materials	1.3 Forest trees-related	1.4 Plant-related	1.5 Physical support	2.1 Amenity	2.2 Identity	2.3 Didactic	3.1 Cycling	3.2 Sink	3.3 Prevention	3.4 Refugium	3.5 Breeding
Artificial surfaces/ Urban	●	●			●	●	●	●		●			
Arable land & permanent crops	●	●		●	●	●	●	●	●	●		●	●
Grassland & mixed farmland	●	●	●	●	●	●	●	●	●	●	●	●	●
Forests & woodland shrub	●		●	●	●	●	●	●	●	●	●	●	●
Heathland, sclerophylous veg.			●	●		●	●	●	●		●	●	●
Open space with little/ no vegetation		●		●		●	●	●		●		●	●
Wetlands	●	●	●	●	●	●	●	●	●	●	●	●	●
Water bodies	●	●		●		●	●	●	●	●		●	●

Main relations between classifications & accounting units

Ecosystems:
Socio-ecological landscape units (SELU)
(terrestrial, marine & atmospheric)

Land Cover:
biophysical land units

Monetary Statistics
of Products

Land Functions & Ecosystem Services

Land Use:
productive land functions

Physical Statistics
of Products

Institutional & Production Units
(sectors & industries)

Land Ownership
(private & public)
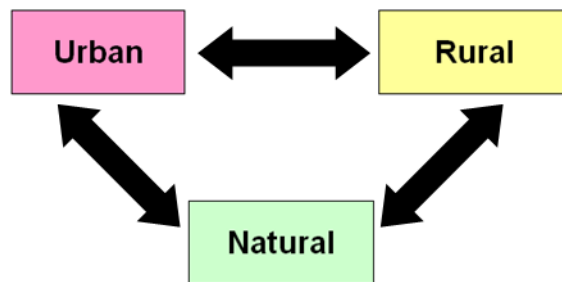
Land use: a necessary compromise

- In principle, land use functions are many

Land Use Functions

possible nomenclature with different LUF intensity

Land Systems   **Land Use Functions**

	UF01 Residence, incl. services	UF04 Industrial production	UF09 Farming, food production	UF12 Nature conservation	... ...	... ...
Urban	●	●	•	•		
Rural	•	●	●	●		
Natural	●		●	●		
	Σ	Σ	Σ	Σ	Σ	Σ

…allowing to address cross-cutting issues e.g.:

- Urban - Rural interaction
- Agro - Environment assessment

Land Use Functions – Agriculture landscape

Supply & Use of Land Cover Resource by Land Use Functions	LUF01 Residential, incl. services	LUF02 Commercial	LUF03 Transport	LUF04 Industrial production	LUF05 Energy production	LUF06 Mining & quarrying	LUF07 Waste dumping	LUF08 Water management	LUF09 Farming, food production	LUF10 Forestry	LUF11 Recreation & Tourism	LUF12 Nature conservation	LUF13 Other uses	ADJUSTMENT FOR MULTIPLE USES	TOTAL
Initial surface															
1 Artificial surfaces															
2.1+2.2 Arable Land & Permanent Crops															
2.3+2.4 Pastures & Mixed agricultural areas															
3.1 Forests															
3.2+3.3 Shrub and other semi-natural land															
4 Wetlands															
5 Water bodies															
A - TOTAL INITIAL SURFACE ~1990															
Net Formation of Land Cover by Use															
LCF1 Urban land management															
LCF2 Urban sprawl															
LCF3 Extension of economic sites and infrastructures															
LCF4 Agricultural rotation and intensification															
LCF5 Conversion of land to agriculture															
LCF6 Forests creation and management															
LCF7 Water body creation and management															
LCF8 Changes of Land Cover due to natural and multiple causes															
B - TOTAL Net Formation of Land Cover															0
Net Extension of Use without Formation of Cover															
1 Artificial surfaces															
2.1+2.2 Arable Land & Permanent Crops															
2.3+2.4 Pastures & Mixed agricultural areas															
3.1 Forests															
3.2+3.3 Shrub and other semi-natural land															
4 Wetlands															
5 Water bodies															
C - TOTAL Net Extension of Use without Formation of Cover															
Final Surface															
1 Artificial surfaces															
2.1+2.2 Arable Land & Permanent Crops															
2.3+2.4 Pastures & Mixed agricultural areas															
3.1 Forests															
3.2+3.3 Shrub and other semi-natural land															
4 Wetlands															
5 Water bodies															
D - TOTAL FINAL SURFACE ~2000 (D = A+B+C)															

Land Use classification based on main (productive) functions – e.g. agriculture landscape

Supply & Use of Land Cover Resource by Land Use Functions	LUF01 Residential, incl. services	LUF02 Commercial	LUF03 Transport	LUF04 Industrial production	LUF05 Energy production	LUF06 Mining & quarrying	LUF07 Waste dumping	LUF08 Water management	LUF09 Farming, food production	LUF10 Forestry	LUF11 Recreation & Tourism	LUF12 Nature conservation	LUF13 Other uses	ADJUSTMENT FOR MULTIPLE USES	TOTAL
Initial surface															
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LCF4 Agricultural rotation and intensification															
LCF5 Conversion of land to agriculture															
LCF6 Forests creation and management															
LCF7 Water body creation and management															
LCF8 Changes of Land Cover due to natural and multiple causes															
B - TOTAL Net Formation of Land Cover															0
Net Extension of Use without Formation of Cover															
1 Artificial surfaces															
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2.3+2.4 Pastures & Mixed agricultural areas															
3.1 Forests															
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5 Water bodies															
D - TOTAL FINAL SURFACE ~2000 (D = A+B+C)															

Expert meeting on Land Use and Ecosystem accounting, 18-19 May 2006, EEA

Land use: a necessary compromise

- In principle, land use functions are many
- But 40 years of statistical tradition in agriculture and forestry have structured data bases on the basis of productive functions ~ provisioning ecosystem services
- Other functions will be addressed as other ecosystem services (regulating, socio-cultural…) – see CICES

(productive) land use classification (FAO)

Code	Level 1	Level 2
	Cultivated, Forest and Aquacultural land	
		Agricultural land
		Forests and other wooded land
		Land with aquaculture facilities
	Built-up and related land	
		Land used for mining and quarrying
		Land used for construction
		Land used for manufacturing
		Land used for technical infrastructure
		Land use for commercial, financial and public services
		Land developed for recreational purposes
		Residential areas
	Land not in use	
		Land for conservation and environmental protection
		Other
	Water bodies	
		Inland waters
		Marine waters

Land use is more than hectares

Attributes of land use:

• Yields

• Crops

• Practices

• Frequentation

• …

• Land use in full is not easy to map ➔ the land cover image is a proxy of land use … and of ecosystems

Land cover classification

- Need for international standard (Geomatics, interoperability of GIS…)
- Need of a classification of mappable land cover units, using in particular Earth observation satellites
- Concertation between EEA, Eurostat, UNSD and FAO
- LCCS3 as standard for classification

LAND COVER CLASSIFICATION SYSTEM 3

(Version 1.1.0 - 17 mar 2010)

UNEP

COOPERAZIONE
ITALIANA

FAO

Loading main window (Initialization of the Shelf...)

LCCS3 entry screen

Main Toolbar

Legend Toolbar

Flowchart of the Elements and their Characteristics as part of the general reference UML

Legend Window

Shelf with Elements and their Characteristics to create a class

Diagram of the "Core Engine" as part of the general reference UML

Shelf of the Properties of the above Elements

Graphic Legend overview

From LCCS3 tutorial...

Fig.1

Fig. 2

Fig. 3

LCCS3 rationale

The systematic description of land cover can be made by describing

- <u>basic vegetal and abiotic objects</u>,

- their <u>characteristics</u> (for the vegetal objects: grass, shrubs or trees, for the abiotic objects: mineral, water or snow/ice),

- their <u>properties</u> (e.g. tree types, managed or non-managed)

- and the <u>spatial patterns</u>, which reflect the way these basic objects are arranged on land (scale dependant).

Basic ojects

- Herbs, grass
- Shrubs
- Trees
- Minerals (sand, rock)
- Ice and snow
- Water

Land Cover Types
(objects*characteristics*classifications)

Based on FAO LCCS3

A	Herbaceous crop
A1	*Herbaceous crop/ Small size fields rainfed (< 2 ha)*
A2	*Herbaceous crop/ Medium to large size fields rainfed*
A3	*Herbaceous crop/ Medium to large size fields irrigated*
B	Tree or shrub crop
C	Multiple or layered crop
D	Tree covered area
E	Shrub covered area
F	Herb covered area
G	Sparse natura l vegetation (terrestrial/aquatic/regularly flooded)
H	Aquatic or regularly flooded tree covered area
I	Aquatic or regularly flooded shrub or herb covered area
J	Bare areas (terrestrial or regularly flooded)
K	Artificial surfaces and associated areas
L	Inland water bodies
M	Glacier and perennial snow

Land Cover Types
and derived Land Cover Functional Units

A	Herbaceous crop
A1	*Herbaceous crop/ Small size fields rainfed (< 2 ha)*
A2	*Herbaceous crop/ Medium to large size fields rainfed*
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L	Inland water bodies
M	Glacier and perennial snow

Based on FAO LCCS3

01	Urban and associated developed areas
02	Medium to large fields rainfed herbaceous cropland
03	Medium to large fields irrigated herbaceous cropland
04	Permanent crops, agriculture plantations
05	Agriculture associations and mosaics
06	Pastures and natural grassland
07	Forest tree cover
08	Shrubland, bushland, heathland
09	Sparsely vegetated areas
10	Natural vegetation associations and mosaics
11	Barren land
12	Permanent snow and glaciers
13	Open wetlands
14	Inland water bodies
15	Coastal water bodies
16	Sea (per memory)

sampling
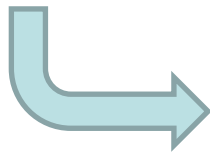
mapping

Land Cover Functional Units for ecosystem accounting

Based on FAO LCCS3

01	Urban and associated developed areas
02	Medium to large fields rainfed herbaceous cropland
03	Medium to large fields irrigated herbaceous cropland
04	Permanent crops, agriculture plantations
05	Agriculture associations and mosaics
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14	Inland water bodies
15	Coastal water bodies
16	Sea (per memory)

Points for discussion

- Mosaics
- Forests
- Coastal land cover units
- …

Land cover stocks and change accounts

- LF01   Urban sprawl and related development
- LF02   Land cover rotation within urban areas
- LF03   Conversion of land to agriculture
- LF04   Land cover rotation within agriculture
- LF05   Conversion of land to forest
- LF06   Land cover rotation within forested land
- LF07   Water bodies management
- LF08   Change due to natural and multiple causes

A possible table for land cover accounting

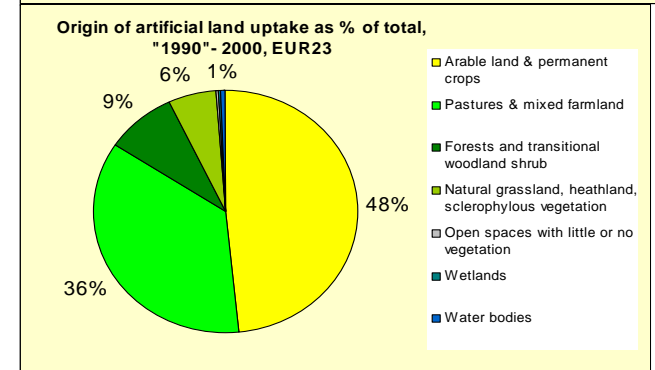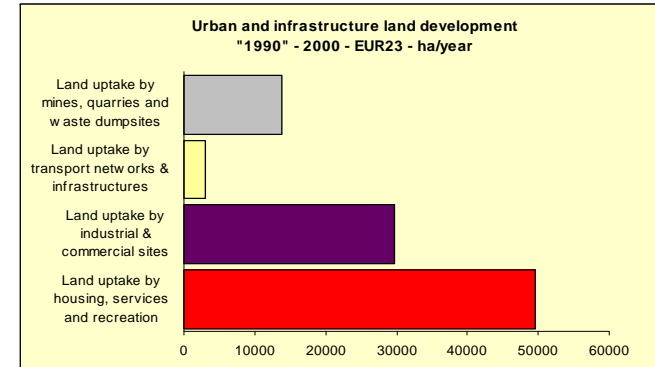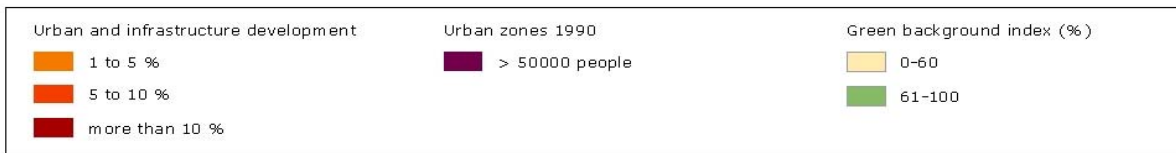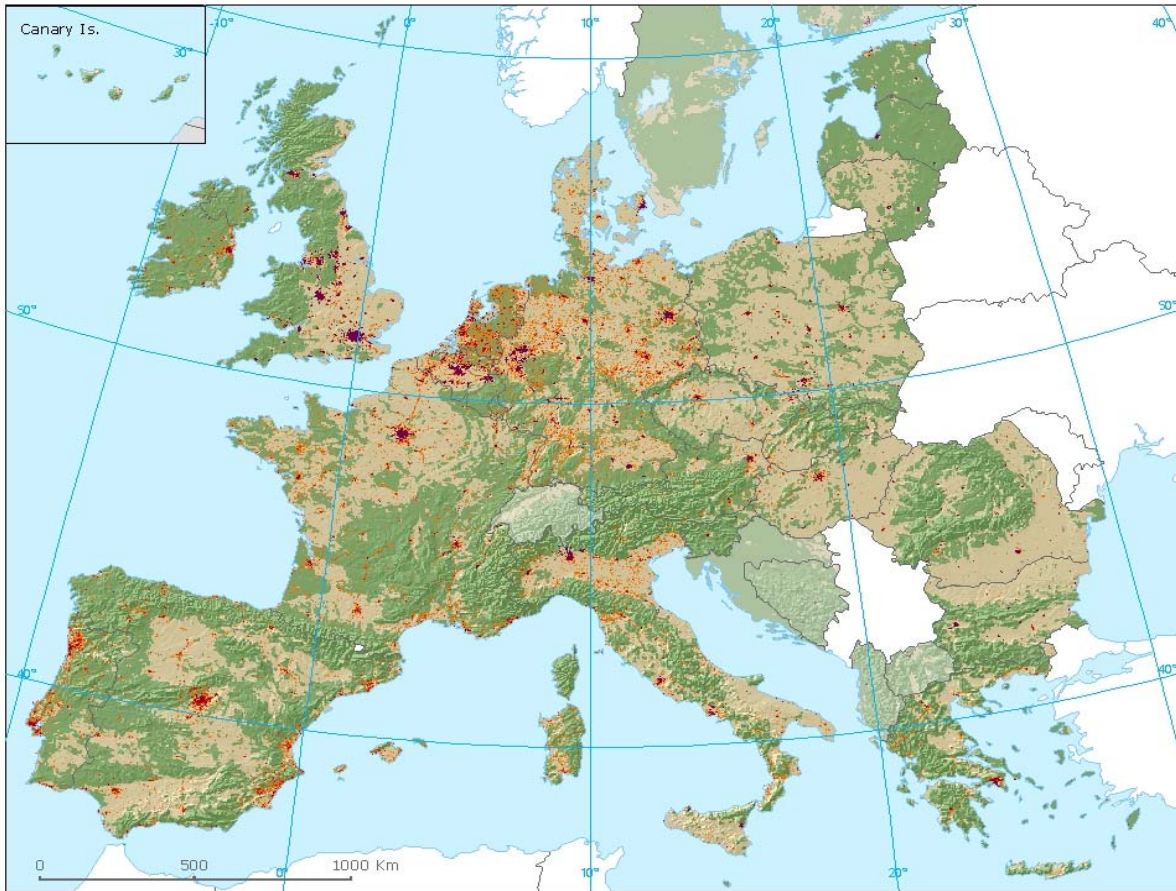|	Consumption of land cover t0										Formation of land cover t1						
	Urban areas	Broad pattern agriculture	Agriculture mosaics	Pastures and natural grassland	Forest tree cover	Other natural land cover	TOTAL				Urban areas	Broad pattern agriculture	Agriculture mosaics	Pastures and natural grassland	Forest tree cover	Other natural land cover	TOTAL
									Stock t0								
								LF01	Urban sprawl and related development								
								LF02	Land cover internal conversions of urban areas								
								LF03	Conversion of land to agriculture								
								LF04	Land cover internal conversions of agriculture								
								LF05	Conversion of land to forest								
								LF06	Land cover internal conversions of forested land								
								LF07	Water bodies creation and management								
								LF08	Change due to natural and multiple causes								
									Stock t1								
									TOTAL								

Landscape index

Land cover accounts for Europe
1990-2000 (26 countries)
2006 update (34 countries)
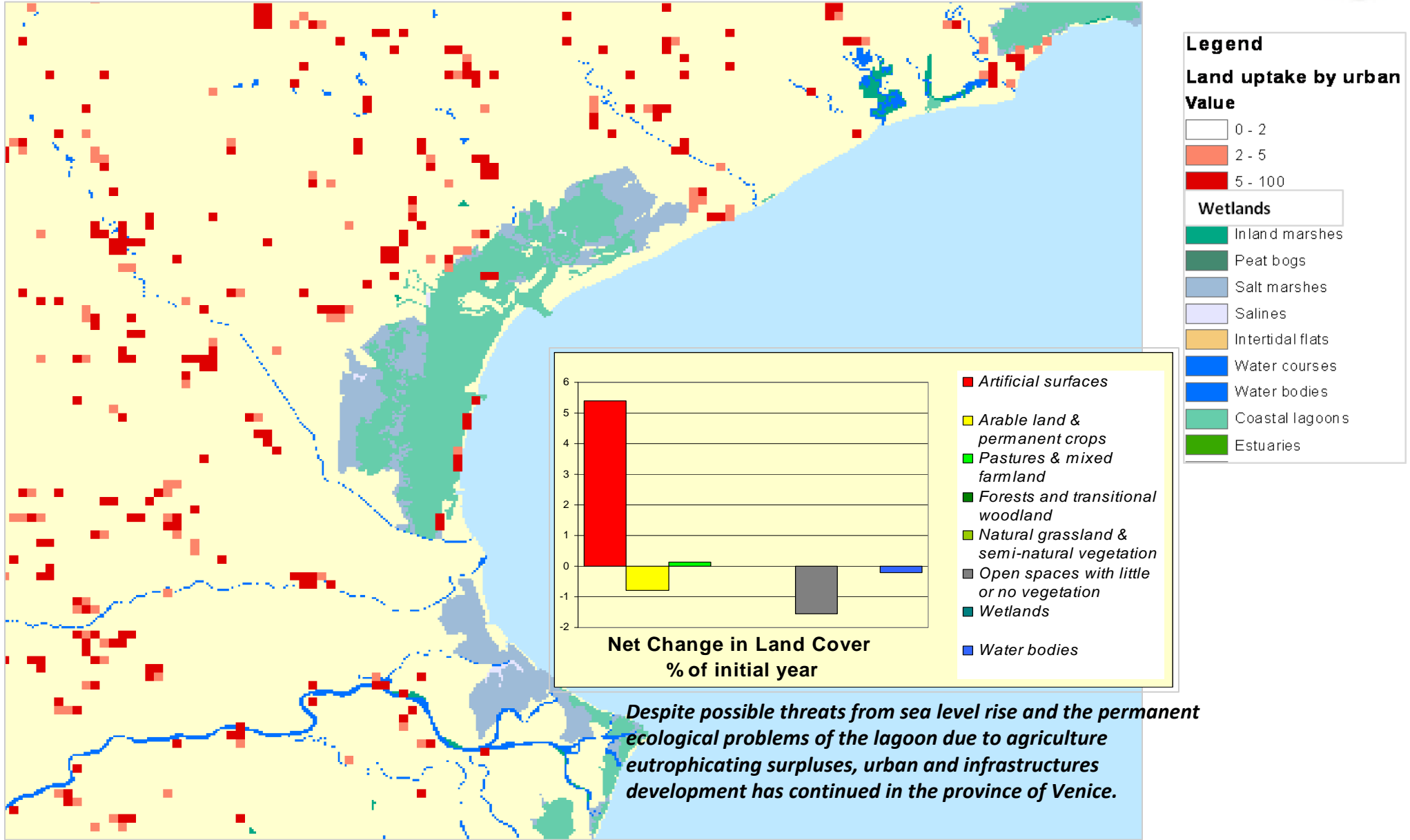
Land cover accounts are produced for 1 km² grid cells

K1000 E3666 N2073

Legend:
- Discontinuous urban fabric (red)
- Industrial or commercial units (purple)
- Coniferous forest (green)
- Sclerophyllous vegetation (light green)
- Water courses (cyan)

Values shown: 71, 14, 2, 7, 6

Total surface: 100 Ha

EEA Report | No 11/2006

Land accounts for Europe 1990–2000

Towards integrated land and ecosystem accounting

ISSN 1725-9177

European Environment Agency

Sprawl of artificial areas 1990-2000

Canary Is.

Urban and infrastructure development
- 1 to 5 %
- 5 to 10 %
- more than 10 %

Urban zones 1990
- > 50000 people

Green background index (%)
- 0-60
- 61-100

Urban and infrastructure land development "1990" - 2000 - EUR23 - ha/year

- Land uptake by mines, quarries and waste dumpsites
- Land uptake by transport networks & infrastructures
- Land uptake by industrial & commercial sites
- Land uptake by housing, services and recreation

(axis: 0, 10000, 20000, 30000, 40000, 50000, 60000)

Origin of artificial land uptake as % of total, "1990"- 2000, EUR23

- 48% — Arable land & permanent crops
- 36% — Pastures & mixed farmland
- 9% — Forests and transitional woodland shrub
- 6% — Natural grassland, heathland, sclerophylous vegetation
- 1% — Open spaces with little or no vegetation
- Wetlands
- Water bodies

Mean annual urban and infrastructures land take as % of Artificial land cover "1990"

(axis: 0.0, 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5)
(categories: at, be, bg, cz, de, dk, ee, es, fr, gr, hu, ie, it, lt, lu, lv, nl, pl, pt, ro, si, sk, uk, EUR23)

Mean annual urban and infrastructures land take as % of total Europe-23 urban land take

(axis: 0.00, 5.00, 10.00, 15.00, 20.00, 25.00)
(categories: at, be, bg, cz, de, dk, ee, es, fr, gr, hu, ie, it, lt, lu, lv, nl, pl, pt, ro, si, sk, uk)

Jean-Louis Weber, CBD Conférence, Libreville, 16 Septembre 2010

Urban sprawl in the province of Venice, 1990-2000, cells of 1 km² , impact on wetlands

Legend

Land uptake by urban
Value

	0 - 2
	2 - 5
	5 - 100

Wetlands

- Inland marshes
- Peat bogs
- Salt marshes
- Salines
- Intertidal flats
- Water courses
- Water bodies
- Coastal lagoons
- Estuaries

Net Change in Land Cover
% of initial year

- Artificial surfaces
- Arable land & permanent crops
- Pastures & mixed farmland
- Forests and transitional woodland
- Natural grassland & semi-natural vegetation
- Open spaces with little or no vegetation
- Wetlands
- Water bodies

Despite possible threats from sea level rise and the permanent ecological problems of the lagoon due to agriculture eutrophicating surpluses, urban and infrastructures development has continued in the province of Venice.

Jean-Louis Weber, CBD Conférence, Libreville, 16 Septembre 2010

Form Land Cover to Ecosystem Account: Landscape Ecological Potential, 1990-2000-2006

Corine land cover map (*CLC is derived from satellite images*)

*

Green Landscape Index (*derived from CLC*)

*
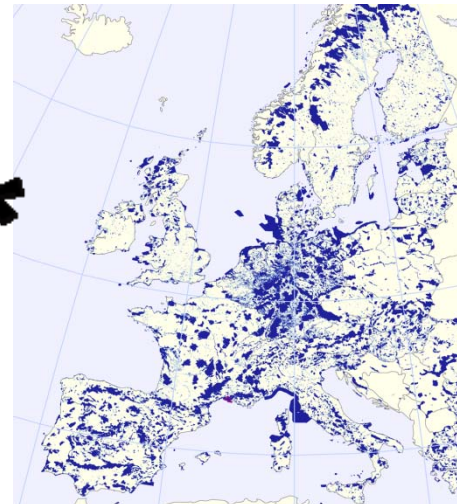
Nature Value (*Naturilis, derived from Natura2000 designated areas*)

*
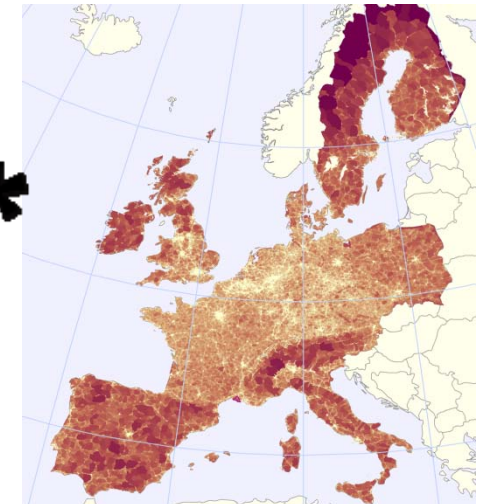
Fragmentation (*Effective Mesh Size (MEFF) derived from TeleAtlas Roads and CLC*)

➡

Landscape Ecological Potential (LEP) 2000, by 1km² grid cell
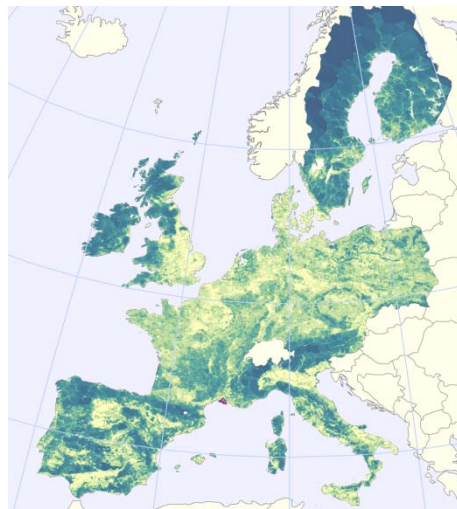
and
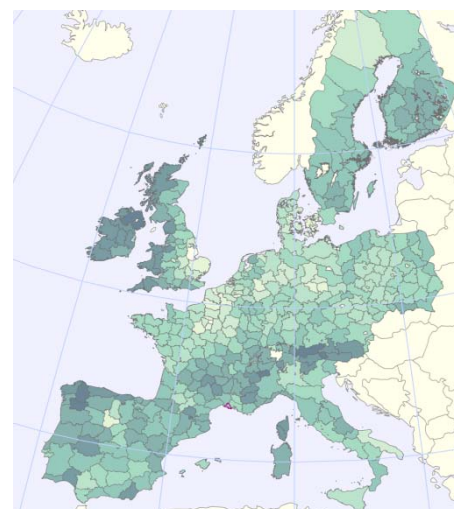
LEP 2000 by NUTS 2/3

Landscape ecosystem potential and change 1990-2000
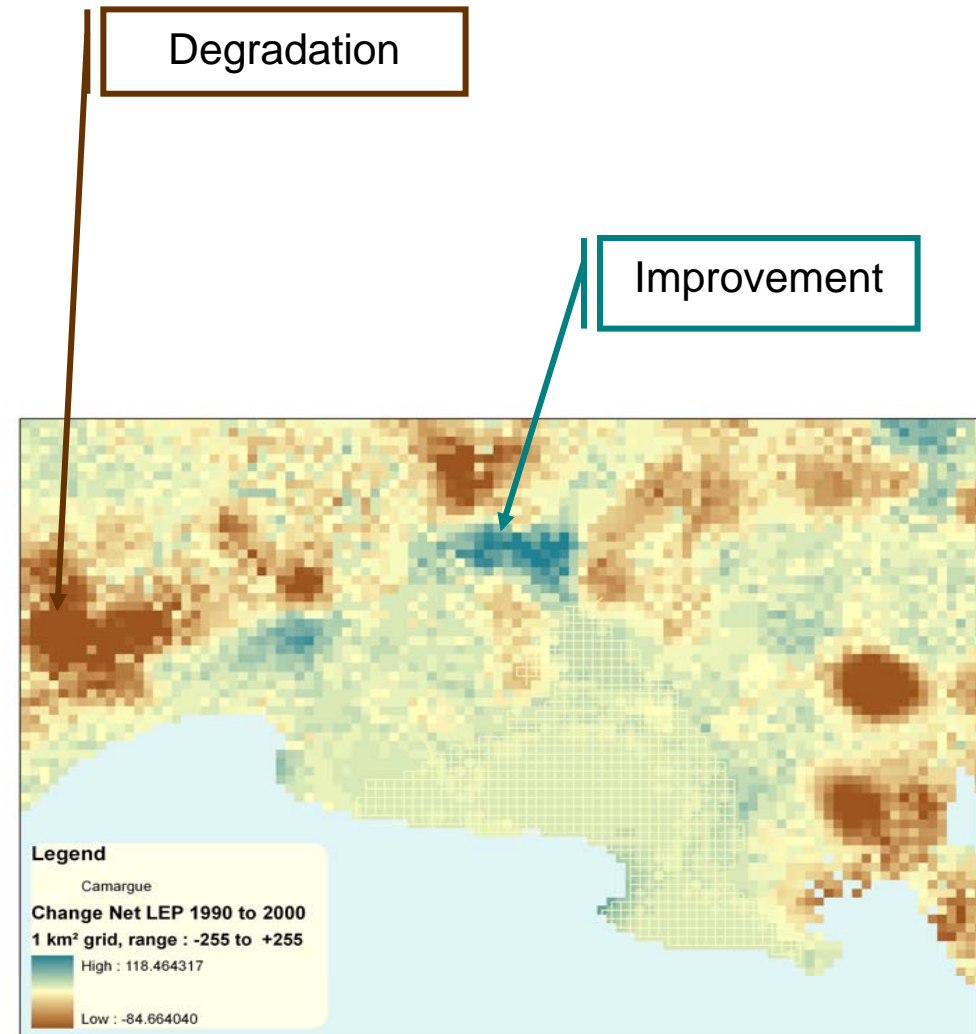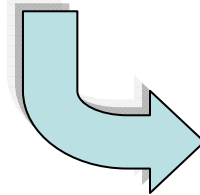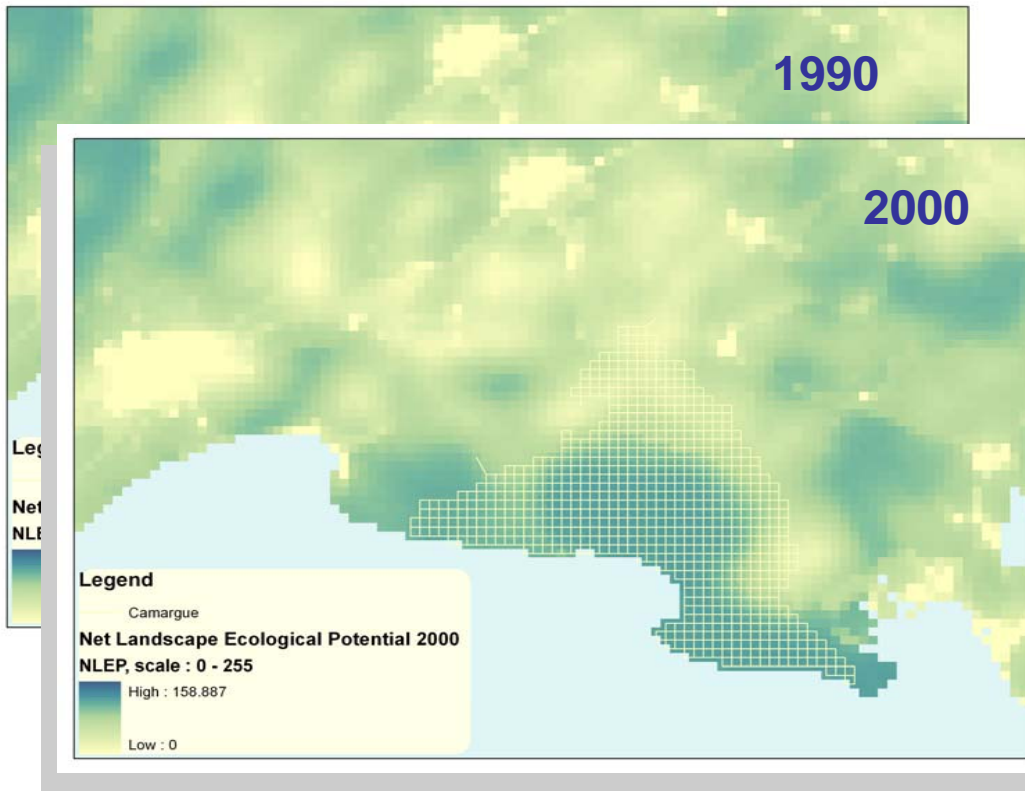
From land cover functional units to socio-ecological accounting units

- Land cover functional units can be fairly co-related to ecosystem services
- Large LCFU are autonomous systems: they influence their neighbourhood more than they are influenced by it.
- Small LCFU are part of broader systems which need to be defined in theory and in practice (as statistical units)
- Complex systems recognized in literature since long:
  - Socio-ecological systems: Johan Rockström , the Resilience Alliance
  - Geosystems: Eloisa Domingues
  - Eco-complexes: Pierre Blandin
  - Ecozones: Gilbert Long et. Al.
  - Etc…

From theoretical to observation units

Theoretical analytical unit

SES / SEPL

Candidate **socio-ecosystem landscape units** for observation & accounting **(SELU)**

Modeled SES/ SEPL

Topographic unit (eg. catchment)

Administrative or cadastral unit

Basic **land cover units** mapped with satellite images
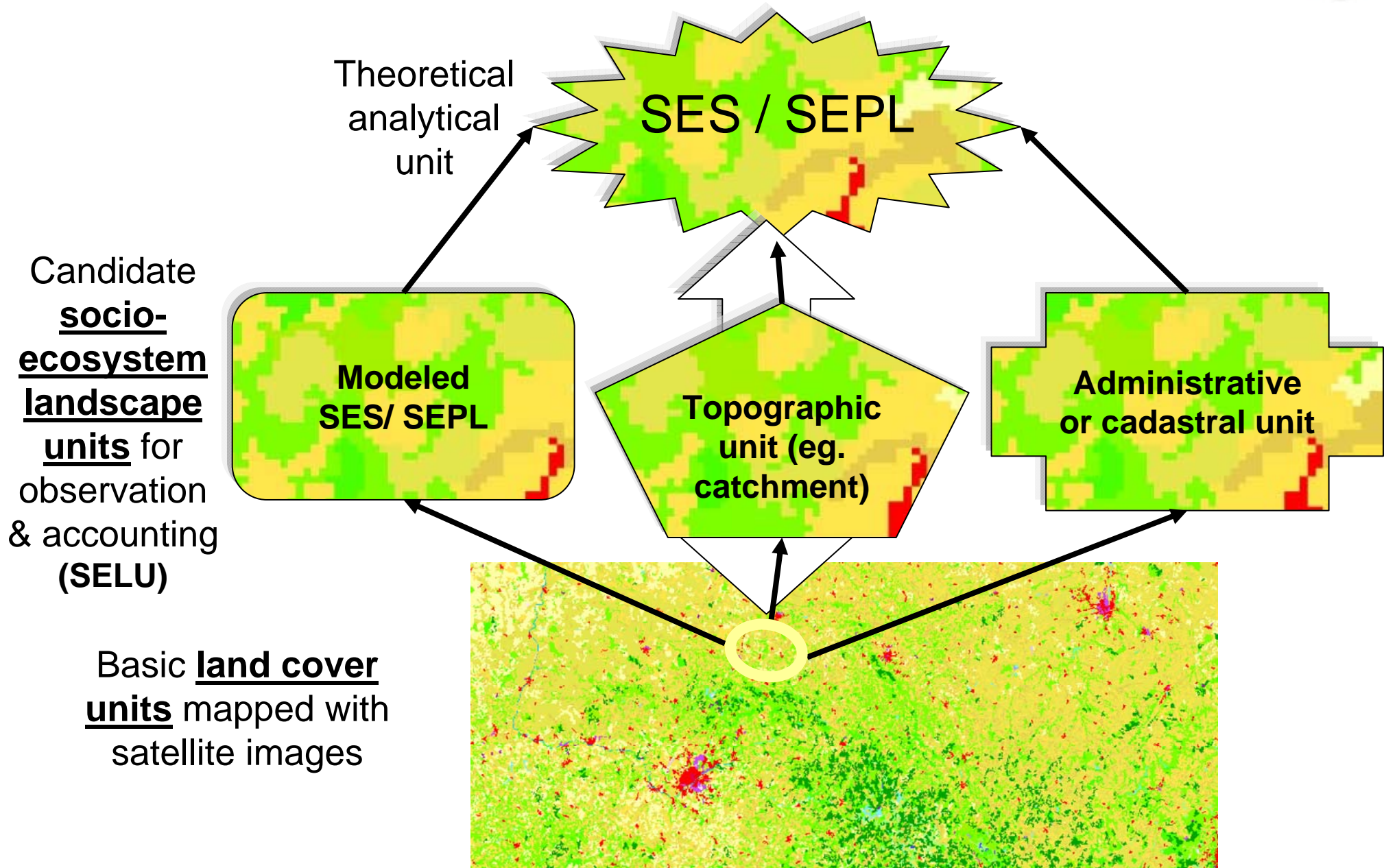
Possible sequence based on land cover modeling and topography

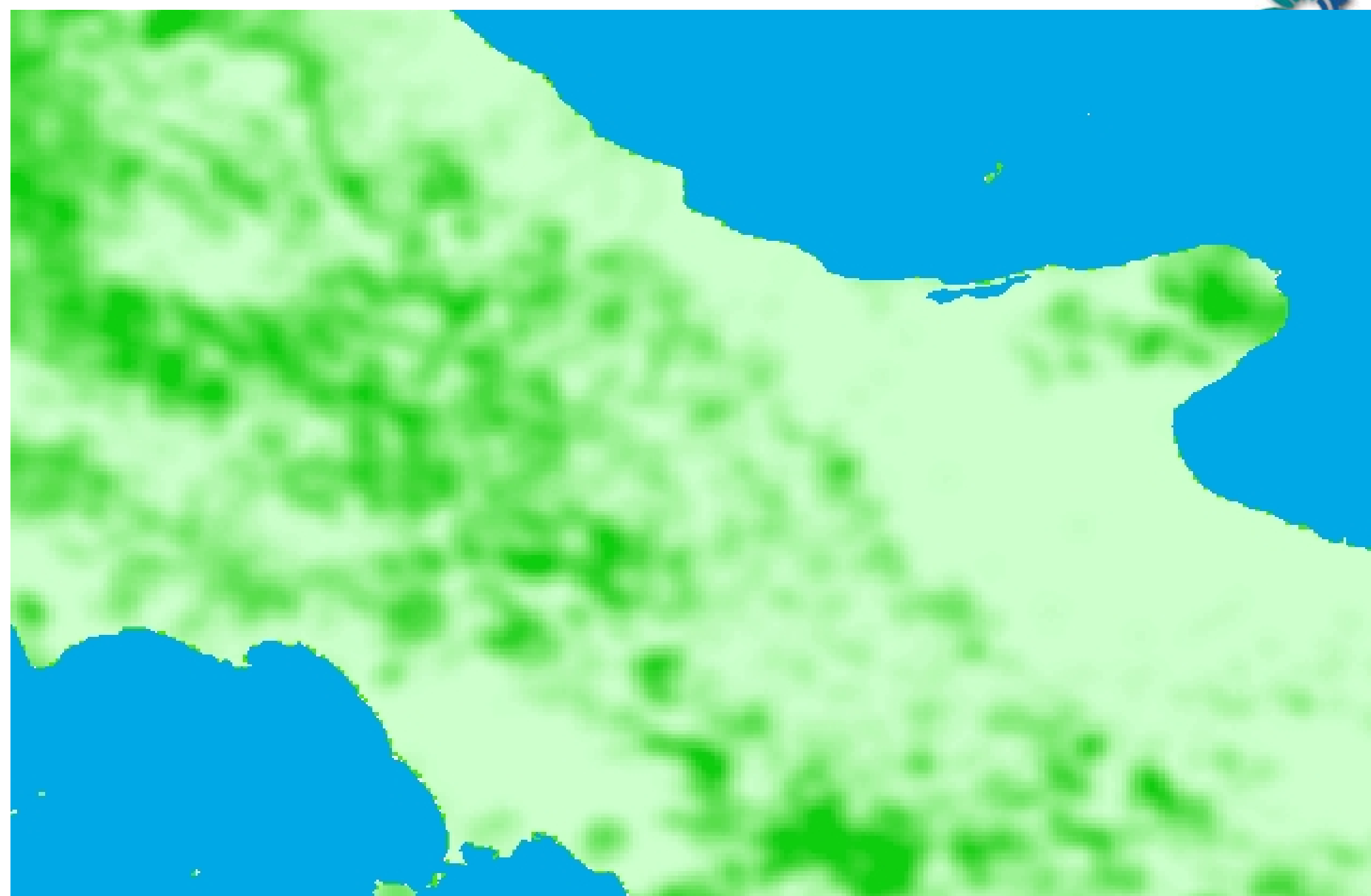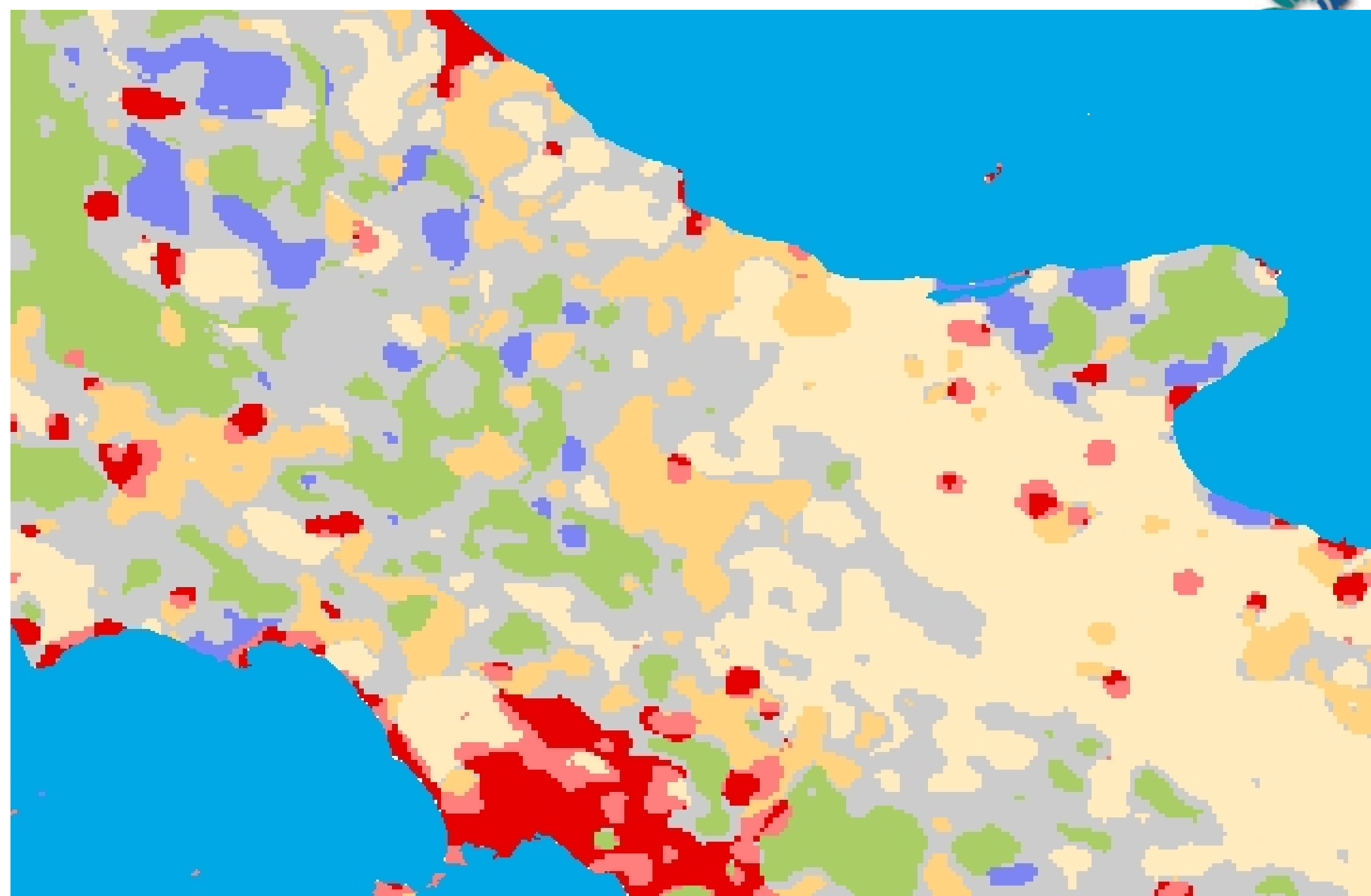SPOT IMAGE - FALSE COLOUR COMPOSITE
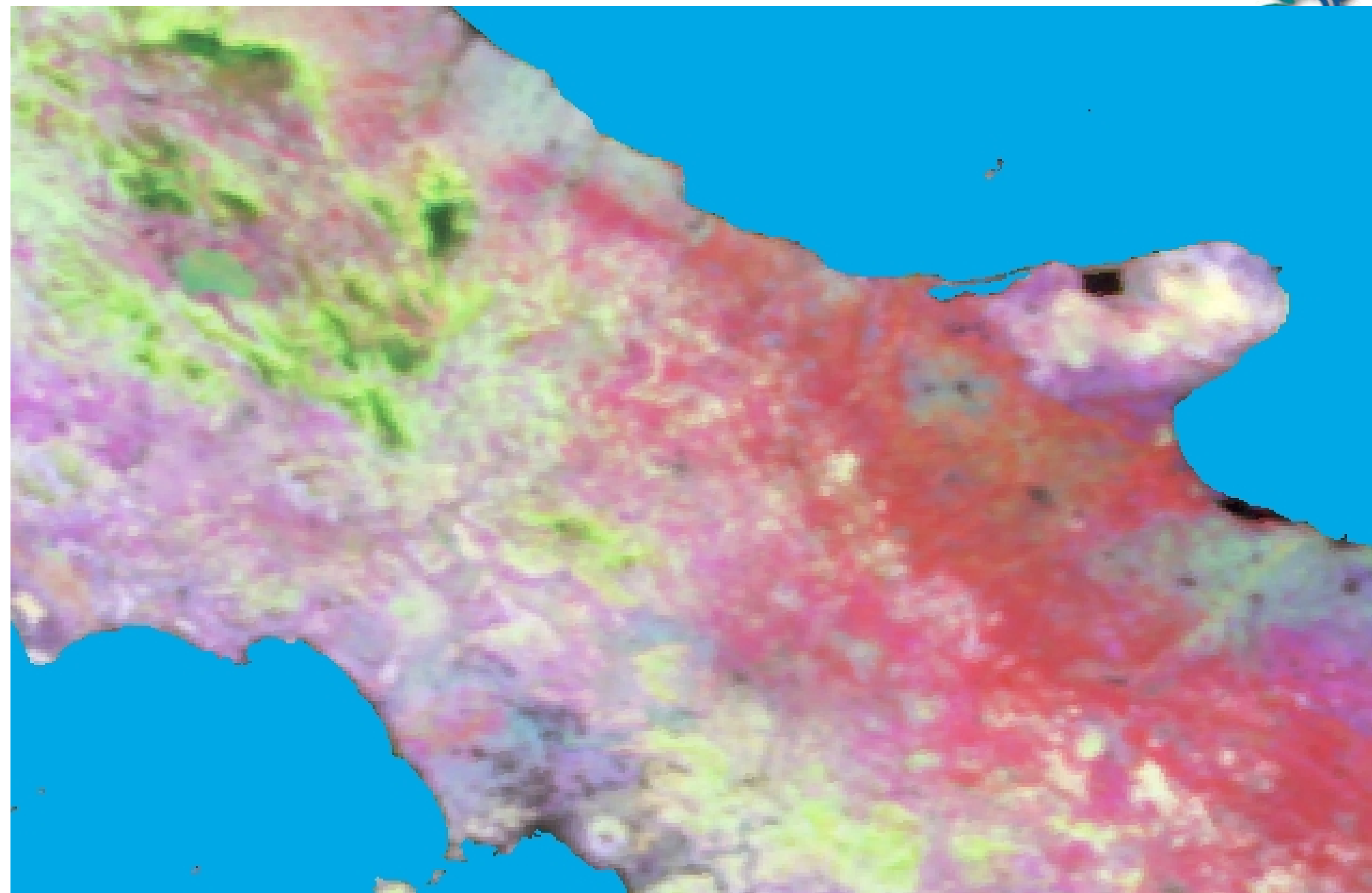
LAND COVER FUNCTIONAL UNITS
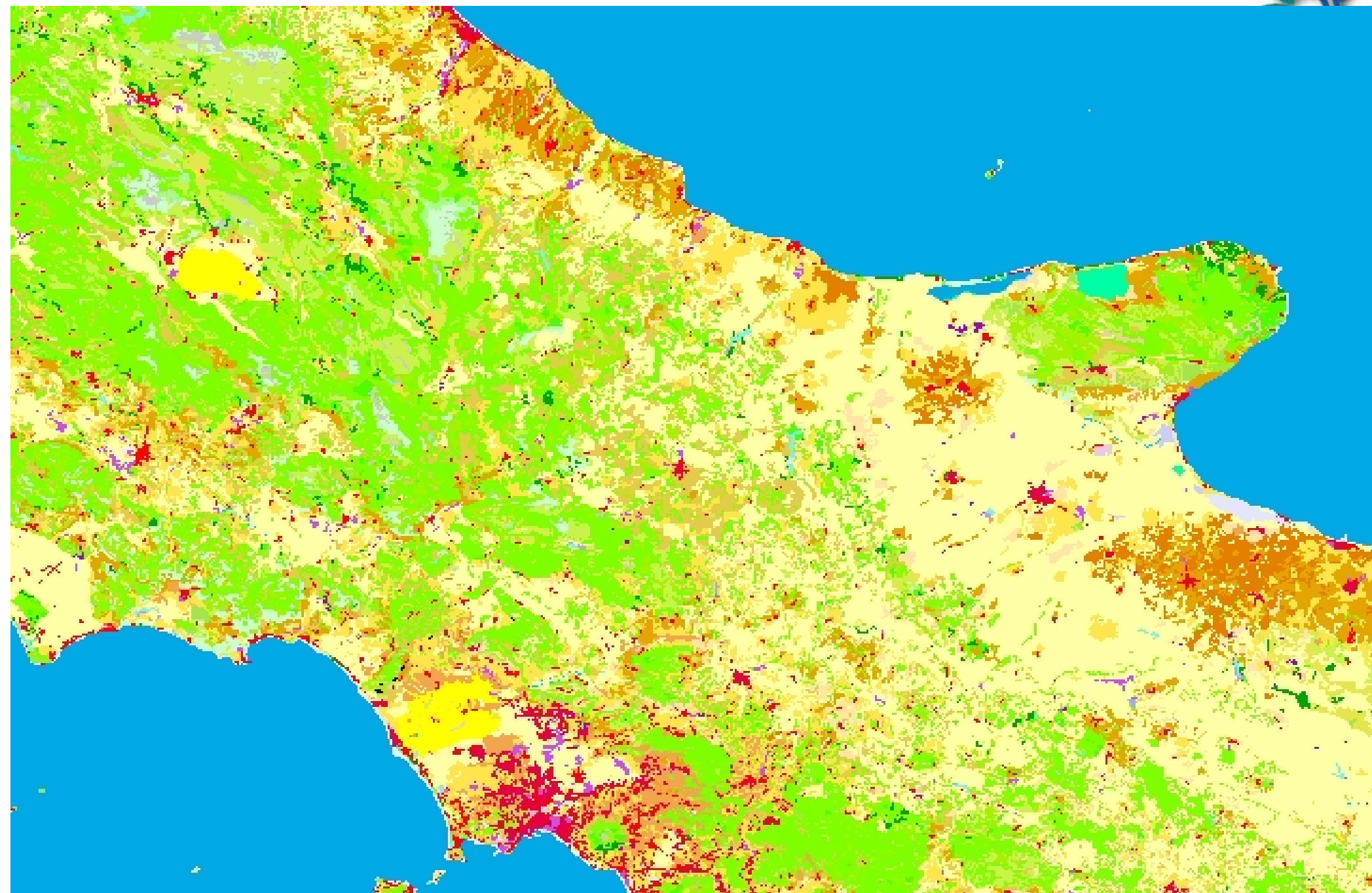
URBAN LAND DOMINANCE
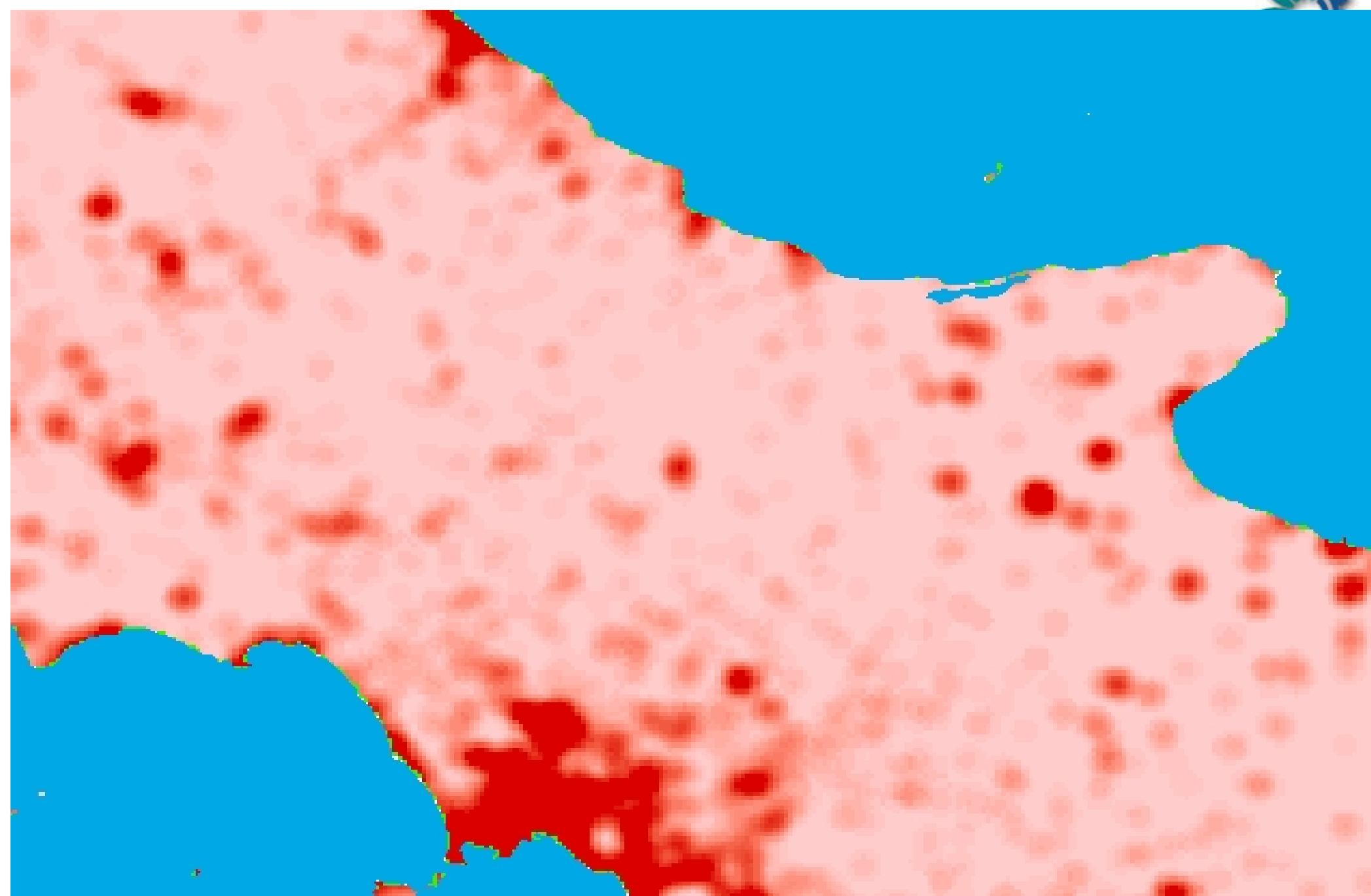
INTENSIVE AGRICULTURE DOMINANCE
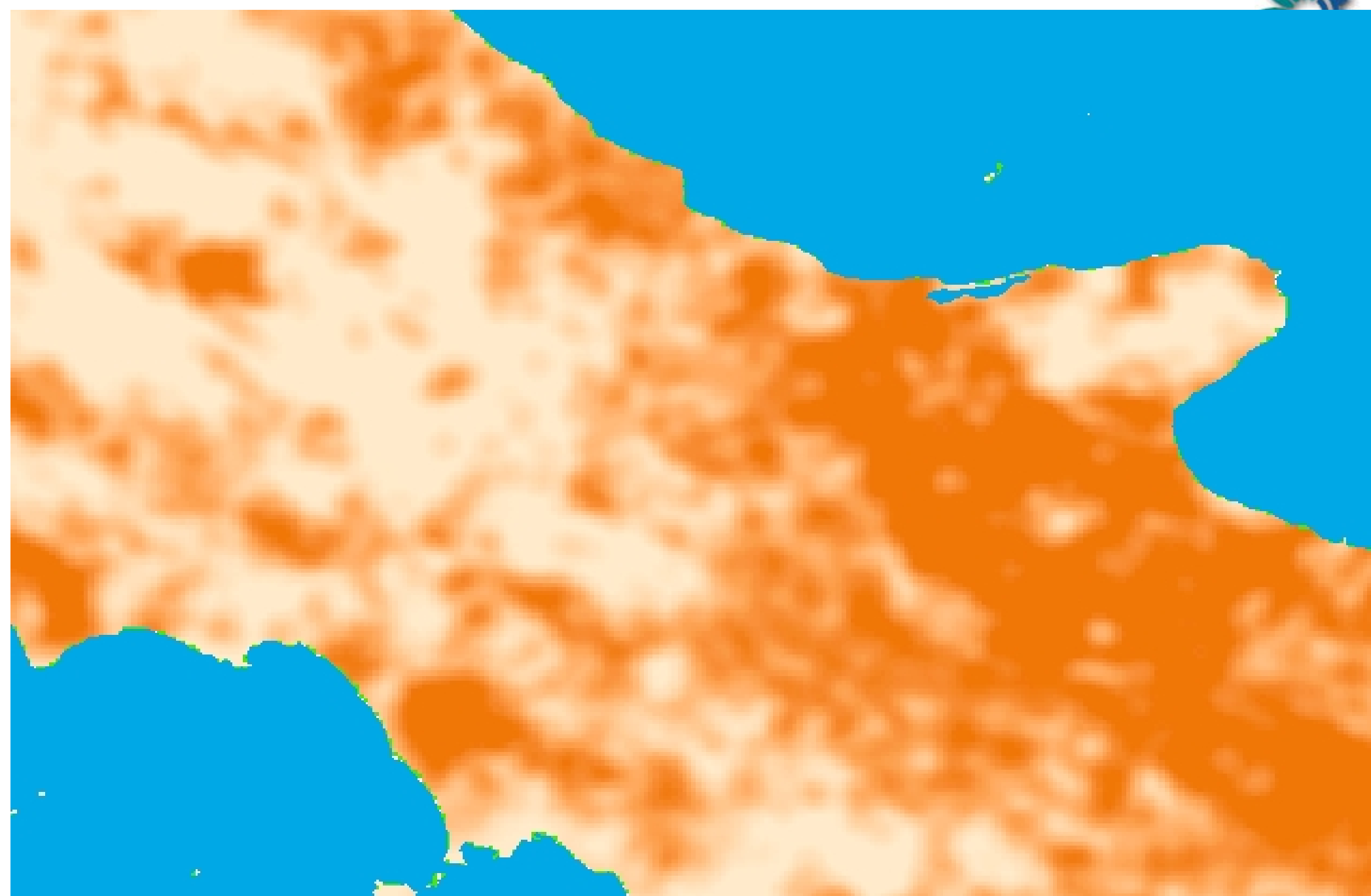
FOREST DOMINANCE

DOMINANT LAND COVER TYPES

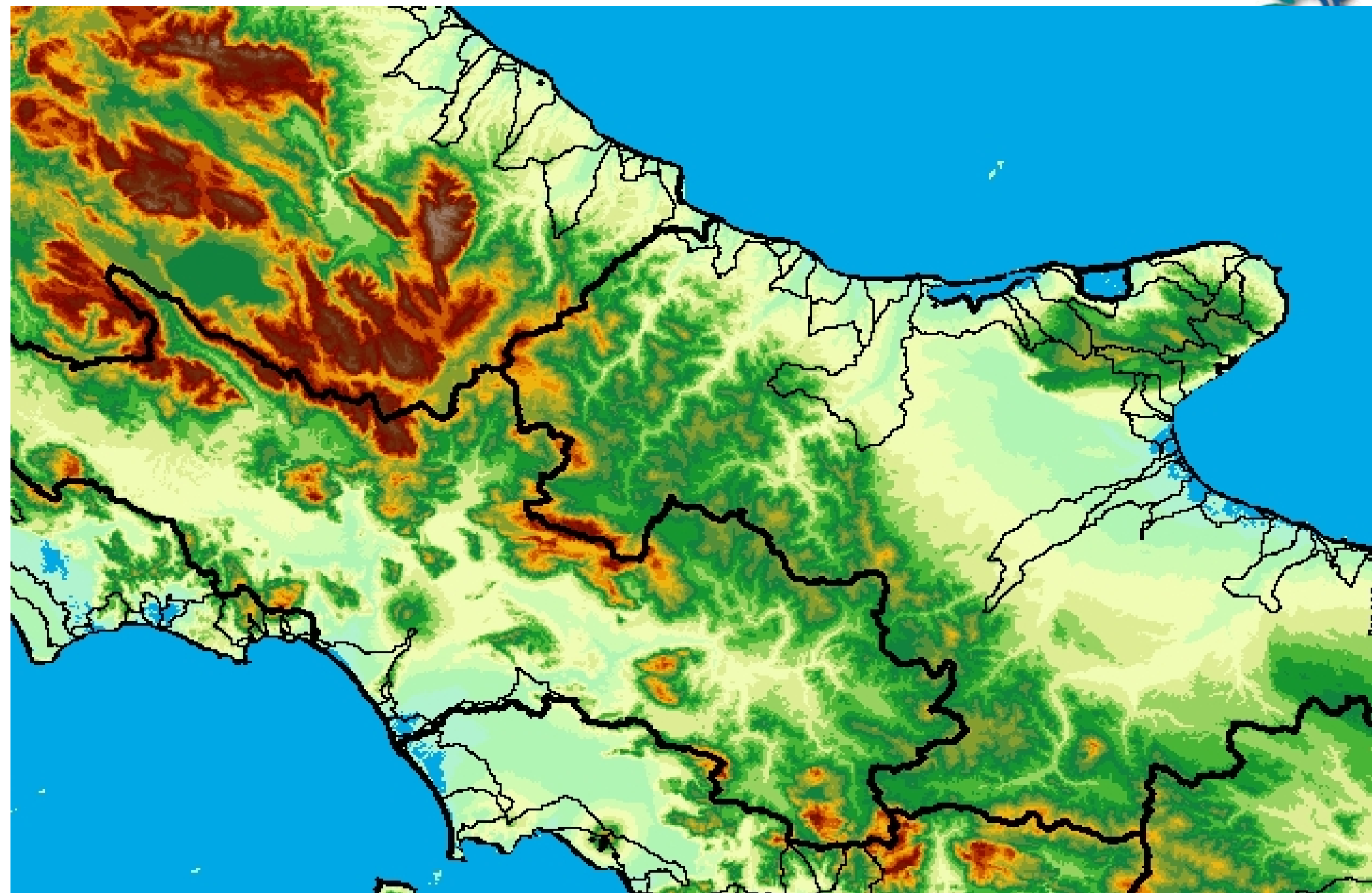# RELIEF (THREE CLASSES) LOW/HIGH/MOUNTAIN
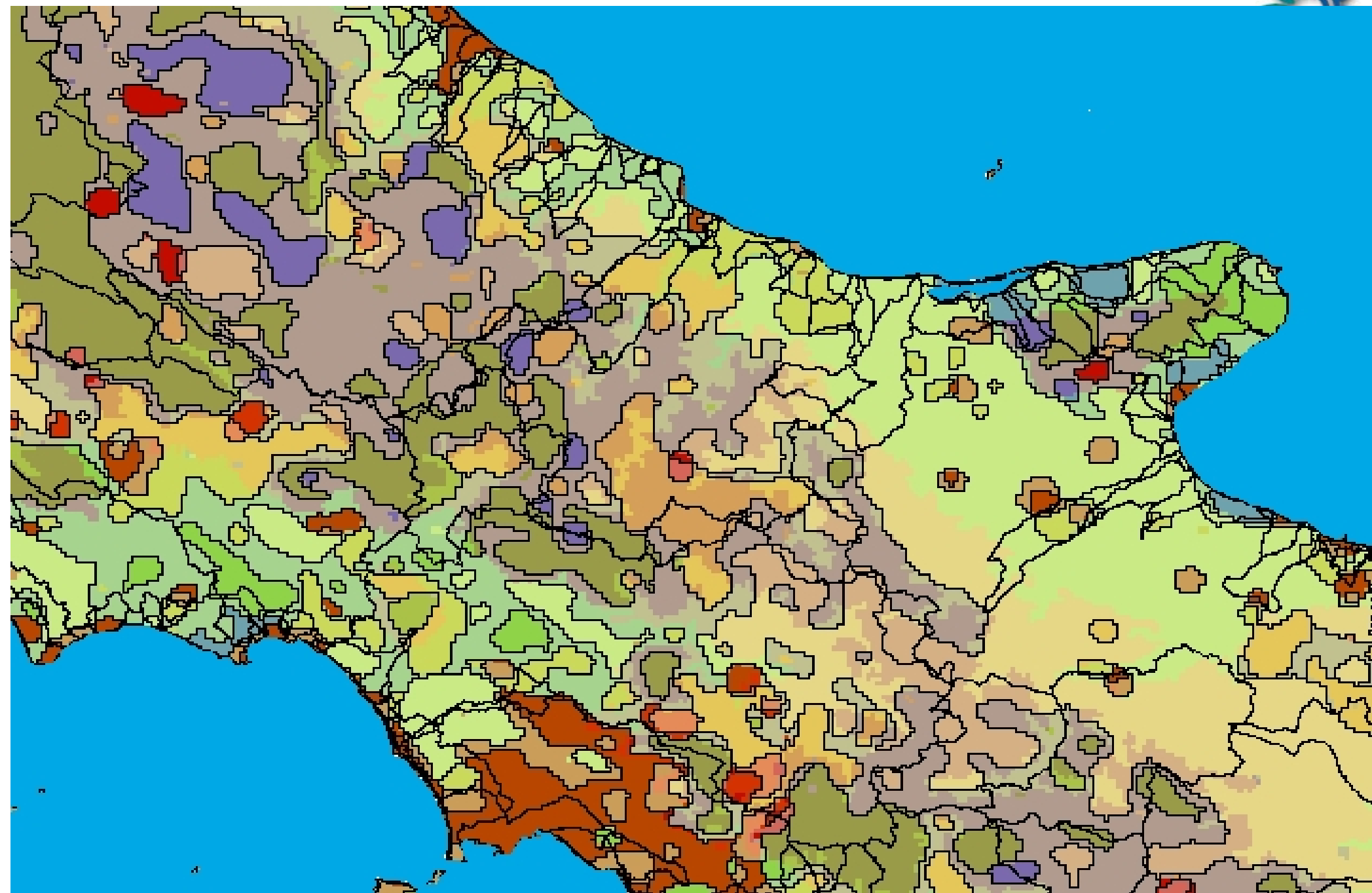
RELIEF (THREE CLASSES) & DLCT
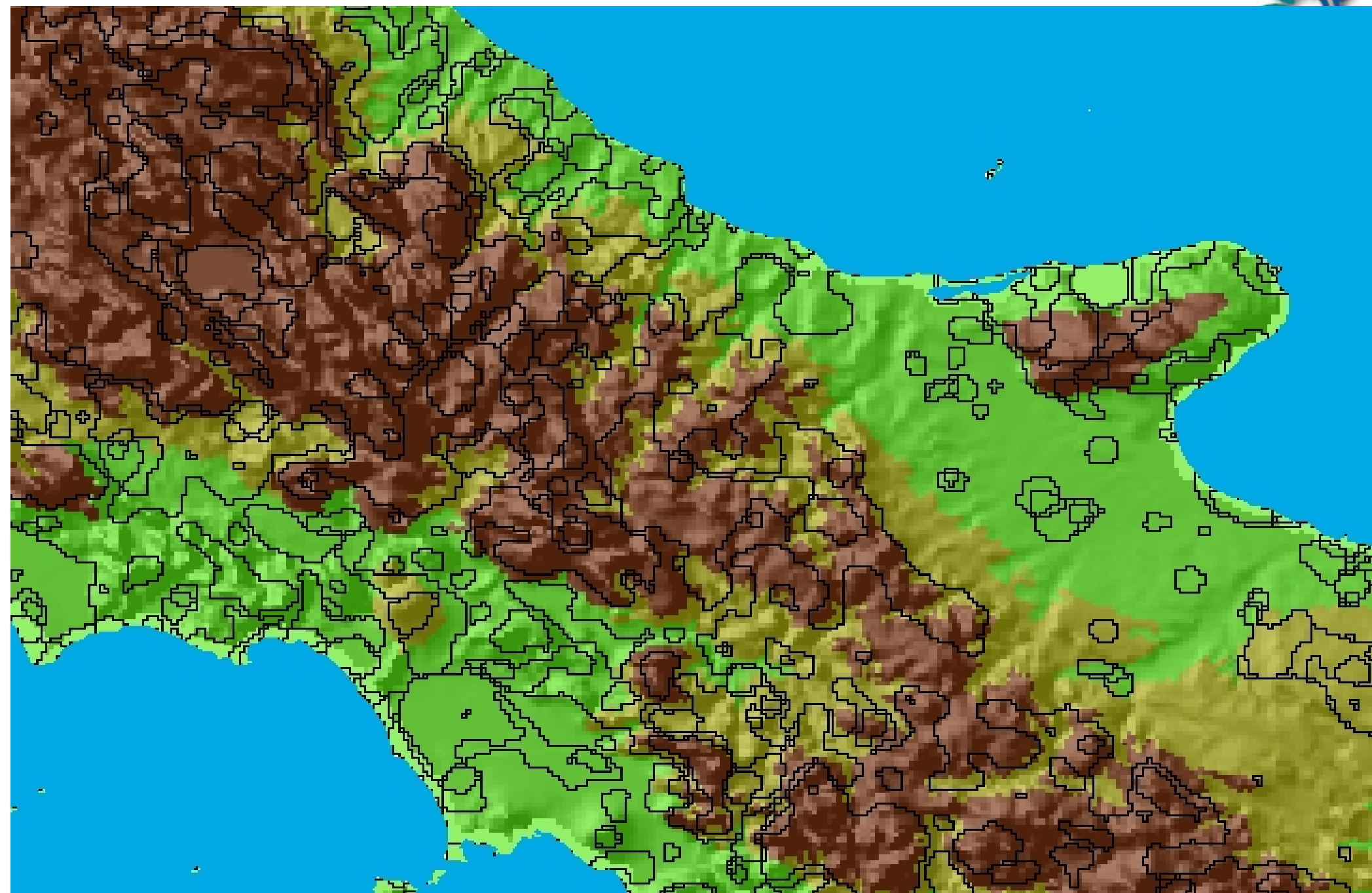
DOMINANT LANDSCAPE TYPE
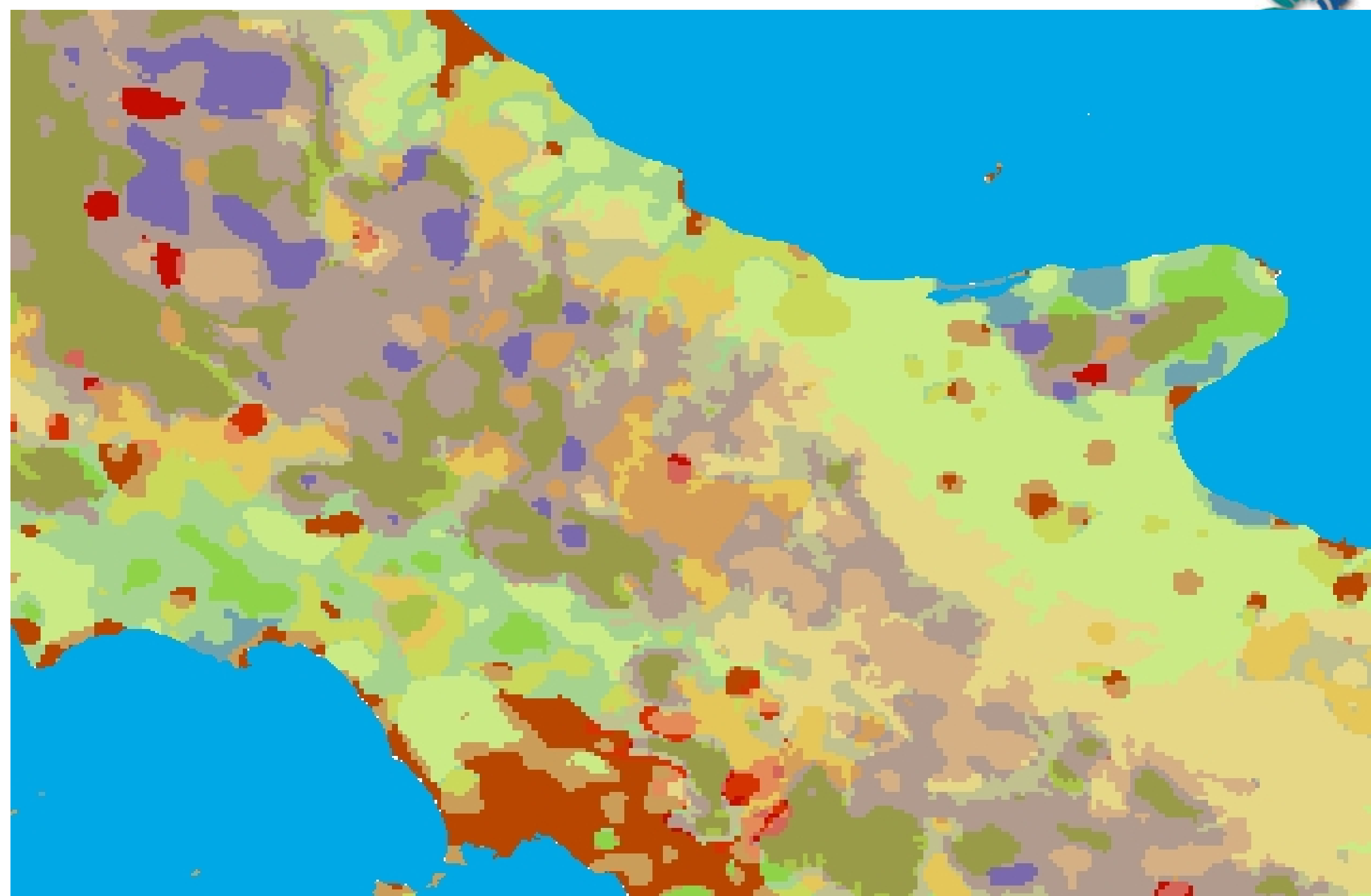
SELU

		Socio-ecological landscape units (SELU)	
1.		**Mountain ecosystem landscapes**	
	1.1	Mountain ecosystems/ Urban and associated developed areas	
	1.2	Mountain ecosystems/ Broad pattern agriculture	
	1.3	Mountain ecosystems/ Agriculture associations and mosaics	
	1.4	Mountain ecosystems/ Pastures and natural grassland	
	1.5	Mountain ecosystems/ Forest tree cover	
	1.6	Mountain ecosystems/ Other dominant natural land cover	
	1.7	Mountain ecosystems/ Composite land cover (no dominant land cover)	
2.		**Highland ecosystem landcapes**	
	2.1	Highland ecosystems/ Urban and associated developed areas	
	2.2	Highland ecosystems/ Broad pattern agriculture	
	2.3	Highland ecosystems/ Agriculture associations and mosaics	
	2.4	Highland ecosystems/ Pastures and natural grassland	
	2.5	Highland ecosystems/ Forest tree cover	
	2.6	Highland ecosystems/ Other dominant natural land cover	
	2.7	Highland ecosystems/ Composite land cover (no dominant land cover)	
3.		**Lowland ecosystems (inland) landscapes**	
	3.1	Lowland ecosystems/ Urban and associated developed areas	
	3.2	Lowland ecosystems/ Broad pattern agriculture	
	3.3	Lowland ecosystems/ Agriculture associations and mosaics	
	3.4	Lowland ecosystems/ Pastures and natural grassland	
	3.5	Lowland ecosystems/ Forest tree cover	
	3.6	Lowland ecosystems/ Other dominant natural land cover	
	3.7	Lowland ecosystems/ Composite land cover (no dominant land cover)	
4.		**Coastal landscapes**	
	4.1	Coastal ecosystems/ Urban and associated developed areas	
	4.2	Coastal ecosystems/ Broad pattern agriculture	
	4.3	Coastal ecosystems/ Agriculture associations and mosaics	
	4.4	Coastal ecosystems/ Pastures and natural grassland	
	4.5	Coastal ecosystems/ Forest tree cover	
	4.6	Coastal ecosystems/ Other dominant natural land cover	
5		**Hydrological systems**	
	5.1	Surface hydro-systems	
	5.2	Aquifers	

Table 5.6.4 lists possible additional indexations of SELU

| Other dominant natural land cover	
Optional: subdominant natural characteristic	
	Shrubland, bushland, heathland
	Sparse vegetation and bare land
	Permanent snow and glaciers
	Open wetlands
	Water bodies
Composite land cover (no dominant land cover)	
Optional: subdominant characteristic	
	Built up and associated areas
	Agriculture
	Natural and semi-natural land cover

Assimilation of data and statistics for multiple dimensions – the grid approach

Assimilation of data and statistics for multiple dimensions – the grid approach
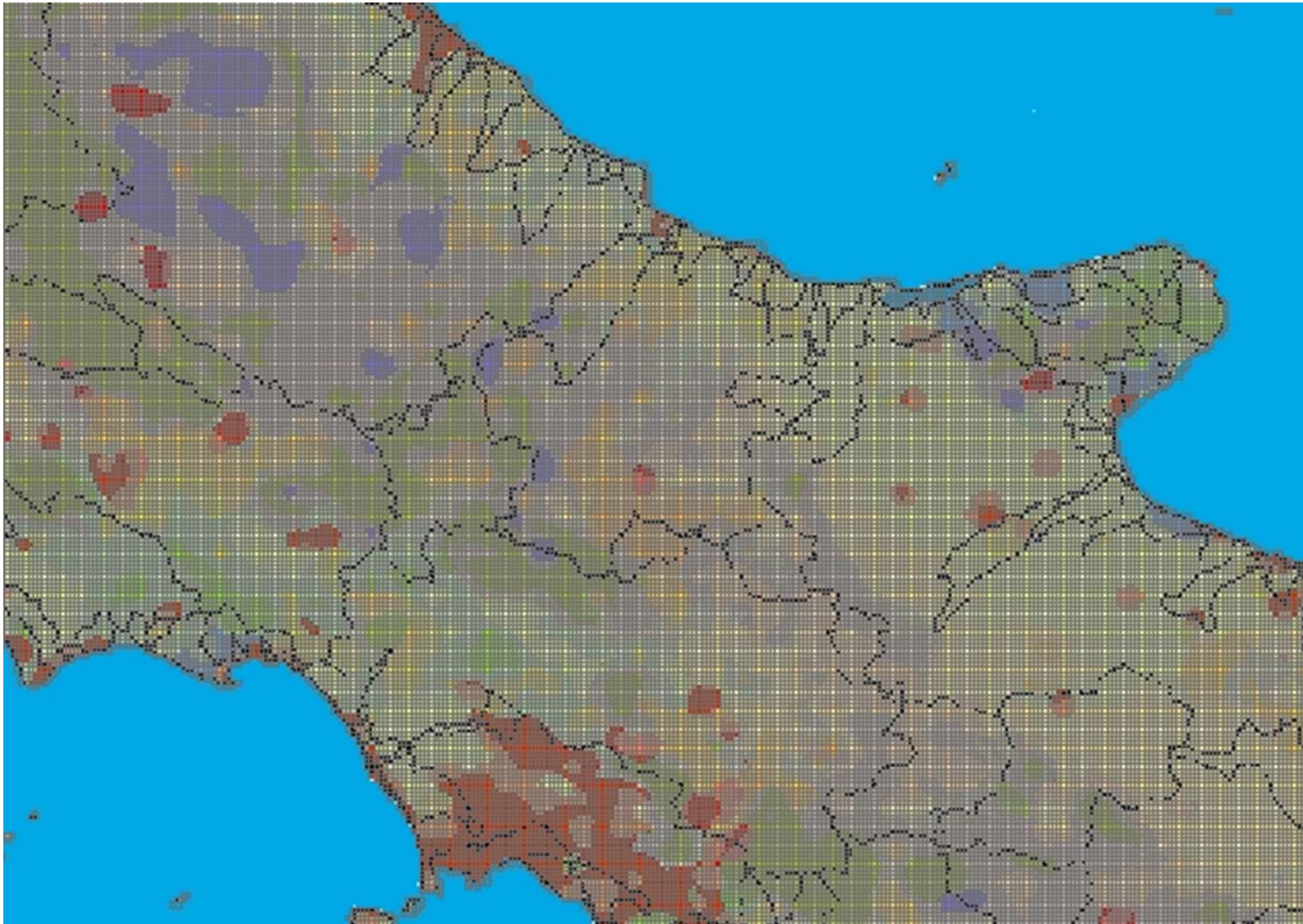
Discussion

- Definition and classification of SELU
  - Missing dimensions???
  - Climate/relief classes…

- Equivalent of SELU for the sea (developed by Andrus Meiner)
  - Coastal water
  - Territorial water
  - EEZ
  - Open sea, zonings?

- Equivalent of SELU for the atmosphere/climate system
  - Global system/ IPCC approach
  - Micro-climates