Master in Interdisciplinary Studies in Environmental, Economic and Social Sustainability

Analysis and Management of Natural Landscapes. 21/22.

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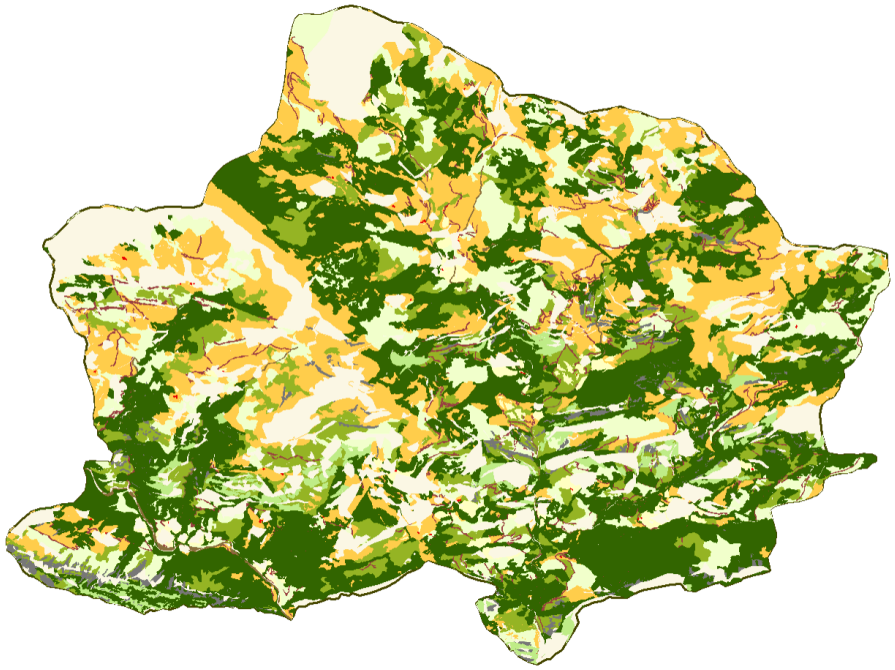
Class 1. Qualitative and quantitative approaches to landscape



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What is landscape?

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Land Use and Land Cover Change

Study case

The concept(s) of landscape

- In the 19th century, Alexander von Humboldt defined landscape as “the total character of a region” (Makhzoumi & Pungetti, 1999)
- Sauer (1925) defined landscape, at a regional level, *as a space defined by different associations of morphologies, both physical and cultural*.

- In 1950, Troll defined landscape as “*a part of Earth’s surface with a space unity and with a specific character, due to its external image, the joint action of its phenomena, which can be delimited by geographic and natural borders”* (Farina, 2006; Sànchez-Mateo, 2010).
- Green *et al*. (1996) consider landscape as a particular configuration of the topography, vegetation cover, land uses and the structure of the population that delimits certain coherence in natural and cultural processes and activities.

- **Landscape ecology** considers landscape as a delimited study unit, result of a complex interaction between special structures and the ecological processes that occur in it.

- Landscape is understood as a differentiated and measurable unit with different relevant ecological characteristics: it is a recognizable and repeated grouping of ecosystems and disturbance regimes (Forman and Godron, 1981).

The concept(s) of landscape

- All of the definitions discussed above agree on:
- Landscape is the result of the **interaction** between **biogeophysical** and **socioeconomic** factors.

- Landscapes can be approached as socioecological systems for their analysis and interpretation.

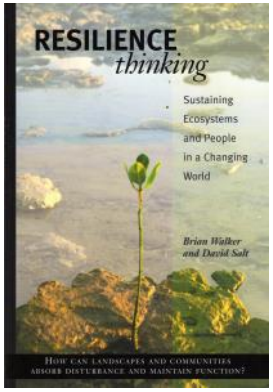
Socioecological systems

Socioecological systems

Division between **natural systems** and **cultural systems** is artificial and arbitrary (Berkes *et al.*, 2003)

To overcome this duality it was proposed to study socioecological systems from an integrated point of view

SOCIOECOLOGICAL SYSTEM



System defined as the result of the interaction between a social (human) component and an ecological (biophysic) component which determines a complex system in continous evolution according to changes.

Socioecological systems can be defined at different scales, from local to global, delimited by spatial or functional limits.

Socioecological systems

ANTHROPOGENIC VISION

Human as center

- Economy as the most important system.
- Nature as resources and ecosystem services provider.
- Nature as waste and pollution sink.
- Sustainability only important regarding to sustainability of human society

BIOCENTRIC VISION

Nature as center

- Human species is just another component of the system.
- Nature considered harmonic by definition.
- Modern and industrial society is responsible of all environmental problems

Reductionist visions!!! They don't match with postnormal science systemic vision and its approaches

Qualitative approach to landscape

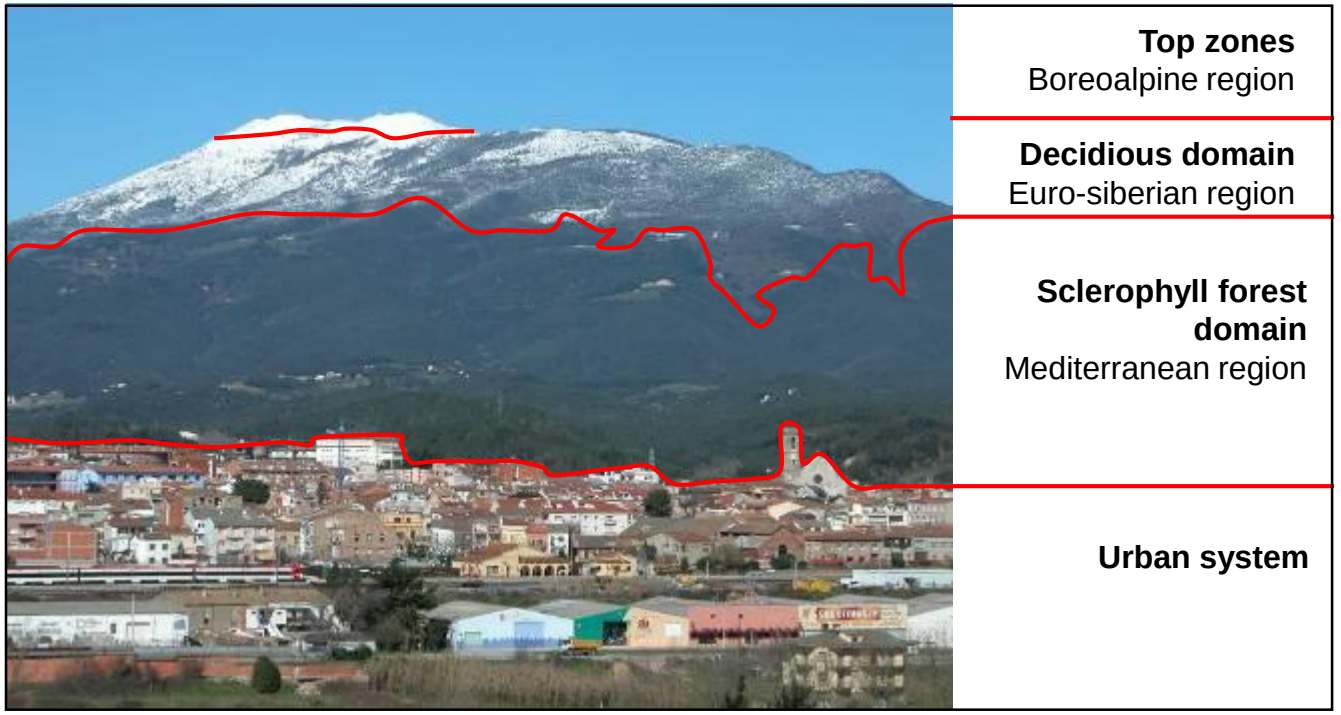
This methodology has been experimented in the National Park and Biosphere Reserve of Montseny aiming to interpret the three biogeographic regions of the massif: Mediterranean, Euro-siberian and Boreoalpine. Also has been tested in Zat Valley (Morocco) to assess the landscape in a Geopark proposal.

The analysis process of this system is based on the following stages:

1. **Chromatic assessment**
2. **Approach and description of the present elements**
3. **Confection of the transect of each socioecological system**

Chromatic assessment | Approach and description of the present elements | Confection of the transect of each socioecological system

Situated at a certain distance, the different biogeographic regions will be identified through the color changes of the vegetation stages. Throughout the year, this chromatic assessment will vary and the contrast will become more obvious in autumn and winter periods.



Chromatic assessment | **Approach and description of the present elements** | Confection of the transect of each socioecological system

In this stage, a visit to each of the biogeographic regions will be done in order to describe the environment and analyze each region profoundly. Each one will be approached from the biodiversity point of view (vegetation and fauna), through the identification of the species, as well as from the social perspective.

The social elements will be considered according to their relevance and classified according the following types:

Tangible elements: Those who express physically (material). Examples: fountains, irrigation canals, livestock buildings….

Intangible elements: Non-material values related to legends, beliefs and view of the world.

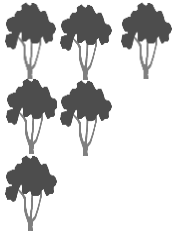
Practices: activities of appropriation and management of the environment (logging, agricultural practices, grazing, collection of plants, mushrooms, wild fruits…).

Chromatic assessment | Approach and description of the present elements | **Confection of the transect of each socioecological system**

The aim is to represent graphically and easily the previously analyzed elements depending on the following code:

- **Wooded stratum**
  - **A** Dominant specie
  - **B** Second dominant specie
  - **C** Third dominant specie
- **Shrub stratum**
  - **A_1** Dominant specie
  - **B_1** Second dominant specie
  - **C_1** Third dominant specie
- **Herbaceous stratum**
  - **a** Dominant specie
  - **b** Second dominant specie
  - **c** Third dominant specie
- **Liana stratum**
  - **a_1** Dominant specie
  - **b_1** Second dominant specie
  - **c_1** Third dominant specie

- **Abundance** (number of represented siluettes)



Dominant specie

Second dominant specie

Third dominant specie

- **Fauna symbols**

Reptiles

Amphibians

Fishes

Birds

Mammals

- **Social elements**

T — Tangible elements

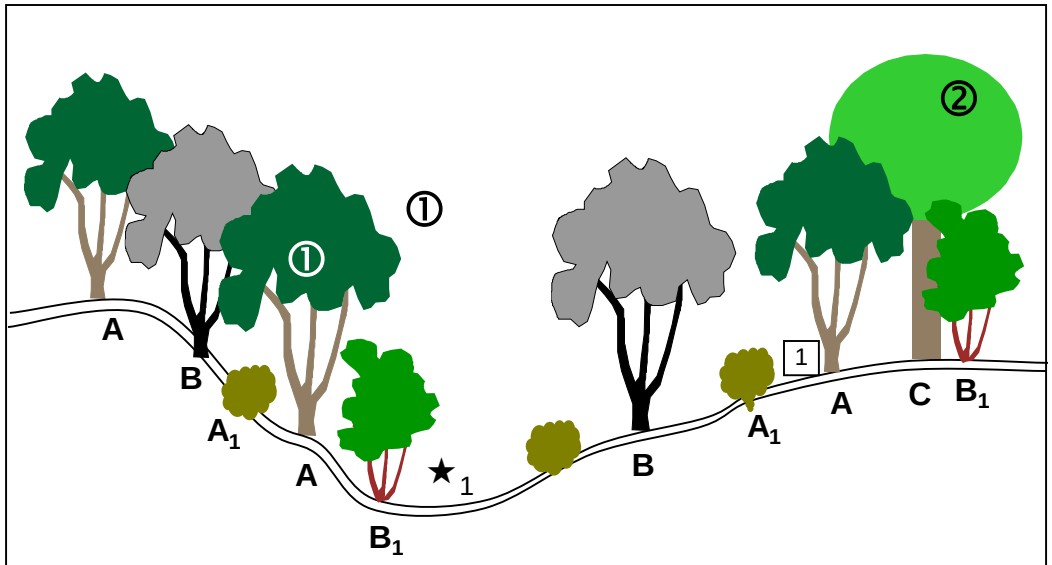
I — Intangible elements

P — Practices

Chromatic assessment

Approach and description of the present elements

Confection of the transect of each socioeconòmical system



VEGETATION
Wooded stratum
A Holm Oak (*Quercus ilex*)
B Cork oak (*Quercus suber*)
C Stone pine (*Pinus pinea*)

Shrub stratum
A_1 Tree heath (*Erica arborea*)
B_1 Strawberry tree (*Arbutus unedo*)

FAUNA
Birds
① Chaffinch (*Fringilla coelebs*)
② Wood Pigeon (*Columba palumbus*)

Mammals
[1] Wild boar (*Sus scrofa*)

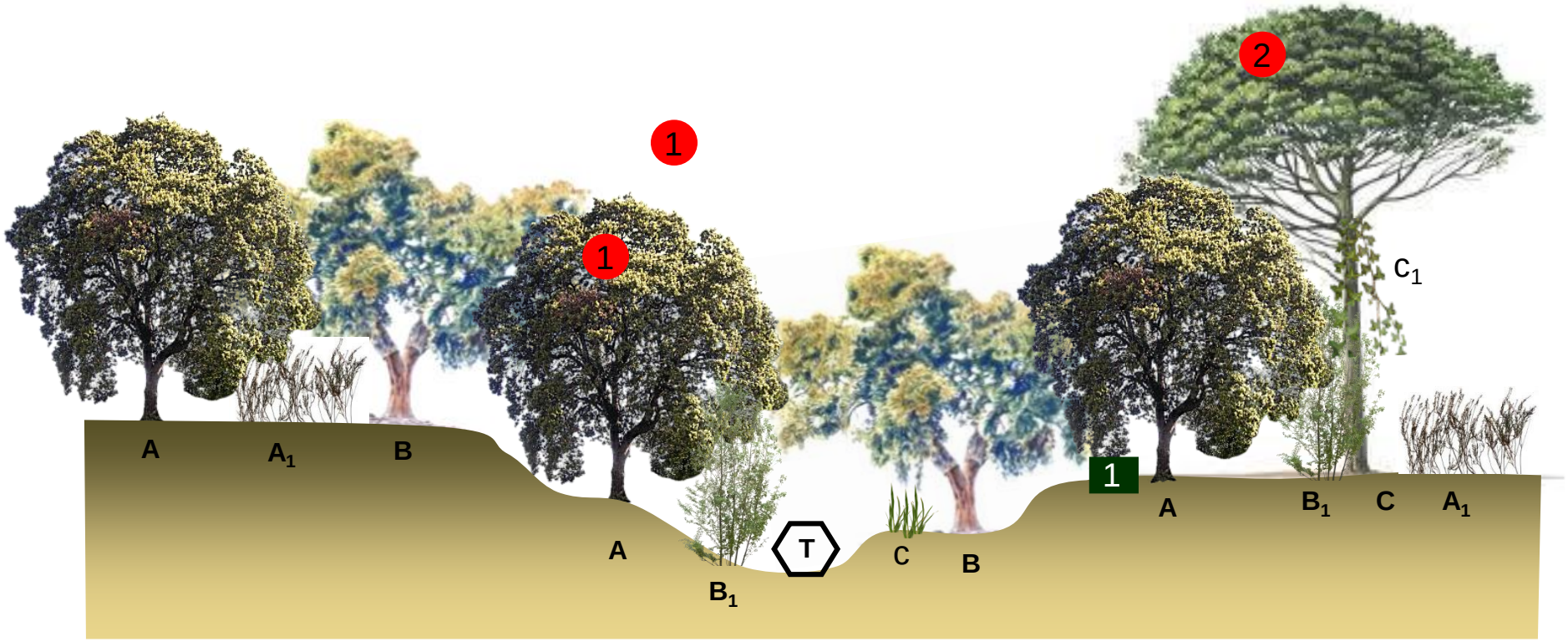
SOCIAL (Tangible)
★$_1$ Carbon emplacement

Non-urban socioecology

Chromatic assessment

Approach and description of the present elements

Confection of the transect of each biotope



VEGETATION

Wooded stratum

A Holm Oak (*Quercus ilex*)
B Cork oak (*Quercus suber*)
C Stone pine (*Pinus pinea*)

Shrub stratum

A_1 Tree heath (*Erica arborea*)
B_1 Strawberry tree (*Arbutus unedo*)

Herbaceous stratum

c false brome (*Brachypodium* sp.)

Liana stratum

c_1 Heura (*Hedera helix*)

FAUNA

Birds

1 Chaffinch (*Fringilla coelebs*)
2 Common Wood Pigeon (*Columba palumbus*)

Mammals

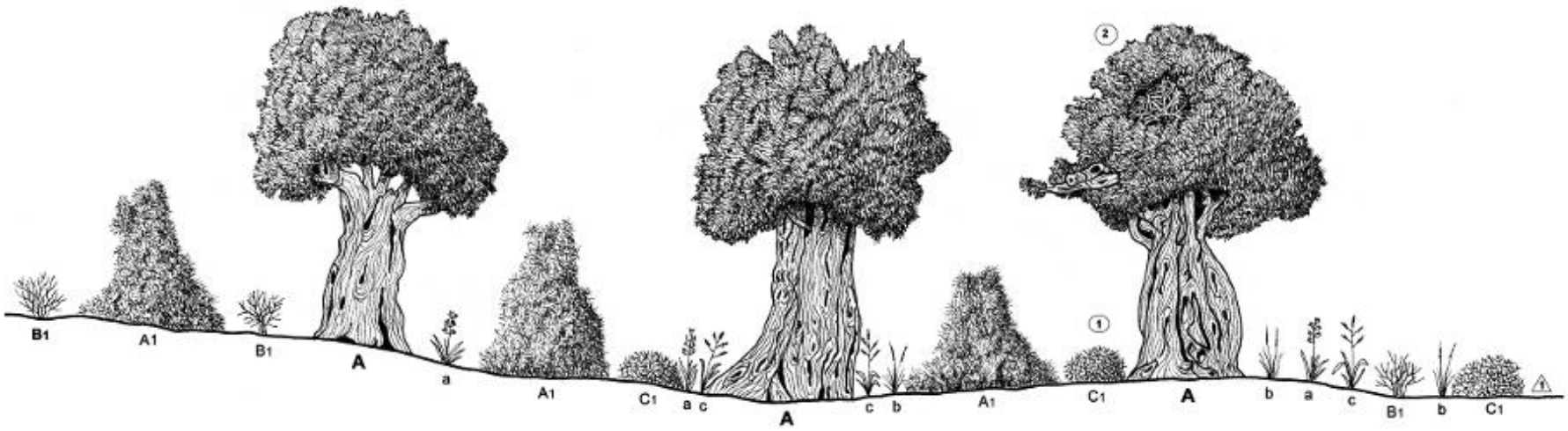
1 Wild boar (*Sus scrofa*)

SOCIAL

T Carbon emplacement

Chromatic assessment: a study case in Zat valley (High Atlas, Morocco)

Chromatic assessment: a study case in Zat valley (High Atlas, Morocco)



Wooded stratum	
A	*Juniperus thurifera*
Shrub stratum	
A_1	*Juniperus thurifera*
B_1	*Juniperus oxycedrus*
C_1	*Ephedra fragilis*
D_1	*Bupleurum spinosum*
Herbaceous stratum	
a	*Asphodelus ramosus*
b	*Stipa tenacissima*
c	*Dactylis glomerata*

Reptiles	
1	*Quedenfeldtia trachyblepharus*
2	*Podarcis vaucheri*
3	*Scelarcis perspicillata*
Birds	
①	*Oenanthe seebohmi*
②	*Lanius senator*
③	*Phoenicurus moussieri*
Social elements	
T1	Singular *Juniperus thurifera* trees
P1	Cattle pasture

Land Use and Land Cover Change

Land use and land cover change

Human Domination of Earth's Ecosystems
Peter M. Vitousek *et al.*
Science **277**, 494 (1997);
DOI: 10.1126/science.277.5325.494

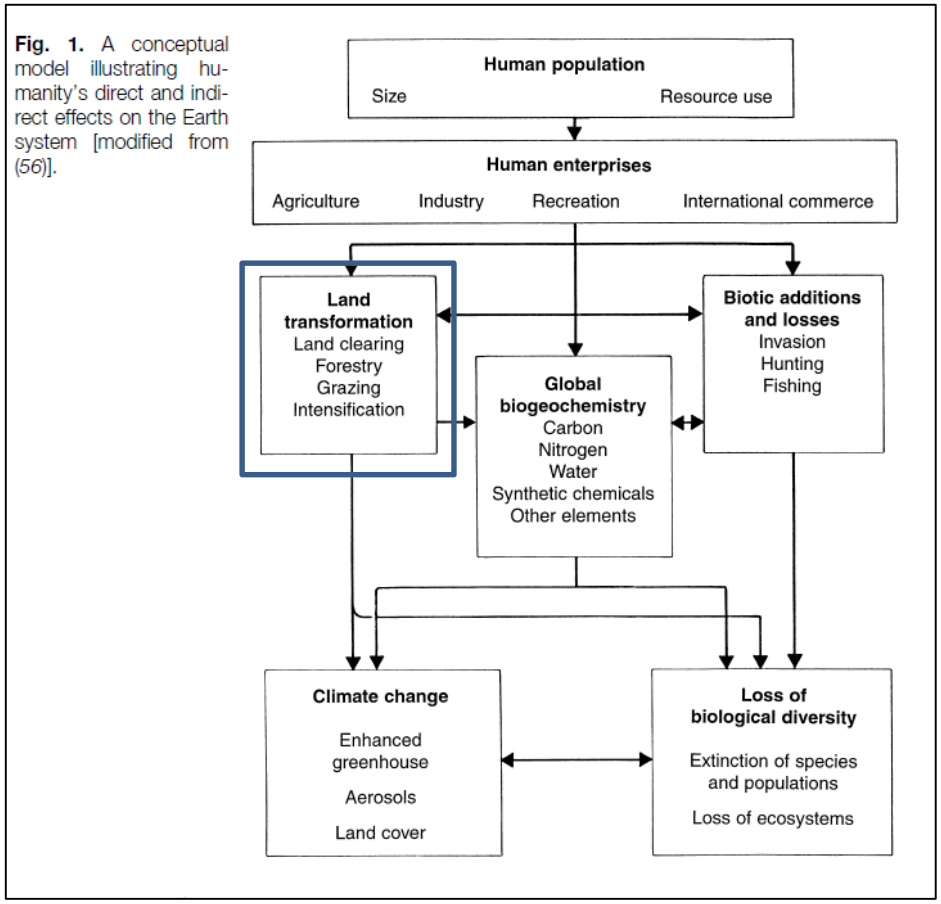


Fig. 1. A conceptual model illustrating humanity's direct and indirect effects on the Earth system [modified from (*56*)].

Land use and land cover change is a central process in global change. Due to this reason is one of the main research fields in Environmental Science.

Land use and land cover change

Human Domination of Earth's Ecosystems
Peter M. Vitousek *et al.*
Science **277**, 494 (1997);
DOI: 10.1126/science.277.5325.494

Land use and land cover change alter the structure and functionality of ecosystems and landscapes. Potential impacts:

- Loss of biodiversity (including agricultural biodiversity).
- Alteration of biogeochemical cycles.
- Increase in the emissions of greenhouse effect gases.
- Reduction in soil quality and functionality.
- Change in vegetation.

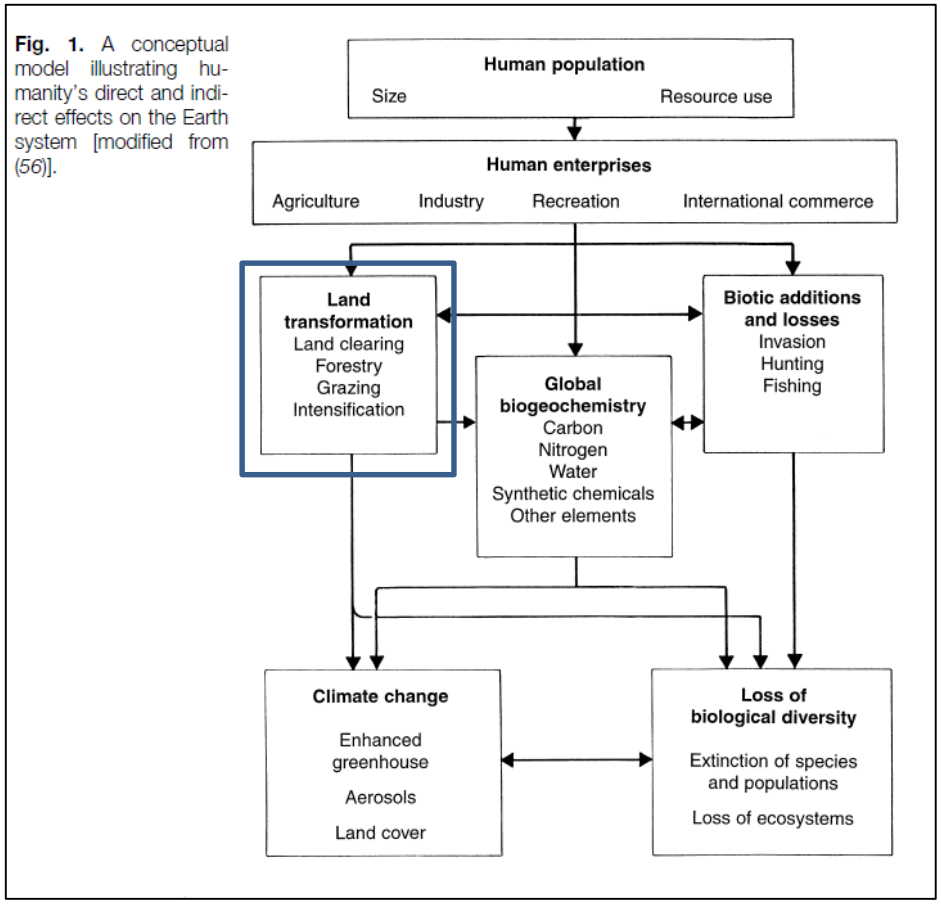


Fig. 1. A conceptual model illustrating humanity's direct and indirect effects on the Earth system [modified from (*56*)].

Land use and land cover change

Some highlights to understand the magnitude of land use land cover change:

• Estimations that 39-50 % of global land cover (excluding land covered by glaciers) has been modified by human activities (Vitousek *et al.*, 1997).

•Primary sector of the economy have been historically the main driver of land use/land cover change.

•Nowadays a third of global land is used for crops and pasture lands (FAO, 2004).

•It is estimated that during the last 300 years, under the influence of population growth:

- •Area occupied by crops **x5.**
- •Area occupied by pasture lands **x3-6.**
- •Replacing mainly forest land (Lambin *et al.*, 2006).

•During last decades this growth concentrates mainly in depeloping countries.

•Western Europe: inverse process, abandonment of agriculture.

Land use and land cover change

Study of land use and land cover change:
LUCC program (Land Use and Cover Change). Created in 1993. Included in the International Geosphere-Biosphere program (IGBP).
The program has been a conceptual and methological reference for the development of a "land use science" (Lambin *et al.*, 2006), becoming an important contribution for the study of global change.

International Geosphere-Biosphere program (IGBP):
http://www.igbp.net/globalchange.4.d8b4c3c12bf3be638a80001026.html

Land use and land cover change

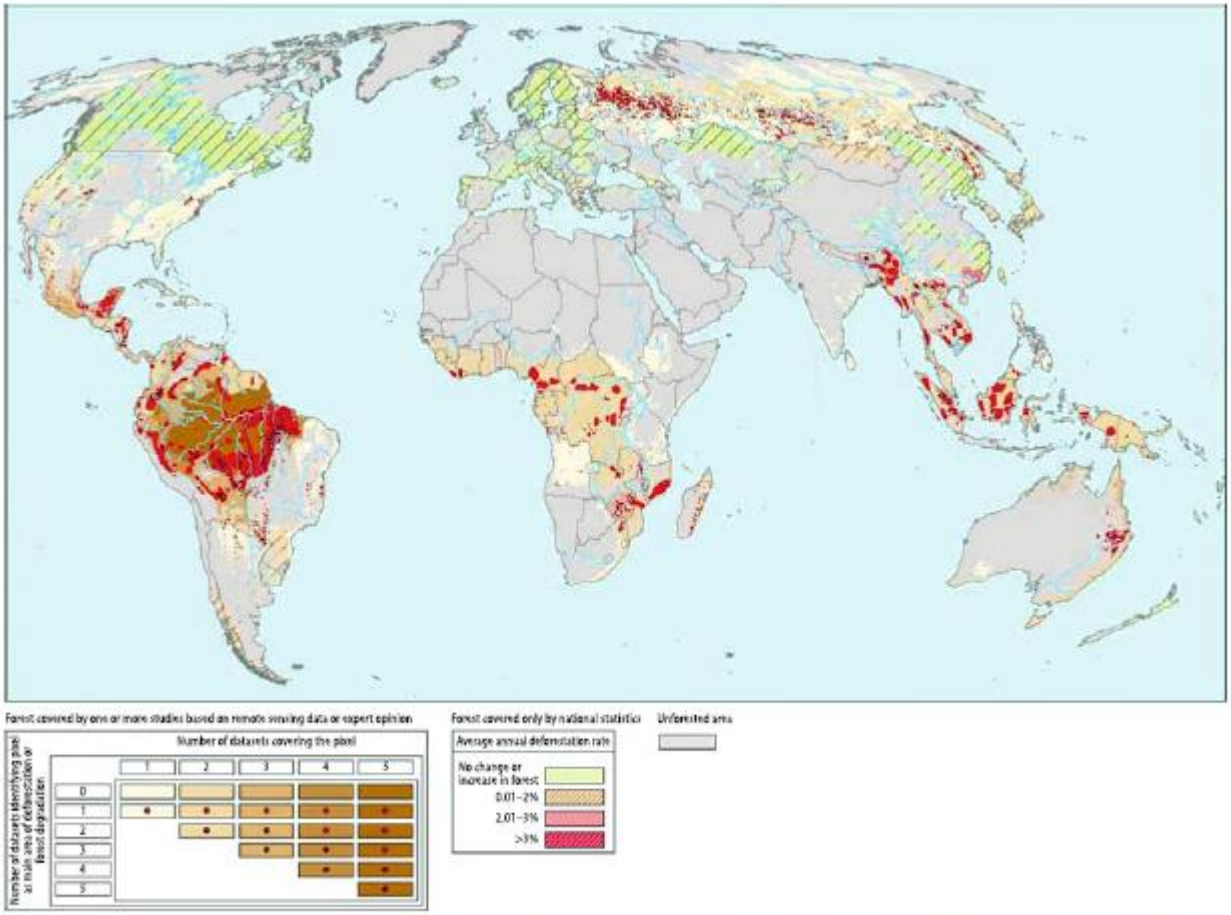
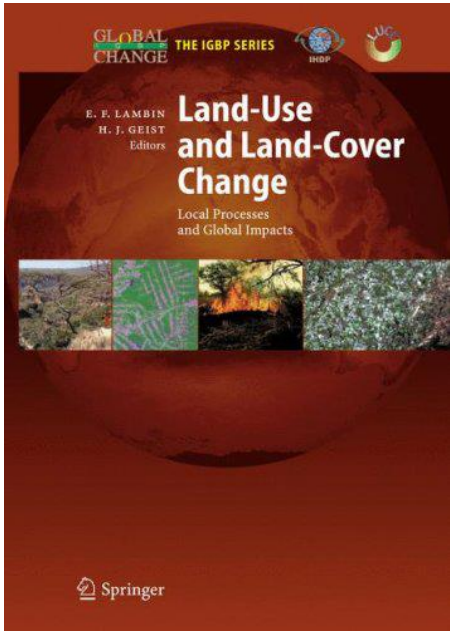


Fig. 2.4a. Results from the LUCC-MA Rapid Land-Cover Change Assessment showing major areas of forest-cover change in the world between 1980 and 2000

Lambin *et al.*, 2006



Land use and land cover change. Driving forces of deforestation

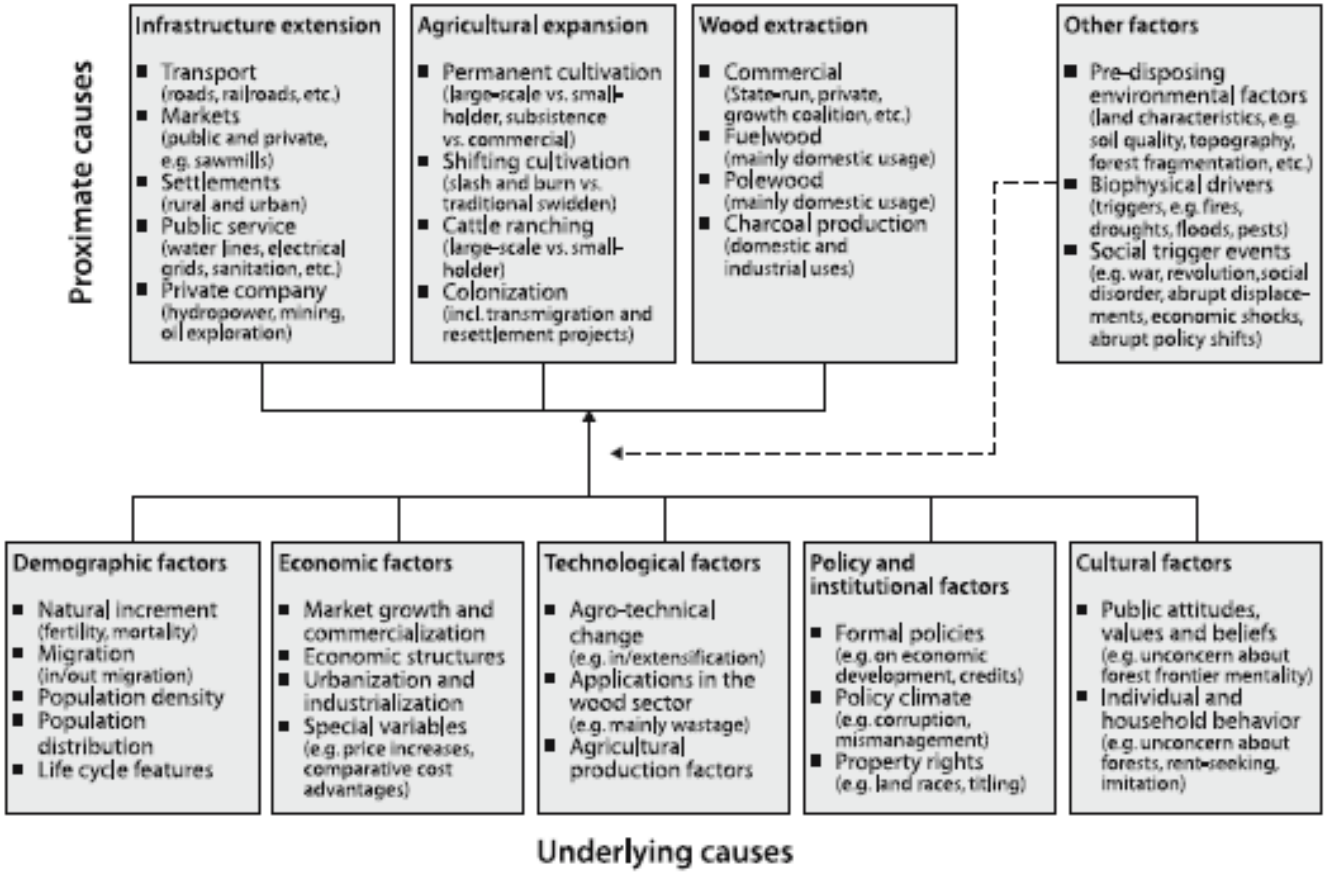


Fig. 3.2. Proximate causes and underlying driving forces of forest decline. *Source:* Geist and Lambin (2002), p. 144

Lambin *et al.*, 2006

Land use and land cover change

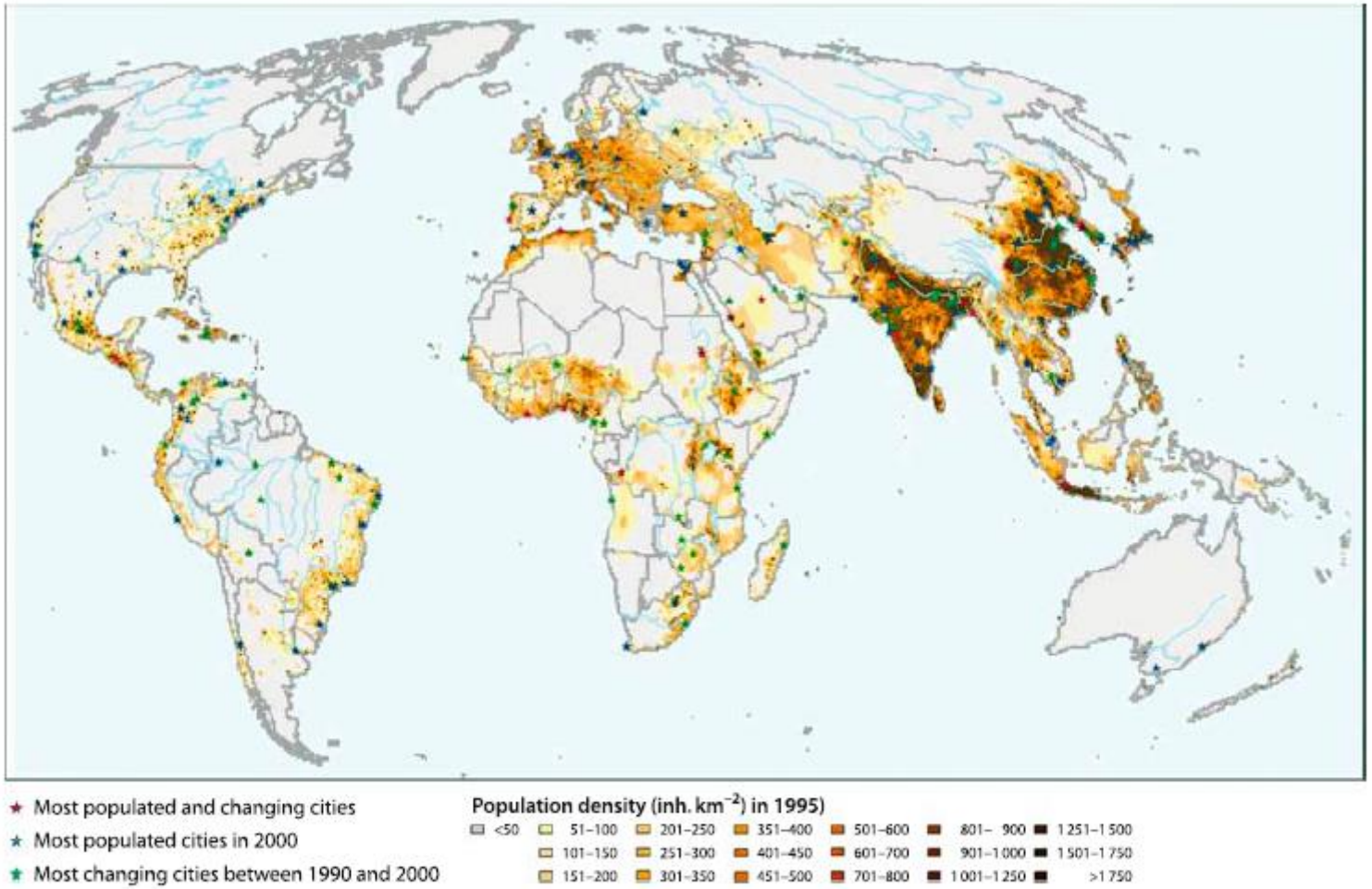


Fig. 2.4c. Results from the LUCC-MA Rapid Land-Cover Change Assessment showing population density in 1995 and most populated and changing cities over 750 000 inhabitants between 1980 and 2000

Urbanization

Lambin *et al.*, 2006

Land use and land cover change

Distinction between land use and land cover:

Land cover: refers to the biophysical conditions of land surface.

Land use: refers to the human transformation of land surface and the purposes or intentions behind it.

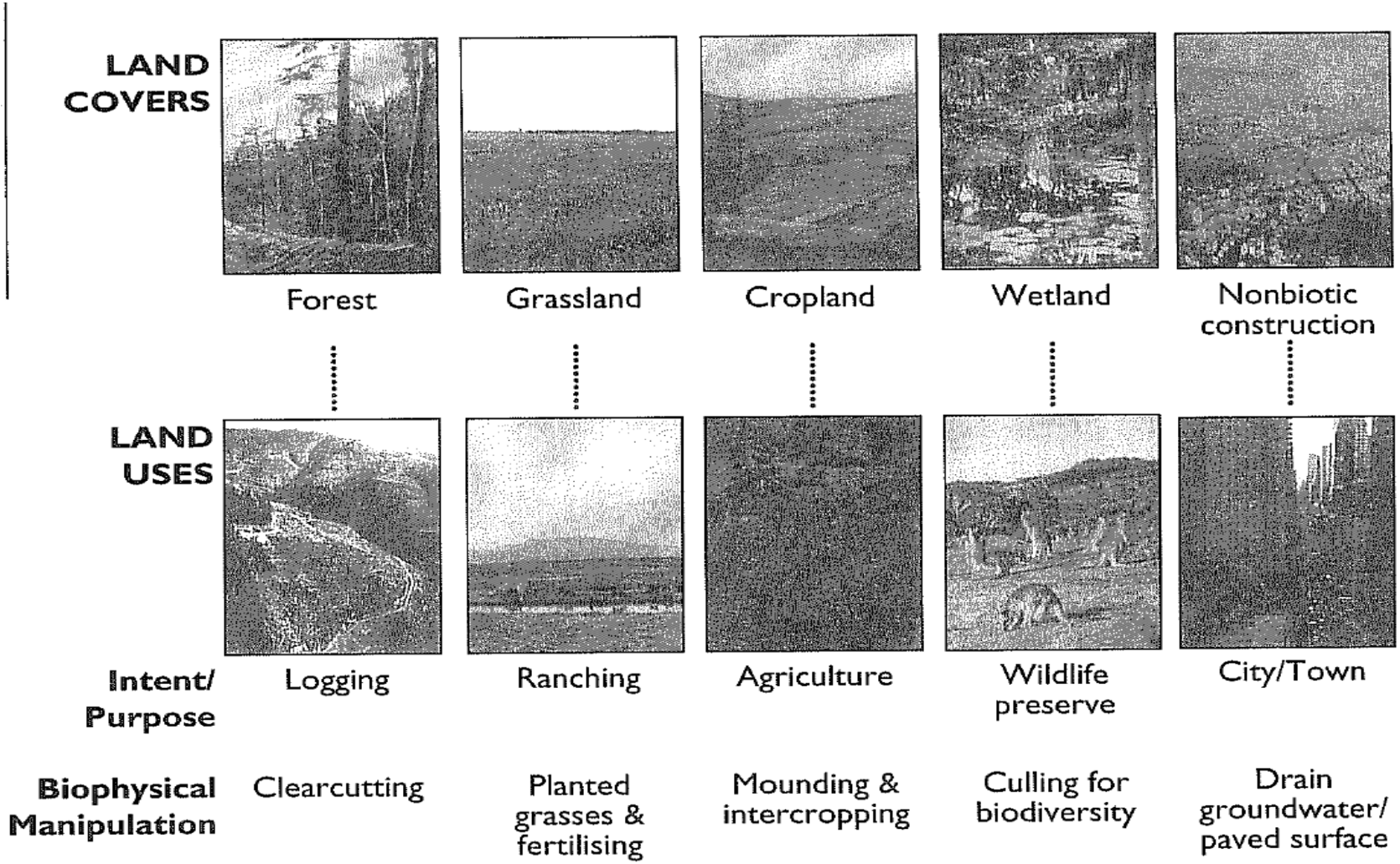
Land uses affect land cover in two different ways:
•Land uses can transform land cover substituting a land cover with another. Deforestation of a forest to transform it in crops.
•Land uses can modifiy the characteristics of land cover without substituting it.

•Land use and land cover are expressions of transformations experienced by socioecological systems.

Land use and land cover change

Land cover: refers to the biophysical conditions of land surface.

Land use: refers to the human transformation of land surface and the purposes or intentions behind it.



Land use and land cover change

The **complexity** of land use and land cover change processes, as well as its **cumulative** nature, demands its study at **regional and local scales**, to contribute to identify properly its causes and effects (Turner et al, 1994).

Since its proposal at the beginning of the 1990s, the LUCC methodology has been successfully applied in multiple study areas all over the world (Lambin *et al.*, 2006).

Equally, it has been successfully applied to Mediterranean mountain areas

Land use and land cover change

Successfully applied to Mediterranean mountain areas:

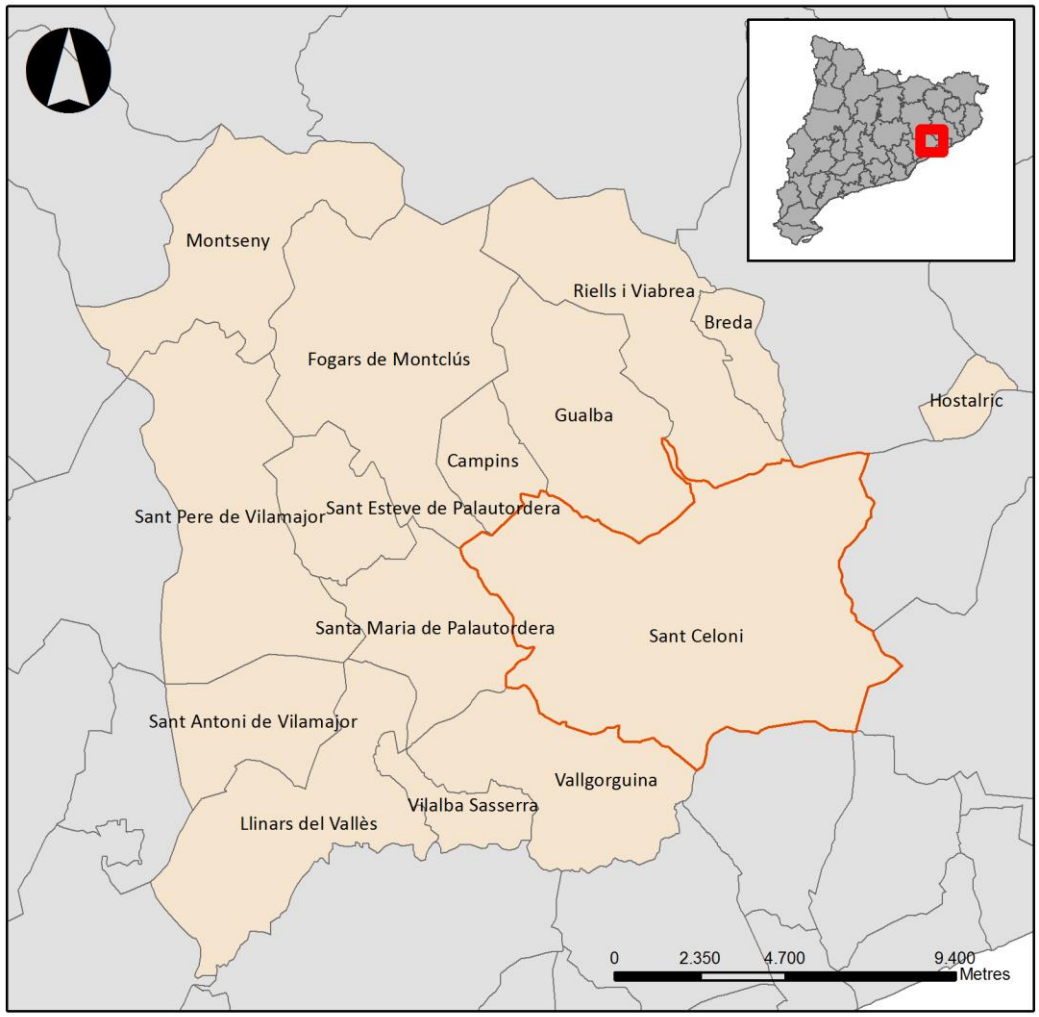
- Bielsa, I.; Pons, X. i Bunce, B. (2005): *Agricultural Abandonment in the North Eastern Iberian Peninsula*. *The Use of Basic Landscape Metrics to Support Planning*. Journal of Environmental Planning and Management 48 (1): 85–102.
- Cohen, M.; Varga, D.; Vila Subirós, J.; Barrasaud, E. (2011): *A multi-scale and multi-disciplinary approach to monitor landscape dynamics: a case study in Catalan pre-Pyrenees, Spain*. Geographical Journal 177: 79-91.
- Lasanta-Martínez; T.; Vicente-Serrano, S. M.; Cuadrat-Prats, S. M. (2005): *Mountain Mediterranean landscape evolution caused by the abandonment of traditional primary activities: a study of the Spanish Central Pyrenees.* Applied Geography 25: 47–65.
- Métailié, J.P.; i Paegelow, M. (2004*): Land abandonment and the spreading of the forest in the Eastern french Pyrenées in the nineteenth to twentieth centúries*. In: S. Mazzoleni; G. Di Pasquale; M. Mulligan; P. Di Martino; F. Rego (eds.): *Recent dynamics of the mediterranean vegetation and landscape*. Wiley.
- Mottet, A.; Ladet, S.; Coqué, N. i Gibon A. (2005): *Agricultural land-use change and its drivers in mountain landscapes: A case study in the Pyrenees*. Agriculture, Ecosystems and Environment 114: 296–310.
- Nogués-Bravo, D. (2006): *Assessing the effect of environmental and anthropogenic factors on land-cover diversity in a Mediterranean mountain environament*. Area 38(4): 432–444.
- Serra P., Saurí D., Pons X. (2008): *Land-cover and land-use in a Mediterranean landscape: a spatial analysis of driving forces integrating biophysical and human factors*. Applied Geography, 28: 189-209.
- Sluiter, R. i de Jong, S. M. (2007): Spatial patterns of Mediterranean land abandonament and related land cover transitions. Landscape Ecology 22:559–576.
- Taillefumier, F.; Piegay, H. (2002): *Contemporary land use changes in prealpine Mediterranean mountains: a multivariate GIS-based approach applied to two municipalities in the Southern French Prealps*. Catena 51: 267–296.

Study Case

Global Change Manifestations in Mediterranean mountain areas:
a study case in Baix Montseny

Study area

El Baix Montseny



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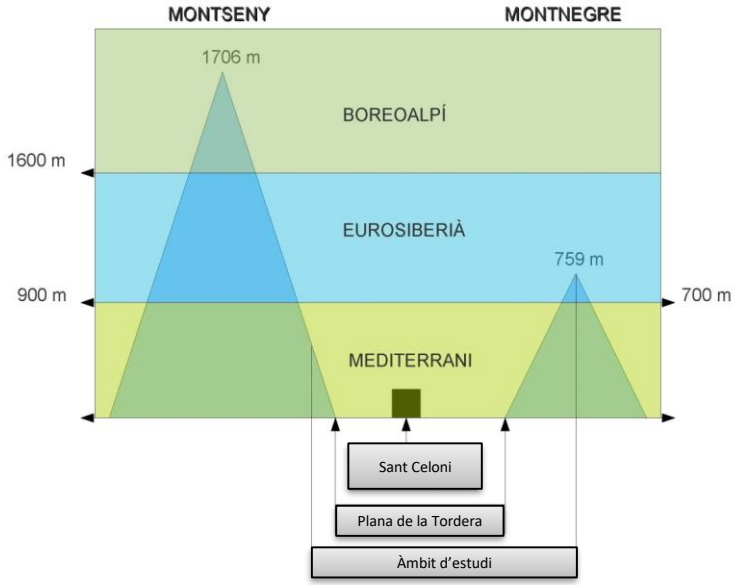
15 municipalities.
Area: 329,3 km^2.
Population: 60.802 habitants (2010).
Population density: 184,6 hab./km^2.



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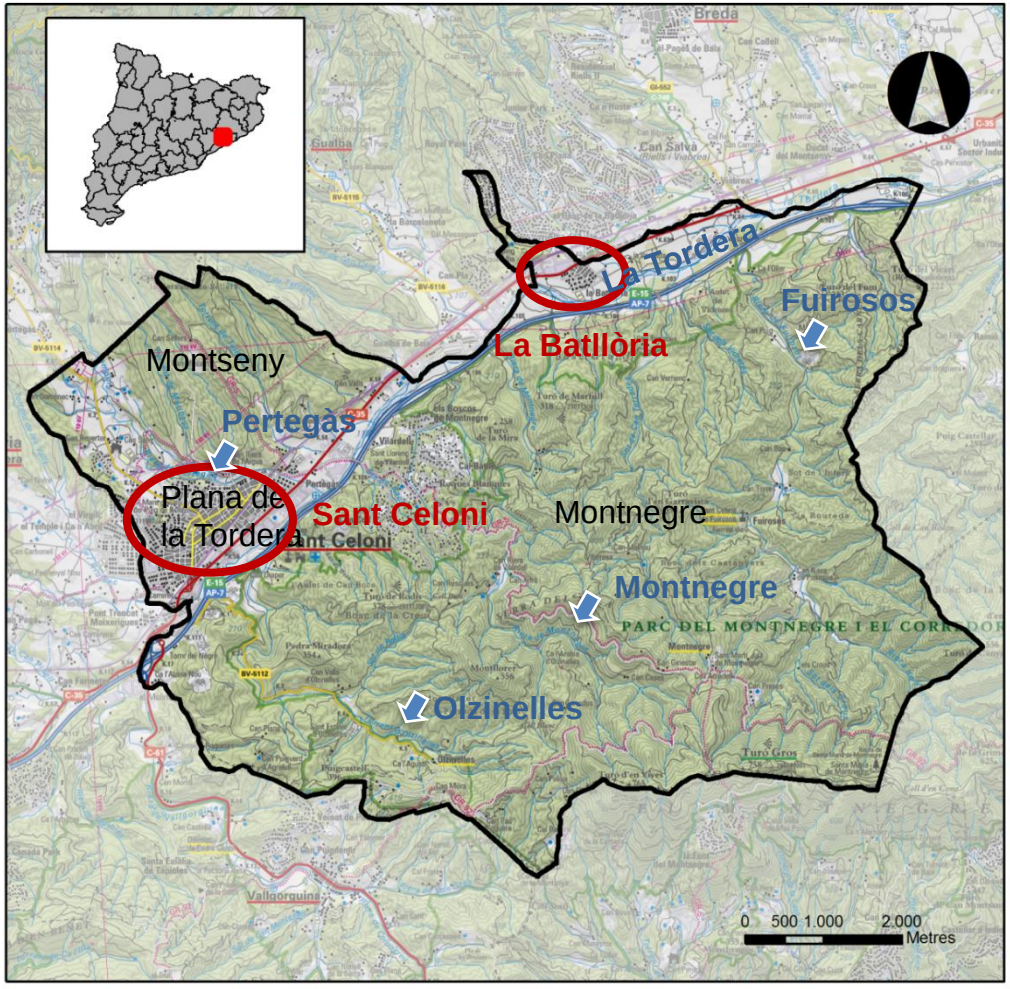
Three biogeographic regions.
Elevated forest area.
Historical predominance of forestry activities

Study area

Municipality of Sant Celoni



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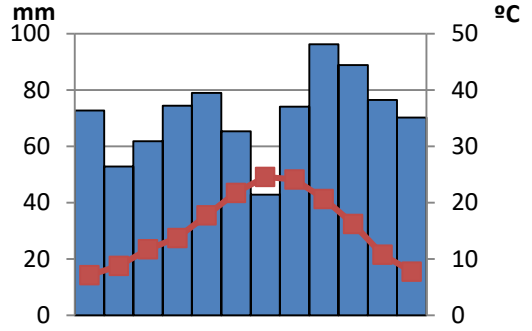
Area: 65,44 km^2.
Population: 16.860 habitants (2010).
Population density: 259,2 hab./km^2.

Mountainous area:

- Montnegre.
- Montseny.
- Tordera plain.

Annual mean precipitation: 750-850 mm
Annual mean temperature: 16ºC.



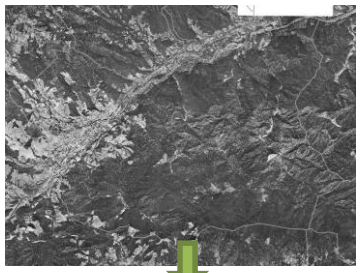
Methodology

GIS Software: ArcGIS, Miramon...

BASE CARTOGRÀFICA

MAPES

Ortophotomap year 1956
(Diputació de Barcelona)

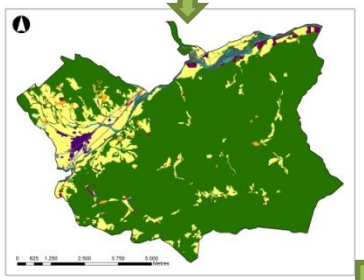


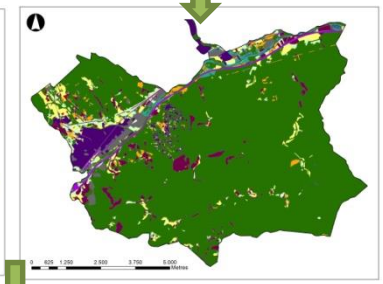
Catalonia Land Cover Map
(3rd edition, CREAF 2006)

Field work

Ortophotomap year 2010
(Institut Cartogràfic de Catalunya)

Land use and land cover map 1956





Land use and land cover map
2010

Analysis of land use and land cover change 1956-2010

Land use and land cover change. Comparative between 1852-63 (amillaraments), 1956 and 2010

Landscape indices calculation

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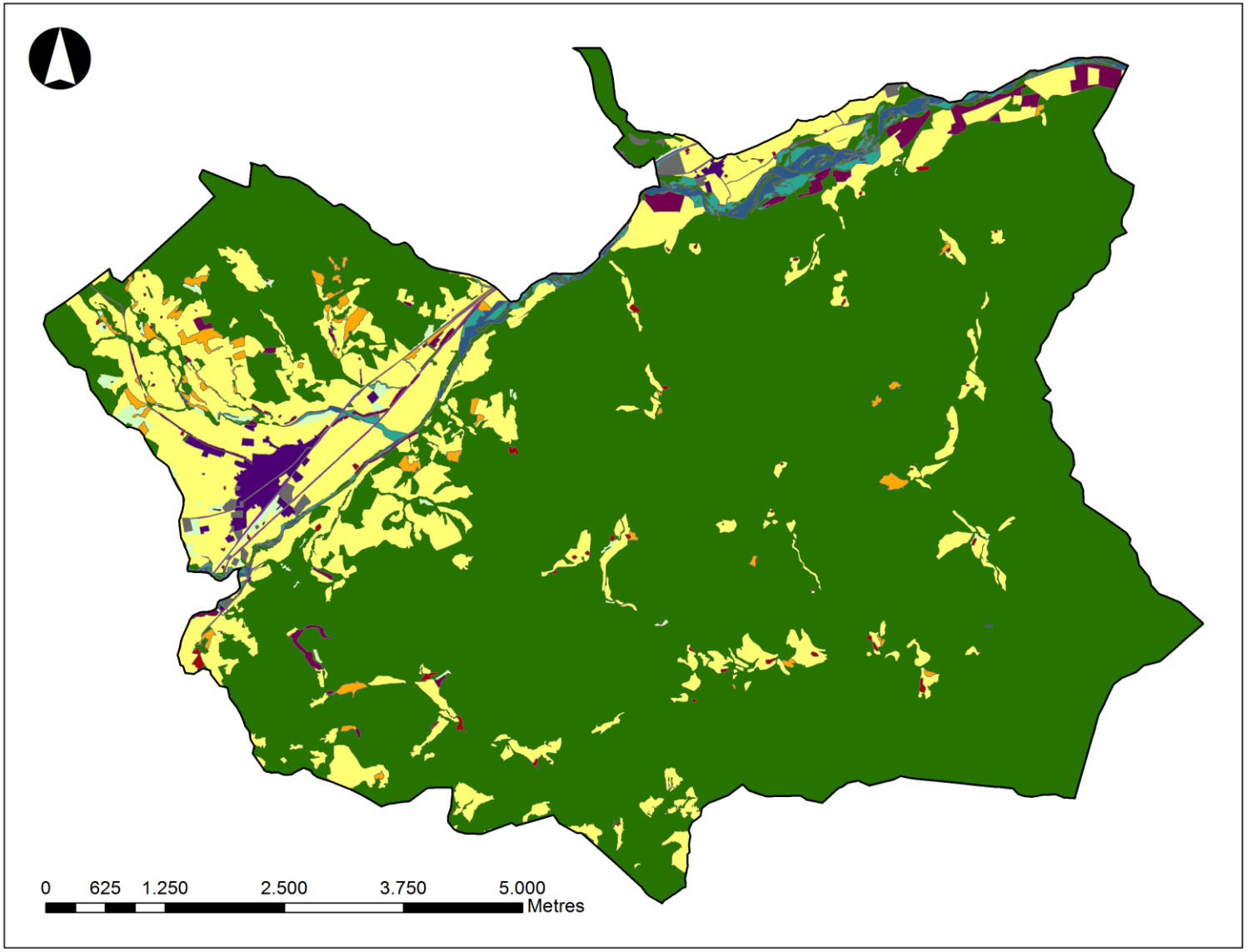
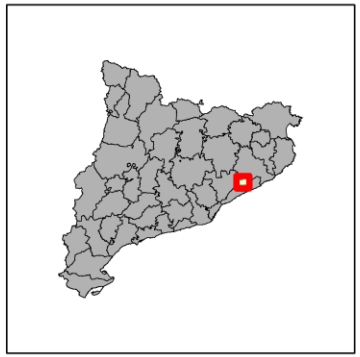
Land use and cover map.1956





Lleg

Class
Forest
Crops
Uncultivated
Grassland
Industrial
Riverbed and surface water
Scrubland
Plantation
Scattered population (farmhouses)
Urban
Communication networks (roads, trai

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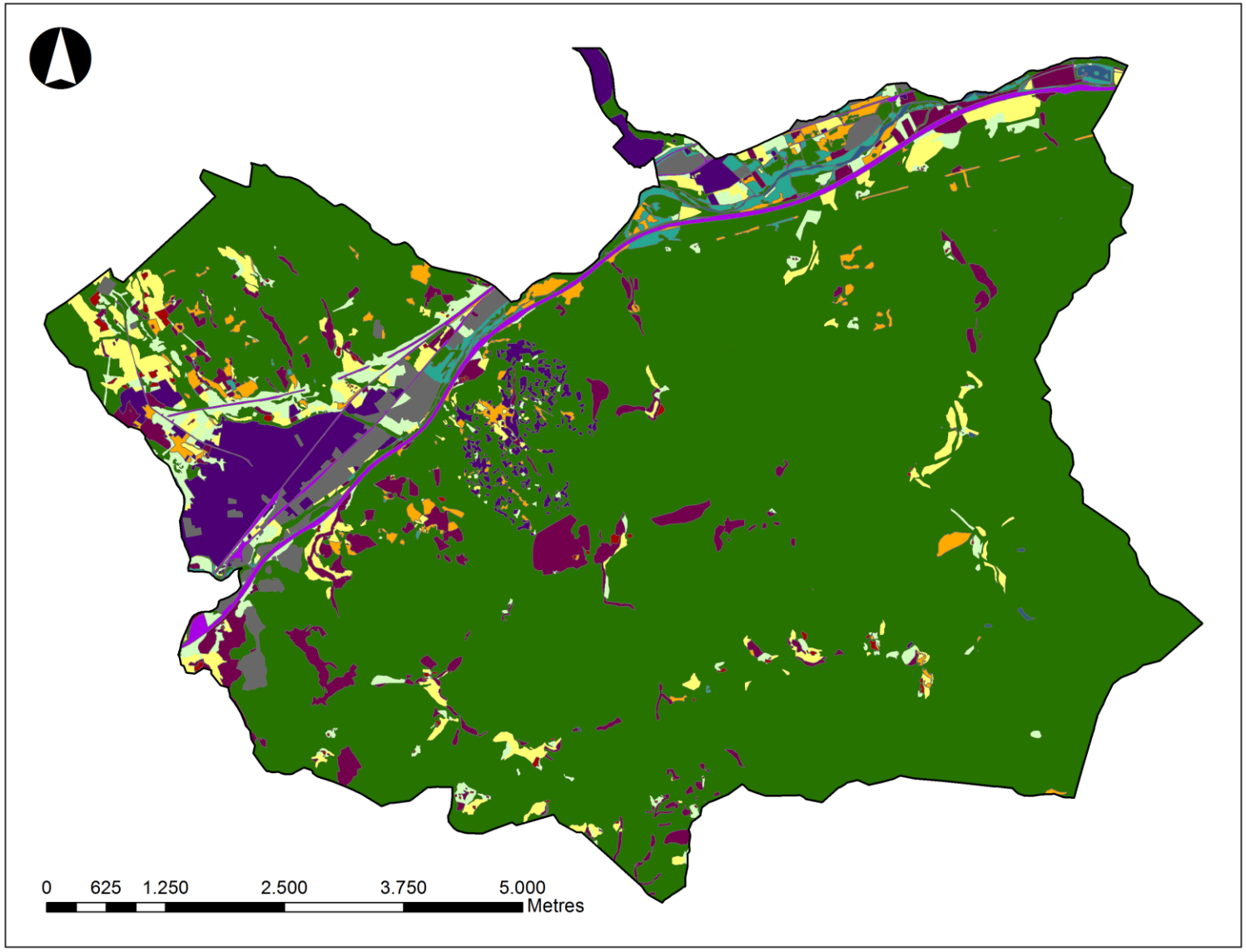
Land use and cover map. 2010



Lleg

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Results

Land use and cover change 1956-2010

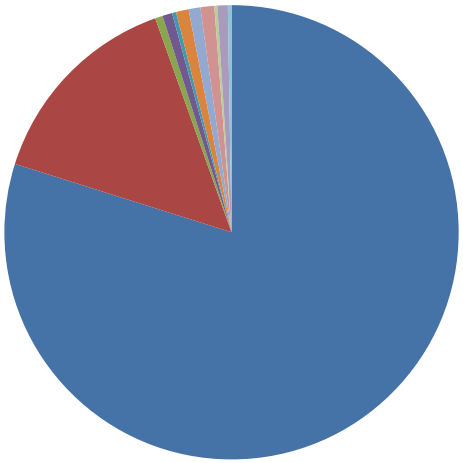
Dominant and stable cover

Important regression

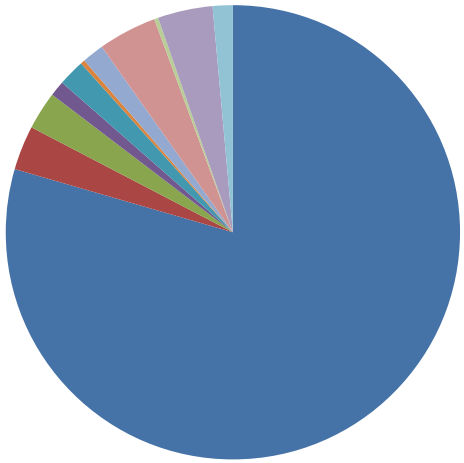
Abandonment of 78,50 % of crops
Since 1956

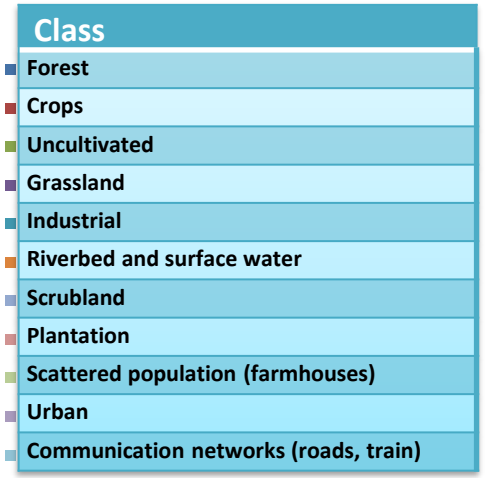
Category	Difference1956-2010 Area (ha)	Percentage (%)	Percentage 1956 (%)	
Forest	-24,56	-0,38	-0,47	=
Crops	-756,13	-11,52	-78,50	↓
Uncultivated	142,65	2,17	403,87	↑
Grassland	26,15	0,40	57,21	↑
Industry	105,17	1,60	553,94	↑
Riverbed and surface water	-38,73	-0,59	-65,90	↓
Scrubland	47,30	0,72	86,02	↑
Plantations	208,83	3,18	323,88	↑
Scattered population (farmhouses)	4,69	0,07	33,37	↑
Urban	208,28	3,17	430,27	↑
Communication networks (roads, train)	76,75	1,17	450,77	↑
Total	0,39	0,00	0,01	

1956



2010





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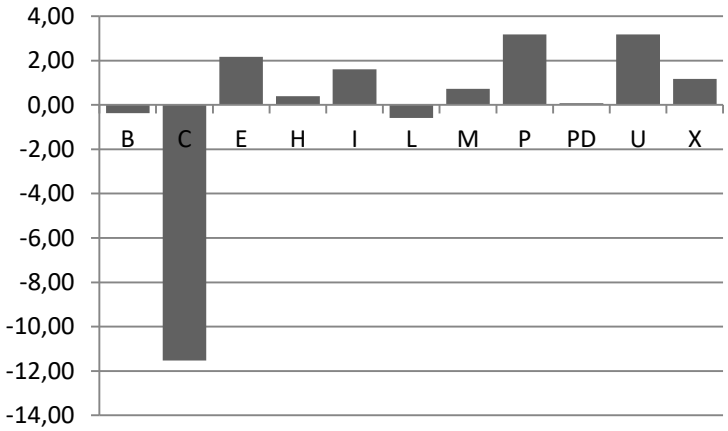
Results

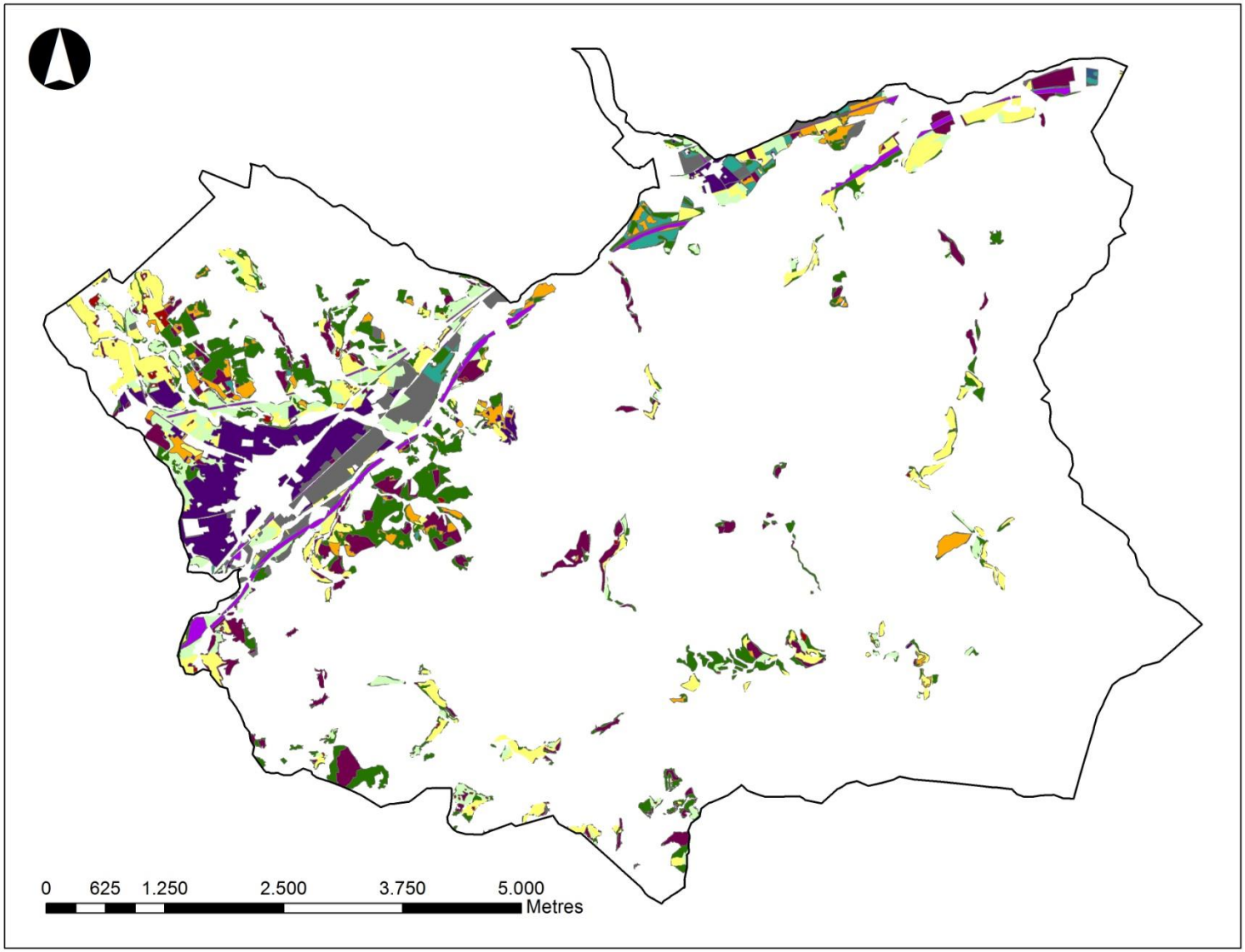
Quantitative analysis of LUCC. 1956-2010.

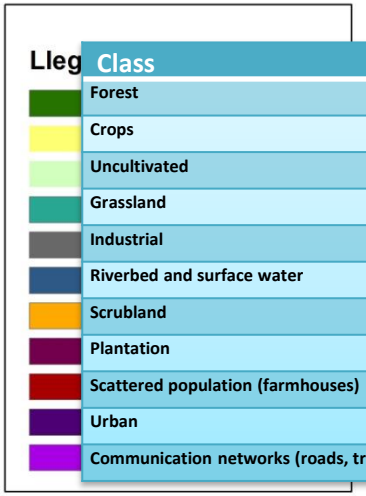
	1956		2010		Difference 1956-2010		
Categoria	**Area (ha)**	**Percentage (%)**	**Area (ha)**	**Percentage (%)**	**Area (ha)**	**Percentage (%)**	**Percentage (%) 1956**
Forest	5240,24	79,87	5215,67	79,49	-24,56	-0,38	-0,47
Crops	963,28	14,68	207,15	3,16	-756,13	-11,52	-78,50
Uncultivated	35,32	0,54	177,97	2,71	142,65	2,17	403,87
Grassland	45,71	0,70	71,86	1,10	26,15	0,40	57,21
Industrial	18,98	0,29	124,15	1,89	105,17	1,60	553,94
Riverbed and surface water	58,77	0,90	20,04	0,31	-38,73	-0,59	-65,90
Scrubland	54,98	0,84	102,28	1,56	47,30	0,72	86,02
Plantation	64,48	0,98	273,31	4,17	208,83	3,18	323,88
Scattered population (farmhouses)	14,04	0,21	18,73	0,29	4,69	0,07	33,37
Urban	48,41	0,74	256,69	3,91	208,28	3,17	430,27
Communication networks (roads, train)	17,03	0,26	93,77	1,43	76,75	1,17	450,77
Total	6561,24	100,00	6561,63	100,00	0,39	0,00	0,01



Code	Class
B	Forest
C	Crops
E	Uncultivated
H	Grassland
I	Industrial
L	Riverbed and surface water
M	Scrubland
P	Plantation
PD	Scattered population (farmhouses)
U	Urban
X	Communication networks (roads, train)

Land use and cover map. Transformation of the category “Crops”. 1956-2010





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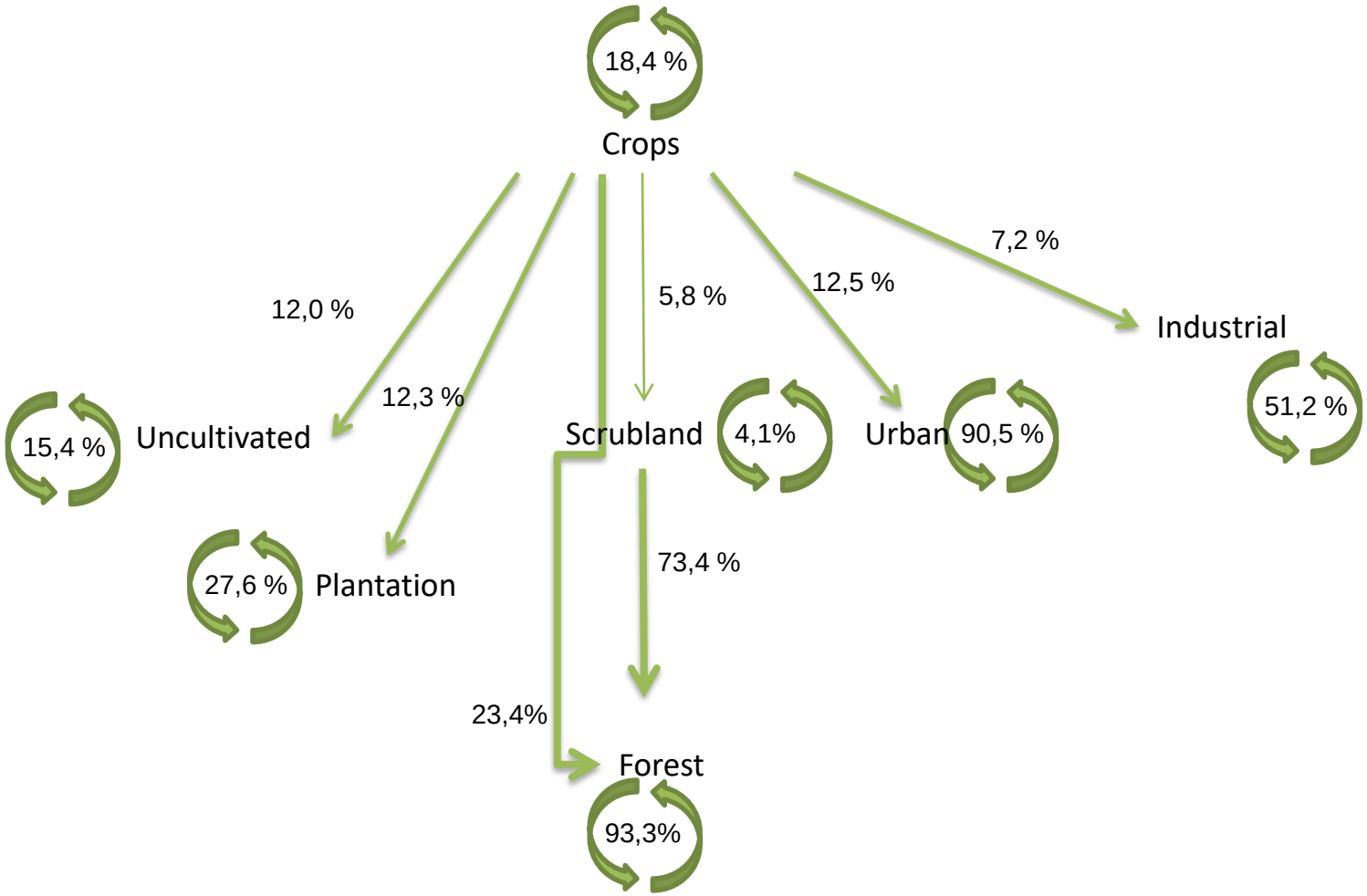
Resultats

Transformation of the category “Crops” from 1956 to 2010



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Results

LUCC

Transformation of the land use/cover categories from 1956 to 2010.
In percentage over the total of each category in 1956

2010	Forest	Crops	Uncultivated	Grassland	Industrial	Riverbed and surface water	Scrubland	Plantation	Scattered Population	Urban	Communication networks (roads, train)
Forest	93.3	23.4	16.1	35.7	1.2	35.3	73.4	22.5	17.9	0.0	7.4
Crops	0.4	18.4	6.0	4.5	0.5	1.3	1.3	5.7	4.6	0.4	1.0
Uncultivated	0.7	12.0	15.4	7.0	6.8	4.0	5.1	7.6	16.5	1.4	2.7
Grassland	0.3	2.7	2.0	18.9	0.2	30.0	0.2	8.3	0.0	0.0	2.3
Industrial	0.5	7.2	8.6	10.0	51.2	6.2	1.7	1.9	1.4	4.2	2.6
Riverbed and surface water	0.1	0.2	0.1	6.3	0.0	12.7	0.1	4.9	0.0	0.0	0.6
Scrubland	0.7	5.8	3.8	6.6	0.4	3.3	4.1	2.2	4.3	0.4	0.9
Plantation	2.3	12.3	13.4	4.7	0.0	3.9	8.1	27.6	7.4	1.0	0.5
Scattered population (farmhouses)	0.0	1.0	3.0	0.0	0.0	0.0	0.7	0.0	37.0	0.0	0.1
Urban	1.3	12.5	24.2	3.4	38.5	0.1	4.0	4.5	10.9	90.5	14.9
Communication networks (roads, train)	0.4	4.5	7.4	3.0	1.4	3.3	1.3	14.9	0.1	2.0	66.9
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

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Results

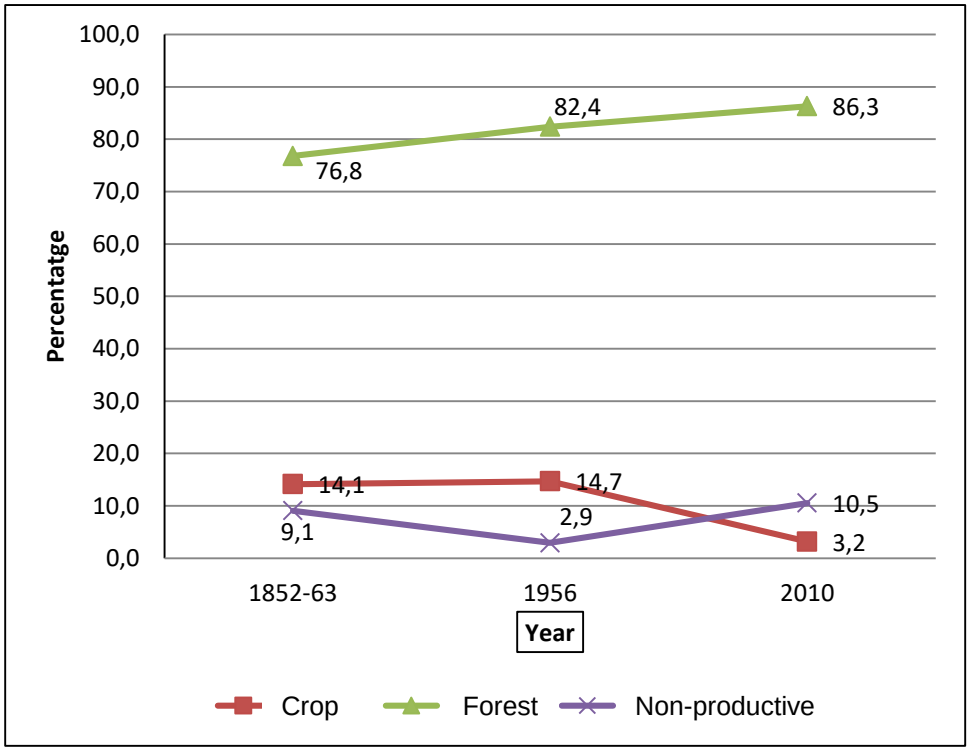
El canvi d'usos i cobertes del sòl

Procedence of the land use/cover categories in 2010 from 1956, in percentage over the total of each category in 2010

1956	Forest	Crops	Uncultivated	Grassland	Industrial	Riverbed and surface water	Scrubland	Plantation	Scattered Population	Urban	Communication networks (roads, train)
Forest	93.7	9.5	22.0	18.6	23.0	24.2	34.8	44.5	12.0	25.7	22.9
Crops	4.3	85.5	64.9	35.6	56.2	7.5	54.5	43.4	52.2	46.8	46.2
Uncultivated	0.1	1.0	3.0	1.0	2.5	0.2	1.3	1.7	5.7	3.3	2.8
Grassland	0.3	1.0	1.8	12.0	3.7	14.3	3.0	0.8	0.0	0.6	1.4
Industrial	0.0	0.0	0.7	0.1	7.9	0.0	0.1	0.0	0.0	2.9	0.3
Riverbed and surface water	0.4	0.4	1.3	24.5	2.9	37.3	1.9	0.8	0.0	0.0	2.1
Scrubland	0.8	0.4	1.6	0.1	0.8	0.1	2.2	1.6	2.1	0.8	0.8
Plantation	0.3	1.8	2.7	7.5	1.0	15.8	1.4	6.5	0.0	1.1	10.2
Scattered population (farmhouses)	0.0	0.3	1.3	0.0	0.2	0.0	0.6	0.4	28.0	0.6	0.0
Urban	0.0	0.1	0.4	0.0	1.6	0.0	0.2	0.2	0.0	17.1	1.0
Communication networks (roads, train)	0.0	0.1	0.3	0.6	0.4	0.5	0.2	0.0	0.1	1.0	12.3
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Results

LUCC. Comparison 1852-2010.



	1852-1956	1956-2010
Forest	↑	↑
Crops	=	↓
Non productive	↓	↑

1852-63: Data obtained from "Amillaramientos". Tax documents which contained information of land use

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