A semi-automated procedure to detect variations of mountain pastures using Landsat imagery

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Introduction

Socio-economic changes and other factors lead in recent decades to a dramatic disappearance of mountain grazing areas and ecosystems in many European countries (Habel *et al.*, 2013)

MAIN EFFECTS

- ✓ Loss of economic resources
- ✓ Reduction of biodiversity
- ✓ Landscape degradation
- ✓ Impairment of ecosystem services
- ✓ Disappearance of traditional cultures

Key problems

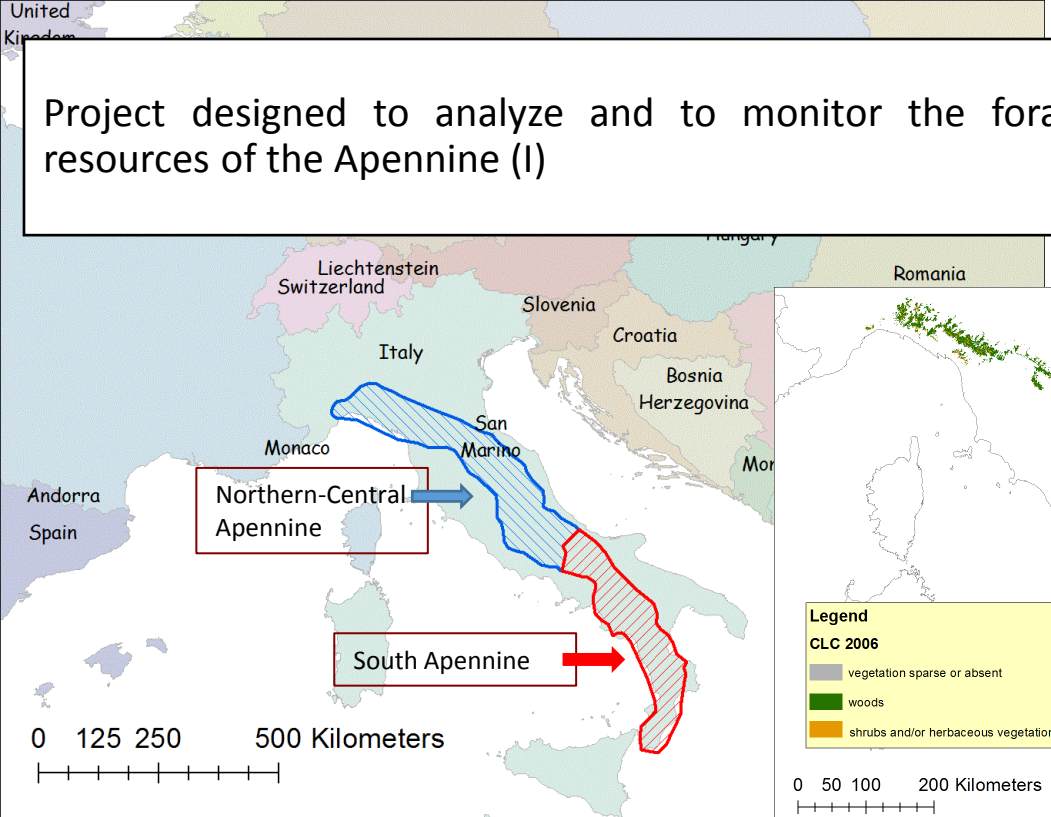
- **Lack of research on changes in grasslands ecosystems**

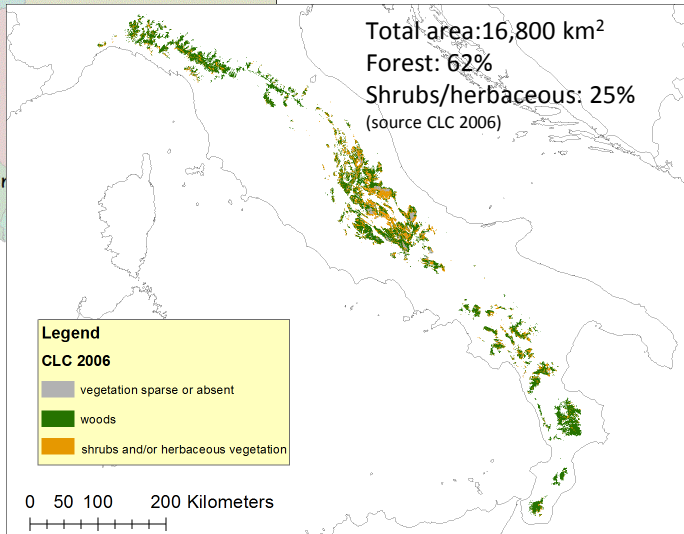
- **Lack of technical tools for public institutions for the management of pastures, particularly in mountain areas:**
  - ✓**conservation**
  - ✓**valorisation**

Aim of the study

To develop a semi-automated method to estimate medium-long term mountain **pastures surface variation**, using Landsat images and NDVI (Normalized Difference Vegetation Index), under a GIS environment.

Project designed to analyze and to monitor the forage resources of the Apennine (I)



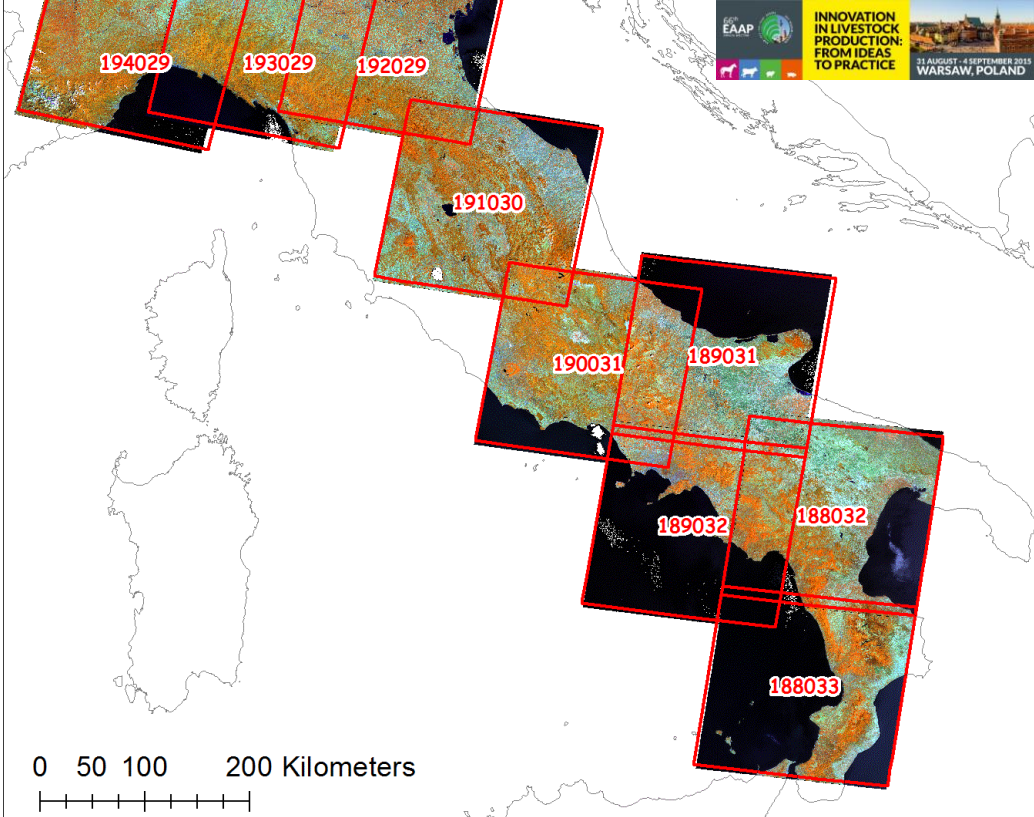


Materials and methods

1. Acquisition Landsat (LS) images (free of charge) covering the study areas for years 1987 and 2013 (http://landsat.usgs.gov/)
2. Calibration and correction of LS images (ENVI, Exelis)
3. Calculation of Normalized Difference Vegetation Index (NDVI) (ArgGIS, ESRI) for each 30 m x 30 m pixel
4. Variation of each pixel from year 2013 to year 1987 (Implementation of pixel-oriented image differencing technique , Singh, 1989).
5. Performance evaluation and calculation of NDVI discriminatory value.

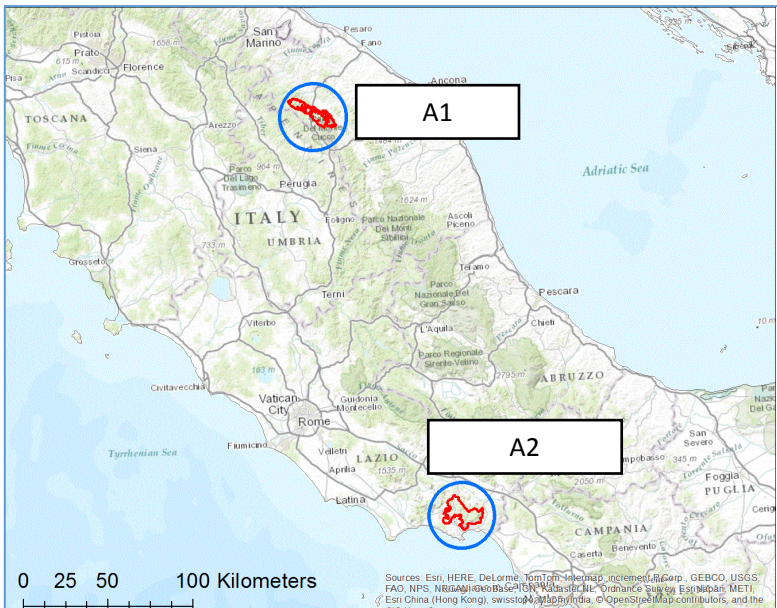
To analyze the land use dynamics in the medium term multispectral images Landsat covering the study area have been acquired

- Years: 1987 and 2013
- Satellite sensors:
  - Landsat 5 Multispectral Scanner (MSS) in 1987
  - Landsat 8 Operational Land Imager (OLI) in 2013
- Month: July
- Resolution: 90 m^2



The case-study of Catria-Nerone and Aurunci mountains

- Central Apennines
  - A1: Catria-Nerone mountains
  - A2:Aurunci mountains
- Surface area (ha):
  - A1: 13,581
  - A2: 13,257



Calibration and correction of images

To make comparable the scenes captured from the two different sensors (1987-MSS and 2013-OLI) and to correct physical measurements derived from spectral reflectance (i.e. water vapor) we computed:

1. radiometric calibration (ENVI software)
2. atmospheric correction (FLAASH method) → Exo-atmospheric reflectance
3. delimitation of areas covered by clouds and their shadows (FMASK method)

Performance evaluation

- Description of actual land cover classes from on-screen visual interpretation of year 2013 aero-photograph images;
- 130 random points.

Sensitivity

$$Se = \frac{TP}{TP+FN} \times 100$$

Specificity

$$Sp = \frac{TN}{TN+FP} \times 100$$

Accuracy

$$A = \frac{TP+TN}{P+N+FP+FN} \times 100$$

TP = true positive; TN = true negative; FP = false positive e FN = false negative.

NDVI discriminatory value

On the basis of performance evaluation, the optimal value to describe the passage from one class to another of land use (e.g. from pasture to shrubs), calculated as difference among medium values of NDVI of each class.

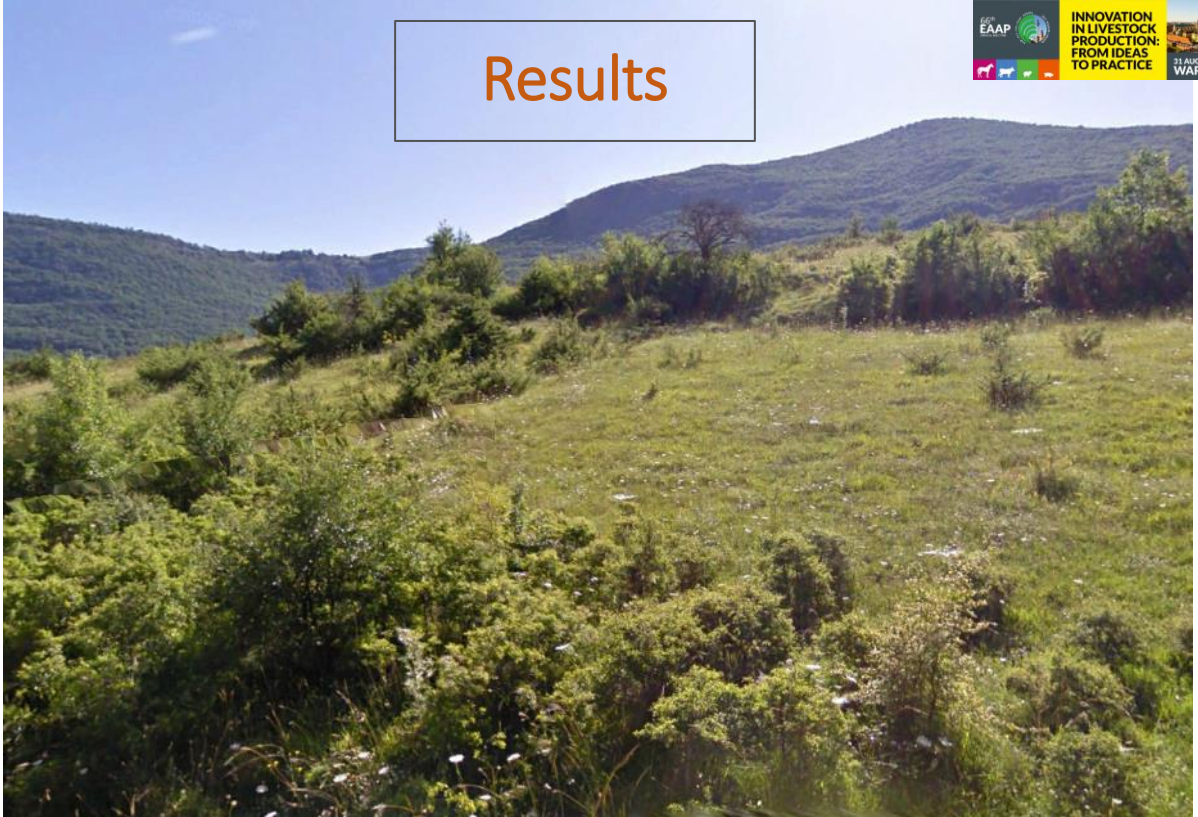
Classes of difference:

5-15 transition from pasture to shrubs

16-25 transition from shrubs to forest

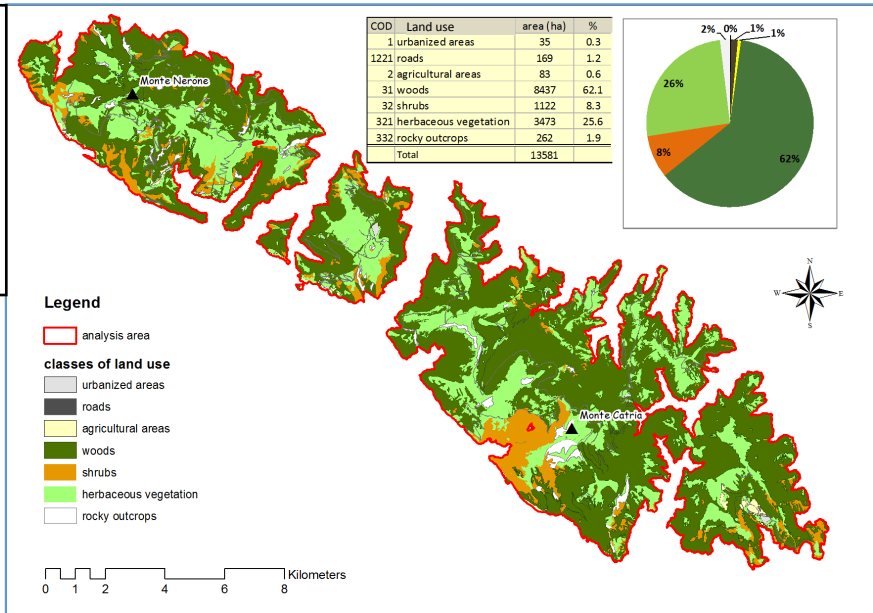
>25 forest

Results



Study area A1

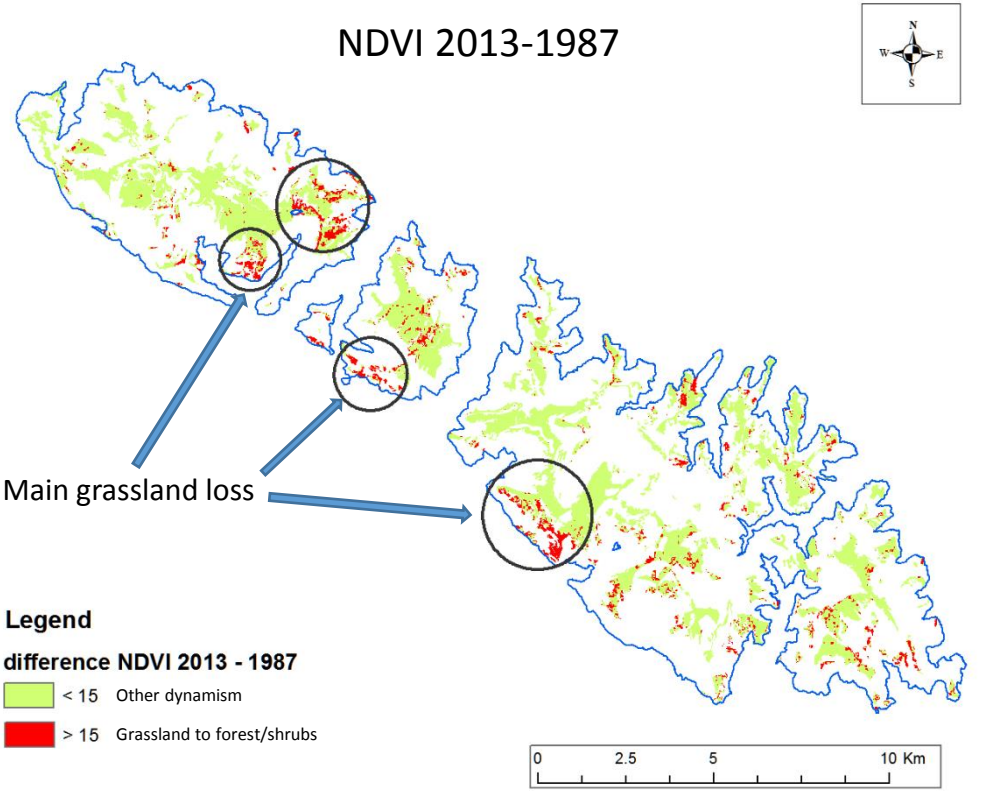
Interpretation of year 2013 land use by means of semi-automatic segmentation multiresolution object oriented method



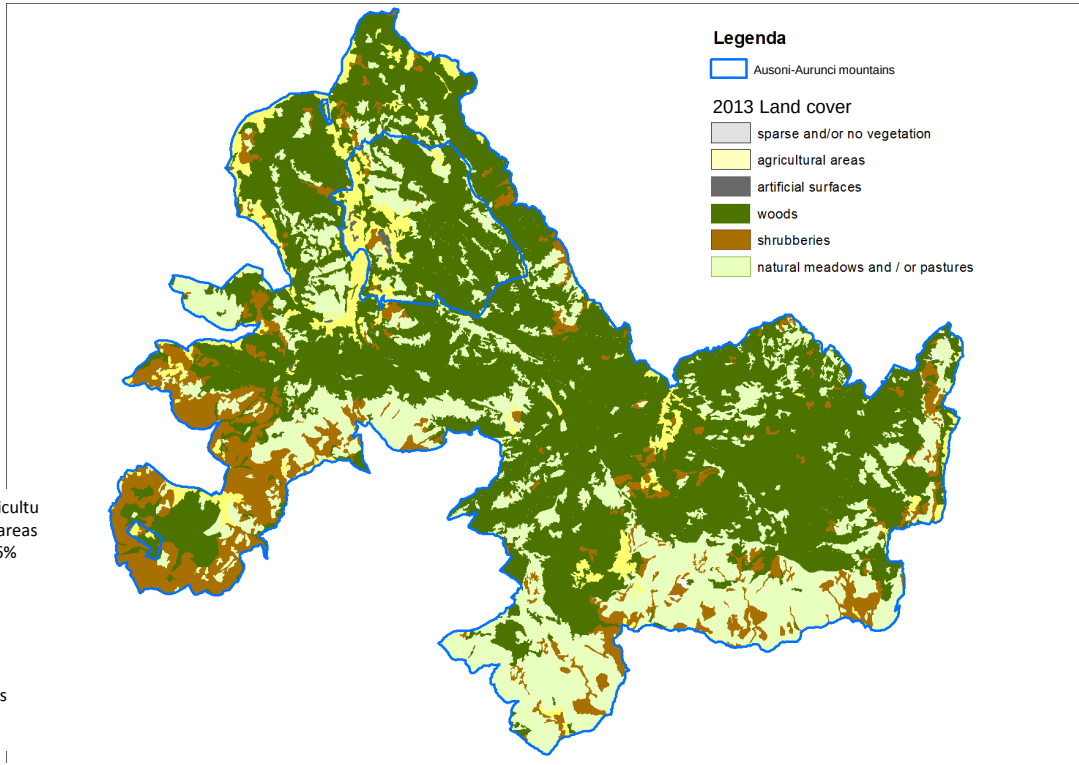
COD	Land use	area (ha)	%
1	urbanized areas	35	0.3
1221	roads	169	1.2
2	agricultural areas	83	0.6
31	woods	8437	62.1
32	shrubs	1122	8.3
321	herbaceous vegetation	3473	25.6
332	rocky outcrops	262	1.9
	Total	13581	

Study area A1

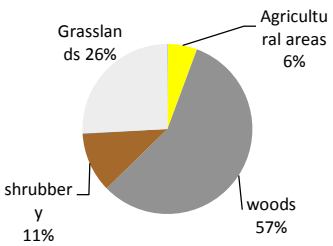
Calculation of 2013-1987 NDVI changes for each land use class.



Study area A2

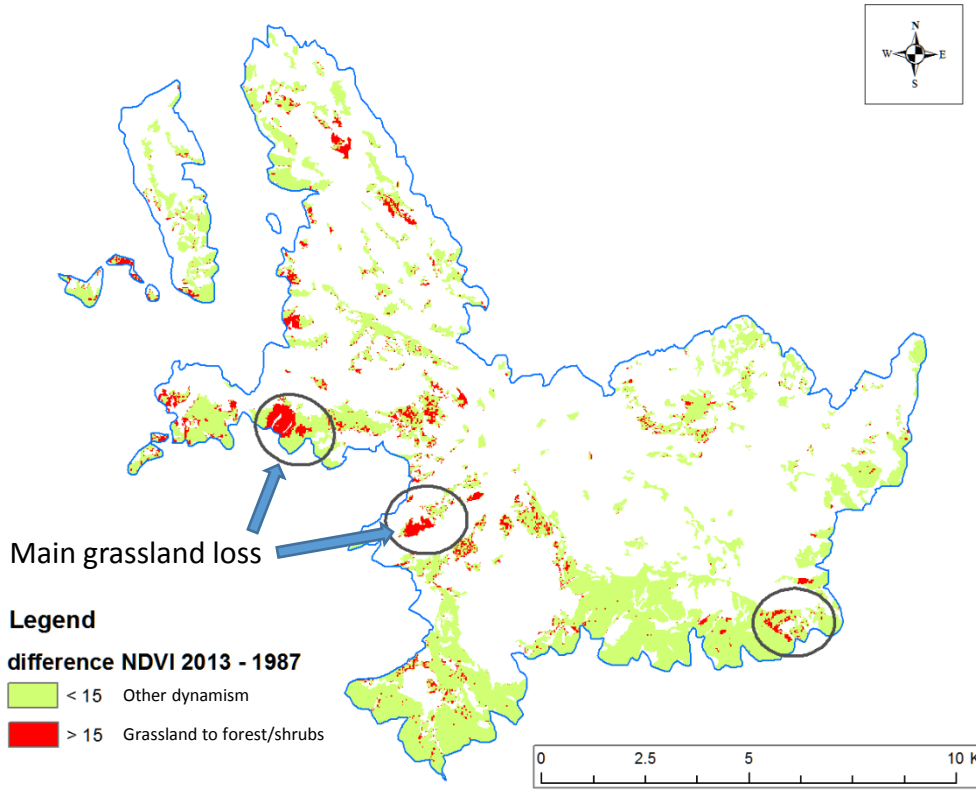


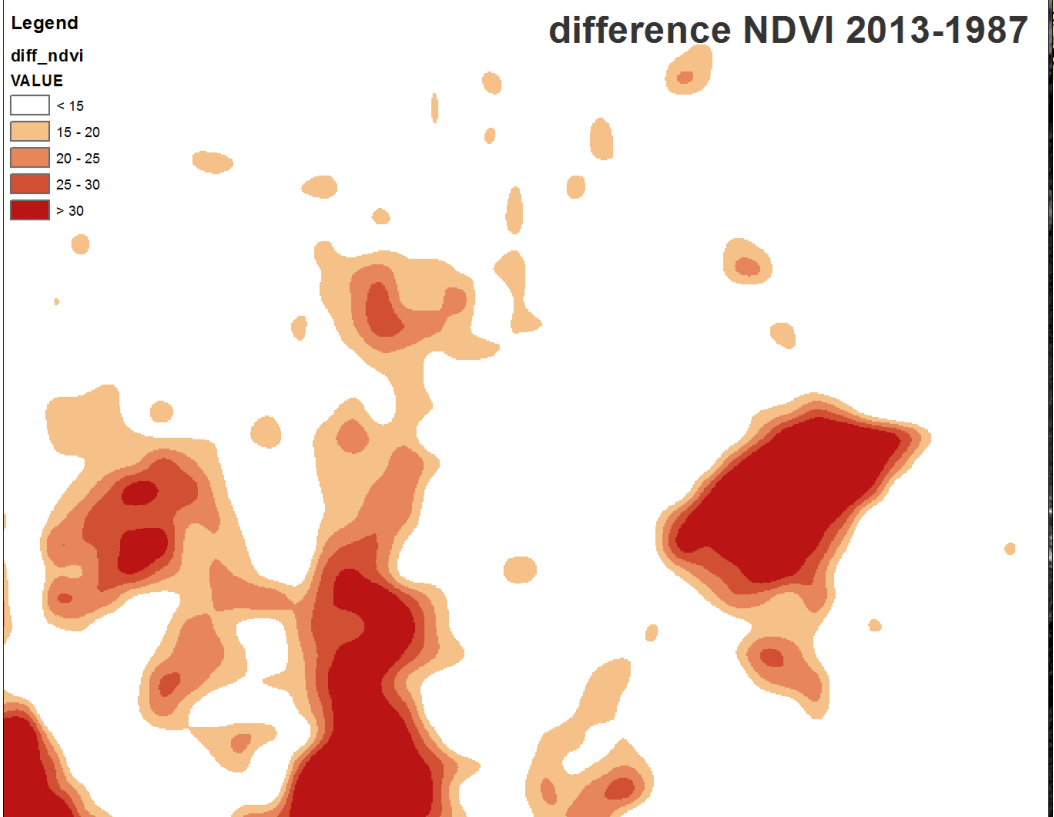
2013 Land use

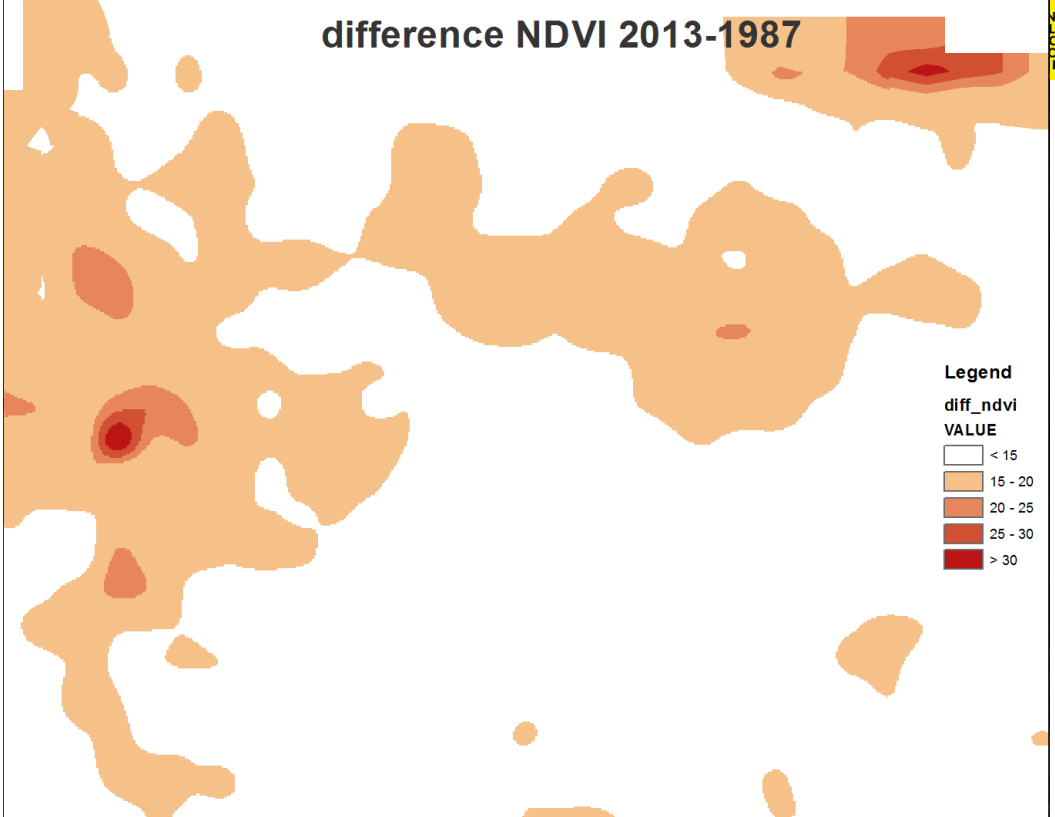


Study area A2

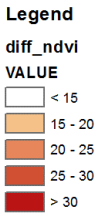
Calculation of 2013-1987 NDVI changes for each land use class






difference NDVI 2013-1987
Legend
diff_ndvi
VALUE
< 15
15 - 20
20 - 25
25 - 30
> 30

difference NDVI 2013-1987



Performance evaluation

	Aurunci	Catria-Nerone
Sensitivity (Se)	84.4	92.1
Specificity (Sp)	69.1	89.0
Accuracy A)	74.6	90.5

$$Se = \frac{TP}{TP+FN} \times 100 \qquad Sp = \frac{TN}{TN+FP} \times 100 \qquad A = \frac{TP+TN}{P+N+FP+FN} \times 100$$

TP = true positive; TN = true negative; FP = false positive e FN = false negative.

- The optimal NDVI difference to discriminate grassland loss is 15 (or >15).
- The derived NDVI data of LC change showed that about 1,360 ha of mountain pastures (5% of the total area mapped) were completely loss during the period under review. A larger part of pasture surface is under transition.
- The largest losses have occurred principally under 1,200 m a.s.l., mainly because of secondary forest succession processes (840 ha), caused by a decrease in sheep and goat grazing.

Discussion and conclusions

- This semi-automated, real-time and cheap methodology can contribute to the monitoring of mountain rangelands changes and helpful for pasture planning.
- The model we propose allows the exact localization of the dynamics of succession grassland -> shrub encroachment -> forest
- The model can be periodically updated (up to every week); this allows to assess the effects of grazing, and, through an adaptive approach, to optimize the management decisions of the entire grazing system (e.g. :It could be useful to address the grazing flocks in some areas, to prevent the closure of the secondary grasslands).

Key questions in the Millennium Ecosystem Assessment

- **How have ecosystems changed?**
- How have ecosystems services and their use chanced?
- How have ecosystems changes affected human well-being and poverty alleviation?
- What are the most critical factors causing ecosystems changes?
- How might ecosystems and their services change in the future under plausible scenarios?
- What can be learned about the consequences of ecosystem change for human well-being at sub-global scale?
- What is known about time scales, inertia, and the risk of nonlinear changes in ecosystems sustainability?
- What are the most important uncertainties hindering decision-making concerning ecosystems?

Thanks for your attention