Mapping land cover changes associated with restoration actions to combat desertification in a Mediterranean sylvopastoral landscape

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Introduction

The aim of this study is to assess remote sensing based approaches to observe and quantify the land cover changes that occurred, in the last decades, in a sylvopastoral area located in southern Sardinia (Italy), where different restoration actions to combat desertification have been implemented.

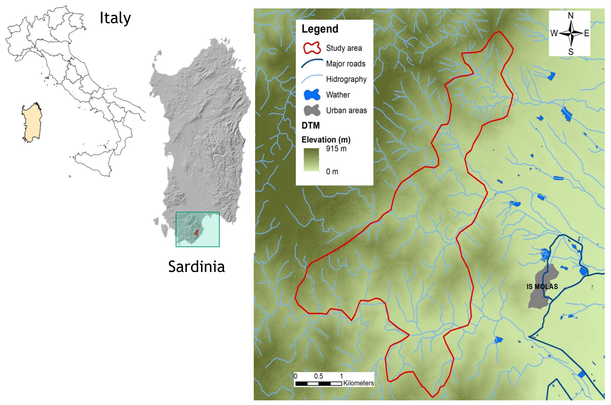
Specific research questions are: can simple and cost-effective remote sensing technologies be useful for assessing and monitoring different long term restoration actions in this geographic context? Can specific land use/cover transitions and associated spatial indicators provide relevant information to evaluate the success of these actions?

The research is being carried out within the PRACTICE EC-FP7 project: "Prevention and Restoration Actions to Combat Desertification. An Integrated Assessment".

Study area

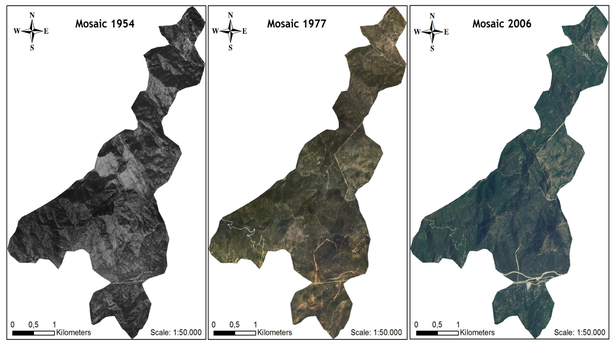
The study area is located in Pula-Pixinamanna (38◦ 59' N, 8◦ 54' W, Italy). The main ecosystem types are Mediterranean garrigue and maquis, mixed evergreen/Mediterranean woodland, and pine forest. This area was strongly affected by land degradation problems mainly associated with overgrazing by domestic animals (until'60s), overexploitation of fuel wood (until '50s) and forest fires. Starting from the late '50s, the site was managed from the Sardinian Forest Service, most anthropic pressure factors were removed, and different restoration actions were undertaken. Meanwhile, some areas still remain under grazing pressure. According to this overview, the following **"actions"** were taken in account and compared:

1. No management area, still under **anthropic pressure.**
2. Removal of pressure factors and s**elf-restoration**, as a management choice.
3. Spatially uniform **reforestation** (mainly stone pine) **without thinning.**
4. **Reforestation** followed by sylvicoltural intervention (i.e. **thinning**) to promote re-naturalization.



Multi-temporal image dataset

A set of digital ortho-rectified aerial photographs have been used for the land cover change analysis (1954, 1977, 2006). The orthophoto of 1954 was not classified due to its poor quality, but it was used to evaluate the study area condition before Sardinian Forest Service management.



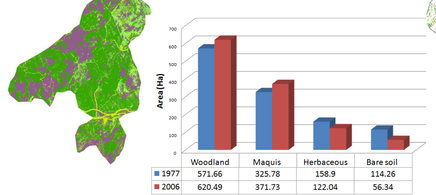
Land cover changes (1977-2006)

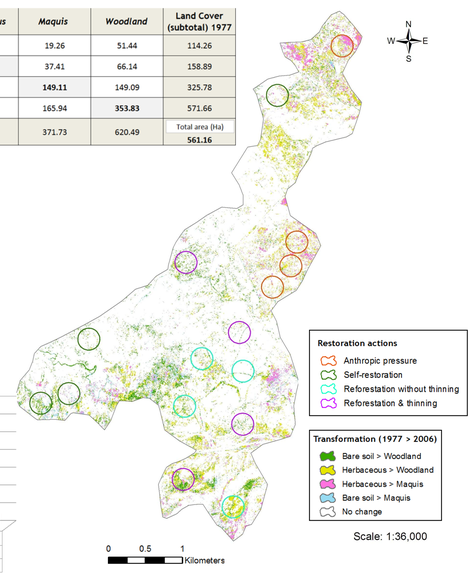
An object-oriented approach was used to classify the aerial photographs of 1977 and 2006. Image segmentation was performed using the ENVI EX software (ITT), while classification was based on Support Vector Machines. The landscape was classified into 4 land cover classes: **bare soil**, **herbaceous** vegetation and degraded shrublands, Mediterranean **maquis**, and **woodlands** (i.e. stone pine plantations). Classification overall accuracy, evaluated using an independent data set of ground truth, resulted of 84%. Land cover change was quantified through the cross-tabulation algorithm, a post-classification change detection technique that performs a cross-correlation between independent classified images (Lu et al., 2004).

Land cover 1977

Land cover 2006

1977 \ 2006	Bare soil	Herbaceous	Maquis	Woodland	Land Cover (subtotal) 1977
Bare soil	16.97	26.60	19.26	51.44	114.26
Herbaceous	14.08	41.26	37.41	66.14	158.89
Maquis	8.91	18.68	149.11	149.09	325.78
Woodland	16.39	35.51	165.94	353.83	571.66
Land Cover (subtotal) 2006	56.34	122.04	371.73	620.49	Total area (Ha) 561.16

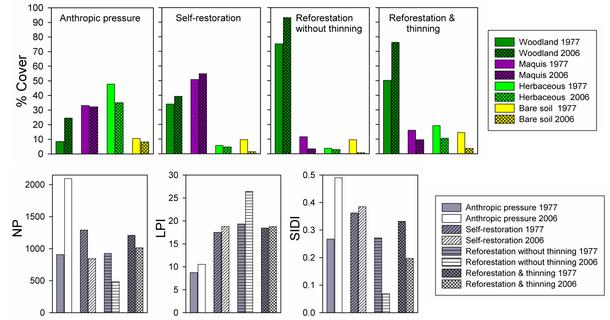




Landscape metrics analysis

Landscape metrics have been used to analyze the landscape spatial and temporal patterns related to the different actions considered. This analysis have been carried out (http://www.umass.edu/landeco/research/fragstats/fragstats.html), in 16 circular areas (150 m radius) representative of the management actions, using the free share software FRAGSTAT.

The following landscape metrics were calculated: percent fraction of woodland, Mediterranean maquis, herbaceous vegetation and bare soil, and number of patches (NP), Largest Patch Index (LPI), Simpson's Diversity Index (SIDI).



Discussion

Object-oriented classification approaches demonstrate to be sufficiently accurate in classifying aerial photographs, maximizing the exploitation of the spatial information provided by these data.

The land cover change analysis results show that the restoration actions to combat desertification adopted in the study area were overall effective in reducing the bare soil and herbaceous/degraded shrubland cover, while increasing the cover of Mediterranean maquis and woodlands.

The comparison of the different actions in terms of land cover fraction and landscape metric heterogeneity provides useful information to evaluate the success of different management choices. Areas still under anthropic pressure have a high cover of bare soil and herbaceous/degraded shrubland, despite some improvements have been observed in the last 30 years. The uniform and dense reforestation without further thinning have determinate a strong dominance of planted woodlands (mainly stone pine), with low spatial heterogeneity and autochthonous Mediterranean maquis vegetation reduction. Both the self-restoration and the reforestation action followed by sylvicoltural interventions to promote re-naturalization allow reducing the bare soil and herbaceous/degraded shrubland cover, while promoting woodlands and maquis vegetation expansion and maintaining a high landscape heterogeneity.

Overall, these results demonstrate the potential of relatively simple and cost-effective remote sensing approaches to evaluate long term restoration action strategies. Future activities will be focused on a field evaluation of the actions and on the integration of socio economic information in the evaluation protocol.

References

Lu, D., Mausel, P., Brondizio, E. & Moran, E. (2004) Change detection techniques. *International Journal of Remote Sensing, 25, 2365-2407.*

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