The effect of land cover change and forest fires on water quality in natural and anthropic head-water basins of the Cantabrian Mountains (NW Spain): a seasonal approach

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INTRODUCTION

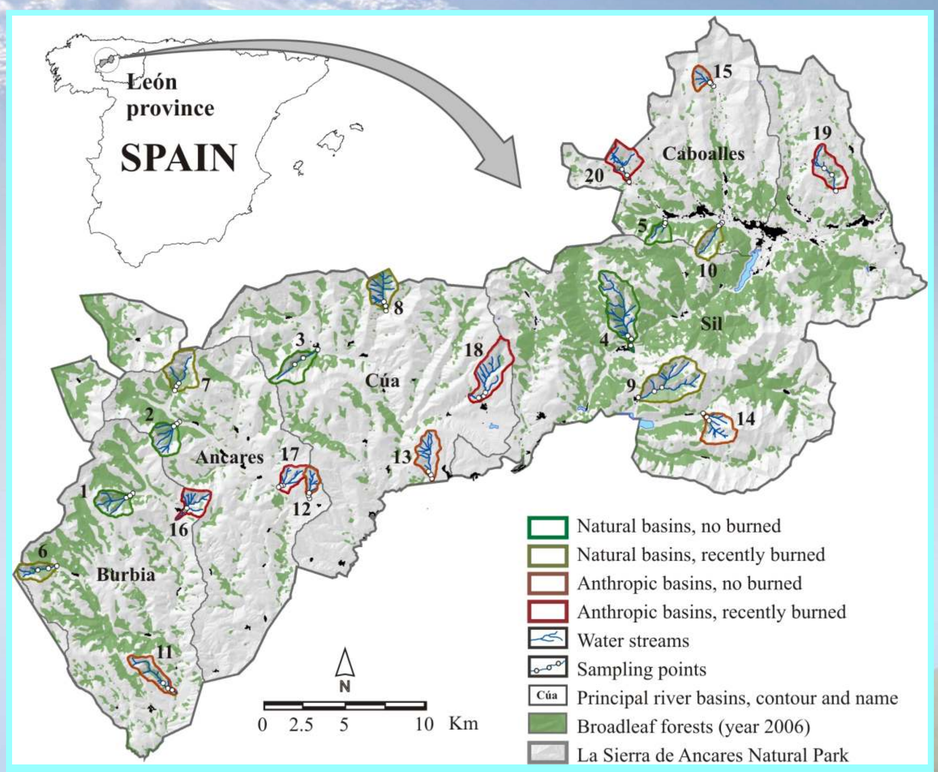
Sustainable mountain development should be a global priority, given the multitude of ecosystem goods and services that mountains provide to the millions people living downstream, such as the freshwater supply to major rivers. Mountains can be considered as the "water towers" of the world, supplying half of the world's population with freshwater for drinking, domestic use, irrigation, industry and hydropower. At the same time, mountainous regions are fragile ecosystems where high rainfall and steep slopes can induce severe surface runoff and soil erosion towards receiving streams. Land cover change and anthropic disturbances may impact water resources (river chemistry and its biotic components), playing an important role in controlling water quality and quantity to major rivers. Regional scale monitoring and modelling may provide useful results for designing territory management plans.

OBJECTIVES

The overarching objective of this work was to evaluate the relationship between land cover change, mainly controlled by land abandonment, human-made forest fires and river streams (water quality and quantity) in twenty head-water basins located in a protected area in the Cantabrian Mountains (NW Spain).

STUDY AREA

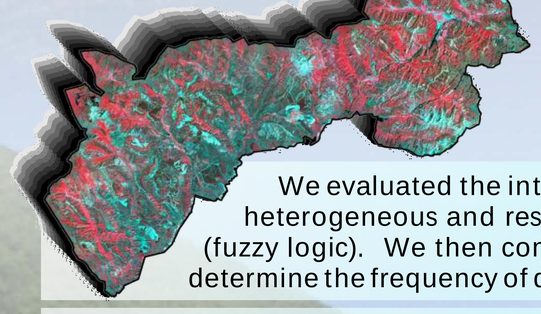
La Sierra de Ancares is a Spanish Natural Park located at the western extreme of the Cantabrian Mountains, covering approximately 100 000 ha. Climate is Atlantic with a mean annual precipitation of 1300 mm and a mean temperature of 8°C, although lower elevations show sub-Mediterranean characteristics. Elevation ranges from 600 to 2200 m.a.s.l. and relief is moderate to steep. Original forests have been elminated since historical times, although traditional practices such as burning, cutting and grazing have been abandoned or reduced during last decades and secondary succession has become a common process.



METHODOLOGY

We addressed this complex relationship through a landscape approach. The outflows of small unitary watersheds with different land cover composition and fire history regimes were monitored during two complete hydrological years. The basins permitted quantitative measurements of biogeochemical input and output to determine effectively landscape functioning.

We characterized a set of physical-chemical water quality parameters in 20 head-water basins, estimated maximum runoffs corresponding to precipitation episodes for each basin. , relate land cover, fire history and seasonality to water quality and quantity and explored if biological indicators (i.e. macroinvertebrates) were concordant with the abiotic approach for assessing water quality on the streams.



Landscape dynamics modelling: land cover change and fire

Selection of natural and anthropic basins across gradients

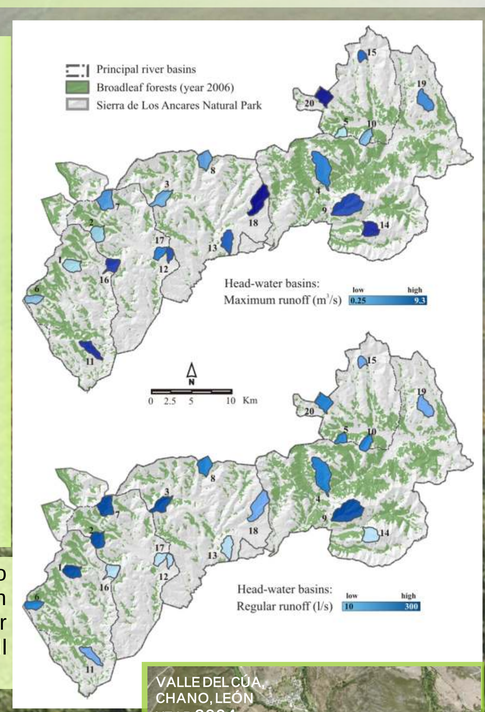
We evaluated the interannual land cover dynamics from hard classified remotely sensed data in heterogeneous and resilient landcapes using supervised classifications and uncertainty analyses (fuzzy logic). We then computed land cover dynamics by means of a model specifically designed to determine the frequency of disturbances (mainly fire events) and the vegetation recovery time.

We then developed highly detailed land cover maps from orthorectified aerial photographs of the years 1956, 1974, 1983, 1990 and 2006 using the categories described below. We calculated the percent coverage of each land cover type for each basin, aggregating data in terms of natural, anthropic, burned and no burned. Fire recurrence between 2000 and 2006 for each basin (in number of times that a fire event affecting more than 100 ha had occurred) was derived from the regional approach using satellite imagery.

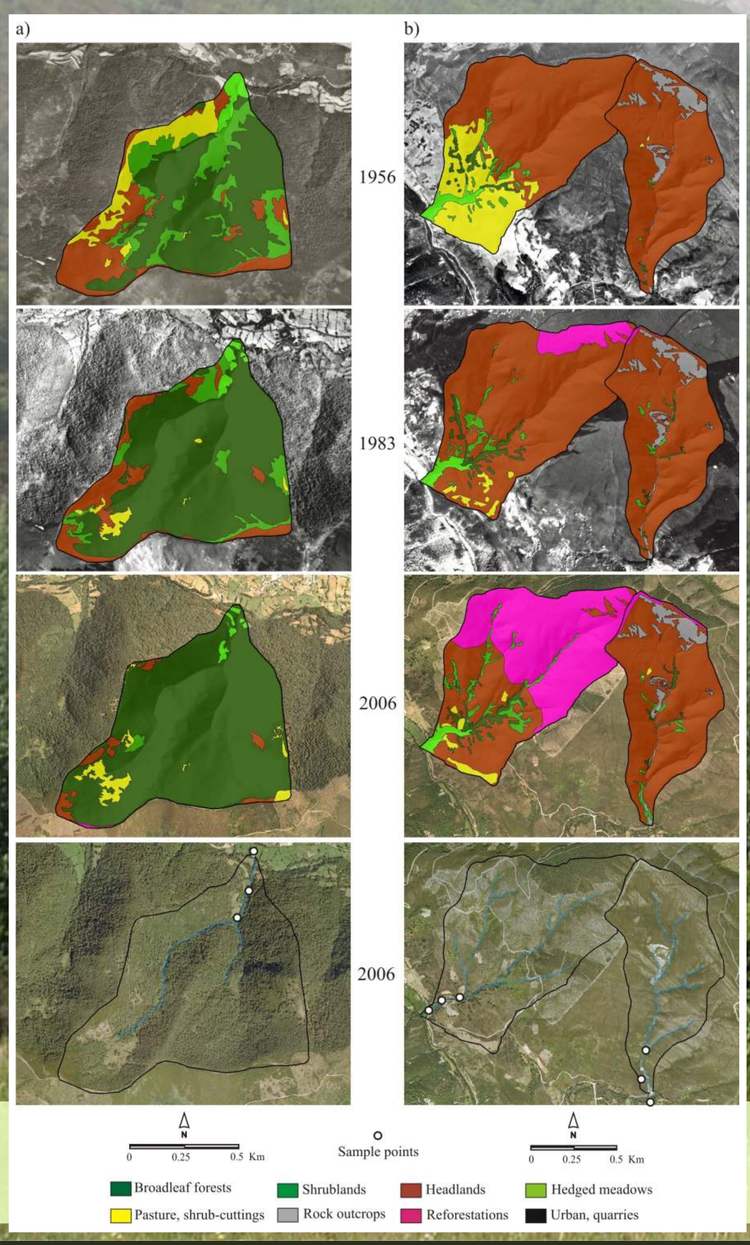
* Land cover change maps and fire recurrence estimates of each basin
* Seasonal water quality parameters and surface runoff models
* Relations between landscape structure, season and water resources

RESULTS

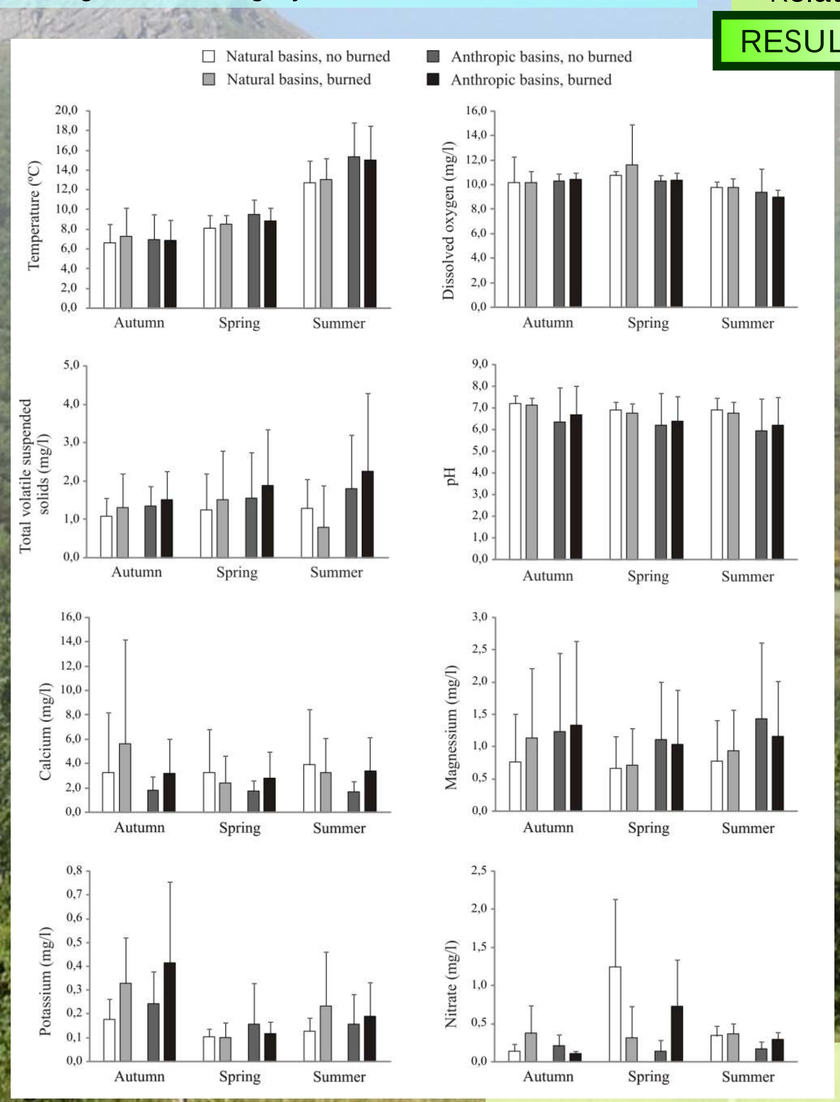
In this study, we observed that land cover changes play major roles in water quality. Stream flow hydrology and biogeochemical cycles are afected by land abandonment, vegetation dynamics and human disturbances. Our results indicate that, dependent upon season, land cover and fire history have a varying impact on water quality. The macroinvertebrate community also differed meaningfully in abundance, species richness and taxonomy.



Maximum runoff (in m3/s) associated to precipitation events and regular flow (in l/s). Natural basins have higher regular water-flows than anthropic basins as well as much smaller values of river floods.



Land cover maps for a natural (number 5) and anthropic (numbers 12 and 17 basins. Sampling points are shown over the ortophotos of the year 2008.



8 Physical-chemical water-quality parameters (mean ± st. deviation)

CONCLUSSION

The presence of forests plays an essential role in regulating freshwater flows and maintaining good water quality.

Land cover change, fire recurrence and seasonality play also a major role in landscape functioning. One question that remains is to evaluate the effect of all landcape heterogenity in water quality.

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