Assessing the impact of recurrent wildfires and tourist activities in a Mediterranean area

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Abstract — The coastal landscapes of Sardinia are characterized by a mosaic of beaches, protected areas and lands subjected to several anthropogenic disturbances. The wildland fire can be considered as a permanent disturbance that induces changes in the spatial pattern of vegetation, canopy cover, and soil properties. The structural characteristics of fire prone species can support the action of other disturbances. The aim of this study was to estimate the impact of both wildland fire and touristic activities on the coastal area of northern Sardinia. A coastal area was sampled by the line intercept method in order to characterize the vegetation. The study found differences in species composition, plant cover, and plant height that can be attributed primarily to the effect of fire, but also to the increased vulnerability of the fire prone ecosystems to the other disturbances.

Index Terms — Coastal areas, shrubland vegetation, vulnerability, anthropogenic disturbances.

1 Introduction

The island of Sardinia is one of the most important touristic areas of Italy. The major influx of tourists occurs during the summer and is concentrated in the coastal areas, where the landscape is characterized by a mosaic of beaches, protected areas and lands with strong anthropogenic disturbances. At local level, a lively discussion about the sustainability of touristic development and methods to be used for measuring or estimating it has been recently developed.

The impact of tourism on coastal areas is usually coupled with the impacts of other natural and anthropogenic disturbances [1].

Fire is the most significant threats for the Sardinian forested areas. In the last three decades, over 3000 wildfires per year have been occurred, with a mean annual burned area of about 41000 ha [2], [3]. However, the last ten years of the wildland fire time series showed a decreasing trend in fire occurrence (about 2700 fires per year) and, particularly, in burned area (about 18000 hectares per year). In addition, the analysis of both fire size and fire number showed that, on average, the 92% of fires have a size lower than 10 ha, and only the 0.7% of fires have a size greater than 200 ha [4].

The above mentioned results can be attributed to improvements in early detection, fire fighting infrastructures, fire suppression efficiency, and also prevention measures. Nevertheless, during severe and extreme environmental conditions, the fire fighting

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organization and strategies can be unable to respond to all the intervention requests.

In these situations, wildfires can become uncontrollable [5], with high risk to determine serious damages to ecosystems and properties and injury and loss of human life.

Since forest fires are predominantly ignited by arson, fire frequency and fire danger are higher during severe and extreme environmental conditions (strong wind, high fuel dryness).

In addition, fire ignition points are mainly concentrated near roads, residential areas, and tourist resorts, especially along the coast.

Finally, since fire recurrence is increasing, wildland fire can be considered as a permanent disturbance that induces changes in the spatial pattern of vegetation, canopy cover, and soil properties [6], [7].

The aim of this study was to estimate the impact of both wildland fire and touristic activities on the coastal area of northern Sardinia.

2 Study area

The north-eastern coast of Sardinia (Fig. 1) is characterized by the typical Mediterranean sub-arid climate, with a remarkable water deficit from May through September, and most of the annual rainfall (~650 mm) occurring in fall and winter.

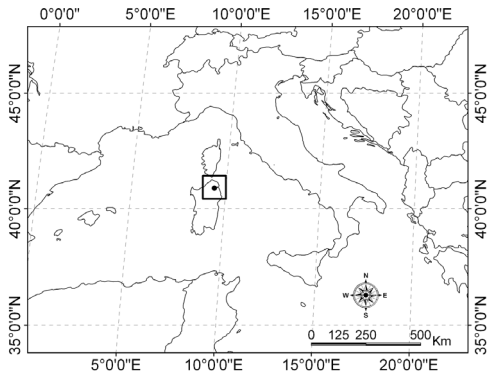

Fig. 1. Location of the study area in North East Sardinia (Italy).

The mean annual temperature is ~17°C, with summer season highs often near 30°C. The average wind speed is relatively high (~4ms^{-1}) in both winter and summer seasons, with ~50–70% of the days showing values between 1.6 and 8 ms^{-1}. The prevailing wind directions at the sites are typically west and north-west, with a cumulative frequency greater than 50%. However, the local wind direction can be modified by the complex terrain typical of the studied areas.

The area is characterized by a mosaic of vegetation types and development stages, where agricultural, grazing and also tourism activities play an important role in the vegetation distribution and landscape dynamics. The vegetation is a dense and uniform maquis shrubland, with plant height ranging from 1.5 to 2 m. Dominant species included *Pistacia lentiscus* L., *Cistus monspeliensis* L., *Arbutus unedo* L., *Olea europaea* L. var. oleaster, *Myrtus communis* L., *Pyrus amygdaliformis* Vill., *Calycotome spinosa* L., *Phyllirea angustifolia* L., *Juniperus phoenicea* L.

In the areas subjected to recurrent fires, the plant height is in the range 0.5 - 1 m and the dominant species is *Cistus monspeliensis* L.

During the summer season, the prevailing intensity and direction of wind, in conjunction with the drought conditions, can sustain high intensity fires that threatened the resort areas and also the beaches, requiring both the adoption of direct suppression attacks and the evacuation of villages, campsites and sometimes beaches.

3 Methods

The time series of wildland fire that occurred during the period 1995-2007 was analyzed in order to establish the main characteristics of fires and the information about the principal variables that describe fire behaviour.

Several themes were acquired and managed using a geographic information system to quantify the spatial variation of the different parameters related to land cover and vegetation characteristics.

Three different plots were used to study the characteristic of vegetation. The first two plots were located on the burned area; the third plot was located in the unburned area. For each plot, three 30 m line transect parallel to the coast and at a distance of 5 m each other were constructed. Shrub vegetation plants were sampled in order to determine plant height and the plant cover by the line intercept method.

Experimental data were analyzed for differences between burned and unburned areas by calculating the t-Student test.

4 Results and discussion

The values of plant height and canopy cover observed over both burned and unburned areas are shown in table 1. Results showed significant differences (t-test, P=0.01) in plant height between burned and unburned areas, while plant cover showed similar values.

TABLE 1

STATISTICS OF PLANT HEIGHT AND PLANT COVER FOR BURNED AND UNBURNED AREAS

		Burned	Unburned
Plant height (m)	mean	0.56a	1.30b
	min	0.15	0.45
	max	1.15	2.60
Plant cover (%)	mean	82.6a	93.7a
	min	74.0	82.0
	max	89.0	100

Mean values followed by the same letters are not significantly different at a P-value=0.01 by t-Student test

These results confirm the general description of the effects of recurrent fires in Mediterranean areas [8]. The recurrent fires that characterized the experimental area reduced the structural evolution of the shrubland vegetation, with direct effects on plant height and species composition.

Table 2 shows the values of plant cover measured in the burned area by the line interception sampling procedure. An increase of plant cover can be observed for increasing distances from the coast. This result seems to suggest that the vegetation near the coast is more affected by the impact of touristic pressure, but also the spatial variations of the environmental conditions (e.g. soil properties, wind intensity, etc.) probably plays a role in this results. The effect of human pressure on the natural process of vegetation recovery after the fire can be attributed to the impact of trampling by tourist, vehicles circulation, parking places.

TABLE 2

MEAN VALUES AND STANDARD ERRORS OF PLANT COVER FOR INCREASING DISTANCES FROM THE COAST; BURNED AREA.

Area	Transect	Plant cover (%)	Standard error
1	5 m	74	0.20
	10 m	83	0.40
	15 m	85	0.48
2	5 m	80	0.32
	10 m	84	0.47
	15 m	89	0.82

The fire regime can probably play a major role; evolved shrubland vegetation preserves itself and the landscape as a mechanical barrier to both natural (weather, soil erosion, etc.) and anthropic effects.

In relation to the species composition, the experimental results showed (table 3) that the burned area is characterized by a low number of species, and a general low frequency of the species already observed in the unburned area, with the exception of the *Cistus monspeliensis*, that increase its frequency from about 32% to 57%.

Fire is the main factor that controls the species composition, with the reduction of tree and shrub sprouters, and the diffusion of

the shrub obligate seeders. Changes in species composition can affect the vulnerability to both recurrent fires and other anthropic disturbances; for example, shrubland vegetation dominated by *Cistus monspeliensis* L. is characterized by the following factors influencing the impact: low height, high values of fine fuel, low values of fuel moisture, and high values of dead fuel.

TABLE 3

DISTRIBUTION OF PERCENT PLANT COVER FOR THE DIFFERENT SPECIES IN BURNED AND UNBURNED AREAS

	Unburned	Burned
Cistus monspeliensis	31.6	57.0
Myrtus communis	-	3.4
Calycotome spinosa	18.0	2.3
Juniperus phoenicea	21.0	-
Phyllirea angustifolia	19.3	11.8
Pistacia lentiscus	-	5.8
Erica scoparia	1.3	-
Olea europaea, var. oleaster	2.3	0.2
Herbaceous	-	1.8

5 CONCLUSION

The study found that the recurrence of fire were primarily responsible for changes in species composition, plant cover, and plant height. The indirect effect of fire disturbances on plant composition and soil properties can be locally aggravated by the impact of touristic activities.

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