Abandonment terraced hillside and answer of the fire system: some results from Mediterranean old fields

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ABSTRACT

The abandonment of agricultural lands promotes temporal changes both in soil characteristics (i.e., increasing organic matter and other quality indicators) and in plant community (i.e., changing its composition and structure, and increasing the fuel load). As a consequence, we can expect differences in the resilience to fire as succession progresses. The aim of this work is to analyse the capacity of an ecosystem to return to pre-fire conditions as a function of the stage of abandonment of old agricultural lands. The study was carried out in the north of Alicante province (E Spain).

In long-term abandoned lands, post-fire rainfall modulated plant response, which in turn determined soil crusting, runoff and erosion dynamics. In recently-abandoned lands, the plant community seemed less dependent on rain to recover. Results show a large increase in soil surface crusting in the short term after the fire and it remained high at medium term in long-abandoned lands colonised by pine forest. Fire scarcely modified runoff and erosion in recently-abandoned lands whereas in forest lands the post-fire values increased by some orders of magnitude and remained highly dependent on rain characteristics in the short and medium term after the fire. The results obtained show evidences of increased vulnerability to fire in long-abandoned lands colonised by pine forests.

Keywords: fire vulnerability, resilience, land-use change, Mediterranean-type ecosystems, E Spain.

INTRODUCTION

The abandonment of agricultural activities is a common feature in mountainous areas of the Northern Mediterranean countries. Succession processes after land abandonment imply temporal changes not only in soil characteristics (i.e., organic matter, microbial activity, structure, water regime and soil erodibility) but also in the plant community (i.e., changes in plant composition, plant structure, fuel load and risk of severe wildfires) (Vallejo et al., 2005).

Fire can affect both soil and vegetation features. Taking into account the dynamics of the ecosystem after the abandonment of agricultural practices, we can expect differences in the effects of fire and in the vulnerability to fire between different stages of land abandonment. The objective of this work is to analyse the capacity to return to pre-fire conditions as a function of the age of abandonment of old agricultural lands.

METHODS

The experimental area is located on the south-facing slopes draining to the Guadalest reservoir (Alicante province, E Spain). The altitude ranges from 400 to 500 m.a.s.l. and the

climate is dry meso-Mediterranean. Mean annual precipitation is 475 mm. The dominant soil type is Calcaric Cambisol developed over Miocene marls and limestones. Soils are silty clay loam, 20-40 cm deep, which have been deeply modified by old agricultural practices. As is common in the region, the slopes were terraced for cropping but have been abandoned since the 1950s. At present, the landscape shows a scattered mosaic of long-abandoned lands (covered by a *Pinus halepensis* forest), recently-abandoned lands (covered by a dry grassland with young *P. halepensis*) and fields in use (almond, carob and olive trees). The area was partially affected by a forest fire in August 1998.

The capacity of the area to return to pre-fire conditions was analysed using variables expected both to be sensitive to fire and to show temporal changes after fire. These were: soil surface compaction (cone penetrometer), runoff and sediment yield (closed erosion plots), and plant cover (point-intercept method). They were assessed on 12 interspersed plots covering 2 land uses (long-abandoned and recently-abandoned) and 2 fire-statuses (burned and unburned) during a 7 year-period. To minimise temporal heterogeneity due to factors other than fire, values from burned plots were related to values estimated for unburned plots in each sampling period.

RESULTS AND DISCUSSION

Plant cover

Figure 1 shows the temporal dynamics of the ratio between the plant cover on burned plots and the plant cover on unburned plots, and how post-fire rainfall influences this dynamics. In recently-abandoned lands the vegetation recovered quickly and showed values similar to the unburned plots less than two years after the fire. The low precipitation during the two years following the fire (285 mm and 411 mm, respectively) did not seem to limit plant growth excessively.

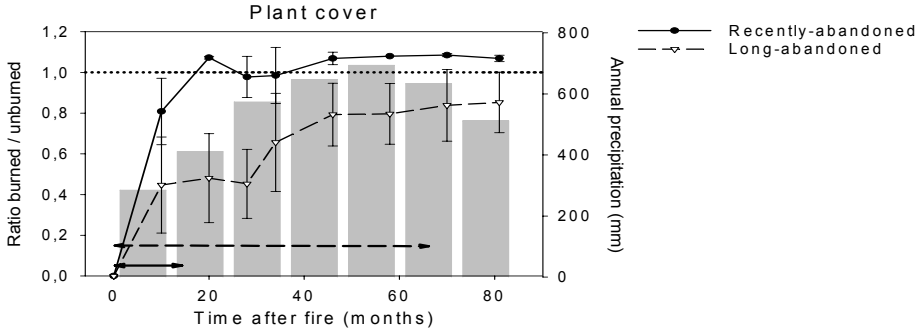

Figure 1. Lines indicate the temporal dynamics of the ratio between plant cover on burned plots and plant cover on unburned plots (mean values and standard deviation). Dotted line indicates same values for burned and unburned plots. Arrows indicate the period of decreased plant cover on burned plots. Bars indicate annual precipitation.

In contrast, in the long-abandoned lands the low precipitations following the fire strongly limited plant growth (Figure 1). Soil cover was less than half that of the unburned plots until 30 months after the fire and it remained lower than the unburned plots at medium term after the fire. This could be explained by the high fire-severity as well as by the dominance of seeder species on these pine plots (Quintana et al., 2004).

Soil surface compaction

Regardless of the land use, our results showed significant soil surface compaction processes in the short term after the fire (Figure 2). From the 3rd to the 12th month after the fire, the mean values of penetration resistance increased by 30% in recently-abandoned lands and by 70% in long-abandoned lands. Short-term increases in soil surface compaction after a fire have been described by other authors and have been attributed to the impact of raindrops over the under-protected soil surface, with silty soils being especially affected (Serrasolses et al., 2004).

In the case of recently-abandoned lands, penetration resistance values returned to those found on unburned plots during the third year after the fire. In long-abandoned lands the penetration resistance tended to be related to rainfall and it remained higher than on unburned plots until the sixth year after the fire (Figure 2). This could be interpreted as follows: after a soil surface becomes unprotected and crusted, the time needed for it to return to pre-fire conditions should be longer the longer the soil surface remains unprotected and when pre-fire values are lower.

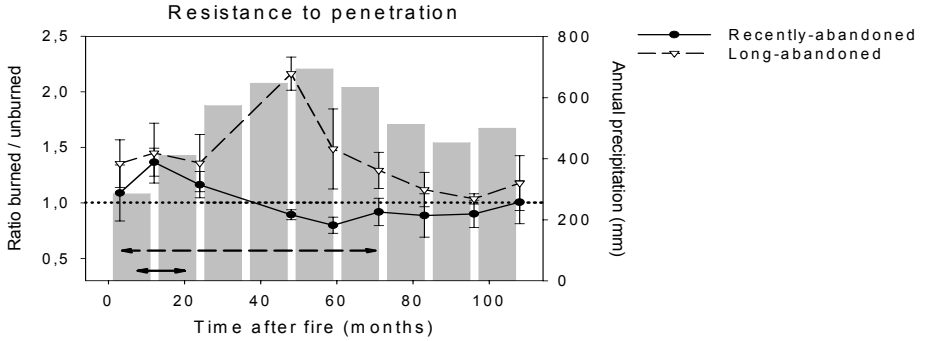

Figure 2. Lines indicate the temporal dynamics of the ratio between soil surface penetration resistance values on burned plots and on unburned plots (mean values and standard deviation). Dotted line indicates same values for burned and unburned plots. Arrows indicate the period of increased resistance to penetration on burned plots. Bars indicate annual precipitation.

Runoff and soil erosion

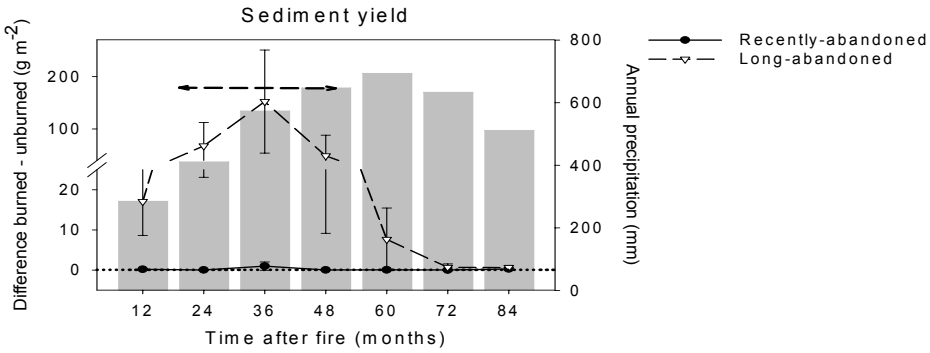

Figure 3. Lines indicate the temporal dynamics of the differences in sediment yield between burned and unburned plots (mean values and standard deviation). Dotted line indicates same values for burned and unburned plots. Arrows indicate the period of increased sediment yield on burned plots. Bars indicate annual precipitation.

Unburned plots showed very low runoff and soil erosion, and the fire scarcely modified these values on recently-abandoned plots (Figure 3). On the contrary, long-abandoned lands affected by fire showed increases of some orders of magnitude in runoff and sediment yield, and they remained higher than the unburned plots for five and seven years, respectively. Moreover, sediment yield was significantly related to rainfall characteristics whereas plant cover remained below 50% (Llovet et al., 2009).

CONCLUSIONS

On the study site, soil surface compaction showed high sensitivity to the direct impact of raindrops and a slow return to pre-fire conditions.

Long-abandoned plots colonised by pine forest showed a lower capacity to return to pre-fire conditions, that is, lower resilience, than recently-abandoned plots.

In plant communities dominated by seeder species, a complex relationship was found between post-fire rainfall events and ecosystem response. Rainfall dynamics controlled plant response, whereas soil surface crusting, runoff and soil erosion were influenced by both rainfall dynamics and plant response.

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