Land abandonment and system response to fire: Some results from old agricultural Mediterranean slopes

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ABSTRACT

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

In long-abandoned lands, post-fire rainfall modulated the plant response, which in turns determined crusting, runoff and erosion dynamics. In recent-abandoned lands, plant community appeared as lesser dependent of rain to recover. Results show that soil surface crusting presented a wide increase at short term after the fire and it remained enhanced at medium term in long-abandoned lands colonised by pine forest. Fire scarcely modified runoff and erosion in recent-abandoned lands whereas in forest lands the post-fire values increased some orders of magnitude and remained highly dependent of rain characteristics at short and medium term after the fire. Results obtained show some 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 the mountainous areas of the North Mediterranean countries. Succession processes after land abandonment implies a temporal evolution of both soil characteristics (i.e. organic matter, microbial activity, structure, water regime and soil erodibility) and 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 evolution of the system after the abandonment of the agricultural practices, we can expect some 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 the pre-fire conditions as a function of the age of abandonment of old agricultural lands.

METHODS

The experimental area is located in 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. The dominant soil type is Calcaric Cambisol developed over Miocene marls and limestones. Soils are silty clay loamy textured, between 20 and 40 cm depth and they were deeply modified by old agricultural practices. As usual in the region, slopes are structured into agricultural terraces which had been being abandoned / which are being abandoned from the 1950's. At present, the landscape shows a scattered mosaic of long-abandoned lands (covered by a *Pinus halepensis* forest), recent-abandoned lands (covered by a dry grassland with young *P. halepensis*) and lands in use (almond, carob and olive trees). The area was partially affected by a forest fire in August 1998.

The capacity to return to the pre-fire conditions was analysed using variables which we could expect to have a big impact with fire and a temporal evolution after fire. They were soil surface compaction (cone penetrometer), runoff and sediment yield (closed erosion plots) and plant cover (point-intercept method). They were assessed during 7 years in 12 interspersed plots covering both land uses (long-abandoned and recent-abandoned) and 2 fire-status (burned and unburned). To minimise temporal heterogeneity due to factors other than fire, values from burned plots were related to values estimated for unburned plots in every sampling period.

RESULTS AND DISCUSSION

Plant cover

Figure 1 shows the temporal dynamics of the ratio between plant cover in burned plots with respect to the plant cover in unburned plots, and how rainfall which took place after the fire influenced this dynamics. In recent-abandoned lands vegetation quickly responded and it 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 excessively the plant growth.

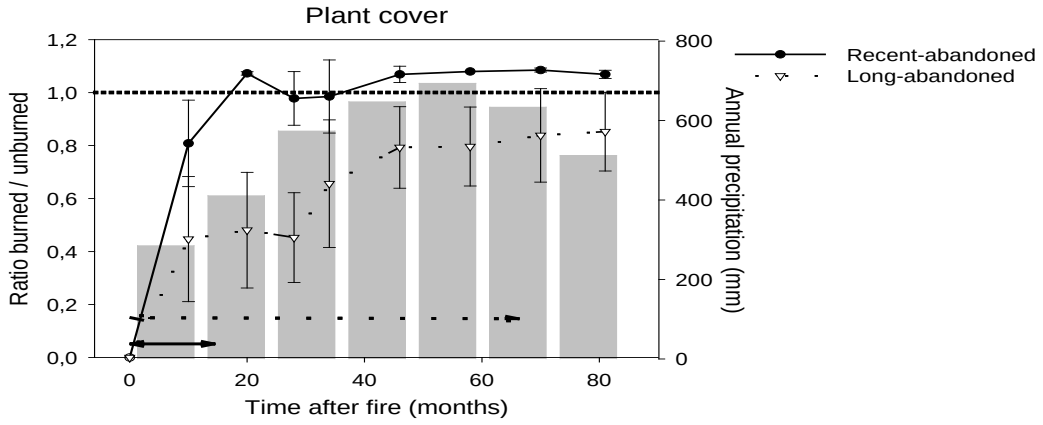

Figure 1. Lines indicate the temporal dynamics of the ratio between plant cover in burned plots with respect to the plant cover of the unburned ones (mean values and standard deviation). Dotted line indicates equivalence between burned and unburned. Arrows indicate the period of diminished plant cover in burned plots. Bars indicate the annual precipitation.

On the contrary, the low precipitations following the fire seem that deeply limited the plant growth in long-abandoned lands (Figure 1). Soil cover was less than a half of the unburned

plots until 30 months after the fire and it remained lesser than unburned plots at medium-long term after the fire. It could be explained by a high fire-severity as well as by the dominance of seeder species in long-abandoned lands colonised by pine forest (Quintana et al., 2004)

Soil surface compaction

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

In the case of recent-abandoned lands, values of resistance to penetration returned to those obtained in unburned plots during the third year after the fire. In long-abandoned lands resistance to penetration tended to be related to rainfall and it remained higher than unburned lands until the sixth year after the fire (Figure 2). It could be interpreted as follows: when soil surface remained unprotected and became crusted, it could require some time with the surface sufficiently protected to return to the pre-fire conditions; this time should be higher when soil surface remained more time unprotected and when values to return were lower.

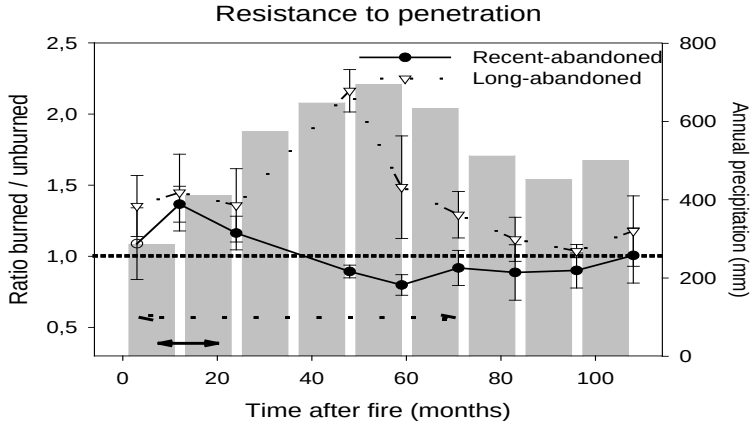

Figure 2. Lines indicate the temporal dynamics of the ratio between resistance to penetration of the soil surface in burned plots with respect to those obtained in unburned plots (mean values and standard deviation). Dotted line indicates equivalence between burned and unburned. Arrows indicate the period of increased resistance to penetration in burned plots. Bars indicate the annual precipitation.

Runoff and soil erosion

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

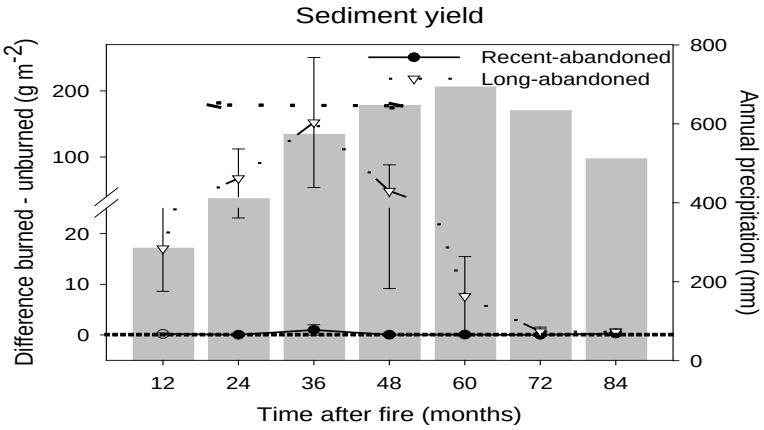

Figure 3. Lines indicate the temporal dynamics of the differences in sediment yield between burned and unburned plots (mean values and standard deviation). Dotted line indicates equivalence between burned and unburned. Arrows indicate the period of increased sediment yield in burned plots. Bars indicate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

CONCLUSIONS

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

Long abandoned lands colonised by pine forest showed lower capacity to return to the pre-fire conditions than recent-abandoned lands.

In plant communities dominated by seeder species, post-fire rainfall events showed a complex relation with the response of the system. Rain dynamics controlled plant response, whereas soil surface crusting, runoff and erosion were controlled by both rain dynamics and plant response.

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