P. pinaster recruitment after a wildfire in NW of Spain

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Summary

Pinus pinaster Ait, the conifer that occupies the largest forest area in the Iberian Peninsula, has also been the most affected by wildfire in the recent years. From 1966 to 2000, about 12,000 ha of *P.pinaster* have been annually destroyed by fire in Spain. Despite the abundant scientific literature on the response to fire of some Pinus species, there are very few studies on the natural regeneration of *Pinus pinaster*. A recently burned area in a *Pinus pinaster* stand on a relatively homogeneous slope of 25-40 %, NW oriented, was selected in the summer of 2003 in Orense (Galicia). The wildfire occurred on August 3rd 2003. 60 experimental plots were installed just after wildfire for seedlings sampling. The first sampling was made six months after fire (February 2004). The other sampling were carried out in May, July and September 2004. Mean seedling density at the end of the first year after wildfire was 3.5 plants/m^2 (2.2-4.8 plants/m^2). Seedling emergence was delayed until the first spring after wildfire. Mean accumulated mortality during that period was 31%. Maximum mortality peak was detected in May 2004. Variables influencing regeneration processes were also explored.

Introduction

Pinus pinaster Ait, the conifer that occupies the largest forest area in the Iberian Peninsula, has also been the most affected by wildfire in the recent years.

It is considered a fire-adapted species, usually showing abundant postfire regeneration (Gil and others, 1990; Vega and others, 2002; Tapias and others, 2004). Besides the canopy stored seed bank, fire regime (Gill, 1975; Whelan, 1995) and pre and post-fire management can also influence regeneration success (Pérez and Moreno, 1998; Martínez-Sánchez and others, 1999). Many other factors such as microsite characteristics, exposition, post-fire climate, competition can also play a decisive role (Vega, 2003; Madrigal, 2005; Vega and others, 2005 a and b). This variability makes very difficult to generalize a regeneration pattern after wildfire.

The aim of the study was to analyze the main *P. pinaster* recruitment variables the first year after wildfire in the S.E. of Galicia.

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Materials and methods

Study site

This study was carried out on Santa Marta hillslopes (41º 57' 10" N; 7º 23' 30" W; 550 m a.s.l.), located in Verín (Orense, N.W. Spain).

A recently burned area in a Pinus pinaster stand on a relatively homogeneous slope of 25-40 % , NW oriented, was selected in the summer of 2003. The wildfire occurred on August 3rd 2003. The study-site was selected by its apparent homogeneity in relation to tree characteristics and the availability of an adjacent unburned site with similar characteristics. Most of the tree crowns were totally scorched, but some patches of combusted crown trees due to torching during fire were interspersed within them. Stand density was 1400 trees ha^{-1} . Understory was dominated by Ericaceae (*Erica cinerea* L. and *Calluna vulgaris* (L.) Hull) and *Pterospartum tridentatum* plants.

Climate is Mediterranean with a slight continental influence. Average rainfall is about 800 mm $year^{-1}$ with a marked dry period in summer of three months. Mean annual temperature is 12 ºC. Soils are Alumi-umbric Regosols (Macías and Calvo, 2001) developed from a schist bedrock.

Experimental design

Sixty experimental plots (5 m x 5 m each) were installed just after wildfire. The first sampling was made six months after fire (February 2004). In the first sampling, all emergent *P. pinaster* seedlings were labelled by small metallic tags, measuring its height. In subsequent samplings, the number of dead seedlings was recorded and newly emerged seedlings were labelled. The other samplings were carried out in May, July and September 2004.

Immediately after wildfire, measurements of the remaining litter and humus layers cover and depth in all the experimental plots were made. Percentage of soil organic cover were visually estimated using a 20 cm x 20 cm quadrat in twenty systematically selected points in each plot. Remaining duff depth was measured on each corner of the quadrat. Tree density was also recorded.

Percentage of litter and plant cover installed from seed or resprouting after fire were visually estimated using a 70 x 70 cm quadrat in each plot.

Data analysis

Pearson correlation coefficient was used to examine the influence of a set of variables on *P. pinaster* recruitment. Final seedling density, accumulated emergence, and accumulated mortality in each plot were the dependent variables. Remaining duff thickness, vegetation cover, litter cover and soil depth for each plot and for the same periods were used as independent variables, respectively.

SPSS 13.0 (2004) statistical package was used for statistical analyses.

Results

Most of the *P. pinaster* seedlings emerged between the end of the winter and the beginning of the spring after wildfire when the greatest *P. pinaster* seedling density was recorded (*table 1*). The highest values of seedling mortality were detected in May 2004 (*table 1*).

Table 1- *Mean P. pinaster seedling density, emergence, mortality and height during the period after wildfire and before clearcutting (September 2003-September 2004). In brackets, standard error*.

Sampling date	Seedling density (plants.m^{-2})	Seedling emergence (%)	Mortality (%)
February 2004	1.68 (0.12)	36.77 (1.66)	4.7 (0.57)
April 2004	4.07 (0.29)	51.50 (2.57)	1.1 (0.20)
May 2004	3.74 (0.24)	8.79 (1.29)	15.7 (0.78)
June 2004	3.59 (0.23)	1.67 (0.26)	5.7 (0.71)
July 2004	3.55 (0.23)	0.73 (0.14)	2.3 (0.45)
September 2004	3.52 (0.23)	0.54 (0.23)	1.4 (0.27)

The range of variation of site characteristics variables is listed in *table 2*.

Table 2- *Variation of some selected variables immediately after wildfire. In brackets, standard error*.

Immediately after wildfire			Annual mean	
Remaining litter cover (%)	Remaining duff thickness (cm)	Relative duff thickness reduction (%)	Litter cover (%)	Vegetation cover (%)
0	1.4 (0.07)	47.9 (2.23)	41.5 (6.2)	4.5 (0.2)

Regression analysis suggested a positive influence of litter cover on *P. pinaster* recruitment (*table 3*). No significant correlations were found for mortality.

Table 3- *Correlations between mean variables measured during the first year following wildfire (n = 60).*

Dependent variable	Independent variable	Sign	r
Mean seedling density (plants.m^{-2})	Litter cover	+	0.500**
Accumulated seedling emergence (plants.m^{-2})	Tree density	+	0.263*
Seedling height (cm)	Litter cover	+	0.347**

* P < 0.05 ** P < 0.01

Discussion

Pine seed germination and seedling emergence takes usually place during the following post-fire wet season in the Mediterranean climate (Thanos and others, 1996; Izhaki and Ne'eman, 2000). In this case, seedling recruitment started in winter and was almost completed on early spring (88% of total emergency). The uniform distribution of precipitation throughout autumn and winter and the low temperatures just before emergence suggests that the emergence delay could have been caused by dormancy. Mean seedling density measured in this study at the end of the first year after wildfire was higher than the 1.1-1.2 seedlings m^{-2} observed by Valbuena and Calvo (1998) in the NW of Spain and Madrigal and others (2005) in *P. pinaster* stands in Central Spain. Very high regeneration (70 seedlings m^2) was measured in *P. pinaster* stands by Madrigal and others (2003) in the very serotinous provenance of Sierra Teleno (León, NW Spain). The seedling density measured in this study is fairly high and seems enough to guarantee the long-term regeneration of *P. pinaster* even with normal levels of mortality during the following years.

It is noteworthy the low mortality measured during the first year after wildfire compared with other previous studies in *P. pinaster* (Madrigal and others, 2005). This was probably due to the mild conditions of the summer 2004 when 71.8 mm of rain were recorded.

Litter cover has been found to be negatively correlated with seedling survival and growth (Pérez and Moreno, 1998). In our study, positive correlations of regeneration variables with percent of soil covered with litter were found. This result agrees with the finding of Castro and others (1990), Martínez and others (2002) and Madrigal and others (2005) in *P. pinaster* stands. In our case, this relationship could be an indirect effect of fire severity. Plots with scorched trees will have in the following months after wildfire more litter cover in the soil. These unburned crowns may have also less seeds damaged by heat than in the case of burned crowns, promoting a more effective seed dispersal.

Conclusions

Very low seedling mortality was measured the first summer after wildfire.

Seedling density measured at the end of the first year after fire guarantee *P. pinaster* regeneration success.

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