Competition factors influencing *P. pinaster* seedlings growth after wildfire and clearcutting in NW of Spain

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Summary

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 province (Galicia, Spain). The wildfire occurred on August 3rd 2003. 15 experimental plots were installed just after wildfire and 4 subplots (5 m x 5 m) were set up for seedlings sampling. One year after wildfire, in September 2004, the stand was harvested. To study the effect of different burned timber management on pine regeneration, a randomized block design was used with two different treatments: clearcutting + slash chopping (tractor with a mechanical chopper) and clearcutting + slash windrowing (manual). In November 2005, 250 *P. pinaster*, seedlings were selected, 147 in clearcutting + slash windrowing plots and 103 in clearcutting + slash chopping ones. Measurements of PAR, vegetation cover and height were made around each plant. Hemispherical photographs were also taken. Simple linear regression was used to analyze the influence of measured variables on seedling growth. Preliminary results showed that PAR was the variable most related with seedling growth between June and November 2005. Competing vegetation cover estimated visually showed acceptable correlations with seedling growth. A significant reduction in seedling growth was measured when competing shrub cover was higher than 25%.

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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. Many factors can play a decisive role in the post-fire regeneration process (Vega, 2003; Madrigal, 2005; Vega and others, 2005 a and b). Understory vegetation can affect the success of pine re-establishment by inter-specific competition for nutrients, water or light (Walstad and Kuch, 1987; De las Heras and others, 2002; Calvo and others, 2006). The competition effect on seedling growth is also an important issue for forest productivity objectives and makes necessary to evaluate the effect on growth of competition to develop a vegetation management strategy.

Numerous competition indices have been developed to quantify interspecific competition (e.g. Mac Donald and others, 1990; Wagner and Radosevich, 1991). Competition for light seemed to be the most critical factor in the initial stablishment of conifers and measures of light condition have been proved that effectively work as evaluators of the effects of interspecific competition (Mac Donald and others, 1990;Wagner and Radosevich, 1991; Gendron and others, 1998; Wang and others, 2000).

The aim of the study was to analyze the usefulness of different vegetation cover estimators on *P. pinaster* seedlings growth after two different clearcutting and slash management treatments.

Materials and methods

Study site

This study was carried out on Santa Marta hillslopes (41º 57' 10" N; 7º 23' 30" W; 550m 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. 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 $year^{-1}$. 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. One year after wildfire, in September 2004, the stand was harvested. To study the effect of different burned

timber management on pine regeneration, a randomized block design was used with two different treatments: clearcutting + slash chopping (tractor with a mechanical chopper) and clearcutting + slash windrowing (manual). Height of seedlings was measured each time from February 2004 to November 2005.

In November 2005, 250 *P. pinaster*, seedlings were selected, 147 in clearcutting + slash windrowing plots and 103 in clearcutting + slash chopping ones. With each seedling as the center, a circular plot with radius 50 cm was installed around each seedling to visually estimate competing shrub cover (in percentage). Measurements to obtain a mean value of competing shrub height were also made. Photosinthetically active radiation (PAR) was measured at the top of every seedling with the quantum sensor of CIRAS-2 (PP Systems).

Hemispherical photographs were used to estimate percent cover of competing vegetation. They were carefully taken benting over each seedling to exclude them from the image. Images were treated using the Gap Light Analyzer (Version 2.0) (Frazer and others, 1999). Also, soil depth was measured near each selected seedling.

Data analysis

Data were analyzed using non parametric linear regression. Dependent variable was relative growth between June and November 2005. Independent variables were: PAR, shrub cover estimated visually, shrub cover estimated through photographs, shrub height, the relationship between *P. pinaster* and competing shrub height and soil depth.

Seedlings were grouped according the estimated shrub cover in each plot in three categories: shrub cover from 0-25%, 25-50% and > 50%. Differences in relative growth between categories were analysed using a Kruskal-Wallis test.

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

Results

A summary of the measures of shrub competition and seedling growth is listed in *table 1*.

Table 1- *Range of variation of studied variables*

Variable	Mean	Range of variation
Competing shrub cover estimated visually (%)	32.7	0-100
Competing shrub cover estimated through photographs (%)	0.24	0-1.31
PAR (μmol m^2 s^{-1})	221.5	40.0-512.0
Soil depth (cm)	16.6	7-38
Seedlings height (cm)	25-8	3-70
Seedling relative growth (%)	4.8	0-32
Competing shrub height (cm)	36-3	0-80

The four competition measurements were acceptable predictors of the relative growth rate of *P. pinaster* seedlings (*table 2*). However, simple measures as shrub height or shrub cover estimated visually were more effective in reflecting its influence on seedling growth than more sophisticated ones. Soil depth was also significantly correlated with seedling growth.

Table 2.- *Correlations between P. pinaster seedling growth and the selected variables for the whole data set.*

Independent variable	Sign	Tau
PAR (μmol m^2 s^{-1})	+	0.330
Competing shrub cover estimated visually (%)	-	0.250
Competing shrub cover estimated through photographs (%)	-	0.138
Competing shrub height (cm)	-	0.229
Shurb/seedling height	-	0.419
Soil depth (cm)		0.381

$P < 0.01$

When each set of data is considered, the best correlations were found for seedlings of the slash chopping treatment (*table 3*).

Table 3.- *Correlations between P. pinaster seedling growth and the selected variables for the seedling in the slash windrowed and slash chopping treatments, separately.*

Independent variable	Data set	Sign	Tau
PAR (µmol m^2 s^{-1})	Slash chopping	+	0.453
	Slash in windrows	+	0.177
Competing shrub cover estimated visually (%)	Slash chopping	-	0.389
	Slash in windrows	-	0.211
Competing shrub cover estimated through photographs (%)	Slash chopping	-	0.295
	Slash in windrows	-	----
Competing shrub height (cm)	Slash chopping	-	0.575
	Slash in windrows	-	----
Shrub/seedling height	Slash chopping	-	0.595
	Slash in windrows	-	0.246
Soil depth (cm)	Slash chopping	+	0.480
	Slash in windrows	+	0.412

$P < 0.01$

Statistical differences in seedling growth were found when the percentage of shrub cover was higher that 50% (*fig. 1*). This effect was more clear in the seedling of slash chopping treatment that significantly reduced their growth when shrub cover was higher than 25% (*fig. 2a*).

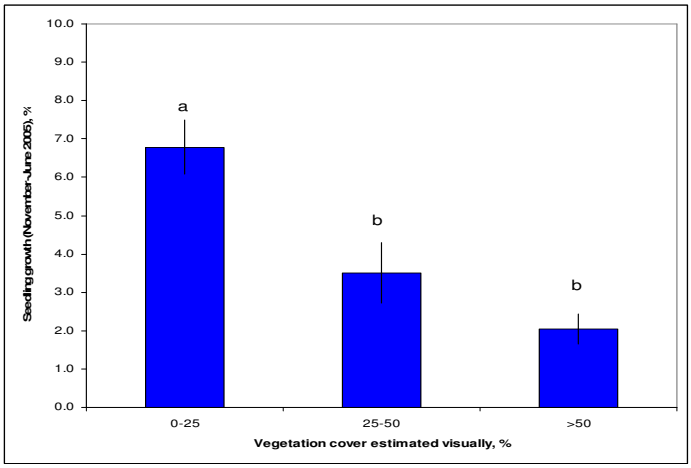

Figure 1- Relative seedling growth between June and November 2005 according to shrub cover (estimated visually) classes.

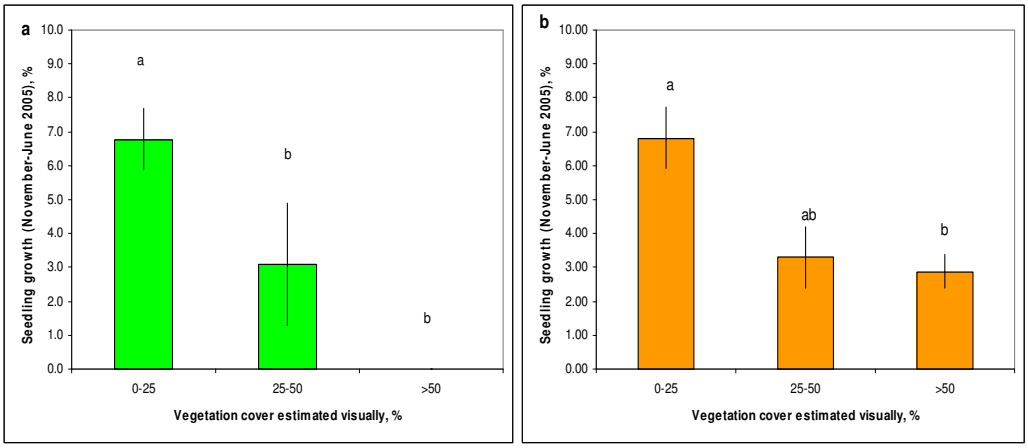

Figure 2 - Relative seedling growth between June and November 2005 according to shrub cover (estimated visually) classes for seedlings of the slash chopping (a) and slash windrowed treatment (b) .

Discussion

Competing shrub played a significant and negative effect on *P. pinaster* growth as this it is considered a light tolerant species. Previous studies (Calvo and others, 2006) have found a negative influence of woody vegetation cover on *P. pinaster* seedling density. In our case, it was detected a progressive reduction in seedling growth as vegetation cover increased. This effect seemed to be stronger in seedlings that suffered the slash chopping treatment after clearcutting, reflecting that these seedlings are suffering a more pronounced stress.

Results of this study did not support the idea about the superiority of PAR or hemispherical photographs measurements in comparison with other (Jobidon, 1992; Wang and others, 2000). As in our case, Ter Mikaelian and others (1999) did not found an advantage of measuring PAR in comparison of visual estimations of cover.

The significant correlation between seedling growth and soil depth bring out the influence of water availability in seedling development.

Conclusions

Light is a significant parameter regulating the growth of *P. pinaster* seedlings.

Simple competition indices such as ratio shrub height/seedling height or shrub cover estimated visually seemed to adequately reflect the influence of competing shrub on *P. pinaster* seedling growth.

Clearing of competing shrub when its cover is higher than 25% would enhance *P. pinaster* growth.

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