# Effect of post-fire thinning on *Pinus pinaster* Ait. stem radial growth

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## Summary

*Pinus pinaster* usually exhibits high recruitment level after wildfire. When seedling density is extremely high early thinning has been recommended. In 2004, an eight-year-old *Pinus pinaster* stand regenerated after fire in Ourense (north-western Spain) was selected for the study. From a very high initial seedling density, three different treatment levels were selected: control (unthinned, 40,200 seedlings/ha), intense thinning (3,850 seedlings/ha), and very intense thinning (1,925 seedlings/ha). In February 2006, 10 trees per treatment were destructively sampled. For each tree, one stem disc was extracted at 30 cm height, and radial growth was calculated for the last seven years (five before thinning and two after thinning). Before thinning no significant differences were observed between treatments. After thinning, radial growth was significantly higher in thinned trees. Differences between two different intensities were observed only the first year after treatment. Intense thinning showed a radial growth 2.09 times higher than control the first year after the treatment and 3.79 the second year. Very intense thinning showed a radial growth 2.71 times higher than control the first year after the treatment and 4.10 the second year. This result suggest that post-fire thinning is a recommended tool to improve seedling growth in overstocked stands, and enhance a faster stand development after fire.

## Introduction

*Pinus pinaster* Ait., is frequently considered a fire-adapted species (McCune 1988; Tapias and Gil, 2000; Vega, 2000; Tapias and others, 2004), and usually exhibits a good post-fire recruitment. When conditions are optimal, this regeneration can be even extremely dense (Vega and others, 2002). In this case, heavy thinning has been recommended to regulate seedling competition, improve seedlings growth and form, accelerate seed production to safeguard species permanence, and to reduce fuel accumulation, especially in areas with short fire return period (Rodríguez–Soalleiro et al., 1997; Vega et al., 2002). Overstocked stands are excellent candidates to analyse the effects of intense silvicultural systems, such as heavy thinning, on seedling growth. Few studies have analysed the effect of this kind of silvicultural treatment on *Pinus pinaster* stands regenerated after fire (Vega and others, 2002; Madrigal and others, 2004).

The objective of this study was to analyse the initial effect of two thinning intensities carried out in a post-fire-regenerated 8-year-old *Pinus pinaster* stand on seedling radial growth.

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# Materials and methods

## Area of study

The study was conducted in a young postfire-regenerated *Pinus pinaster* stand in Laza – Orense, NW Spain – (42º5'43''N; 7º31'9''W). Forest fire took place on September 1996, affecting 575 ha. The site is in a west-facing slope of 20% inclination, at 700 m a.s.l. Climate is Mediterranean, with scarce summer rainfall and slight continental influence (Carballeira and others, 1983). Mean annual precipitation is 1338 mm, and mean annual temperature is 9.6 ºC. Soils are alumi-umbric regosols and leptosols (Macías and Calvo, 2001), about 30 cm depth. Main shrub species were *Pterospartum tridentatum* (L.) Willk., and *Halimium lasianthum* subsp. *alysoides* (Lam.) Greuter.

In February 2003, in an area presenting good pine regeneration (mean density of 54000 seedlings/ha and mean seedling height of 1.6 m) 15 20x20 m plots were radomly stablished. In each plot, in 10 2x2 m plots, total seedlings were counted, and height, crown width, basal diameter and diameter at the base of live crown were measured for all seedlings (*table 1*). Shrub height, cover and biomass were also measured for each plot.

**Table 1** - *Seedlings mean characteristics by treatment before thinning*

| Parameters | Very intense thinning | Intense thinning | Control |
|---|---|---|---|
| Seedling density (seedlings/ha) | 70200 (*6974*) | 53700 (*6240*) | 40200 (*4803*) |
| Basal diameter (cm) | 2.83 (*0.17*) | 3.09 (*0.15*) | 3.36 (*0.17*) |
| Total height (cm) | 154.36 (*9.89*) | 159.09 (*10.36*) | 168.34 (*8.31*) |
| Diameter at the base of live crown (cm) | 2.20 (*0.13*) | 2.38 (*0.12*) | 2.60 (*0.14*) |
| Crown width (cm) | 46.17 (*1.01*) | 51.23 (*2.64*) | 55.21 (*3.24*) |
| Shrub height (cm) | 59.68 (*6.27*) | 60.67 (*3.23*) | 74.91 (*5.96*) |
| Shrub cover (%) | 20.37 (*4.67*) | 28.96 (*3.81*) | 24.74 (*3.12*) |
| Shrub biomass (kg/ha) | 3019 (*671*) | 3698 (*853*) | 4528 (*812*) |

Standard error in brackets

## Silvicultural treatments

In February 2004 heavy thinning treatments were carried out in 10 of the 15 plots randomly selected, by clear strip felling. A forest tractor with a chain stripper was used to thin between leave strips, and manual brush-cutters were used to thin within leave strips to achieve the desired density. Thinning slash was left on site. In five plots a very intense thinning treatment was carried out, leaving a residual density of 1,925 seedlings/ha. In the other five treated plots, thinning was intense (IT), (3,850 seedlings/ha). This second treatment simulated another more conservative alternative and it allowed comparing seedling response. The other five plots (NT) were left unthinned as control, with a mean density of 40,200 seedlings/ha. In treated plots shrub was cleared out as well.

## Tree sampling

In February 2006 stem discs were extracted at 30 cm height from 10 trees from each treatment representing all size range of the study area. Geographycal north was painted in each disc. Selected discs did not present knots or irregularities. The surface of the stem discs was smoothed by sanding. Digital photographs were taken of each disc, and were analysed using the software ImageJ 1.36b (National Institute of Health, USA: http://rsb.info.nih.gov/ij/). Radial widths (0.01 mm) for the last seven years (five before thinning and two after the treatment) was measured in four radii (north, south, east and west) for each disc.

We used meteorological data from a meteorological station located 15 km from the study site to analyse the influence of meteorological parameters (mean maximum and minimal temperature from April to August, mean monthly rainfall from April to August) on seedling radial growth during the study period.

### *Statistical analysis*

We used a repeated–measures analysis of variance (ANOVA) to test the effect of thinning on absolute and relative radial growth. Time was the within–subject factor, whereas treatment was the between–subjects factor with three levels (very intense thinning, intense thinning and no thinning). Mean comparisons among treatments were performed with Student–Newman–Keuls test. Assumptions of ANOVA were previously checked. To analyse the relationship between meteorological parameters and seedling radial growth, linear regressions were carried out. The statistical package SPSS 11.0 for Windows (SPSS Inc. 2004) was used for analysis.

## Results

No significant differences between treatments were observed before thinning in absolute and relative radial growth (*fig. 1*). First year after thinning, thinned seedlings showed a significantly ($p<0.05$) higher absolute radial growth than control. Moreover, very intense thinned seedlings presented significantly ($p<0.05$) higher radial growth than intense thinned seedlings. However, the second year after thinning, no significant difference was found between both thinning treatments. Again, thinned seedlings showed significantly ($p<0.05$) higher absolute radial growth in this second year after treatment compared with control. Intense thinning showed a radial growth 2.09 times higher than control the first year after the treatment and 3.79 the second year. Very intense thinning showed a radial growth 2.71 times higher than control the first year after the treatment and 4.10 the second year.

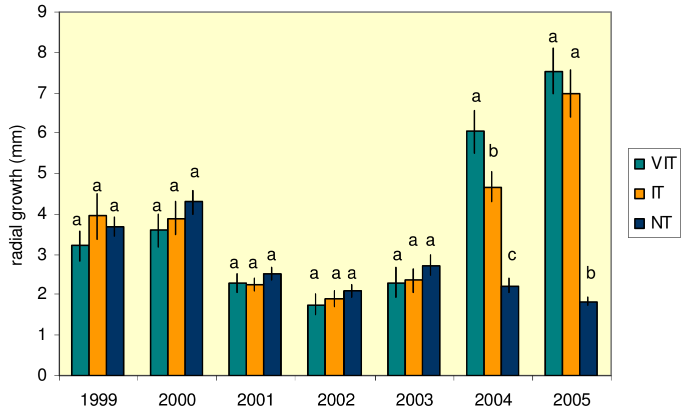


**Figure 1** – Absolute radial growth per treatment. Latin lyrics: significant differences between treatment values (p<0.05). Vertical bars: standard error. (VIT=very intense thinning; IT=intense thinning; NT=no thinning).

Significantly (p<0.05) higher relative radial growth was observed in thinned seedlings during two years following thinning compared with control (*fig. 2*). No differences were observed between very intense and intense thinned seedlings in relative radial growth during the whole study period.

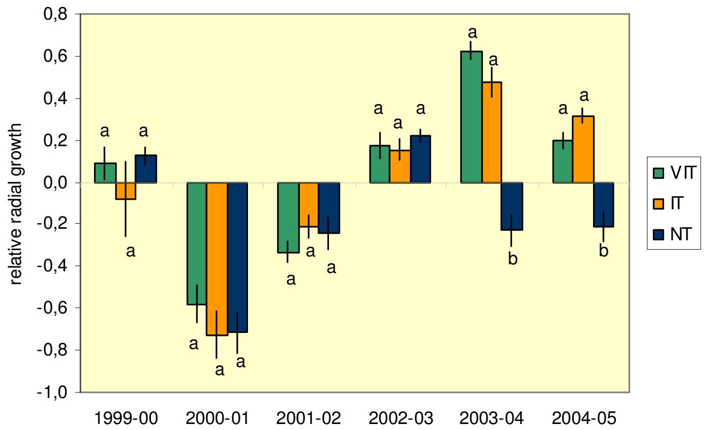


**Figure 2** – Relative radial growth per treatment. Latin lyrics: significant differences between treatment values (p<0.05). Vertical bars: standard error. (VIT=very intense thinning; IT=intense thinning; NT=no thinning).

No significant relationship was observed between meteorological parameters and mean absolute radial growth before thinning (*fig. 3*). However a general tendency was observed, with higher radial growth during years of lower mean monthly maximum temperatures and higher precipitation from April to August.

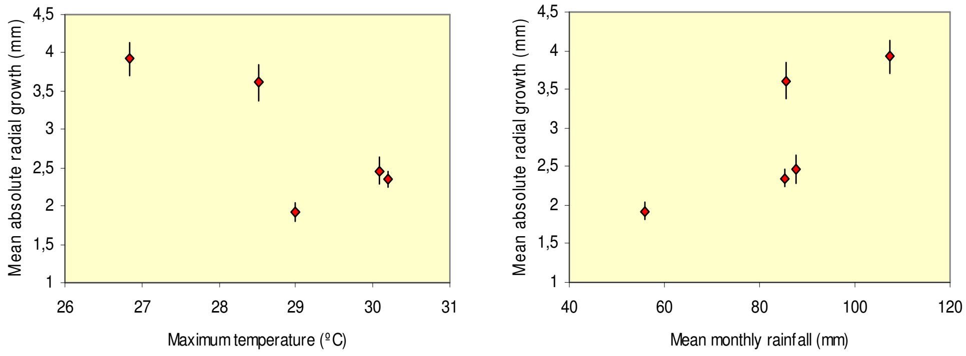


**Figure 3** – Relationship between mean absolute radial growth before thinning and maximum temperature (left) and mean monthly rainfall (right) from April to August. Vertical bars: standard error.

However, if control seedlings are analysed separately, for the whole study period, significant relationships ($p<0.05$) were observed between absolute radial growth and mean monthly maximum temperature and mean monthly precipitation from April to August (*fig. 4*).

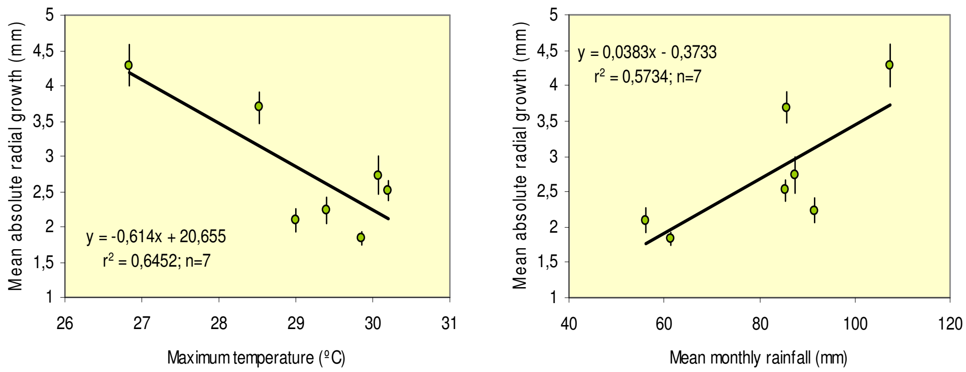


**Figure 4** – Relationship between mean absolute radial growth for unthinned seedlings and maximum temperature (left) and mean monthly rainfall (right) from April to August. Vertical bars: standard error.

## Discussion

The increase of diameter growth of thinned seedlings compared with control seedling could be a consequence of an improvement of soil water availability and photosynthetic capacity, and the increase of humus mineralization (Aussenac, 2000). Different studies in the Mediterranean area have observed increment of seedling diameter growth after this very early treatment (Ne'eman and others, 1995; Tapias and others, 1997; Pardos, 1998; Vega and others, 2002; González-Ochoa and others, 2004; Madrigal and others, 2004). Moreover, this severe canopy aperture increase wind action, and this higher exposure may result in an increase the allocation to tissues with structural functions (Coutts and others, 1999; Kneeshaw and others, 2002). A higher diameter growth with a more intense treatment has been reported in other pine studies, as a consequence of a lower competition intra – specific and higher radiation exposure (Peltola and others, 2002; Madrigal and others, 2004; Tong and others, 2005).

Climatic variables can be limiting factors for ring width. Maximum temperatures may affect negatively radial stem growth (Nyakuengama and others, 2002). Rainfall during growing season can also affect ring width due to increase soil water availability (Lebourgeois, 2000; Nyakuengama and others, 2002).

## Conclusions

Thinning resulted in an increment in ring width, probably as a consequence of the improvement of growth conditions. The fast and high intensity growth after thinning could be consequence of high intensity treatments and juvenile age of the stand. Higher intensity thinning resulted in larger ring width, at least for the first year after thinning. Post-fire thinning can be a recommended silvicultural tool to mitigate growth decrease in overstocked juvenile stands.

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