



Contents lists available at ScienceDirect

Forest Ecology and Management

journal homepage: www.elsevier.com/locate/foreco

The influence of fire severity, serotiny, and post-fire management on *Pinus pinaster* Ait. recruitment in three burnt areas in Galicia (NW Spain)

José A. Vega*, Cristina Fernández, Pedro Pérez-Gorostiaga, Teresa Fonturbel

Centro de Investigación e Información Ambiental (CINAM)-Lourizán, Consellería de Medio Ambiente e Desenvolvemento Sostible, Xunta de Galicia, P.O. Box 127, 36080 Pontevedra, Spain

ARTICLE INFO

Article history:

Received 28 February 2008
Received in revised form 4 July 2008
Accepted 7 July 2008

Keywords:

Wildfire
Fire severity
Pinus pinaster
Regeneration
Forest harvesting
Slash management

ABSTRACT

The effect of fire severity and post-fire management on *Pinus pinaster* recruitment was evaluated in three burnt areas in Galicia (NW Spain) exhibiting different levels of serotiny. Three sites were sampled, each of which had two of the following levels of fire severity: combusted crown, scorched crown and unaffected crown. Viable seed rain was closely related to the canopy cone bank and stand serotiny level. Soil burn severity also favoured seed dispersal. Relative germination success increased with soil burn severity whereas initial and final seedling density depended on both the canopy cone bank and soil burn severity. A positive influence of fire severity on the final/initial seedling density and final density/total seed dispersal ratios was also observed.

Different post-fire management options were used at each experimental site following local operational routines. Harvesting and slash logging resulted in significantly higher seedling mortality. However, at the end of the study period, seedling density in all stands was sufficient to ensure re-establishment of *P. pinaster* forest.

© 2008 Elsevier B.V. All rights reserved.

1. Introduction

Fire is considered a major ecological factor in the Mediterranean ecosystems, particularly in pine forests (e.g. Naveh, 1994; Ne'eman et al., 2004; Pausas and Verdú, 2005; Fernandes and Rigolot, 2007; Pausas and Verdú, in press; Pausas et al., in press). Despite the abundant scientific literature on the post-fire regeneration of some Mediterranean *Pinus* species (e.g. Saracino and Leone, 1994; Martínez-Sánchez et al., 1995, 1999; Daskalidou and Thanos, 1996; Thanos et al., 1996; Ne'eman, 1997; Spanos et al., 2000; Espelta et al., 2003; Pausas et al., 2003), there is much less information on the post-fire natural regeneration of *Pinus pinaster* (Castro et al., 1990; Luis et al., 2002; Martínez et al., 2002; Gallegos et al., 2003; Madrigal et al., 2005a,b; Calvo et al., 2008) and many aspects related to the post-fire establishment success remain unexplained. Fire severity has been recognized as a relevant factor that affects *Pinus halepensis* post-fire pine recruitment (Pausas et al., 2003; Broncano and Retana, 2004), but specific information on its influence on *P. pinaster* post-fire regeneration is lacking. Some mechanisms and processes that influence post-fire seed germination and initial establishment of pine seedlings may be affected by the severity of fire. On one hand, severe fire may

potentially affect the canopy seed bank by total or partial combustion of cones and seeds. *P. pinaster* seed germination is not heat-stimulated. On the contrary, the probability of germination decreased on seeds directly subjected to temperatures higher than 130–200 °C (Martínez-Sánchez et al., 1995; Escudero et al., 1999; Reyes and Casal, 2002; Alvarez et al., 2005; Torres et al., 2006). These results suggest that crown fires could have a negative effect on the success of post-burn regeneration. However, field studies relating crown damage levels and seed germination for *P. pinaster* are very few (Martínez et al., 2002).

On the other hand, the soil seed bank may also be drastically reduced during wildfire although the viability of pine seeds stored in soil appears to be poor and the contribution of this bank negligible (Ferrandis et al., 1996; Izhaki and Ne'eman, 2000). Seedbed characteristics are also markedly modified after severe fires. Ash deposition may have negative effects on pine post-fire regeneration (Ne'eman et al., 1992, 1993; Reyes and Casal, 1998, 2004; Eshel et al., 2000; Izhaki et al., 2000; Vega et al., 2005a,b), although severe fires can simultaneously increase nutrient availability and enhance seedling growth (Ne'eman et al., 1992; Pausas et al., 2003; Eugenio et al., 2006).

Serotiny is common among pine species in fire prone ecosystems (Agee, 1998; Keeley and Zedler, 1998) and seeds stored in serotinous cones are released after fire favouring a massive germination (e.g. Daskalidou and Thanos, 1996). Considerable variation in the level of serotiny exists among *P. pinaster*

* Corresponding author. Tel.: +34 986 805003; fax: +34 986 856420.
E-mail address: jvega.cifal@siam-cma.org (J.A. Vega).