Effects of fire on tree survival and regeneration in a Mediterranean ecosystem

Filipe Xavier Catry, Francisco Castro Rego, Miguel Nuno Bugalho, Tito Lopes, Joaquim Sande Silva, Francisco Moreira

Instituto Superior de Agronomia - Centro de Ecologia Aplicada 'Prof. Baeta Neves', Tapada da Ajuda 1349-017 Lisboa, Portugal, E-mail: fcatry@mail.telepac.pt

Abstract: Portugal is the only European Mediterranean country where the annual average burnt area has increased in the last two decades. Although forest fires at national level annually represent very important losses, few studies evaluated the mortality and the capacity of auto-regeneration of the different tree species in burnt areas. After a wildfire that occurred in September 2003, we started a research project in a public protected area in central west Portugal. The main goal of this study, still ongoing, is to evaluate the post-fire regeneration capacity of different tree species occurring in the country. We expect to quantify the survival/mortality rates of selected tree species in relation to variables such as fire severity, tree height and diameter, and evaluate species regeneration strategies as well as their growth rates after fire disturbance. In this study 667 trees from 11 species were selected for monitoring, namely: *Castanea sativa, Crataegus monogyna*, *Eucalyptus globulus*, *Fraxinus angustifolia*, *Olea europaea* var. *sylvestris*, *Pinus pinaster*, *Pinus pinea*, *Pistacia lentiscus, Quercus coccifera*, *Quercus faginea* and *Quercus suber*. Results obtained two springs after fire, show that almost all broadleaved trees (9 species) survived to the fire. Contrarily, the majority of coniferous trees died after the fire. Despite the very low mortality observed in broadleaved trees, most of them didn't regenerate from the crown, but only from the base, trunk or roots, which means that the recovering process will be much slower. Exceptions to this were cork oak and eucalyptus. Within native species, *Quercus suber* is by far the most resilient to fire. For most part of the monitored tree species, which resprouted from the base of the trunk, *Eucalyptus globulus* was the one that recovered faster, followed by *Fraxinus angustifolia* and *Quercus faginea*.

Keywords: *Post-fire recovery; mortality; tree species; natural regeneration.*

Catry, F.X. Rego, F.C., Bugalho M.N., Lopes T., Silva, J.S. & Moreira, F. (2006). Effects of fire on tree survival and regeneration in a Mediterranean ecosystem. *In*: Viegas, D.X. (Ed.); *Proceedings of the 5th International Conference on Forest Fire Research.* CD Rom (5 pp.). ADAI, Figueira da Foz.

1. Introdution

Forest fires in Portugal constitute a problem that have worsened, with Portugal being the only European Mediterranean country where the annual average burnt area has increased in the last two decades, from 100.000 to 155.000 hectares (EC, 2005). In 2003 and 2005, about 426.000 and 325.000 ha were burnt, respectively (DGRF, 2006). Although forest fires represent very important environmental, social and economic losses at national level, very few studies evaluated the mortality and the capacity of auto-regeneration of the different Mediterranean tree species in the burnt areas.

In the end of 2003 we started a research project in a public protected area (the Tapada National de Mafra - TNM), after a wildfire that affected about 3000 hectares at Mafra municipality, and about 70% of the total area of TNM. The main goal of this study, still ongoing, is to evaluate the post-fire regeneration capacity of different tree species occurring in Portugal. We expect to quantify the survival/mortality rates of selected tree species in relation to variables such as fire severity, tree height and diameter, and evaluate species regeneration strategies (sprouting from base, roots, trunk, and crown or seed establishment) as well as their growth rates after fire disturbance. In this project we are also monitoring the growth and survival of trees planted after the fire to compare the benefits of the two recovering options (planted *versus* natural regeneration), and monitoring the impacts of wild herbivores on the regeneration process. Here we only present the mortality rates observed 2 years after the fire, as well as growth rates, for several tree species that are present in the area. During 2007 we expect to present final results on mortality rates 3 years after fire, related with tree characteristics and fire severity, and also the recovery state of all the trees that survived.

2. Methods

Study area

The study area is located in central west Portugal (38°58′30″ N, 9°15′52″ W), 8 km far from the sea and about 30 km northwest of Lisbon, in a public protected area (TNM), that was severely affected by a wildfire in September 2003. The altitude in the study area ranges between 100 and 350 m and the soils are humic cambisols derived from sandstone. The mean annual precipitation is 798 mm, and the three driest months are June, July, and August, accounting for only 3.1% of total annual rainfall. Mean annual temperature is 14,6ºC. The vegetation is mainly dominated by mixed forest and shrublands. Forest is composed by broadleaved and coniferous species, and shrublands are dominated by genus *Erica* spp. and *Ulex* spp..

Plot selection

The study area (885 ha) was mapped and divided into a regular grid of 500 m, and 15 points (centers of each grid) were randomly selected in the burnt area as the initial point for field transects. In the beginning, we needed to change the initial

location of some of these points because they were located in areas without trees. Transects were established at each point to assess fire intensity and the vegetative condition of each tree.

Data collection and analysis

This study began three months after the wildfire, and a total of 667 trees from 11 species were selected for monitoring (minimum of 30 trees for each species). We monitored the regeneration process of the most common tree species in the burnt area, namely: *Castanea sativa* Mill. (chestnut), *Crataegus monogyna* Jacq. (weissdorn), *Eucalyptus globulus* Labill. (eucalyptus), *Fraxinus angustifolia* Vahl. (narrowleaf ash), *Olea europaea* L. var. *sylvestris* Brot. (wild olive), *Pinus pinaster* Ait. (maritime pine), *Pinus pinea* L. (umbrella pine), *Pistacia lentiscus* L. (evergreen pistache), *Quercus coccifera* L. (kermes oak), *Quercus faginea* Lam. (Portuguese oak), and *Quercus suber* L. (cork oak). For each tree the following data were collected: species, total height, diameter at breast height (DBH), the part of the tree affected by the fire – crown damage and bole char severity (a measure of fire intensity), and regeneration state (presence, type and growth of sprouts). Diameter for *Pistacia lentiscus*, which can be considered as a small tree or shrub, was not measured at breast height (DBH) but at the base of the trunk.

We analysed the database to access the mortality rate for each species in the first and in the second year after the wildfire. We also analysed the growth of the sprouts for each tree species which regenerated from the base of the trunk (modal height), in the second Spring after the fire

3. Results and discussion

Preliminary results obtained show that almost all the broadleaved trees (9 species), survived to fire (Table 1). Based on the knowledge of the study site, we can say that the few broadleaved trees that didn't survive were already in bad physiological conditions before the fire (mainly *Castanea sativa*). The only publications we found about mortality in the 9 broadleaved species we studied concerns *Quercus suber* (discussed below), *Quercus coccifera* and *Pistacia lentiscus*; for the last two species no mortality was observed (Konstantinidis & Tsiourlis, 2002).

Contrarily to the broadleaved, the majority of the coniferous trees (2 species) died after the fire. The results obtained suggest that *Pinus pinea* is a little more resistant than *Pinus pinaster*. Rigolot (2004) presented results on the *Pinus pinea* mortality in SE France, where 39% trees died after the fire; this author also concluded that this species is less fire sensitive than *Pinus halepensis* (which reached a mortality of 69%).

Table 1. Mortality for each species in the first and in the second year after the fire, and number of sampled trees.

Species	Mortality Rate (%)		Sampled Trees
	1st Year	2nd Year	
Castanea sativa (Chestnut)	17	27	30
Crataegus monogyna (Weissdorn)	0	0	74
Eucalyptus globulus (Eucalyptus)	0	0	31
Fraxinus angustifolia (Narrowleaf Ash)	0	0	72
Olea europaea var. *sylvestris* (Wild Olive)	0	0	80
Pinus pinaster (Maritime Pine)	90	90	52
Pinus pinea (Umbrella Pine)	60	64	42
Pistacia lentiscus (Evergreen Pistache)	0	0	70
Quercus coccifera (Kermes Oak)	0	0	71
Quercus faginea (Portuguese Oak)	1,2	2,4	82
Quercus suber (Cork Oak)	1,6	1,6	63

Most part of broadleaved trees that survived to fire did not regenerate from the crown, but only from the base, trunk or roots, which means that the recovering processes will be much slower. Exceptions to this were *Quercus suber* and *Eucalyptus globulus*. Within native species, *Quercus suber* was by far the most resilient to fire, as it seems to quickly regain its initial condition. The insulating properties of cork apparently can provide adequate protection to the dormant buds occurring along the tree trunk and canopy (Silva & Catry, *in press*; Pausas, 1997). Several authors reported the positive relation between the probability of survival and the cork thickness of *Quercus suber*, showing that mortality rate can range from 0 to 100% (Barberies *et al*., 2003; Pausas, 1997; Cabezudo *et al*., 1995; Lamey, 1893). In our study area, the trees were not cork harvested for at least 30 years or more, thus it seems that the deep bark has been very effective in the protection against the fire, and 98% of trees resprouted vigorously from the crown.

For most part of the monitored tree species which resprouted from the base of the trunk, the observed sprouts height (mode) in the second spring after the fire varied from 60 to 350 cm. Results are shown in Figure 1.

Catry, F.X. Rego, F.C., Bugalho M.N., Lopes T., Silva, J.S. & Moreira, F. (2006). Effects of fire on tree survival and regeneration in a Mediterranean ecosystem. *In*: Viegas, D.X. (Ed.); *Proceedings of the 5th International Conference on Forest Fire Research.* CD Rom (5 pp.). ADAI, Figueira da Foz.

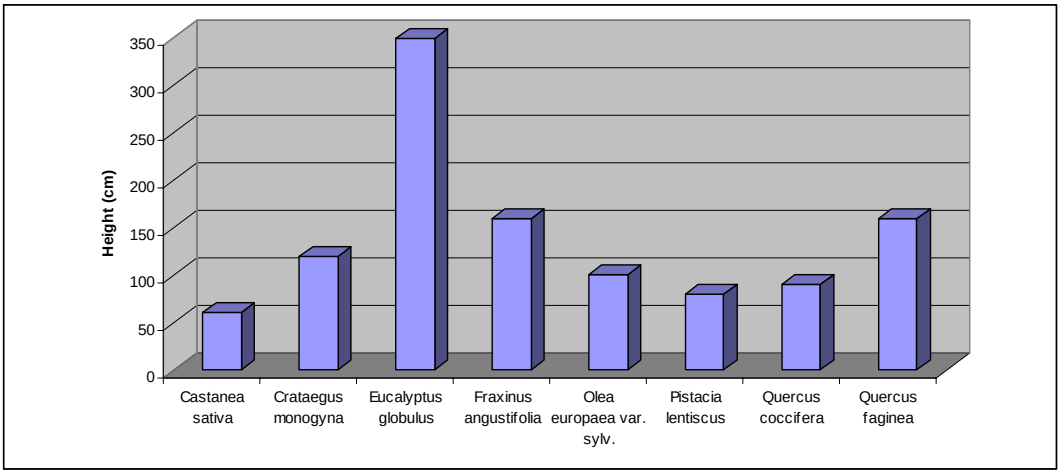

Figure 1. Modal height (cm) of the sprouts for each tree species which regenerated from the base of the trunk, in the second Spring after the fire.

The species with larger growth was *Eucalyptus globulus*, with almost 350 cm height, followed by *Fraxinus angustifolia* and *Quercus faginea*, with about 150 cm height. The species with lower development was *Castanea sativa*. The heights observed for *Quercus coccifera* and *Pistacia lentiscus* are very similar with the ones observed by Konstantinidis & Tsiourlis (2002) two springs after the fire (100 and 80 cm, respectively).

4. Conclusions

Despite the very low mortality recorded in broadleaved trees, most of them did not regenerate from the crown, but only from the base, trunk or roots, which means that the recovering processes will be much slower. Exceptions to this were *Quercus suber* and *Eucalyptus globulus*. Within native species, *Quercus suber* was by far the most resilient to fire. Contrarily, the majority of the coniferous trees didn't survive after the fire and in these cases, the regeneration process occurs mainly from seeds. For tree species which resprouted from the base of the trunk, *Eucalyptus globulus* was the one that recovered faster, followed by *Fraxinus angustifolia* and *Quercus faginea*.

The knowledge of the different species response after fire, still poorly or not studied for many Mediterranean species, constitutes a fundamental aspect in the management of burnt areas, as well as in fuel management using prescribed burning.

Acknowledgements

The present study is supported by Fundação para a Ciência e a Tecnologia, Project POCI/AGR/61407/2004. We also would like to acknowledge to the Tapada Nacional de Mafra Administration and personnel for their logistic support.

References

Barberis, A., Dettori, S. and Filigheddu M.R., 2003. Management problems in Mediterranean cork oak forests: post-fire recovery. *Journal of Arid Environments,* 54, 565-569.

Cabezudo, B., Latorre, A. and Nieto, J., 1995. After fire regeneration in a *Quercus suber* forest in the South of Spain (Istan, Malaga). *Acta Botânica Malacitana,* 20, 143-151.

EC, 2005. *Forest fires in Europe 2004*. Official Publication of the European Commission, S.P.I.05.147 EN.

DGRF, 2006. *Incêndios florestais – Relatório de 2005*. Divisão de Defesa da Floresta Contra Incêndios. Direcção-Geral dos Recursos Florestais, Lisboa.

Konstantinidis, P. & Tsiourlis, G., 2002. Preliminary results of the post-fire resprouting growth of typical Mediterranean maquis species (Sithonia Peninsula, N. Greece). *In*: Viegas, D.X. (Ed.) *Proceedings of the Conference on Forest Fire Research & Wildland Fire Safety*. ADAI, Luso, CD Rom, 7 pp..

Lamey A., 1893, *Le chêne-liège, sa culture et son exploitation*, Paris Nancy, Berger-Levrault et Cie éditeurs.

Pausas J., 1997. Resprouting of *Quercus suber* in NE Spain after fire. *Journal of Vegetation Ecology,* 8, 703-706.

Rigolot, E., 2004. Predicting postfire mortality of *Pinus halepensis* Mill. and *Pinus pinea* L.. *Plant Ecology*, 171, 139-151.

Silva, J.S. & Catry, F., 'in press'. Forest fires in cork oak (*Quercus suber*) stands in Portugal. *International Journal of Environmental Studies*.