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THE EFFECT OF BURNED PINE TREES ON POST FIRE GERMINATION AND ESTABLISHMENT

G. Ne'eman, H. Lahav and I. Izhaki.

Department of biology, Oranim, University of Haifa, Tivon 36910, Israel.

INTRODUCTION

Plant species are classified according to their reaction to fire as "seeders", "resprouters", or intermediate types (Keeley and Zedler 1978). Most perennial species of the sclerophilous Mediterranean vegetation in Israel are resprouters, not killed by the fires (Naveh 1973). The consequence is that fire does not change the spatial distribution of the plants. Pinus halepensis and Cistus salvifolius are obligate seeders (Lahav 1989, Trabaud and Oustric 1989), and Rhus coriaria a facultative one. The death of the plants as a result of a wild fire is followed by massive germination in the winter. Many factors are known to affect seed germination and establishment after fire (Trabaud 1987, Kelley 1991). Most of the studies deal with the burned area as homogeneous and uniform. In reality, every forest is a mosaic of big trees, small ones, bushes and gaps (Olsvig-Whittaker 1988). Consequently fire intensity varies a lot at different locations in the forest (Christensen 1987). Old burned pine trees have an influence on the germination and establishment of different plant species. Big black ash circles with almost no plants can be observed under the canopy of the old burned trees for at least two years after the fire (Kutiel and Kutiel 1989, Lahav 1989). In the present study we present field data on the differential influence of the old burned pine trees on the germination and establishment of some plant species. The possible influence on the development of the forest in the future is discussed.

METHODS

The study site is a natural Pinus halepensis Mill. forest, located on Mt. Carmel Israel (32° 44' N 35° 01' E), 320 m above sea level and 7 km from the sea shore. A study site was established after a massive fire in September 1989, where we observed the resilience of the burned forest. The results of this study were collected during the first 18 months after the fire. A uniform 70 X 70 m plot was chosen for this study due to its relative homogeneity. Thirty burned pine trees with different trunk perimeters were selected at random. The density and height of Pinus halepensis, Cistus salvifolius,
and Rhus coriaria were measured within 0.5 X 0.5 m portable wire quadrat. The quadrats were divided into three groups: "zone 1" - all quadrats between the trunk and half of the distance to canopy border; "zone 2" - all quadrats between the canopy border and the first group; and "zone 3" - all quadrats outside the canopy border. The last group represents the area between the trees, not beneath the direct influence of them. One-way analysis of variance (ANOVA) procedure was used to evaluate the effect of different zones and burned trunk perimeters on seedling density and seedling height.

RESULTS

Seedling density of Pinus and Cistus per 1 square meter was significantly higher out of the border of the burned canopy (zone 3) than under the burned canopy itself (zone 1 and 2, for Pinus $F_{2,6}=4.20$, $P<0.05$; for Cistus, $F_{2,8}=20.38$, $P<0.0001$, Fig. 1). Seeding density pattern of Rhus was the opposite, with a peak near the burned trunk (zone 1), and with almost no seedlings out of the burned canopy (zone 3) ($F_{2,6}=7.45$, $P<0.001$, Fig. 1). Seedling density was ranked as Cistus>Pinus>Rhus in each zone (Fig. 1). No significant differences in the height of all species were detected in the different zones (for Pinus, $F_{2,6}=2.87$, $P>0.05$; for Cistus, $F_{2,6}=0.36$, $P>0.05$; and for Rhus $F_{2,6}=2.02$, $P>0.05$, Fig. 2).

![Figure 1. Seedling density as a function of different zones beneath the burned pine canopy.](image)

Pinus and Cistus seedling density was negatively correlated with the perimeter of Pinus burned trunk ($r=-0.65$, $P<0.0001$, $n=30$; $r=-0.51$, $P<0.005$, $n=30$, respectively), while
the opposite phenomena was observed for Rhus seedlings ($r=0.52$, $P<0.005$, $n=30$, Fig. 3). Seedling density of Pinus and Cistus was lower under big burned trees than under small ones (for Pinus, $F_{2,30}=7.40$, $P<0.001$; for Cistus, $F_{2,23}=1.68$, $P>0.05$, Fig. 3). Pinus, Cistus and Rhus seedlings' height was correlated with trunk perimeter ($r=0.32$, $P>0.05$, $n=30$; $r=0.48$, $P<0.01$, $n=30$ and $r=0.59$, $P<0.01$, $n=19$) respectively (Fig. 4).

![Figure 2](image1)

**Figure 2.** Seedling height as a function of different zones beneath the burned pine canopy.

![Figure 3](image2)

**Figure 3.** Seedling density beneath the burned pine canopy as a function of pine tree size.
DISCUSSION

Spatial patterns in vegetation can be the result of microsite heterogeneity of the habitat where different plant species grow in different niches (Auerbach and Shmida 1987). Trees were found to change soil nutrient status on forest floor (Klemmedson 1987). Such a change can influence the distribution of plant species. Mediterranean oak trees were found to be the major cause for microsite differentiation of species in their community (Olsvig-Whittaker et al. 1991). The effect of the trees may continue even after their deaths. The burned Pinus halepensis trees have a dominant influence on the spatial distribution of seedlings (Kutiel and Kutiel 1989, Lahav 1989, Izhaki et al. 1991, Ne'eman et al. 1991).

Heat stimulation, charred wood and ash are regarded, in general, as positive factors in seedling recruitment after fire. As the pine forest is not homogeneous, fire intensity, temperatures, charred wood and ash accumulation are not homogeneous either (Christensen 1987). The differential reaction of plant species to those environmental factors may explain the spatial pattern described in our results. Big trees have more biomass, which serves as fuel in a forest fire, than small trees have. The result is a higher temperature for a longer time period during the fire, and larger amounts of ash after it. This is also true for the comparison of three zones located under and around the same tree. Near the trunk (zone 1) there is more accumulation of biomass which causes higher intensity of fire and more ash than at the border of the burned canopy (zone 2), and than
outside it (zone 3). Only one species (*Rhus coriaria*) germinates and grows better under the burned canopies of the big trees (Izhaki et al. 1991). *P. halepensis* and *C. salvifolius* are more abundant outside than under the burned canopies (zone 3), and under small than under big trees. The high temperatures on soil surface (Raison et al. 1986) may explain the seed bank mortality of most species. Most of *P. halepensis* seeds are dispersed from cones after the fire (Naveh 1973, Lahav 1989) and therefore may not suffer from those high temperatures. Post fire ash provides nutritional conditions which have a positive affect on the development of many plant species (Kutiel and Naveh 1987a, 1987b). In his review Keely (1991) does not mention the possible influence of ash on germination. Moderate amounts of ash may improve germination of certain seed species (Lahav 1989, Ne’eman unpublished data). Large amount of ash may cause salinity and high osmotic values which will prevent seed imbibition and germination. This may be another reason for the low germination under the canopies of the big burned trees. Seed bank mortality and high amounts of ash may also explain the almost total absence of annual species beneath the burned trees (Ne’eman et al. 1991). The few species that do grow there seem to be adapted to germination after heat treatment (Lahav 1989) and to the high osmotic values in the ash.

The results of the differential species specific effect of the burned pine trees is that the few pine seedlings which did germinate under the burned canopies have both reduced inter- and intraspecifc competition and improved mineral nutrition. It is hypothesized that the big burned pine trees will be replaced by the pine seedlings growing under them, and consequently they will build the future pine forest. Such conclusions may have practical importance in management of burned Mediterranean pine forests.

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REFERENCES


