Optimization of silvicultural treatments in *Pinus halepensis* Mill. stands for reducing wildfire severity

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Introduction

Greece is a Mediterranean country in which the problem of fire is great, due to the climatic conditions prevailing in summer (high temperatures and drought). Having encountered the high cost demanding for the suppression actions, the efforts had now concentrated to the modification of fuel stratum characteristics based on silvicultural interventions.The research was conducted at the even aged forests of Kassandra Peninsula which occupies an area of about 35000 ha and where *Pinus halepensis* reaches its optimal growth. In the current research an attempt is being made to quantify the optimum combination of silvicultural treatments in order to efficiently reduce wildfire's potential spread and intensity.

Materials and Methods

The quantification is based on the establishment of 52 experimental plots of 500 m^2 and the estimation of the silvicultural characteristics of a sample of *n*=1488 individuals of *Pinus halepensis* Mill. In all sample plots the silvicultural parameters measured for all individuals, were: the number of stems per plot, the diameter (DBH, cm) at breast height for trees with diameter > 4 cm, basal area (G, m^2), total height (H, m), crown length (L, m) and canopy cover (%). In addition, slope and aspect topographic parameters were estimated for each sample plot. Critical wildfire hazard indicators such as Torching (TI) and Crowning Index (CI) estimated before and after the establishment of silvicultural treatments via the NEXUS (Scott and Reinhardt 2001) wildfire simulator software. NEXUS incorporates the most commonly used models of surface and crown fire behavior to simulate its full range possible in a forest stand. It offers the possibility to modify canopy characteristics inde-pendently in order to assess the effects of silvicultural treatments on fire behavior. In the current study several surface fuel models were used as inputs covering a wide range of the typical Mediterranean vegetation.

Discussion

From the results, it is concluded that combinations of simple silvicultural interventions decreased the fire parameters in all cases. The fireline intensity was reduced more than 65% to almost 66%, flame length to 54% and spread rate to 9,5%. In addition, the majority of the crown fires were characterized as "Condition" type while in 10 cases the fire remained to the surface. Before the treatments fully Active crown fire was the main type observed, along with 6 Passive and 5 "Condition" crown fires .

Results

Unmanaged stands

The mean stand parameters are presenting in the Table 1. The potential mean wildfire characteristics based on NEXUS software are presenting in Table 2.

The weather inputs are corresponding to Normal Summer conditions as per Rothermel (1991). The imputed 20ft wind speed was equal to 21,7mi/h (35km/h). For the simulations Rothermel's near maximum crown fire model was used by setting ROSMhigh multiplier to 1,7 (Scott 2006). The mean value of the Wind Reduction Factor was 0,125 (Albini and Baughman 1979) and the mean slope 27%. The understory vegetation composed by kermes oak (2m height), low maquis (1,5 height) and high maquis (3m height), typical of the Mediterranean vegetation of Greece (Dimitrakopoulos 2002).

Table 1. Stand parameters

	Crown bulk density (kg/m^3)	Crown fuel load (ton/ac)	Crown base height (m)	Canopy cover (%)	Basal area (m^2/ha)
Mean	0,146	4,284	5,913	0,564	36,466
St. Dev.	0,061	1,883	2,697	0,143	16,495

Table 2. Mean wildfire characteristics

	Fireline intensity (kW/m)	Spread rate (m/min)	Flame length (m)	CI (mi/h)	TI (mi/h)	Critical flame length (m)
Mean	33071	32,93	27,15	16,04	15,06	2,72
St. Dev.	7527	4,06	4,53	5,44	68,08	0,88

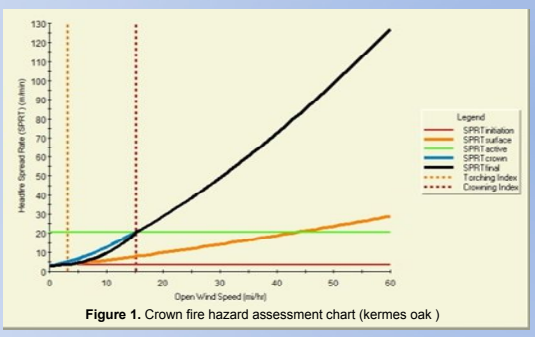

Figure 1. Crown fire hazard assessment chart (kermes oak)

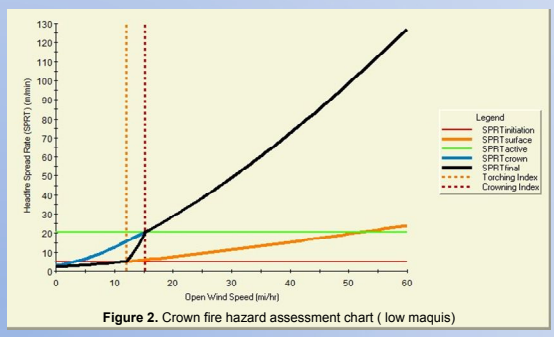

Figure 2. Crown fire hazard assessment chart (low maquis)

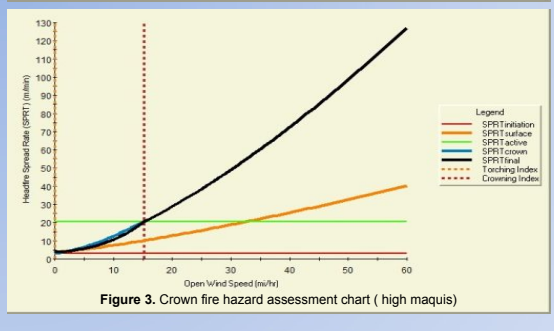

Figure 3. Crown fire hazard assessment chart (high maquis)

Managed stands

Three major fuel stratum modifications constituted the base for the simulated silvicultural interventions:

-Removing the understory of each stand and replacing by pine litter.

-Decreasing crown density by removing the 15% of the initial basal area.

-Increase height to live crown (to 3m). The new conditions leaded to dead fuel moisture content reduction (1%) and to WRF increase to 0,135.

Table 3. Mean wildfire characteristics after treatments

	Fireline intensity (kW/m)	Spread rate (m/min)	Flame length (m)	CI (mi/h)	TI (mi/h)	Critical flame length (m)
Mean	11275	29,81	12,49	20,63	260,64	3,21
St. Dev.	6636	14,58	6,36	29,08	105,7	0,79

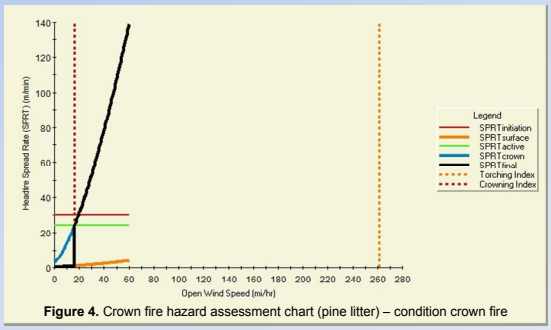

Figure 4. Crown fire hazard assessment chart (pine litter) – condition crown fire

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