Effects of Various Site Treatments on 2R Establishment of *Pinus radiata* D. Don in the Blackwood Valley of W.A.

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SUMMARY

Five methods of establishing second rotation (2R) *Pinus Radiata* D. Don on a site in the Blackwood Valley, W.A. were tested to determine which method resulted in best growth in the initial five years.

A random plot design comprising three blocks, each with the five treatments, was established in Lewana plantation. The treatments were burning and mulching , both with and without the application of fertiliser, and a control treatment to simulate first rotation plantations. Analysis was performed on height and diameter measurements taken over a five-year period. The levels of scrub and pine wilding regeneration in each treatment and hence associated fire hazard were also assessed. No follow up weed control was applied.

The best results were achieved with mulching of residual first rotation (1R) logging slash on site with a standard application of a 60 g/tree nitrogen-phosphorus fertiliser. This produced the greatest tree growth, measured regularly for five years after planting. Survival was better than 90 per cent.

Mulching apparently inhibited the development of scrub species, and provided greater retention of moisture and nutrients, resulting in increased pine growth.

INTRODUCTION

In the Blackwood Valley situated between Bridgetown and Nannup in the lower south-west of Western Australia, about 17 000 ha has been planted to *Pinus radiata* D. Don. The deep fertile soils within the valley provide an ideal site for pine afforestation.

Harvesting of the early first rotation (1R) plantings has commenced. The general method for second rotation (2R) establishment was to burn the logging slash, which reduced the fire hazard and provided easy access for planting, but possibly resulted in the reduced productivity reported in 2R plantations in South Australia by Keeves (1966).

Fire volatizes much of the nitrogen. Other nutrients are mineralised or volatized, and then leached out, making them unavailable to plants and significantly reducing growth rates (Grier 1975). Burning also results in increased abundance of understorey species and unwanted pine wilding regeneration. This creates a fire hazard and unpleasant working conditions for further tending. A site preparation technique was required to promote maximum growth rates, while also reducing the fire potential, in the establishment phase of 2R crops.

An alternate method for 2R establishment was to mechanically crush the slash into a mulch, which may counter the possible loss of nutrients caused by burning and produce superior growth rates.

The objective of this study was to determine a 2R establishment technique which would:

(1) produce increased growth rates in the pine;

(2) minimise the development of flammable scrub amongst the young fire-sensitive pines;

(3) minimise competition to the planted pines from scrub and pine seedling regeneration.

METHODS

A compartment in Lewana plantation near Nannup, W.A. was selected for the study. The 15-year-old compartment suffered extensive damage from cyclone Alby in April 1978, so was subsequently clearfelled. Although this was not a full rotation for *P. radiata*, similar problems caused by logging debris for 2R establishment existed.

The study area was divided into three contiguous blocks, each of which was divided into five plots of 0.033 ha. In August 1978 the following treatments were applied randomly within each block (Fig. 1):

(1) control - logging debris was scraped clear with a bulldozer, taking care not to disturb the top soil, and planted seedlings were fertilised;

(2) logging debris was burnt, and fertiliser applied to planted seedlings;

(3) logging debris was burnt, but seedlings were not fertilised;

(4) logging debris was mulched by crushing with a bulldozer, and fertiliser applied to planted seedlings;

(5) logging debris was mulched, but seedlings were not fertilised.

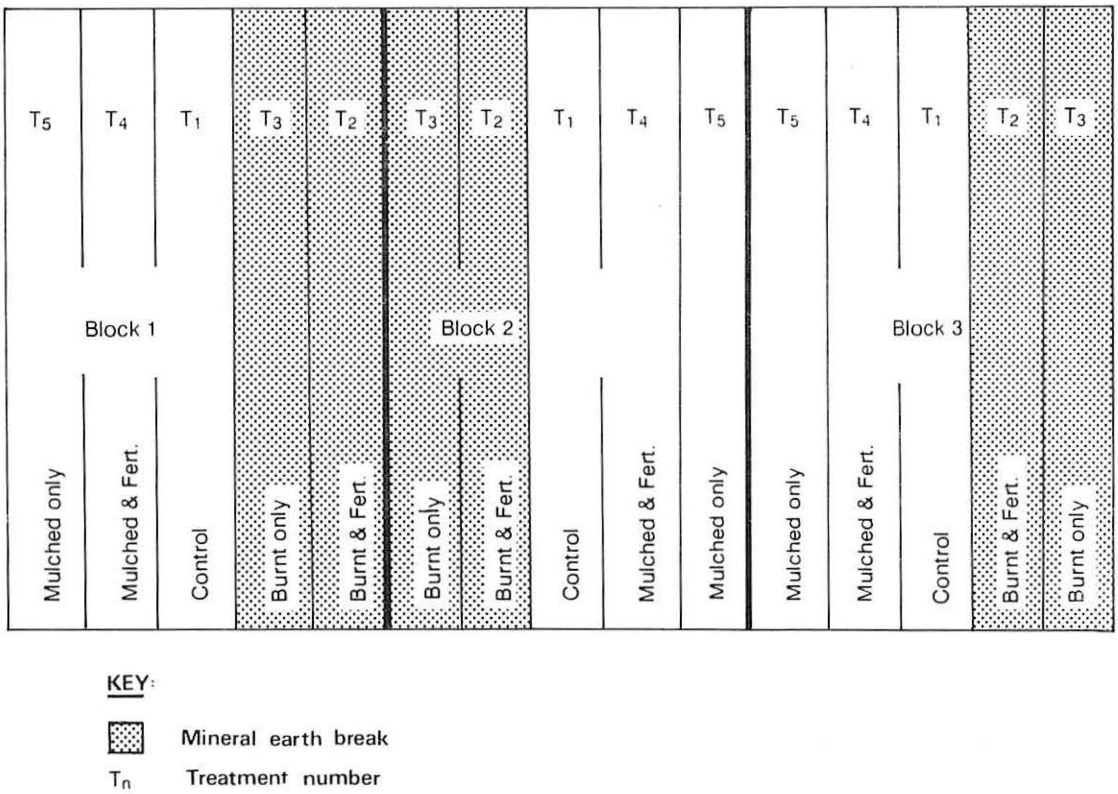

Figure 1:
Plot layout of five treatments for 2R pine establishment.

Details of the burning regime used, including fire rate of spread, flame height and intensity were recorded (Table 1).

Table 1
Summary of Fire Data From Establishing Burning Treatments

Fuel weight	Needle bed	10 t/ha (x = .3 m deep)
	Slash	60 t/ha (x = 1 m deep)
	Cover	80% ground cover of slash
Weather	Temperature	21°C
	Relative Humidity	43%
	Mean wind speed (2 m)	6.4 km/hr
	Mean wind direction	north
Fire behaviour	Mean head fire flame height	3 m
	Mean rate of spread	100 m/hr
	Intensity	1200-2000 kw/m

Open-rooted *P. radiata* seedlings were planted at 3.6 x 2.4 m spacing in September 1978, one month after site preparation was completed and while soils were still very moist. Each treatment contained 30 trees, consisting of three rows of ten trees.

Agras No. 1 (nitrogen-phosphorous fertiliser) was applied to seedlings in the relevant treatments at a rate of 60 g/tree. The parameters measured in the trial were height and diameter of the pines. Assessments of understorey species and pine wildings were also made. In 1979, 1980, 1981 and 1983 heights of all trees in each treatment were measured. In 1983, tree diameter at breast height over bark (d.b.h.o.b.) was measured for all planted trees.

Initially, five 1 m^2 quadrats were randomly located in each plot and the number of plants of *Acacia* spp., *P. radiata* regeneration (wildings), other native species and exotic weed species was estimated. However, by 1983 increased variation between plots in scrub density necessitated the use of belt transects to sample plant numbers and cover. Five transects, each measuring 5 x 2 m, were randomly located in each treatment. Fire hazard was rated according to the number of competing plants per hectare.

Analysis of variance and the Student-Newman-Keuls multiple range test were used to determine significant differences between the treatments. To test for the effect of treatment on stem taper, the slope of regressions of tree height to diameter were tested using a variation of the t-test (Zar 1974).

RESULTS

Survival was satisfactory, at more than 90 per cent, in all treatments.

Tree height

The mulching plus fertiliser treatment (treatment 4) produced the best height growth over the initial five years (Fig. 2). Analysis of variance showed a significant difference ($p < 0.05$) in tree height between treatments but no significant difference between the blocks. By 1983 all treatments, except 2 and 5, were significantly different from each other ($p < 0.05$).

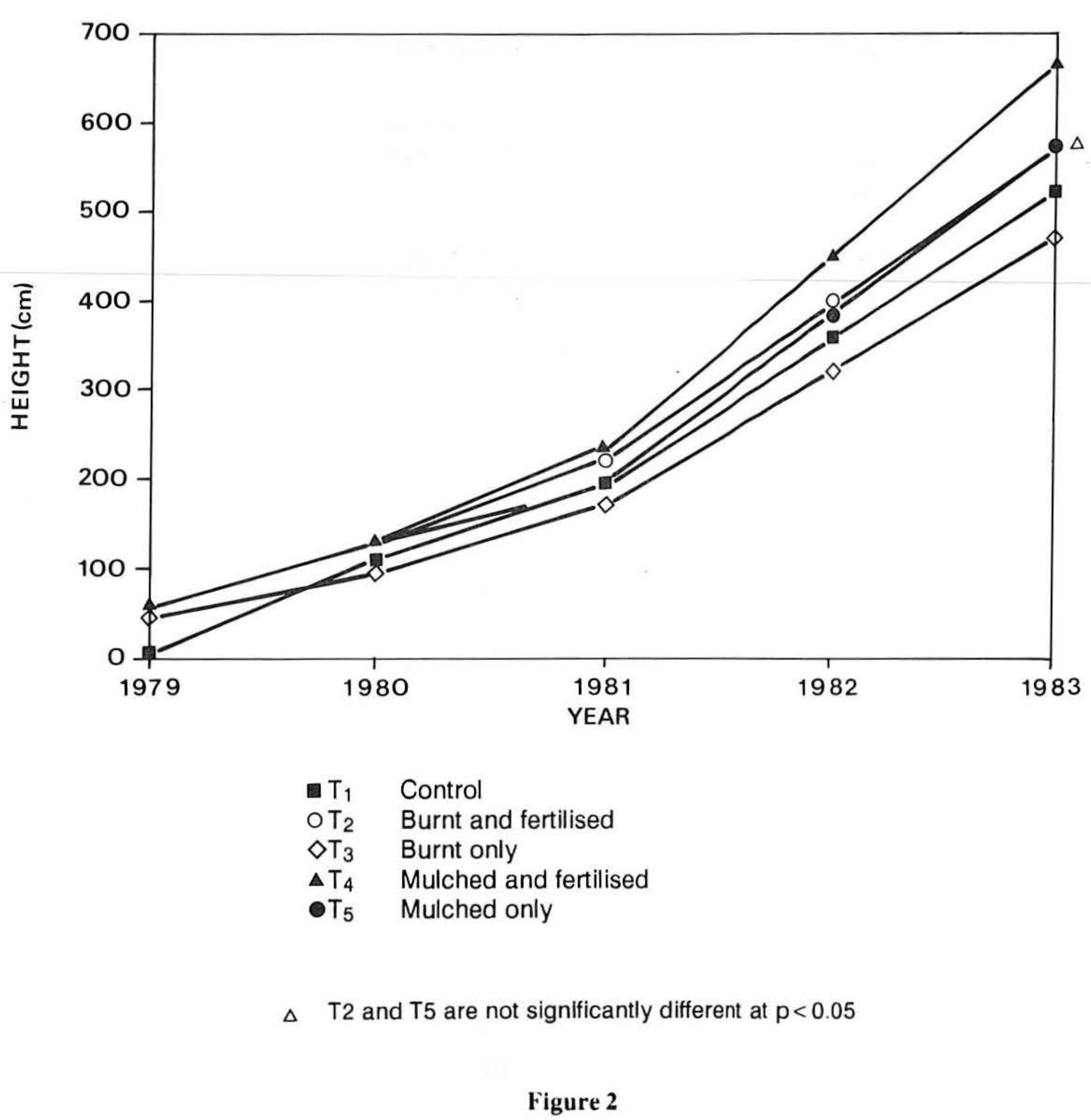

Figure 2

Height growth of five 2R treatments over five years.

Tree diameter

Trees in the mulched, fertiliser treatment (treatment 4) grew faster over the first five years then trees in all other treatments (Table 2). Analysis of variance showed a significant difference between treatments ($p < 0.05$). Treatment 4 was significantly different from all other treatments, but there was no difference between treatments 1 and 2 or 2 and 5.

Table 2
Variation in diameter for each site treatment by age 5 years.

T	T3	T1	T2	T5	T4
x	5.147	6.359	6.627	7.232	8.239

Treatments underlined are not significantly different at $p < 0.05$.

■ T_1	Control	▲ T_4	Mulched and fertilised
○ T_2	Burnt and fertilised	● T_5	Mulched only
◇ T_3	Burnt only		

Stem taper, as shown by differences in height-diameter regressions, was significantly different in the burnt treatments (treatments 2 and 3) ($p < 0.05$). These trees were less tapered than those in other treatments (Fig. 3).

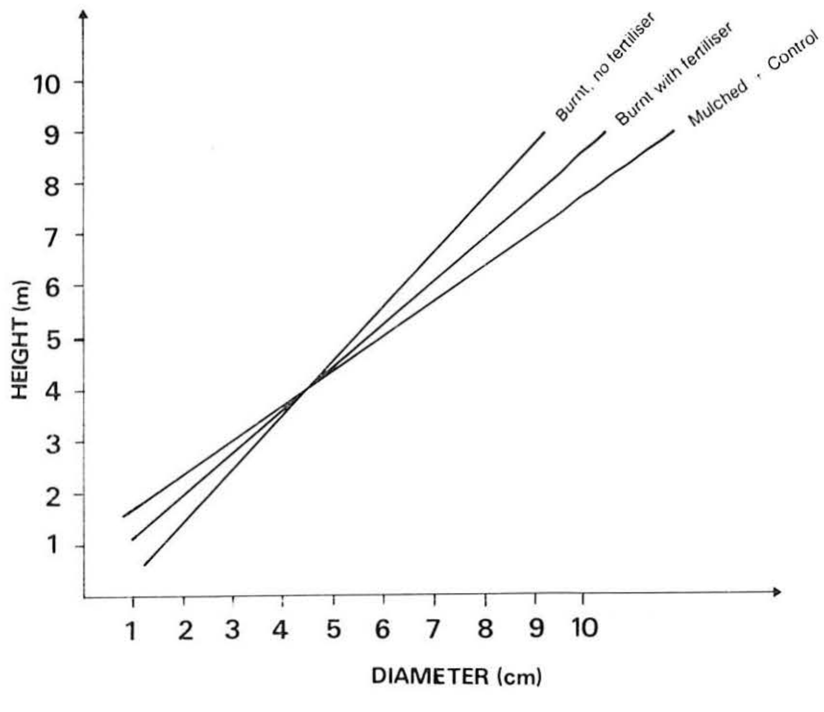

Figure 3
Regressions of height and diameter of *P. radiata* in different treatments five years after establishment.

Understorey species

The dominant understorey species was *Acacia pulchella*, which was present in all treatments. It was most prevalent in the control (treatment 1), and then in the burnt plots (treatments 2 and 3) where, after five years, there were 5 600 stems/ha compared with 2 300 stems/ha in the mulched plots (Fig. 4). The maximum population was in the second year after the treatment.

Other species found in low numbers were *Hibbertia* spp., *Macrozamia reidlei*, *Pteridium esculentum* and *Persoonia elliptica*. Exotic grass species occurred in all plots, but with no significant difference between treatments.

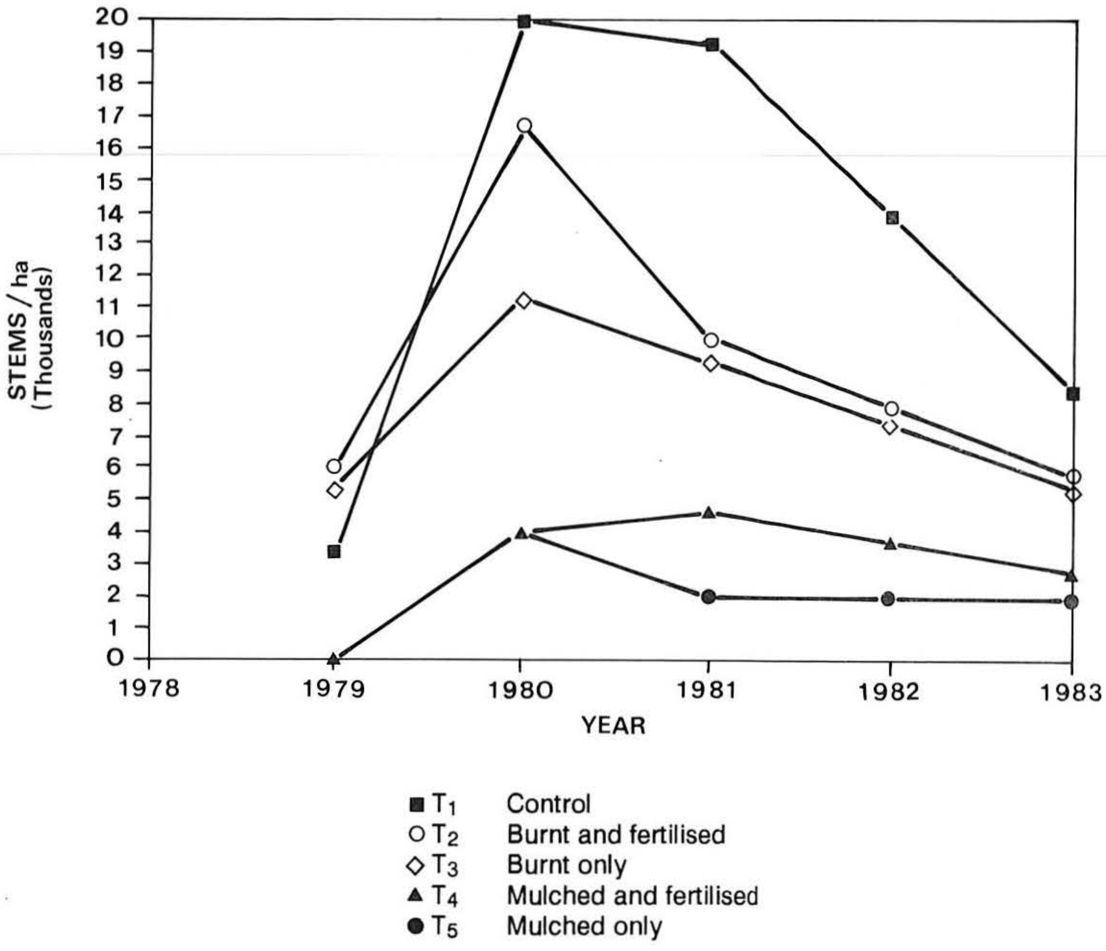

Figure 4

Mean number of *Acacia pulchella* plants in each treatment.

Flammable scrub (fire hazard).

Burnt plots carried no fuel, therefore provided no fire hazard for the first two years. However, after age 5 years, they carried three times the scrub biomass of mulched plots (Fig. 4). The mulched plots contained an estimated 70 t of slash and needlebed initially, based on the data for burnt plots given in Table 1, but by age 5 years all of the needlebed and much of the slash had decomposed into the soil. The control plots followed a similar level of fire hazard to the burnt plots.

Pine regeneration

By 1983, five years after planting, wildings occurred in all treatments in low numbers (fewer than 2 000 stems/ha) with no significant difference between treatments (Fig. 5). In the mulched, no fertiliser treatment (treatment 5), the numbers by age 3 years had reached 7 000, then declined.

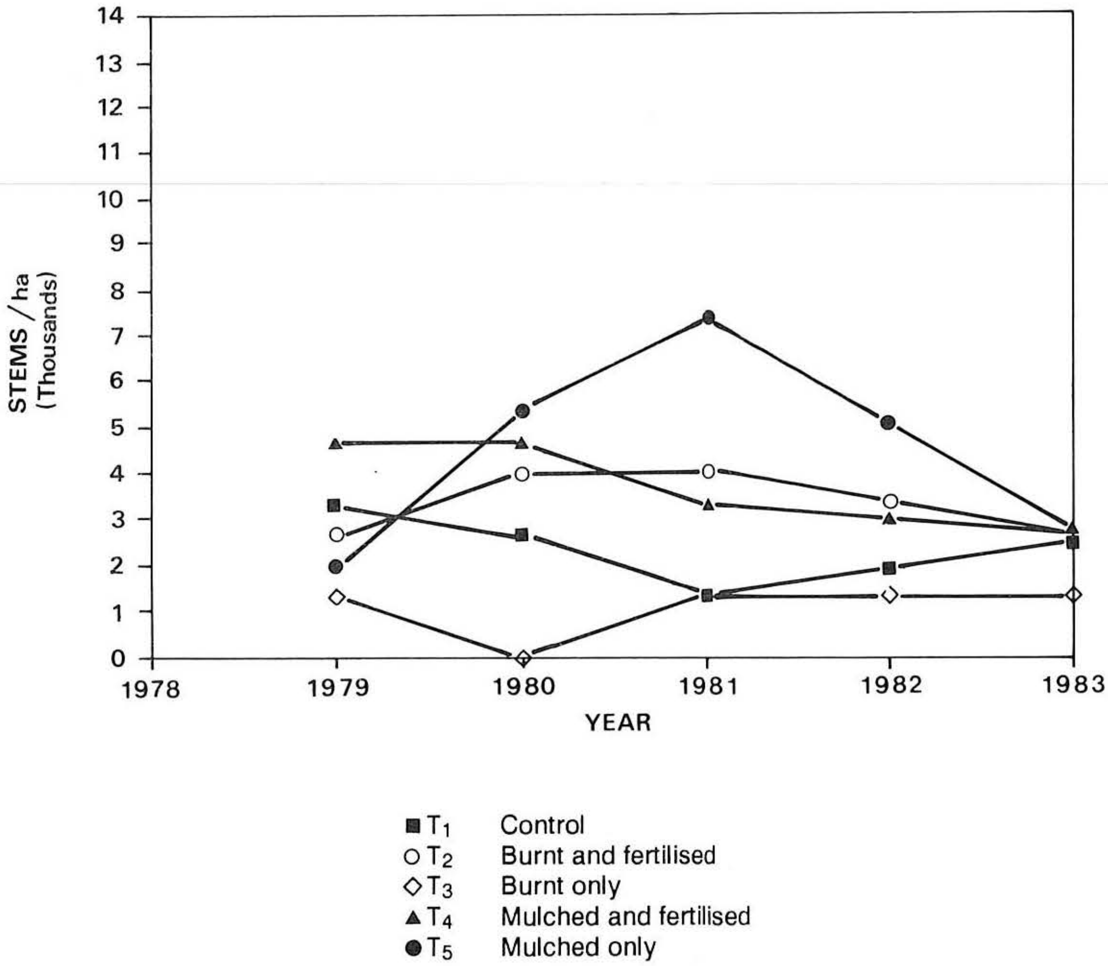

Figure 5

Mean number of *P. radiata* wilding regeneration in each treatment.

Plate 1

Control treatment (treatment 1), five years after establishment.

Plate 2
Burnt plus fertiliser treatment (treatment 2), five years after establishment.

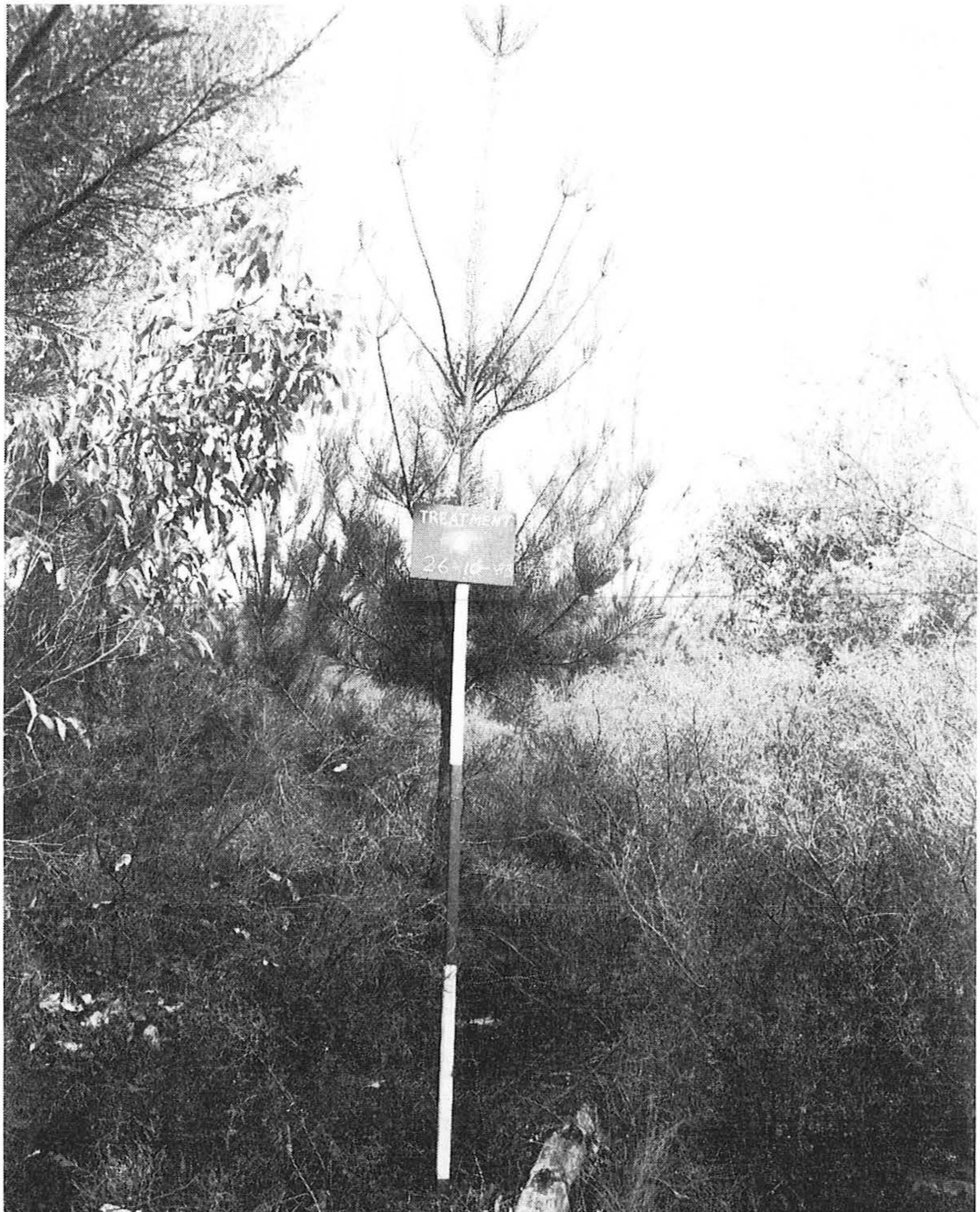

Plate 3

Burnt but no fertiliser treatment (treatment 3), five years after establishment.

Plate 4

Mulched plus fertiliser treatment (treatment 4), five years after establishment.

Plate 5

Mulched but no fertiliser treatment (treatment 5), five years after establishment.

DISCUSSION

Superior growth rates of 2R pine seedlings were achieved in the mulching treatments (treatments 4 and 5) over the first five years. This improved growth could be attributed to both the mulching treatment and to the lack of the scrub competition which reduced growth in the burnt plots. The comparative effects could not be assessed. Soil moisture tends to be the most limiting factor affecting tree growth . In this respect mulching has the ability to retain soil moisture, by insulating the soil against direct evaporation, and suppressing exotic weed and scrub species thus reducing transpiration. Farrell *et al.* (1981), in an experiment using gypsum blocks, have shown that moisture levels under mulched *P. radiata* logging slash were higher and extended through the summer/autumn period. As a result a longer growing period was availabe to trees on mulched sites.

Most nutrients in a site are in the log and litter debris (Farrell 1984) and up to 70 per cent of the nitrogen may be lost by burning (Christensen 1977). The retention of litter and logging residue provides a slow release of nutrients to the re-established pine crop.

The conventional practice of burning 1R logging debris is to provide a clear area for planting and remove the associated fire hazard. In our study this treatment resulted in stimulation and germination of indigenous scrub species, particularly *Acacia pulchella*. This additional competition for moisture and nutrients has had a significant effect on stem taper (Fig. 3) where trees in the burnt plots tended to be more slender.

In addition, the differences in height growth (Fig. 1) also showed the effect of weed competition. Jack (1970) showed that up to two years growth can be lost due to competition from weeds. Levels of growth response in the treatments used in this study presumably would have been more uniform if some form of scrub control had been used. The analysis of variance of tree heights in Figure 2 showed no significant difference between blocks, indicating that site quality was consistent throughout the study area (Baker 1950).

Growth differences between the fertilised and non-fertilised plots for both burnt and mulched treatments would most likely be due to a nutrient imbalance on the soil. Waring (1972) placed great importance on having the correct balance between nitrogen and phosphorus (N and P) available to the tree roots . He suggested that the growth advantage gained by the application of N and P continues to widen throughout the life of the plantation.

The control treatment used in this study simulated the current 1R practice. However, growth rates obtained after five years were better for all other treatments, with the exception of the burnt plot without fertiliser (treatment 3) (Fig. 2; Table 2). This suggested that 1R productivity could be increased with a different establishment method.

Fire hazard

Pines are extremely fire sensitive and fire protection is a necessary management consideration. However, the plantation from about age 5 years until canopy closure is possibly most vulnerable to damage by fire. The trees at this stage are generally short and have thin bark. This study has shown that mulching provides the least fuel from scrub species and therefore fire hazard, in the long term (Fig. 4).

Pine regeneration

By 1983, five years after planting, natural pine regeneration was present in all treatments in relatively low numbers and was not considered a large management problem (Fig. 5). The reasons include:

(1) in control plots the seed source was physically removed, leaving only a small amount of seed contained in the soil;

(2) the fire intensity in the burnt plots may have been high enough to consume or kill most of the seed;

(3) the mulch layer may have had an inhibiting effect on seed germination;

(4) competition effects reduced numbers considerably after large populations grew in the first two or three years, particularly in the mulched, no fertiliser, and burnt, fertiliser treatments.

Overall, the trends varied considerably. In summary, for the deep fertile soils found in the Blackwood Valley, growth rates in the five years after planting increased with the use of mulching and fertiliser treatments. This is preferred to the standard procedure of burning the slash to reduce the fire hazard. The fire potential in burnt slash is reduced for the first two years but after five years *Acacia* regeneration is approximately three times more dense than that of the mulched treatments, thus creating a severe fire hazard. Pine regeneration was found to occur in low numbers, and thought not to present any major management problem.

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