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SOME EFFECTS OF A
WILD FIRE
ON A
SOUTHERN PINE PLANTATION

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**SOME EFFECTS OF A WILD FIRE ON A
SOUTHERN PINE PLANTATION**

BY

A. P. VAN LOON

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SUMMARY

This report describes some effects of a wild fire on a 6½-year old plantation of *P. elliotii* Engelmann and *P. taeda* L., evident ten years after the fire's occurrence.

Survival percentages for both species for a number of fire-damage classes are presented and *P. elliotii* is shown to have survived the fire remarkably well.

Detailed growth analysis carried out on stems of *P. elliotii* failed to produce evidence that the growth rate of the surviving trees has been depressed by the intensity of the fire.

Fire-caused defect is shown to be common in stems of *P. taeda*, regardless of fire intensity, while for *P. elliotii* only some of the stems which were most savagely burnt showed presence of internal defect.

The feasibility of control burning under *P. elliotii* without causing excessive leaf scorch is demonstrated.

INTRODUCTION

A fire which burnt 693 acres of young Southern Pines in the Barcoongere Plantation in October, 1956, provided an opportunity to institute a study in which the degree of visual fire damage suffered by individual trees was described and growth following the fire studied.

The Barcoongere Plantation is located on the New South Wales North Coast, about 400 miles north of Sydney (see figure 1). The area has an elevation of approximately 100 feet above sea level and a mean annual rainfall of 62 inches. (Latitude 29° 56'; Longitude 153° 12'.)

Routine planting commenced in 1948 and, at the time of the fire's occurrence, about 3,500 acres had been planted; 90 per cent of the acreage carried *P. elliotii* Engelman, the remainder *P. taeda* L.

The area burnt contained 584 acres of *P. elliotii* aged from 5½ to 7½ years and 106 acres of *P. taeda* aged 6½ years (see figure 2).

Damage in the burnt area varied from light to very heavy, and immediately after the fire a study was commenced to evaluate some effects of the fire on the two *Pinus* species concerned.

This study, which originated from the North Coast Research Centre at Coffs Harbour, was concluded in 1959 when all information then available was reviewed.

The study plots were revisited in May, 1966, when all surviving trees were remeasured and a small number of trees in each fire damage class was felled to observe the presence and extent of internal damage.

The 1966 observations are based on the same trees which provided the information in 1956 and 1959 and the results therefore should be fully comparable; at the same time the conclusions which may be drawn now are by necessity limited to the original 1956 experimental design and measurements.

Much of the information from the 1959 internal report is repeated here in order to familiarize the reader with details of the fire behaviour, the condition of the stand burnt and the experimental procedure.

FIRE DETAILS

A. Weather and fuel conditions

The fire, believed to have been caused by the exhaust of a motor-vehicle, started at 11.30 a.m. on the 29th October, 1956, on the NE. side of Compartment F11 (see figure 2).

Figure 1

MAP SHOWING LOCATION of BARCOONGERE SF

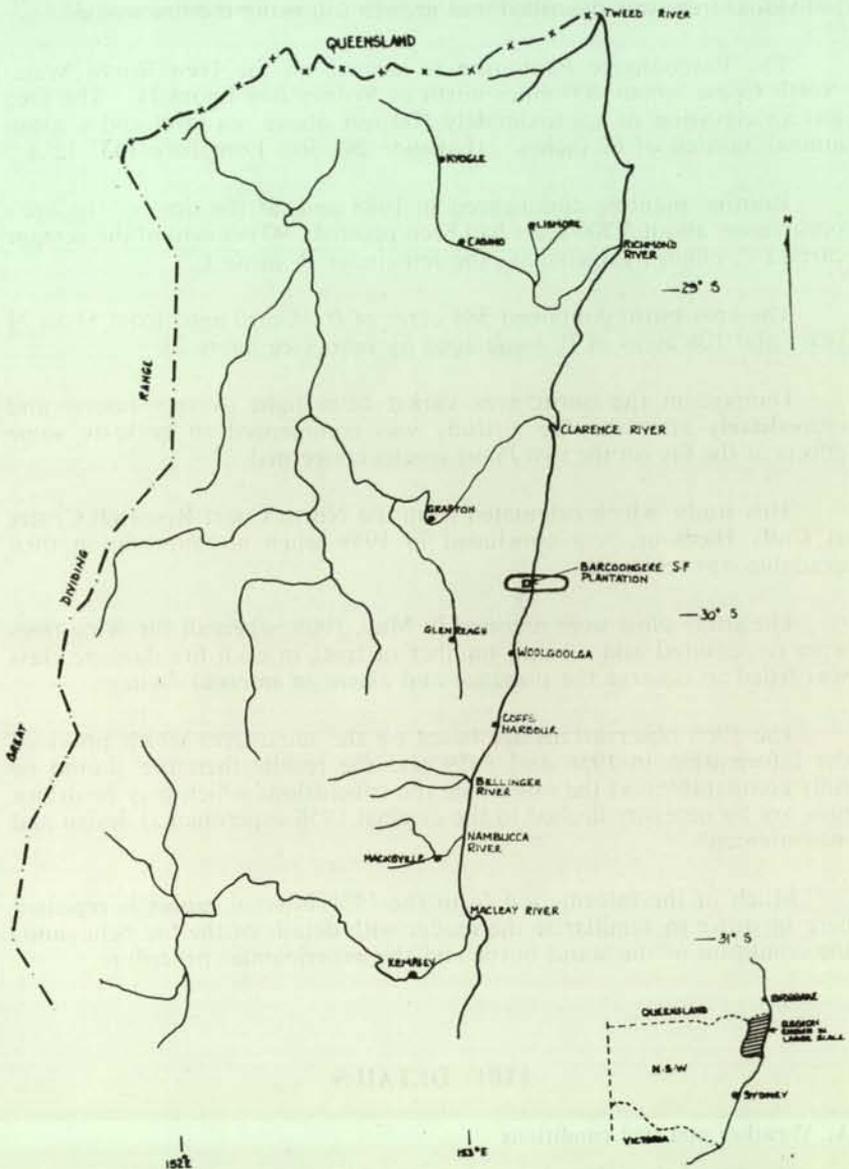


FIGURE 1. Locality sketch of North Coast, showing Barcoongere Plantation

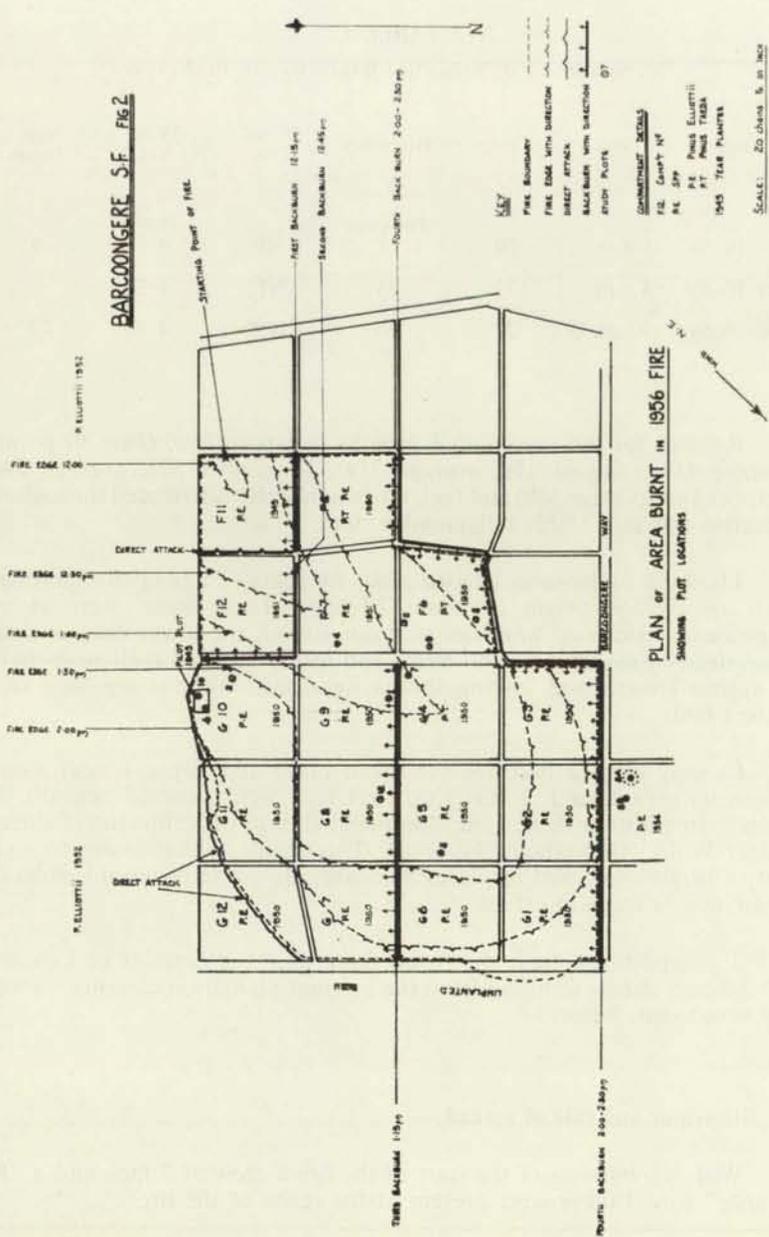


FIGURE 2. Locality sketch of Barcoongere plantation, showing area burnt, plot location, etc.

Weather conditions at the time of the fire were relatively mild, (see Table 1), and fire danger rating for the day was only moderate.

TABLE 1
METEOROLOGICAL RECORDS—BARCOONGERE PLANTATION

Date	Time	Temp.	Humidity	Wind Dir.	Wind Vel.	Max. Temp.
29-10-56	9 a.m.	70°	Per cent 61	NE	mph 4-7	78°
29-10-56	3 p.m.	72°	54	NE	4-7	..
30-10-56	9 a.m.	72°	38	NW	4-7	77°

Rainfall for the preceding 4 months had been low, (July 80 points, average 418; August 119, average 319; September 321, average 294; October 149, average 380) and fuel, fairly uniformly distributed throughout the area, was in a highly inflammable state.

The bulk of the area carried pines 6½ years of age (1950 plantings) with an average height of about 20 feet. These stems were as yet unpruned and carried branches to ground level, the lower ones in some cases dead or moribund. All stems had just completed their main burst of spring growth and leading shoots were soft, without any sign of a resting bud.

Canopy closure had not yet taken place and dense Bladey Grass (*Imperata cylindrica* J. Beauv.) up to 4 feet high occurred beneath the pines. In addition there were widespread clumps of Yellowtop (*Pultenea villosa* Willd.) throughout the area. This shrub, which grows to eight feet in height, occurred in places as dense, almost impenetrable thickets of an acre or more in extent.

Scattered throughout the forest floor were the remains of logs and other heavy debris resulting from the original plantation clearing, carried out seven years before.

B. Behaviour and rate of spread

Within 6 minutes of the start of the fire a crew of 7 men and a "La France" Fire Tanker were present at the scene of the fire.

Both flanks of the fire were immediately attacked with hose lines and approximately 75 per cent of the fire perimeter had been dealt with when one of the hoses burst. The delay caused by fitting a new hose allowed the fire to escape.

A further direct attack and 3 backburns carried out between 12.15 p.m. and 1.15 p.m. failed to arrest the spread of the fire, which was not contained until a fourth backburn, lit between 2 p.m. and 3 p.m., more than 20 chains ahead of the main front finally controlled it. By then 4 firefighting units and 21 men were used to secure the backburn.

Figure 2 shows the origin and the approximate half-hourly progress of the fire, as well as the location of the backburns.

The fire burnt as a crown fire through most of the area, but its intensity varied considerably over small areas. Patches ranging from $\frac{1}{4}$ -square-chain to over an acre were completely scorched, while adjacent stems still carried green tops. (Figure 3 shows location of scorched patches within a compartment; figure 4A shows the appearance of a scorched area shortly after the fire, while figure 4B indicates the recovery of a similar area eleven months later.)

Spot fires, mainly caused by flaming material of the shrub Yellowtop, were frequent and started up to 400 yards down wind from the fire front.



FIGURE 3. General view over burnt area, Barcoongere Plantation, immediately following the fire of October, 1956. Note location of severely burnt patches (dark areas).



FIGURE 4A. *Pinus elliotii*, planted 1949 (aged $7\frac{1}{2}$ years at time of fire). Appearance of severely burnt patch shortly after fire



FIGURE 4B. View of same general area as figure 4A, showing recovery of burnt *P. elliotii* eleven months after fire

A rough indication of the heat generated by the fire could be gauged by the state of aluminium tags and copper wire attached at a height of 5 feet 3 inches to a number of trees in the burn. Many aluminium tags were melted and some of the copper wire had fused or melted through. As aluminium melts at about 500° C and copper at 1,100° C, it is believed that the temperatures reached exceeded these figures in parts of the area.

The forward spread of the fire expressed as chains per hour at half-hourly intervals is given in Table 2.

TABLE 2
RATE OF FORWARD SPREAD EXPRESSED IN CHAINS PER HOUR

Period	Forward Spread (chains per hour)
11.30-12.00	20
12.00-12.30	60
12.30-1.00	70
1.00-1.30	80
1.30-2.00	30
2.00-2.30	30
(backburn included)	

The total distance travelled by the head fire equalled 135 chains, the final fire perimeter was approximately $4\frac{3}{4}$ miles and an area of 693 acres of the plantation was burnt.

EXPERIMENTAL PROCEDURE

Immediately following the fire the North Coast Research Centre established twelve plots (60 feet x 60 feet) in various intensities of burn for both species at various ages (see figure 2 for plot location).

Within 3 weeks of the fire's occurrence each of the 700 stems in these plots was classified in degrees of damage suffered and measured for diameter over bark. In addition, bark thickness and height were recorded for a limited number of selected stems. No observations were made on stem damage.

Five fire damage classifications were used to describe the degree of visual damage suffered. These were:

- 1 No green needles, few or no brown needles remaining; leader drooping.
- 1/2 Intermediate between 1 and 2.
- 2 Few or no green needles, brown needles mostly present on tree; leader erect or drooping.
- 2/3 Intermediate between 2 and 3.
- 3 Green needles at top clearly visible; leader erect.

The degree of damage varied so much over short distances (even within single plots of area about 0.1 acre) that it was necessary to consider individual stems when attempting to determine the effects of differing fire intensities on the survival and growth of the stand.

All the plots established in November, 1956, were remeasured in February and June, 1957, February, 1958, September, 1959, and again in May, 1966.

FIRE EFFECTS

I. Survival

Of the 700 stems under observation, 396 were *P. elliotii* and 304 *P. taeda*. The distribution of stems for each species in damage classes and the survival percentage of each damage class is presented in table 3.

TABLE 3
DISTRIBUTION AND SURVIVAL OF DAMAGE CLASSES BY SPECIES

Damage Class	Species	No. of stems observed	Survival
			Per cent
1	<i>P. elliotii</i>	158	31.0
	<i>P. taeda</i>	151	0.6
1/2	<i>P. elliotii</i>	69	76.7
	<i>P. taeda</i>	25	28.0
2	<i>P. elliotii</i>	49	93.8
	<i>P. taeda</i>	51	49.0
2/3	<i>P. elliotii</i>	54	94.4
	<i>P. taeda</i>	7	71.4
3	<i>P. elliotii</i>	66	96.9
	<i>P. taeda</i>	70	90.0

The vastly superior survival of *P. elliotii* when compared with *P. taeda* is further illustrated in figure 5. Of particular interest is the high (93 per cent +) survival of *P. elliotii* in classes 2, 2/3 and 3; it appears that this species is able to survive fire damage to the extent of losing virtually all its green needles (fire damage class 2) remarkably well.

Of the 326 stems which failed to survive the fire (both species, all ages), 62 per cent died in the first eight months following the fire, the remainder within sixteen months. Subsequent mortality was very light and occurred probably without connection with the fire.

As the poor survival of *P. taeda* (33 per cent all classes) drastically reduced the number of stems under observation of this species, the following sections dealing with the effects of fire on growth refer only to *P. elliotii*.

FIGURE N° 5

SURVIVAL PERCENTAGE FOR BOTH SPECIES
BY FIRE DAMAGE CLASSES

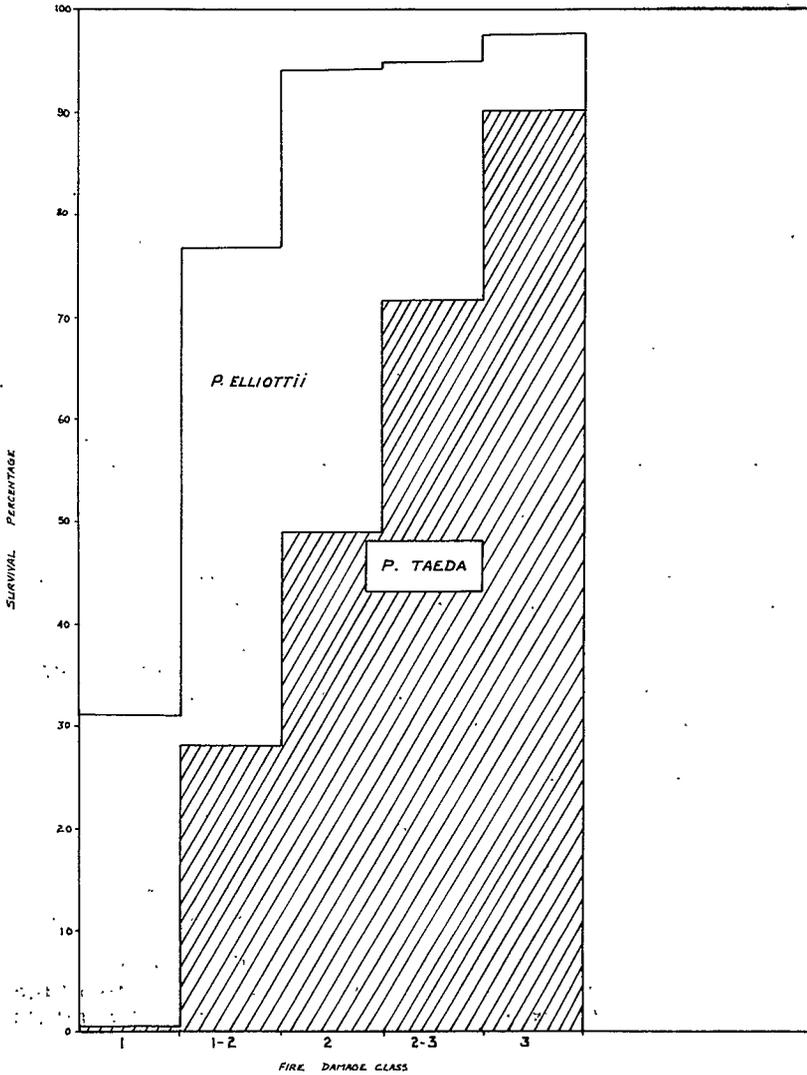


FIGURE 5. Survival percentages for both species by damage classes

II. Diameter growth

a. Diameter and Sectional Area Growth

As the majority (66 per cent) of *P. elliotii* stems under observation were $6\frac{1}{2}$ years of age at the time of the fire (1950 plantings) calculations on growth have been confined to this age class.

A thorough evaluation of the effect of various fire intensities on growth is complicated by the following factors:

- (a) The absence of controls of equal age.
- (b) Initial differences in tree diameter between damage classes.
- (c) Reduction in density which occurred in the most heavily burnt plots due to mortality.

In 1959 all surviving *P. elliotii* stems from the 1950 plantings were grouped in fire damage classes and the mean diameter growth for each class was expressed as a percentage of its initial (post fire) diameter. (See insert in figure 6.)

This indicated superior growth for the three least damaged classes (3, 2/3, 2) compared with the two most heavily damaged groups (1, 1/2).

However, it is not meaningful to express growth over a period of ten years as a percentage of initial diameter when initial diameters of each class differ, as in this way the class with the smallest initial diameter tends to show the greatest percentage increase.

Therefore, figure 6 (which is based on the same trees as used in 1959) shows actual mean diameters for each class from ages 6 to 16.

In the absence of data for unburnt trees of the same age, growth of four unburnt thinning plots, which were planted one year later but on similar site quality, is also shown.

It is interesting to note that:

- (1) Trees in fire damage class 2 (few or no green needles remaining) have produced the greatest mean diameter increment.
- (2) The decrease in growth of the two worst damaged classes (1, 1/2) evident in the first 3 years has not been maintained.
- (3) For ages 9 to 12 and 13 (the only periods available for comparison) the periodic increment for all classes of fire-damaged stems has been no less than that for comparable unburnt thinning plots.

In order to offset the reduction in density caused by mortality in the most heavily burnt plots, covariance analyses were carried out to determine the relationship between growth of individual trees and stand density for the various damage classes.

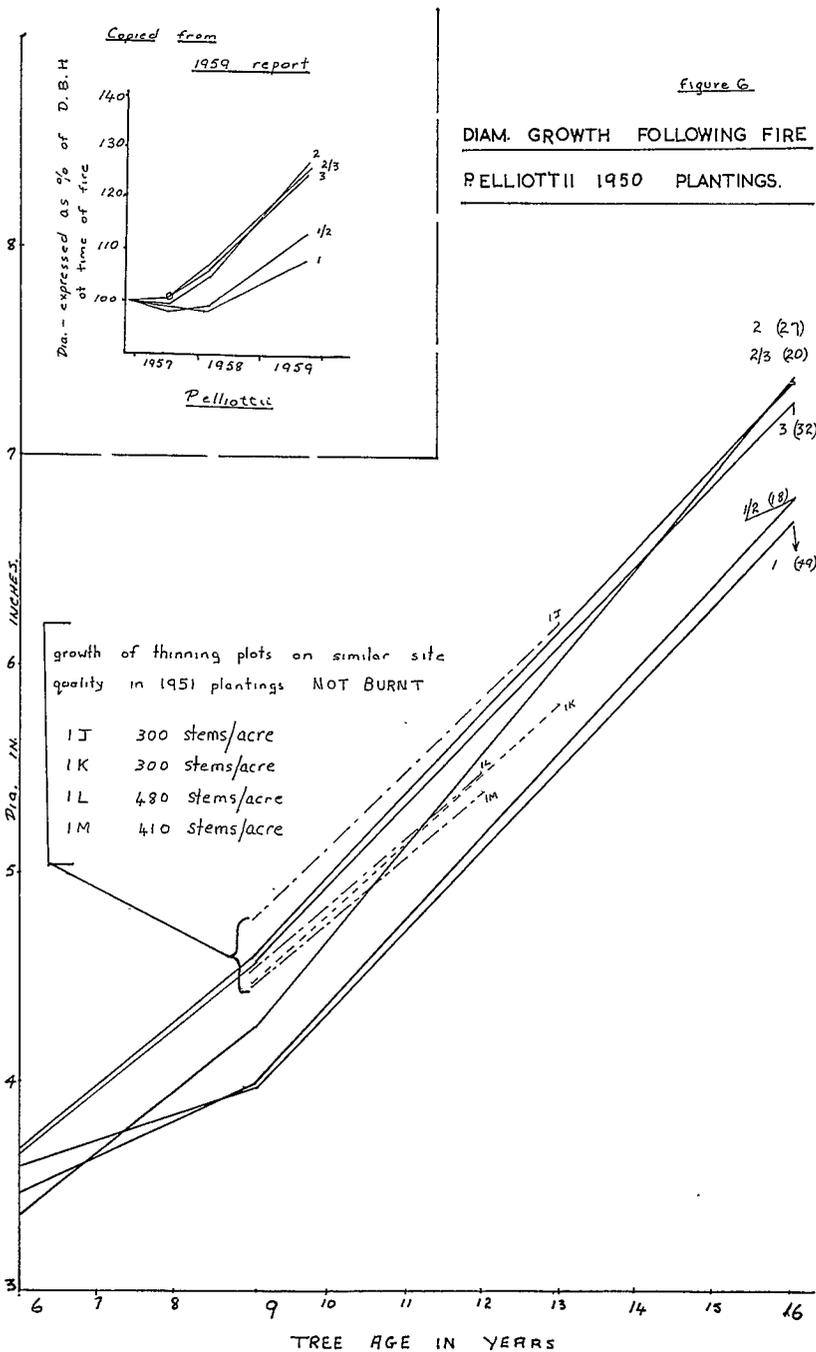


FIGURE 6. Diameter growth following fire—*P. elliottii*, 1950 plantings

The damage classes have been grouped in a logical manner to ensure that sufficient numbers of observations were available for comparison. Table 4 sets out the various stand parameters in 1959 for the burnt plots available in *P. elliotii* (1950 plantings).

TABLE 4
THE STAND STRUCTURE OF BURNT PLOTS—AGE 9 YEARS (1959)

Plot No.	Damage Class	No. of Trees in Class	Mean Diameter (\bar{D})	BA/acre	Mean Dominant Height
3	1	11	4.25	13.21	23.1
12	1	34	3.82	14.52	..
12	1/2 + 2	15	4.27	7.95	..
12	ALL	49	3.95	22.46	25.3
2	1/2 + 2	24	4.10	27.52	..
2	2/3 + 3	9	5.14	15.74	..
2	ALL	33	4.39	43.26	28.5
1	2/3 + 3	41	4.47	55.10	25.8

The data demonstrate that there is a direct relationship between the intensity of the 1956 fire and the basal area per acre in 1959. The plots with low basal areas consist only of trees in the most heavily damaged classes.

A preliminary investigation established that within any one stand there existed a direct relationship between the 1959 tree diameter (D) and its periodic annual sectional area increment (ΔD^2) for the period 1959-1966.

For convenience, ΔD^2 of any tree was calculated by squaring the final diameter, subtracting the square of the initial diameter, and dividing by the number of years in the period. Therefore, the tree increments have not been corrected for the circular cross sections and are in square inch units.

The regression of ΔD^2 on D was calculated for each damage class in each plot. The regression data is listed in table 5.

TABLE 5
REGRESSIONS OF SECTIONAL AREA INCREMENT ON TREE DIAMETER—BURNT PLOTS

Plot No.	Damage Class	n	(\bar{D})	ΔD^2	a	b	s^2	s^2b
3	1	11	4.25	5.59	-6.216	2.7809	3.5748	1.3974
12	1	34	3.82	3.64	-1.591	1.3707	0.9839	0.0923
12	1/2 + 2	15	4.27	4.38	-2.329	1.5717	0.3255	0.0813
2	1/2 + 2	24	4.10	3.81	-2.985	1.6556	1.6772	0.1175
2	2/3 + 3	9	5.14	5.71	-7.517	2.5751	0.8786	0.4690
1	2/3 + 3	41	4.47	4.25	-1.836	1.3616	0.9977	0.0541

s^2 = Mean square deviation from regression.

s^2b = Variance of b .

Direct comparisons of the tree growth regression for damage classes within the one plot (i.e., with stand density held constant) could only be made for plot 12, between classes 1 and (1/2 + 2), and for plot 2 between classes (1/2 + 2) and (2/3 + 3).

This was done by the usual covariance analysis (Snedecor, 1956; chapter 14) because the variances are homogeneous. The results are given in appendix 1.

The hypothesis tested was that there is no difference in growth between tree damage classes within each plot between 1959 and 1966, and this hypothesis was accepted.

b. The Comparison of Growth Regressions between Plots

As already stated, the fire had actually performed a thinning in the plots being investigated. Normally a thinning is expected to cause an increase in the rate of growth of individual trees and the magnitude of this response would be expected to bear some relationship to the intensity of thinning or the residual basal area per acre.

However, if the fire has had an adverse effect on the rate of growth proportional to the intensity of the fire, then any stimulation in growth expected through thinning might be cancelled out by this adverse effect and the trend might even be reversed.

The regression equations listed in table 5 have fairly similar values for the regression coefficient "b" and the hypothesis was set up that there was no difference in the value of "b" for either plots or damage classes. An appropriate test is given in appendix 2, resulting in the acceptance of the null hypothesis. It was concluded that all plots can be represented by a series of parallel regression lines ($b = 1.5275$).

Consequently, differences in growth rates of trees of the same diameter in different plots would be demonstrated by differences in elevation of parallel regression lines.

Adjusting the values of "a" given in table 5 to "â" on the basis of this common regression coefficient, there is a clear trend of â becoming increasingly negative with increasing density (see table 6).

TABLE 6
ADJUSTED INTERCEPTS AND STAND DENSITY DATA—BURNT PLOTS

Plot No.	â	B.A./acre	(\bar{D})	ΔD^2	B.a. Increment/ac.	Mean Dom. Height
3	-0.90	13.21	4.25	5.59	4.04	23.1
12	-2.16	22.46	3.95	3.87	5.44	25.3
2	-2.37	43.26	4.39	4.33	9.39	28.5
1	-2.58	55.10	4.47	4.25	11.46	25.8

This is the expected trend for a range of normal thinning intensities and there is no evidence of a changing trend due to fire intensity or fire damage.

However, since all plots have been burnt, there is the possibility that the absolute level of growth has actually been depressed relative to unburnt stands, even though the trend is normal.

Some evidence on this matter can be obtained by using the individual tree growth data from the unburnt plots J, K, L, and M. As previously stated, these plots are actually one year younger than the burnt plots, but their growth period used in this comparison is from 1960 to 1963 or 1964 (at which dates these plots were thinned for a second time). Thus the comparison involves plots starting at the same age, but with growth measured for a shorter length of time within the 1959–1966 period available for the burnt plots. The heights and sites indices for all of the plots are broadly comparable. (Figure 9.)

Regressions of ΔD^3 on D were calculated for the four unburnt plots and again the test of appendix 2 indicated that there was a common regression coefficient ($b = 1.0940$) for the unburnt plots, but this common regression coefficient is significantly different from that of the burnt plots ($b = 1.5275$).

When the value of “ a ” for the unburnt plots is adjusted for this common slope of 1.0940, the adjusted values generally follow an expected trend with the basal area per acre of the plots (table 7).

TABLE 7
ADJUSTED INTERCEPTS AND STAND DENSITY DATA—UNBURNT PLOTS

Plot No.	\hat{a}	BA/acre	ΔD^2	BA increment per acre	Mean Dominant Height
1K ..	— 1.36	33.1	3.50	5.57	28.0
1J ..	— 1.19	37.3	4.01	6.58	28.1
1M..	— 1.72	44.8	3.11	6.93	28.4
1L ..	— 1.59	53.6	3.27	8.57	29.3

Because of differences in the slopes of the regression lines between the burnt and the unburnt stands, the values of “ \hat{a} ” cannot be directly compared. However, if the regressions of ΔD^2 on D are drawn, the superior growth of individual trees of the same diameter in the burnt stands for similar stand densities is clearly shown. (Figure 7.)

PINUS ELLIOTTII

Figure 7

The Relationship between TREE GROWTH, TREE SIZE
and BASAL AREA PER ACRE for

Burnt Plots —————
Unburnt Plots - - - - -

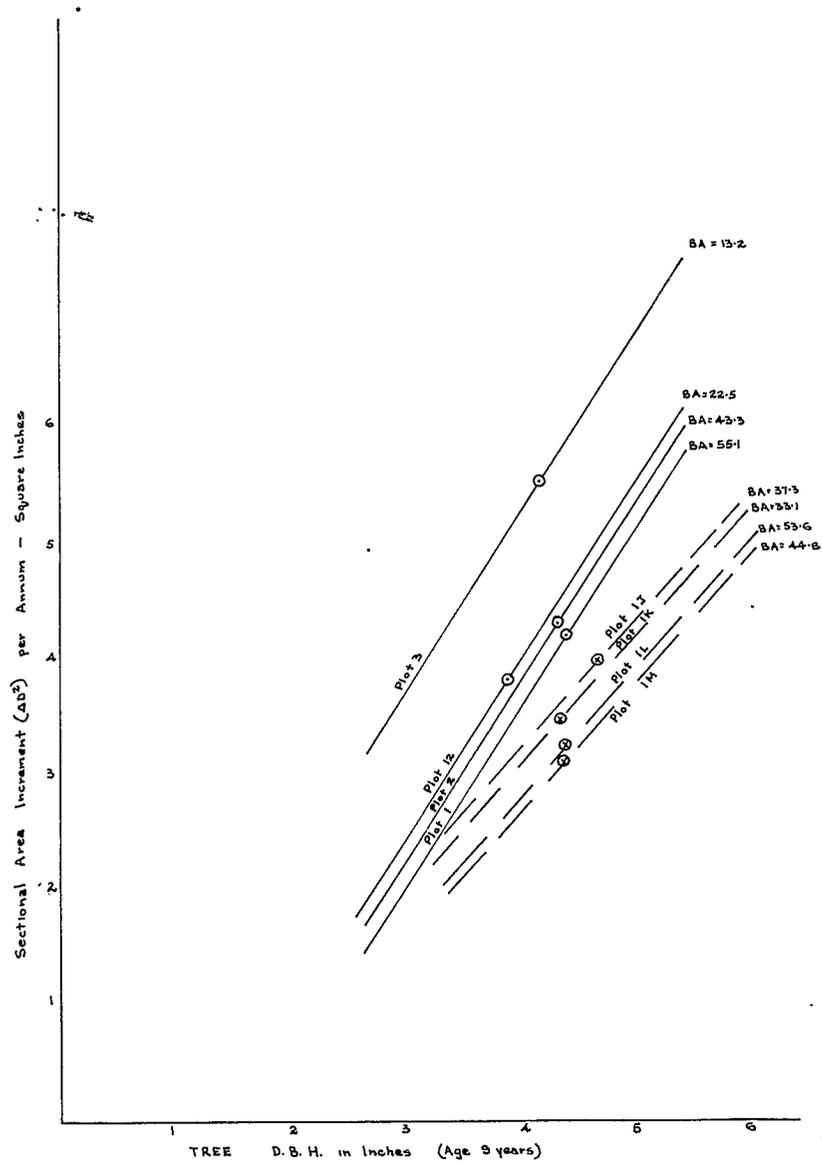


FIGURE 7. The relationship between tree growth, tree size and basal area per acre

It cannot be stated that these differences are a result of the fire. Differences in growth years, sites, provenances, etc., could all lead to the same differences. However, the possibility that these differences are due to fire should not be overlooked and this matter should be investigated further.

c. Growth per Unit Area

It has been shown that the growth in sectional area of the mean tree is higher in the heavily burnt plots than in the lightly burnt, but that this increase in growth is possibly equivalent to a thinning response.

The data on growth in table 6 show a higher basal area increment per acre for the lightly burnt plots than the heavily burnt plots, but this is also regarded as a stand density effect rather than a true effect of fire intensity.

This becomes clearer when the basal area increment per acre for both burnt and unburnt plots is plotted against stand basal area per acre. (See figure 8.)

There is a clear relationship between growth per acre and initial stand density and it is obvious that most of the plots were at densities which were too low to give maximum growth per acre for the site.

It is also clear that the growth per acre of the unburnt plots has been somewhat lower than that of the burnt plots, and this follows from the differences in the individual tree regressions already discussed.

However, the reason for this cannot be determined because the plots involved are not strictly comparable.

Nevertheless, although these comparisons suffer from the absence of replicated designs, it must be concluded that there is no evidence to suggest that the growth rate of the surviving trees has been depressed by the intensity of the fire, or the initial damage caused, during the period from 1959 to 1966.

However, the losses in basal area growth per acre which resulted from reduced stand density through fire mortality should not be overlooked. The largest growth per acre occurred on the least damaged plot because the stocking was not greatly reduced by the fire.

The planned use of fire to achieve a desired reduction in stand density, as for instance in the case of unmerchantable first thinnings, warrants further investigation.

BASAL AREA increment against BASAL AREA
for burnt and unburnt plots

Figure 8

○ Burnt

⊗ Unburnt

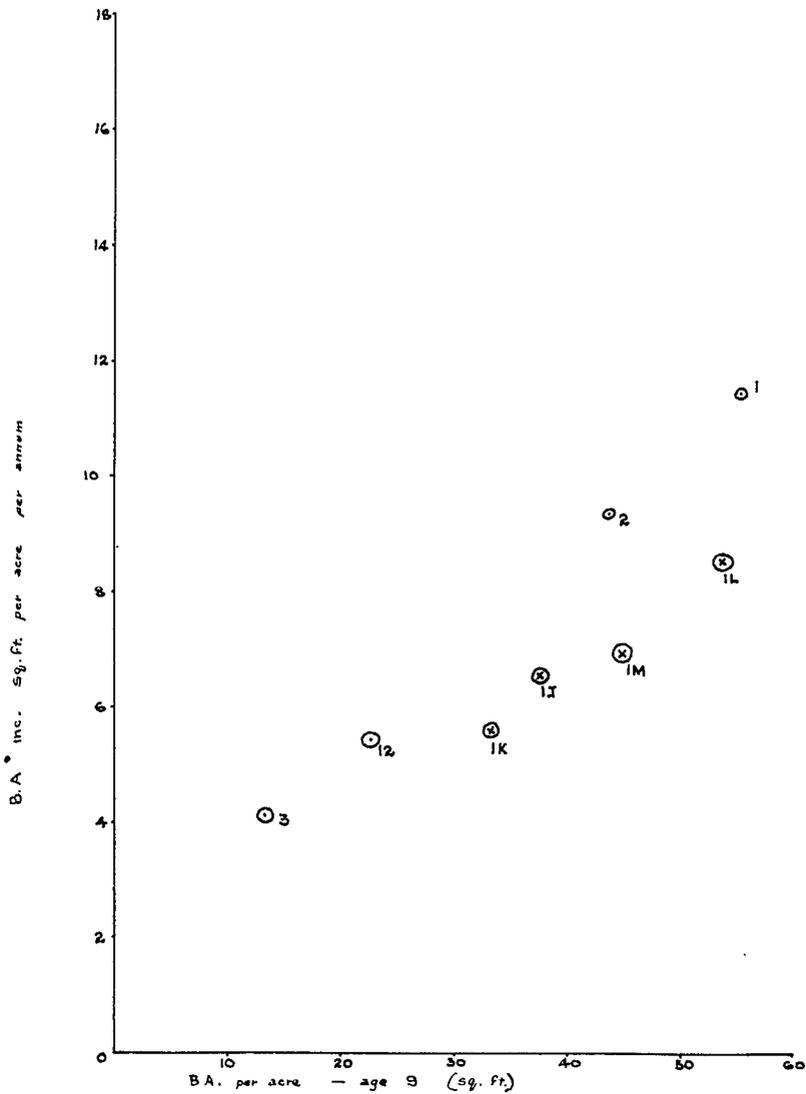


FIGURE 8. Showing basal area increment against basal area

III. Bark thickness

Bark thickness was measured in November, 1956, (i.e., immediately after the fire) and again in June, 1957, and June, 1966.

Results of these measurements are given in table 8, using twice bark thickness (i.e., the value to be subtracted from the overbark diameter to obtain D.B.H. under bark).

TABLE 8
TWICE BARK THICKNESS CHANGES—NOVEMBER, 1956—JUNE, 1957—JUNE, 1966

Species	Damage Class	No.	Nov., 1956, <i>a</i>	June, 1957, <i>b</i>	<i>a-b</i>	June, 1966, <i>c</i>	<i>c-a</i>
<i>P. elliotii</i>	Light (2/3, 3)	24	1.092	0.956	0.136	1.432	0.340
	Moderate (2)	5	1.063	0.988	0.075	1.470	0.407
	Heavy (1, 1/2)	8	0.938	0.919	0.019	1.138	0.200
<i>P. taeda</i>	Light (2/3, 3)	15	0.915	0.865	0.050	1.296	0.381
	Moderate (2)	7	0.675	0.650	0.025	1.114	0.439

There was a decrease in bark thickness in the period November, 1956, to July, 1957, for all classes of fire damage. The least damaged stems lost more bark during the first eight months after the fire than those more heavily damaged (column *a-b*), but the heavily damaged stems probably had more bark consumed during the fire.

In the period 1956–1966 all stems increased in bark thickness but the least damaged stems showed a greater increase than those heavily damaged.

In the June, 1966, measurements, stems in the heaviest damage class show a smaller bark thickness than those less severely damaged; this may affect their resistance against further fires. However, there appears to be no reduction in bark thickness for stems moderately burnt when compared with those only lightly damaged. There is no evidence to suggest that the patterns of growth in sectional area previously discussed are caused by differential bark growth of trees in different damage classes.

IV. Height growth

Although only selected heights have been measured in this study and the number of measurements in most damage classes is too small to allow a valid comparison, figure 9 presents trends in height growth by fire damage classes.

Mean dominant heights (tallest 40 per acre) of the 1951 thinning plots are included to give an indication of unburnt stems on a similar site.

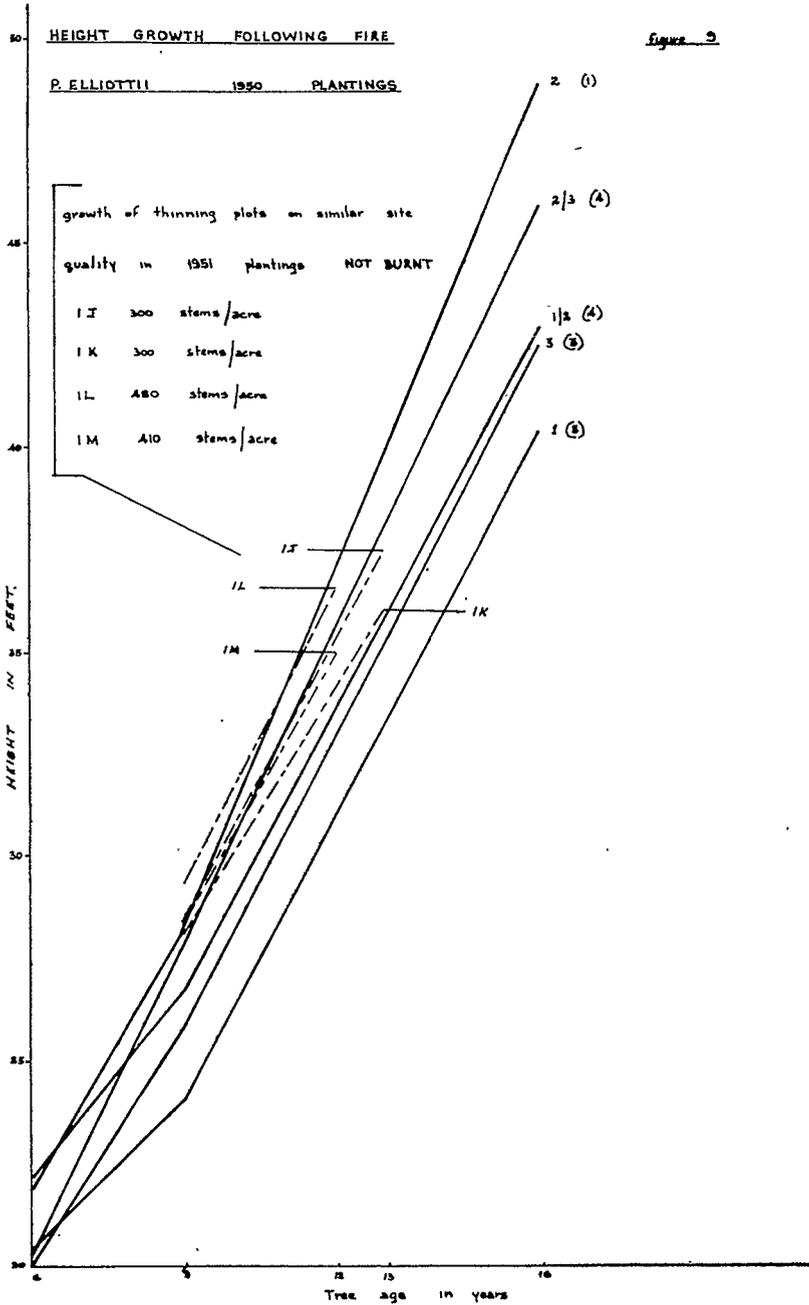


FIGURE 9. Height growth following fire—*P. Elliottii*, 1950 plantings

It may be inferred that:

- (1) Stems in the medium damage class (1/2, 2, 2/3) grew no less in height than those only lightly damaged (class 3).
- (2) Height growth of all fire damaged stems compares favourably with that of unburnt stems, at least between the ages 9 to 12 and 13.

A spot fire which damaged 0.2 acres of the 1954 *P. elliottii* plantings, then 2½ years old and averaging 3.5 feet in height, afforded an opportunity to install an unburnt control adjacent to a fire damaged plot.

All trees in these plots were measured for height in 1956, 1959, and 1966 and the results of these measurements are shown in figure 10.

Again there is little evidence of a reduction in height growth for moderately damaged stems when compared with the unburnt control.

V. Timber defect

During the May, 1966, measurements, a small sample of stems in each fire damage class for both *P. elliottii* and *P. taeda* was felled to observe if any fire-caused defect could be detected.

The sample was deliberately kept small in order not to drastically reduce the stocking in any plot as well as to allow provision for future sampling.

Two trees were felled in each of the plots with the exception of plots 9 and 11, which were not sampled as they carried only four and eight surviving stems respectively.

Sample trees were randomly selected in the office, with the provision that whenever possible the two trees sampled within each plot were in different fire damage classes and were of similar diameters.

For each tree 1-inch thick discs were cut at heights of 1 foot, 3½ feet and 6 feet above ground level, while those trees in which defect was detected at these heights were also sampled at 1-foot intervals above and below the damaged discs until the defect was no longer visible.

Results of these tests, by species and damage classes, are presented in table 9.

TABLE 9
THE FREQUENCY AND DEGREE OF FIRE CAUSED DEFECT

Species	Fire damage class	No. of trees sampled	No. of trees showing defect	Photo reference, appendix 3 and 4	Degree of Defect	Limits of defective section
<i>P. elliottii</i> ..	1	3	1	3/2	Severe	2 ft-7 ft
	1/2	3	1	2/32	Light	1 ft-7 ft
	2	3	0	..	nil	..
	2/3	2	0	..	nil	..
	3	3	0	..	nil	..
<i>P. taeda</i> ..	1/2	1	0	..	nil	..
	2	1	1	8/24	Severe	1 ft-7 ft
	2/3	1	1	7/3	Moderate	1 ft-6 ft
	3	3	2	7/9	Severe	1 ft-7 ft
	..	..	..	10/33	Light	1 ft-5 ft

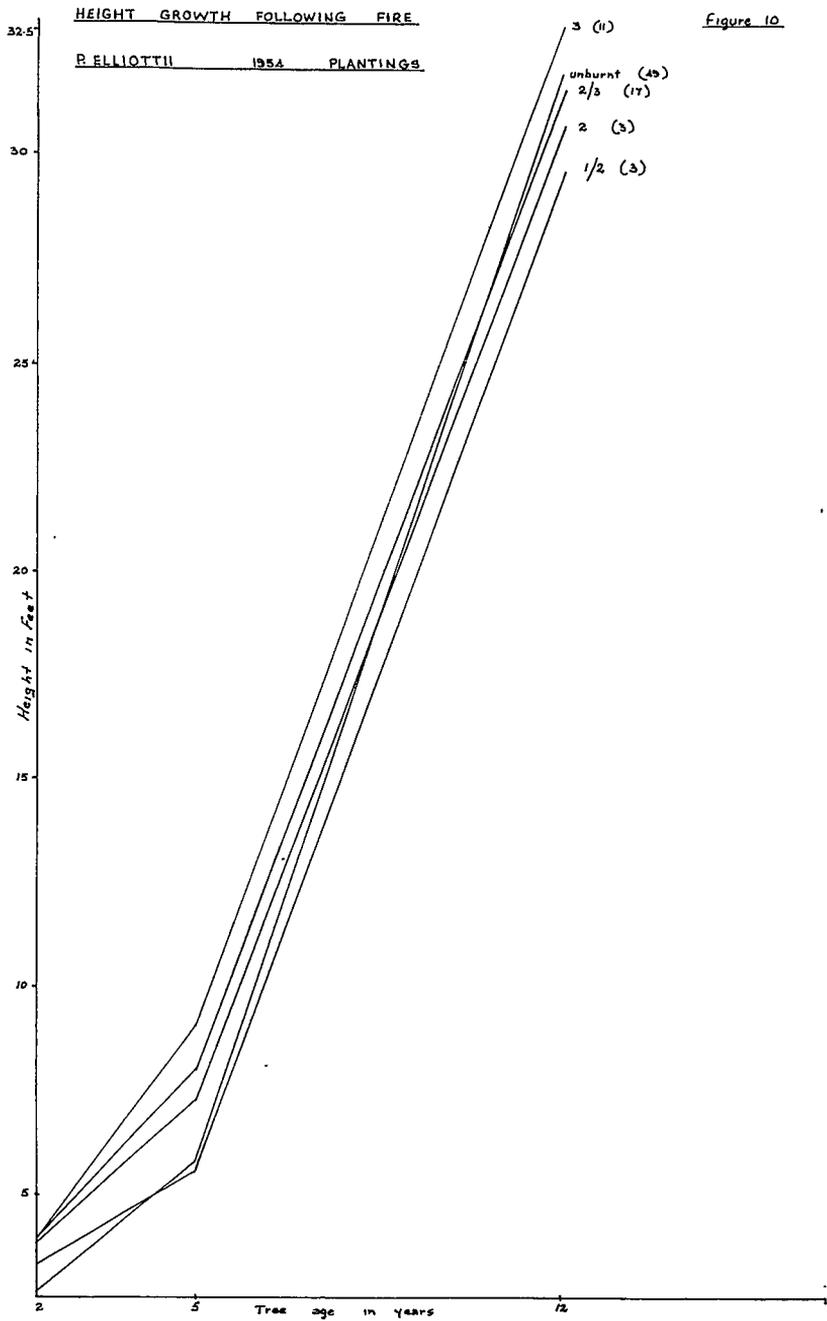


FIGURE 10. Height growth following fire—*P. elliotii*, 1954 plantings

As indicated in the section on survival, *P. elliotii* is a far more fire-resistant species than *P. taeda*.

Only 2 out of 6 of the most heavily scorched *P. elliotii* showed any sign of defect, while no defect was detected in 8 moderately or lightly damaged stems.

For *P. taeda*, 2 out of 3 stems, even in the lightest damage class, show light to severe defect.

The maximum height above ground level at which defect was detected was 7 feet for both species, but it is emphasised that the bottom 7 feet of a Pinus log is its most valuable section.

Photographs depicting the defects observed are presented in appendices 3 and 4.

The principal cause of the defect had been the death of phloem and cambium in restricted areas. This has had the result of exposing the sapwood to the atmosphere with the consequent death of sapwood proceeding radially inwards from the injured area.

Resin has been secreted following the injury to cover the exposed wood and has impregnated the wood radially inwards from the injured surface. The wood which now covers the injury has grown in from the uninjured cambium surrounding the dead area and is thus not connected to the inner wood; due to the irregular nature of its growth, irregularities in grain direction can be expected.

The degrade of the timber will be due principally to the structural weakness of boards associated with the injury and secondly to the increased resin production.

Abnormal quantities of resin are considered a defect because it makes the boards more difficult to machine and to coat with paint.

The damage to the wood caused by the fire would seriously downgrade the quality of the timber unless the size of the injured areas were very small.

It is recommended that when the trees reach a sufficient size, a number of them should be subjected to a mill study and the converted timber graded for quality.

One *Pinus elliotii* was noted to have been infested by termites and was felled upon this evidence. The termites which were no longer active had gained entry through a fire scar which extended from the base of the tree to a height of 3½ feet. The photographs of the stem (appendix 3) shows discs cut at 1, 3, and 4 feet—labelled 6/22-1, 6/22-2, and 6/22-3 respectively. Termite damage did not extend above 4 feet.

CONTROL BURNING

At the time of the May, 1966, measurements, a small exercise in control burning was conducted. A 40-acre block (Block B, Compartment 16) carrying 12-year-old *P. elliotii*, which were pruned and non-commercially thinned in 1962, was selected for this purpose.

Oven-dry weight of fuel on the forest floor averaged $7\frac{1}{4}$ tons per acre (range $4\frac{1}{4}$ —10) and fuel consisted of the following fractions:

- (a) Dead pine needles $3\frac{3}{4}$ tons
- (b) Dead pine twigs 1 ton
- (c) Dead grass and understorey leaves 1 ton
- (d) Live grass and understorey leaves $\frac{1}{2}$ ton
- (e) Miscellaneous fine litter 1 ton

Average fuel moisture content was 48.4 per cent. Temperature and relative humidity for the period involved is shown in figure 11. Windspeed on the day of the burn (9-5-66) measured at 5 feet above ground level for 14 minutes after time of ignition was a steady 2 mph from a SE. direction.

The fire was lit at 4 p.m. at a single ignition point in the extreme NW. corner of the block, in order to burn against the wind.

The maximum spread from the ignition point 14 minutes after lighting was 20 feet, and during this period the maximum flame height reached was 8 feet, in dense bladey grass bordering the road. However, seven observations at 2-minute intervals indicate an average maximum flame height of $4\frac{1}{2}$ feet and a flame angle of 70 degrees

By 5 p.m. (i.e., 1 hour after ignition), the fire had developed a "trickling" nature and this is believed to be due to a marked decrease in temperature and a corresponding increase in relative humidity (figure 11).

Consequently, it was decided to allow the fire to continue its natural spread and to observe the extent of this at 7 a.m. on the following day.

Despite relative humidity approaching 100 per cent for a continuous period of 13 hours, the fire was then still burning along most of its front and had burnt an area of $8\frac{1}{2}$ acres, roughly shaped like an isosceles triangle, with two sides of 13 chains along the roads forming the block boundary.

At this stage the fire was easily extinguished along its front of almost 20 chains by raking a small trail; this operation was completed in about two man hours.

As it was felt to be undesirable to leave the remaining 31 acres of the block unburnt, action was taken on the following night to burn the remaining area.

Weather conditions at 4 p.m. were virtually identical with those of the previous day and it was realised that the objective of burning the remaining area could not be realised by single point ignition.

It was therefore decided to adopt a method of grid spot lighting. As between 4 p.m. and 5 p.m. flame heights in junction zones between burning spot fires were considered excessive (8-10 feet), further lighting was postponed until 8 p.m.

Temperature & Relative Humidity records for control burn at BARCOONGERE S.F. 9-11/5/66. Figure 11

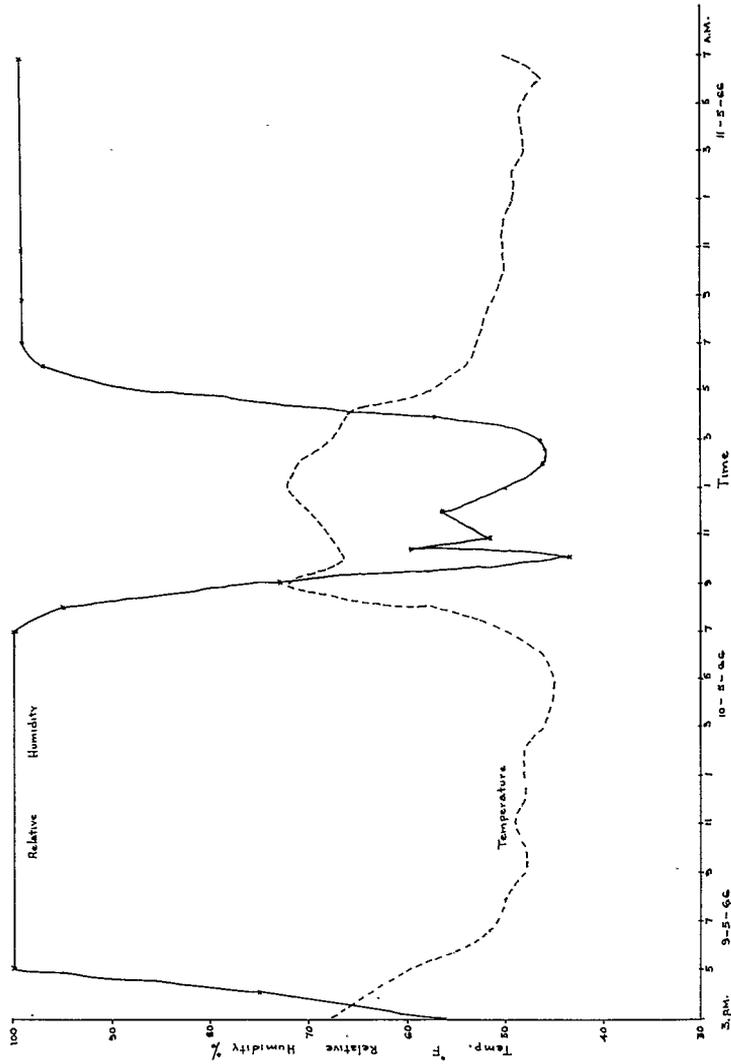


FIGURE 11. Temperature and relative humidity recordings at Barcoongere S.F. for control burning, 9-11th May, 1966

Between 8 p.m. and 11 p.m. the remaining area was burnt, mainly on a spot grid basis. Flame heights, especially in junction zones, were still considerably higher than those obtained under the backburn of the previous day.

Five weeks after the burn, 8 random lines of trees were assessed for degree of scorch. Of the 1,063 stems assessed, 80 per cent showed no sign of any scorch, 13 per cent were lightly scorched (bottom 1/3rd of crown), 3 per cent were moderately scorched (bottom 2/3rd of crown), and 4 per cent were fully scorched.

Sampling of fuel present on the forest floor 5 weeks after the burn, when most (but not all) dead and scorched needles had fallen, indicated a quantity of $2\frac{3}{4}$ tons per acre, which included fuel not burnt in the fire. The fuel reduction achieved, therefore, equalled $7\frac{1}{4} - 2\frac{3}{4} = 4\frac{1}{2}$ tons per acre.

CONCLUSIONS

Authentic studies into fire effects which enable a revaluation of such effects after a passage of time are extremely rare in New South Wales.

It was therefore considered worthwhile to attempt to draw certain conclusions on the effects of a fire on surviving stems which are evident 10 years after the fire's occurrence.

It must be realised, however, that this report describes certain effects of one fire only and caution must be exercised in the application of any findings.

P. elliotii has proved itself an extremely fire-hardy species. Even when damaged to the extent of losing virtually all green needles (fire damage class 2), mortality was very low and it was not possible to show a long term reduction in either diameter or height growth. In addition no timber defect could be detected in stems burnt to this or a lighter extent.

The most severely scorched stems (fire damage class 1), however, showed high mortality (70 per cent and tended to show a light initial reduction in growth as well as some timber defect).

P. taeda is much less tolerant to fire. Insufficient data was available for growth comparisons, but survival in all but the lightest damage class (3) was very poor.

Timber defect was present in most of the stems sampled, regardless of damage class.

In recent years the Commission's policy has not been directed towards control burning of Southern Pine plantations.

As in this study no detrimental effects can be attributed to light or moderate fire intensities on *P. elliotii*, it may be possible to subject plantations of this species to an occasional control burn without fear of excessive damage.

It is not the object of this report to advocate large scale control burning, but the observations presented here may be of assistance to those responsible for plantation fire control in areas or seasons of high risk.

However, in *P. taeda* plantations, fire should be excluded whenever possible.

The marked difference in fire tolerance between the two species deserves full attention whenever both species are considered for establishment. This will especially apply in areas with a bad fire history.

It is intended to maintain the study plots, particularly for further determination of timber defect.

*

ACKNOWLEDGEMENT

I gratefully acknowledge the assistance of Mr R. A. Curtin, Officer-in-Charge, Research Centre, Forest Office, Taree, in the preparation of growth analysis presented in section II.

*

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APPENDIX 1
COVARIANCE ANALYSES FOR DAMAGE CLASSES WITHIN PLOTS 12 AND 2

Line	Plot	Class	$\frac{X}{D}$	$\frac{Y}{\Delta D^3}$	f	a	b	Σx^2	Σxy	Σy^2	Deviations from regression		
											f	SS	MS
1	12	1	3.817	3.641	33	-1.591	1.3707	10.6570	14.6076	51.5090	32	31.4863	0.9839
2	..	1/2 + 2	4.266	4.376	14	-2.329	1.5717	4.0038	6.2928	14.1221	13	4.2317	0.3255
3	Within Regression Coefficients		..	..	..	..	..	..	45	35.7180	0.7937
4	Combined		..	..	..	..	..	..	1	0.1175	0.1175 NS
5	Intercepts		47	..	..	14.6608	20.9004	65.6311	46	35.8355	..
6	Overall		..	..	..	..	..	..	1	0.0828	0.0828 NS
7	Overall		48	-1.876	1.4522	16.7585	24.3364	71.2592	47	35.9183	..
1	2	1/2 + 2	4.105	3.811	23	-2.985	1.6556	14.2758	23.6354	76.0301	22	36.8987	1.6772
2	..	2/3 + 3	5.138	5.714	8	-7.517	2.5751	1.8734	4.8242	18.5730	7	6.1502	0.8786
3	Within Regression Coefficients		..	..	..	..	..	..	29	43.0489	1.4844
4	Combined		..	..	..	..	..	..	1	1.4001	1.4001 NS
5	Intercepts		31	..	..	16.1492	28.4596	94.6031	30	44.4490	..
6	Overall		..	..	..	..	..	..	1	0.0320	.. NS
7	Overall		32	-3.508	1.7867	23.1251	41.3167	118.2999	31	44.4810	..

- CONCLUSION:**
1. For Plot 12 there is no apparent difference in growth behaviour between tree classes 1 and (1/2+2). Samples of 34 and 15 trees.
 2. For Plot 2 there is no apparent difference in growth behaviour between tree classes (1/2+2) and (2/3+3). Samples of 24 and 9 trees.

APPENDIX 2

APPROXIMATE TEST OF THE HYPOTHESIS THAT REGRESSION COEFFICIENTS ARE SAMPLES FROM A COMMON POPULATION

Since the standard errors of estimates ($s^2_{y \cdot x}$) given in table 5 indicate heterogeneous variance the usual methods are not applicable. The test below was suggested by McIntyre (Curtin, 1964) and is applied to both burnt and unburnt plots.

A. Burnt plots

	b		s ² _{y·x}	s ² _b	w	wb
b1	2.7809	.. ..	3.5748	1.3974	0.7156	1.9900
b2	1.3707	.. ..	0.9839	0.0923	10.8342	14.8504
b3	1.5717	.. ..	0.3255	0.0813	12.3001	19.3321
b4	1.6556	.. ..	1.6772	0.1175	8.5106	14.0901
b5	2.5751	.. ..	0.8786	0.4690	2.1322	5.4906
b6	1.3616	.. ..	0.9977	0.0541	18.4843	25.1682
				Sums	52.9770	80.9214

where s^2_b is standard error of coefficient "b" and w is $1/s^2_b$.

$$\Sigma w b^2 = 128.0091$$

$$\bar{b} = \Sigma w b / \Sigma w = 1.5275$$

$$(\Sigma w b)^2 / \Sigma w = 123.6060$$

$$s^2_{\bar{b}} = 1 / \Sigma w = 0.0189$$

Difference is $\chi^2_{(5)} = 4.4031$ which is not significant $P = 0.05$

B. Unburnt plots

	b		s ² _{y·x}	s ² _b	w	wb
1J—b1	1.320	.. ..	0.4191	0.0681	14.6843	19.3833
1K—b2	0.915	.. ..	0.4667	0.0338	29.9581	27.4117
1L—b3	0.973	.. ..	0.4414	0.0116	86.2069	83.8793
1M—b4	1.416	.. ..	0.4178	0.0258	38.7597	54.8837
				Sums	169.6090	185.5580

$$\Sigma w b^2 = 209.9975$$

$$\bar{b} = 1.0940$$

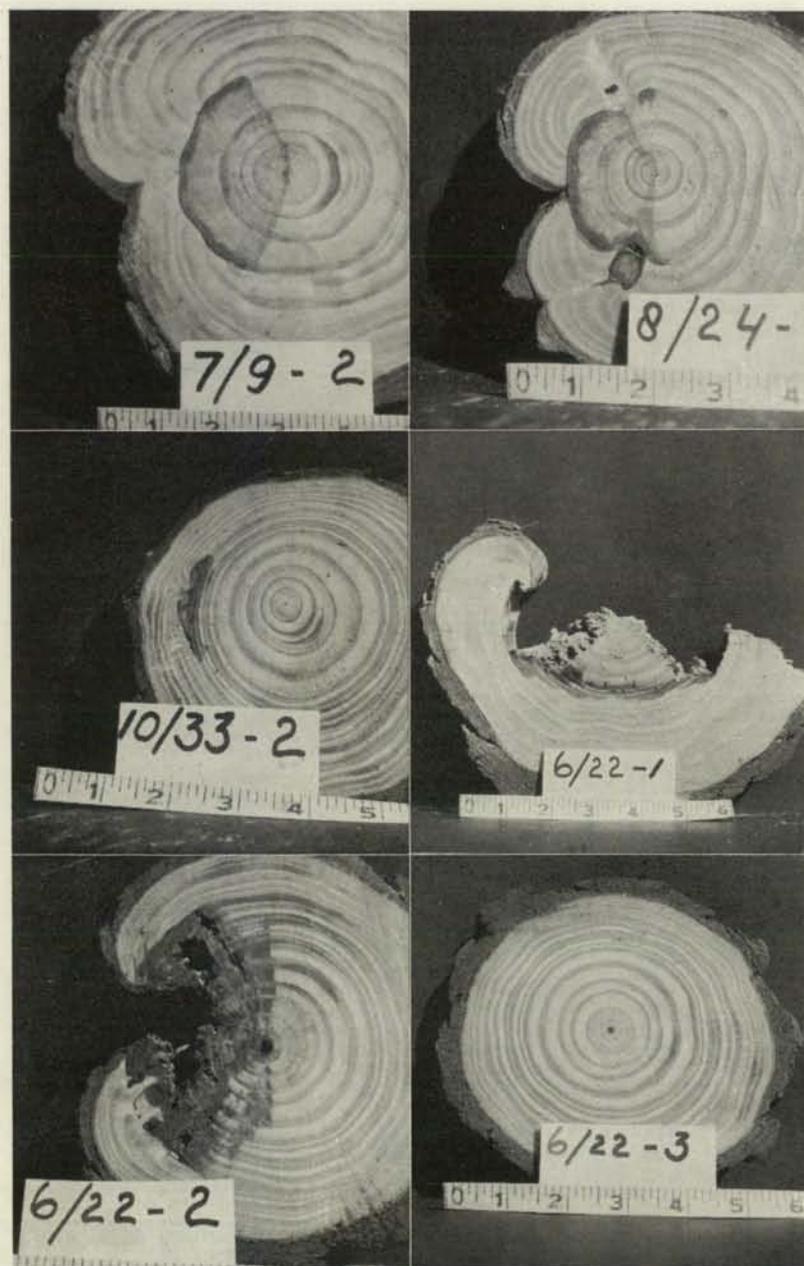
$$(\Sigma w b)^2 / \Sigma w = 203.0067$$

$$s^2_{\bar{b}} = 0.02428$$

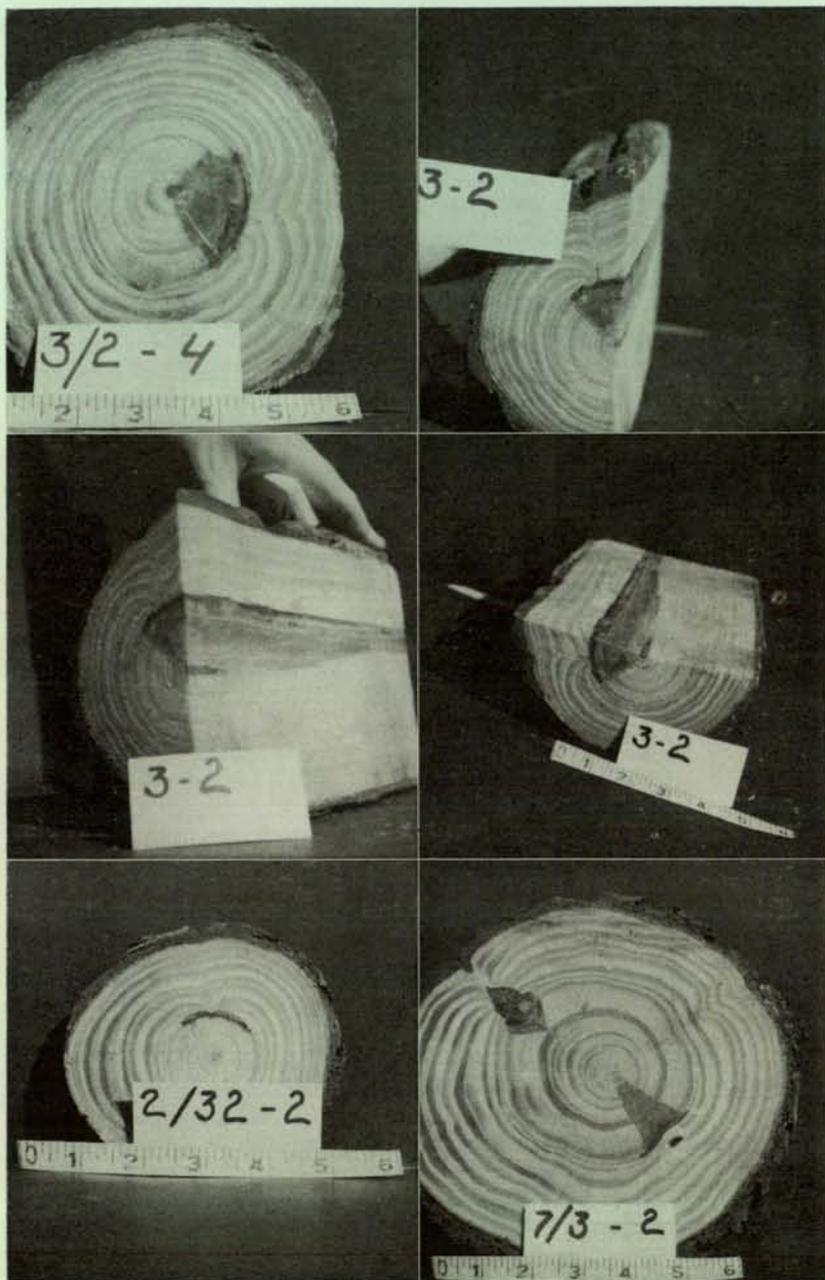
$\chi^2_{(3)} = 6.9908$ which is not significant $P = 0.05$

When all regressions are combined, burnt and unburnt, $\chi^2_{(9)}$ becomes 16.92 which is significant at 5 per cent probability level. It is concluded that the regression of ΔD^2 on D for the burnt plots are parallel with a slope of 1.5275, and those of the unburnt plots are also parallel with a slope of 1.0940, but these common slopes are different from one another.

APPENDIX 3



APPENDIX 4



FORESTRY COMMISSION OF N.S.W.—RESEARCH PUBLICATIONS

RESEARCH NOTES—

- No. 1. Field Identification of Seedlings of the Major Tree Species in the Blackbutt and Flooded Gum Areas. A. G. FLOYD, 1958.
- No. 2. Investigations in Sowing of Flooded Gum. A. G. FLOYD, 1960.
- No. 3. N.S.W. Rainforest Trees. Part I: Family Lauraceae.
A. G. FLOYD and H. C. HAYES, 1960.
- No. 4. Raising and Planting of Flooded Gum. G. N. BAUR, 1959.
- No. 5. Nursery Spacing and Grading of Slash Pine Seedlings.
G. N. BAUR, 1960.
- No. 6. The Effects of Low Pruning on Increment in Radiata Pine Plantation.
K. R. SHEPHERD, 1961.
- No. 7. N.S.W. Rainforest Trees. Part 2: Families Cappariaceae, Escalloniaceae, Pittosporaceae, Cunoniaceae, Davidsoniaceae.
A. G. FLOYD and H. C. HAYES, 1961.
- No. 8. Forest Vegetation in Northeastern New South Wales.
G. N. BAUR, 1962.
- No. 9. Silvicultural Practices in Rainforest of Northern N.S.W.
G. N. BAUR, 1962.
- No. 10. Investigations into the Natural Regeneration of Blackbutt (*Eucalyptus pilularis*).
A. G. FLOYD, 1962.
- No. 11. Entomological Research on the Cause of Mortalities of *Eucalyptus saligna* (Sydney Blue Gum).
K. M. MOORE, 1962.
- No. 12. Insect Attack on *Pinus* spp. K. M. MOORE, 1962.
- No. 13. The Cypress Pine Sawfly Subspecies: *Zenarge turneri turneri* and *Z. t. rabus*.
K. M. MOORE, 1963.
- No. 14. The Effect of Pretreatment on Germination of Slash Pine Seed.
W. G. FORREST, 1964.
- No. 15. Relationship of Vessel Diameter to *Lyctus* Susceptibility in some N.S.W. Hardwoods.
R. K. BAMBER and RUTH ERSKINE, 1965.
- No. 16. Chemical Control of Forest Weeds.
W. G. FORREST and R. R. RICHARDSON, 1965.
- No. 17. Forest Types in New South Wales. 1965.
- No. 18. Investigation into the Growth of an Irregular Eucalypt Forest in Northern New South Wales.
B. J. TURNER, 1966.
- No. 19. Investigations in Regenerating the Tallowwood—Blue Gum Forest Type.
A. P. VAN LOON, 1966.
- No. 20. The Biology of Three Species of Phasmatids (Phasmatodea) Which Occur in Plague Numbers in Forests of Southeastern Australia.
P. HADLINGTON and K. G. CAMPBELL (in press)

PAPERS FOR BRITISH COMMONWEALTH FORESTRY CONFERENCES

7th CONFERENCE (Australia and New Zealand)—

- Forest Utilisation—Less Valuable Species.
L. S. HUDSON and P. T. COOKE, 1957.
- Timber Sales Policy and Procedure. R. J. RITCHIE, 1957.
- Defoliation of Alpine Ash (*Eucalyptus delegatensis*) by Phasmatids.
K. R. SHEPHERD, 1957.
- Principal Exotic Forest Trees in N.S.W. 1957.

8th CONFERENCE (East Africa)—

The application of Basal Area Control to thinning of *Pinus radiata* Plantations in New South Wales.

S. W. GENTLE, J. L. HENRY, and K. R. SHEPHERD, 1962.

Forest Entomological Research in New South Wales.

K. G. CAMPBELL, P. HADLINGTON, and K. M. MOORE, 1962.

TECHNICAL PAPERS—

(This series contains limited numbers of papers, primarily intended for distribution within the Forestry Commission.)

- No. 1. Seminar on Management of Low Site Quality Plantations, Moss Vale.
1963.
- No. 2. Observations on the Growth of Coachwood (*Ceratopetalum apetalum*) in a Selection Forest.
G. N. BAUR, 1963.
- No. 3. Seminar on Economics of Forestry, conducted by A. J. Leslie, Bathurst.
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- No. 4. Pre-emergent Weedicides in Forest Nurseries, Green Hills State Forest.
P. A. CASIMIR, 1963.
- *No. 5. Future of Rainforest in N.S.W.
G. N. BAUR, 1964.
- *No. 6. Forestry as an Economic Form of Land Use.
W. D. MUIR, 1964.
- No. 7. Germination Test Methods for Tree Seeds.
A. G. FLOYD, 1964.
- No. 8. Forest Types of the Cypress Pine Zone.
A. D. LINDSAY (in press)
- No. 9. Raising and Planting out of Blackbutt in Jiffy Pots.
A. G. FLOYD, 1965.
- No. 10. Proceedings of the Fourth Silvicultural Research Officers' Conference, Coff's Harbour.
1965.
- No. 11. Major Plantation Species in New South Wales.
(in press)
- No. 12. Experimental Plantings of Conifers—North Coast.
I. P. BURGESS, (in press)

OTHER PUBLICATIONS—

- Climatological Basis of Forestry.
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- Watershed Management in the United States of America.
K. M. GRAY, 1958.
- A Contribution towards a Watershed Management Research Programme for the Hunter Valley, N.S.W.
K. M. GRAY, 1959.
- Log Extraction by Crawler Tractor. A report of Logging Operations in Eastern New South Wales.
C. H. GRUGEON, 1961.
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* Out of Print



L0000352

Addendum

Forest Resources Series No. 21,
Fauna Survey, Wingham Management Area, Port Macquarie Region,
Part 3. Reptiles and Amphibians,
Forestry Commission of New South Wales,
Greg P. Clancy. January 1992.

Reference (voucher) specimens of all species collected during the survey were lodged with the Australian Museum. Subsequent to the publication of this report, Ross Sadler (Herpetology Section) clarified the identity of seven individuals of skink that had previously been considered to belong to a single species. The seven individuals were initially considered to be *Lampropholis delicata* but are now known to be *Lampropholis amacula*. They were recorded on plots DUL1, DUL3, DUL5, DUL7 (2), DUH4 and DLL3. (Note: not all *L. delicata* were re-classified as *L. amacula*). *Lampropholis delicata* is a common and well-known species in New South Wales while *L. amacula* has only been described comparatively recently [Ingram, G.J. and Rawlinson, P. (1981). Five new species of skinks (genus *Lampropholis*) from Queensland and New South Wales. *Mem. Qld. Mus.* 20(2): 311-317.]

Both species are very similar in appearance and are easily confused. Although this is the first record for *L. amacula* in this area (and one of the first for New South Wales), it is likely that further surveys will find it to be widely distributed and common. Neither species are currently considered to be "endangered" in New South Wales.

The changes in nomenclature do not affect the results or interpretation of data in this report.