FORESTRY COMMISSION OF N.S.W.

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INVESTIGATIONS IN REGENERATING THE TALLOWWOOD - BLUE GUM FOREST TYPE

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CONTENTS

SUMMARY

Investigations described in this report concern mainly the regeneration of the Tallowwood-Blue Gum forest type.

The report includes laboratory studies of various effects on the germination of seed and data of four years' observations on the flowering and seeding habits of Tallowwood and Blue Gum.

Seed bed preparation is shown to be necessary and the method of tractor clearing to be better than that of burning. Mechanical clearing by means of extending existing snigtracks incorporates many advantages of full clearing with reduced costs.

The dusting of seed with Dieldrin powder resulted in a highly significant improvement in percentage stocking, while the presence of cover (50 per cent canopy) did not assist germinates.

The number of seedtrees per acre proved not to be a reliable guide to the quantity of seed to be expected and effective seed throw is shown not to exceed fifty feet from the base of the tree.

Attempts at the introduction of faster growing desirable species showed good promise.

INTRODUCTION

Tallowwood (*Eucalyptus microcorys*)*, is widely distributed in north eastern New South Wales and south eastern Queensland between the Pacific Ocean and the higher altitudes of the coastal escarpment of the Dividing Range, while Sydney Blue Gum (*E. saligna*), although it extends some three degrees of latitude further south than Tallowwood, generally occupies similar sites. Both species reach optimum development as an association on and below the coastal plateaux with an altitudinal range of 1,000 feet-3,000 feet above sea level, where the rainfall is not less than 35 inches per annum and frequently exceeds 60 inches, with a peak distribution in the summer months. The association only occurs on fertile to very fertile soils.

The Tallowwood-Blue Gum association often borders rainforest areas, and in the absence of fire rainforest frequently invades the type. Principal associated commercial species include Brush Box (*Tristania conferta*), Turpentine (*Syncarpia glomulifera*), Silvertop Stringybark (*E. laevopinea*), New England Blackbutt (*E. campanulata*), White Stringybark (*E. globoidea*), Diehard Stringybark (*E. cameronii*), Narrowleaved White Mahogany (*E. acmenioides*), and Whitetopped Box (*E. quadrangulata*).

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* Authorities for botanical names are given in Appendix I.

Tallowwood is the most valuable species in the type; it commands high royalties and is generally free from serious defect. Its timber combines great strength and durability with comparative ease of working and it is considered to be one of the best hardwoods in New South Wales (Anon., 1957).

However, it has a slow growth rate and its rotation is generally estimated at 125 years; it is considered to be one of the most shade tolerant species in the genus.

Blue Gum, although fast growing, is less desirable and generally very defective, especially in regrowth stands. In all trials described in later sections the main emphasis has been placed on Tallowwood.

The understorey of the Tallowwood-Blue Gum type is extremely dense and mainly composed of rainforest elements such as *Callicoma serratifolia*, *Cryptocarya rigida*, *Ackama paniculata*, *Elaeocarpus reticulatus*, *Schizomeria ovata*, *Orites excelsa*, *Synoum glandulosum*, *Endiandra sieberi*, *Duboisia myoporoides*, *Drimys* spp., *Casuarina torulosa* and the Acacias, *A. elata*, *A. binervata* and *A. irrorata*. Many vines and epiphytes also occur.

When the canopy is removed or opened and the soil exposed, the combination of high summer rainfall and good soil leads to a rapid and vigorous colonisation by agricultural weeds, in addition to the species originally occupying the site. This prolific weed growth is one of the most important factors hindering successful regeneration of the type.

As an accelerated programme of road construction, caused by increasing demands for high quality hardwoods, has opened up considerable areas of the Tallowwood-Blue Gum type in recent years, the need for a satisfactory technique to regenerate the type is of high priority.

The two prime requisites for regeneration are:—

(a) A satisfactory seed source,

(b) An exposed mineral soil;

and the trials to be reported involved studies in flowering, seeding and seed germination as well as combinations of various methods and degrees of site preparation, cutting systems, canopy cover, seed source and sowing rates.

Experiments described were mainly conducted in the period January, 1960 to February, 1961, in the Bulga-Dingo Management Area (elevation 1,800 ft-2,200 ft; Lat. 31° 39′ S, Long. 152° 10′ E, 25 miles north west of Taree, N.S.W.) and the Bellangry Management Area (elevation 2,800 ft-3,000 ft; Lat. 31° 12′ S., Long. 152° 24′ E., 46 miles N.N.W. of Taree) (see Appendix 2).

Appendix 3 lists all regeneration trials in numerical order; due to the lengthy treatment description of these trials they will frequently be referred to by number in the following sections which review the results of these experiments.

SECTION I. SEED STUDIES

(a) Germination Tests

Germination tests have been carried out on many seed batches of most species in the Tallowwood-Blue Gum type. An experiment to determine the longevity of seed under room temperature storage conditions is in progress, while tests have been conducted on optimum temperatures for germination, the effect of stratification at 30 °F, and the effects of soaking in different strengths of hydrogen peroxide.

Method

All general tests have been conducted in a constant temperature oven set on 80 °F to 90 °F. The method used has been that recommended by Grose and Zimmer (1958), with modifications, suggested by Floyd (1964) in relation to the marking of segments and the length of the hypocotyl when counting.

Due to variations in seed weight and size, 0·1g per subsample was used for Tallowwood and New England Blackbutt and 0·05g subsamples for Blue Gum and Brush Box.

It proved difficult to sample Tallowwood seed satisfactorily, primarily because of the large size differences between seed and chaff, and standard errors at the 95 per cent level approached 15 per cent of the mean. The number of Tallowwood seeds per pound varied from 53,500 ($\pm$ 8,800) to 172,700 ($\pm$ 13,500) at the 95 per cent level.

Germination tests of eight seedlots from 1959 and 1960 collections show a mean number of viable seeds per pound of 80,000.

Fertile Tallowwood seed differs greatly from the chaff and can be distinguished readily with the naked eye. This can lead to considerable bias when attempts are made to weigh out a sample of seed to an exact weight (e.g. 0·100 g) by the addition or subtraction of small quantities of seed to or from the sample being weighed. It is consequently recommended that, in future tests, samples should only approximate to a weight of 0·1 g, and that subsequent calculations should be adjusted accordingly.

Due to variations in total numbers of seeds per pound a figure was calculated, for use in storage tests, to show the percentage of viable seeds to total seeds.

(b) Storage Tests

Nine seedlots of Tallowwood of various ages are stored in airtight containers at room temperature. These are tested annually in order to determine viability and thus longevity of Tallowwood seed under these conditions.

Figure 1 illustrates that there is no definite falling off in Tallowwood viability at least in the first six years of room temperature storage.

Only seedlot T23 falls within the 6-10 years age group and it tends to show a marked decrease in viability. It will be interesting to note if this trend is confirmed by Tallowwood seedlots now approaching this age.

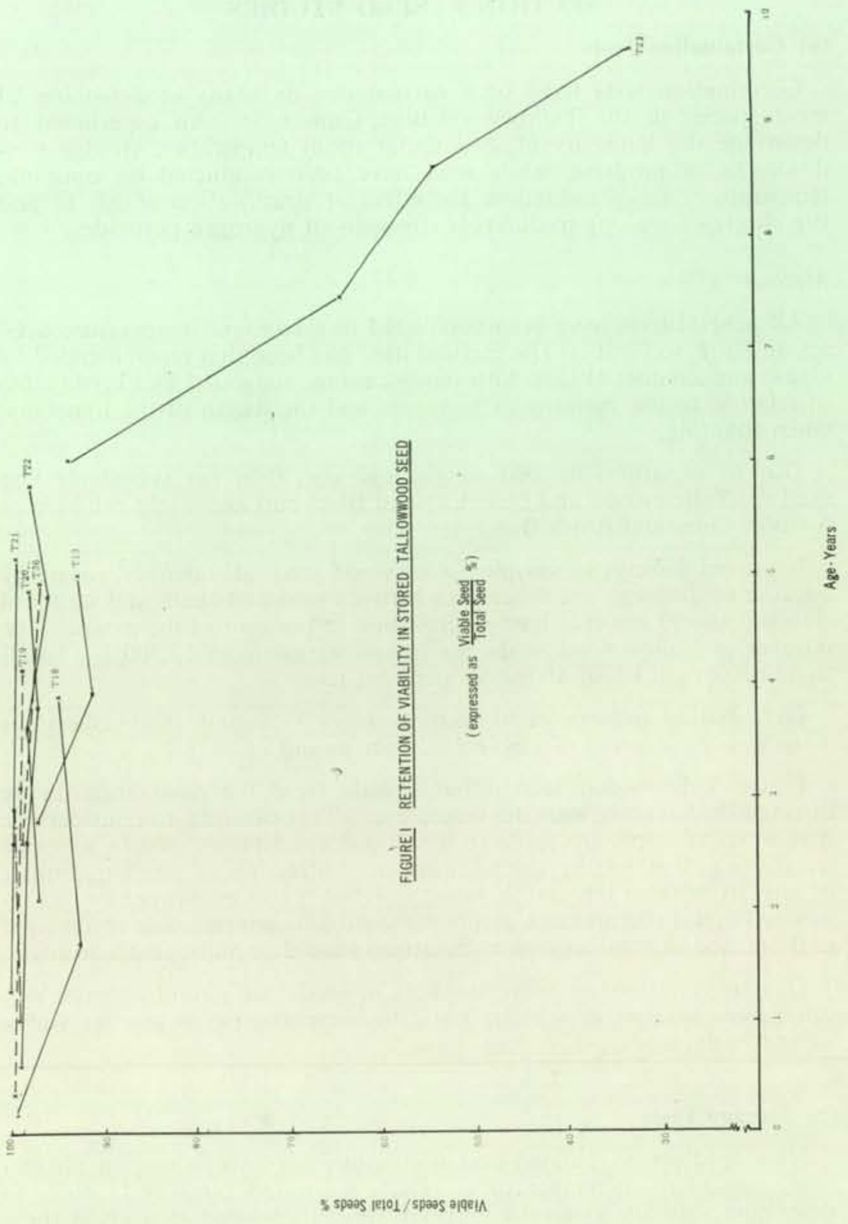


FIGURE I RETENTION OF VIABILITY IN STORED TALLOWWOOD SEED

(expressed as $\frac{\text{Viable Seed}}{\text{Total Seed}}$ %)

Similar tests are conducted on three lots of Blue Gum seed, two of New England Blackbutt seed and one of Brush Box. Figure 2 shows a marked decrease in viability of Blue Gum seed in the first five years of similar storage. This decrease was tested by performing an analysis of variance on the arcsin transformation of the percentage of viable seeds to total seeds, and differences between years were highly significant.

The storage potential of New England Blackbutt is subject to doubt while the only lot of Brush Box included in this test shows no decrease in viability up to age three years.

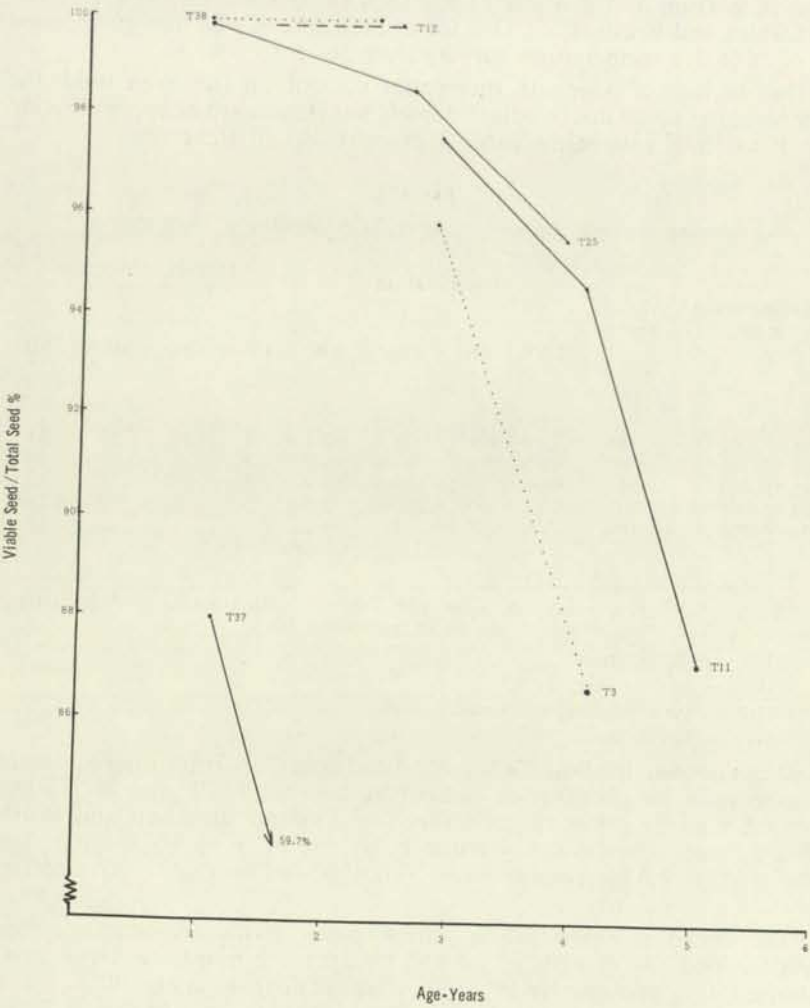


FIGURE II RETENTION OF VIABILITY IN STORED SEED

(expressed as $\frac{\text{Viable Seed}}{\text{Total Seed}}$ %)

Sydney Blue Gum

New England Blackbutt

Brush Box

(c) Optimum Temperature

A series of tests was conducted to determine the optimum temperature for germination for the main species in the type. Five lots of twenty subsamples each containing 30 fertile seeds were selected for Tallowwood and Blue Gum and five lots of ten such subsamples for New England Blackbutt and Brush Box. One lot of each species was then germinated at each of five temperatures varying from 56 °F to 106 °F.

Due to lack of adequate thermostat control on the oven used, the temperatures could not be adjusted finely but were raised at approximately 10 °F to 15 °F intervals. Table 1 gives results of these tests.

TABLE 1

Showing optimum temperature range for germination of main species

Temperature Range	Approx. Temp.	Germination				Day of Maximum Germination			
		TW*	sbG	eBB	bB	TW	sbG	eBB	bB
		%	%	%	%				
56 °F- 62 °F	59°	98·8	98·7	99·3	82·7	13	12	13	21
69 °F- 71 °F	70°	98·5	99·1	97·6	98·9	7	6	7	10
83 °F- 87 °F	85°	96·9	98·2	95·6	98·9	5	4	7	7
94 °F- 97 °F	95°	93·2	97·1	60·6	72·0	5	5	9	11
104 °F-106 °F	105°	1·0	5·5	0	98·2 (unhealthy)	..	..	..	18

* Note: Species symbols are from the Forestry Commission booklet, *Forest Species of New South Wales*, Form FC88, published 1963.

TW = Tallowwood.
sbG = Sydney Blue Gum.
eBB = New England Blackbutt.
bB = Brush Box.

It can be seen that both Tallowwood and Blue Gum reach their optimum temperature for germination somewhere between 83 °F and 97 °F, but probably in the lower range, while New England Blackbutt and Brush Box definitely require temperatures below the 94 °F to 97 °F range, but above 65 °F. A temperature of 88 °F is now used for routine germination tests.

The speed of germination varies greatly with temperature; for Tallowwood the number of days to maximum germination drops from thirteen at approximately 59 °F to seven at approximately 70 °F. The average daily mean temperature in Taree is slightly less than 60 °F from May until September and slightly above 70 °F for the period December to March (Anon., 1956). The summer mean relative humidity is approximately eighty per cent.

(d) Stratification

Twenty samples of 0·1 g of Tallowwood seed were weighed. Ten of these were stratified at 30 °F for three weeks while the remaining ten samples were stored at room temperature for the same period. At the end of the three weeks a normal germination test was set up. Results were:

	Stratified	Unstratified
Germination Capacity	94·2	100·0
Viable Seeds per pound	31,300	37,200
Day of Maximum Germination ..	3	3

Statistical analysis shows that there is no apparent effect of stratification on germination. At no stage during these investigations did any of the species exhibit signs of primary or secondary dormancy which have been demonstrated in alpine and sub-alpine eucalypts of Southern Australia (Grose, 1963; Cunningham, 1960).

(e) Peroxide Soaking

Trappe (1961) recommended the use of 30 per cent solutions of hydrogen peroxide for short periods to sterilise seed coat and stimulate germination of pine seed.

Two series of tests were conducted on Tallowwood seed. In the first, ten sub-samples of ten seeds each were counted out and each was treated for different lengths of time with 30 per cent hydrogen peroxide. Germination testing was then carried out at 80 °F. Results are shown in Table 2.

TABLE 2

Showing effects of soaking in 30 per cent hydrogen peroxide on germination of Tallowwood seed

	No. of days of test	Germination	Seeds Retaining Viability
		Per cent	Per cent
Control—soaked in water for 30 minutes	20	96·2	79·0
Soaked in H_2O_2 for 15 minutes	20	91·3	92·0
Soaked in H_2O_2 for 30 minutes	20	98·7	78·0
Soaked in H_2O_2 for 60 minutes	20	94·0	83·0

Conclusion

Soaking in 30 per cent hydrogen peroxide makes no difference to speed or number of germinates.

In a visual observation test, four groups of five sub-samples of 0·1 g of Tallowwood seed were weighed out. These were treated in four different ways.

(a) Control—untreated.

(b) Soaked in 6 per cent H_2O_2 for 30 minutes.

(c) Soaked in 6 per cent H_2O_2 for 60 minutes.

(d) Soaked in 6 per cent H_2O_2 for 120 minutes.

These were then germinated at a temperature range of 101 °F to 107 °F. Results were:

(a) Fungus commenced on second day.

(b) Fungus commenced on fourth day.

(c) Fungus commenced on fourth day.

(d) Fungus commenced on fourth day.

Hence, soaking Tallowwood seed in weak solutions of hydrogen peroxide appears to have an inhibitory effect on fungus production. As fungus production may be one of the inhibitors of seed germination this could have some application. However, in routine germination tests, conducted at 88 °F, fungal infestation rarely occurs.

SECTION II. FLOWERING AND SEEDING

In order to observe the periodicity and pattern of flowering and seeding of the main species in the Tallowwood-Blue Gum type, nine stationary seed traps (installed in six stands) were used to collect information. Additional seed traps were arranged within regeneration treatments to study seedfall per unit area based on the method of Wilm (1946). The results of these unit area studies are referred to in section IVe on rates of sowing.

The seed traps were designed as described and illustrated by Cunningham (1960). Traps were made of canvas material with ⅜-inch steel rod framing, the top frame being 3 ft by 3 ft, and collections were funnelled into gauze bottomed tins.

Seed trap contents were macroscopically examined by species for: inflorescence primordia, inflorescence bracts, immature buds, first opercula, mature buds, flowers, second opercula, immature and mature fruits, fertile seed and chaff. Trap contents were dried at room temperature, the dry contents were then sieved and the fraction between 0·078 inch and 0·0073 inch screens was microscopically examined using a ten times binocular head-piece magnifier.

Unfortunately the mesh of the gauze at the bottom of collection tins was large enough to allow part of the chaff to pass through, thus rendering chaff data unreliable, while it was not always possible to arrange trap collections at four-weekly intervals as was intended.

When comparing data from all traps in use at the one time in various areas it becomes apparent that altitude has a large influence on stages of flowering and seeding. The time of flowering and seedfall on Myall River (elevation 800 ft-1,200 ft) precedes Bulga-Dingo (1,800 ft-2,200 ft) by one to two months, while Bellangry (2,800 ft-3,000 ft) follows Bulga-Dingo by a similar margin.

(a) Tallowwood Seedfall

Tallowwood flower and seedfall for both Bulga-Dingo (six traps) and Bellangry (three traps) are shown in figures 3 and 4, for the four-year period June, 1960 to June, 1964. Insets in each figure show corresponding seed and flower falls for the same period on a mean annual basis.

FIG 3

TALLOWWOOD BLUE GUM FLOWER FALL

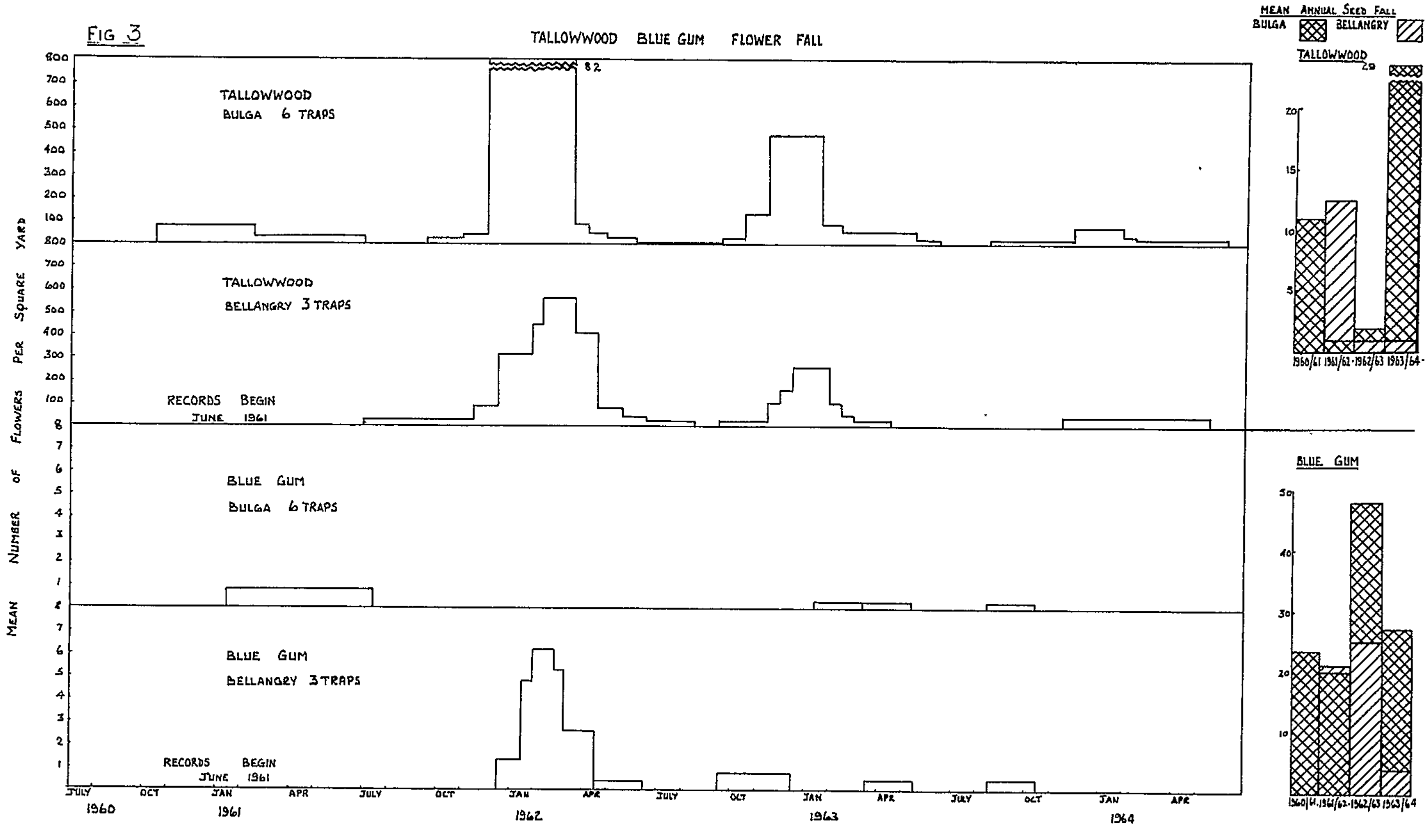


FIG 4

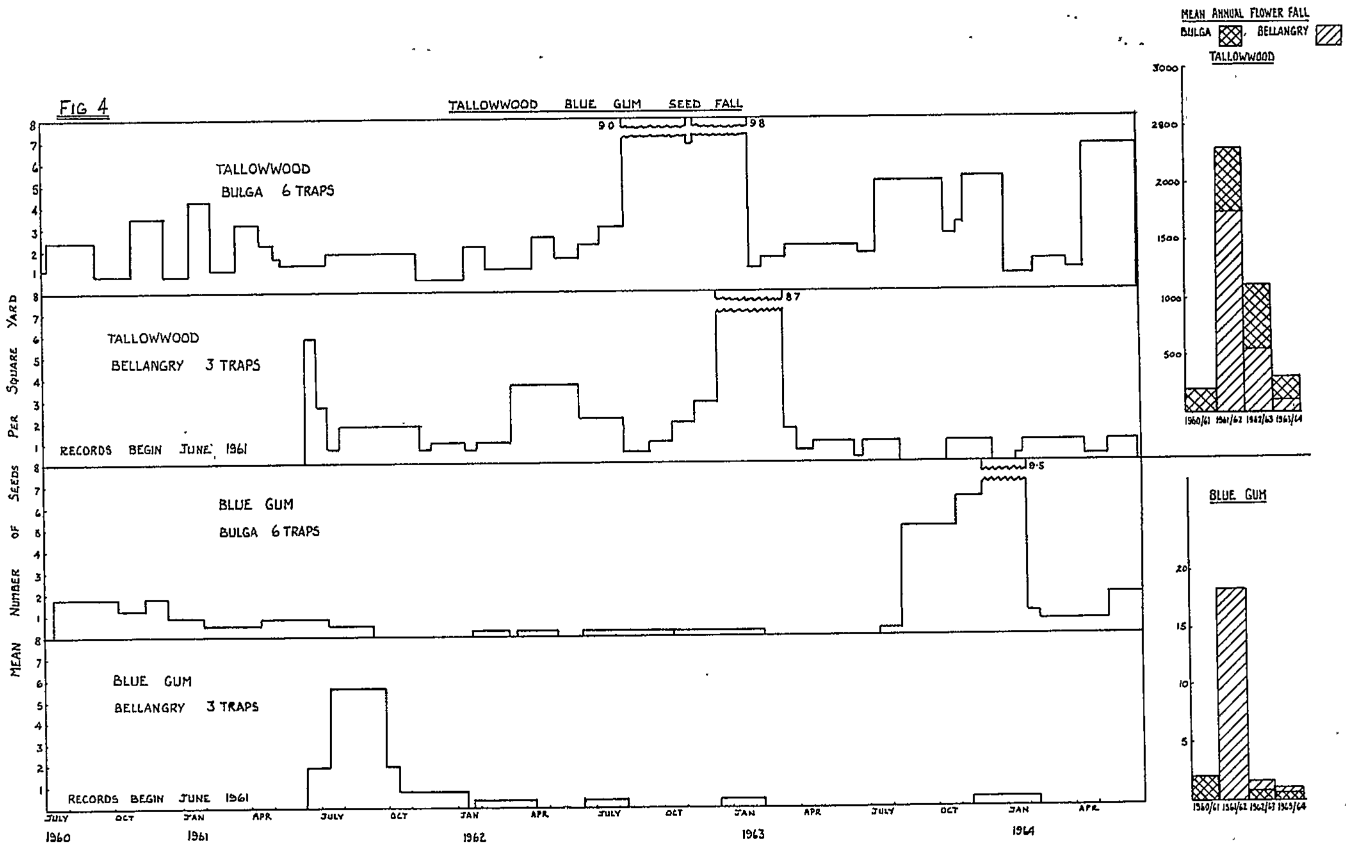

TALLOWWOOD BLUE GUM SEED FALL
TALLOWWOOD
BULGA 6 TRAPS
TALLOWWOOD
BELLANGRY 3 TRAPS
RECORDS BEGIN JUNE 1961
BLUE GUM
BULGA 6 TRAPS
BLUE GUM
BELLANGRY 3 TRAPS
RECORDS BEGIN JUNE 1961
MEAN NUMBER OF SEEDS PER SQUARE YARD
JULY OCT JAN APR JULY OCT JAN APR JULY OCT JAN APR JULY OCT JAN APR
1960 1961 1962 1963 1964
90 98 87 8·5
MEAN ANNUAL FLOWER FALL
BULGA BELLANGRY
TALLOWWOOD
BLUE GUM
1960/61 1961/62 1962/63 1963/64

FIG. 5

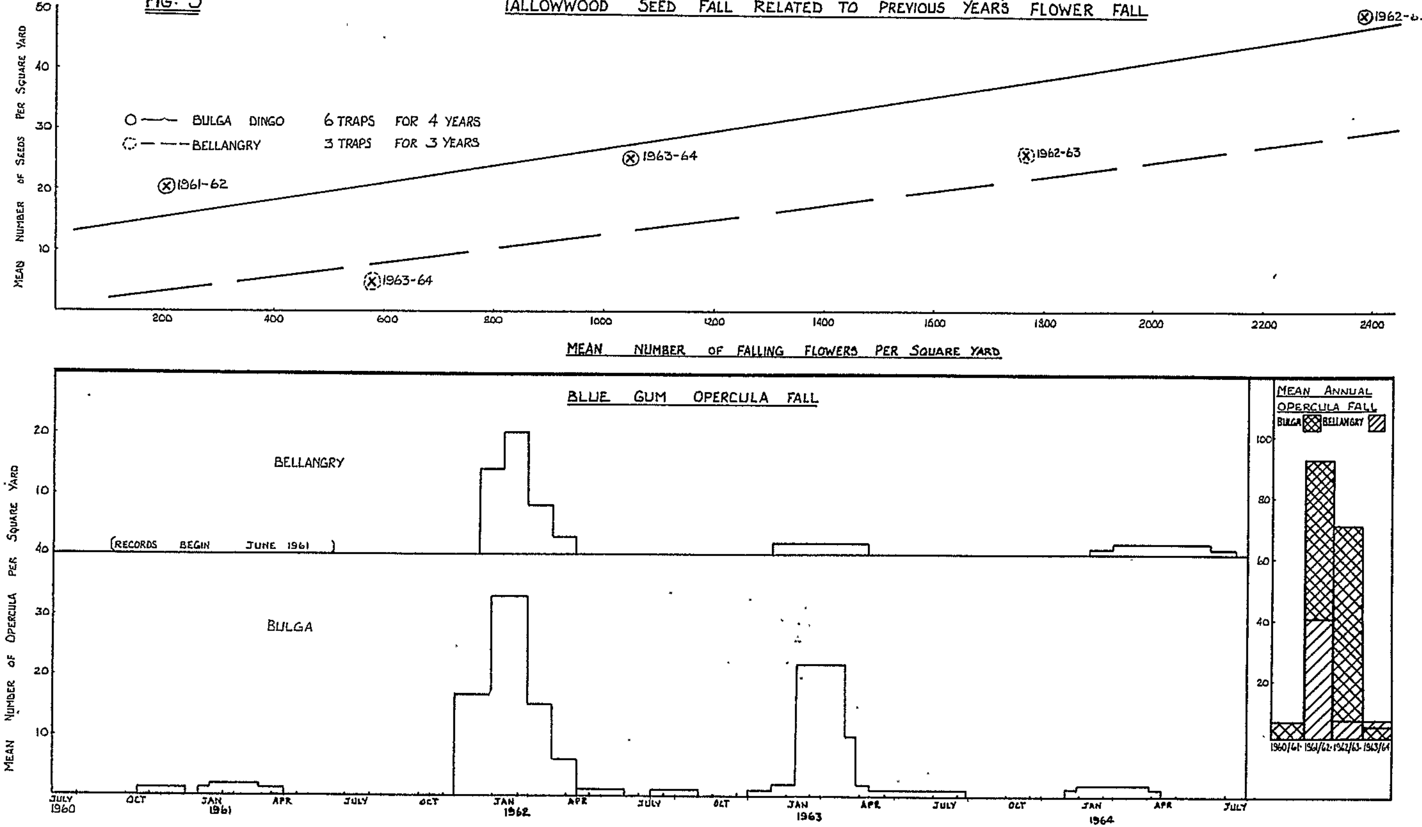

TALLOWWOOD SEED FALL RELATED TO PREVIOUS YEAR'S FLOWER FALL
MEAN NUMBER OF SEEDS PER SQUARE YARD
BULGA DINGO 6 TRAPS FOR 4 YEARS
BELLANGRY 3 TRAPS FOR 3 YEARS
1961-62
1963-64
1962-63
1963-64
1962-63
MEAN NUMBER OF FALLING FLOWERS PER SQUARE YARD
BLUE GUM OPERCULA FALL
BELLANGRY
(RECORDS BEGIN JUNE 1961)
BULGA
MEAN NUMBER OF OPERCULA PER SQUARE YARD
JULY 1960
OCT
JAN 1961
APR
JULY
OCT
JAN 1962
APR
JULY
OCT
JAN 1963
APR
JULY
OCT
JAN 1964
APR
JULY
MEAN ANNUAL OPERCULA FALL
BULGA
BELLANGRY
1960/61
1961/62
1962/63
1963/64

Figure 5 shows seedfall related to the previous year's flower fall and indicates a good linear relationship between the two. Indications are that the number of flowers falling is directly related to the number of capsules maturing and that seedfall follows some twelve months later. This enables the size of the seed crop to be forecast some twelve months in advance of site preparation.

This is in contrast to many other species in the genus. Florence (1961) shows a two year lapse between flowering and seeding for Blackbutt; Cunningham (1960) shows for *E. regnans* that, although seed of this species matures one year after flowering, it is not generally shed until the second or third season after flowering. Grose (1960) states that in *E. delegatensis* flowering occurs in February and March and the resulting seedcrop remains on the trees for at least two years. Blue Gum also shows a two year interval as will be shown in the next section.

This early seedfall from Tallowwood capsules can probably be attributed to the fragile nature of the capsule, pedicel and peduncle as compared with other eucalypts, resulting in very rapid drying out of the inflorescence after it matures. Tallowwood capsules often shed seed while green and most capsules have fallen from the tree within two months after seedfall has occurred.

The results of opercula counting were very disappointing; in all cases the number of fallen flowers exceeded the number of opercula and in no way could the opercula count be used to estimate the number of flowers remaining. The reasons for this are obscure, but it is suggested that repeated wetting and drying in the trap while awaiting collection may have caused disintegration of the opercula. Bud and inflorescence primordia fall showed no clear relationship, while chaff data is unreliable due to known losses prior to collection.

Annual seedfall figures for Tallowwood are shown in Table 3.

TABLE 3

Annual Tallowwood seedfall, 1960 *to* 1964

Year	Bulga-Dingo	Management Area	Bellangry	Management Area
	Per trap	Per acre	Per trap	Per acre
1960-61	22·3	107,932	..	..
1961-62	20·0	96,800	21·3	103,092
1962-63	48·5	234,740	25·0	121,000
1963-64	26·8	129,712	4·3	20,812

As germination tests have indicated a mean number of 80,000 Tallowwood seeds per pound, annual seedfall at Bulga-Dingo ranged between 1 lb 3 oz and 2 lb 15 oz per acre, while Bellangry totals are between 4 oz and 1 lb 8 oz. However, it should be realised that the mean distance from these traps to seed trees is 37 feet, which is the equivalent of at least eight Tallowwood seed trees per acre.

The loss of Tallowwood flowers is considerable, trap collections indicating that less than one percent of flowers reaches maturity.

(b) Numbers of Tallowwood Seeds per Capsule

Tallowwood capsules were collected from twelve trees on a range of sites in the Bulga-Dingo and Bellangry management areas. Capsules were allowed to dry out in the laboratory until gentle shaking produced no more seed or seed particles. Results are shown in Table 4.

TABLE 4

Number of Viable Tallowwood Seeds per Capsule

Locality	Elevation	Date of Collection	Date Seed Extraction Terminated	Number Capsules	No. Seed Particles	No. of Viable Seed
	feet					
....	..	28-4-61	19-7-61	20	1,700	5
....	..	28-4-61	19-7-61	20	1,700	18
....	..	28-4-61	19-7-61	20	1,550	31
Bulga-Dingo	2,000	..	19-7-61	14	1,102	12
Bulga-Dingo	1,800	9-5-61	19-7-61	96	Not counted	55
Bulga-Dingo	..	..	19-7-61	64	Not counted	63
Bulga-Dingo	2,400	12-7-61	19-7-61	40	Not counted	35
Bulga-Dingo	..	15-8-61	21-8-61	53	Not counted	119
Bulga-Dingo	..	15-8-61	21-8-61	26	Not counted	12
Bellangry ..	2,800	16-11-61	8-1-62	10	Not counted	23
Bellangry ..	2,800	16-11-61	8-1-62	16	Not counted	26
Totals ..				379		399

This indicates a mean number of viable seeds per capsule of 1·05, while the number of seed particles per capsule (where determined) averaged 81·8. The number of viable seeds per capsule varied from 0·25 to 2·24 in collections from different trees.

(c) Blue Gum Seed Fall

The traps used for Tallowwood results were also sampled for Blue Gum. The mean distance from trap to Blue Gum seed tree was 67 feet, as compared with 37 feet for Tallowwood.

Results for flowers, seed and opercula are presented in figures 3, 4 and 5. These figures indicate that in Blue Gum it takes two years for a flower crop to produce a seed crop.

Mean annual Blue Gum seedfall is shown in Table 5.

TABLE 5

Annual Blue Gum Seedfall, 1960 *to* 1964

Year	Bulga-Dingo		Bellangry	
	Per trap	Per acre	Per trap	Per acre
1960-61	11·2	54,200	..	..
1961-62	0·5	2,400	12·0	58,100
1962-63	1·2	5,800	0·7	3,400
1963-64	29·0	14,000	0·7	3,400

Germination tests for Blue Gum show an average number of 415,000 seeds per pound. Annual yields at Bulga therefore ranged from 0·08 oz to 2·08 oz per acre, and for Bellangry from 0·13 oz to 2·24 oz per acre.

SECTION III. SEED BED PREPARATION

The fact that some form of seed bed preparation is essential to regenerate the type has been realised for a long time. The dense nature of the understorey and surface litter prohibits contact between seed and mineral soil and the lack of natural regeneration and advance growth is a notable feature of cut-over stands.

Basically, burning and tractor clearing are the only two methods of exposing mineral soil available to the silviculturist. Provided an adequate seed source is available and climatic conditions are favourable, Tallowwood germination will occur on soil exposed by either method. However, survival, subsequent growth and costs vary between treatments.

(a) Burning

Wildfire has been responsible for some excellent stands of Tallowwood (e.g., those on Compartments 5, 6, 7 of Bulga State Forest which originated in 1942), and the first intentional regeneration burn with seed trees in 1947 at Doyles River produced a very good stand.

Photo 1.—Bulga/Dingo Management Area, Experiment No. 9 (50 per cent shade including 2 tallowwood seed trees per acre) ready for burning. November, 1960.

Photo 2.—Bulga/Dingo Management Area—Experiment No. 11 (2 Tallowwood seed trees per acre) ready for burning. October, 1960.

Due to the moist nature and density of the understorey, some felling of understorey is often required to ensure an adequate burn. The amount of felling required varies from stand to stand depending on composition, logging intensity, understorey, topography, etc.

The cost of felling (with or without seed trees) and burning at Bulga State Forest for the period February, 1958 to January, 1961 averaged $22.40 per acre (minimum $14, maximum $32). These costs were obtained over ten separate experiments, totalling 903 acres. Seed bed classifications of these experiments show that an average of 14 per cent (minimum 9 per cent, maximum 27 per cent) of the areas provided an unsatisfactory seedbed due to absence of, or a very poor, burn.

At Bellangry similar costs for four experiments (total 72 acres) in 1960-61 averaged $34 per acre.

The number of occasions on which fire can be used for seed bed preparation in the type is limited, and on several occasions (Bulga Compartments 96 and 103) areas felled for regeneration burns had to be abandoned due to the early arrival of summer rains.

The practice of burning has many additional disadvantages. Seed trees left to provide or augment seeding may be burnt without adequately fulfilling their function, while the danger of fire escape from silvicultural burns cannot be overrated.

All regeneration areas were sampled by the use of permanent millacre quadrats (1/1,000th acre) at one chain intervals on random lines. The number of quadrats sampled varied between 30 to 50 per treatment and each quadrat was assessed for absence of germinates, number of germinates by species, height of tallest seedling of each species, and distance to nearest Tallowwood seed tree. Each quadrat was also classified as to the type of seedbed and the degree of shade occurring.

The percentage of millacres stocked is considered the most reliable guide to indicate effective stocking of an area, and has been used to compare results of seedbed preparation trials.

For the germination of Tallowwood a burnt seedbed is usually satisfactory. Table 6 shows percentage stocking figures at age six months for burnt areas where seed supplies were considered adequate (either minimum 2 Tallowwood seed trees per acre or sown at a minimum rate of 3 oz per acre—see rates of sowing section).

TABLE 6

Showing Percentage Stocking of Tallowwood (Millacre Quadrats) on Burnt Sites—Age 6 months

Experiment No. (see Appendix 3)	Stocking Tallowwood (age 6 months)
	per cent
1	71
3	31
6	26
8	64
9	9
11	40
12	32
13	25
15	80
16	30
18	95
For 11 trials	Mean = 45

The only badly failed treatment (experiment 9) occurred when the majority of seed trees, providing the seed source, were burned down in the fire.

Weeds

A burnt seed bed is rapidly colonised by weed species so that within six months the area is generally overgrown with fire weeds and vines (Photo 3). Some of the weeds occurring are annuals, some are frost susceptible, others continue their competition with the tree seedlings indefinitely. In four out of the twelve experimental burns (Experiments 3, 5, 12, 13), extremely dense stands of wattle (*Acacia irrorata* and *A. elata*) resulted, virtually completely suppressing Tallowwood germinates.

Photo. 3—Bulga/Dingo Management Area, Experiment No. 9 (50 per cent shade including 2 Tallowwood seed trees per acre) showing weed growth. November, 1963.

The common weeds occurring are:

Sago Bush	*Helichrysum diosmifolium*
Ink Bush	*Phytolacca octandra*
Wild Tobacco	*Solanum mauritianum*
Wild Tomato	*Solanum armatum*
Stinking Roger	*Tagetes minuta*
Peach-leaved Poison Bush ..	*Trema aspera*
Fire Weed	*Senecio lautus*
Cobblers Peg	*Erigeron canadensis*
Hop Bush	*Dodonea triquetra*
Soldier Vine	*Kennedia rubicunda*
Lantana	*Lantana camara*

Rubus moluccanus and *Rubus moorei*

Browsing

A lush weed crop attracts cattle and marsupials in search of food and many seedlings are repeatedly browsed, accentuating their battle with the weeds. In six Tallowwood seeded burns where observations on browsing were made, 28 per cent of Tallowwood seedlings suffered browsing damage (see Table 7).

TABLE 7

Showing Percentage of Tallowwood Seedlings Browsed

Experiment No.	Browsed
	per cent
1	57
5	25
8	13
9	30
10	25
11	20
Mean	28

At Bulga State Forest, scrub wallabies (*Wallabia rufogrisea*) are outnumbered by pademelons (*Thylogale thetis*), and the comparatively low stature of the latter seems to indicate that seedlings over five feet are fairly safe from serious browsing. The initial slow growth in height of Tallowwood makes it doubly susceptible.

The control of dingoes by trapping and shooting, encouraged by the Pastures Protection Board Dingo bonus, and the implementation of fire protection are contributing factors to a substantial increase in marsupial population in recent years.

As exclusion of protected fauna from regeneration areas seems impracticable the problem may best be overcome by ensuring a high initial seedling stocking.

Tallowwood stocking on burnt sites gradually diminishes. Those experiments which have been re-assessed over a 30-month period show the trend clearly (see Table 8).

TABLE 8

Percentage Tallowwood stocking (Millacre Quadrats) at various ages on burnt sites

Experiment No.	Stocking			Mean Dom. Height at Age 30 months
	6 months	15-18 months	27-30 months	
	per cent	per cent	per cent	feet
1	71	67	61	3·0
3	31	15	7	3·8
6	26	23	10	3·1
8	64	78	69	4·2
9	9	9	7	8·8
11	40	33	33	3·1
Mean	40	36	31	4·5

As it is difficult to consider all 30 months old germinates "established", it would appear that an initial stocking level of 30 per cent, as considered adequate for most species, may be too low for Tallowwood and that the optimum stocking at age six months should be at least 40 per cent.

Tallowwood height growth is disappointing, at age 30 months the mean dominant height is only 4·5 feet. The slowness is well illustrated in Table 20, Section Vc, where heights at age 45 months are compared for Tallowwood and seven other species.

Conclusion

1. The critical point in burning for regeneration is when to burn. The high rainfall and moist nature of the type limits the number of occasions on which fire can be used and this may well be an overriding factor for management on a large scale.

2. Having obtained the burn, subsequent weather must be suitable for germination and establishment. Rainfall data indicate that January may be the best time for sowing.

3. When seedtrees are used to supply or augment seeding, it is essential that the seedfall has not occurred prior to burning, while seedtrees are often burnt down in the fire before fulfilling their function.

4. Under conditions of high soil fertility and adequate moisture the dense colonisation of weeds may be the dominating factor affecting tree seedling survival and growth. The weed problem makes it essential to sow with a minimum delay after burning.

5. Costs for felling (including understorey) to obtain an adequate burn can be substantial.

6. The method creates a large risk to fire protection. There are numerous instances of fire escapes from silvicultural burns.

7. Where part of the canopy is retained the fall of scorched leaves can seriously hinder germination.

(b) Tractor Clearing

As the suitability of snig tracks as a seed bed has long been appreciated, seed bed preparation by means of tractor clearing was incorporated in the first series of regeneration treatments.

Full Clearing

The fact that clear felling and burning involved considerable expenditure ($22.40 per acre at Bulga and $34.60 at Bellangry) meant that a comparable but more economic method was worth considering. The early tractor clearing experiments set out to clear as much mineral soil as possible.

Unit costs for tractor clearing closely approximated those for felling and burning at Bulga in 1960 (see Table 9).

TABLE 9

Comparing Costs and Efficiency Between Burning and Tractor Clearing

Experiment Number	Tractor Clearing		Burning	
	Soil Exposed	Costs/acre	Soil Exposed	Costs/acre
	per cent	$	per cent	$
1	..	..	73	26.00
2	77	31.80	..	..
3	..	..	87	32.00
4	88	29.40	..	..

The number of experiments involving full tractor clearing is insufficient to allow valid comparisons between the treatments. Only five tractor clearings were incorporated in the 1960 and 1961 series, two of these under maximum canopy. However, it has been established that for the germination of Tallowwood a tractor-cleared seed bed is usually satisfactory (see Table 10).

TABLE 10

Showing Percentage Stocking of Tallowwood (Millacre Quadrats) on Tractor-cleared Sites—Age 6 Months

Experiment No.	Stocking Tallowwood
	per cent
2	75
4	39
7	12
10	14
14	27
Mean.. .. .	33

A tractor-cleared seed bed remains receptive for a relatively long period, weeds are generally slow in getting established and clearing does not result in dense Acacia stands, as happens following burning treatments.

In a quantitative study of dry matter production of each major weed species one year after burning or tractor clearing, Floyd (1965) found "that the burnt site produced 1,343·2 Kgm of dry matter per acre in comparison with 392·1 Kgm on the tractor cleared site". The reduction in weed growth also results in less intrusion by animals and reduced browsing damage. The continued receptivity of seed bed and increased survival chances are particularly important when Tallowwood seed trees are employed to provide seed or shelter. In contrast to burning, where all seed on the trees falls almost immediately after the fire and no new seed crop can be expected for many years, tractor clearing does not interfere with the current or future seed crops. Seedshed, therefore, is more gradual and prolonged and adverse climatic conditions at any one time are less pronounced.

Survival figures for tractor clearing bear this out well. Stocking figures at age 18 months exceed those for age 6 months (see Table 11).

TABLE 11

Percentage Tallowwood Stocking (Millacre Quadrats) at Various Ages on Tractor-cleared Sites

Experiment Number	Tallowwood Stocking			Height at Age 30 months
	6 months	15-18 months	27-30 months	
2	75	63	54	3·2
4	39	20	15	1·2
7	12	76	50	0·9
10	14	23	31	4·6
14	27	50	45	1·8
Mean Tractor Clearing ..	33	46	39	2·3
As Against Burning (Table 8).	40	36	31	4·5

This reversal of initial stocking in favour of burning to an established stocking in favour of tractor clearing was also demonstrated by Floyd (1962) for the *E. pilularis* association. The reduced height growth on tractor-cleared sites is offset by a similar reduction in weed growth, allowing greater establishment figures at age 30 months, than for burning treatments.

The trend clearly indicates that seed trees can play an important part on tractor-cleared seed beds. The retention of non-merchantable Tallowwood trees is therefore recommended, provided that the number per acre is small enough to permit sufficient light. It is considered, however, that all merchantable stems should be removed in logging. This will reduce the canopy and alleviate the need for a second logging, while improvements in sowing techniques should ensure adequate stockings.

Time of year is not a limiting factor in tractor clearing and only excessively wet conditions limit the use of machinery. The relatively dry spring period from August to December is very suitable, allowing sowing to be carried out in late January-February.

Conclusions

1. Time of year is not a limiting factor in preparing a seed bed mechanically, as is the case with burning.

2. Slower weed establishment allows a substantial time lapse between site preparation and seeding.

3. Seed trees, where left, are not subject to damage and contribute to stocking over a number of years.

4. Less weed growth results in reduced competition between tree seedlings and weed species and tree seedling losses through etiolation are reduced.

5. Costs are not significantly higher than those for burning.

(c) Snigtrack Extension

In the original tractor clearing experiments described above the main aim of the treatment was to clear as much mineral soil as possible. It was soon realised that a less complete operation could reduce costs and still produce sufficient seed bed disturbance to promote adequate regeneration.

After logging operations, a certain portion of the surface is already cleared in the form of snig tracks. This amount varies depending upon logging intensity, topography, type of tractor and operator, etc., but seems to vary between 10 per cent and 20 per cent of the area. Assessments in the Tallowwood-Blue Gum type indicate that, including log dump sites, approximately 16 per cent of logging areas is tractor disturbed.

Although no provision was made to test the "snigtrack extension" method against burning or tractor clearing, a few small experiments have tested this method since 1962 (Experiments 19, 20, 21 and 22). The results lack the conviction of a properly planned experimental series, but they clearly show the possibilities of the method.

Using the original tracks as main arteries a network of new tracks can be dozed fairly quickly, avoiding major obstacles. The seed bed area can be increased by burning the area between tracks without incurring all the disadvantages associated with clear felling and burning. However, due to subsequent litter fall and increase in weed population, this practice is not to be encouraged unless less than 50 per cent of the site has been tractor disturbed.

Table 12 illustrates the costs and percentage of seed bed disturbance achieved by this method.

TABLE 12

Showing Costs and Percentage of Seed Bed Disturbance Achieved by Snigtrack Extension Method

Expt No.	Area Treated in acs.	Area Original Snig-track	Area Additional track Snig-	Area Cleared	Area Burnt	Area Disturbed	Area Nil Disturbance	Cost per acre	Type Tractor
		per cent	per cent	per cent	per cent	per cent	per cent	$	
19	11	16	55	71	Nil	71	29	4.40	D7
20	27 }	12	48	59	29	89	11	{ 7.60	D6
21	34 }							{ 5.60	D6
22	110	Not observed		47	30	77	23	11.00	D4

In only one case (Experiment 21) was useless overstorey removed after extensions; the low felling cost of $8 per acre was attributed to easier working conditions. The full cost for the experiment was $13.60 per acre, for which all overstorey other than two Tallowwood seed trees per acre was removed and 89 per cent of the total area was made seed receptive. When compared with costs quoted in Table 9 (approximately $30 per acre) for burning or tractor clearing this appears very satisfactory.

The results of canopy experiments, rate of sowing and new species trials illustrate the advantages of minimum canopy on Tallowwood establishment. In three of four snigtrack extended areas overhead was not removed promptly, and this has almost certainly had a detrimental effect on Tallowwood stocking.

TABLE 13

Showing Percentage Stocking (Millacre Quadrats) after Snigtrack Extension at Age 6 Months

Experiment Number	Year	Overhead Removal	Stocking Tallowwood at age 6 Months
			Per cent
19	1962	Nil	21
20	1963	Nil	47
21	1963	All	49
22	1964	Nil	13
Mean			32·5

The low stockings for Experiment 22 are believed to be caused by heavy shade accentuated by the narrow tracks cleared (D4 clearing).

The removal of overstorey poses several problems, particularly if the proportion of species other than Tallowwood is large, as a large seedfall from these species prior to or concurrent with Tallowwood sowing will certainly affect Tallowwood survival. The felling of useless overstorey prior to snigtrack extensions will seriously hinder the tractor and increase costs and the problem may best be overcome by felling immediately after tractor work is completed, thus virtually limiting seed cast to areas covered by tree heads.

Type of machinery used plays an important part. A D4 tractor used in Experiment 22 proved unsatisfactory; its narrow gauge tracks severely limited the slope which could be worked, the narrow blade cleared only narrow tracks which remained heavily shaded by adjacent understorey, and lack of power prevented the shifting of occasional heavy obstructions. A D7 with "powershift" seems highly suitable. Further experiments should determine the most economic machine for the purpose and whether certain modifications to blade or frame are advantageous.

Topography does limit the area that can be treated but this is not considered a serious disadvantage as steep sides and gullies seldom regenerate well, regardless of treatment.

As the snigtrack extension method makes a smaller percentage of the site receptive than does burning or full clearing, it is considered that maximum use should be made of the reduced area to ensure adequate stocking. This can be achieved by reducing spacing, increasing the plant percent, or the planting of stock raised in jiffy pots.

Tractor operators new to the snigtrack extension system should be closely supervised initially as the tendency to over-clear, and thus increase costs, appears to be a natural one.

(d) No Site Preparation

On one experiment in the series (Experiment 17) no site preparation was carried out. Thirty-four random millacre quadrats located in the treatment failed to show any Tallowwood germinates.

SECTION IV. SOWING AND SEEDFALL RATES

In Section IIIa it was suggested that a 40 per cent stocking of millacre quadrats was desirable if an area was to be considered adequately regenerated. The quantity of seed required to achieve this stocking was investigated by spot sowing areas at different rates and by sampling natural seedfall in roving traps.

The rate of sowing trial at Bulga on a burnt seed bed consisted of a 2 x 4 x 2 factorial design with two levels of spotspacing, four levels of number of seeds per spot and two levels of insecticide in three randomised blocks. At Bellangry, also on a burnt seed bed, all seed used was treated with insecticide and the 2 x 3 design consisted of two levels of canopy cover and three levels of number of seeds per spot. The results from these experiments are treated in the following sub-sections. The percentages of spots stocked per plot were transformed to angles by arcsin transformation before analysis.

(a) Seed Robbers

The importance of seed robbing insects in the regeneration of the eucalypts has been discussed by Cunningham (1960). The Bulga sowing trial enabled a comparison of the percentage of spots stocked with Tallowwood seedlings on 24 plots in which the seed had been dusted with 25 per cent dieldrin powder (1 teaspoon per 1 pound of seed) with a similar number of plots in which no dieldrin was used.

The mean percentages of spots stocked for all sowing rates and spacings after back transformation were:

Dieldrin	28·9 per cent
No dieldrin	8·6 per cent

This inexpensive precaution in dusting seed before sowing resulted in a highly significant ($P > 0{\cdot}01$) improvement in percentage stocking.

Moreover, when seed is not treated with insecticide the variability within and between treatments becomes very large, possibly because of variations in the insect population and because, if a spot of seed is discovered, it will probably be completely robbed no matter how many seeds are present. Because of this increase in variability the remaining treatment comparisons are confined only to plots which had been treated with dieldrin.

(b) Rate of Sowing and Spacing—Bulga

Seed was sown in spots by means of a three-inch diameter shaker, the top of which was drilled with 28 holes of $\frac{3}{32}$-inch diameter (designed to deliver four ounces of seed per acre in 680 shakes). Because of the large size difference between Tallowwood seed and chaff it was suspected that continued shaking while sowing could cause a separation of seed from chaff in the tin and result in a seed delivery gradient as the shaker was emptied. An attempt to reduce this variation was made by purifying the seed by screening through a $\frac{1}{10}$-inch screen.

The four sowing rates tested consisted of one and two shakes of unsieved seed and one and two shakes of sieved seed. At intervals, as the experimental area was sown and seed levels in the shakers dropped, 24 samples of 10 shakes each were collected from both the sieved and unsieved seed shakers and these samples were subsequently germinated in the laboratory. Results from the germination tests gave an average delivery rate of $16{\cdot}4 \pm 22{\cdot}3$ per cent viable seeds per shake of unsieved seed and $30{\cdot}1 \pm 26{\cdot}2$ per cent for the sieved seed. Therefore it was concluded that sieving did not reduce the variability of delivery rates, but approximately doubled the delivery per shake. This means that two of the four sowing rates tested were nearly equivalent. These rates were:—

(a) 1 shake unsieved seed = 16·4 seeds per spot,
(b) 2 shakes unsieved seed = 32·8 seeds per spot,
(c) 1 shake sieved seed = 30·1 seeds per spot,
(d) 2 shakes sieved seed = 60·2 seeds per spot.

These rates of sowing per spot were applied both at 8 feet x 8 feet spacing and 4 feet x 4 feet spacing in three random blocks and the mean percentages of spots stocked at age 6 months are shown in Table 14.

TABLE 14

Back Transformed Mean Percentage of Spots Stocked—Bulga

Rate—Seeds per Spot	Spacing		All Spacings
	4 x 4	8 x 8	
Per cent	Per cent	Per cent	Per cent
16·4	25·9	28·6	27·6
30·1	32·2	28·3	30·2
32·8	31·9	35·2	33·5
60·2	50·5	26·4	38·5
All Rates	35·1	29·8	32·5

The analysis of variance performed on the transformed data showed a significant interaction between spacing and rate. This interaction is attributed to the large difference in stocking between the two spacings at the highest delivery rate. The interaction between spacing and rate was not expected, and is believed to be false until new evidence is obtained. Although there is a trend of increased percentage stocking with rate, no main effect was statistically significant.

(c) Rate of Sowing and Shade—Bellangry

In the Bellangry experiment all spacings were at 8 feet x 8 feet, all seed was dusted with dieldrin and only three sowing rates were used because of the equivalence of two shakes of unsieved seed with one shake of sieved seed. Samples were gain taken from the shakers and germinated to determine the mean delivery of viable seeds per spot. The three sowing rates were replicated twice in the no shade treatment and once in the 50 per cent canopy treatment. Unfortunately one plot in the shaded treatment was accidentally oversown and because of the loss of this plot and the differing numbers of replications in each treatment, normal analysis could not be carried out. However the transformed data were analysed by the method of fitting constants (Snedecor, 1956, p. 388). This method allows an analysis of variance to be carried out and gives unbiased estimates of the population means. The actual and estimated means are given in Table 15.

TABLE 15

Back Transformed Mean Percentage of Spots Stocked—Bellangry

Rate Seeds per Spot	Shade		No Shade		All	
	Estimated	Actual	Estimated	Actual	Estimated	Actual
	per cent	per cent	per cent	per cent	per cent	per cent
19·3	21·5	17·6	53·4	56·6	36·7	40·0
36·7	33·7	22·3	66·8	74·5	50·3	53·6
73·4	48·1	81·1	79·8	69·5	64·8	74·1
All ..	34·0	40·3	67·1	66·9	50·6	54·4

The analysis of variance showed that the presence of cover (50 per cent canopy) significantly reduced the percentage stocking. The main effect due to sowing rate was not significant, but again a trend is clearly evident.

It appeared that in both the Bulga and the Bellangry experiments, much of the sums of squares due to rate could be explained by a regression of stocking percentage on rate. Nevertheless, the high error variance occurring in these experiments demonstrates that more replications are required for sensitive tests and that those factors unaccounted for in the experimental designs are of considerable importance. It would appear that a more basic approach is required in the study of the ultimate fate of seed placed on a mineral seed bed, particularly with respect to factors of the micro-environment which have been ignored in these experiments. The large differences in percentage stocking between Bulga and Bellangry, which occurred for similar treatments in 1961, remain unexplained and there is some evidence from previous experiments that in other seasons the trend may be reversed.

(d) The Relationship Between Rate of Sowing and the Number of Seedlings per Unit Area

Although the percentage of stocked spots tends to increase with increasing rates of sowing, differences in rates were rarely significant. However, these trends may be expressed quantitatively by regression equations. In order to obtain some degree of comparison with those areas which were assessed by millacre sampling rather than marked spots it was decided to use the regression of the number of Tallowwood seedlings per acre on the number of viable seeds per acre. Theoretically it may be expected that such a relationship would pass through the origin. When the data is graphed a linear relationship appears to exist but the variance of Y (Number of seedlings per acre) appears to vary with X (number of viable seeds per acre). Thus the data can be fitted to regression model IA (Snedecor, 1956, p. 153) in which the regression coefficient

$$b = \Sigma \frac{(y/x)}{n}.$$

This model is particularly interesting since the ratio y/x is an expression of plant percent. Four regressions were calculated based on the treatment differences already mentioned for the sowing trials. The coefficients, their standard errors and confidence intervals at the 95 per cent level are given in Table 16.

TABLE 16

Regressions of number of seedlings per acre (y) on number of seeds per acre (x). $(y = bx)$

Treatment	b	S_b	$t_{(.05)} \times S_b$	n	Significance
1. Bulga—No Dieldrin ..	0·00884	0·00333	0·00687	24	*
2. Bulga—Dieldrin ..	0·01690	0·00262	0·00541	24	*
3. Bellangry — Dieldrin — Shade	0·04302	0·01823	0·04690	6	N.S.
4. Bellangry — Dieldrin — No shade	0·08738	0·01908	0·03310	9	*

Corresponding plant percents are 0·88, 1·69, 4·30 and 8·74 for treatments 1 to 4 respectively. The coefficient for treatment 3 is not significantly different from zero and the differences between treatments

1 and 2 and 3 and 4 are not significant, although the trend is obvious and differences approach significance. These regressions are shown graphically in figure 6.

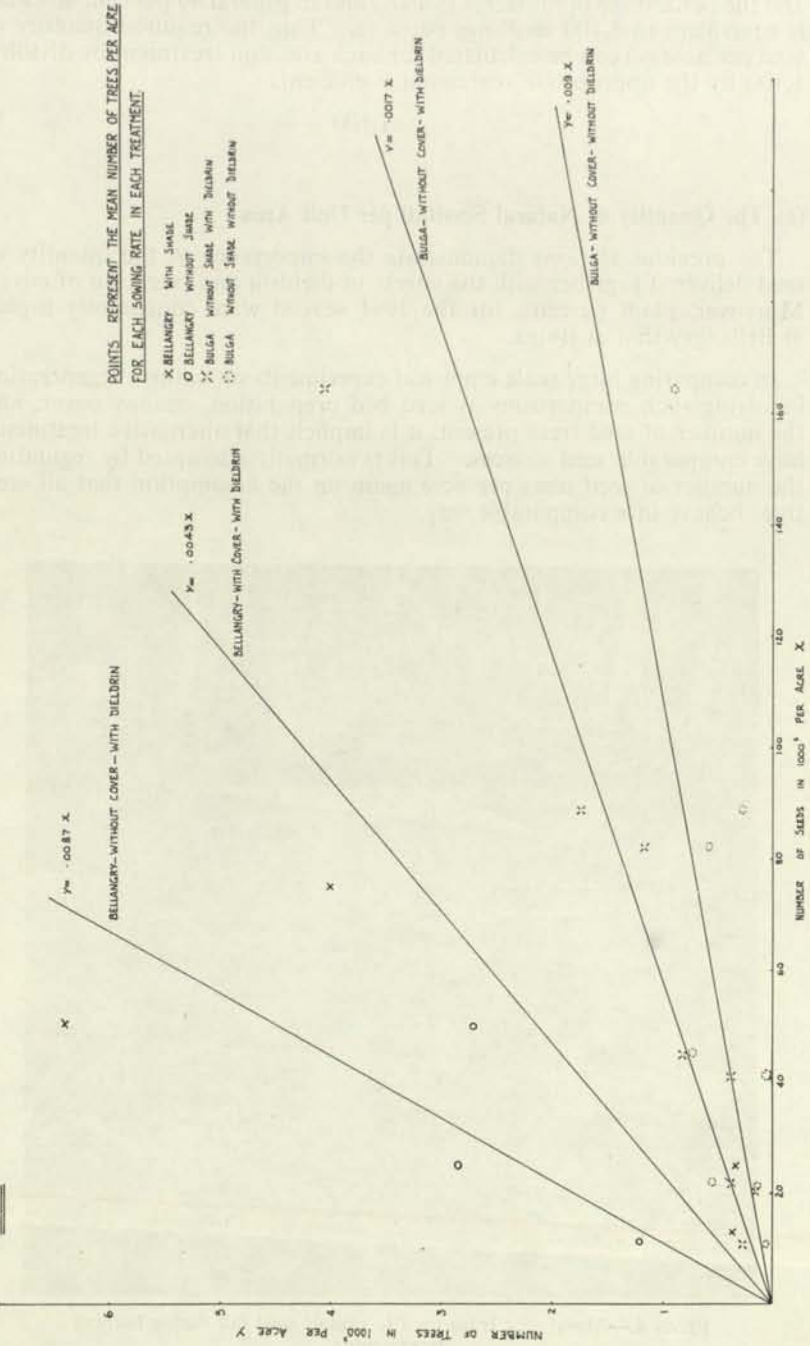


FIG 6

These regressions can be used to calculate the quantity of seed per acre required to give the recommended millacre stocking of 40 per cent. There is a good relationship between the number of seedlings per acre and the percentage of millacres stocked and in general 40 per cent stocking is equivalent to 1,100 seedlings per acre. Thus the required quantity of seed per acre (x) can be calculated for each area and treatment by dividing 1,100 by the appropriate regression coefficient.

$$x = \frac{1,100}{b}$$

(e) The Quantity of Natural Seedfall per Unit Area

The previous sections demonstrate the importance of the quantity of seed delivered together with the effects of dieldrin and retention of cover. Moreover, plant percents for the 1961 season were consistently higher at Bellangry that at Bulga.

In comparing large scale empirical experiments on natural regeneration involving such comparisons as seed bed preparation, canopy cover, and the number of seed trees present, it is implicit that alternative treatments have comparable seed sources. This is normally attempted by regulating the number of seed trees per acre again on the assumption that all seed trees behave in a comparable way.

Photo 4.—Metal seed traps used to sample seed fall during burning treatments.

However, routine Tallowwood seed collection work demonstrates that seed yields vary both between individual trees and between adjacent compartments, and the assumptions made in large scale experimental treatments may not be justified unless some attempt is made to relate the quantity of seedfall to treatment effects.

Accordingly, some of the experimental areas were sampled for seed fall by the roving trap technique as described by Cunningham (1960). Two traps were randomly placed in each treatment and removed to new random positions after each short sampling period. Because of the fragile nature of Tallowwood capsules and the severity of regeneration burns, seed commences to fall almost immediately after burning treatments. Therefore several metal traps were constructed for the initial sampling period and these traps were set up just prior to burning in order to sample the immediate post-fire seedfall (Photo 4). Subsequently these traps were replaced by the light-weight canvas traps for roving.

The average seedfall per square yard for the first six months after treatment has been estimated for six of the experimental areas, using the method suggested by Wilm (1946). The results are given in Table 17.

TABLE 17

Viable Tallowwood Seeds per Square Yard

Experiment Number	Seed Trees	Seeds	Standard Error	Coeff. Variation
	per acre	sq. yd		per cent
8—Burnt	Many	29·0	11·7	40·3
9—Burnt	2	5·1	1·7	33·3
10—Tractor-cleared ..	Many	14·0	5·2	37·1
14—Tractor-cleared ..	Many	7·5	1·6	21·3
15—Burnt	2	14·9	10·8	72·5
18—Burnt	1	16·4	6·4	39·0

It is apparent from the high standard errors that the means have very wide confidence limits. The sampling technique can be improved by using more traps and sampling at shorter intervals. This is particularly so for burnt areas where the majority of seed trapped fell in the first time period after burning.

Nevertheless, the results do lend weight to the suspicion that the number of seed trees is not a good guide to the quantity of seed to be expected and that treatment comparisons can be erroneous in the absence of seedfall data.

(f) Comparison of Large Scale Trials with Rate of Sowing Regressions

The number of Tallowwood seedlings per acre on those large scale experiments for which seed quantity data is available can be compared with the regressions obtained from the rate of sowing trials. However, there are no regressions available for Bellangry in which no dieldrin was used, or for Bulga under 50 per cent canopy, but the regressions do form a basis for limited interpolation. These experiments are listed in Table 18 and are shown graphically on figure 7.

Fig 7

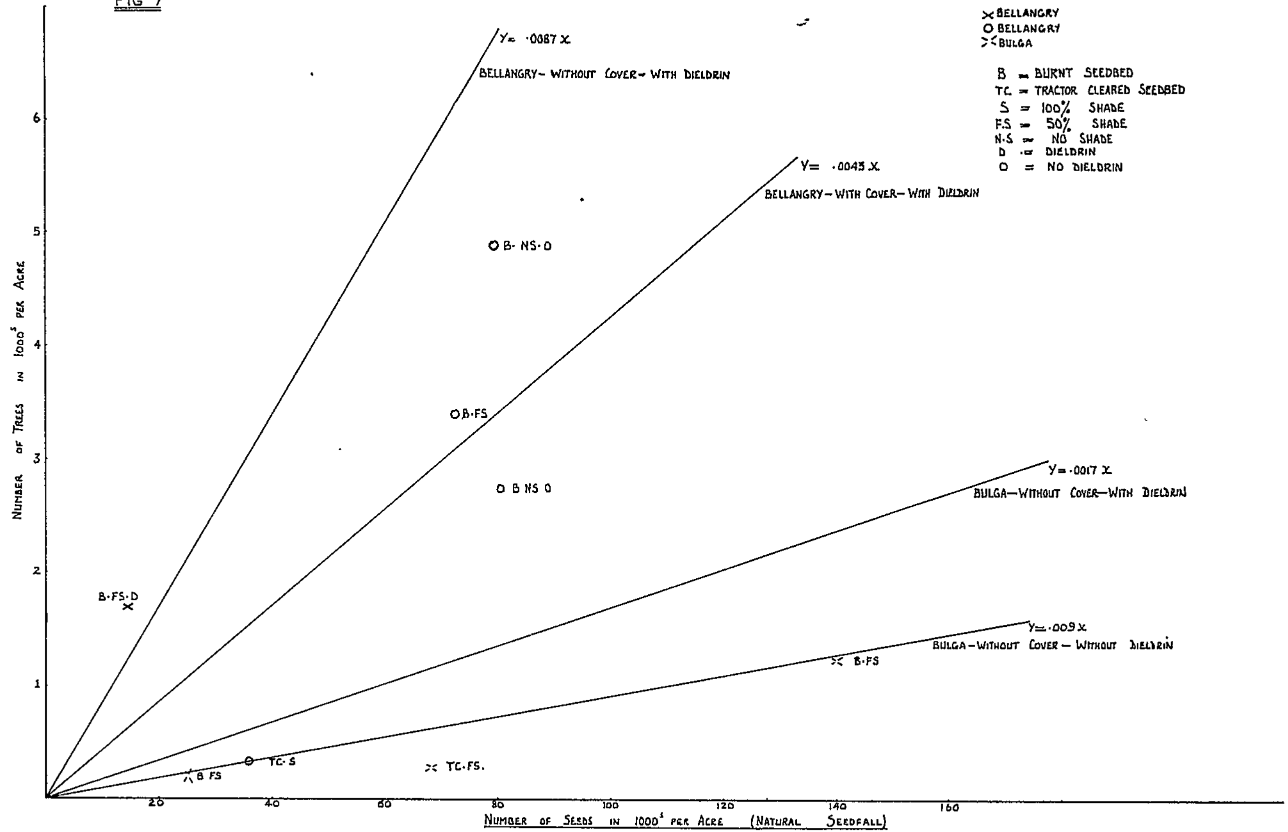

Y= ·0087 x
Bellangry – Without Cover – With Dieldrin
Y= ·0045 x
Bellangry – With Cover – With Dieldrin
Y= ·0017 x
Bulga – Without Cover – With Dieldrin
Y= ·009 x
Bulga – Without Cover – Without Dieldrin
x Bellangry
O Bellangry
>< Bulga
B = Burnt Seedbed
T.C. = Tractor Cleared Seedbed
S = 100% Shade
F.S = 50% Shade
N.S = No Shade
D = Dieldrin
O = No Dieldrin
O B·NS·D
O B·FS
O B NS O
B·FS·D
B·FS
B FS
TC·S
TC·FS.
Number of Trees in 1000s per Acre
Number of Seeds in 1000s per Acre (Natural Seedfall)
1
2
3
4
5
6
20
40
60
80
100
120
140
160

TABLE 18

Large Experimental Areas for which Seed Supply has been Estimated. Stocking at Age 6 Months—Tallowwood

Experiment No. and Treatment	Thousands of Seeds	Thousands of Seedlings	Stocking (Millacre Quadrats)	Approx. Ounces of Seed
	per acre	per acre	per cent	per acre
8. Burnt—50 per cent canopy—No dieldrin	140·4	1·22	64·0	28·1
9. Burnt—50 per cent canopy—No dieldrin	24·7	0·17	9·5	4·9
10. Tractor—50 per cent canopy—No dieldrin	67·8	0·39	14·0	13·6
14. Tractor—100 per cent canopy—No dieldrin	36·3	0·33	27·5	7·3
15. Burnt—50 per cent canopy—No dieldrin	72·1	3·44	80·0	14·4
16. Burnt—50 per cent canopy—Dieldrin	13·1	1·66	29·7	2·6
18. Burnt—0 per cent canopy—No dieldrin	79·4	4·94	95·0	15·9
—. Burnt—0 per cent canopy—No dieldrin	81·3	2·73	70·0	16·3

Examination of figure 7 shows that these data generally lie within the expected range of stockings and that agreement with the regressions is quite reasonable. Plant percents appear to be similar whether the seed falls naturally or is sown artificially in spots. However, the large increase in plant percent which is available from dieldrin treated seed cannot be obtained by seed tree methods. Nevertheless, if an area is to be regenerated by seed tree methods pertinent information on seed tree spacing is given in the next section.

SECTION V. OTHER REGENERATION ASPECTS

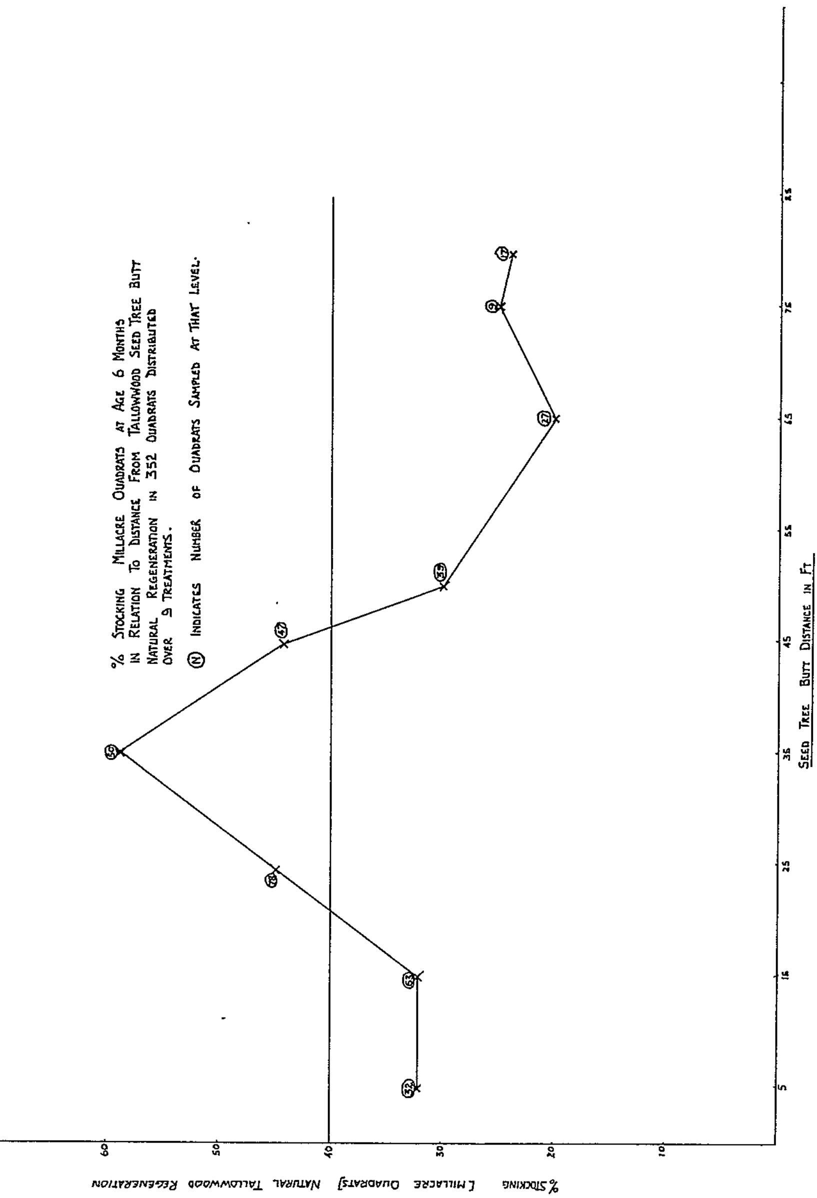
(a) The Use of Seed Trees

Previous reference has been made to Tallowwood seed trees in relation to their production in the sections on flowering and seeding (Section IIa) and rates of sowing (i.e., quantity of seed per unit area—Section IVe).

In nine experimental treatment areas where Tallowwood seed trees were employed as the only seed source (experiments 6, 7, 8, 9, 10, 11, 14, 15, 18) observations were made on the relation between percentage stocking (millacre quadrats) and distance to the base of the nearest tallowwood seed tree.

For a total of 352 quadrats in these areas figure 8 shows that to ensure an initial stocking (age 6 months) of 40 per cent, the distance from a seed tree butt should not exceed 50 feet, while even for 30 per cent stocking 55 feet is the maximum distance permissible (i.e., 100 feet to 110 feet between seed trees).

FIG 8



Therefore if seed trees are to be used as the only seed source, a minimum of four evenly-spaced Tallowwood seed trees (approximately 24 inches d.b.h.) should be left per acre. In some stands this number may not be present, while where they are, their use can prove very expensive. Due to the high inflammability of the soft fibrous bark, which is persistent to the smaller branches, Tallowwood is a very fire susceptible species and seed tree losses in regeneration burns are frequently high.

Bulga-Dingo Management Plan assessment data show an average royalty value for a merchantable 24-inch Tallowwood to be $8.27. Therefore the use of four seed trees per acre risks royalty losses amounting to $33.07. Should these seed trees survive the regeneration burn without either heavy losses or the occurrence of serious defect, a second logging operation will be necessary with an inevitable reduction in stocking.

(b) The Effect of Cover

Throughout the experimental treatments three main cutting systems were used to observe the effect of cover upon the germination and survival of Tallowwood. The systems are:—

(a) Full canopy retention;

(b) 50 per cent canopy retention;

(c) Clear felling (with or without seed trees).

The wide variations which occur between treatments due to differences in locality, time of treatment, site preparation and, in particular, quantities of seed supplied per unit area prohibit statistical analyses of the effect of cover on germination and percentage stocking of Tallowwood (although Bellangry rate of sowing trials (Section IVc) show shade to be significantly adverse).

By confining observations to 1961 treatments on burnt seed beds (in order to reduce these variations as much as possible) we can clearly notice trends in species composition and early height growth.

As the canopy, where retained, has a major influence on the composition of the regenerated stand, tables used in this section quote stocking percentages (millacre quadrats) and mean heights for "other species" as well as mean heights for Tallowwood. "Other species" include *E. saligna*, *E. campanulata*, *E. quadrangulata*, *E. laevopinea*, *E. acmenioides*, *E. globoidea*, *E. gummifera* and *Tristania conferta*.

Table 19 shows the percentage stocking (millacre quadrats) for "other species" with varying degrees of shade and compares mean heights at age 15 months for Tallowwood and other species.

TABLE 19

Showing Effect of Shade on Tallowwood and Other Species and Differences in Mean Heights

Degree of Canopy Retention	Experiment Number	No. of Millacre Quadrats Assessed	Stocking (Millacre Quadrats)		Mean Dom. Heights at Age 15 Months	
			Other Species	TW*	Other Species	TW
			%	%	feet	feet
Full Canopy	6	39	20	(23)	0·2	0·5
50 per cent Canopy ..	9, 15, 16	139	52	(37)	4·1	2·7
Clear Felled .. .	11, 18	80	8	(59)	2·6	4·1

* N.B.—Tallowwood stocking figures are not comparable due to varying seed quantities.

An examination of Table 19 suggests that:

(1) The retention of full canopy adversely affects early height growth of germinates.

(2) The retention of 50 per cent canopy creates a high stocking of less desirable species, which are able to outgrow Tallowwood in the early stages.

(3) Clear felling minimises competition from less desirable species and promotes early height growth of Tallowwood.

(c) Introducing New Species

The slow growth rate of Tallowwood and the poor quality of second growth Blue Gum prompted an investigation into the introduction of suitable new species.

Many useful species are associated with the Tallowwood-Blue Gum type, such as *E. pilularis, E. cameronii, E. grandis* and *E. campanulata* while *E. cloeziana* and *E. obliqua* were also considered worthy of trial.

Trial sowings were replicated in square chain plots under no shade and 50 per cent shade both at Bulga and Bellangry.

Both the 50 per cent shade replications proved ineffective, probably due to an extremely heavy stocking of natural germinates of shade-providing species (see also the effect of cover, Section Vb), while the no shade Bulga plots also failed (here a 30-day lapse between burning and sowing assisted in creating very severe weed competition). The Bellangry no shade treatment now shows an interesting stand, the results of which are summarised in Table 20.

TABLE 20

Showing Percentage Stocking and Heights for Eight Species in the New Species Trial

Species	Spots Stocked		Heights in feet, age 45 months	
	Age 9 months	Age 45 months	Best	Mean
	per cent	per cent		
E. grandis	90·0	51·5	32·0	25·0
E. campanulata	62·5	42·1	25·0	20·0
E. pilularis	60·0	40·6	30·0	19·5
E. saligna	100·0	56·2	20·0	18·0
E. cameronii	62·5	34·5	22·0	11·0
E. obliqua	22·5	14·0	20·0	10·0
E. microcorys	92·1	42·1	16·5	5·5
E. cloeziana	37·5	No Survivors		

The way in which Tallowwood is outclassed in height growth is striking, and the relative success of *E. pilularis* (probably the most desirable species) is encouraging. *E. grandis* performed very well, but as young stands of this species have recently been proved to be very defective, its introduction cannot be recommended.

Both *E. campanulata* and *E. cameronii* show up well, but *E. obliqua* and *E. cloeziana* appear less suitable.

E. laevopinea was not included in this trial but the performance of this species on similar sites warrants its inclusion in further trials.

It is suggested that the introduction of *E. pilularis* and *E. laevopinea*, either by sowing or jiffy pot planting, could be further tried on a semi-routine basis, preferably by snig track extension treatments.

CONCLUSIONS

The results from this series of experiments tend to illustrate that many difficulties are still associated with regenerating the type to Tallowwood.

The extremely slow height growth of this species, even in those experiments where conditions would be expected to approach the optimum for its development, make the practice of Tallowwood regeneration of doubtful benefit.

Seed trees have proved to be of only limited use; seedfall can occur throughout the year and it is extremely difficult to forecast the time and quantity of seedfall in any one period in one year and in any one stand, while a minimum of four seed trees is required per acre to obtain adequate stocking.

As seed bed preparation by means of burning is generally both costly and hazardous, while also providing maximum competition (and the disadvantages associated with this), mechanical clearing followed by sowing or planting appears the best method available to obtain a satisfactory stocking. Taking costs into account, the method of snigtrack extensions (preparing approximately sixty per cent of the mineral soil) seems the most promising method available.

This method of clearing combined with the introduction of more vigorous species, such as *Eucalyptus pilularis* and *E. laevopinea*, either by spot sowing or Jiffy pot planting, is recommended for further trial.

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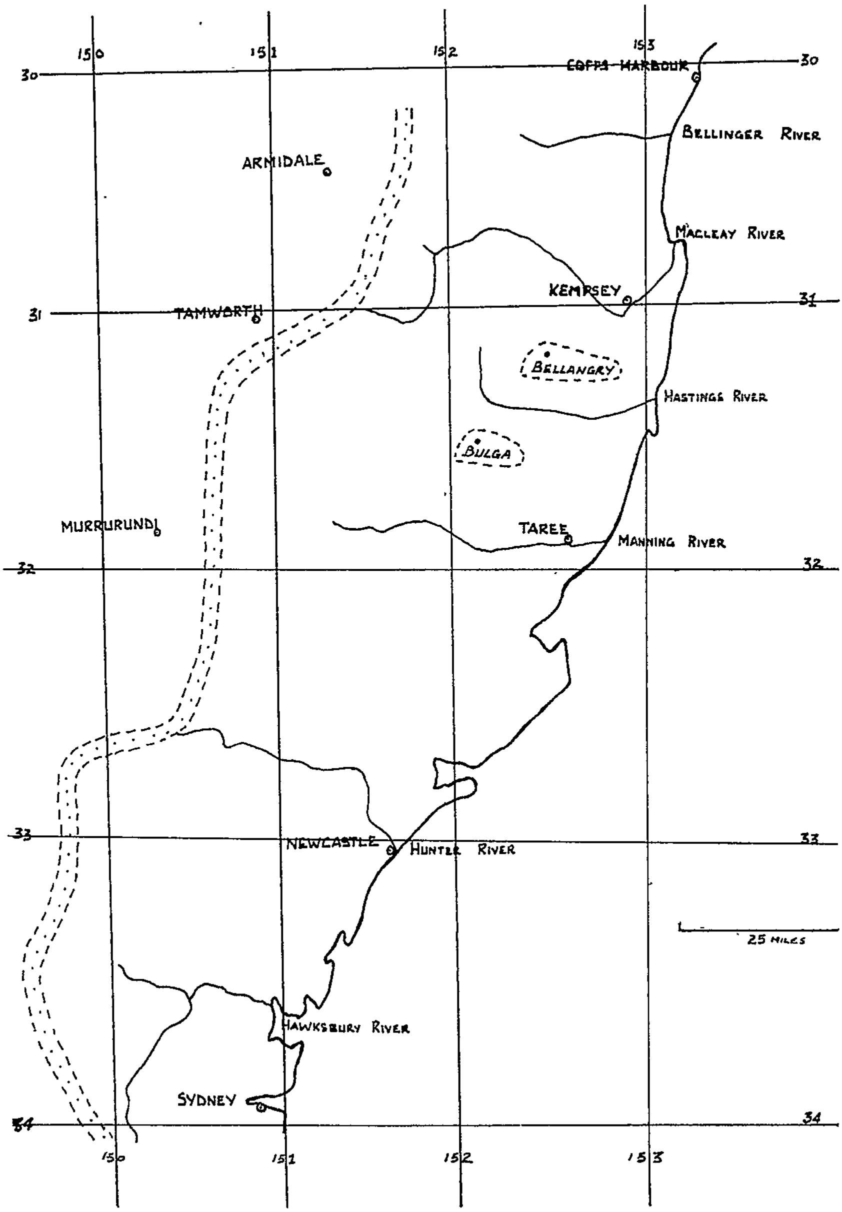
APPENDIX 1

LIST OF SPECIES MENTIONED IN TEXT

Botanical Name	Common Name	Family
Acacia binervata D.C.	Two-veined Hickory Wattle.	Leguminosae.
Acacia elata A. Cunn.	Cedar Wattle	Leguminosae.
Acacia irrorata Sieb. ex Spring. ..	Black Wattle	Leguminosae.
Ackama paniculata Engl.	Corkwood	Cunoniaceae.
Callicoma serratifolia Andr. ..	Callicoma	Cunoniaceae.
Casuarina torulosa Ait.	Forest Oak	Casuarinaceae.
Cryprocarya rigida C. Meissner ..	Rose Maple	Lauraceae.
Dodonea triquetra Wendl.	Hop Bush	Sapindaceae.
Drimys spp.	Drimys	Magnoliaceae.
Duboisia myoporoides R. Br. ..	Duboisia	Solanaceae.
Elaeocarpus reticulatus Smith ..	Blueberry Ash	Elaeocarpaceae.
Endiandra sieberi Nees	Pink Walnut	Lauraceae.
Erigeron canadensis L.	Cobblers Peg	Compositae.
Eucalyptus acmenioides Schau ..	Narrow-leaved White Mahogany.	Myrtaceae.
Eucalyptus cameronii Blakeley & McKie.	Diehard Stringybark ..	Myrtaceae.
Eucalyptus campanulata R. T. Bak. & H. C. Sm.	New England Blackbutt..	Myrtaceae.
Eucalyptus cloeziana F. Muell. ..	Gympie Messmate ..	Myrtaceae.
Eucalyptus delegatensis R. T. Baker	Alpine Ash	Myrtaceae.
Eucalyptus globoidea Blakeley ..	White Stringybark ..	Myrtaceae.
Eucalyptus grandis Hill ex Maiden ..	Flooded Gum	Myrtaceae.
Eucalyptus gummifera Gaertn.-Hochr.	Bloodwood	Myrtaceae.
Eucalyptus laevopinea R. T. Bak. ..	Silvertop Stringybark ..	Myrtaceae.
Eucalyptus microcorys F. Muell. ..	Tallowwood	Myrtaceae.
Eucalyptus obliqua L'Herit.	Messmate	Myrtaceae.
Eucalyptus pilularis Sm.	Blackbutt	Myrtaceae.
Eucalyptus quadrangulata Deane & Maiden.	White-topped Box ..	Myrtaceae.
Eucalyptus regnans F. Muell. ..	Mountain Ash	Myrtaceae.
Eucalyptus saligna Sm.	Sydney Blue Gum ..	Myrtaceae.
Helichrysum diosmifolium Vent. ..	Sago Bush	Compositae.
Kennedya rubicunda Vent.	Soldier Vine	Leguminosae.
Lantana camara L.	Lantana	Verbenaceae.
Orites excelsa R. Br.	Prickly Ash	Proteaceae.
Phytolacca octandra L.	Ink Bush	Phytolaccaceae.
Rubus moluccanus L.	....	Rosaceae.
Rubus moorei F. Muell.	....	Rosaceae.
Schizomeria ovata D. Don.	Crab Apple	Cunoniaceae.
Senecio lautus Forst. ex Wild ..	Fireweed	Compositae.
Solanum armatum R. Br.	Wild Tomato	Solanaceae.
Solanum mauritianum Scop. ..	Wild Tobacco Tree ..	Solanaceae.
Syncarpia glomulifera Sm.	Turpentine	Myrtaceae.
Synoum glandulosum A. Juss. ..	Scentless Rosewood ..	Meliaceae.
Tagetes minuta L.	Stinking Roger	Compositae.
Trema aspera Blume	Peached-leaved Poison Bush.	Ulmaceae.
Tristania conferta R. Br.	Brush Box	Myrtaceae.

APPENDIX 2



Locality map showing areas of main Field Trials

APPENDIX 3

DETAILS OF FIELD EXPERIMENTS

Expt No.	State Forest	Month Year	Cutting System	Seed Source	Seed bed Preparation
1	Bulga/Dingo	Jan., 1960	All trees removed except seed trees	4 TW/acre + 4sbG/acre	Burnt.
2	Bulga/Dingo	Jan., 1960	All trees removed except seed trees	4 TW/acre + 4sbG/acre	Tractor-cleared.
3	Bulga/Dingo	Jan., 1960	Clear felled	Spot sown—3 oz/acre	Burnt.
4	Bulga/Dingo	Jan., 1960	All trees removed except 3 per acre of species other than Tallowwood.	Spot sown—3 oz/acre. Nil TW seed trees.	Tractor-cleared.
5	Bulga/Dingo	Jan., 1960	Clear felled	Nil seed trees—not sown	Burnt.
6	Bulga/Dingo	Jan., 1961	Full canopy retained	Full seed tree source	Burnt.
7	Bulga/Dingo	Jan., 1961	Full canopy retained	Full seed tree source	Tractor-cleared.
8	Bulga/Dingo	Jan., 1961	Species other than Tallowwood removed to create 50 per cent canopy.	All TW left as seed	Burnt.
9	Bulga/Dingo	Dec., 1960	50 per cent canopy retained, including 2 TW per acre.	2 TW/acre	Burnt.
10	Bulga/Dingo	Jan., 1961	Species other than Tallowwood removed to create 50 per cent canopy.	All TW left as seed	Tractor-cleared.
11	Bulga/Dingo	Oct., 1960	All trees removed except seed trees	2 TW/acre	Burnt.
12	Bellangry	Feb., 1960	All trees removed except seed trees	2 TW/acre	Burnt.
13	Bellangry	Feb., 1960	All trees removed except seed trees	2 TW/acre ringbarked—sown 3 oz/acre.	Burnt.
14	Bellangry	Feb., 1961	Full canopy retained	Full seed tree source	Tractor-cleared.
15	Bellangry	Jan., 1961	50 per cent canopy retained, including 2 TW/acre	2 TW/acre	Burnt.
16	Bellangry	Jan., 1961	All Tallowwood removed, 50 per cent canopy retained.	Spot sown. Nil TW seed trees.	Burnt.
17	Bellangry	Jan., 1961	50 per cent canopy retained, including 2 TW/acre	2 TW/acre	No preparation.
18	Bellangry	Jan., 1961	All trees removed except seed trees	2 TW/acre	Burnt.
19	Bulga/Dingo	Dec., 1961	All trees removed except seed trees	2 TW/acre	Snigtrack extension.
20	Bulga/Dingo	Nov., 1962	50 per cent canopy retained, including 2 TW/acre	2 TW/acre	Snigtrack extension.
21	Bulga/Dingo	Nov., 1962	All trees removed except seed trees	2 TW/acre	Snigtrack extension.
22	Bulga/Dingo	Dec., 1963	50 per cent canopy retained, including 2 TW/acre	2 TW/acre and sown	Snigtrack extension.

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