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TRIP TO TASMANIA, NOVEMBER 24 1990

by

Phil Cannon

Report No. 2 March 1991

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INFORMATION FROM AUSTRALIA ON THEMES OF INTEREST TO THE NEW ZEALAND EUCALYPT BREEDING COOPERATIVE

Theme	Page number(s) in Phil Cannon's "Trip to Tasmania" Report	Additional References (Authors)
Wood Quality and Pulp Yield	12, 13, 26	Dean *et al*, Raymond *et al*
Tissue Culture	9, 11, 16	Rasmussen, Chandler *et al*
Rooted Cuttings	11, 12	de Little *et al*
Grafting	26, 27	
Hybridization	28-30	Potts
Frost Resistance	7, 9, 43	Volker, Potts *et al*, Raymond *et al*
Induced Flowering	42	
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Note: All references are attached.

TRIP TO TASMANIA

NOVEMBER 24, 1990

by Phil Cannon

EXECUTIVE SUMMARY

Between November 6-17, 1990, the author made a trip to Tasmania. The principle objectives of this trip were as follows:

1 To understand what is happening in the field of eucalypt genetics research in Tasmania.

2 To determine if there were good possibilities for exchanges between the New Zealand Eucalypt breeding cooperative and entities or individuals carrying out genetic improvement work with eucalypts in Tasmania.

3 To get a good feel for the environment in which the most commercially important eucalypt species grow naturally in Tasmania.

4 To learn everything else possible about why and how eucalypts are grown in Tasmania.

Towards reaching these objectives, 68 different activities (i.e., places visited or conversations held) took place. The places where these activities occurred are shown in Figures 1-5; and the essence of each of these activities is recorded in this report roughly in the order in which it took place

A list of researchers working in the field of forest genetics in Tasmania is given in Table 1. It was possible to meet with 11 of these individuals in one-on-one sessions during the course of this visit. Hospitality was always first class, and the author is very grateful to all those individuals cited for their willingness to discuss their respective genetics projects.

Generally in Tasmania there seems to be much good to excellent research on the development of specific biotechniques which can be useful to a forest geneticist (i.e., the development of techniques for making hybrids, techniques for cloning (both through tissue culture and rooted cuttings) techniques for evaluating resistance to frost, techniques for evaluating wood properties, techniques for flowering induction, etc). However, there is not yet a clearly defined or well coordinated breeding strategy that is being now acted upon at the level of individual companies and much less for Tasmania as a whole. There are intentions to improve existing strategies, however, and it would seem that if exchanges were to take place between New Zealand's Eucalypt Breeding Coop and breeding efforts in Tasmania that the former could offer useful suggestions on appropriate breeding strategies in return for training in some of the aforementioned biotechniques.

Relative to mainland Australia, where there are nearly 600 species of eucalypts, Tasmania has few native eucalypt species (only 28) and only a dozen or so of these are widespread. However, several of these, such as *E. globulus, E. regnans, E. obliqua, E. viminalis* and *E. delegatensis*, are important internationally as well as in Tasmania. Getting familiar first-hand with the environmental conditions that these trees grow in naturally was quite insightful.

Generally soils throughout the majority of Tasmania which this author visited are derived from basalts or dolerite with important exceptions being the granitic area in northeastern corner of Tasmania (basically north and east of Pioneer) and where there are upliftings of sedimentary materials (basically near the coast). Generally soils derived from basalt are among the richest for tree growth; these are recognized easily because they usually form a bright red B horizon. The B horizon of dolerite derived soils, by contrast, is yellowish.

Rainfall in Tasmania varies markedly with respect to altitude and degree of exposure to the rain bearing westerlies. Thus rainfall in the eastern valleys of Launceston and Hobart is only 600 to 800 mm per annum whereas rainfall at 500 masl in the surrounding hills might be as high as 1400 mm and rainfall in areas directly exposed to the westerlies (mainly in Western Tasmania) might be as high as 2000 to even 2500 mm. Throughout Tasmania, rainfall is heaviest during the winter months.

Where the different species of eucalypts grow is evidently very dependent on altitude, (which influences temperature and rainfall) and the soil. *E. regnans* is confined to relatively low altitudes 30-500 m (although there is significant variation in provenances), to areas which receive more than 1200 mm of rainfall and to the very best of soils. *E. obliqua* has roughly the same climatic restrictions except that it can survive well on the poorer soils, therefore it is quite widespread in Tasmania. *E. delegatensis* is also widespread, but is most prevalent at altitudes between 500 and 1000m. It can tolerate frequent and moderately deep levels of snow and is by far the largest growing eucalypt at high elevations even though there are several other eucalypts that survive well at and above 1000m. Often a peppermint eucalypt such as *E. amigdalina* (lower elevations) or *E. rodwayi* (higher elevations) will be found in association with some of the aforementioned species. Some of these can grow on quite tough sites (i.e., very droughty soils or soils with poor internal soil drainage), but they generally have slow growth rates.

TABLE 1: Individuals working in the field of eucalypt genetics and improvement in Tasmania. Addresses are given in Appendix I.

Name	Institution	Topics of Major Concern
Dr Wayne Tibbets	APPM	Genetic variation in frost tolerance
Geoff Dean	APPM	Genetic variation in pulp yields
Ian Ravenwood	APPM	Management of genetics trials Induction of flowering
Dr Dave de Little	APPM	Head of Forest Research Eucalypt entomology
Gillian Rasmussen	APPM	Tissue Culture
Keith Orme	Forest Resources	Breeding of eucalypts
Sandra Heatherington (1)	Forest Resources	Vegetative propagation of clones
Dr Carolyn Raymond	CSIRO	Breeding strategist
Rick Hand	CSIRO	Provenance/progeny collections Seed orchard
Brad Potts (1)	Univ. of Hobart	Phenology and breeding of eucalypts
Peter Volker	Australian Newsprint Mills	Progeny testing
Peter Kube	Forestry Commission	Provenance/progeny testing
Dr Peter Ades (2)	Melbourne Univ.	Quantitative geneticist

(1) It was not possible to meet these individuals during this trip.

(2) Actually living and working on the mainland, rather than Tasmania.

In Tasmania, eucalypts have been grown via a variety of silvicultural systems:

1 Naturally (usually seeding in after a fire);
2 Using a seed tree system;
3 By aerial seeding from an aircraft; or
4 By plantation methods.

Largely techniques 1 and 2 are no longer relied on for ensuring future forests in Tasmania; at present aerial seeding accounts for about 80% of the total land area being reforested , with plantations making up the remainder. Mensurational studies have shown that growth rates of stands established by aerial seeding are generally 1 to 2 m^3/ha/yr whereas on the same land and with slightly improved genetic stock, it is often possible to achieve about 20 m^3/ha/yr using intensive plantation silviculture. This large increase in wood production is largely due to better site preparation, better stocking, better weed control, and higher fertility (through fertilization). Generally the economic benefits for producing wood through intensively managed plantations are preceived to far outweigh those through aerial seeding and private pulp and paper companies universally elect to use this reforestation technique. The Forestry Commission of the Government, probably responding more to public pressures to reforest cutover lands than to financial motivations, usually uses the far cheaper aerial seeding technique.

By far the main reason that eucalypts are grown in Tasmania is for pulp wood. However the potential for producing veneer is also given some recognition (much more than sawn timber). The Japanese market, which has consumed vast amounts of old growth eucalypt chips in the past, continues to be seen as a major consumer of Tasmanian produced chips and pulp in the future, however the trade with Japan is down at present since Japan, fearing that Tasmanian wood chip supplies would soon be dwindling due to effective lobbying by the "greenies", began to look elsewhere for potential wood chip sources and actually found some (mainly the beech forests in Chile and the scrub hardwood growth of eastern USA) which were as good for pulping purposes and more reliably obtained than Tasmanian sources. Currently many Tasmanians are actually quite concerned about how to get back into the mainstream of the Japanese market.

Although much export of the wood resource of Tasmania is currently in the form of chips, in the future, as pulpwood from the eucalypt plantations comes on stream, it is expected that most of the wood will be pulped locally and then exported, either to the mainland or internationally (and for this reason, the majority of weight for selection of improved breeds of eucalypts is given to pulp yield). However, before this can happen, Tasmania and the Australian Government have to decide upon a long-term (as in 30-50 years) policy with respect to whether or not pulp mills will be encouraged to flourish in Tasmania. At present, future prospects are all quite nebulous with those keen to see the industry take off being held pretty much in check by the "greenies" who have used the ecological misdemeaners that the pulp companies have committed in the past as quite effective arguments for limiting their build up in the future.

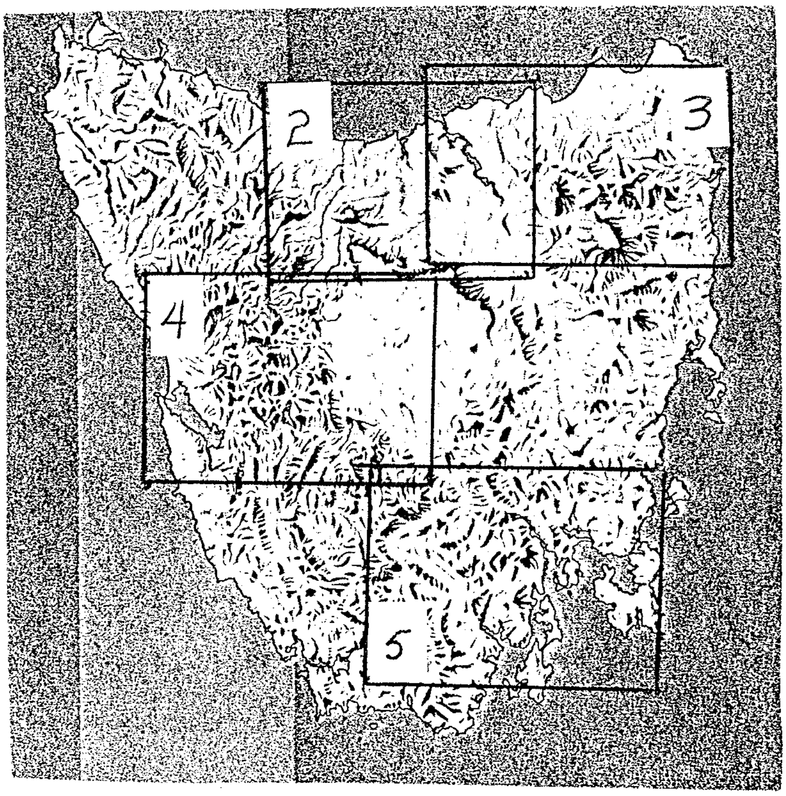
FULL REPORT

This section includes a description of what was learned from each of the 68 forestry and/or forest genetics related activities undertaken while in Tasmania. For purposes of orientation, Tasmania is divided into 4 zones as shown in Figure 1. The places where these activities took place were as follows: (1) the Northwestern Zone; (2) the Northeastern Zone; (3) The Central Plateau (and Western Conservation Areas) Zone; and (4) the Southeastern Zone. These zones are shown in greater detail in Figures 2, 6, 8 and 9, respectively.

The activities are recorded in this report roughly in the chronological order with which they took place. Fairly careful detail is given to those activities which involve eucalypt genetics research (since that is the authors field in New Zealand). Relatively less detail is given on activities which pertain to general silviculture or wood utilization; a fuller account of these activities may be available from the N.Z. Eucalyptus Management Cooperative.

FIGURE 1. The four areas visited in Tasmania during Phil Cannon's 1990 visit are shown in the map below.

Larger scale maps of boxed areas 2, 3, 4 and 5 can be found in this report in Figures 2, 6, 9 and 10, respectively. These figures also list activities undertaken in each of the corresponding regions and show where they occurred.



AREAS VISITED IN NORTH WESTERN TASMANIA (See Figure 2)

1 APPM Forestry and Forest Research Station

The layout of this forestry center, at Ridgley, is first class. There are offices for about 12 people, one lab, and a small auditorium in the main building. Basically it houses all of the principal APPM players for forestry and forest research. The surrounding grounds include all of the headhouses, green houses, raised nursery beds and controlled environment chambers that APPM needs for producing all of its stock for the western half of its domain in northern Tasmania (basically from Deloraine west) with the exception of the nursery space required for the second phase in the production of bare-root stock (read on for a description of this process).

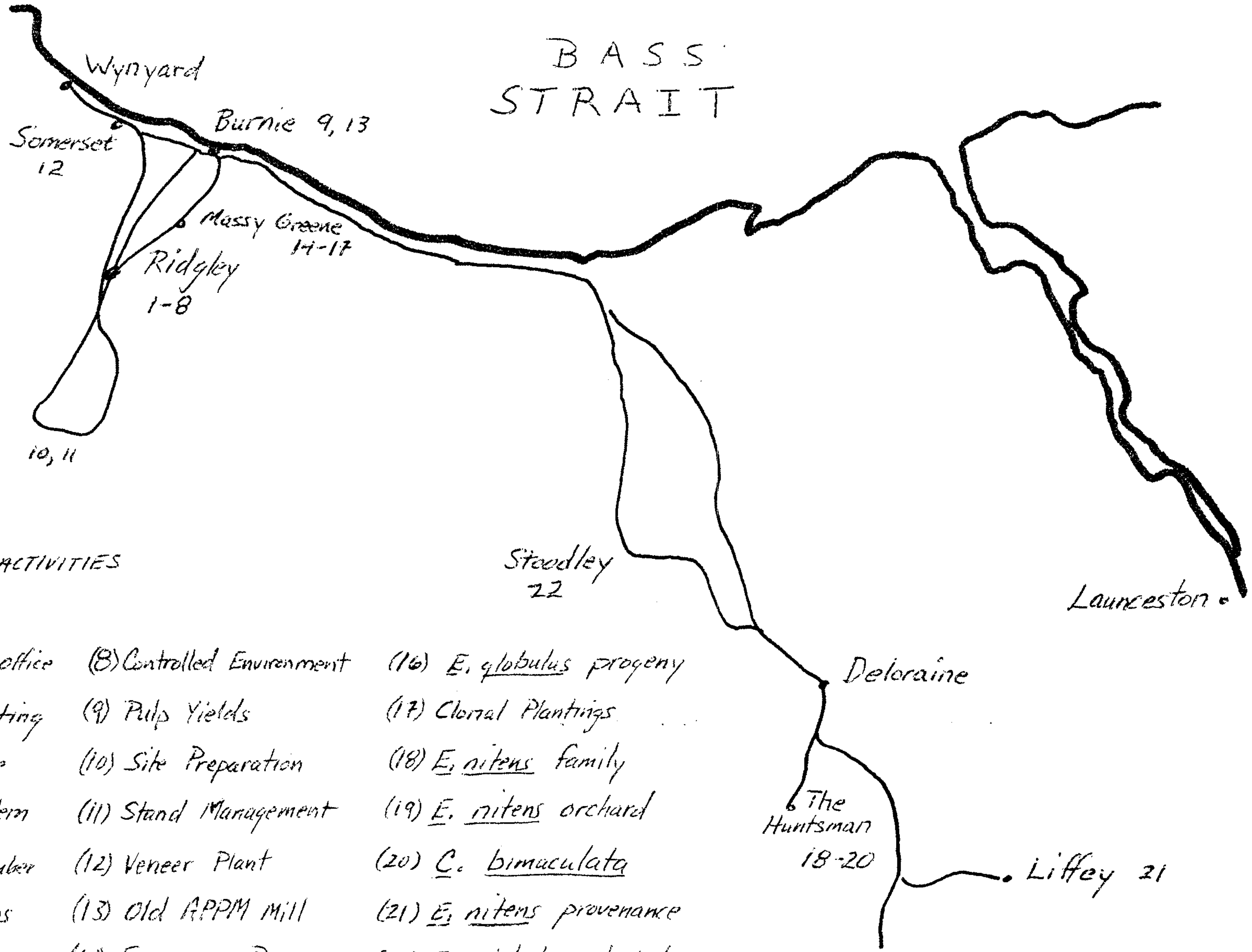
Forest operations are directed by Tom Fisk, Forest Research by Dave de Little. Both of these fellows are extremely enthusiastic about their work, are extremely articulate and appear to be excellent leaders. Through them the next 19 activities mentioned in this report were set up and the author is extremely grateful for their collaboration.

2 Induced Frosting - explained by Wayne Tibbets

Resistance to cold is critical to the survival of eucalypts in the main area that APPM is planting to eucalypts (i.e., the 600 to 700 masl plateaulands south of Ridgley). For this reason the company wants to know which genotypes of eucalypts have the highest resistance. There is a conviction at APPM that the use of an artificial induced frosting technique can give reliable and much speedier readings than waiting for natural freezes in nature.

The induced frosting technique, in its barest essence, involves using a cork borer to punch leaf disks out of the plants that are to be assessed, immersing each leaf disk in a separate test tube partially filled with deionized water and then placing this test tube in a rack with other test tubes containing similar samples. This rack is subsequently placed in a polyethelene glycol bath which, in proper combination with a mixing motor, a heating element and with a digital temperature readout mechanism can induce exact temperatures (to 0.1°C) down to at least -20.0°C. Subsequent to running the samples down to a freezing temperature and then thawing them out, the electrical conductivity of the water in the test tube is measured. In samples where cell membranes have burst, there will be, as compared with samples without burst membranes, a much higher conductivity. For most effective screening, the temperature should be set to a point where approximately 50% of the leaf disks would be expected to burst. This has to be a fine-tuned operation because the difference between the least and the most frost-tolerant provenances is only 0.3°C in summertime and 1.0°C in wintertime. Generally

Figure 2. Places visited in northwestern Tasmania. (▬▬) Shoreline; (⁀) Route taken.



LIST OF ACTIVITIES

1) APPM Forestry office
(2) Induced Frosting
(3) Tissue Culture
(4) Paper Pot System
(5) Germination Chamber
(6) Production Benches
(7) Greenhouse
(8) Controlled Environment
(9) Pulp Yields
(10) Site Preparation
(11) Stand Management
(12) Veneer Plant
(13) Old APPM Mill
(14) _E. regnans_ Progeny
(15) _E. nitens_ Progeny
(16) _E. globulus_ progeny
(17) Clonal Plantings
(18) _E. nitens_ family
(19) _E. nitens_ orchard
(20) _C. bimaculata_
(21) _E. nitens_ provenance
(22) _E. globulus_ plantation

provenances from Northern New South Wales and the Central Victorian highlands have shown superior frost tolerance as compared with sources from East Gippsland (Errinundra) and Southern New South Wales. Information as to variation in frost tolerance at the family level is not available although Wayne Tibbets had just returned from Florida where he had been processing APPM data on just this point. For more information on the technique used for inducing frosting or some of the results which have been obtained from using this technique, refer to Raymond *et al* (1986) or Tibbits and Reid (1987).

3 Tissue Culture - Work done by Gillian Rasmussen, explained by Dave de Little

As at FRI, APPM is doing tissue culture work with *Eucalyptus nitens* and other eucalypt species. Generally the APPM effort seems to have progressed further at this point in time than the work at FRI because they have about 5 times as many culture plates and their plates tend to have much greener and healthier looking shoots.

Although I did not press for information from APPM, because I sensed that their tissue culture work is being done with a substantial degree of confidentiality, Dr. de Little did indicate that they use Mands media usually as their base recipe and that they had done a substantial degree of investigation on the removal of contaminants from the media; some plates had activated charcoal in them to remove chemical contaminants and bacteria were flushed out periodically using a soy agar. Another item (as I remember) was that the flourescent lights were pink giving a little more infra red light than the white lights used at FRI.

One problem that remains a nemesis for APPM is getting cultures to root and then weaning them from laboratory conditions. They have a contract with Tasman Forestry Ltd to help them through this stage and Gillian Rasmussen expects to be in New Zealand in about March of 1991. It may well be worthwhile for her to link up with Kathy Horgan of FRI at this time to exchange information on eucalypt tissue culture. I have spoken with both parties and Kathy Horgan intends to invite Gillian Rasmussen to a tissue culture conference which is being held in February of 1991.

4 APPM's paper pot system

This technique is not more than a modern, well functioning, concertina paper pot system. A neat feature is that the concertina is expanded initially by putting a wall of vacuum suction on each end of the concertina and then pulling these walls apart. After the paper pots have been filled, (with a mix of subsoil (60%) pea gravel (20%), peat (20%) and trace amounts of fertilizer) a group of women expertly do the transplanting of recently germinated and slightly hardened seedlings (grown in punnets in a growth chamber : see ahead). This transplanting is done by using forceps curved at the end to first grasp the seedling by the root tip and then jam a seedling into the media until its root collar was level with the surface. It seemed like each woman was transplanting about 2 seedlings per second: amazing!

After being pricked out, seedlings are taken to raised benches (1m height) which have saram (plastic screen giving 50% shade) coverings (for details see item 6 ahead). This saram is removed for progressively longer periods as the seedlings become established. Seedlings which are pricked out in early spring (about September) will reach a plantable seedling size by about December and cost 10 cents apiece. Seedlings pricked out in about November-December are, when they are about 15 cm tall, planted tube and all in a nursery bed at a 10cm by 10 cm spacing where the roots will, with time, penetrate the paper pot and extend out into the soil. This outplanting in the nursery phase is the only operation that is not conducted at the main Ridgely office. These seedlings will subsequently be undercut and root pruned and will generally be treated as bare-root stock: they will be ready for planting in winter. They are called half-half stock and cost about 20 cents apiece. The main reason for using half-half stock rather than classical bare-root stock is to avoid loss of seed since half-half stock production gets almost 100% of the seed into the seedling state whereas sowing directly in the nursery bed gives a low level of success. (APPM might be well off to study the liquid sowing technique that NZFP has worked out which also has a high success rate). A main point is that with these two planting systems, APPM produces inexpensive seedlings that can be planted in either summer or winter.

5 Germination chamber

The germination chamber was like an 8x8x2.5 meter refrigerator with pink florescent lamps and a misting systems. Seedlings were germinated in punnets filled with the same potting mix that was used for most seedling raising purposes at the Ridgley nursery.

6 Raised production benches

There were approximately 100, 20m long by 2m wide production benches at Ridgley. They are about 1 m off of the ground, have a heavy screen base and have a metal A-frame-like structure over the top which supports a sprinkling system on the underside and rolls of seram on the top side. They seemed to have been very well designed from an ergonometric point of view (See Figure 3).

FIGURE 3. Features of the raised seedling beds in APPM's nursery.

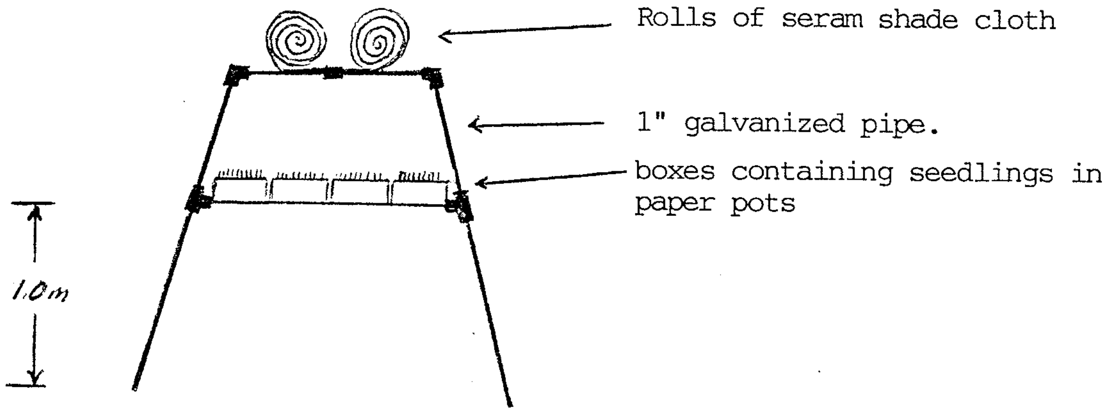


FIGURE 4. Layout of a portion of the field trials at Massy Greene for rooted cuttings, tissue culture plantlets, hybrids and second generation Open Pollinated selections.

Massy-Greene Drive

71-250 Cuttings King Island	Northern NSW 72-171 T/C Tissue Culture	72-72 T/C	G/o 505 OP orchard 2nd gen.	72-309 Cuttings	72-272 Cuttings	72-72 T/C	72-299 Cuttings
72-272 Cuttings	72-273 Cuttings & T/C	G/o 112 Seed	G/o 171 Seed	Nit 508 Seed	71-250 Cuttings	72-72 Cuttings	G/o 112 Seed
72-309 Cutting	Nit 508 Seedling	72-278 Cutting	72-72 Cutting	72-171 T/C	G/o 505 Seedlings	G/o 171 Seed	72-270 Cuttings
72-72 T/C	72-171 T/C	72-108 Cutting	G/o 171 Seed	72-72 Cuttings	G/o 505 Seedlings	Nit 508 Seedlings	72-171 T/C
71-250 Cuttings	72-309 Cuttings	G/o 112 Seedlings	72-272 Cuttings	72-309 Cuttings	72-72 T/C	72-270 Cuttings	71-250 Cuttings
72-72 Cuttings	Nit 508 Seedlings	72-210 Cuttings	72-270 Cuttings	72-299 Cuttings	G/o 112 Seedlings	72-272 Cuttings	G/o 499 Seed

7 Greenhouse for clonal stock

APPM is very interested in developing several of the techniques which can be used for capturing useful genetic variation through vegetative means. Tissue culture has already been mentioned in this regard. Another potentially useful approach is through vegetative propagation of cuttings. To assure that APPM has a capability for making ample numbers of cuttings, APPM has a greenhouse which is mostly filled with about 100 cuttings of each of about 100 of those clones which they would like to continue working with. These are all potted in 1 gallon plastic pots filled with a 50-50 peat vermiculite mix. They also have some hybrid plants in the greenhouse. Generally they have had good success with propagating *E. grandis* through rooted cuttings; variable success with propagating *E. globulus* (some clones have up to a 70% success rate when struck whereas others have essentially nil); and essentially no success to date with the propagation of
E. nitens.

8 Controlled Environment

APPM has a controlled environment chamber which can control humidity (through misting) and temperature quite effectively. The control mechanism actually comes from DSIR at Palmerston North. This facility has been used to help rooted cuttings get established (although there have been tremendous problems with *Botrytis sp.*). It is also being counted on for use in the weaning process of the tissue-culture-produced plantlets in a way similar to the procedure used by Tasman Ltd at Te Teko.

9 Pulp yield with Geoff Dean

Pulp yields, expressed as percent pulp obtained from bone dry chips when pulped using the Kraft process to a Kappa No 18, have been run for 460 *E. globulus* trees and at least that number of *E. nitens*. The variation in pulp yields from *E. globulus* has already been reported (Dean, French and Tibbits, in Press) and a similar paper for nitens should be available within two months. These papers indicate degrees of variation in pulp yield for the species, however, they do not give the exact pulp yield for a given family as seed from some of these trees has been disseminated internationally and this would be giving away too much information. Geoff Dean is willing to do pulping studies on request, however. The marginal cost per sample is $400/tree.

The accuracy of the sampling depends on the height up the tree with the highest yields and minimal variation between samples being obtained from samples taken at about 30% of total tree height. This is destructive sampling. Another sampling technique being studied for possible substitution is the NIRA (near infra red atomic absorbtion) technique. This was developed by ICFR (the old Wattle Research Institute) in South Africa. The "extractives" technique, presented in this report under the Forest Resources Ltd section, has not been found to be reliable by Geoff Dean's crew.

Obviously these pulping studies are costing plenty of money (as much as 600 trees per year times $400/tree = $2,400,000/yr) so it is evident that APPM is placing major emphasis on pulp yield as a criteria for selection in their tree improvement program. Heavy investigation in the vegetative propagation end of the program should, in theory, couple nicely with this pulp yield information; this would also permit APPM to sidestep some of the conventional steps of tree improvement and the costs and time which are associated with them.

The big risks, as I see it, are two. First of all, if there is not an adequately cheap delivery system to be found (i.e., *E. nitens* cannot be propagated vegetatively at a cheap enough cost for production plantations) then there will be plenty of wastage with the present course of investigation.

Secondly, this pulp yield research (and in fact most forest research at APPM) is being done as if there will soon be a huge kraft pulp plant installed in Northwestern Tasmania. However, the 450,000-ton-per-year kraft pulp plant which was projected for Wesley Vale (near Devonport) has in fact been dealt a serious set back. "Greenies" so opposed to having a pulp mill dumping more pollution into the waters of NW Tasmania (there is already considerable pollution from the Titanium plant near Burnie and the 95,000 tons/year APPM cold soda pulp mill in Burnie) asked the government to put practically impossibly tight contamination restrictions on the projected pulp mill; the net result was that the mill construction could not be started anywhere near the designated start up date and the investors withdrew. Because of this, there is considerable doubt, even among APPM employees, that both government approval and the critical funding can be brought together successfully in the future. If this does not happen, then the current research will have largely been a waste.

10 **Site Preparation**

Site preparation in the extensive plateau country owned by APPM South of Ridgley was shown to us by Kevin Young. Root raking to get a vegetation free surface and then ripping and fertilizing seem to be pretty standard practices for much of Tasmania. Details of the operation should be available in the trip report presented by the Euc Management Coop.

11 Stand management

The practice which Kevin Young showed us involved the routine thinning of every third row at about age 5 in stands which would be prepared for veneer production. Subsequently thinnings were made from this residual stand into the opened rows. In this way there was a minimal damage to the residual stems and stand density could be reduced to about 300 stems per hectare which is considered to be about the density you need if you want to end up with veneer logs. Kevin also stressed the importance of doing a good job of pruning to about 6m on trees left as residuals.

12 Veneer plant

APPM has a modern slicing veneer plant in Somerset, just 15km to the west of Burnie. A very substantial part of their production comes from many of the eucalyptus species of Tasmania. Regardless of the species of eucalypt, the veneer is classified as ash or oak depending on whether it is a lighter or darker colored wood, respectively. Small shake-like defects in the wood called "stripe" are a major problem, the cause of this is attributed to insects. Kino deposits can also be a problem. These can occur when a tree suffers a heavy defoliation (35% or more). As I recall, to feed this plant in the future totally from plantation stock, the company will only need a total of somewhere between 200 and 500 ha of eucalypt plantations managed for veneer, only a small fraction of the total plantation area.

13 The old APPM pulp mill

The APPM pulp mill located in downtown Burnie, almost on the waterfront, is nearly 50 years old and was one of the first mills in the world to successfully pulp eucalypt trees. It uses the cold soda process and makes about 95,000 tons of pulp per year. It uses old growth at present. Undoubtedly it could be used for consuming some of the eucalypt plantations being established in present times, but the large eucalypt planting scheme (about 2,700 ha/yr) that is being carried out at present is being done with a view that a kraft plant with 5 times the wood processing capacity will be installed to consume it. This proposed new plant has met with some stiff and so far effective opposition which cites, among other things, that the contamination of the sea in front of the old APPM mill as one reason why a new mill should not be constructed.

14 *E. regnans* progeny trial at Massy Greene

This progeny trial belongs to the second stage of the two-stage *E. regnans* improvement program for Australia. In the first stage, bulked seedlots from 49 different provenances were test planted at 12 sites to determine their performance. On the basis of results from this trial, the provenances were divided about equally into 4 groups

1 Those with fast growth and low frost tolerance.
2 Those with moderately fast growth and high frost tolerance.
3 Those with high frost tolerance and slow growth.
4 Those with low frost tolerance and slow growth.

Furthermore within groups (1) and (2) it was found that the outstanding provenances came from the Strzeleki Ranges of Victoria and the Upper Derwent Valley of Tasmania.

For the second stage, therefore, a new collection of 385 fully identified open-pollinated families was made from the best provenances in these two areas.

Two sets of seedlings were raised from this collection. One was used for induced frosting tests (see item 2 for technique) and the other was used for field testing. Five sites are being used for field testing. For the Massy Greene site, 215 of the families are represented and there are 11 replicates in a single tree plot design. The experiment occupies about 4 hectares.

15 The *E. nitens* progeny test

There are 200 *E. nitens* families being tested in randomized complete blocks. I did not note the plot size (possibly single tree plots). This test was established in 1986.

16 The *E. globulus* - Alpha Lattice design

This design uses 2 trees per test plot which gives a measure of within plot variation. The fellow who designed it was a Scotsman who felt he had a lot of new designs forthcoming; hence the name Alpha. It has its own software package and seems to have attracted APPM. One thing that is already apparent, even though the experiment was only planted in 1989, is that there can be large differences between individuals of the same family within the same plot. These within-family differences are hard to pick up with the STP design.

The Alpha Lattice design is available from the Scottish Agricultural Statistics Service at the University of Edinburgh.

17 Clonal plantings

Rather than describe all of the material that is under consideration in the two-year-old clonal testing block, a diagram of a portion of the test itself is reproduced in Figure 4. Obviously APPM has made substantial progress with tissue culture and cuttings propagation with several eucalypt species and hybrids. It should be pointed out that APPM is relying heavily on the eventual development of an economic vegetative propagation system to give them the best genotypes for their future plantation efforts. A big advantage of vegetative propagation is that it enables the geneticists to capture the Specific Combining Ability of a cross rather than just the General Combining Ability of a parent (or the parents if it is a controlled cross). However, to date vegetative propagation with *E. nitens*, the major species APPM is working with, is still not economically practicable at APPM either through vegetative propagation or tissue culture (there are problems with rooting the plantlets). Obviously APPM has taken a bit of gamble in its approach to tree improvement; so far the cheap and reliable delivery system (through vegetative propagation) that they need for it to work has remained a little beyond their grasp and it seems unlikely that it will be in place by the 1992 date. In the meantime, to cover their bets, it would seem that APPM should keep up and perhaps modify their open pollinated breeding program so that it could be flexible enough for both the identification of the best genotypes to be used for cloning and, should this fail, for the identification of parents for a seed orchard. I got the feeling (especially when Dave de Little was answering Mike Carson's questions on the APPM breeding program) that APPM is still trying to figure out what its best program would be and that a thorough review of their program by someone such as Mike Carson or Tony Shelbourne would be highly advantageous.

18 *E. nitens* family test

At The Huntsman, APPM had laid out a 200 family *E. nitens* Single Tree Plot (STP) test. The test plots were laid out between windrows with the block size being 14 trees wide by 21 trees long. The only trend that was obvious was that trees that were planted nearest to the windrows were generally much larger (as in 2 to 7 times the volume) as trees which were 10 metres or more away from the windrows.

This fact may not hurt the resolution of the experiment too much since the STP testing design is extremely robust. However, it does suggest that current silvicultural techniques (i.e., windrowing) are denying *E. nitens* the chance of growing anywhere close to their full genetic capacity, at least in areas such as The Huntsman. Furthermore selection based on trees grown under these circumstances may favour trees capable of growing under tough conditions rather than trees growing under more favourable conditions. If it is possible to economically ensure that site conditions are more favourable (for instance more like the area in proximity of the windrow) then different families might be selected. This is an issue that APPM will have to resolve themselves. If they plan to stick to site preparation by windrowing (which is by far the most prevalent site prep technique in Tasmania to date) and they want to improve the resolution of their breeding experiments, block shapes could be adjusted to make sure that no trees being tested are planted within 10 to 15 m of the windrows.

19 *E. nitens* seed orchard

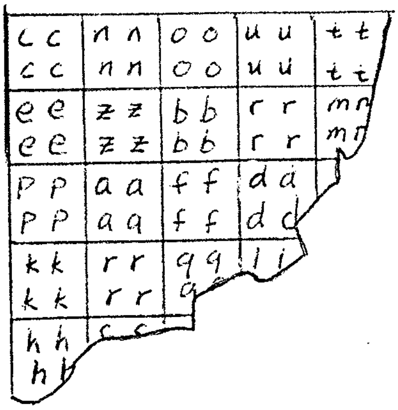
Perhaps about 12 years ago APPM became aware that they would eventually want to be able to supply their own *E. nitens* seed for planting purposes; so they decided to make a seed orchard. This orchard has an interesting development as shown in Figure 5. Initially, 35 families (not chosen with any particularly selective criteria as far as I know) were planted such that 4 trees of each family were planted in a square plot in each of 10 blocks. At about age 6, the 3 worst trees for each family in each 4-tree plot were rogued giving the initial selection.

A few years later all of the remaining trees were measured and analyzed by family means. Then the worst third of the families were rogued from the orchard, the middle third of the families were sacrificed for a pulping study (forming the base for Geoff Dean's article on pulp yield from different *E. nitens* families) and the best third remained standing to provide the trees for the seed orchard.

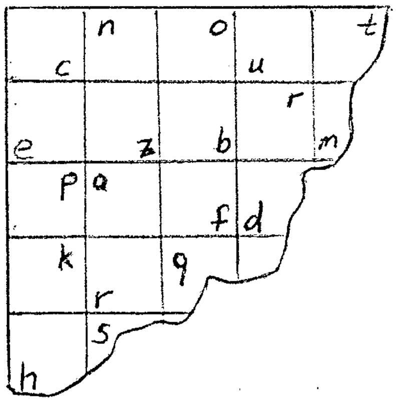
There are now, after the two stages of rogueing, roughly 100 trees per hectare, and APPM is counting heavily on this orchard to provide improved seed. Actually seed production did not appear to be too bad for *E. nitens* but none-the-less it is doubtful that unaided this relatively tiny orchard will supply all the *E. nitens* seed that APPM could use or sell. To increase productivity of the orchard, therefore, APPM is relying on the use of Paclobutrazol (coal tar) and Chrysomelid destroying insecticides.

Paclobutrazol, an antigibberellin-forming substance, has been used by many of the fruit producing industries (including several in New Zealand) to increase flowering. It can be applied either as a soil drench (Tasman Forestry Ltd has experience with this) or it can be injected into the xylem from spring-loaded syringes fixed at about breast height around the bowl of the tree. APPM has experience with both techniques and with determining the optimal dosages to be used. For the soil drench method, the optimal dosage, according to Gillian Rasmussen, is 2 grams of active ingredient per centimeter diameter of the tree. The appropriate amount is mixed with about 0.5 litres of water and applied to the soil in the region of the root collar using a large syringe. The best time for applying this chemical is about October or November. The large influx in flowering can be anticipated in about 15 months. Quite small trees can be treated, but they should at least have some flower initials naturally

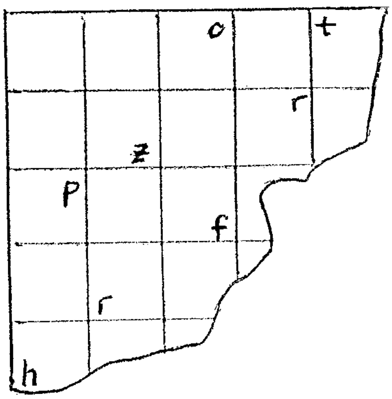
FIGURE 5. Stages in the development of the E. nitens seed orchard at The Huntsman.



(a) Initially 4 trees (for example oooo) each of 35 families are planted in a square pattern at a 3 x 3 m spacing.



(b) At about age 6, the 3 worst trees for each family are removed.



(c) At about age 9 the worst third of all families are thinned to waste, the middle ranking third of the families are felled and studied for their kraft pulp yields and the best third remain in the orchard to cross and provide improved seed for APPM's plantations.

before the paclobutrazol is applied. At APPM they find that treatment with this substance increases flowering by about 50 fold.

20 Sampling for *Chrysophtharta bimaculata*

The second big way that APPM intends to promote seed production in their seed orchard is by control of defoliating insects, many of which can eat the flower initials as well as the foliage thereby limiting seed production directly and indirectly (indirectly because they reduce the amount of carbohydrates available for seed production).

According to Dave de Little, the worst insect defoliators are the Paropsine Chrysomelids (Tasmania has 36 species of these) and the most devasting of these is *Chrysophtharta bimaculata* (although several of the other species can also be important).

In the springtime (October), when the trees are flushing, the adult beetles reach their peak activity. This is partly because they are stimulated by a heavy production of leaf oils. Actually the type of oil produced, cineol or phelandrine, and the relative amounts of their production do much to influence which type of Paropsine beetle will be attracted. The relative production is determined in large measure by whether the eucalypt belongs to the Symphyomyrtus or Monocalyptus subgenera and whether the foliage is juvenile or mature. In terms of oils, *E. nitens* produces both types and so seems to attract a large number of Paropsine defoliators; none-the-less there is also evidence that some *E. nitens* families are far more attractive to certain species of Chrysomelids than are other *E. nitens* families, this phenomena is being studied at present to determine if it is related to variation in the oils produced .

Another thing that happens in springtime is that it warms up; when temperatures begin to exceed (23°C?) almost to the degree, the female *Chrysophtharta bimaculata* beetles begin to fly and fly hard until they have found a suitable site to lay their eggs and the males seem to be right on their tails. Their favourite target is the bronzy coloured new foliage of a suitable eucalypt where the female will oviposit about 30 eggs. If all of these eggs could develop through the 4 larval stages the effect on the host eucalypts would be devastating. Fortunately, however, Tasmania has a number of natural predators which help control either the eggs or the larvae (see de Little *et al* 1990 for a fuller description of these).

So it was, that during my springtime visit to APPM, Ian Ravenwood had the task of monitoring the *C. bimaculata* build-up in the *E. nitens* seed orchard and I had the good luck of being able to accompany him.

When we first arrived at the Huntsmans it was about 1.00 p.m. We ate lunch, discussed the layout of the seed orchard and then decided to do the monitoring. There was no evidence of *C. bimaculata* flying about the site at this time, however we did find some bimaculata on the leaves and some egg masses on the younger leaves. As far as I could tell essentially all of these eggs were already eaten or soon would be by the ladybird beetles (*Cleobora agricola*) which were ubiquitous and clung tightly to the egg masses. Ian and I had pretty much come to the conclusion that everything was under control and were about to leave when all of a sudden (perhaps over a period of 10 minutes) the air was filled with zooming Chrysomelids. Apparently it was one of the first warm days in spring and the temperatures had just surpassed the critical threshold of 23°C.

At any rate, the sudden explosion in number of these insects was most impressive and when later discussing it with Dave de Little was enough to tip the decision towards doing an aerial spray.

Doing an aerial spray for Chrysomelids is a bit risky. The most effective insecticide is a synthetic pyrethroid "Dominex" which is effective for about 6 weeks. In normal plantations it might be used quite sparingly (maybe one-third of all nitens plantations would be sprayed once during a rotation), however, because of the great value of the nitens seed, APPM wants to do an especially effective job of controlling *C. bimaculata* in the seed orchard.

One of the drawbacks of the synthetic pyrethroid being used is that it can kill trout when present in the water in trace amounts. APPM has some political problems with this aspect and so is considering wider use of a strain of *Bacillus thurengiensis* as an alternative. This *B.t.* strain is the Santiago strain which was originally developed to kill the Colorado beetle. It is apparently very effective against the *C. bimaculata* (and does not harm trout), however its efficacy is for only two weeks.

21 *E. nitens* provenance test

The *E. nitens* provenance test is monitored by the Forestry Commission and has been laid out at Liffey and Esperance. Results of these tests at 10 years are shown in Table 2. We were shown the test at Liffey and were impressed by the substantial visual variation in performance between provenances.

We were also shown some *E. obliqua* which had been aerially seeded in two years earlier in an adjacent plot. It was hard to see that a valuable forest might eventually form in this plot whereas many of the younger *E. nitens* provenances were already well on their way.

22 Forty-five year old *E. globulus* plantation

This plantation is looking quite nice at this time. When it was 42 years old, a volume table was developed from measurements which had been made periodically since its establishment. This table is reproduced here as Table 3. It is of interest to note that PAI and MAI are still quite low at age 10 and that both increase tremendously by age 15. It is significant that the MAI and basal area stay fairly constant between 15 and 45 years of age (at about 29 m^3/ha and 49 m^2/ha, , respectively) with the major change in stand statistics being the progressive increase in diameter classes; whereas at age 15 nearly 90% of basal area comes from trees with diameters between 15 and 30 cm diameter, by age 40 more than 80% of the basal area is concentrated on stems with 30 to 50 cm dbh.

TABLE 2 Stem volume (under-bark) of *Eucalyptus nitens* provenances, age 10 years, Liffey, northern Tasmania (assessed 13/8/1990).

Locality	Provenance	Stem volume ($m^3 ha^{-1}$)	Adjusted volume ($m^3 ha^{-1}$)	Adjusted MAI ($m^3 ha^{-1} yr^{-1}$)
6 Mt Erica	Toorongo	210.1	212.6	21.3
21 Dummy	Toorongo?	170.0	196.7	19.7
16 Mt St Gwinear	Toorongo	187.5	192.2	19.2
13 Badja Mountain	Southern NSW	181.9	188.3	18.8
7 Mt Skene	Macalister	184.1	186.8	18.7
18 Federation R	Rubicon	165.6	181.3	18.1
12 Tallaganda	Southern NSW	165.2	170.3	17.0
17 Mt Torbrek	Rubicon	163.9	170.2	17.0
14 Anembo Trig	Southern NSW	159.2	159.2	15.9
8 Mt Wellington	Macalister	172.9	142.4	14.2
9 Toolangi	Rubicon	119.9	125.8	12.6
3 Powelltown	Toorongo	120.8	124.9	12.5
4 Tweed Spur	Rubicon	120.7	116.5	11.7
5 Toorongo	Toorongo	124.2	113.4	11.3
20 Connors Plain	Macalister	114.5	112.7	11.3
11 Blue Range	Rubicon	114.1	97.4	9.7
15 Noojee	Toorongo	80.2	91.6	9.2
10 Bendoc	Errinunda	94.8	90.0	9.0
1 Mt Kaye	Errinunda	71.6	67.4	6.7
19 Ebor	Northern NSW	61.2	57.8	5.8
2 Gunmark R	Errinunda	69.4	54.5	5.5
L.S.D.(0.95)		75.2	64.3	6.4

Table 3 Volume table from stand simulation for *E. globulus* at Stoodley

The model was based on an assumed stocking at 10 years of 1750 stems ha^{-1}, the known stocking at age 42 of 570 stems ha^{-1} and an estimated entire stem volume at age 42 of 1045 m^3. The predicted volume (m^3 ha^{-1}), basal area (m^2 ha^{-1}) and stocking (stems ha^{-1}) are shown for each 5-yearly age level and diameter (DBHUB) class, together with the periodic annual increments (PAI) and mean annual increments (MAI) in volume

Age (years)		Diameter class (cm) 0–5	5–10	10–15	15–20	20–25	25–30	30–35	35–40	40–45	45–50	50–55	55–60	Total	PAI (m^3 ha^{-1})	MAI (m^3 ha^{-1})
10	Volume	0·7	12·3	48·9	68·7	3·6	0·0	0·0	0·0	0·0	0·0	0·0	0·0	134	13·4	13·4
	Basal area	0·2	2·5	7·7	9·5	0·5	0·0	0·0	0·0	0·0	0·0	0·0	0·0	20		
	Stocking	170	528	626	412	14	0	0	0	0	0	0	0	1750		
15	Volume	0·2	6·4	34·3	88·3	145·2	135·4	6·1	0·0	0·0	0·0	0·0	0·0	416	56·4	27·7
	Basal area	0·1	1·1	4·2	9·3	13·8	12·1	0·5	0·0	0·0	0·0	0·0	0·0	41		
	Stocking	44	218	335	381	349	210	7	0	0	0	0	0	1544		
20	Volume	0·1	3·6	22·4	65·1	126·9	184·1	177·7	21·6	0·0	0·0	0·0	0·0	601	37·1	30·1
	Basal area	0·0	0·5	2·4	5·8	10·1	13·7	12·6	1·5	0·0	0·0	0·0	0·0	47		
	Stocking	13	108	189	238	254	231	155	15	0	0	0	0	1203		
25	Volume	0·0	2·1	15·3	48·5	102·5	167·5	216·7	182·0	6·4	0·0	0·0	0·0	741	27·9	29·6
	Basal area	0·0	0·3	1·5	3·9	7·3	11·0	13·4	10·9	0·4	0·0	0·0	0·0	49		
	Stocking	3	59	118	159	182	185	163	100	3	0	0	0	972		
30	Volume	0·0	1·2	10·7	36·7	82·3	143·8	207·3	239·9	131·0	0·0	0·0	0·0	853	22·4	28·4
	Basal area	0·0	0·2	1·0	2·7	5·4	8·6	11·6	12·9	6·8	0·0	0·0	0·0	49		
	Stocking	0	32	78	111	133	144	140	117	50	0	0	0	805		
35	Volume	0·0	0·7	7·6	28·0	66·1	121·4	186·6	243·2	244·2	48·4	0·0	0·0	946	18·6	27·0
	Basal area	0·0	0·1	0·7	2·0	4·0	6·7	9·7	12·0	11·6	2·3	0·0	0·0	49		
	Stocking	0	17	53	80	100	113	117	109	83	14	0	0	686		
40	Volume	0·0	0·4	5·4	21·5	53·3	101·8	163·9	228·7	270·5	180·3	0·0	0·0	1026	15·9	25·6
	Basal area	0·0	0·1	0·5	1·5	3·1	5·3	8·0	10·9	12·0	7·8	0·0	0·0	49		
	Stocking	0	8	36	59	77	89	96	96	85	45	0	0	591		
45	Volume	0·0	0·2	3·8	16·6	43·0	85·2	142·3	208·4	268·2	277·7	50·8	0·0	1096	14·1	24·4
	Basal area	0·0	0·0	0·3	1·1	2·4	4·3	6·6	9·1	11·2	11·3	2·0	0·0	48		
	Stocking	0	4	25	44	59	71	79	82	79	64	10	0	517		

AREAS VISITED IN NORTHEASTERN TASMANIA (see Figure 3)

1 Birralee Eucalyptus Seed Orchard

This seed orchard was visited with Kieth Orme, the geneticist for Forest Resources. The orchard contains *E. nitens* on one side and *E. globulus* on the other.

Data for pulp yield has been collected for about 60 of the globulus trees using the extractive procedure. To run the extractive procedure, an increment core sample is taken from breast height, ground up, dried to 0% moisture content and then leached with water thereby removing the extractives; subsequently, the sample is dried again and then reweighed. The difference in weight before and after leaching is attributed to extractives. Interestingly, there is an inverse relation between the quantity of extractives and the pulp yield, so once this curve is calibrated (and apparently Kieth has this calibration) pulp yields of additional core samples can be rapidly determined. This sampling procedure has the added benefits of being relatively cheap (at 60 dollars per sample) and of being non-destructive.

I asked Kieth how reliable his technique is and he showed me some data which he intends to publish shortly which suggests that the method might be quite useful. He had used this extractives technique on samples from a large number of the same trees of *E. globulus* which had been destructively sampled and pulped to determine their kraft pulp yield (reported on by Dean *et al* (in press)).

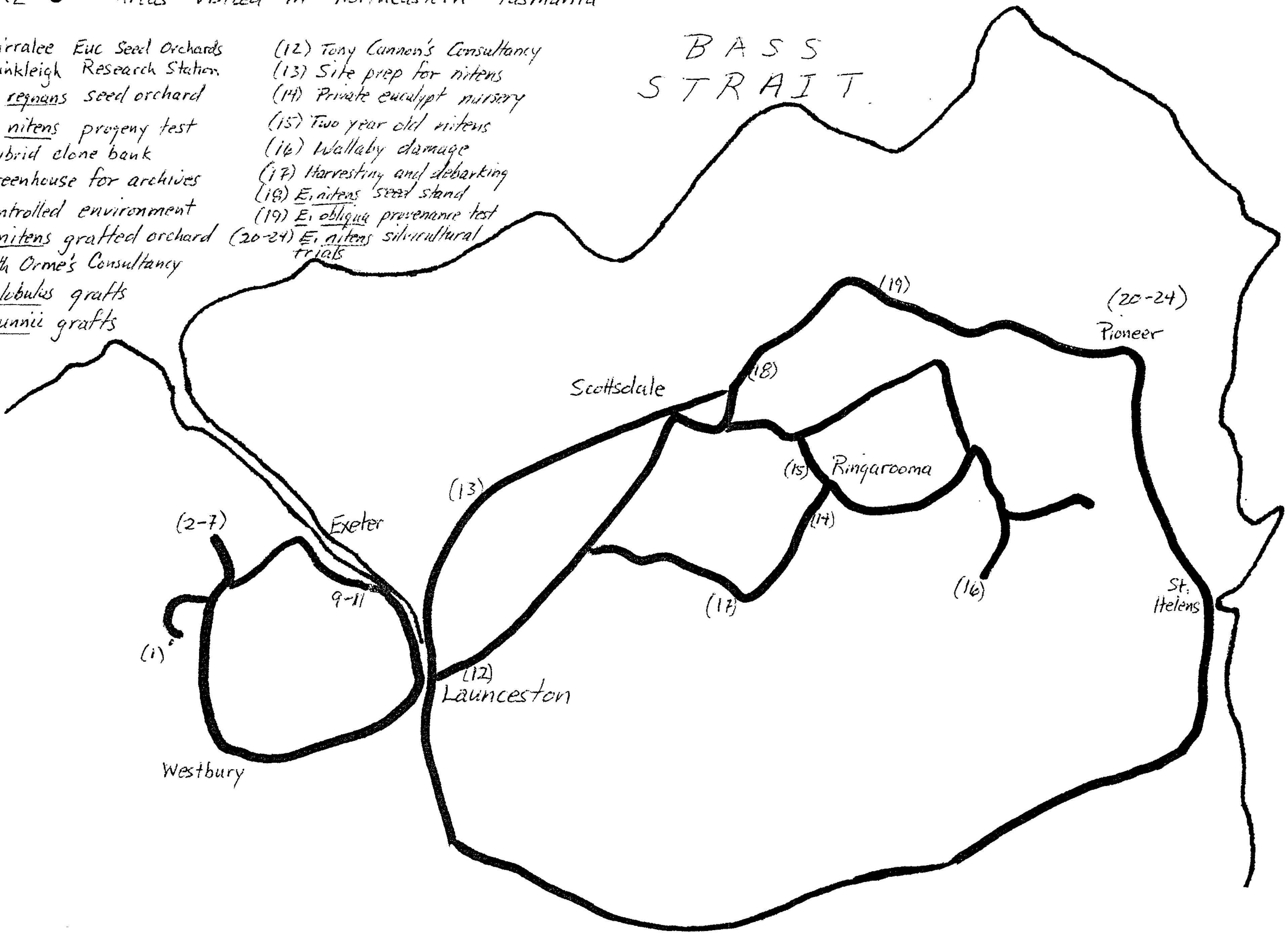
Besides *E. globulus*, Keith Orme has also used the extractives technique to estimate pulp yields for various families of *E. nitens*. The essence of his findings are that average pulp yields are about 52.5% for *E. nitens* and 54.5% for *E. globulus* with maximum pulp yields of individual trees tested to date being about 56% and 60%, respectively for these two species.

I am not sure that any of the New Zealand pulp and paper companies envision using the kraft process for pulping eucalypts; however, if there are one or two companies which might use this process, then the possibility of using the extractives technique to estimate pulp yields should be seriously considered.

Another interesting feature of the Birralee Seed Orchard was that paclobutrazol had been tried on several of the *E. globulus* trees and the flowering response was simply outstanding (at least 100 times that of untreated trees).

FIGURE 6 Areas Visited in Northeastern Tasmania

(1) Birralee Euc Seed Orchards
(2) Winkleigh Research Station
(3) *E. regnans* seed orchard
(4) *E. nitens* progeny test
(5) Hybrid clone bank
(6) Greenhouse for archives
(7) Controlled environment
(8) *E. nitens* grafted orchard
(9) Keith Orme's Consultancy
(10) *E. globulus* grafts
(11) *E. gunnii* grafts
(12) Tony Cannon's Consultancy
(13) Site prep for nitens
(14) Private eucalypt nursery
(15) Two year old nitens
(16) Wallaby damage
(17) Harvesting and debarking
(18) *E. nitens* seed stand
(19) *E. obliqua* provenance test
(20-24) *E. nitens* silvicultural trials



2 Winkleigh Research Station

This is the place where Forest Resources does its genetics and vegetative propagation research. The office facilities are quite new and comfortable and reasonably equipped. Almost all of the research done in these laboratories is centered on eucalyptus breeding and propagation. The reason that Forest Resources has been willing to invest heavily in this research is because it is installing a large chemi thermo mechanical pulpmill in nearby Georgetown. This is expected to require that about 8,000 ha of eucalypt plantations be cut annually. Obviously research to make these plantations yield more pulp per hectare could have important implications.

3 *E. regnans* seed orchard

Forest Resources has a small young *E. regnans* seedling seed orchard. Forest Resources themselves, however, do not expect to plant much *E. regnans*.

4 *E. nitens* progeny test

This test was a complete randomized block with each family being represented by approximately 6 trees in a row plot in each of 6 blocks. There might have been 50 families represented. The test is about 2 years old at present.

5 Hybrid clone bank

Forest Resources has the first *E. globulus* clones to have been produced in the Southern Hemisphere. These were propagated from cuttings and outplanted into small stands about five years ago near the Winkleigh Research Office. Nearby there are also four-year-old clones of perhaps 40 crosses between several species including gunnii x nitens, gunnii x globulus and gunnii x maidenii. About two thirds of these are represented by 2 trees apiece, the remainder are in small stands (4 trees by 4 trees or 6 trees by 6 trees).

6 Greenhouse for archives

Forest Resources has just completed the construction of one large (about 15m x 30m) greenhouse and a large controlled environment chamber (also about 15m x 30m). This is because the company is excited by the possibilities of cloning the eucalypt species it is working with and because they are pleased with the progress that has been achieved to date in about 10 smaller greenhouses. The work itself is being done mainly by a woman named Sandra Heatherington who unfortunately was not present when I was visiting. Kieth, who is Sandra's director, however, explained the procedure.

Seedlings, grafts or cuttings of genotypes that will eventually be mass propagated are held in sections of the big greenhouse or the smaller greenhouses designated as archives. Within each archive each individual plant has a one gallon plastic bucket to grow in. The planting media is loose (seemingly comprised of grain husks, perlite and sand and not unlike our peat and perlite combination) and each pot is watered by trickle irrigation.

Untouched, plants in each pot might grow to about 1.5m in height before the rooting volume of the pot limits their further growth, but this never happens because the main stem and branches are systematically pruned. When a new shoot has about 20 to 25cm in growth (about 0.5 cm diameter) it can be severed at its base, trimmed slightly (cutting off the top of the shoot so that there are only two sets of leaves on the cutting and cutting the remaining leaves in half to reduce transpiration) dipped in a rooting hormone (3ppm IBA in talc as I recall with a little Benlate added to discourage fungi) and then planted ("stuck") in a tray of the same rooting material as detailed above.

Many of the plants in the archives are grafts. This is probably because by grafting you can get all of the genes of a superior tree in plantation without having to cut the tree (which would have to be done to propagate by cuttings), and also because grafting has a higher probability of succeeding for most temperate eucalypts.

Two types of grafting techniques are commonly used, the cleft graft and the bottle graft. The bottle graft technique is actually a modified side graft as shown in Figure 7. Since the cleft graft is simpler, however, it is used wherever possible.

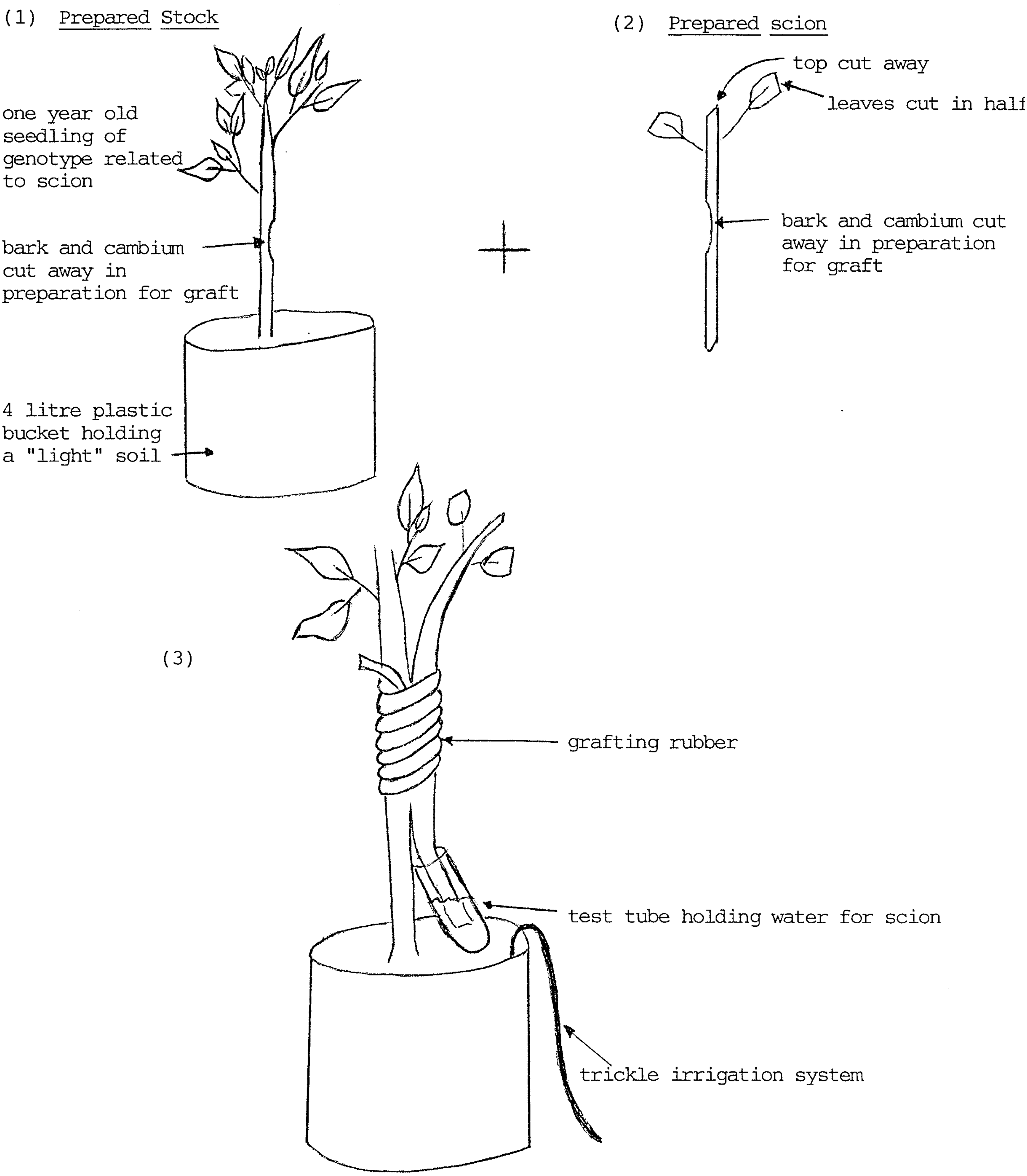
7 Controlled environment chamber

This building was spanking brand new at the time of my visit and still did not have all of the instrumentation fully in place. It will be very similar to the controlled environment chamber seen at APPM.

8 *E. nitens* grafted orchard

This *E. nitens* grafted seed orchard is about four-years-old at present. It is only about one-half hectare in size but includes ramets of many of those clones which Kieth has identified as giving superior pulp yields (using the extractives testing procedure). The orchard is well established.

FIGURE 7. The bottle graft technique sometimes used to help difficult grafts to form with eucalypts at the Forest Resources clonal archives in Winkleigh.



9 Kieth Orme's Consultancy

Over the past 20 to 30 years, Kieth Orme has been involved heavily with genetic improvement of the eucalypts and has performed several world-wide consultancies on *E. globulus* provenance testing and eucalypt breeding techniques. He has amassed a wealth of information and practical experience as a result and is now in a position to offer consulting services abroad as well as direct the Forest Resources genetics program from Winkleigh. To make sure there are no conflicts of interest, he has set up his consultancy base in his own home.

Undoubtedly one of Kieths major joys is the actual performing of the crosses. I was indeed lucky in that Kieth was willing to show me how this is done and to and let me try to do all of the steps involved.

The whole process begins when the eucalypt trees being worked with get close to flowering or more precisely to the stage of anthesis (i.e., when the operculum falls off). This stage is recognizable because the operculum shifts from a light green colour to a greenish yellow colour. At this stage the flowers can be harvested for pollen or they can be prepared for artificial cross-pollinization. Both of these techniques will be explained in turn.

To get pollen it is important to harvest the flowers just before the operculum opens to avoid possible contamination. Harvesting involves cutting about a dozen branches that have a heavy flower crop on them and trimming the stems so that these can be placed in a large water-containing beaker in order that the flowers will continue to receive water (the same concept as a floral bouquet). Each beaker should contain the flowering branches of only one tree and should be placed in a room which is free of wind and insects (especially flys). The flowers will continue to develop for a few days and then the operculums will begin to fall off. This is the perfect stage for pollen collection. With those flowers which have just opened, the stamens are cut off with scissors and then placed in an open petri dish. The dish is labeled as to its pollen source and then placed in a dessicator (silica gel) for several days.

When the pollen has almost no moisture in it (about 5%) it can be stored. To get the pollen separated from the stamens, dump the contents of the dish into a sugar shaker. The screw-on cap of the shaker should be modified with a fine mesh welded into it so that when the contents of the shaker are dumped out, only the pollen can make it through the mesh. The dried pollen is then stored in a hermetically sealed glass vial. Put this in the fridge if it will be used within the next year or in the freezer for longer term storage. Freeze drying can also be used for longer term storage.

To prepare flowers for artificial cross pollination, the first step is to emasculate each flower. This is done by cutting off the operculum and the underlying stamens. To make a quick clean job of it, the cut should be made just below (maybe 1.0mm) where the opeculum would normally fall off. For small flowered eucalypts (such as nitens and gunnii) a modified wire stripper can be used effectively. The modification here is to file the biting parts of the stripper so that they slice more easily and cleanly through the flower. The gap in the middle of the biting parts must be left large enough so that the stigma is unscathed.

For eucalypts with larger and tougher capsules, such as *E. globulus*, a scalpel curved towards the cutting side is an effective emasculating device. A cut needs to be made about three-fourths of the way around the capsule before the operculum will lift off.

All the flowers on a limb to be bagged must be emasculated. If there are some flowers which are already opened or some that are not yet ready for emasculation, then these should be removed (to prevent contamination). Kieth has found that if he prunes the branches with flowers about 10cm beyond the point where the flowers are attached, that these branches can then function as an internal structure which will keep the bag out and away from the flowers.

When the limb is fully prepared (i.e., all flowers emasculated and all branches suitably pruned) the bag (a french bag which is considerably more flexible than sausage casing and has a flat dimensions of 20 cm x 45 cm) is placed over the limb and is snugly secured with a bright plastic flagging on the proximal end. The date of the bagging is then written on the plastic flagging along with the number of flowers inside the bag.

About one week later, the flowers should be ready for pollination, maybe even a day or so earlier. When the flower is ready, the head of the stigma will become shiny and sticky with an exudation. The bag is removed and the pollen (which has been stored in vials) can be painted on the stima with one or two gentle swipes with a paint brush. When all of the flowers have been pollinated, the bag is replaced and the name of the male parent (i.e., the pollen source) is added to the flagging.

About two weeks after artificial pollinization, the stima are no longer receptive and the bags should be removed (but leaving the flagging on of course!) to promote healthy development of the flowers. At this time it will be possible to determine the percentage of successful crosses because the unsuccessful attempts will have aborted.

Obviously Kieth has a large amount of expertise on deciding which types of crosses would be best to make and for being able to make the crosses. In large measure his consultancy consists of offering these services to his clients. He is willing to travel, and prefers it when possible, but he could also make some custom made crosses for companies or institutes which only need seed with certain characteristics.

10 *E. globulus* grafts

In preparation for his consulting services Kieth has established a small orchard of *E. globulus*, the scion of which come from specially chosen individual trees. Some of the chosen individuals have been determined to have especially high kraft pulp yields, while others have been chosen for good rootability (a common problem with the cloning of globulus is that cuttings from many genotypes do not root well).

11 *E. gunnii* grafts

Of all of the eucalypts, the one that can handle the most cold and can still develop a reasonably shaped bole (for timber production) is *E. gunnii*. Reports have it that whereas *E. globulus* and *E. nitens* can handle minimal temperatures of -7°C and -12°C, respectively, *E. gunnii* can handle temperatures of down to -18°C even though it does not grow extremely fast. Obviously in many temperate parts of the world where cold is a limiting factor for the eucalypts, *E. gunnii* , or better still *E. gunnii x E. nitens* hybrids with intermediate cold tolerance and growth would be of considerable interest. A problem is that there are generally no seed orchards of *E. gunnii*, which can be used for supplying seed or for making the crosses. A major, if not the only, exception to this situation is in Kieth's front yard where he has about one-half hectare of eight-year-old *E. gunnii* grafts, some of which are already flowering. Obviously he intends to use this orchard to produce many *nitens* by *gunnii* crosses. In some aspects, Kieth is bound to do well, *nitens* crosses easily with *gunnii*, however some of the *gunnii* trees in Kieth's orchard appear to be having some health problems; insects are involved so maybe a proper insecticide will help remedy the situation.

12 Tony Cannon's Consultancy

In Launceston, from his house, Tony Cannon along with two partners operates what is essentially a eucalyptus consultancy firm for Northeastern Tasmania. Tony's job is mainly one of providing forestry expertise, helping landowners to purchase, valuate, sell or harvest native eucalypt forests and to raise eucalyptus plantations. Plantation work includes site preparation, planting, protecting, and management. His consultancy firm owns essentially all of the equipment which they need to carry out the above tasks and since many of these tasks involve heavy equipment, the financial layout to establish this tiny but complete consultancy must be somewhere between 0.5 and 1.0 million dollars.

Tony did not go into this consultancy blind, before he started he had had about 10 years of experience working for Forest Resources doing many of the same types of jobs that he gets called on to do today. Besides actually providing and supervising labour, a tremendous amount of Tony's work comes about as a result of clients who need to know how to best interpret the copious amount of forestry legislation, forest subsidy schemes and the varying market opportunities to their advantage. Tony, with his ears constantly on the rails, is able to provide this advice.

It is of interest to note that Tony and his partners really believe in what they are doing to the point that they borrowed substantially to establish a couple of plantations for themselves (about 300 ha in total). Ordinarily, I might expect that they would do quite well, the plantations they established (one two-year-old and one three-month-old) are growing extremely well with full stocking; never-the-less the chip market in Tasmania has been upside down for about a year (because the Japanese are wary of getting caught in deals where Australians might later be politically prohibited from honouring their part) and also the world (and especially Australia) seems to be moving into a deep recession. In a trip to the field, Tony showed me several of the forestry projects that he is involved with, these are recorded here in items 13-18.

13 Site preparation for nitens

Site preparation for this eucalypt species consists of harvesting merchantable eucalypts from the original native forest, root raking the residual slash into windrows, burning these windrows and then ripping all of the between-windrow sections of land (about 40 metres wide) at 3 metres between rips. The ripper has three teeth, the center one is deepest and can rip to a depth of 1.5m.

14 Private eucalypt nursery

Tony contracts out a private nursery to raise his eucalypt stock. Commitments have to be very firm and precise long in advance (probably 6 to 8 months), otherwise his firm could get stuck with several thousand to hundreds of thousands of seedlings which it will never be able to use. Top pruning is common; the stock looked excellent.

15 Two-year-old nitens

This plantation looked absolutely superb with over 90% stocking and most trees already over 5m in height. It looked to be about 50 ha in extent.

16 Wallaby damage

Wallabies are a bigger concern than possums in this part of Tasmania. They hide in the "islands" of native bush which are common in gullies between plantations and next to streams (which by law cannot be felled within a 50m distance from the streambed) and feed on the young eucalypts at night.

Control of wallabies is very similar to possum control; carrots drenched in 1080 poison is the most common measure.

Based on damage to young seedlings near one of the "islands" which we visited, Tony decided to establish a small poisoning program.

17 Harvesting and debarking

When harvesting in native forests, trees are pulled to a landing using a rubber-tired skidder. There a grapple deals with them, first by removing the bark by forcing the logs to spin and slide through the tongs of the grapple, then by sorting logs by classes and finally by loading the logs on the truck.

18 *E. nitens* seed stand

In one plantation where *E. nitens* had been planted, Tony noted that there was a relatively heavy seed set. He has collected seed from this for his own uses and still has about 7.0 kilos for sale. The original source of the seed is the Toorongo Plateau of West Gippsland, Victoria.

19 *E. obliqua* provenance trial

While in Tasmania, it was possible to make a second trip to the north eastern section. This time in conjunction with the Eucalyptus Management Coop. Items 19 through 24 reflect some observations made during this section of the trip; fuller documentation may be obtainable from the Eucalyptus Managemernt Coop.

The *E. obliqua* provenance trial has been established by the Forestry Commission about 12 years previously. The test, laid out in row plots in a randomized block design, showed that there was a remarkable variation in growth between provenances. Still, none of the provenances came close to matching the growth of *E. nitens*.

20 *E. nitens* seed orchard

To establish this Forest Resources seed orchard, 6 seedlings were planted adjacently for each of 20 selected parent trees. At age 2 this number was reduced to 2 trees per parent tree and at age 4 to one tree per parent tree. Additionally the trees representing the worst third of the parent trees were also culled.

The seed orchard, now 9 years old, has been producing seed for about 2 years and paclobutrazol has been applied to increased production. The spring injection technique has been employed to apply this chemical into the xylem using a concentration of 2,000 ppm of the active ingredient.

21 Thinning and pruning trials

Nine hectares of plantation were initially mechanically thinned removing every third row. Subsequently the remaining two rows were also thinned to achieve predetermined densities of 33%, 55% and 67% of original stocking. Some pruning trials have also been initiated to establish the cost of pruning and to determine its effect on tree growth.

22 Herbicide trial at Camden

During our visit, a number of herbicide trials were seen. In this particular trial, established on an ex forest site, glyphosate (Roundup) and Caragard applied at 1 and 2 kg a.i. per hectare and glyphosate and Atrazine applied at 1 and 3 kg a.i./ha were found to give the best weed control.

23 Site preparation for *E. nitens*

During our visit we also saw several site preparation demonstrations. The following description is a summary of practices which Forest Resources relied on to establish *E. nitens* on a site near Camden in N.E. Tasmania.

The area had been selectively logged in 1978. It was in a condition of scrubby growth by 1989 so in the summer of 89/90 it was cleared on the contour using root rakes to form windrows. Then the soil was ripped to a depth of 60cm by a TD20 bulldozer (about a D7 I would guess) which also pulled a set of giant stump jump discs (an important innovation for site preparation in logged over areas) to form mounds.

During the winter, the mounds were sprayed with Atrazine at 6 kg a.i./ha. This herbicide binds onto the clay and gives good weed control for 6-9 months.

Then, in August the site was planted with *E. nitens* potted planting stock which had been topped at 15cm to harden it against frost and wallaby grazing.

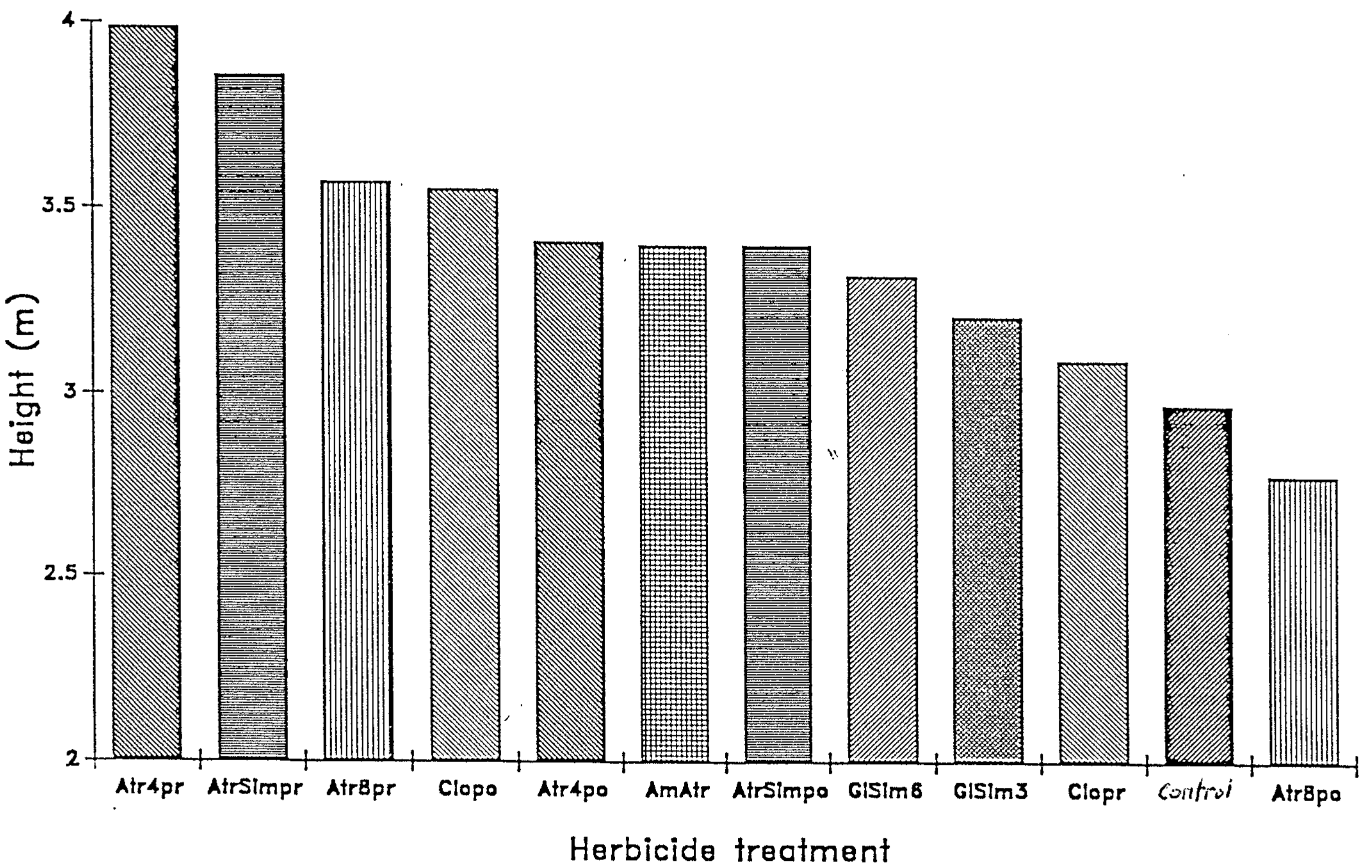
Each seedling was then fertilized with 200 grams of 4-7-0 fertilizer (Sulphate of Ammonia and Superphosphate) applied in a 15cm radius ring around the seedling. Seedlings will also receive another 400 gms per seedling in the following winter.

Possums and wallabies are controlled through the first winter using the 1080 poisoned carrots which is dyed blue (apparently birds cannot see blue as well as orange).

24 **Weed control experiment at Pioneer**

The last field stop made in Tasmania was at a complex but very telling herbicide experiment near Pioneer. There were 12 different treatments which had been applied and in many of these *Acacia melanoxylon* had been interspersed. The effect of the various herbicide applications is summarized in Figure 8 .

Figure 8 Height of Eucalypt seedlings 2 years after planting, following weed control with various herbicides.



THE CENTRAL PLATEAU AND WESTERN CONSERVATION AREAS (see Figure 9)

This section of the trip was done by the author while he was alone (i.e., Saturday evening, the ninth, and Sunday). In hand for this period were a copy of Woolhouse's Forest Trees of Tasmania (Woolhouse, 1984), and a good map of Tasmania. Over 800 km of Tasmania roads were covered with a good car. Additionally several short hikes were made on foot. The basic objective was to get a strong gut feeling for the conditions that eucalypts grow under in the colder high altitudes of the Central Plateau and in the wetter regions found in western Tasmania.

1 **Pencil pines**

Tasmania has at least six conifer species that are unique (I think) to Australasia. One of these is the Pencil pine *Athrotaxis cupressoides*. Stands of this pine are found when the top of the Central Plateau is nearly reached after climbing the escarpment by road out of Deloraine. The countryside and views are spectacular, the climate is harsh.

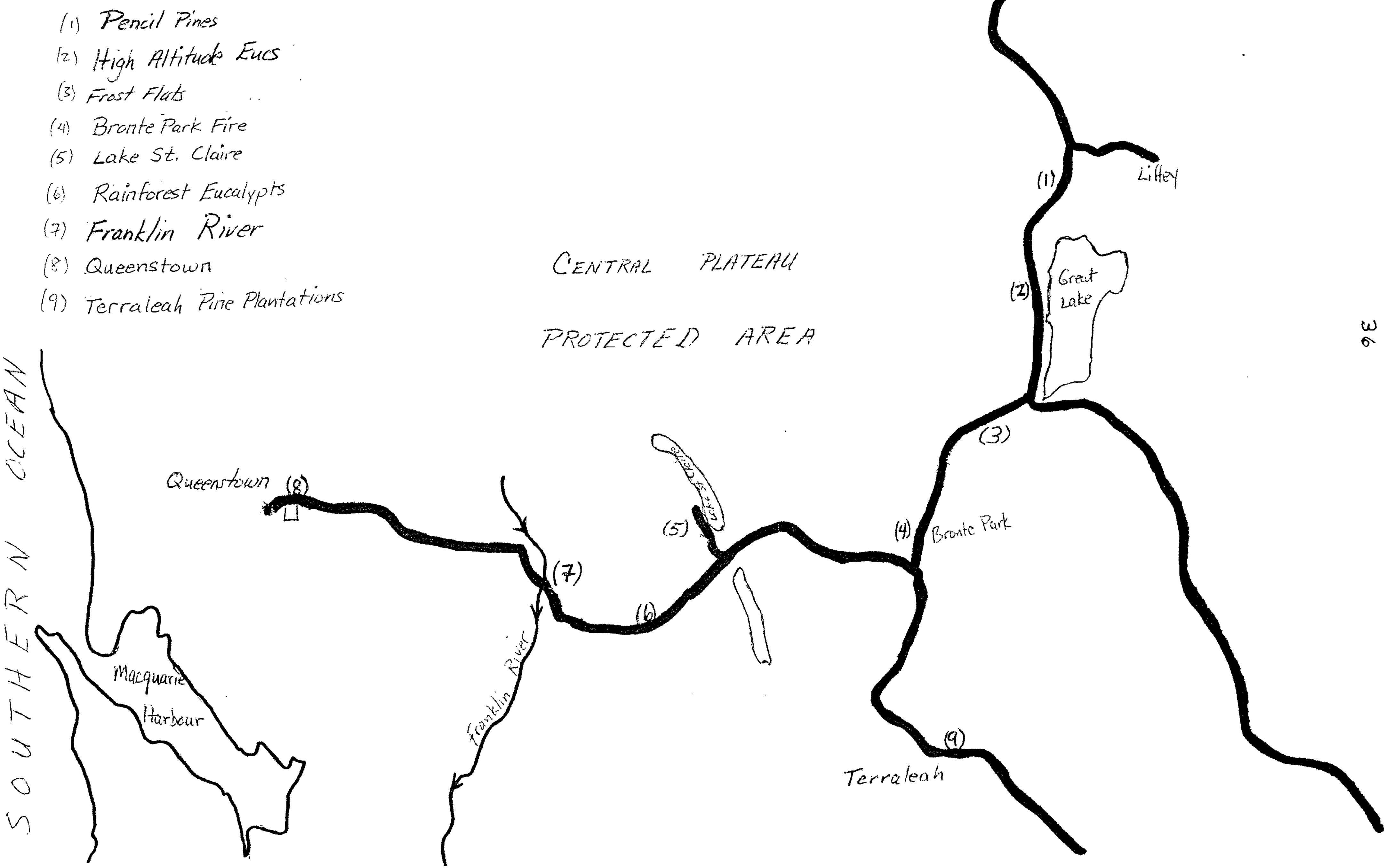
2 **High Altitude Eucs**

Through out much of the mid-elevations of the Central Plateau (700 to 1000 masl) there are about 8 species of eucalypt which can survive. However at about 1200 masl there seems to be a fairly well defined timberline with only occassional patches of trees going up 100 or 200 m higher in altitude. Eucalypt species which are common in the area mid-elevation include, *E. dalrympleana, E. gunnii, E. coccifera, E. pauciflora,* and *E. delegatenis*. Of these, *E. coccifera* can handle the most cold whereas *E. delegatensis* is capable of attaining the greatest size (trees of over 1.5m dbh and 50 metres of height are not uncommon). About 6" of snow fell as I travelled into this area and I will admit that this phenomena, occurring in mid-November (!), gave me a great respect for the hardiness of these eucalypts. It also gave the whole area a cold beauty of its own.

3 **Frost flats**

Much of the Central Plateau is fairly flat, apparently a result of being a massive block uplift; never-the-less, in the flattest areas and especially in areas which form slight basins it is common to find that there are no trees growing, whereas nearby, in areas with only one or two metres more elevation than these basins, various species of high altitude eucalypts can survive. The only obvious explanation for this phenomena is that these shallow basins are frost flats and that temperatures in them can be too harsh for any tree species to survive. A

FIGURE 9 Areas Visited in Central and Western Tasmania



very substantial part of the Central Plateau has these "frost flat" type conditions so that there are naturally patches of treeless areas from 0.1 ha to 1000 ha in size across the plateau.

4 Bronte Park fire

A few years ago there was a fire which raged across the Central Plateau in the area of Bronte Park. According to Tony Cannon, who, along with his crew, helped fight the fire, the event lasted about one week. All around Bronte Park, there is charred evidence of the fire, but much of this is already hidden now from casual observation, partly because the fire might rarely have been much more than a ground fire (fuels are rather scarce at this elevation) and partly because eucalyptus growth, from old trees and new, has rushed in to fill the void.

5 Lake Saint Claire

The Lake Saint Claire-Cradle Mountain National Park is one of the largest calling cards that Tasmania has for attracting tourists. The park has some beautiful and well kept paths, the most famous of which is the path that runs all the way from Lake St. Claire to Cradle Mtn., supposedly a seven day hike. All along the part of the path that I was able to hike (only about 2 hours worth due to timing) there was native eucalypt forest. The elevation is slightly lower here than much of the central plateau and many of the *E. delegatensis* had grown to an enormous size.

6 Rainforest eucalypts

Westerly winds bring most of the rain to Tasmania, so it is natural that on the western slopes of this island there is more rain. So much rain, in fact that it limits the number of eucalypt species which can grow in this area, only 2 of the 28 species native to Tasmania, *Eucalyptus brookerana* and *Eucalyptus nitida*, are common throughout (according to Woolhouse, 1984). (*E. subcranulata* can also be found occassionally at higher elevations). Excessive soil moisture may be one of the most limiting factors since most eucalypt species do not like wet feet and even these two species are found only where soil drainage, because of topographic position or soil texture, is better than average for the area (Woolhouse, 1984). Other factors which might play a hand in limiting the existance of many eucalypt species in the area are restricted sunlight (there is rainfall or drizzle 225 to 250 days of the year in much of this area), or climatic conditions which are too favourable to leaf defoliating fungi or insects. The real reason for such a paucity of eucalypt species is unknown as far as I could tell but by finding out the reasons, perhaps some clues could be had as to why eucalypts often fail elsewhere in the world when planted in drizzly climates.

7 Franklin River

The Franklin River is one of the major rivers draining the Central Plateau and the western slopes of Tasmania. A path leads through the woods along the river. Walking along this path showed that the major component by far of this forest is beech (Northofagus *cunninghamii*), but there are also plenty of celery topped pine (*Phyllocladus aspleniifolius*) and silver wattle (*Acacia dealbata*) which seem to grow quite quickly. Also to be found are a few eucalypts sprinkled throughout. Presumably most of these are *E. brookerana* or *E. nitida* since these are obviously mist forests.

8 Queenstown

Queenstown is a mining town to the hilt and reflects the boom-bust cycle of a one resource economy. At present activity is moderately slow; still it is possible to see that the entire mountain of nearby Mt. Lyell is seemingly being leveled to get at the iron and copper ores which it contains. As far as the eye can see the 15km stretch along the main highway from before Gormantown to Queenstown is almost devoid of tree or other plant life. Is this because all around only tailings cover the ground and these are too acid for plant life (as is commonly the case following strip mining elsewhere)? Is it because the topsoil has been scraped off or buried? Or is it because there are air borne contaminants as a result of some processing which is done locally? I am sorry I did not have time to find out because the extensive moonscape topography around Queenstown is intriguing.

9 Tarraleah pine plantations

Australian Newsprint Mills (ANM) has been pulping old growth eucalypts for about 50 years to make pulp for newspaper. However, before newspaper can be fully manufactured it needs some long fibre mixed in. Historically this long fiber came from imported pine pulps. However, about 10 to 15 years ago ANM apparently decided to try to produce some, if not all, of its pine pulp. To do this, they have established extensive *Pinus radiata* plantations, many of which are located on either side of Highway A10 near Tarraleah. These plantations appear to be growing extremely well and are largely unaffected by *Dothistroma pini* although there are a few trees that show light but tell tale symptoms of the disease it causes.

SOUTHEASTERN TASMANIA (see Figure 10)

The first part of the tour through southeastern Tasmania (Stops 1 through 6) was arranged independently, the second part (Steps 7 through 13) was arranged by the Eucalyptus Management Coop.

1 Conversation on *E. regnans* dieback

Dr Frank Podger is one of several forest pathologists who has spent considerable time studying diseases of eucalypts in Australia and is famous (at least amongst pathologists) world-wide for the work he has done with *Phytophthora*-caused diseases. In more recent years he has been assigned to CSIRO in Hobart and has become familiar with many of the studies that have been conducted in Tasmania to get at the causes of dieback problems in *Eucalyptus regnans*. According to Bill Nielson 125 scientist years have already been spent studying the eucalypt dieback problems in Tasmania. Since NZFP is having some problems with a dieback in *E. regnans* as well, it seemed that it might be opportune to discuss what is happening at NZFP with Frank and see if he could shed some light on the problem.

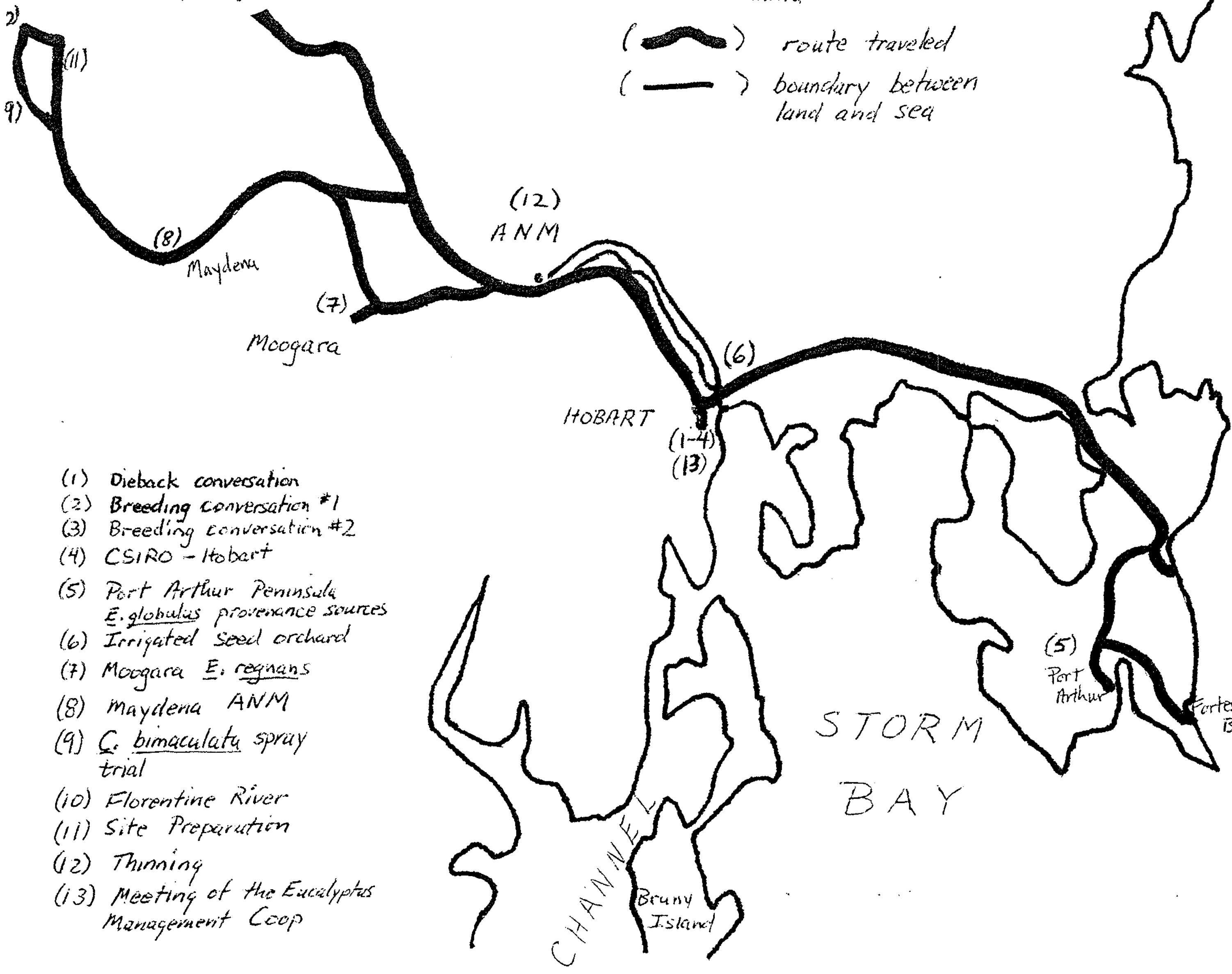
We met at the bar at the Prince of Wales, also present were Peter Carter, Rick Hand and Carolyn Raymond. The conversation began when I showed Frank some microscope photos and some scanning electronic micrographs of the problem. Frank had already seen the problem in plantations at NZFP but had not been privy to these photographs. On examining these, and on reconsidering the problem, he felt that the following sources of information might prove insightful:

1 Barry Tomlinson from Harvard's Petersham Forests has done some studies on xylem physiology which shows that there are constrictions at branches.

2 Henry Nix at the Australian National University has done a considerable amount of work with the bioclimatic data of the different eucalypt species. We could purchase the BIOCLIME data for the species we want or alternatively arrange some kind of trade by sending them climatic data for our eucalypt species.

3 Trevor Booth of CSIRO Canberra has had a considerable amount of experience interpreting BIOCLIME data for eucalypt species.

FIGURE 10 Areas Visited in Southeastern Tasmania



(1) Dieback conversation
(2) Breeding conversation #1
(3) Breeding conversation #2
(4) CSIRO - Hobart
(5) Port Arthur Peninsula *E. globulus* provenance sources
(6) Irrigated seed orchard
(7) Moogara *E. regnans*
(8) Maydena ANM
(9) *C. bimaculata* spray trial
(10) Florentine River
(11) Site Preparation
(12) Thinning
(13) Meeting of the Eucalyptus Management Coop

4 John Patzinra has done some experiments on the rooting habits of eucalypts; one thing he has found using split plant experiments is that if some of the roots are growing in dry soil, then the whole tree behaves as if it is affected by drought (could this happen in pumice derived soils?).

5 The galls that form on the leaf may be a subclinal expression of the Warrington Symptom (Warrington, 1980). After talking with Frank about this, Rick Hand took me to the CSIRO greenhouses where dozens of the seedlings which he is raising for a seed orchard had developed the symptom. The Warrington Symptom consists of raised galls that in size and shape resemble the galls at NZFP, however, the Warrington Symptom galls are pale and nearly translucent whereas the NZFP galls are tinted a dark brownish-orange. The Warrington-Symptom galls can be induced in a range of eucalypt species when these grow continuously in atmospheres where the relative humidity exceeds 65%.

6 Carr and Carr is another source of information on eucalypt stomate physiology.

2 Breeding Conversation No. 1

This conversation with Carolyn Raymond and Rick Hand was held over dinner with the purpose of getting to know each other and learn a little about the research work each of us is involved with.

3 Breeding Conversation No. 2

This was set up to be a continuation of the first conversation, however Mike Carson was also present and this was most helpful. Through Mike's queries it became apparent that the current mandate of the CSIRO breeding program is largely basic research, determining heritabilities for a number of characteristics, conducting phenological studies and doing some experimental breeding. However, the mandate for the CSIRO breeding group does not extend to applied breeding; this task is largely left to the research staffs of the pulp and paper companies.

Although we were only observers for awhile, it seemed that whereas this division of research responsibilities might lead to a reduction in competition between the various forest genetics groups in Tasmania, it would also lead to a lack of synergism. As was shown in Table 1, there are 12 people doing forest genetics work in Tasmania spread out between six different organizations; from the signals that we picked up communication linkages between many (but not all) of these organisations were weak.

One of the big pluses of this conversation with Carolyn and Rick is that we re-established a mutual willingness to collaborate whenever possible. Actually the first linkages in this good relationship were established by Tony Shelbourne in his visit to Tasmania one year previously.

4 CSIRO

The CSIRO is established in one of the mansions of the classy part of the old Hobart port town. The building is comfortable and might house about 15 to 20 scientists.

5 Port Arthur peninsula *E. globulus* provenance sources

One of the immediate advantages of our relationship with the CSIRO geneticists was that Rick Hand spontaneously volunteered to show me some of the provenance collection and phenological work that he is doing on the Port Arthur peninsula. This was a fascinating trip for the author because 10 years ago he had been involved with the establishment of two provenance tests of *E. globulus* and other temperate eucalypt species in the Andes of Colombia (2400 masl); it was fascinating to see the areas where some of these collections had been made (actually Kieth Orme, then with the Forestry Commission, had organized the seed for these provenance tests). It was also fascinating to see the type of trees that have been collected from for this type of tests; because of difficulties with climbing tall trees and because tightly grown trees in a stand seldom have significant flower production, most of the trees collected from were open-grown and had heavy crowns. The theory is that seedlings from these trees will have better form when grown in a compact stand.

In terms of the phenological study, Rick and several other collaborators around Australia simply fill in some blanks on an index card indicating the species they found flowering (i.e., when the operculum falls off), when and where it was flowering and the amount of flowering they found at the time of the visit. This card is then mailed to Canberra and CSIRO puts it into its flowering data bank which can be easily accessed and which will eventually be analyzed and published.

6 Irrigated Eucalyptus Seed Orchard

To facilitate a number of experimental breeding techniques and crosses, CSIRO, under the direction of Rick Hand, has set up a 2 hectare flowering and seed production area a few kilometres north of Hobart (at Cambridge). At the time of our visit the irrigation system was just about ready for a test run; apparently irrigation at some point in the development of flowers is essential for good seed production, however the exact timing and amount of water to apply is not yet well defined.

7 Moogara

Moogara is the area from which the most frost tolerant *E. regnans* provenances are found. It has a slightly higher elevation than much of the surrounding area and perhaps because of this the fluctuations in temperature are more gradual than some other areas of Tasmania (maybe because collection of cold air from higher elevations cannot occur). It also has moderately rich soils derived from basalt and dolerite and a well distributed rainfall pattern.

Peter Volker showed us a few of the trees which had been selected (many of them by Rick Hand) for the current *E. regnans* progeny test. As mentioned earlier, in the first stage of the CSIRO *E. regnans* genetics improvement program it was decided that Moogara had the most frost-tolerant provenances whereas Strzeleki had the fastest growing provenances; for this reason, all progeny for the second stage of testing were to come from selected trees of Moogara or Strzeleki. Here, at Moogara, trees generally had reasonably good form but they tended to be open grown (again because of the difficulty of collecting seed in closed stands). A total of 300 seedlots were collected by ANM; another 250 were collected jointly by APM and CSIRO.

Then Peter showed us the 205-family *E. regnans* progeny test (single tree plot design) which is right on top of the Moogara Plateau. The test, now one-year-old, appeared to be well laid out (20 replications) with excellent survival and reasonable growth; presumably progeny come from the same parents as the parents represented in APPM's trial at Massy Greene.

8 Maydena

This is the office for forest operations of ANM (Australian Newsprint Mills) in the Florentine and Styx Valleys. It is also the point where sawlogs are cut and offcuts are then sent onto the pulpmill for chipping. It seems to have been a highball outfit (i.e., capable of doing forestry activities very fast) but there have been recent laws passed which now bar ANM from cutting trees for sawtimber. This cramps their style a bit and also is forcing them to rush ahead with their plantation operations to ensure a wood resource for the future.

9 *C. bimaculata* spray trial and regeneration by seed tree and aerial seeding

Chrysophtharta bimaculata is known as the number one enemy of *E. regnans* in this area. To better determine the impact of this defoliating insect and how to control it, some tests with insecticides have been established. The two insecticides being extensively investigated are a synthetic pyrethroid and a strain of *Bacillis thurengiensis*.

In one of these tests, trees in untreated control plots grew only 50% as much in height as trees in plots where insecticide treatment gave best control and the effect of a single defoliation is expected to essentially stop growth for 2 years.

The implications of these data are astonishing, if ANM seriously wants to grow *Eucalyptus regnans* in plantations in the Florentine Valley, it may have to spray routinely for *C. bimaculata*.

Also observed and discussed at this site were two other reforestation techniques which have been tried in the past, one of which is still common today.

The seed tree method, now outmoded, involved leaving a couple of huge trees per hectare at the time of harvest to provide seed for the next generation. From the thick regrowth that I observed, it seems that this technique definitely works from a biological point of view, but there may have been some economic conditions which mitigated against its continuance (some of the seed trees are amongst the largest trees in the world and might have 30 to 50 m^3 of wood in them . . . . a lot of wood to leave standing).

With the improvement of aviation and better ground control, it became possible to aerially seed cutover areas. The technique here was to collect seed by the barrelfull from eucalypts local to the area which was to be reseeded. Then, when the area had been cutover and burned, it was seeded aerially. This technique is relatively cheap, is still the most common reforestation technique in Tasmania, and is commonly used on cutover lands controlled by the Forestry Commission. The big advantage of this system is that it generally leads to the establishment of a new forest and thus takes a lot of the political heat off of clearcutting the natural forest. The problem with it is that it seldom leads to highly productive forests; stocking can be highly irregular and there is no provision for genetic improvement, fertilization or weed control. It is estimated that forests established by this technique (and presumably by the seed tree method) average only $2m^3$/ha/yr. These growth rates are unacceptable by private companies so they usually rely on planting and managing seedlings in plantations and strive to obtain 15 to 20 m^3/ha/yr.

10 **Florentine River**

The Florentine River is wide (maybe 25m) if not too deep, and drains a huge gentle shaped valley about 50 km long and 20 km wide. It is still a pleasant place, but it is astounding to realize that this whole valley, which was once an enormous old growth eucalypt forest, is now almost entirely cutover. What is even more astounding is that there is not more apparent wealth in Tasmania as a result of having exploited this resource as well as other rich eucalypt forests on the island. Furthermore, even the Forestry Commission in Tasmania is operating in the red. How can this happen? How can a people take charge of a God-given resource and go broke by exploiting it? I am sure this is not the first time such a gift has slipped through the fingers of man but to see the path that this situation is leading to (i.e., a degradation of Tasmania's forests) the only logical conclusion I could reach was that Tasmanians have a population problem which is forcing them to degrade their habitat in order to keep alive today. This is very much the same situation that many of the third world countries find themselves in (espeically in the rainforest regions of Africa, Asia and South America) and I felt sad for Tasmania. Fortunately, as will he emphasised later in this report, Australia is conducting some research to improve this situation.

11 Site Preparation

Two types of sites are being prepared for plantations by ANM in the Florentine Valley; sites that have only recently been harvested for their merchantible old growth, and sites which were harvested years ago but which were not satisfactorily restocked by aerial seeding.

In both cases, site preparation consists mainly of windrowing using root rakes on D-7s and a large modified back hoe which can also be used for raking. The windrows seem to be about 60m apart and following their formation and some drying are burned. Still, even after burning, these windrows serve as homes for the odd wombat. The land between the windrows is always ripped; fertilization and weed control are other common practices in ANM's young eucalypt plantations.

12 Thinning

Following aerial sowing, regrowth can come up like hair on a dog's back. To enable some stems to develop into large exploitable logs at a reasonably young age, therefore, it is necessary to reduce intertree competition.

One of the ways of doing this is to send in mechanical harvesters (if the land is not too steep) which can directionally fell trees which are marked for removal and then drag them off of the plot (presumably they can be used for pulp).

We saw one 20 year-old stand where this had been done a few years earlier and the results were remarkable. In an adjacent, unthinned control plot there may have been 800 eucalypt stems per hectare plus a lot of limbs and trashy undergrowth. The net result seemed to be that very little light penetrated the canopy and that this control plot was stagnating.

On the thinned plot, by contrast, there were only about 250 stems per hectare with all of the smaller stems which had previously occupied the site having been removed. These 250 trees already included most of the stems which would eventually have been merchantable without a thinning, plus these trees now had ample room to grow as a result of the thinning, so they can be expected to reach merchantable dimensions decades earlier.

There are two reservations as to the practicality of this system. One is expense; it is probable that forest establishment through plantations would have given better initial stocking and growth rates and therefore a more rapid attainment of the eventual goal (to have 250 merchantable saw log trees/ha). The other reservation hinges on the damage to the residual trees during the thinning operation. Even with directional felling, it was observed that a large number (about 15%) of the residual trees had had sections of their bark smashed away where a neighbouring tree had fallen against them in the thinning operation. Studies are now being run by CSIRO and the Young Eucalypt Program to see if there is serious ingress of butt rotting pathogens under these circumstances. Kino deposits can also occur in response to bruising.

13 Meeting of the Eucalyptus Management Cooperative

Besides numerous field trips, there were four sessions to the meeting of the Eucalyptus Management Cooperative : (1) the business session; (2) the presentation of the Eucalyptus Management Cooperative to Tasmanian Foresters; (3) the continuation of the business session; and (4) The "quo vadis" session. I sat in on sessions 1, 2 and 4 and will report only briefly on these (it is assumed that the Eucalypt Management Coop will provide a much more thorough report on all of these sessions).

1 In the business meeting, progress was reported by Ian Nicholas, Errol Hay and Heather McKenzie on the growth, regimes and nelder trials for *E. saligna*, the regimes and nelder trials for *E. nitens* and the growth and regimes trials for *E. regnans*. From the reports and from the general consensus of the group, it would appear that some of these studies are now approaching a natural and generally satisfactory conclusion, but that several other studies have mushroomed into existance to the point where there are now too many permanent sample plots to measure and analyze for the crew available.

Peter Carter then presented a practical interpretation of the nitens nelder studies showing how the results of these studies could influence his company's (NZFP) decisions as to how to manage this species in terms of stand density.

A well elaborated complaint was then lodged by Paul Smale who said that his group (Paul works for NZFP but also collaborates heavily with Shell in the NZFP-Shell joint venture in Northlands) might not be interested in continuing with the Eucalyptus Management Coop if the only information that they could expect was that which would be generated by Permanent Sample Plot data. What he and his group need, according to him, is more information on the best silvicultural options to use when growing the eucalypts in his part of New Zealand.

There was no argument from the group that more information on best silvicultural options was not badly needed, not only for the north part of the North Island, but for all of New Zealand. However, as Heather McKenzie succintly put it, there is not yet a mandate for the Euc. Management Coop to do these studies and there is not enough staff or funds to see them through even if such a mandate did exist.

Persuing his role well as chairman of the cooperative, Peter Carter then stepped in to still this incipient squabble and suggested that all members of the cooperative give the issue some thought during the week and that the matter be settled at the weeks end during the "quo vadis" session.

2 Ian Nicholas gave an extremely lucid slide presentation to a large group (I estimate about 70) of Tasmanian foresters. His talk covered the objectives and progress to date in three programs:

(a) Special Purposes Timbers program;
(b) The Eucalyptus Management Cooperative; and
(c) The Australian Blackwood Program.

The talk was very well received.

3 During the "Quo vadis" session, it was deicded to amplify the scope of the research activities of the Eucalyptus Management Cooperative to include research on site suitability and the determination of appropriate establishment techniques. Also the possibility merging this cooperative with the Eucalyptus Breeding Cooperative was raised by Peter Carter. There is no doubt that this possibility is real, but Peter suggested that the matter be considered and discussed within companies between cooperative members and between cooperatives with the objective of setting up concrete proposals by the next meeting (March, 1991).

14 The Young Eucalypt Program

Following Ian Nicholas' presentation to the Tasmanian Foresters, Chris Palzer gave a summary of what the Young Eucalypt Program had accomplished during its five years of existance (which is very nearly completed).

About 5,000,000 dollars were alloted by the Australian government for research activities in the Young Eucalypt Program (YEP). Most of the research was done by CSIRO scientists, however the board of directors, which decided which topics would be studied, was heavily weighted with representatives from forest industries.

The research undertaken mainly encompasses two topics: (1) how to thin naturally seeded or aerially seeded forests so that a larger number of larger logs are produced more quickly and (2) how to improve the value of the eucalypt wood produced through better processing and marketing.

The thinning research was dominated by the persuit of "the ultimate thinning machine", a mechanical harvester which could enter into regenerated stands with pole size trees and release final crop trees without damaging the bark on residual trees. Many, many models were tried; the one that has tentatively be classified as the "best" is featured in Figure 11.

Damage to bark of residual trees remains one of the biggest problems; research shows that following bruising, wood discoloration and decay extend longitudinally at a rate of 20cm per annum and volumetrically at a rate of 1,800 to 2,000 cm^3 per annum for up to 15 years. At this point, the compartmental barriers to the spread of decay begin to break down permitting fungal ingress into previously protected zones of wood (Anon, 1989).

Although there are some risks involved, there is no doubt that thinning of plantations established by seeding can increase their productivity tremendously (refer to Figure 12) and throughout Australia there are an estimated 300,000 hectares of young regrowth forest which are suitable for thinning (Anon, 1989), so the usefulness of these studies could be quite high (depending upon the market).

In terms of improving processing techniques and improving the marketing of eucalypt products there is no doubt in this authors mind that information leading to improvements in these fields is absolutely essential if Tasmania is to break away from being treated as an exploitable third world country in terms of its forest resources (see discussion under item 8 of this section). A list of 33 publications produced by YEP, most of which deal with some aspects of these topics, is reproduced in Appendix II.

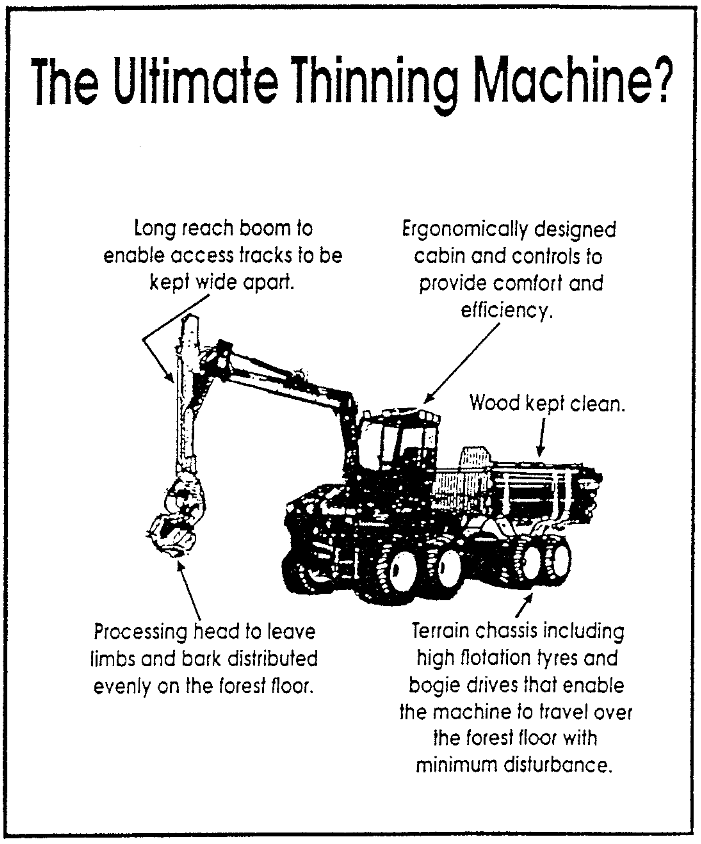


FIGURE 11. An illustration showing some of the ideas being incorporated into an effort to design the ultimate thinning machine. (From the Young Eucalypt Program (Anon, no date)).

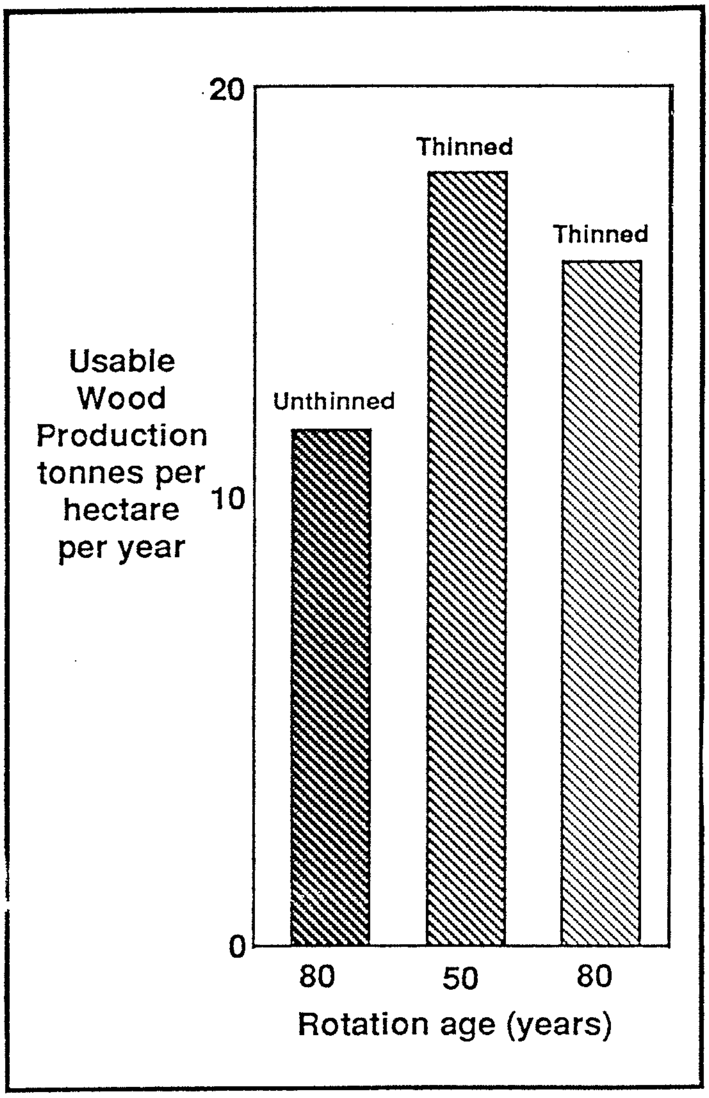


FIGURE 12. Graph showing boosts in wood production which can be expected from thinning eucalypt stands regenerated from aerial seeding (From the Young Eucalypt Program (Anon, no date)).

REFERENCES

Note: A copy of any of these references is available on request from the Eucalypt Breeding Cooperative GTI-FRI, Rotorua.

ANON. No date. The young eucalypt program. CSIRO Canberra 4p.

ANON. 1989. The young eucalypt program: Annual report 1988-89. CSIRO, Canberra.

DEAN, G.H. J. French and W.N. Tibbits (in press). Variation in pulp and papermaking characteristics in a field trial of *Eucalyptus globulus*. Appita Preprint.

de LITTLE, D.W., ELLIOTT, H.J., MADDEN, J.L. and BASHFORD, B. 1990. Stage-specific mortality in two field populations of immature *Chrysophtharta bimaculata* (Olivier) (Coleoptera: Chrysomelidae). J. Aust. Ent. Soc. 29: 51-55.

RAYMOND, C.A., HARWOOD, C.E. and OWEN, J.V. 1986. A conductivity method for screening populations of eucalypts for frost damage and frost tolerance. Aust. J. Bot. 34, 377-93.

TIBBITS, W.N., and REID, J.B. 1987. Frost resistance in *Eucalyptus nitens* (Deane and Maiden) Maiden: genetic and seasonal aspects of variation. Aust. For. Res. 17, 29-47.

WOOLHOUSE, R.D. 1984. Forest trees of Tasmania. Forest Resources, Long Reach, Tasmania 96p.

WARRINGTON, I.J. 1980. Humidity-induced gall formation on *Eucalyptus* species. Aust. For. Res. 10: 185-9.

APPENDIX I

ADDRESSES OF TASMANIAN EUCALYPT BREEDERS

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APPENDIX II
PUBLICATIONS FROM THE YOUNG EUCALYPT PROGRAM

REPORTS, PAPERS AND PUBLICATIONS

Beardsell, M., McCormack, R., and Roberts, E. (1987). Thinning Systems Report No. 4. Thinning and debarking using the Lako grapple harvester.

Clark, N.B., Hands, K.D., and Phillips, F.H. (1985). Pulpwood Values Report No. 5. Unbleached kraft of *Eucalyptus regnans* aged 40 years and over.

Clark, N.B., Logan, A.F. and Phillips, F.H. (1986). Pulpwood Values Report No. 6. Bleaching of kraft pulps of *Eucalyptus regnans* aged 40 years and over from southern Tasmania.

Clark, N.B., Logan, A.F., and Phillips, F.H. (1986). Pulpwood Values Report No. 7. Kraft pulping of *Eucalyptus obliqua* aged 40 years and over.

Clark, N.B., Logan, A.F. and Phillips F.H. (1987). Puplwood Values Report No. 8. Kraft pulping of *Eucalyptus regnans* less than 10 and up to 40 years of age.

Clark, N.B., Hands, K.D., and Phillips, F.H. (1987). Pulpwood Values Report No. 9. Kraft pulping of *Eucalyptus obliqua* less than 10 and up to 40 years of age.

Clark, N.B. (1987). Pulpwood Values Report No. 10. The values of different age classes of ash-type eucalypts as pulpwood.

Clark, N.B. (1988). Pulpwood Values Report No. 11. Kraft pulping of *Eucalyptus regnans* aged from 10-19 years to 50-59 years.

Clark, N.B. (1988). Kraft pulping properties of thinned and unthinned 19-year-old *Eucalyptus delegatensis* from Victoria. CSIRO Aust. Div. For. and For. Prod. Div. Rep. No. 036.

Clark, N.B., Logan, A.F., Phillips F.H. and Hands, K.D. (1989). The effect of age on pulpwood quality. Part 1. The Kraft pulp properties of southern Tasmania *Eucalyptus regnans* and *Eucalyptus obliqua*.

Clark, N.B. (1989). Plywood quality and value. Paper presented to the 43rd Appita Annual General Conference, Brisbane. Topic A5.

Clark, N.B. (1989). The effect of age on pulpwood quality. Part 7. Kraft pulping properties of *Eucalyptus delegatensis* aged from 10-19 years to 50-59 years from Victoria. CSIRO Aust. Div. For. and For. Prod. Div. Rep. No. 054.

Clark, N.B. (1989). The effect of age on pulpwood quality. Part 8. Kraft pulping properties of *Eucalyptus sieberi* aged from 10-19 years to 50-59 years from Victoria. CSIRO Aust. Div. For. and For. Prod. Div. Rep. No. 081.

Fagg, P., and Roberts, E. (1987). Thinning Systems Report No. 3. Non-commercial thinning using herbicide injection.

Kerruish, C.M. (1987). Towards better management of eucalypt regrowth. *Aust. Forest Grower* 10(3).

Kerruish, C.M. (1988). The Young Eucalypt Program. Paper presented to and published in the proceedings of the AFDI Bicentenary Forestry Conference, Albury. Vol. 2.

McCormack, R., and Roberts, E. (1986). Thinning Systems Report No. 1 OSA Feller-Forwarder.

Roberts, E., and McCormack, R. (1986). Thinning Systmes Report No. 2 Non-commercial thinning using clearing saws.

West, P.W. (1987). A model for biomass growth of individual trees in a forest monoculture. *Ann. Bot.* 60:571-577.

West, P.W., Beadle, C.L. and Turnbull, C.R.A. (1989). Mechanistically based, allometric models to predict tree diameter and height in even aged monoculture of *Eucalyptus regnans* F. Muell. *Can. J. For. Res.* 19, 270-3.

Wingate-Hill, R. and MacArthur, I.J. (1987). Economics of debarking and chipping small-diameter regrowth eucalypt thinnings. *Aust. For.* 50(3) 157-165.

Wingate-Hill, R., MacArthur, I.J. and Cunningham, R.B. (1987). The performance of a Valon Kone VK 16E mobile ring debarker with *Eucalyptus regnans* F. Muell. CSIRO Division of Forest Research, User Series No. 10.

Wingate-Hill, R., MacArthur, I.J. and Gabriel, W.C.L. (1988). Development of roller compression debarking mechanisms for small-diameter eucalypts. CSIRO Division of Forestry and Forest Products. User Series No. 1.

Wingate-Hill, R., MacArthur, I.J. and Cunningham, R.B. (1988). The Indexator weighing system. CSIRO Division of Forestry & Forest Products, User Series No. 15.

Wingate-Hill, R. and MacArthur, I.J. (1989). Performance of a Valon Kone 800 ring debarker with stringy-barked eucalypt logs. CSIRO Division of Forestry and Forest Products, User Series No. 6.

Wingate-Hill, R. and MacArthur, I.J. (1989). Moisture loss and end cracking during transport of logs from eucalypt regrowth thinnings. CSIRO Division of Forestry and Forest Products. User Series No. 8.

Wingate-Hill, R., MacArthur, I.J., Payne, R.A. and Roberts, E. (1989). Performance of fixed grapples on excavator-loaders in debarking rough-barked, small-diameter eucalypt logs. CSIRO Division of Forestry and Forest Products. User Series No. 5.

Wingate-Hill, R., Cunningham, R.B. and MacArthur, I.J. (1989). The relationship between bark/wood bond strength and other properties in logs of *Eucalyptus regnans* F. Muell during air drying. Appita 42(2): 115-119.

Wingate-Hill, R., MacArthur, I.J. and Payne R.A. (1989). Performance of a modified Logma processor in debarking small-diameter *Eucalyptus sieberi* logs. CSIRO Division of Forestry and Forest Products. User Series No. 4.

REPORTS AND PAPERS IN PREPARATION

Roberts, E. (1989). Early spacing of young, even-aged eucalypt regrowth using herbicides. YEP Report.

Roberts, E. (1989) A feller-forwarder based shortwood thinning system in young, regrowth eucalypts. YEP Report.

Roberts, E., Talsma, T. and Kerruish, C.M. (1989). The impact of a feller-forwarder thinning system on some physical properties of the soil. YEP Report.

Wingate-Hill, R., Cunningham, R.B. and MacArthur, I.J. (1989). Properties of small diameter *E. regnans* F. Muell logs related to debarking and changes during drying.