TREE DECLINE AND REVEGETATION

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Department of Conservation and Land Management

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PREFACE

This Volume of the Tree Decline and Revegetation Newsletter combines the "Research into Rural Tree Decline Newsletter" and the "Annual Revegetation Newsletter".

When Jill Landsberg asked for someone to take over the editing of the Tree Decline Newsletter, Elaine Davison volunteered. This meant that all three persons worked out of the same Department, and, since the contributions overlapped in many respects, it seemed sensible to combine the publications. Perhaps readers would like to give us their views on this? The combined mailing list includes 150 persons, and we hope that readers will find the Newsletter useful for contacting others working in related fields.

ACKNOWLEDGEMENTS

We are grateful to the Department of Conservation and Land Management in Perth for its financial support of this volume, and to several persons who have provided invaluable assistance, Glenda Godfrey for the typing, layout and organising the mailing list and Louise Burch for the cover design and arranging printing.

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EDITORIAL

Decline and regeneration

Trying to determine why an endemic population of native plants has declined and died is an important prerequisite in attempts to re-establish woody species in a specific area. In Australia, agricultural clearing has left a relic tree population persisting on sites affected by local and regional changes.

Tree diebacks are usually complex with no simple cause and effect relationships. Manion (1981) suggests that there are three or more factors involved in such declines. Predisposing factors are those which weaken a plant growing in the wrong location; such factors may be all too obvious when trying to establish exotic trees, but when sites are changing slowly due to altered land-use, their effects may be subtle and not readily recognised. Manion defines inciting factors as those short-term physical or biological factors which cause sudden damage. Severe frost, insect defoliation or drought can cause drastic injury from which an already debilitated tree has difficulty recovering. Contributing factors, such as canker fungi, root-rot fungi or bark beetles, are regarded as indicators of a weakened host rather than primary causes of tree decline. Are these concepts helpful in the Australian context when trying to elucidate the physical and biological causes of decline and death?

In recent years there have been many attempts to re-establish trees and shrubs in order to reverse environmental degradation. Fencing remnant woodlots in order to reduce grazing and encourage regeneration is one of the most effective ways of preserving what is left. In 1987-88 Horsham (Vic.) directed most of its Land Protective Incentive Scheme money for fencing projects (p 36) and recently the W.A. Government has provided fencing grants for relic native vegetation. Replanting and reseeding schemes have been enthusiastically adopted by many communities and a number of items in this newsletter detail their achievements. There are encouraging signs of community willingness to tackle the problems caused by past land management. Trees are survivors, but they need the conditions to grow vigorously, not just survive.

Reference

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1. RESIDUAL VEGETATION

Condition of roadside vegetation in relation to nutrient status

R.J. Hobbs & P.G. Cale — CSIRO, Division of Wildlife & Ecology, LMB 4., PO Midland, WA 6065

Project commenced September 1988: will finish February 1989.

It is funded by the W.A. Roadside Conservation Committee.

Aim
To examine the importance of soil nutrient status in determining the condition of roadside vegetation, especially in relation to weed invasion and insect herbivory.

Background
Roadside vegetation is open to many forms of degradation. Two of the potentially major problems are invasion by non-native herbaceous species and tree dieback, possibly related to insect attack. Recent studies have indicated that elevated soil nutrient status can allow rapid establishment of non-native annuals, especially when associated with soil disturbance (Hobbs & Atkins, Aust. J. Ecol. 13, 1988). Similarly, studies in eastern Australia have shown that increased nutrient availability may be responsible for high levels of insect attack on remnant woodlands (Landsberg, Morse & Khanna, this issue). Soil nutrient status may thus play a key role in determining the condition of roadside vegetation, and gradual nutrient build-up (e.g. through fertiliser drift) may be detrimental. Rehabilitation efforts may also be wasted if the primary cause of degredation is elevated soil nutrients and this is not treated first. The study therefore aims to establish whether there is any relationship between soil nutrient status and vegetation condition in a selection of vegetation types. This will, at the same time, provide more general information on roadside vegetation in the study area.

Methods
The study is being conducted within the CSIRO study site at Kellerberrin in the central wheatbelt. Two types of roadside vegetation were sampled:

1. Mallee community dominated by *Eucalyptus erythronema*
2. Woodland and shrubland containing *Santalum acuminatum*.

39 *E. erythronema* sites and 30 *S. acuminatum* sites were sampled. We attempted to obtain the complete range of vegetation condition available in the area, in terms of both degree of insect damage and weed invasion. In each of these, sampling was carried out to determine:

a. Soil nutrient status
b. Leaf nutrient content
c. Damage to leaves due to herbivory
d. Degree of weed invasion

It was originally planned also to sample the insect fauna at each site, but it was found that insect densities were exceptionally low (this is presumably a function of the weather conditions this year, since other researchers have also reported exceptionally low insect abundancies). Ten of the mallee sites were therefore picked for more intensive insect sampling and further foliar sampling.

Results from this study will be made available later this year as a CALM Technical Report.

2. INSECT RELATED TREE DECLINE

Tree dieback and insect dynamics in remnants of native woodlands on farms.

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Abstract of a paper in press: Proc. Ecol. Soc. Aust. Vol. 16 "Australian Ecosystems: 200 Years of Utilization, Degradation and Reconstruction".

In many of Australia's temperate regions, eucalypt woodland now occurs only as a remnant stands on pastoral lands, and many of these remnants are being seriously degraded by rural dieback. From measurements made in contrasting matched stands of trees having understories dominated either by pasture (heavy use by livestock) or by native shrubs and grasses (light use by livestock), we concluded the following:

(1) Defoliation by insects, dieback and tree death were all more severe in the pasture stands.
(2) Despite site stress such as soil acidity, tree branches that were protected from herbivory produced prolific regrowth foliage.
(3) Insect abundance was not directly related to numbers of trees, since tree numbers were similar in both types of stands but insects were much more abundant in the pasture stands.
(4) Floristic and avian diversity were much reduced in pasture stands, but levels of predation of insects were similarly high in both types of stands during our study.
(5) Insects feeding on trees with an understorey of pasture grew bigger and more quickly, probably because values of nitrogen in soils and foliage were higher in the pasture stands.

The most likely cause of this nutrient enrichment was redistribution of nutrients by livestock. Thus nutrient enrichment may be a key factor contributing to the abundance of defoliating insects, and hence to rural dieback, in remnants of woodland used by livestock.

Dieback of rural eucalypts: tree phenology and damage caused by leaf-feeding insects

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Aust. J. Ecol. (1988) 13, 251-267

During three growing seasons, phenology and damage on leafy shoots of healthy eucalypts and others with dieback were monitored on pastoral properties in the Australian Capital Territory. Leaves from the dieback trees tended to be younger than those from nearby healthy trees. Leaves that were not lost prematurely lived for similar lengths of time on both dieback and healthy trees, but more leaves were initiated on the dieback trees. Dieback trees were also less active reproductively. During the study, chewing insects caused most of the damage on leaves, and there was usually more of this damage on leaves from the dieback trees. Young leaves accumulated damage at a much faster rate than older leaves, and this probably contributed to the relatively greater damage on the leaves from the dieback trees. However, the differences in the amount of damage on the leaves from healthy and dieback trees were not solely due to the differences in ages of the leaves. Generalized linear models which equalized the effects of the differences in leafing phenology produced adjusted estimates for damage to leaves that were still higher for dieback trees.

A comparison of methods for assessing defoliation tested on eucalypt trees

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Abstract of a paper in press in Australian Journal of Ecology

Little is known of the extent to which differences in methodology contribute to differences in reported levels of tree defoliation. In this study several common methods of assessing defoliation were compared, on *Eucalyptus blakelyi* trees growing in a stand known to sustain a range of defoliation levels. Assessments were made of whole trees and of individual leaves collected at discrete intervals and of tagged samples of leaves that were monitored over a year. Despite fortnightly monitoring intervals, I was not able to identify with certainty any specific cause of loss of whole leaves other than senescence. Annual defoliation assessed on discrete samples of leaves was higher than annual defoliation assessed on monitored samples, presumably because the age of leaves in the discrete samples was sometimes underestimated. Leaf-level defoliation assessed from visual estimates was consistently higher than digitizer measurements of leaf areas, but calibration of estimates resulted in similar values. Values derived for tree-level defoliation from leaf-level measurements differed widely, depending on the method of calculation. For the samples collected from trees in this study, mean % defoliation per leaf was not an adequate descriptor of defoliation for the samples, since the frequency distributions of defoliation per leaf were markedly non-normal. This problem was avoided by using the samples, rather than the individual leaves, as the basic unit of expression of defoliation, with the total % defoliation per sample being calculated from the ratio of total area of damage to total potential area, summed for all the leaves in the sample. For expanding leaves, the percentage of area damaged was not equivalent to the percentage of area missing from the expanded leaves, because of differences in the relative rates of growth of holes and leaves.

Eucalypt dieback research in the New England Tablelands, NSW

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Our research on defoliation of eucalypts in relation to dieback (funded by ARGS, 1983-1986), is in its final phases. The following list summarizes items of interest to other researchers:

1 The last 100 copies of the book **Dieback-Death of an Australian Landscape** have been purchased from the publishers in Sydney, Australia to be retained and sold to people interested in the topic. Copies are available until depleted from the Zoology department, UNE Armidale 2351 for $19.95. An extensive bibliography (current to 1986) was completed, but at the last minute the book editors deleted it from the book due to space constraints. We would be happy to distribute this to anyone upon request for the cost of the photocopying, $1.00.

2 Two manuscripts are in preparation, that summarize our extensive data on defoliation of healthy and dieback eucalypts in the New England tablelands. They include: Spatial and Temporal Variability in Defoliation of Australian Eucalypts and its Consequences to the Dieback Syndrome; and Phenology and Leaf Growth Dynamics of Eucalypts, with Reference to the Dieback Syndrome.

3 Five years of litterfall data collection in healthy and dieback eucalypt woodlands has just been completed by one of us (ML) and analyses are under way.

4 One final field experiment is still ongoing (and could take 30 years to complete!). This involves the experimental defoliation of peppermint (*Eucalyptus nova-anglica*) saplings repeatedly after every re-flushing until tree mortality has occurred. Since I do not know how many defoliations will result in mortality, this experiment is being conducted on my property (ML) where continuous observations are easy to make.

5 The results of an analysis of ENTIRE tree canopy defoliation (between a dieback and a healthy peppermint, *E. nova-anglica*) have been completed and submitted for publication. This project was funded by an Earthwatch grant (to ML) and required many, many pairs of hands and hours involved in clipping! The data was assessed with Cliff Ohmart and W. Thompson (CSIRO, Forest Research).

Species trials, Harden/Boorowa N.S.W.

John A. Beckhouse, Advisory Forester, Forestry Commission of N.S.W., Queanbeyan

These trials were established in 1986, in possibly the worst Eucalypt dieback area of the Southern Tablelands, to demonstrate:

(i) comparative growth and survival of a range of tree and shrub species and
(ii) relative susceptibility to insect attack.

Five plots were located on properties with road frontages in the Harden/Boorawa area. Each plot included ten plants of each of thirty species, ranging from the commonly grown (such as *Eucalyptus globulus* and *Melaleuca armillaris*) to the less well-known (such as *E. macarthurii* and *E. botryoides*).

Overall, growth has been very good and their roadside locations have given a high level of visibility. While there were a few surprises, most species performed as expected in the conditions.

The best performing species have been:

Acacia mearnsii
Eucalyptus macarthurii
E. aggregata
E. globulus globulus
E. globulus bicostata
E. botryoides
E. camaldulensis
Casuarina cunninghamiana

There was little insect attack of significance in the first year of growth, but was noticeable on four eucalypts and *Atriplex nummularia*. In the second year, insect attack was severe and widespread, and almost continuous. It was interesting to note the differences between the five plots, and more so the one species planting, where of ten plants, one might be totally defoliated, another (not adjacent) partially defoliated and the other eight almost untouched.

The insects commonly observed attacking some of the species and the level of attack are shown in the accompanying tables.

It is interesting to note that, at the times of observation, defoliating beetles were not seen. Autumn gum moth was clearly the most serious pest.

The combined effect of this defoliation and frost killed many of the *E. globulus* group.

Of the group, *E. globulus globulus* was generally less affected by insects, but *E. globulus bicostata* was better able to handle the extreme conditions.

These insects only attacked the juvenile leaves. There was no indication of any attack on the intermediates.

Similarly, of the *E. camaldulensis* group, *E. camaldulensis subcinerea* grew better and was less attacked by insects.

Table 1: Degree of insect attack on eucalypt trial species.

Species	Degree of insect attack (no. of plants) Nil	Slight	Moderate	Severe	Total no. of surviving plants
E. acaciiformis	35	5	0	0	40
E. aggregata	30	3	0	0	33
E. blaxlandii	33	1	1	0	35
E. botryoides	31	2	1	2	36
E. camaldulensis	34	10	0	0	44
E. camald. obtusa	26	8	5	9	48
E. camald. subcinerea	39	8	0	0	47
E. cinerea	3	10	9	25	47
E. cladocalyx nana	18	0	0	0	18
E. gardneri	16	0	1	2	19
E. globulus bicostatea	0	2	10	30	42
E. globulus compacta	5	4	14	12	35
E. globulus globulus	4	3	11	12	30
E. leucoxylon macrocarpa	37	8	4	6	42
E. macarthurii	31	8	4	6	49
E. melliodora	48	1	0	0	49
E. scoparia	41	5	1	0	47
E. sideroxylon	42	7	0	0	49

Table 2: Insects observed on eucalypt trial species

Species	Insects Observed (prevalence) Autumn gum moth.	Sawfly	Gall wasp	Cup moth	Euc. scale.	Bag moth	Leaf hoppers
E. aggregata	*						
E. blaxlandii						*	
E. botryoides			*				
E. camaldulensis		*	*	*		*	
E. camald, obtusa	**	**			*		
E. camald, subcinerea	*	**					*
E. cinerea	***						
E. gardneri	**				*		
E. globulus bicostata	***						
E. globulus compacta	***						
E. globulus globulus	***						
E. leucoxylon macrocarpa		*					
E. macarthurii	*				*		
E. melliodora					*		
E. sideroxylon		*			*		

(Note: * **occasional** to *** **frequent**)

Jarrah leafminer

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1. Documentation of crown decline and wood decrement due to leafminer outbreaks in the Manjimup region has been completed.
2. Transfer from CSIRO to CALM of information available on the ecology of leafminer was effected at a one day workshop held in April 1988. Manipulation of local parasitoid populations does not appear to be a useful option.
3. The efficacy of an autumn fire in reducing leafminer outbreaks will be addressed experimentally in 1989. Pre-burning data on population density and crown condition were collected this spring.
4. The occurrence of parasitized mines was mapped north to Jarrahdale. There has been a considerable contraction in the above, possibly related to the first wet winter in many years in south-western Australia.
5. A pilot remote sensing study with CSIRO, using a Geoscan Scanner, is underway.
6. CALM has formed a Task Force on economically important insect species of Jarrah forest. Its objectives are to:

    a) co-ordinate and evaluate research into the causes of insect problems in the jarrah forest, the development of appropriate methods of control, and the impact of pest insects on conservation values, wood production and water quality.

    b) Make recommendations to CALM's Policy Directorate on relevant high-priority matters that are not being adequately researched.

Gum leaf skeletonizer, *Uraba lugens* Walk. (Lepidoptera:Nolidae) in Western Australia.

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Outbreaks of *Uraba lugens* Walk. have long been known to occur in the eastern states of Australia and South Australia mainly on *Eucalyptus camaldulensis* (Bridlecombe 1962, Campbell 1962, Cobbinah 1978, Harris 1974). Until recently *U. lugens* has not been considered a serious defoliator of eucalypts in Western Australia; although from Department of Agriculture records, an outbreak was recorded in 1947 at Yericoin. However, during 1982-83 extensive defoliation of *E. marginata* (jarrah) by *U. lugens* was observed in the southern jarrah forests of Western Australia (Abbott 1987). Since that time the area of affected forest has trebled (Table 1). The most severe areas of defoliation extending from Nannup and Greenbushes in the north to Walpole in the south.

Table 1

Area of southern jarrah forest heavily defoliated by *U. lugens*

Year	**Area** (hectares)
1983	90 000
1984	230 000
1985	300 000
1986	240 000

[After Abbott 1987, Strelein 1988]

A number of inconsistencies exist in the comparison of eastern states populations to populations of *U. lugens* in Western Australia. Most of the eastern and South Australian outbreaks involve bivoltine populations. In the southern jarrah forest of Western Australia however, *U. lugens* is univoltine, ovipositing in March and pupating in late January early February (Abbott 1987, Strelein 1988). Harris (1974) reported an isolated univoltine population of *U. lugens* in the highlands of Victoria, however no other reports are known of similar populations.

The distribution of this insect in Western Australia extends from Geraldton in the north to Esperance in the east. Discovery of egg rafts on *E. occidentalis* in late November, 90km west of Esperance (Farr and Frost 1988, personal observations) suggest the possibility of bivoltine populations at these distribution extremes. The Australian National Insect Collection has specimens of *U. lugens* adults collected in these areas during November (I. Abbott, pers comm 1988). Such evidence supports the claims of Morgan and Cobbinah (1977) that the biotypes described by Campbell (1962) are the response of the insect to different climatic regimes.

Another variation of the Western Australian population to that of the eastern states populations is its outbreak host. Studies by Cobbinah (1978) revealed *E. marginata* to be a poor host for *U. lugens*, very few larvae surviving past the fourth stadium. Therefore outbreaks of this insect on *E. marginata* may be a response to a change in the plant's physiology due to environmental influences (Farr 1985) or the possibility of a further biotype of *U. lugens.*

Behavioural differences have also been observed for the Western Australian population. Unlike eastern states populations, *U. lugens* oviposits and feeds in the upper-canopy and crown and is thought to pupate in the bark and on the upper part of the trunk. Eastern states *U. lugens* oviposits and feeds on the lower branches of its hosts and pupates in the soil (Cobbinah 1978. However, this behavioural difference may be due to the nature of its Western Australian forest host *E. marginata.* The bark of *E. marginata* is rough and longitudinally fissured, whereas that of *E. camaldulensis* is smooth. Also most of *E. marginata* foliage is in the upper part of the canopy, due to its forest habitat.

Prior to 1988 few parasitoids had been recorded for *U. lugens* in Western Australia. However, recent sampling of jarrah canopies in the southern forests and *E. occidentalis* in remnant stands of vegetation in the Western Australian wheatbelt have revealed three species which were reared from *U. lugens* in the laboratory.

Euplectrus sp. an ectoparasite, family Eulophidae (Manjimup, October 1988).

Casinaria sp. an Ichnumonid also found parasitising *Mnesampela privata* (Fitzgerald, July and November 1988).

Apanteles sp a Braconid, a number of species of this genus being recorded in South Australia (Manjimup, August 1988).

All of the above species have also been found in South Australia (G. Allen, Waite Agric. Res. Inst., pers. comm. 1988).

Research is currently being conducted on the Western Australian population of *U. lugens* in order to clarify the differences in its biology, extent and dynamics of the outbreak and possible causes of the outbreak. The ultimate aim of this study is to achieve population control using either forestry management or augmented biological control.

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A Spondyalaspid Infesting *Eucalyptus occidentalis* in the Western Australian wheatbelt

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MlEucalyptus occidentalis, commonly known as flat-topped yate, is found throughout the Western Australian southern wheatbelt in remnant stands of vegetation on farming properties and uncleared land. Farmers in the region recognise the important role of this eucalypt in reducing water table levels thus contributing to the control of salinity. A decline in health of these trees, characterised by a scorched appearance of the crown was first officially noted between Gnowangerup and Ongerup in June 1982. Since then the decline in vigour of *E. occidentalis* has spread so that by 1983 the entire range of this eucalypt was affected.

The cause of this tree decline was attributed to an outbreak of a Spondyalaspid, tentatively identified as *Cardiaspina brunnea* (Froggatt). According to Taylor (1962) there is no description of this species by Froggatt although a detailed illustration was made of the lerp case. *C. brunnea* was originally thought to be confined to N.S.W. on *E. paniculata* and *E. rubida,* although there is some doubt as to the identity of the hosts (Taylor, pers comm 1987). The outbreaking Spondyalaspid in Western Australia has been observed on *E. occidentalis, E. wandoo, E. platypus* var *heterophylla, E. sargentii, E. gomphocephala* (planted) and *E. rudis.*

Since these species are not closely related to the N.S.W. hosts there is some doubt as to the identification of the Western Australian insect. As yet only a few specimens of the late instar nymphs have been collected in Western Australia and there are no known adult specimens.

Damage due to this insect on *E. occidentalis* is most apparent from March to July when leaf browning occurs. Investigation of the affected area during July 1988 revealed extensive epicormic growth on trees known previously to be severely attacked. However population levels of the Spondyalaspid had subsided from the high numbers observed during 1982 to 1986. Knowledge of other species of *Cardiaspina* particularly *C. albitextura* (Morgan 1984) and *C. densitexta* (White 1969), where these species are cyclic outbreakers, suggest that further outbreaks of *C. brunnea* (?) are likely to occur. Investigations are therefore being made into the biology and population dynamics of this insect together with clarification of its identity. Eggs have been collected in July and November 1988 indicating at least two generations a year if not more. A trapping programme has been established with the co-operation of local farmers and national park rangers. This, together with leaf tagging techniques is hoped to shed some light on the biology of an insect that until now has been exceedingly elusive.

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3. SALINE AREAS

Modelling dryland salinity hazard in the Murray Darling Basin

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This is a part of a major study of dryland salinity distribution and afforestation opportunities being undertaken by researchers from the Divisions of Wildlife and Ecology and Water Resources supported by substantial funding from the National Afforestation Program over the next three years.

An increase in the extent of dryland salinity is one of the now generally recognised implications of past clearing. Depending upon circumstances, it may take 40-100 years for the effect of clearing to be expressed as an increase in dryland salinity. With such a long delay period between clearing and the expression of the dryland salinity implications and the fact that substantial clearing (46% has been cleared in the last 200 years) has been undertaken in the Murray Darling Basin in the last 100 years, dryland salinity can be expected to increase. Determination of the dryland salinity hazard will provide an indication of the extent and severity of this increase, the development of which has already been set in motion.

The background to the approach taken has been to use the relationship established by Greig and Devonshire (1981) which related stream salinity (S ppm) levels to the proportion of the catchment area underlayed with sedimentary rock (R %) and covered with forest tree cover (i.e. >30 projected foliage cover, T %) and annual precipitation (P mm/an).

viz. log S= 2.8824+ 0.0045R- 0.0092T- 0.0008P

A similar exercise has been undertaken for Victoria (see Research into Rural Tree Decline vol 4 p46). Although developed at the level of individual catchment the relationship has been applied in a disaggragated form to each of the 6467 one-eighth degree grid cells (each of approx 140 sq km) which make up the Murray Darling Basin.The assumptions made in applying the Greig and Devonshire relationship to the Murray Darling Basin for the purpose of modelling dryland salinity hazard include:

a. the stream salinity at any point along a stream is the combined effect of the component parts of the upstream catchment. For this study the one-eighth degree grid cells are defined to be ìthe component parts.
b. during periods of base stream flow, the stream salinity levels reflect the goundwater salinity levels of the upstream catchment.
c. the salinity levels of the groundwater reflect the dryland salinity hazard.
d. for the dryland salinity hazard to be expressed, the saline groundwater must rise close enough to the landscape surface to have a detrimental effect upon the current vegetation.

This analysis will be used to identify target sites for the second part of this research directed at ascertaining afforestation requirements and opportunities.

Clonal trees for saline areas throughout Australia

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Since 1986 the Department of Botany at the University of Western Australia has been screening Australian native shrub and tree species for salt and waterlogging tolerance. The research is part of a multidisciplinary project including UWA, Murdoch University, CSIRO Division of Forestry and Forest Products, Alcoa of Australia Ltd, Plantex Australia Pty Ltd and funded by the Department of Industry, Technology and Commerce under the Biotechnology Research Grants Scheme (see Bell *et al.* 1988). The main screening program has been completed and some of the results will be reported here.

Altogether eight screening trials were conducted with a total of 101 species, 323 provenances and 16,736 seedlings included in the experiments. The number of seedlings selected for micropropogation was 140 seedlings, all from the most severe stress of salt waterlogging conditions. This number represents approximately 7% selection pressure. The most tolerant species (Table 1) were able to tolerate saline waterlogged conditions up to a salinity of sea water concentrations or above for short periods or in the case of some *Casuarina* and *Melaleuca* species for long periods of time. Tolerant seedlings were able to cope with these high salinities under freely drained conditions extremely well in the glasshouse.

Many species have been micropropagated and initial field trials of salt tolerant clonal material were established in 1988. A more extensive range of species and sites is planned for 1989 and 1990 field trials. Correspondence with people throughout Australia who are interested in incorporating salt tolerant clones in field trials is welcomed.

Salt tolerant clones are available for most soil types and all climatic types within Australia. The greatest number of species are suitable for temperate, arid and semi-arid climatic types (Fig. 1). All salt tolerant clonal plants have been propagated from seedlings with known superior tolerance. Therefore, planting clones in saline soil will produce uniformly high success rates compared to seedlings which tend to have erratic and variable performance. The benefits of planting trees in saline areas are listed in Table 2. The 22 most tolerant species from the salt screening program encompass the complete range of rural benefits (Vercoe & McDonald 1987). The tree technology project of Alcoa of Australia Ltd is marketing the salt tolerant clones and would welcome any enquiries by contacting Mr. David Kabay on (09) 364 0241 or at the above address.

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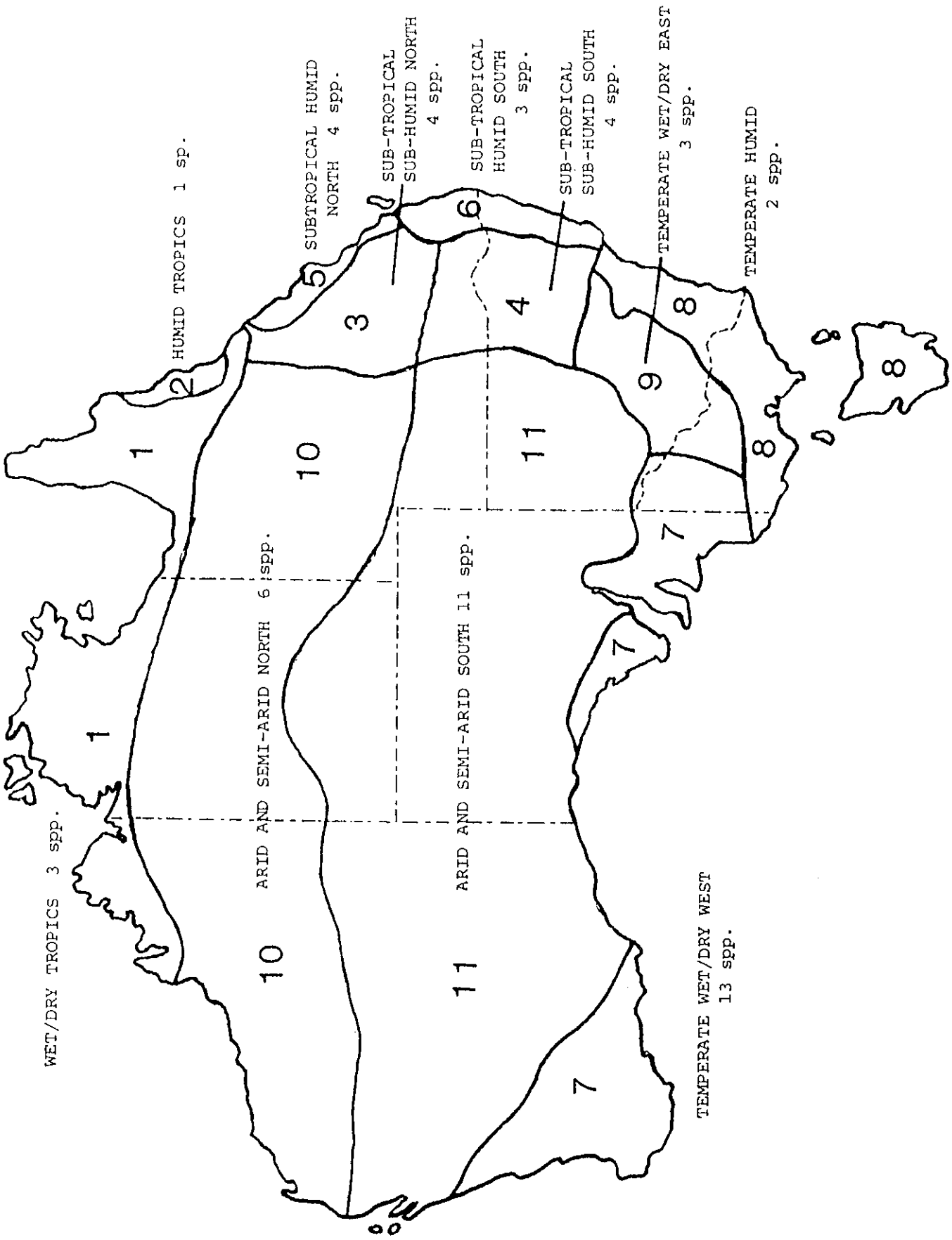

Figure 1, Distribution of the 22 most salt-waterlogging tolerant species within Australian climatic regions.

Table 1: The 22 most tolerant species for saline waterlogged conditions screened in the glasshouse. Codes for climatic zone and utilisation are given in Fig 1 and Table 2, respectively.

	Form	Climatic zone	Soil type	Frost Tolerance	Utilisation
Acacia acuminata	small tree	7	sandy loam	low	1,3,5,7,8
coriacea	small tree	10,11	sand	low	3,5,6,7,8,9
cyclops	large shrub	7	clay	nil	5,7,8
stenophylla	small tree	3,4,6,7,9,10,11	clay	low	3,5,6,7,8,9
Casuarina glauca	medium tree	5,6,8	sand to clay	low	1,3,4,5,7,8
obesa	medium tree	7,11	sand to clay	low to med	1,3,4,5,6,7,8
Eucalyptus camaldulensis	medium tree	1,3,4,7,9,10,11	sand to clay	variable	1,2,3,4,5,7,8
intertexta	medium tree	11	clay loam	nil	3,4,5,9,10
microtheca	medium tree	1,3,4,5,10,11	sany loam to clay	low	3,5,8,9,10
occidentalis	medium to large tree	7,11	sand to clay	low	1,3,5,8,10
raveretiana	medium tree	5	clay	low	1,3,4,5,7,8
sargentii	small to medium tree	7	sand to loam	low	1,3,5,8,10
spathulata	small tree or mallee	7	sand loam to clay	nil to low	3,5,8,10
striaticalyx	small to medium tree	11	clay	low	3,5,8,9
tereticornis	medium to large tree	1,2,3,4,5,6,8,9	sand	low to med	1,2,3,4,5,7,8
Melaleuca acuminata	shrub	7	?	low	7,8
eleuterostachya	shrub	10	clay	low	7,8,10
glomerata	shrub to small tree	7,10,11	sand to clay	low	7,8,10
halmaturorum	shrub	7	sand	low	7,8,10
sp. *aff. lanceolata*	shrub to medium tree	7,11	sandy loam	low	7,8,10
lateriflora	shrub	7	sandy loam	low	8,
thyoides	shrub	7,11	sand to clay	low	3,7,8,9

Table 2: Uses for the 22 most salt-waterlogging tolerant species (from Vercoe and McDonald 1987)

	Utilisation	No. species
1.	Timber	8
2.	Pulp	2
3.	Posts and poles	15
4.	Industrial fuel	6
5.	Domestic fuelwood	15
6.	Fodder	3
7.	Shade/shelter/windbreaks	15
8.	Land reclamation/revegetation	21
9.	Ornamental	6
10.	Other products	9

Condobolin salinity abatement demonstration

C.D. Short

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A 300 hectare catchment just north of the Condobolin township has areas of severe dryland salinity. The catchment has been extensively cleared in the past. Salt affected areas within the catchment have been increasing in extent over recent years. Preliminary investigations of a number of properties have identified the source as a fluctuating watertable in the lowlying areas affecting extensive areas of the community golf course and three other properties.

The salt abatement tree planting strategy will involve plantings on localised areas of high recharge to reduce inflow into the groundwater system. These sites will include roadside and boundary plantings, recharge and runon areas and waterlogged areas.

Seven properties are involved in addition to the town environs, abandoned abattoir complex and the community golf course.

Establishment of trees in an area of dryland salting in Central Queensland, 1984-1988

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B.A.Cowie — Queensland Department of Primary Industries, Biloela Research Station, PO Box 201, Biloela QLD 4715

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By 1984 farmers were seeking advice about planting trees in areas that had become too saline for crops and local information was not available. A site near Thangool where dryland salting had developed and where studies were in progress was planted with various eucalypts that could provide timber for construction, posts etc. Across this area of black earth/grey clay the soil conductivity (1:5) ranged from 0.4 to 3.6 DS/m at 0 to 60 cm (0.4 to 4.1 DS/m at 0 to 30 cm).

Seven plantings from 1984 to 1987 included a range of eucalypts and a few *Leucaena leucocephala*, various planting times and planting techniques. Until the final planting the trend was for less than half of the trees to survive, species survival generally being in the order:
E. camaldulensis > *E. moluccana* > *E. tereticornis* > *E.melliodora* and
E. sideroxylon (slow to establish) > *E. citriodora* and *E. robusta*. Soil conductivity (0 to 60cm) limits for most trees to survive were > 3.0 dS/m for *E. camaldulensis* < 3.0 dS/m for *E. tereticornis* < 2.5 dS/m for *E. moluccana* and *E. robusta*.
E. citriodora would be considered unsuitable for the site. Tree heights as indicators of growth rates were in the order *E. camaldulensis* and *E. tereticornis* >*E. moluccana* > *E. sideroxlyon*.

The following recommendations were derived for tree establishment:

- raise trees in styrene stock, not net pots, in the nursery;
- spray for insects before planting out;
- plant directly into the soil on site after rain in spring or summer;
- use straw mulch;
- avoid waterlogging soon after planting;
- use tree guards or protect the site from wildlife;
- on sites similar to this saline clay soil plant *E. camaldulensis*, *E. tereticornis* or *E. moluccana* for timber;
- have equipment to water if necessary;
- control leaf miner, particularly on *E. camaldulensis*.

Occasional monitoring and completion of the Final Report are planned for 1988.

Publication(s):

Standley, J. and Cowie, B.A. (1985). Studies on an area of dryland salting near Thangool, central Queensland. Part II. Establishment of trees in the saline area. In 'Landscape, Soil and Water Salinity. Principles, Processes, Management, Prevention and Case Studies'. Queensland Department of Primary Industries, Conference and Workshop Series, QC85002, pp C6-6 to 6-11.

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4. AGROFORESTRY RESEARCH

Agroforestry research in south-eastern Queensland

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and R.M. Jones — CSIRO Division of Tropical Crops and Pastures, Cunningham Laboratory, 306 Carmody Road, St. Lucia Qld. 4067

Officers of the CSIRO Divisions of Forestry and Forest Products and Tropical Crops and Pastures as well as staff of the School of Environmental Studies of Griffith University are presently writing up their findings for the agroforestry study STAG (the acronym stands for Soil, Trees and Grass). The experiment is located at Samford (Lat. 27°S, Long. 152°E, 50 m asl) and was sown to a *Setaria* pasture in November/December 1983 and planted with *Eucalyptus grandis* seedlings in November 1984. The design was of a Nelder fan type with nine circles and eighteen spokes. Tree stocking increases towards the centre of the experiment from 22 trees ha^{-1} in the outside circle to 3580 trees ha^{-1} in the inner circle. The purpose of the experiment was to identify the main problems in developing a stable tree/pasture agroforestry system in a subtropical environment and to assess how the components competed for water, nutrients and light.

The site receives an annual rainfall of about 1100 mm, two-thirds of which falls in the six warmest months (October-March).

The soils are red and yellow podzolics and originally supported a tall open-forest of *E. microcorys, E. maculata, E. propinqua* and *E. tereticornis.* The site was not one which normally supported *E. grandis* but based on earlier trials it was known that reasonable growth could be achieved for at least three years. Separate harvest blocks of trees at four representative spacings were installed to provide biomass data which could in turn be applied to the trees in the Nelder fan.

Monitoring of tree growth (height, DBHOB, and diameter at 0.3 m, 1.0 m. 2.0 m and 3.0 m) was carried out at approximately six-weekly intervals. Less frequent measurements were made of crown depth and crown spread. Pasture production and its botanical composition were assessed at least twice yearly and the pasture slashed to 0.15 m as considered necessary and to simulate grazing.

For the first three years it was found that pasture production was not reduced under tree stockings up to 300 trees ha^{-1} (Table 1). However when pasture production was reduced at higher tree stockings it was accompanied by a proportional increase in green leaf and its nitrogen content, while there was a reduction in phosphorus content.

Tree height growth has been favoured in the closer spacing near the centre of the experiment since age 1 year. The increase in height from the outer circles has been quite appreciable (8.4 m at 42 stems ha^{-1} to 11.4 m or more at stockings over 305 stems ha^{-1}). Maximum diameter growth was at the densest stocking at age 1.5y but has progressively moved out to be at 158 stems ha^{-1} at age 3.5y. Maximum individual tree biomass of about 40kg at age 3y was at a stocking of 305 stems ha^{-1}.

Table 1. Pasture and tree production at selected spacings in the STAG experiment

Tree stocking	Summer 1986 pasture yield (kg ha^{-1} DM)	Relative yield of pasture as percentage of yield in open and up to 158 stem ha^{-1} at age 2.5y	N% content of pasture green leaf	Tree mean height at age 3.5y (m)	Tree mean DBHOB at age 3.5y (cm)	Estimated stem conical volume age 3.5y (m^3)
3580	150	1	1.63	11.8	8.6	0.029
1140	1400	60	1.36	11.9	11.4	0.053
305	3780	115	1.24	11.4	13.5	0.071
82	4660	100	1.16	9.7	14.0	0.069
42	4580	100	1.07	8.4	12.1	0.048

The experiment shows it is possible with careful management to grow eucalypts and pasture together on the one piece of land. There is considerable scope to vary both tree and pasture species in attempting to find suitable combinations for other climatic and edaphic conditions. Even in this relatively equable climate, the availability of soil water has been shown to be the major controlling factor for tree and pasture growth.

Other aspects studied in the project were water usage by both trees and pasture in relation to tree stocking, soil microbial biomass in relation to tree density, the effect of tree stocking on wind profile measurements and nutrient cycling through litterfall by the trees.

REFERENCE

J. Eastham, C.W. Rose, D.M. Cameron, S.J. Rance and T. Talsma (1988). The effect of tree spacing on evaporation from an agroforestry experiment. Agric. For. Met. 42, 355-368.

Water use by trees and pasture at a range of tree spacings in an agroforestry experiment

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Abstract of a PhD thesis awarded in 1988 by the School of Australian Environmental Studies, Griffith University, Brisbane, to J. Eastham.

Components of the water balance were measured at three spacings of *Eucalyptus grandis* planted in a Nelder design into a pasture dominated by *Setaria sphacelata* cv. Kazungula in an agroforestry system. Trees under study were planted 2.4, 6.5 and 12.4 m apart forming approximate planting densities of 2150, 304 and 82 stems per hectare. The experiment was carried out throughout 1985 and 1986 in a subtropical climate near Brisbane, Australia, where mean annual rainfall is 1099 mm. At the beginning of the study period trees were approximately 1.5 years old and mean tree heights at close, medium and wide spacings were 5.3, 4.3 and 3.7 m, and their stem diameters at 1.3 m were 0.045, 0.042 and 0.038 m. By the end of the study period in December 1986, mean tree heights at close, medium and wide spacings had increased to 10.1, 9.8 and 8.3 m, and their diameters to 0.092, 0.120 and 0.119 m.

Over the two year study period, combined evaporation from trees and pasture was evaluated at each tree spacing using measurements interpreted by the soil water balance equation, with changes in soil water content measured by neutron moisture meter. Evaporation from pasture within small lysimeters (0.15 x 0.15 m square, 0.30 m deep) was measured under each tree spacing, and linear relationships between soil water content and the ratio of pasture to pan evaporation were obtained. The contribution of pasture evaporation to the combined evaporation at each tree spacing was estimated using these relationships, allowing tree and pasture water use to be separately estimated. Root length density distributions of trees and pasture were studies at a range of distances from the tree stem, providing data to elucidate competition between tree and pasture, and inter-tree competition for water. Productivity of trees and pasture at the three tree spacings studied was monitored throughout the two year period, and related to their respective water use.

Evaporation was generally highest from pasture under wide tree spacings, and decreased as tree density increased. Differences in pasture evaporation between tree spacings were generally greatest in summer months reaching maxima of 4.4, 3.8 and 3.0 mm day^{-1} in December 1985 under wide, medium and close tree spacings respectively. The decrease in evaporation with increasing tree density was partially due to lower evaporative demand, as radiation on pasture was found to decrease as tree density increased. Lower vapour pressure deficits due to reduced windspeeds and poorer coupling to the regional vapour pressure deficit may also have reduced evaporative demand. Lower pasture evaporation was also found to be caused by lower stomatal conductance of pasture under low radiation at close tree spacings. Low water contents in the pasture root zone under the densely planted trees due to high interception loss by the tree canopy, and water uptake by dense overlapping tree root systems may also have caused low pasture evaporation rates. Furthermore, dry soil conditions and increased shading decreased pasture root production, thus reducing the pasture's capacity to compete for water under the densely planted trees.

Trees provided shelter for the pasture during periods of low terrestrial minimum temperatures, and frost damage to the pasture was least severe under close tree spacings, and increased at wider spacings. Pasture at HD showed a 15% reduction in green leaf area compared with a 30-55% reduction at MD and a 60-90% reduction at LD. Decreases in leaf area due to drought or frost reduced pasture evaporation, with the greatest reduction occurring at wide tree spacings where the frost damage was most severe.

Pasture production and water use efficiency was greatest at the intermediate tree spacing, due in part to a smaller proportional allocation of assimilate to root production, the root:shoot ratio being lowest (2.0) in pasture under the medium tree density compared with 8.5 and 3.3 for pasture under close

and wide tree spacings respectively. Low pasture production and water use efficiency at close tree spacings were due to low radiation and proportionately greater root production. Reductions of 60-90% in green leaf area due to drought and frosting caused low pasture production under wide tree spacings, and low water use efficiency may have been caused by a greater contribution of soil evaporation to pasture evaporation at this density.

Inter-tree competition for water at close spacings caused trees to develop a deeper and more dense root system compared with trees planted at wider spacings which produced shallow, laterally extensive systems. Trees planted at wide spacings were therefore able to withdraw water at greater distances from the stem where soil water contents were higher. However, progressively greater depths, reducing water contents to wilting point at all measured depths of the soil profile between 2.0 and 5.6 m.

Transpiration rates per tree were lowest at close tree spacings being 13.3 x 10^{-3} m^3 day^{-1} from densely-planted trees compared with 54.5 and 72.9 x 10^{-3} m^3 day^{-1} from medium and wide tree spacings respectively in November/December 1985. The low transpiration rate was due partly to low soil water contents in the root zone and may also have been caused by lower evaporative demand associated with lower radiation interception per tree due to mutual shading, and lower windspeeds and air saturation deficits at close tree spacings.

During a drying period of approximately one year, soil water contents in upper soil horizons became depleted at each tree spacing, and an increasing proportion of water was extracted from progressively deeper soil horizons. However, total water uptake decreased due to low conductances in the soil-root-xylem pathway associated with low root density in the deeper wetter soil horizons. The ratio of tree transpiration to equilibrium evaporation was found to decrease linearly with decreasing soil water content (or soil conductance) at each tree spacing.

Biomass production per tree was initially highest at close tree spacings, probably due to less competition from the surrounding pasture for water due to greater shading on the pasture than at wide tree spacings. During dry conditions in 1986, biomass production per tree was lowest at close spacings being 0.019 kg day^{-1} compared with 0.069 and 0.045 kg day^{-1} at medium and wide spacings at the beginning of the year. The lower biomass production from densely-planted trees was probably due to low radiation interception and low soil water contents limiting tree growth. However, tree water use efficiency was found to be highest at close spacings where it was 4.6 and 3.9 kg m^{-3} in 1985 and 1986 respectively, compared with 1.9 and 1.3 kg m^{-3} for medium and wide spacings in 1985, and 2.7 and 2.9 kg m^{-3} for medium and wide spacings respectively in 1986. The higher water use efficiency at the close tree spacing was due partly to a lower proportion of assimilate allocated to roots at this spacing where the root:shoot ratio was found to be lowest. Tree root:shoot ratios were 0.19, 0.32 and 0.77 in the close, medium and wide tree spacings respectively. Low saturation deficits also may have contributed to the higher water use efficiency from the densely planted trees.

The annual total of combined evaporation from trees and pasture expressed per unit area at each tree spacing was highest in both years at close tree spacings, being 30% higher than the medium and wide tree spacings respectively in 1986. Tree transpiration and interception loss per unit area were also highest from close tree spacings. Soil water depletions decreased and drainage losses increased with increasing tree spacing. Differences in water balance components at the three tree spacings were attributed to the relative importance of the tree and pasture components of evaporation at each tree spacing. At close tree spacing, trees formed a closed canopy, so higher evaporation from trees dominated the combined evaporation. In contrast, combined evaporation at wide tree spacings was strongly influenced by the lower evaporation of the pasture, which covered a large percentage of the area at that density.

5. DATABASES

TREDAT - A tree performance database for Queensland

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Forest Research Centre,
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Commencement Date - January 1985
Completion Date - Ongoing

OUTLINE

A computer database comprising information collected from actual tree plantings throughout Queensland has been established to assist in species selection advice for tree planting projects.

The project, called TREDAT, has been developed jointly by the Queensland Forestry Department and CSIRO Division of Forestry and Forest Products. Information is gathered on predesigned forms covering -

- Site description (e.g. soils, original vegetation, land condition)
- Management history (e.g. spacing, weed control, site preparation)
- Botanical identity (e.g. species, provenance)
- Species performance (e.g. health, vigour, usefulness)

TREDAT presently holds 4700 sets of data on species performance covering a total of approximately 800 species of trees and shrubs. While these data are adequate as an aid to species selection in several regions of the state, the quality of information will continue to improve as the number and extent of records increase. The database is intended to be used in combination with other sources of information and advice from trained staff to provide the assistance needed for effective establishment and management of trees.

Access to information from TREDAT is presently limited to direct enquiries to the Forest Research Centre at Gympie where the computer is based. However, it is planned to produce booklets and tree advice sheets specific to various regions of Queensland based on data from TREDAT. A farm trees handbook covering more detailed tree growing information is also in the early stages of development.

Reference

Brown, A.G., Wolf, L.J., Ryan, P.A., Voller, P. (1988) TREDAT: A Tree Crop Database. Submitted to Australian Forestry.

Mathematical programming for optimising landholder allocations of native species to diverse landscape habitats.

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Traditionally tree planters have had to rely upon information gleaned from books, informed opinion, bitter experience and good luck for identifying 'right tree - right place' combinations. Unfortunately, integrating these diverse information sources and consistently recalling correct recommendations for each possible site is difficult and error prone. The computer program SELECT has been developed to assist the Yass River Valley Revegetation Project in this task (Research into Rural Tree Decline vol 4, p53 and this newsletter, p 39).

SELECT was developed to assist with two tasks:-

1. select suitable habitat for a particular species of interest,
2. select suitable species for a particular habitat of interest.

Eight major types of landscape habitat, defined primarily in terms of soil and landform, were identified within the valley ranging from inhospitable acid skeletal soils and sensitive potentially saline areas to the appealing riverbank areas. Published species distribution maps provided a list of candidate species for the Yass River valley. To establish SELECT's database each habitat type was classified as preferred, desirable or undesirable for each species. From this database the SELECT can in fact identify species suitable for a complex habitat comprising for instance 'acid skeletal soils on exposed ridges' as well as for simpler habitats (e.g. 'well drained soils').

It has subsequently been used to allocate 25 000 tubestock of native species raised by the Project over the past two seasons. This has been achieved with the knowledge that the species chosen were suitable for the habitats identified by the landowner.

Although SELECT has been used to allocate species suitable for planting specific landscape habitat(s), each landowner's planting request is processed sequentially. Consequently, nursery stock are unlikely to be optimally allocated. For instance, although obviously not identical, the habitat preference profiles of many species have a degree of similarity. Therefore initially at least, various combinations of preferred species will meet landowner requests; unfortunately many of these combinations will jeopardise subsequent landowner's allocation.

Mathematical programming can be used to achieve an optimum allocation of the nursery's tubestock despite the competing and diverse requirements of the landowners. In addition, given that the allocation entitlement of any landowner depends upon the time spent at the propagation nursery, mathematical programming can allocate tubestock in accordance with entitlements earned. Thirdly, ecological reasoning suggests that a mixture of suitable species is preferable to planting a pure stand albeit within the constraints of the habitat preference profile of the species and their availability. For the Yass River Valley Revegetation Project the mathematical programming formulation will take into account:

1. the species-habitat preference relationships captured in the SELECT program,
2. the earned entitlements of individual landowners,
3. the preference for species diversity in landholder allocations.

A micro-computer mathematical programming package (LP88 v7.03, Eastern Software Products) is being evaluated for its capability for this allocation task. The development of interfaced modules (REVEG) to LP88 permit data entry and tailoring of output. The matrix generator module permits response entry of available species and numbers, species-habitat preference profiles and landowner entitlements. The report generator module transforms the mathematical programming solution into a invoice for each landholder detailing the name and number of each species and the habitat into which these should be planted. Simultaneously a species inventory of nursery stock is maintained.

6. REGENERATION TECHNIQUES

Regeneration of salmon gum woodlands on farmland

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Project commenced: November 1988, and will run until 1990.
The project is funded by World Wildlife Fund Australia.

Aims

1. To investigate and develop low-cost methods of promoting regeneration of tree and shrub species within degraded woodland areas on agricultural land in the WA wheatbelt.
2. To increase the awareness within rural communities of the importance of woodland conservation and rehabilitation.

Background

Salmon gum (*Eucalyptus salmonophloia*) woodland is an important plant community in the Western Australian wheatbelt which is severely under-represented in the reserve system. However, many small patches of salmon gum persist on farmland, where they have been used predominantly for shelter for stock. Very little regeneration of salmon gum is observed, and unless this is promoted the woodland will disappear as the existing mature trees die. This project aims primarily to find effective methods of encouraging regeneration of both trees and understorey. The main factors thought to inhibit regeneration are grazing and trampling by stock, rabbit grazing, lack of suitable seed bed, competition from annual weeds and lack of local seed source. We have therefore devised an experimental program to identify which of these factors have to be addressed to allow regeneration to occur.

Methods

1. Initial survey of woodland on agricultural land within the CSIRO Kellerberrin study area, using aerial photography, soil maps and field survey.
2. Selection of study sites on the bases of tree species present, degree of degradation and size of block.
3. Liaison with farmers to obtain permission to use blocks for experimental manipulation.
4. Carry out experimental manipulations in late summer 1989 and monitor regeneration in spring 1989-90, with follow-up monitoring in subsequent years.

Progress to date

Four blocks have been selected, each 1-2ha surrounded by agricultural land, all with predominantly salmon gum with little understorey and varying degrees of weed invasion.

For these blocks an experimental layout (replicated block design) has been devised, and the following fencing treatments will be carried out in late summer 1989:

1. Unfenced
2. Fenced against stock
3. Fenced against stock and rabbits

Within each of these, these further treatments will be applied:

1. Control (no further treatment)
2. Herbicide added
3. Scarification of the soil surface
4. Addition of shrub and tree seed
5. Combination of herbicide and seed addition
6. Combination of scarification and seed addition.

Each treatment will occupy a 25 x 25 quadrat.
There are no results to date. However, farmer support for the project has been extremely encouraging and all recognise the need for woodland regeneration.

River red gum regeneration for stream bank stabilisation

C.D. Short

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There is increasing concern about river bank erosion along the inland rivers of N.S.W. This is especially so along the Murray, Murrumbidgee and Edward rivers. These rivers are extensively used for agricultural purposes and recreation.

One area that has come under focus is a length of the Edward river at Deniliquin. This area received extensive recreational usage. The river banks in this area are undercutting and unstable.

The investigation proposes to test stabilisation techniques by comparing a fenced and unfenced section of the river. Each planted initially with a reed (*Phragmites* spp.) to help stabilise the bank and then plant river red gum (*Eucalyptus camaldulensis*) seedlings if natural regeneration does not occur.

Re-establishment of native tree species on the highly erodible sandhills of far south-west N.S.W.

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Sandhills are the most erodible part of the landscape due to their light soil texture and elevation. Over clearing of sandhills has occurred and reforestation is the most suitable method of land rehabilitation and control of further soil degradation. Use of species native to the area is preferred because of the difficulty in establishing trees in the 250mm mean annual rainfall zone.

Two tree species dominate the sandhills of far south-western N.S.W. They are white cypress pine and mallee. White cypress pine will establish in better rainfall years but its regeneration is lacking in the southern and western parts of the state. It is known that grazing by domestic, feral and native animals reduce regeneration of the species.

Exclusion of grazing animals from an area containing parent trees may be necessary for regeneration to occur. Areas will be fenced out to exclude various animals and regeneration and survival observed.

Mallee has been observed to regenerate on sites that have been cleared, cropped and then stubble burnt. In order to establish mallee on sites that have been cropped for a long time, it is thought that reseeding the area, followed by burning will provide a technique for re-establishing trees on sandhills that have been inadvisably cleared. This will be tested.

Establishment of a native grass (*Danthonia richardsonii*) on roadside verges

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Start Date
September 1988 to September 1989

Location
Canberra

Funding
Dept. Main Roads, New South Wales

Aims
The project aims to test the applicability and performance of *Danthonia richardsonii* in revegetation of roadside and other open spaces.

Selected strains of *Danthonia richardsonii* have been developed as a low maintenance ground cover for open spaces and for roadside and other revegetation work (Lodder 1987). This project is funded by the National Capital Development Corporation. *D. richardsonii* should be more compatible with plantings of other slow growing native species than highly productive exotic pasture grasses while still providing adequate ground cover for erosion control.

The New South Wales Department of Main Roads (D.M.R.) has funded an extension of this project with a view to the possible use if this species in seed mixes for roadside revegetation.

Site details
A site was chosen on the Federal Hwy approximately 20 km north of Canberra after consultation with the D.M.R.

Method
The performance of *Danthonia* is being tested in comparison with two standard grass mixes commonly used by government authorities. The site is approximately 12 x 100 m and has been divided to include 4 replicates for each treatment. Two planting times are planned, one in spring (October) and the other in autumn (March). These are the best times for germination and establishment of *Danthonia* (Hagon and Groves 1977). A herbicide/no herbicide treatment may also be included in the trial.

Existing vegetation was removed with Roundup* and the site was cultivated to form a uniform seed bed. The exotic mixtures were sown at rates recommended by the authorities. The standard mixes were sown by tractor-drawn spreader and *D. richardsonii* was sown by hand operated garden spreader. Plots were mulched with a straw-bitumen mulch which has been shown to increase survival and seedling establishment (Hagon and Groves 1977). No fertilizer treatment was included in this experiment.

A demonstration area has been included where seed of native shrub species used by the D.M.R. has been sown with the three grass treatments to assess the ability of the native shrubs to establish and grow initially under a grass canopy.

Results

All treatments in the spring sowing have established well following exceptionally good rain. Initial seedling germination and establishment have been monitored by counting density of each taxon in quadrats. After establishment, survivorship over the summer, cover and weed invasion will be monitored regularly.

A complementary project assessing the regeneration biology and suitability for commercial seed production of a range of colourful native herbs is currently underway (funded by the National Capital Development Corporation). We intend to eventually include seed of these species in revegetation mixes for roadside planting.

References

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Evaluation of pre-emergent herbicides for landscape tree establishment

C.J. Nazer and J.D. Clark — Horticultural Services Unit, ACT Parks and Conservation Service, GPO. Box 158, Canberra ACT 2601

Summary
Trials were conducted between 1976 and 1980 in Canberra to evaluate pre-emergent herbicides for landscape tree plantings. They involved napropamide, propyzamide, methazole and simazine alone and in mixtures. Application of the herbicides was made soon after planting native and exotic trees during the summer months. Mixtures of napropamide and propyzamide with methazole or simazine were developed which can be used around common landscape trees during establishment to control many annual weed species for a season or longer from a single application.

Increasing the productivity and sustainability of agriculture by the use of trees on farms. Direct seeding of native hardwoods

R.E. Hall and
L.P. Thatcher

Rutherglen Research Institute, Department of Agriculture and Rural Affairs, Rutherglen, Vic. 3685

To get large numbers of trees planted by farmers, it is necessary to have a cheap reliable method of planting. Direct seeding is one method of planting large areas quickly, but present techniques are not very reliable. This trial is aimed at isolating the variables, and developing techniques of planting that give reliable results at a reasonable cost.

One is planting seed directly in the soil on a monthly basis through the growing season. The trial is a randomised design and will continue for three years. 1988 plantings have indicated that July, August and September plantings in the better drained soils are satisfactory, provided suitable weed control measures are adopted.

The major treatments are time of sowing, method of weed control (an expensive part of growing trees) and species of seeds planted. the treatments are replicated 3 times.

This program is funded by the National Agroforestation Program and has two main aspects:

1. Direct seeding trial (PADDOCK 2)

Germination and Survival (Nov 1988)

Time of Planting	Melaleuca	Allocasuarina	Eucalypts	Acacia	Monthly total
May	5	12	22	64	103
June	42	2	4	39	87
July	30	12	114	66	222
August	11	21	148	86	266
September	54	68	231	179	532
October	-	-	15	2	17
Species Total	142	115	534	436	1227

2. Natural regeneration

The second aspect is direct seeding directly from trees (natural regeneration) into three soil treatments including pasture, sprayed pasture and uncultivated ground. A burning treatment will be superimposed on the area in December 1989. At the time of writing this report (23/11/88) there has been no germination of eucalypts on any of the treatments.

A further aspect of the direct seeding work is collection of seed from local provenances. This seed is checked for viability in the hot house, and seedlings raised for future plantations.

Direct seeding of trees

Rod Bird, Keith Cumming, Gavin Kearney and Don Jowett

Pastoral Research Institute, P.O. Box 180, Hamilton, Victoria 3300. (055) 730905

Funding has been obtained through the National Soil Conservation Program to evaluate methods of direct seeding of trees on farms for erosion and salinity control on shelter.

Direct seeding is a technique with demonstrated potential to reduce the cost and increase the speed of rural revegetation. However, consistent results among years and soils have yet to be achieved and the basic objective of the present work is to develop methods of successful direct sowing of trees for a wide range of soils and climatic conditions in western Victoria - the volcanic plains (1), Ordovician sandstones (2), Dundas tablelands (3) and the Wimmera plains (4). Thirty-eight species, including those indigenous, will be assessed at each of the four sites.

The project has three components:-

a. Effect of ground preparation, seedbed factors and time of sowing which affect tree seed germination and seedling establishment (12 treatments).
b. Use of residual herbicides before sowing for weed control in the early phase of tree establishment (12 herbicides x 2 rates x 2 applications methods).
c. Use of overspray herbicides in autumn or winter for weed control in the second year (12 herbicides x 2 rates).

The work began in September 1987 and will be repeated over three years in order to gauge effects of climatic variation on specific treatments.

The herbicides will be assessed at 2 rates to determine seedling tolerance and effectiveness for weed control. In Part (b) the seeds are sown in a narrow band either shielded from herbicides or from which the herbicide has been scalped off. Our assessment will be based on seedling germination, establishment, growth rate over one and two years, seedling mortality and weed control.

Early results for the first year are presented in Tables 1 and 2. A consistent finding in Part (a) was the need for soil disturbance. Use of the scalping disc implement was superior to any other form of cultivation.

The growth of seedlings on plots in Part (a) that have been kept weed free (1.5 m width) exceed others threefold, emphasising the importance of weed control. The scalping and shielding methods generally were effective in protecting the tree seedlings from contact with the herbicides.

The triazine group and Oust were the most effective weed control chemicals (Table 3). Oust was the best but it is not yet widely registered and its price is uncertain. Simazine appears to be the most economical herbicide with satisfactory performance.

Table 1: Mean seedling count per 12 m in January 1988 in Part (a) *
Data are total of all species sown.

Preparation	Operations [A]	Sowing time	B. Swamp (1)	Glent. (2)	Mel.F. (3)	Nurab. (4)
1. No disturbance	S,D	Oct.	1.0	15.7	0.3	3.0
2. Mouldboard	S,D	Oct.	21.7	40.7	35.7	25.7
3. Rip	S,D	Oct.	4.7	30.3	37.3	4.3
4. Scalp	S,D	Oct.	205.7	133.3	149.0	7.7
5. Rip & cult.	S,D	Oct.	84.7	35.3	47.7	12.7
6. Rip &cult.	R,S,D,R	Sept.	111.0	37.3	75.0	2.7
7. Rip & cult. handweed	S.D.R	Oct.	100.0	76.0	68.0	14.7
8. Rip & cult.	R,S,D,R	Oct.	114.0	50.3	37.0	3.3
9. Rip & cult. no cover	S	Oct.	13.0	39.3	40.7	3.8
10. Rip & cult.	R,S,D,R	Apr.	-	-	-	-
11. Rip & cult.	R,S,D,R	Nov.	40.3	60.7	128.0	-
12. Rip & cult. no pest control	S,D,R	Oct.	54.0	58.3	29.7	8.7

*All treatments sprayed two weeks prior to sowing with Roundup at 6 l/ha
[A] S = sow, D = drag a bag to cover, R = roll to compact seedbed.

(1) Volcanic plains
(2) Ordorician sandstones
(3) Dundas tablelands
(4) Wimmera plains

Table 2: Mean seedling count per 12 m in January 1988 in Part (b)*
Data are total of all species sown

Herbicide	Rate/ha	B. Swamp Sc	B. Swamp Sh	Glent. Sc	Glent. Sh	Mel. F. Sc	Mel. F. Sh	Nurab. Sc	Nurab. Sh
1. Roundup only	6 l	308	66	149	26	143	31	12	8
2. Goal	12 l	295	72	188	39	268	51	12	10
	4 l	313	32	76	82	249	36	7	14
3. Kerb	9 l	415	49	181	61	211	59	5	10
	3 l	328	68	206	18	208	20	13	13
4. Glean	30 g	270	56	188	51	215	41	19	15
	10 g	313	46	175	56	149	37	12	11
5. Atrazine	4.5 l	284	50	111	97	182	34	7	14
	1.5 l	329	79	139	52	176	25	10	6
6. Simazine	6 l	306	72	119	48	172	35	5	10
	2 l	240	84	184	51	142	11	11	13
7. Propazine	7.5 l	123	56	157	55	208	39	14	12
	2.5 l	381	43	162	79	198	38	10	10
8. Dual	6 l	259	46	102	32	183	33	21	8
	2 l	423	64	124	62	227	33	17	14
9. Metribuzin	0.9 kg	425	94	144	52	204	49	12	8
	0.3 kg	352	46	128	65	124	25	17	9
10. Linuron	4.5 kg	308	101	134	40	199	66	17	12
	1.5 kg	507	55	184	51	179	25	14	14
11. Enide	18 kg	360	34	184	60	224	68	8	9
	6 kg	281	- 113	91	44	210	31	13	14
12. Oust	0.6 kg	122	35	105	45	60	18	3	2
	0.2 kg	234	71	87	42	107	13	6	8

Sc = scalping away a 20 cm wide band of herbicide affected soil prior to sowing

Sh = shielding the seeding line from herbicide

*All treatments sprayed two weeks prior to sowing with Roundup at 6 l/ha.

Table 3: Mean % weed cover in sprayed strips alongside the seedline after 3 months (January) and 9 months (July) - Part b.

	Rate/ha	B. Swamp Jan	B. Swamp July	Glent. Jan	Glent. July	Mel.F. Jan	Mel.F. July	Nurab. Jan	Nurab. July
1. Roundup	6 l	30	96	58	98	27	96	29	68
2. Goal	12 l	17	65	22	81	15	80	15	45
	4 l	22	89	35	88	21	87	19	56
3 Kerb	9 l	24	94	34	88	27	89	25	57
	3 l	27	88	41	94	26	90	20	58
4. Glean	30 g	18	91	11	99	13	92	12	75
	10 g	27	96	30	98	21	96	14	70
5. Atrazine	4.5 l	9	95	5	98	10	99	15	76
	1.5 l	24	92	38	97	24	99	27	83
6. Simazine	6 l	10	91	12	99	12	97	20	72
	2 l	18	93	23	97	24	97	19	83
7. Propazine	7.5 l	7	92	11	96	10	98	18	77
	2.5 l	19	94	31	97	24	96	17	71
8. Dual	6 l	22	91	50	96	32	96	18	59
	2 l	31	96	35	94	27	97	19	66
9. Metribuzen	0.9 kg	24	92	21	98	14	96	16	69
	0.3 kg	27	98	32	96	23	94	26	80
10. Linuron	4.5 kg	23	93	21	98	13	92	19	72
	1.5 kg	23	99	30	97	20	98	18	81
11. Enide	18 kg	25	79	33	90	24	71	21	36
	6 kg	27	95	33	89	32	94	21	39
12. Oust	0.6 kg	0	50	0	87	1	49	0	73
	0.2 kg	4	85	2	90	4	71	6	74

7. REVEGETATION PROJECTS

The protection of remanent vegetation in Victoria - some first thoughts

Rob Youl — Land Protection Division, Department of Conservation Forests and Lands , 250 Victoria Parade, East Melbourne Vict 3002

When Victorians started to get serious about trees in the early 1980s we looked especially to planting. This was a forestry reaction to a complex problem. Foresters knew most about planting because that was what we had been doing in our plantations for 100 years.

As we progressed we realised that natural regeneration and transplanting could also be very valuable. We were forced as well to conclude that a major effort should be made to protect existing farm trees, especially if they still grew in company with understorey.

We are only just taking up this challenge. One of the first regions to do so was Horsham. Ironically, being close to the SA border, it had suffered badly from 'panic clearing' in the wake of the well known SA legislation designed to protect native vegetation on farms.

In 1987-88, Horsham directed most of its LPIS (Land Protection Incentive Scheme) money to fencing remnants of indigenous forest and woodland. Other regions have started to follow suit.

Analysing the problem

We probably need to think of the protection of remnants in several phases:

Legislation	Is legislation necessary or will a thorough and imaginative extension program suffice? This is a fundamental question. How will the Victorian Flora and Fauna Guarantee assist us? Would legislation damage the trust and co-operation that generally exists in Victoria between the land management agencies and farmers' organisations?
Inventory	We would use satellites, aerial photographs, ground surveys and standard maps, perhaps in concert with other activities such as fauna surveys and regional roadside surveys.
Policy	We need to set priorities for the use of Government resources, both fiscal and human, and utilise existing bodies such as the Roadsides Conservation Committee.
Who else do we involve?	Conservation groups, the CFA, universities, farm tree groups, the nursery trade, other community groups, municipalities, Greening Australia, the National Trust, utilities such as V-Line, the SEC, RCA and Telecom, and, above all, private landowners.
What co-operation is necessary internally?	Obviously several arms of CFL are involved; as well there are the Garden State Committee, the Urban Forests Committee and Greening Australia.
What extension programs do we have already?	Land for Wildlife; LPIS; Victoria Conservation Trust's ability to covenant; the fact that field staff can provide simple management plans to landowners: these are all part of extension.
Monitoring	Just what would we have to do in this field? Human beings tend to be poor at keeping records so foolproof systems must be devised.

Start now!

The time has come to embark upon a broad campaign to protect remanent vegetation. I say this for several reasons:

- the value of tourism to the economy; remnants are the flesh of the landscape
- management of remanent stands doesn't cost much
- local nurseries specialising in indigenous species are flourishing in many areas
- salinity is now widely recognised as a problem for all of us
- people are becoming more interested in the horticultural potential of Australian wildflowers
- municipalities are becoming more active in environmental matters, including the use of planning schemes to protect vegetation
- in our bicentennial year we developed a greater awareness of our heritage

The role of the departmental field staff

Most CFL staff members already have a good grounding in the conservation of indigenous remnants:

- they understand ecology
- they are observant and experienced
- they know the geography and botany of their region well
- they know a lot about fire and weeds
- they know landowners personally

A complex problem

A series of four workshops held recently indicated to us that the whole subject is a very broad one.

Important aspects are:

- animal behaviour, from insects through to mammals, and especially grazing pressure - we include wild animals as well as domestic ones, kangaroos especially
- the role of fire (in fact make a point of getting to know your local Municipal Fire Protection Officers)
- recreational use and public pressure
- management will differ often for private and public land, for the publicly owned remnants will usually be subject to a greater diversity of uses and abuses
- there are still many remnants in towns, and that introduces further complications (in fact, the protection of these remnants is one of the three basic activities in urban forestry in Australia)
- exposure
- weeds, both the standard species that everyone accepts are weeds, and the new group of 'environmental' or 'bushland' weeds
- drainage (off the land or onto it) and subsequent water quality
- Aboriginal associations
- collectors, especially of Australian plants
- regeneration techniques, and in particular selection of species and seed sources
- rubbish disposal (often something of a local tradition, and sometimes involving toxic substances)

- agriculture
- utilisation of resources, including timber and gravel
- the ecology of 'pests' such as mistletoe and dodder, and especially the role of fire in their control
- tree care such as the proper techniques for coppicing and pruning, especially important on roadsides maintained by municipal staff
- the value of fencing as a simple and effective protective technique
- developing a special relationship with municipal engineers
- overdevelopment (why not leave a remnant as it is, rather than bisecting it with a bicycle path or establishing a picnic area?)
- the correct departmental presence to sustain (a sign, a fence, occasional patrols?)
- drift of fertilisers and sprays and the effects of saltladen winds even long distances from the coast

Reading list

Breckwolds, Roland. **The Last Stand**. (AGPS: Canberra) 1986.

Evans, Boyden. **Revegetation Manual**. (Queen Elizabeth II National Trust: Wellington NZ) 1983.

Cambell, R. *et al.* **Victoria Felix: Improving Rural Land with Trees**. (Monash University: Melbourne) 1988.

Costermans, L.F. **Native Trees and Shrubs of south-eastern Australia**. (Rigby: Melbourne) 1981.

Venning, J. **Growing Trees for Farms, Parks and Roadsides**. (Lothian: Melbourne) 1988.

Yass River Valley Revegetation Project

John Ive (Chairman) c/- Division of Wildlife and Ecology, CSIRO, P.O. Box 84, Lyneham ACT 2602

The Yass River Valley Revegetation Project (YRVRP) is a community group dedicated to revegetation in the Yass district. Its achievements were highlighted in 1988 when it was awarded the Greening Australia National Award. Keen to promote the objectives of Greening Australia the following is provided as background to the Project's activities in the hope that it may motivate the formation or activities of like-minded groups.

A broad-based committee of 20 are responsible for planning and managing the Project's activities. The committee comprises local landholders, representatives from the Soil Conservation Service, Department of Agriculture, Forestry Commission, Shire Council, CSIRO, service clubs etc. Sub-committees target specific interest areas including a) farm planning and planting b) education c) publicity d) public lands and environment e) special projects f) nursery

Committee meetings are held monthly throughout the Yass district with regular guest speakers invited to provide expert briefing on topics of specific interest to all members.

Since its formation in 1984 the Project has:

- assisted landholders to produce comprehensive farm plans
- constructed a nursery capable of producing 25 000 plants per annum.
- involved local schools in tree growing activities and introduced an annual school book award
- hosted annual field days for the past two years
- acquired funding to purchase a direct seeding machine
- been directly responsible for the propagation and planting of 45 000 seedlings in the Yass district over the past three seasons

Apart from initial funding for two years under the Community Employment Program (CEP), the Project has operated on a voluntary basis. The period of CEP funding was used to establish a core resource base (including the construction of the nursery complex) from which the Project could continue to operate at minimal expense. When CEP funding ceased the Project reassessed its goals and although interest waned in some quarters the Project continues with modified goals consistent with the need to be self-funded.

Self-funding has been achieved by:

- introduction of membership fee of $5 per annum
- charging a purchase fee of 10c per seedling
- hire fee of $40 per day for the direct seeding machine
- encouraging donations from local businesses and community groups
- specific grants from National Tree Program, National Soil Conservation Programme and National Afforestation Programme.

Project membership includes both private (e.g. farmers) and public (e.g. Forestry Commission) landholders, local government (Yass Shire Council) and state (e.g. Soil Conservation Service) and federal (e.g. CSIRO) resource agencies. Recruitment of farming women has frequently been the catalyst necessary to attract their husbands to the Project.

To benefit from the Project, members are required to attend activity days for seed collection, nursery propagation etc. so as to be involved in all aspects of revegetation - not just planting seedlings. A greater commitment to after-planting care has been evidenced as a result.

A micro-computer program SELECT (see this newsletter, p 24) was developed to assist in the correct selection of native species to plant in each of the diverse habitats in the Yass Valley. This program was awarded a certificate of commendation in the 1987 ABC Countrywide Tree Care Award. The Project received a high commendation award in 1988 for an entry on the development of wildlife habitats.

A direct seeding machine has been purchased in recognition of the enormous task undertaken by the Project, and the limitations of tubestock planting. The machine is the first of its type to be used on the eastern coast of Australia.

The Project actively promotes itself through the local and rural press, and by holding annual field days and displays at local shows.

In 1988, the Project was involved in presentation of a keynote paper to the International Conference hosted at Albury by the Australian Forestry Development Institute. The paper "Rural land degradation in Australia: the role of trees in ecological solutions" received a commemorative award.

The Project has hosted visits by representatives of the Potter Farmland Plan Project and the Centre of Farm Planning and Land Management (Melbourne University), International Council for Research in Agroforestry (Kenya), Society of Growing Australian Plants and Trees on Farms in addition to other Australian and overseas farmers.

Currently the Project is actively supporting a large dryland salinity demonstration project being undertaken in the Yass Valley by the NSW Soil Conservation Service.

Northern Tablelands Tree Establishment Programme.

Co-ordinators:
Supervising Committee: Northern Tablelands Trees on Farms Committee.

Mr David Green — Project Co-ordinator, Soil Conservation Service of NSW, PO Box 267, Armidale NSW 2350

Participants:
- Seventeen landholders located within 50 kilometers of Armidale, in northern NSW.
- National Afforestation Programme, Canberra.
- Trees on Farms, NSW, comprising Soil Conservation Service, Agriculture and Fisheries and Forestry Commission.

Synopsis:
1. The Northern Tablelands of New South Wales is a prominent pastoral region of the State. The area has been badly affected by severe dieback of eucalypt trees.
2. The loss of large numbers of trees (both from extensive clearing and from dieback) has resulted in soil erosion, the beginnings of soil salinity and a drastic lack of shade and shelter for stock, crops and pastures. There has also been a decline in commercial honey producing trees, timber and firewood. Aesthetic utility has also been greatly diminished.
3. This project aims to establish 17 demonstration properties incorporating large scale plantings of trees and shrubs plus regeneration by protection of existing native species. This will demonstrate to the graziers and the general public the financial, ecological and aesthetic benefits of trees. Practical and economic methods of establishment will also be demonstrated.
4. It is proposed to employ a team which will collect local seed, grow open rooted stock, plant and sow seedlings, fence areas and monitor and maintain plantings. In many phases of the work they will be assisted by volunteers and various community groups.
5. The project has a high level of community support. The benefits of such a major planting project on the Northern Tablelands will be extensive. The project is to be implemented using the combined resources of Commonwealth, State and Local Governments, community groups and rural landholders.

Objectives of the programme:
1. To establish a range of tree species at all sites which will help ameliorate environmental problems such as dieback.
2. To demonstrate different planting patterns which are both effective and economic.
3. To establish windbreaks, woodlots and provide shelter for livestock.
4. To encourage and demonstrate effective farm planning involving trees.
5. To assess and disseminate information from this and other sources pertinent to rural tree establishment.
6. To co-operate with other organisations involved in tree establishment within the region.

Advisory Committee
To apply the knowledge and expertise which exists within the local community, an Advisory Committee will be formed and will meet regularly to assist with technical aspects of the Project. Members of this Committee will represent the wider community interest and will provide recommendations for the local Trees On Farms Committee, which will be practical, achievable and have a scientific basis.

Eucalyptus regeneration program Northern Tablelands of N.S.W.

November 1988

David Curtis — Botany Department, University of New England, Armidale N.S.W. 2351

This study is funded by The New England Dieback Research Fund and the Australian Special Rural Research Fund and employs David Curtis as a part-time Project Leader.

Broad achievements of the project:

- Approximately 130 ha were fenced for regeneration, with over 2 000 trees and shrubs regenerated and monitored.
- About 15 000 trees were planted in 10 trials. Overall survival rate was about 87% (see below for successful and unsuccessful treatments).
- About 6 ha were sown directly in 21 trials embracing about 30 different techniques and resulting in about 3 000 seedlings when the project ended. Mean height of all these trees is about 1 m though many trees are now 2-3 m high.
- Flowering cycle of 13 eucalypt species (112 trees) was recorded, including detailed measurements of seedfall.
- Seedling recruitment (124 newly established seedlings from natural seedfall) was monitored and survival and height changes measured.
- Historical research was carried out on the changes to the native vegetation since European settlement and the lead up to dieback.
- The overall thrust of the project has been to increase our knowledge of the mechanisms by which eucalypts common on grazing land of the Northern Tablelands regenerate naturally. This information is being used to re-establish eucalypts in areas affected by tree decline by integrating natural regeneration, planting and direct seeding.

Publications completed

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Curtis, D.J. and Reeve, I. (1988). Planting Trees - How they do it in Victoria. Armidale Tree Group Publ. 88/6, Rural Development Centre Publ. 156, 30 pp.

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Curtis, D.J. and Gentle, C. (1988). Some Notes On Whole Farm Planning. Armidale Tree Group Publ. 88/3 25 pp.

Drew, H. and Curtis, D.J. (1987). Armidale Tree Group - Releafing New England. Armidale Tree Group Publ. 87/1, 16 pp.

Nadolny, C. and Curtis, D.J. (1987). Tree Decline! A joint approach to bring trees back to the Tablelands. Armidale Tree Group Eucalyptus Regeneration Programme, 3pp.

Reeve, I. and Curtis, D.J. (1988). Sowing the seeds - a guide to nurturing Community support for tree planting programs. Armidale Tree Group Publ. 88/5, Rural Development Centre Publ. 154, 30 pp.

Reeve, I. and Curtis, D.J. (1988). Community Tree Groups - a guide to their organization and Management. Armidale Tree Group Publ. 88/4, Rural Development Centre Publ. 154, 30 pp.

Publications (in prep.)
M.Sc.Thesis

Book, Video, Wall-charts and teacher notes to popularize the results of the work. The script of the video is finished along with drafts for the soundtrack and animation. Shooting to commence over summer. One-third of the book has been drafted.

Community involvement
Dieback is ultimately a problem of human land management and a solution must involve community groups, individuals, scientists, and government. This project has fostered community involvement by:

1. Six monthly progress reports to 40-50 interested landholders, researchers and government officials.
2. Field days.
3. News articles in local press.
4. Encouragement of students, friends and others into the field.
5. Frequent talks at schools and to other groups.
6. Establishment of Armidale Tree Group which has supplied trees and helped with plantings, seminars and publicity. Any knowledge gained from this study has been put into effect by the group in their mass plantings.
7. Publications (see above).

Preliminary recommendations
Planting native trees

- Ripping of the ground is essential (except for machine planting).
- A guard is essential for frost and hares (milk cartons work well, gro-tubes are better but more expensive). Trees guarded with milk cartons in the planting trial at the harsh Salisbury Court site had a survival rate of 52% after 2 years while unguarded trees had a survival rate of only 14%. this result was replicated at Malpas Dam where main tree deaths were due to unguarded trees being eaten by hares. Very few guarded trees died in the first season.
- Mark trees well (e.g. stake). The stake holds the guard in place and makes maintenance easier.
- Weed free zone of 0.5 m in all directions is essential (chipping by mattock, 2 prior sprays of Roundup, Roundup + Simazine or chisel ploughing were all found to work well; cultivation with no follow up has a lower success. One of our aims for the next year is to reduce chemicals and labour and still obtain the same weed free environment.
- Machine planting into pre-sprayed ground worked.
- Follow up maintenance (watering, weeding) is advisable but not always necessary if prior treatment and weather is good e.g. mulching reduces need for weeding or watering. Planting needs to be weed-free for first season at least.
- Spring plantings recommended but planting in all seasons can be successful.
- Local provenances are essential as are locally hardened seedlings.
- Species choice is important.
- No advantage was found using Terrasorb.

The Malpas planting of 12 000 trees used the techniques which arose from this research i.e. pre-ripped, chipped, sawdust mulch, stake, milk carton, Nutricote fertilizer and water at planting. Only local provenances and hardened seedlings were planted. Survival rate was 95% in the first season and growth rates have been excellent.

Direct sowing of native trees and shrubs

- Most consistently successful treatment was: graded and ripped or chisel-ploughed. Some success with other treatments such as:
- two prior spraying of Roundup and good weed control after germination;
- prior spraying with Atrazine and Roundup;
- chisel-ploughing several times;
- Sow in clearly defined rows which are well marked. Spot sowing had limited success.
- Sow at 100-200 seeds/m. Better to sow heavily.
- Collect seed from near to the site.
- Acacia seed consistently grew better than eucalypts with 5-10% survival of seed sown being common (compared with <0.1% for eucalypts).
- Hold acacia seed in boiling water for 10-20 seconds to break the seed coat, withdraw and dry. The seeds can be sown any time later.
- Mulches sometimes assist survival, particularly sawdust over spot-sown acacias.
- Sow seed about 0.5-1 cm deep.
- Sow in spring (Sept-Oct), when rainfall is good.
- Choose the site carefully and be philosophical!

Treatments which achieved limited success:

- Broadcasting seed over large area.
- Burning before sowing (may be better in unimproved pastures).
- Cultivating.
- Areas without weed control.

Main causes of death of sowing: drought in early period of establishment, weeds, grasshoppers, (goats!).

Treelot trials in western New South Wales

G.O. Metcalf — Soil Conservation Service of New South Wales, P.O. Box 198, Chatswood NSW 2057

Abstract of paper in J. Soil Cons. N.S.W. 42 (2), 52-61, 1985

During 1960-1972 a number of tree plantings were made at two sites near Condobolin in semi-arid western New South Wales. Most of the forty species planted were eucalypts. Heights of individual trees were measured annually between 1967-1980.

The relative performance of selected tree species investigated within the trials is discussed. Criteria for comparison include survival, vigour or growth rate, expected mature height, drought tolerance and habit.

Species highly recommended were:

Brown mallee (*Eucalyptus astringens*)

Burdett's gum (*E. burdettiana*)

Slaty gum (*E. dawsonii*)

Stocking gum (*E. kondininensis*)

Yellow box (*E. melliodora*)

Swamp yate (*E. occidentalis*)

Reference

Metcalf, G.O. (1985). Treelot trials in Western New South Wales. J. Soil Cons. N.S.W. 42(2): 52-61.

Rural tree regeneration in the Midlands of Tasmania.
National soil conservation project - commenced March 1987
- completed August 1989.

Libby Pinkard, Tasmanian Forestry Commission, Surrey House,
199 Macquarie Street, HOBART. 7000

Synopsis
The project seeks to develop low-cost tree establishment techniques for use on degraded land in the dry, frosty Midlands environment of Tasmania. Tunnel, sheet and wind erosion and soil salinity are all increasing problems in the area, and broadscale tree re-establishment is viewed as an important method of stabilizing soils and reducing groundwater recharge, as well as providing shelter for stock. Research is undertaken on private properties throughout the Midlands.

Methods
Direct Seeding Trials

Research into techniques of increasing the effectiveness of direct seeding is seen as a high priority. Work is centering on weed control techniques, sowing techniques, sowing rates, ground preparation techniques and species selection. Six trial sites have been established over a range of environmental types. Due to a very dry season in 1987, a few results are currently available.

Planting Trials

A planting trial was established to investigate cheaper methods of establishing nursery-raised seedlings. The trial was planted with slimline (5cm diameter tubes) & paperpot (3cm diameter,6cm depth) stock, and a number of treatments were implemented, such as watering regimes, fertilizer regimes, bagging seedlings and mulching.

The trial has been established for a year, and preliminary results indicate the following:

1. Slimline stock had better initial survival than paperpot stock. However, paperpot stock had higher growth rates and the initial height advantage of planted slim-line stock was not maintained by age 1 yr.
2. Plastic bag shelter improved early survival and growth rates, but after 12 months growth rates of other treatments were comparable.
3. The addition of fertilizer or water during the first year had no effect on growth rates.
4. Mulch, while providing no initial survival/growth advantage, improved the ease of follow-up weed control.

Another series of planting trials will be established in 1989 to investigate a range of species with potential for use in the Midlands. Twelve species will initially be trialed; hopefully this number will be expanded in subsequent years.

Other Investigations
1. A small pot trial is being conducted to investigate the effects of atrazine pre-emergent residual herbicide on eucalypt seed germination and seedling development. Preliminary results indicate that atrazine at even high rates (64 ha^{-1} equivalent) has no effect on seed germination. However, rates as low as 2 ha^{-1} appear to dramatically reduce seedling survival.
2. Natural regeneration is currently being monitored on one site. It is hoped to expand work in the forthcoming year to incorporate a wider range of sites.

Re-establishment of native plants on agricultural land

Rosemary Collins

Main Roads Department, Northam WA 6401
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Introduction

A section of the Great Eastern Highway 18km long was realigned and reconstructed close to Northam (WA). This involved the Main Roads Department having to resume 224 ha of mainly agricultural land from the adjacent landholders.

Aim

To establish indigenous vegetation on the land previously used for cereal cropping and sheep grazing. As well as creating an aesthetically pleasing buffer zone between the highway and adjacent landholders, the native vegetation would aid in suppressing the major weed growth problem.

Method

The area of land that has been resumed has been a good testing ground for a variety of different revegetation techniques on the york gum woodland and scrub heath soils.

On the york gum woodland soil direct seeding has been carried out. Chemical weed control has been used prior to deep ripping at a 300mm depth and then followed by scarifying. The other method has been to remove 50-100mm topsoil which contains the weed seeds and artificial nutrients as opposed to using chemical weed control.

Seedlings from normal rootstock and those grown in caroll tubes have both been hand planted on the scrub heath soil. The former on york gum woodland soil as well.

From using Chatfield's tree planting machine there has been the advantage of being able to add a seedling attachment so that native seedlings and seeds could be planted simultaneously.

Results

Most of the seeding trials are still in the early stages. The acacias have been the most dominant species to germinate regardless of weed competition which appears to be the largest inhibitor of native seed germination.

The machine planting has proved very successful on both types of soil. It has had an average survival rate of 80%-90% in the york gum woodland region. Its success on the scrub heath soils has been very dependant on the species used. Banksias have not taken well to machine planting in the sandplain area so they have been hand planted, seedlings grown from carroll tubes.

There is a 5 year revegetation proposal for the area that has been discussed. Although hand planting and some machine planting began prior to this, the bulk of the revegetation work has taken place since 1986/87 and should be completed by 1991/92.

Other roadside revegetation projects that the Northern Main Roads Department have been involved with include:

(a) Mechanical tree planting and seeding of at least 50000 trees and 20kg seed along the Great Eastern Highway between Northam and Southern Cross in the past 4 years.

(b) Mechanical tree planting between Greenhills and Shackleton on the York to Bruce Rock Road during 1986 and 87.

(c) Direct seeding 25km north of Bruce Rock on the Bruce Rock to Merredin Road during 1988.

Factors inhibiting return of trees to abandoned agricultural land

Roslyn Muston — Centre for Applied Biological Research

Robert Whelan — Department of Biology, University of Wollongong, P.O. Box 1144, Wollongong NSW 2500

This article describes a major, long-term project which has received establishment funding from the University of Wollongong and material support from the Sydney Water Board in 1988. It is planned to involve team input from research ecologists, post-graduate research students and Water Board catchment management professionals to solve problems associated with rehabilitation of disturbed areas within catchments.

Background

Rural tree decline is now generally considered to be a serious problem. There has been considerable community concern and research investment into the causes of tree decline on rural lands. Although there are programs which aim to increase the number of trees by encouraging the use and development of plantation techniques, much less attention has been given to natural mechanisms of forest recovery on rural lands yet this may offer a cost-effective approach to regeneration which is appropriate in many areas. There is little documentation to indicate a potential for invasion of abandoned rural land by long-lived tree species nor the factors which have the potential to inhibit natural regeneration. Suggestions have been made that a lack of tree invasion, particularly on agricultural land once it has been intensively farmed, must be due to inhibiting factors such as residual agricultural chemicals, over-frequent application of fire, competition with dominant grass and fern species, allelopathic influences of existing species. In addition, in areas where plantation techniques have been used, seedling establishment problems due to grazing by native and exotic grazing animals have been encountered.

This study aims to contribute to the community's desire to see rural tree declines arrested and return of tree accelerated.

Project outline

The study is located within the Metropolitan Water Catchment Area on an area of basaltic soils which was used, until the 1940's, for orchard growing and grazing of livestock. The Metropolitan Water Catchment area is a vast tract of forested land,consisting of five adjoining river catchments which are largely undisturbed and isolated from public access. Water quality is acceptable at present, with minimal treatment, and the whole Metropolitan Water Catchment Area is considered to be of high wildlife conservation significance. Rehabilitation of these disturbed areas is considered an important management objective and to achieve it, techniques which are sensitive to both the objectives of harvesting of high quality water and wildlife conservation need to be used.

The patches of abandoned agricultural land include important Water Board buildings and facilities and are adjacent to stored water. *Pteridium esculentum* (bracken fern) and *Imperata cylindrica* (blady grass) dominate these areas and the great proportion of them have remained treeless since the Water Board assumed its management in 1888 and farming land was resumed between the 1920's to 1940's. Invasion of trees from the adjacent *Eucalyptus elata* and *Eucalyptus saligna* x *E. botrioydes* forests appears extremely slow and in some areas non-existent.

The dominant grassland vegetation presents an extreme fire risk to Water Board facilities and problems are encountered with reduction in the water quality due to postfire erosion of exposed soil surfaces and the input of charcoal into the adjoining stored water. Management of the high quality of the stored water would be facilitated if the grassland could be replaced by a tree canopy which possessed fire survival properties. A recent attempt at direct-seeding and mass planting of tree seedlings by the Water Board both failed to accelerate tree return.

The research is designed to measure: (i) the potential for and the rate of natural invasion of trees into the grasslands; (ii)to determine what factors, if any, are inhibiting the return of tree through natural forest recovery mechanisms and (iii) to prepare a schedule by which the Water Board can accelerate the development of a forest canopy of desirable tree species.

A series of replicated experimental sites has been established using five old orchard holdings. These sites will be used to examine germination and establishment of tree species. Firstly, the investigations include the availability and distribution of naturally dispersed tree seed, the potential for germination of tree seed in the soils in the grasslands and the spatial and temporal patterns of existing seedling establishment. Secondly, we are examining the impact of: herbivory, fire, competition with *Pteridium esculentum* and *Imperata cylindrica*, mowing and ploughing on establishment of seedlings planted into each experimental treatment.

Future developments

It is hoped to add other related studies to this core as appropriately skilled personnel become attracted to the team. Possibilities include: the relationship between tree removal and changed water table levels, alteration to soil characteristics as a result of former landuses and management strategies which will contribute to the protection of young forests in the recovery phase of forest development.

Direct Seeding of jarrah in rehabilitated bauxite mines

Dr John Koch

Alcoa of Australia Ltd, P.O. Box 252,
Applecross W.A. 6153

Commencement/Finalization date

1985/1995 (approx.)

Brief outline

The return of a jarrah forest ecosystem in rehabilitated bauxite mined areas of the Darling Range is a priority objective. Direct seeding has several advantages over conventional planting as a means of establishing jarrah. These include better hygiene control for *Phytophthora cinnamomi* (jarrah dieback), lower costs, higher establishment rates, random spacing instead of lines of trees and possibly better tree form.

A series of experiments was commenced in 1985 to assess direct seeding as a method of establishing jarrah and other eucalypts as dominant species. The main questions to be answered were:

- What seeding rate should be used to obtain a desired density of trees?
- What is a reasonable and manageable density of trees to establish?
- What will the survival rate of these trees be with and without the presence of the dieback disease?
- What type, rate and timing of fertilizer is required for optimum growth?
- What is the growth rate and form quality of direct seeded jarrah compared to planted jarrah?
- How cost effective is direct seeding?

Laboratory germination testing and field establishment counts indicated that figures of about 16 viable/germinable seeds/g (depending on seed lot) and an establishment rate of about 10% (depending on site conditions, rainfall etc.) could be used to predict potential seedling numbers.

Early experiments aimed to establish approximately 3 000 stems/ha of seeded jarrah. However this has been reduced to 2 000 stems/ha due to the perceived effort and high costs which may be needed to manage a stand at the higher density. The oldest jarrah stand on any minesite is 18 years old (planted not seeded). Survival rates in the longer term are good; only approximately 1% mortality per year has been recorded in earlier jarrah plantings where there was minimal consideration of site factors likely to favour jarrah survival. Now more attention is given to site selection and it is likely that survival rates will be higher, and sufficient to meet long term stocking rate objectives.

Fertilizer experiments established in 1985 and 1986 have shown that a fertilizer containing N and P is necessary for good growth of seeded jarrah. Diammonium phosphate (DAP) is the most cost effective and efficient fertilizer to use. More growth can be obtained by using very high rates. However a rate of 400 kg/ha (72 kg/ha N, 80 kg/ha P) applied in late winter or early spring produces good growth.

Growth rates of seeded jarrah are initially lower than those for planted jarrah. This is for two reasons - the planted seedlings are already 6 months old with an established root system, and they also receive an individual dose of fertilizer placed close to the jiffy pot. None of the experiments are old enough as yet to determine the relative growth rates of the two methods in the long term or to examine the form of the trees.

From a cost effectiveness point of view direct seeding is currently about one quarter to one third the cost of planting. This represents significant savings for the rehabilitation operation.

Publications

Koch, J.M., Sudmeyer, J.E. and Pickersgill, G.E. 1988. Response of seeded eucalypts and understorey to broadcast nitrogen and phosphorus fertilizer on a rehabilitated bauxite mine/ Alcoa of Australia Ltd. Environmental Research Bulletin Number 19.

Davis, S., 1987. Fertilizer requirements for field establishment of jarrah and marri by seed in rehabilitated bauxite mined areas. Curtin University, Applied Biology 301 Project Report.

Alcoa Wellard Wetland Development Project

Dr Owen Nichols

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Applecross, W.A. 6153

Commencement/Finalisation Date

1983/1995 (approx.)

Brief Outline

It has been estimated that over 75% of wetlands on the Swan Coastal Plain have been filled or drained. Any development which could reverse this trend and provide much needed habitat for waterbird species would have significant conservation benefits.

Alcoa operates an alumina refinery at Kwinana, Western Australia. Once the alumina has been extracted from the bauxite, the residue, known as red mud, is stored in clay lined impoundments. The clay used in constructing these residue areas is obtained from farm land at Wellard, approximately 8 km south-east of Kwinana, and 40 km south-east of Perth. In 1979/1980, Alcoa began developing plans to extract clay from an area of farm land at Wellard. Clay extraction would leave a pit up to 5 m deep, covering an area of 25 ha. Several options were considered for the rehabilitation of this site. These included rehabilitation to farmland or sanitary landfill, the use of water for irrigation, or rehabilitation as a wetland.

Following discussions with relevant Government authorities, the wetland option was selected since it was thought to have the highest potential long term benefits.

Detailed plans were then developed in consultation with Government departments and the Royal Australasian Ornithologists Union (RAOU). The specific objectives of rehabilitation were to:

- provide a fresh water wetland system which would cater for a wide range of waterfowl species;
- revegetate adjacent areas to provide a buffer around the wetland, and habitat for more bird species;
- re-establish plants characteristic of similar wetland systems in the area;
- retain good water quality in the wetland;
- encourage, in the long term, the use of the site as a valuable resource for research and educational purposes.

Rehabilitation was completed in 1983. The site has since been evaluated by both the RAOU and Murdoch University, and developments are very encouraging. Fish, crustaceans and small invertebrates have colonised the lake and serve as a useful food source for grebes, herons and other wading birds. Frogs live in the vegetation growing in shallows, and are eaten by herons and egrets. Sixty-one bird species have been recorded to date. Thirty-six of these are waterbird species. The combination of waterbird and other bird species is important, since it means that a greater number of habitats are being conserved in the one ecological unit.

Vegetation communities are developing well and the site is now almost fully vegetated.

Future plans will be developed jointly by Alcoa and the RAOU. The wetland area will be extended when more clay is needed in 4-5 years.

An important lesson from Wellard is that the project has shown that mining need neither leave a hole in the ground which serves no useful purpose, nor simply restore the pre-existing land use. With planning, suitable earthworks and planting, a wetland which has real conservation, research and educational value can be established in suitable areas.

Alcoa would be happy to share information obtained at this site with other organisations contemplating similar developments.

Publication

Bamford, M. (1986). Wellard Claypits: Review of Progress on Alcoa's Rehabilitation Project, August 1986. RAOU Report No. 26.

8. NEWS ITEMS

Request for advice

The Soil Conservation Service of New South Wales Western Region would be pleased to receive information on "dieback" and re-establishment of rosewood (*Heterodendrum oleifolium*) in arid and semi-arid lands. They would also be grateful for comments, or advice relating to the articles by Short (p 26, 27), Green (p 41) and Metcalf (p 45).

Books, journals, magazines etc.

Did you know that "Treespeak" a bimonthly newsletter is published by Greening Australia (South Australia) Inc. GPO Box 9868, Adelaide, South Australia 5001.

A new journal 'International Tree Crops' has just been published. You can obtain more information from the International Tree Crops Institute, P.O. Box 283, Caulfield South, Victoria 3162.

Interested in controlling mistletoe? Steven Burke has produced an information sheet about the mistletoe problem. For copies, contact him at Department of Conservation, Forests and Land, 378 Cotham Road, Kew. Victoria 3101.

Victoria's central tree register

In 1987 the Natural Resources Conservation League of Victoria decided to keep a record of all the trees planted in that state. The League has done this by establishing a 'Central Tree Register'. This has shown that 16 241 454 trees were planted in Victoria in 1987! Do other states keep similar registers?

Seminars

7 February 1989 Mt Barker, Western Australia

Insects & Rural Tree Decline - towards a solution

A number of speakers addressed this problem and the role of rehabilitation. Workshops were then held which developed recommendations on:-

1. the role of farmers
2. the role of scientists
3. the role of governments
4. educating the wider community.

The proceedings will be published later this year and can be obtained from:

Denmark Environment Centre
P.O. Box 142
Denmark Western Australia 6333

Conference/Workshop

11-15 September 1989 Busselton, Western Australia

Nature Conservation - The role of corridors

The Conference/workshop is being organised by the CSIRO Division of Wildlife and Ecology, the Western Australian Department of Conservation and Land Management, the Western Australian Main Roads Department and the Western Australian Roadside Conservation Committee.

Conservation of much terrestrial biota depends largely on remnants of native vegetation which have been isolated to varying degrees as a result of changing land use. Many of these remnants consist of corridors of varying widths left alongside roads, railways or watercourses some of which join up with large patches. What is the current role and future of these corridors in the long-term conservation of regional biota, and how best can they be managed?

Each subject will be introduced and reviewed by a keynote speaker in a 45 minute presentation in morning plenary sessions. These will be followed by contributed papers of 20 minutes duration which are related to the subject under review.

Subjects for the plenary session will include the following:-

- inventory and assessment of corridors
- values of corridors
- movement of biota
- management-establishment/maintenance/rehabilitation

Nominated subjects related to the morning plenary session will be discussed during workshops in the afternoon. These will be under the control of a chairperson who will lead the discussion with the aim of producing a series of recommendations as to where future research and management priorities lie.

The proceedings will be published in a similar format to the proceedings of the conference held at Busselton in 1985 entitled "Nature Conservation - the role of remnants of native vegetation" (published by Surrey, Beatty and Sons).

Further information can be obtained from:-

Miss Penny Hussey,
Nature Conservation Conference,
P.O. Box 104,
Como, W.A. 6152

Roadside Conservation Committee (RCC)

Penny Hussey Executive Officer, P. O. Box 104, Como WA 6152

The RCC was set up in November 1985 to co-ordinate and promote the conservation and effective management of rail and roadside vegetation for the benefit of the environment and people of Western Australia. Its funds, provided by the State Government, include $23 000 for research and technical investigations in the financial year 1988/1989.

Revegetation of degraded areas falls within the ambit of the RCC, therefore projects involving revegetation along rail and roadside would be eligible for RCC funding. A contribution towards the travel costs of student projects, for example, would be considered, where the expected result of the project would be of interest to roadside managers.
Interested researchers should apply to the Executive Officer at the above address.

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