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TREE DECLINE AND REVEGETATION

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DEPARTMENT OF CONSERVATION & LAND MANAGEMENT WESTERN AUSTRALIA

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Greening Australia™

TREE DECLINE AND REVEGETATION

N ◆ E ◆ W ◆ S ◆ L ◆ E ◆ T ◆ T ◆ E ◆ R

Department of Conservation and Land Management

PREFACE

Congratulations! Your contributions and interest made Vol. I of the Tree Decline and Revegetation Newsletter a great success. We had 300 copies printed and had distributed them all by the end of 1989.

Volume II of the Newsletter is similar to last year's. There are the same number of items but they address a wider range of issues. We were even sent a book to review!

In the soliciting letter for items and interest for Volume II we asked for volunteers to take over the Newsletter in 1991. We feel that new editors will keep the interest and momentum going. Two groups from over east (the W.A. perspective!) volunteered and we are negotiating with them at the moment. You, the contributors and consumers, will be notified of this sometime in the spring.

We have enjoyed our time as editors, especially the feedback we have had from you. Thanks for making it fun.

ACKNOWLEDGEMENTS

We are grateful to the Research Division of the Department of Conservation and Land Management in Perth and Greening Australia (WA) Inc. for their financial support. We thank Glenda Godfrey for the typing and layout of the Newsletter and for organising the mailing list. We also thank Louise Burch for the cover design and arranging printing.

DISCLAIMER

The views expressed in these articles are those of the authors and do not necessarily reflect the opinions of the editorial committee or of the funding bodies.

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1. RESIDUAL VEGETATION

Measurement of tree canopies

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A system for monitoring tree canopies in a small area is being developed using the ESRI geographic information system ARC/INFO.

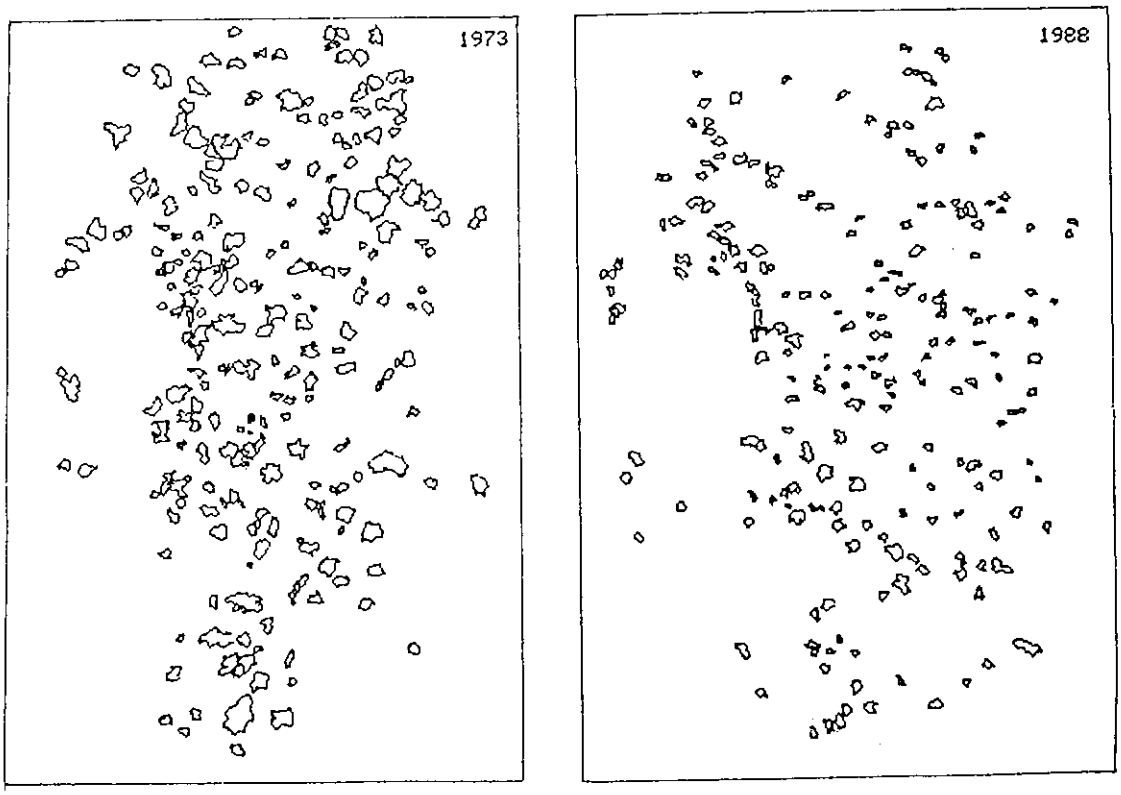
Tuart (*Eucalyptus gomphocephala*) forest at Star Swamp Bushland Reserve has declined noticably in the last fifteen years, at a time when this urban coastal remnant near Perth was being saved from development by the local community. Here oral history is very reliable from long term residents, who have noted tree deaths, smaller tree crowns and a lack of regeneration for the majestic tuarts.

A student at the Botany Department of the University of Western Australia is currently working on a method to calculate the changes in tuart between 1953 and 1988.

The canopies are digitised from aerial photographs using ARC/INFO and then edited to allow polygons to be built. The total area not covered by tree canopies is easily accessible from the data-base and can be compared to the same area in a different year as a measure of the forest decline.

A comparison of canopies between 1953 and 1988 reveal that the tuart forest, once similar to stands near Ludlow W.A., has degraded to an open woodland.

The following diagrams show tuart canopies for the same area of forest around Star Swamp in 1973 and 1988.



Changes in the canopy of tuart (Eucalyptus gomphocephala) around Star Swamp between 1973 and 1988.

Salmon gum research

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CALM's Tree Research Centre has operated from Narrogin since 1985 and has been associated with research on the direct seeding of native trees into old farmland and the ecology of insect pests associated with wandoo (*Eucalyptus wandoo*) decline in the Great Southern Region of W.A.

There has been a change of research staff and policy at the centre in 1989. The Research Centre has commenced projects on the ecology and management of remnant vegetation on private land.

The initial focus of the research is on the composition and condition of salmon gum (*Eucalyptus salmonophloia*) woodland, and how this community responds to protection from sheep grazing. Monitoring plots have been established on a 200 ha farm remnant south of Lake Taarblin that was ringbarked for clearing 75 years ago. The bush was not cleared and the ringbarking event resulted in the deaths of all mature trees and the subsequent regeneration of a dense even-aged stand.

The remnant is typical of many salmon gum woodlands in the W.A. wheatbelt, occurring on low lying clay flats surrounding large wetland areas many of which have lost their tree cover through increased inundation and salinity.

There is widespread mortality of the salmon gums throughout the remnant woodland where the monitoring plots have been established. This could be attributed to self-thinning as competition for resources increases. A rise in the watertable and salinity could also be contributing to the tree deaths.

The dying trees appear to lose their crowns first and then attempt to recover the lost foliage through epicormic replacement along the trunk. Fissures have been noted in the trunks of dead and healthy trees and these may assist in the establishment of pests and diseases. Sites of borer attack on the trunks of live and dead trees have been found near the plots. Few trees appear to survive this regeneration process.

Monitoring of stems per hectare, tree health, water table height and salinity at the plots, along with changes in understorey species will be carried out for an indefinite period. Similar monitoring will be conducted in mature salmon gum woodland at a nearby water reserve for comparison purposes.

Population dynamics, effects on hosts and control of Australian mistletoes (*Loranthaceae*)

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ARC approved funding for this research to commence in 1990. The work continues earlier studies of the demography, growth rates and infection requirements of arid zone mistletoes at Middleback SA and at Alice Springs NT, Dr Mark Stafford Smith (CSIRO Division of Wildlife and Ecology) is collaborating in the work at Alice Springs.

The current research addresses multiple aims:

1. The spatial and temporal dynamics of selected mistletoe populations will be monitored in relation to available hosts. In conjunction with measurements of growth rates, these data will permit the construction of models of mistletoe infection and spread through host populations. The mistletoe species that have been selected are:

   Amyema quandang parasitising *Acacia papyrocarpa*. A marked population of this long-lived, slow growing, "benign" mistletoe has been monitored since 1981 at Middleback.

   Amyema preissii on *Acacia victoriae*. A study site containing this fast-growing, short-lived, "aggressive" mistletoe will be established at Alice Springs in 1990. Due to the rapid turnover in *Amyema preissii* populations, this species will provide the initial data for construction of a generalised model of mistletoe dynamics.

   Amyema miquelii and *A. pendulum* parasitising various eucalypt hosts. These two mistletoe species are probably the most damaging to eucalypts in temperate southern Australia. Marked populations are currently being established in remnant woodlots and forest near Armidale.

2. Work on the effects of varying levels of *Amyema preissii* and *A. quandang* infection on host growth and survival was begun at Alice Springs in 1985. The work will be extended to the eucalypt-parasitising mistletoes at Armidale, and will be conducted under field conditions and in the glasshouse.

3. Severe *A. miquelii* infection is causing occasional deaths of *Eucalyptus blakelyi* and *E. melliodora* in the Armidale region. The efficacy and costs of mistletoe control using fire, herbicides and lopping will be investigated and the effects of each method on host growth and survival compared.

Recent publications

Reid, N. and Lange, R.T. (1988). Hosts, dispersion and persistence through drought of two arid zone mistletoes. Aust. J. Bot. 36:299-313.

Reid, N. (1989). Dispersal of mistletoes by honeyeaters and flowerpeckers: components of seed dispersal quality. Ecology 70:137-145.

Reid, N. (1990.) Mutualistic interdependence between mistletoes (*Amyema quandang*), and honeyeaters and mistletoe birds in arid woodland. Aust. J. Ecol., in press.

2. FUNGAL RELATED TREE DECLINE

Outbreak of Dutch elm disease in New Zealand

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Dutch elm disease is a major disease of elms (*Ulmus* spp.) which has destroyed many of these magnificent trees in Europe and North America. It does not occur in Australia. Its introduction would be a major threat to the many elms planted as ammenity trees in this country.

In January 1990 Dutch elm disease was found for the first time in Auckland, New Zealand. An eradication campaign has been mounted by the N.Z. Ministry of Forests and all known infected trees have been felled, fumigated and buried or burned.

Dutch elm disease is caused by the fungus *Ceratocystis ulmi*. The fungus infects and blocks vessels in the outermost annual ring. Water movement ceases through these vessels, so that the leaves wilt and die. The pathogenic fungus is carried to healthy elms by bark beetles but the fungus can also spread to adjacent trees through root grafts.

Symptoms: In Britain the first symptoms of the disease appear in spring and include wilting of the shoots followed by yellowing and browning of the leaves. Affected branches begin to die back from the tip and in a severe attack the entire tree is killed before the end of the summer. If the tree survives it is often killed the following spring.

When infected branches are cut across, dark spots can be seen in the outer annual ring, often in sufficient numbers to form a definite ring. These spots can be seen as streaks in the wood longitudinal section.

Spread by bark beetles: Dutch elm disease can be spread by bark beetles belonging to the genus *Scolytus* or *Hylurgopinus*. *S. multistriatus* is common on elms in Victoria.

In summer and autumn adult female beetles bore into the bark of moribund elms, tunnelling out breeding galleries in which they lay eggs. The larvae which develop from the eggs feed in the bark and outer sapwood by tunnelling away from the breeding gallery. Pupation occurs in the same region. Adult beetles emerge through small circular holes eaten through the bark and carry the spores of *C. ulmi* on their bodies having brushed against the fungus growing and fruiting in the galleries. Before breeding, young beetles often feed on the tops of elms, particularly in the crotch of healthy twigs. These wounds frequently become infected with fungal spores carried on the beetles.

Hosts: Dutch elm disease attacks only members of the elm family but resistance varies considerably between different species of elm.

What to do: If you think that you have seen symptoms of Dutch elm disease please notify the Australian Quarantine and Inspection Service, your local Department of Agriculture or Forestry Service.

[This account has been compiled from the Commonwealth Department of Health, Plant Quarantine leaflet on Dutch Elm Disease, with additional information from colleagues in Australia.]

Growth (increment and phenology) of jarrah on dieback sites

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The annual increment of jarrah (*Eucalyptus marginata*) in forest infested with the soil-borne, pathogenic fungus *Phytophthora cinnamomi* (i.e. on dieback sites) was compared with the growth of matched trees in adjacent uninfested (healthy) forest for at least 4 years (Davison and Tay 1988). In addition, leaf production and flowering were followed on the same trees for at least 3 years (Davison and Tay 1989). Observations were made at three sites in the high rainfall zone of the jarrah forest.

Growth rate and phenology of jarrah trees in dieback and healthy areas was not consistent betweeen sites. On one site, Churchmans, trees in the dieback area grew significantly faster than trees in the adjacent, uninfested forest. The cambium was active more often and trees had young leaves in their crowns more frequently than trees in the healthy area. This is interpreted as a growth response following a reduction in competition for water from understorey plants which have been killed by *P. cinnamomi*. However, on two other sites, Karnet and Ross, annual increment of trees in both the healthy and dieback areas was similar even though the dieback areas of these sites were as open as the dieback area at Churchmans. Trees in the dieback area of Karnet had young leaves in their crowns less frequently than trees in the healthy area, at Ross the reverse occurred.

Jarrah does not flower every year. There were no differences in the timing of flowering between trees in healthy and dieback areas on the same site. However trees on the different sites flowered at different times. Flowering was earliest at Ross, the most southerly site and latest at Churchmans, the most northerly site.

The inconsistancy of jarrah's behaviour in healthy and dieback areas of different sites makes it impossible to describe any specific effects which *P. cinnamomi* has on jarrah trees. However if site factors are also considered, the picture becomes clearer. The three sites differ in their drainage, the soil profile at Churchmans drains more rapidly than the soils at Karnet and Ross. At these two sites perched water-tables develop above an impeding rocky layer in the profile. *P. cinnamomi* kills understorey species so that, with reduced interception of rainfall and reduced competition for soil water, dieback sites will be wetter than surrounding areas. If the soil profile is well drained we would expect an increase in tree growth with the cambium being active more often and a longer leaf flush on these well drained dieback sites. This is what we observed at the Churchmans site.

On a site where perched water-tables develop, however, we would not necessarily expect increased tree growth. Jarrah does not occur naturally on seasonally waterlogged sites within the jarrah forest, so that if a perched water-table site becomes wetter due to the death of understorey species, perched water-tables will be more extensive and be more persistant than on sites where *P. cinnamomi* does not occur. Jarrah seedlings are rapidly damaged by short term waterlogging (Davison and Tay 1985) so that any increase in the frequency and duration of perched water-tables is likely to affect jarrah trees. This will be most severe in years of above average rainfall.

In addition to direct effects of increased soil wetness on jarrah, if aeration is adequate, sporulation of *P. cinnamomi* increases with increasing soil moisture. In waterlogged soil, infection of jarrah roots is greater than in soil at field capacity (Davison and Tay 1987). On perched watertable sites such as the Karnet and Ross sites, we would expect increased infection of jarrah roots by *P. cinnamomi* than on a well drained site such as Churchmans, but we would also expect more root damage associated with waterlogging.

P. cinnamomi lesions can be quantified on tree roots. We think we can recognise xylem damage associated with waterlogging. We have started to quantify these types of damage on trees at the Churchmans and Karnet sites.

References

Davison, E.M. and Tay, F.C.S. (1985). The effect of waterlogging in seedlings of *Eucalyptus marginata*. New Phytol. 101, 743-753.

Davison, E.M. and Tay, F.C.S. (1987). The effect of waterlogging on infection of *Eucalyptus marginata*. seedlings by *Phytophthora cinnamomi*. New Phytol. 105, 585-594.

Davison, E.M. and Tay, F.C.S. (1988). Annual increment of *Eucalyptus marginata* on sites infested with *Phytophthora cinnamomi*. Aust. J. Bot. 36, 101-106.

Davison, E.M. and Tay, F.C.S. (1989). Phenology of *Eucalyptus marginata* on sites infested with *Phytophthora cinnamomi*. Aust. J. Bot. 37, 193-206.

The impact of *Phytophthora cinnamomi* in the Stirling Range National Park, W.A.

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Research Summary

(A manuscript on this research is in preparation for the Western Australian Department of Conservation and Land Management Technical Report series)

Field studies to assess the impact of the soil-borne pathogenic fungus, *Phytophthora cinnamomi*, on the plant communities of the Stirling Range were carried out between December 1988 and April 1989. A total of 536 plant species were collected, with the Proteaceae and the Myrtaceae the two largest families in the study region. Of the 330 species examined for susceptibility to *P. cinnamomi*, one third were recorded as having at least some individuals in a population killed by the fungus, with 29% of these highly sensitive to the pathogen (more than 80% of plants in a population killed). Species susceptibility paralleled species phylogeny with the results that some families had large numbers of susceptible species while others were apparently unaffected by the pathogen. Notably, 84% of proteaceous species assessed for susceptibility to *P. cinnamomi* were at least partially affected by the fungus. Proteaceous elements had a mean projective foliage cover of 39% in healthy plant communties, but had a mean cover of only 14% at sites which had been invaded by the fungus. In contrast, some species with low levels of susceptibility to the pathogen, such as some monoctyledonous species, were found to be more abundant at infected sites than at healthy sites. Changes in the floristic structure of plant communities may influence the composition of associated animal communities. In particular, vertebrate flower visitors may be vulnerable since 58% of the species with vertebrate-pollinated flowers were found to be susceptible to the pathogen.

Impact of *Phytophthora cinnamomi* and other plant pathogens on ecosystems of the Southern Sandplain region of Western Australia

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Background

The impact of *Phytophthora cinnamomi* in Western Australia has mainly been investigated in forested areas with few studies conducted outside the areas of State Forest. This study will produce a list of species from areas of shrublands along the south coast rated for their susceptibility to the pathogen. This will allow the identification of highly susceptible species to be targeted in both management plans and in genetic conservation programs. The project will be an extension of studies conducted in the Stirling Range National Park in 1988/89.

Aims

(a) To investigate the impact of *Phytophthora cinnamomi* and other plant pathogens in a range of plant community types and assess the susceptibility of plant species to the pathogen.

(b) To examine historical records to identify factors which may have contributed to the spread of *Phytophthora cinnamomi* through the Southern Sandplain region.

(c) To establish permanent monitoring sites to assess the rate of change in plant communities affected by *Phytophthora cinnamomi*.

(d) To investigate climatic correlates in the activity of *Phytophthora cinnamomi* and other plant pathogens in shrublands of the Southern Sandplain region.

(e) To investigate the ecological impact of *Phytophthora cinnamomi* and other plant pathogens on animal communities associated with shrublands of the Southern Sandplain region.

(f) To investigate the impact of *Phytophthora cinnamomi* and other plant pathogens on the productivity of selected monocotyledonous and dicotyledonous species from shrublands of the Southern Sandplain region.

(g) Develop a diagnostic mycology laboratory capable of culturing and identifying fungi.

(h) Establish a mycological herbarium and a mycological culture collection.

3. INSECT RELATED TREE DECLINE

Insect outbreaks in forest in south-western Australia

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1. During the year relevant reports were written on outbreaks of the bullseye borer *Tryphocaria acanthocera* in karri (*Eucalyptus diversicolor*) and on plantation entomology, with special reference to pine (*Pinus radiata, P. pinaster*) and blue gum (*E. globulus*).

2. An experimental autumn fire was carried out in 120 ha of jarrah (*E. marginata*) forest near Collie. The object is to assess the impact on population density of jarrah leaf miner (*Perthida glyphopa*) and on the crown of jarrah.

3. Prescriptions for the release of parasitoids and predators of *Ips grandicollis* in pine plantations were prepared. Other CALM staff have implemented these prescriptions.

4. Prescriptions for monitoring of selected pine plantations to ensure the earliest possible detection of wood wasp (*Sirex noctilio*) and for detailing the action required should Sirex establish in WA, were written. These prescriptions have been implemented by other CALM staff.

5. Some progress in objectively mapping leaf miner outbreaks near Collie was achieved through the involvement of the CSIRO Remote Sensing Group.

6. Newly collected data from near Collie and Manjimup indicate that prescribed spring 1988 burning had little influence on population density of jarrah leaf miner.

7. Data currently being analysed seem to point to annual variation in weather as an important influence in the population dynamics of jarrah leaf miner.

8. My statistical colleague Matthew Williams has looked rigorously into ways of calculating average levels of damage to leaves caused by insects and fungi. A paper is in preparation. A summary of damage caused by insects and fungi to five cohorts of tagged leaves of jarrah is near completion.

9. This year jarrah leaf miner continued to expand northwards in State forest. For the first time it has expanded in two places onto the Darling Plateau from the adjacent Swan coastal plain.

Gum leaf skeletonizer (*Uraba lugens*) in the southern jarrah forest of Western Australia.

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In 1983 a severe outbreak of *Uraba lugens* occurred on jarrah *(E. marginata)* in the south west of Western Australia. Prior to this *U. lugens* was observed to attack isolated rural trees but otherwise was not considered a problem in W.A. Severe defoliation by *U. lugens* in 1983 led to a scorched appearance of jarrah crowns facilitating detection of high population areas from the air.

Aerial observations revealed that areas of severe defoliation existed at distinct locations south east of Nannup and Manjimup and north of Walpole (see Strelein 1988). Infested areas in successive outbreak years expanded from a total of 45 000 ha in 1983 to greater than 160 000 ha in 1986 such that the infestation was advancing on approximately a north easterly front. Ground monitoring of the outbreak using spot checks and observing the canopy with binoculars verified this.

In 1988 the population of *U. lugens* decreased. This was observed to be mainly due to pathological factors such as increased rates of parasitism (prior to 1988 no parasitoids of *U. lugens* had been found in W.A.; Ian Abbott pers. com.) and a mortality factor not yet identified.

As a result of the population decline no discrete areas of crown damage were seen during the 1988-89 aerial survey. Also oviposition rates for the succeeding 1989 generation were so low that egg rafts were difficult to find.

Working from previous data on the front location for 1987-88, ground spot checks during November 1989 revealed that the north easterly front had retracted, leaving three discrete areas of light population levels: 1) near Kirup; 2) Carter and Yornup; 3) Mersea and Warrup forest blocks. Thus these areas could be, according to Berrymans (1986) outbreak theory, population loci from where a new outbreak could spread given the right environmental conditions.

Investigation on the survival rates of *U. lugens* (data as yet not analysed) seems to indicate low survival of the early instars when fed jarrah compared to survival rates for larvae fed *Eucalyptus camaldulensis* in South Australia (Cobbinah 1988). Whether this low survival rate on jarrah is consistent throughout each generation or could vary through environmental fluctuations is not known. At present in the W.A. jarrah forest *U. lugens* populations appear to be kept in check through regulation of two phases of their life cycle.

1. Low survival of early stadia (1-4) possibly due to host quality.

2. High mortality in instars 6-8 due to parasitism by *Euplectrus* sp and an unknown mortality factor.

REFERENCES

Berryman, A.A. (1986). Forest insects, principles and practice. Plenum Press.

Cobbinah, J.R. (1983). Suitability of various eucalypts for growth of the larvae of *Uraba lugens* (Walk.). For. Ecol. Man. 6:361-366.

Strelein, G.J. (1988). Gum leaf skeletonizer moth, *Uraba lugens*, in forests of Western Australia. Aust. For. 51:197-204.

Levels of insect defoliation in forests: Patterns and concepts

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Abstract

Are some forest types more prone to defoliation by insects than others? Recent research has attempted to answer this question empirically, by comparing levels of defoliation recorded in a range of forest types, and theoretically, by making predictions from current herbivory theory.

Conclusion

Are some forest types more prone to defoliation than others? Our review of the available data suggests that at the ecosystem level the answer may be a qualified no: levels of background defoliation, measured as the proportion of leaf area missing from sampled foliage, appear to be rather uniform, tending toward 9%. However, recent research has indicated problems with the more traditional methods of measuring defoliation, and comparable data controlling for methodological variation are too few to determine how universal any generalizations may be. In addition, apparent uniformity in defoliation at ecosystem level masks considerable temporal and spatial variation within forest communities, populations and individuals. No single theory of herbivory is consistent with all the patterns in this variation.

Much of the current theory about patterns of herbivory assumes that observed levels of defoliation predominantly reflect the outcome of narrow insect-plant coevolution. However, this assumption may not be appropriate for systems in which the evolutionary interactions are one-sided, or in which patterns of herbivore distribution are ecologically labile. A better understanding of patterns of defoliation in forests will be achieved by further testing of the insect-plant interaction models, and hypotheses derived from them, in a context broadened to include the often neglected challenges posed by climate and predation.

Editors' note

Abstract and conclusions of an article in Tree 4, (4), 96-100 1989. Copies of the article are available from the authors.

Dieback of rural eucalypts: Does insect herbivory relate to dietary quality of tree foliage?

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Accepted for publication in Aust. J. Ecol.

Abstract

Foliar dietary quality, and the damage that insects caused to the foliage of dieback-affected and healthy *Eucalyptus blakelyi* trees, were monitored for three years, on pastoral properties in the Australian Capital Territory. Compared with healthy trees, the foliage of dieback trees was more heavily grazed by insects, and its dietary quality was generally superior. Some of the differences in dietary quality were related to the average age of the foliage of healthy and dieback trees, but when statistical models were used to equalize the effects of differences in leaf ages, leaves on dieback trees nonetheless tended to have lower specific weights, and were sometimes rounder and contained more nitrogen. Regression analyses of herbivory against each of the dietary quality variables showed that the only significant relationship that was consistent for both of the years monitored was for foliar nitrogen and herbivory for both dieback and healthy trees. In the first year, regressions between herbivory and specific leaf weight, shape, or sugar content were also significant, but only amongst the dieback trees. This may indicate that these relationships were a response to, rather than a primary cause of, the repeated high defoliation of the dieback trees. Multiple regression equations incorporating annual means of several quality variables explained a high proportion of the variance in annual herbivory, but were grossly different between years.

Dieback of rural eucalypts: Response of foliar dietary quality and herbivory to defoliation

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Accepted for publication in Aust. J. Ecol.

Abstract

Rural dieback of *Eucalyptus blakelyi* trees growing on pastoral properties near Canberra is associated with chronic defoliation by insects. In order to test the effect of defoliation on subsequent herbivory, I artificially defoliated three healthy trees by clipping their terminal branchlets. The foliage that regrew on the clipped trees was nutritionally superior to the foliage it replaced, and was much more heavily damaged by grazing insects. There was a transient increase in the tannin content of the regrowth foliage, but this was apparently ineffective in defending it from subsequent herbivory.

Compared with the foliage on nearby *E. blakelyi* trees that also produced major flushes of leaf growth during the same period, the regrowth on the clipped trees had enhanced dietary qualities and suffered more insect damage. Leaf age contributed to many of the differences in dietary quality, but when adjustments were made for the effects of leaf age the same trends remained. Five of the nearby trees were suffering from the chronic insect grazing associated with rural dieback, and the other five appeared healthy. The dietary quality of regrowth foliage on the clipped trees was qualitatively more similar to that of foliage on the dieback trees. Thus the chronic herbivory associated with rural dieback may be partly self-perpetuating, given this positive feedback between defoliation and dietary quality, and an apparent absence of other effective controls on insect populations.

Dieback of rural eucalypts: The effect of stress on the nutritional quality of foliage

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Accepted for publication in Aust. J. Ecol.

Abstract

Canopy dieback of *Eucalyptus blakelyi* trees is often associated with defoliation by insects: the foliage of trees with dieback is nutritionally superior for insects and is more heavily damaged by them. I investivated whether differences in the nutritional quality of foliage were genetically determined, or caused by environmental stress. In a series of glasshouse experiments, with seedlings and grafted plants derived from dieback and healthy populations of trees, I tested the influence of: deprivation of nutrients, drought, waterlogging, saline waterlogging and addition of excess phosphate on the nutritional quality of foliage. Differences in the foliar properties of plants from different genetic sources were not consistent with the differences between the source populations. Most of the environmental stresses applied caused a reduction in foliar quality (decreased water and nitrogen contents, and increased specific leaf weights). I hypothesize that the enhanced nutritional quality of the foliage of dieback trees is more likely to be a consequence of benign growing conditions (e.g. improved soil fertility), than of environmental stress. Field data for soil properties and the effect of drought on mature trees are consistent with this view.

Summary of research involving eucalypt dieback in the New England tablelands

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1. Longterm fieldwork with Prof. Harold Heatwole (Zoology Department, UNE) is being summarized and written up. The abstract of our first paper is listed:

Spatial and temporal variability in defoliation of Australian eucalypts and its consequences for the dieback syndrome

Abstract Leaves in the canopies of eucalypt trees were measured for several aspects of growth and damage from 1982 - 1986, to gauge the impact of leaf defoliation on tree health as correlated with eucalypt dieback. Over 5 000 leaves were monitored, including replicate branches at three canopy heights of several individuals of each of 12 species at six sites. Three types of site were selected, representing the most common conditions in the eastern Australian tablelands: woodlands (comprised of healthy trees but with slight signs of dieback), healthy trees in pastures, and dying trees in pastures. Within each site, the commonest native tree species were selected for study; species were not always the same between adjacent sites, because of interspecific differences in distribution patterns.

Some eucalypts suffered much greater defoliation than others, and this correlated with their observed susceptibility to dieback. *Eucalyptus nova-anglica* (peppermint) and *E. stellulata* lost up to 300 per cent and 274 per cent leaf surface area respectively in one year, and these trees suffered severe dieback. In contrast, *E. caliginosa* and *E. dalrympleana* annually lost as little as 20 per cent and 8 per cent respectively, and showed little evidence of dieback. Other aspects of leaf growth were quantified for each canopy, including numbers of leaves flushing, amounts of leaf area affected by galls and miners, and leaf longevities. The original hypothesis - that defoliation by insects is a major correlate of dieback - was rejected, because more than half of the leaves monitored senesced from causes other than insect damage. However there is evidence that defoliating insects are an important contributing factor, with greater impact than on forest and pasture trees of other continents. It is suggested that repeated defoliation, particularly when trees suffer from other stresses, contributes to eucalypt dieback.

2. A field experiment on defoliation of New England peppermint continues, whereby saplings are being defoliated artificially every time they leaf out again. The trees still appear healthy, although they have been defoliated over a three-year period.

3. Mature New England peppermints (*E. nova-anglica*) were assessed for their total insect load in the foliage during January, the height of summer. This fieldwork was conducted in collaboration with Geneivieve Carruthers of the Ecosystem Management Department (UNE). We selected two mature and healthy peppermints, and then fogged their entire canopies, collecting all insects for counting and identification in the laboratory. Leaf samples from different regions of canopy were harvested for measurement of damage. From this, we hope to determine how important Christmas beetles are in the abundance and distribution of herbivores throughout peppermint canopies.

Assessment of the damage caused by gum tree scale insects, *Eriococcus coriaceus*, to their host plant, *Eucalyptus blakelyi*

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Most studies on eucalypt herbivory assess the impact of defoliating insects but ignore the effects of non-defoliating insects such as sap-suckers. A reason for this is that the damage caused by non-defoliating phytophages can be insidious and therefore difficult to assess. However, some non-defoliating eucalypt pests are common and their host plant relations merit investigation.

One such pest is the gum tree scale insect, *Eriococcus coriaceus*, which is widespread throughout south-eastern Australia, particularly in urban plantings. Damage is caused primarily by the adult females which tap directly into the phloem to suck sap. Since the insects ingest a diet that is rich in carbohydrate, the excess is excreted as a sticky solution known as honeydew. Ants are attracted by the honeydew as a food source and may tend the scale populations. Honeydew not eaten by the ants is often spattered over nearby leaves and stems where the carbohydrate forms a substrate for the growth of sooty moulds; this is why many scale infested trees often have a black, unsightly appearance The growth of sooty mould over the leaf surfaces may interfere with photosynthesis and gas exchange and thus exacerbate the damage caused by scale insect feeding activity.

Despite this potential for damage, trees are only occasionally killed by scale infestations. Just how damaging then are infestations of gum tree scale insects to their host plants? In order to assess the impact of scale insect infestations, a glasshouse experiment using potted seedlings of *Eucalyptus blakelyi* was set up. The performance of 19 uninfested control plants was compared against that of 19 trees infested with an initial population of 100-200 adult females, which was left unchecked for a 6 month period during autumn-winter.

Results from the comparison showed certain differences due to scale insect infestation.

- The height of infested plants was significantly reduced to about 70% that of uninfested control plants.
- There was no significant difference in the total number of leaves but the total leaf area of infested plants was significantly reduced to about 60% that of control plants. This occurred because infested plants compensated for reduced leaf production on the major shoots by producing a basal coppice. However, the basal coppice produced by infested plants consisted of numerous, small leaves whose leaf area was insufficient to compensate for the reduced leaf area on the major shoots.
- All plant parts analysed for dry weight at the end of the experiment were significantly reduced in infested plants, usually to about half the dry weight of control plants. Roots and lignotubers were most significantly affected by scale insect infestation: these were reduced by three-quarters and two-thirds respectively relative to control plants.

As well as directly reducing growth, carbon allocation patterns were also affected.

- Analysis of the dry weights of various plant parts, expressed as a percentage of total plant dry weight, showed that infested plants allocated more matter into leaves at the expense of the roots.
- The root/shoot ratio (= root weight/shoot weight) for infested plants was significantly reduced to about 60% that for control plants, confirming that infested plants allocated much less dry matter into the roots.

- The leaf area ratio (= leaf area/plant dry weight) was significantly higher for infested plants implying that scale insect infestations resulted in plants that were "leafier" on a per weight basis. This agrees with the observation that infested plants allocated more dry weight to leaf matter, despite the fact that leaf area was significantly reduced on these plants. There was no difference in the specific leaf area (= leaf area/leaf dry weight).

These data demonstrate that infestations of gum tree scale insects can have a severe impact upon the growth of eucalypt seedlings if left unchecked. However, in the field, a combination of predators (notably Coccinellidae), parasitoids and adverse weather conditions usually keeps populations in check. No attempt was made in this study to separate the effects due to sooty mould from those due to insect feeding activity. Monitoring of leaves showed that about half the total number of leaves were affected to some extent by sooty mould; it would therefore be reasonable to assume that sooty moulds accounted for a significant portion of the overall damage. Studies are currently under way to further investigate the damage caused by scale insect infestations and to examine, in particular, the contribution of sooty moulds and water, nutrient, and defoliation stress to the host plant.

4. SALINE AREAS

Dieback of isolated sub-coastal stands of eucalypts due to aerial salt

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In some areas of the southern Victorian coast remnant stands of eucalypts are dying back from the seaward edge. The decline appears to be due to strong, salt laden winds and is most apparent inland of surf beaches and very windy coastlines such as around Port Campbell and Wonthaggi. A large number of stands are affected and the syndrome occurs up to 30 km inland from the sea. Grazed tall stands on southwest facing slopes are most severely affected. The study is taking place over a 600 km^2 area in the Wonthaggi-Inverloch region of southwest Gippsland.

The aims of this study are to document this decline syndrome, determine under what environmental and physiological conditions it occurs, determine the mechanism whereby airborne salt damages the vegetation and to make some recommendations regarding management of remnant stands in near coastal environments. Work to date has included the mapping of all remnant stands within the study area, collection of aerosol salt over a 12 month period to determine the level of exposure of the stands and experiments investigating the effect of aerosol salt on various eucalypt species. A survey of 45 remnant stands was also conducted to investigate whether airborne salt is acting in conjunction with other factors in causing tree decline. Data was collected on vegetation health, floristics, soils, land form and land management.

Preliminary results indicate that airborne salt is causing a gradual decline of numerous stands on southwest facing slopes, that stand structure (particularly the presence of an understorey) is very important in determining the extent of the decline, and that there are species differences in airborne salt sensitivity but these are often overridden by grazing impacts on stand health.

This project is funded in part by The Department of Conservation, Forests and Lands and the R.E. Ross Trust.

Establishment of trees in an area of dryland salting in central Queensland, 1984 - 1989

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Progress with this revegetation study to 1987, reported as Parts II, IV and V, was summarised on page 16 of the first volume of the Newsletter. More recent work to 1989 has been reported in Part VI. The complete salinity study from 1977 to 1989 (in Parts I to VI) has been combined as Queensland Department of Primary Industries Bulletin Series QB89006 for which the summary is given in the following paragraphs.

Many farmers in central Queensland have reported developing areas of dryland salting. One area was near Thangool where sunflower and sorghum grew poorly or died. The problem was attributed to areas of high watertable and evaporative concentration of salts. Water flowing from nearby hills where the trees had been cleared was carried through gravel layers and relatively permeable 'softwood scrub' soils until its flow was impeded by heavier textured black earth/grey clay 'brigalow clay' soils where the watertable rose.

A sequence of rubble drains and an open drain were installed on site from 1978 to 1980 and a piezometer network was laid from the hill slopes to the site. Water levels and quality were monitored, revealing increasing salt concentrations from the Permian parent materials of the hills to the site. After 1980 some of the area was reclaimed for cropping but there was no marked reduction in the watertable. A slotted PVC pipe drain with mesh sock, buried in a trench alongside the saline area in 1986, proved inadequate for lowering the watertable further.

An electromagnetic induction instrument (EM 38) was used in 1985 to map the saline area where trees had been planted. Horizontal EM 38 readings were more highly correlated than vertical readings with soil electrical conductivity (1:5) (EC) for all depth increments from 0 to 120 cm. They were also more highly correlated with EC than with soil chloride. Soluble and exchangeable cation profiles corresponding to the range of EM 38 readings were also measured.

An area of the black earth/grey clay was chosen for monitoring tree survival, tolerance to salinity and growth rates. Within this site EC ranged from 0.4 to 3.6 dS/m at 0 and 60 cm (0 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 successful final planting (85% survival) the trend was for less than half of the trees to survive more than 3 months, species survival generally being in the order *E. camldulensis* > *E. moluccana* > *E. melliodora* and *E. sideroxylon* (slow to establish) > *E. citriodora* and *E. robusta*. EC limits (0 to 60 cm) for most trees to survive were > 3.0 dS/m for *E. camaldulensis*, < 3.0 dS/m for *E. tereticornis*, and < 2.5 dS/m for *E. moluccana* and *E. robusta*. Further losses were minor after 6 months and minimal after 12 months. *E. citriodora* and *Leucaena leucocephala* would be considered unsuitable for the site. Tree heights, as indicators of growth rates, were generally in the order *E. camalulensis* and *E. tereticornis* > *E. moluccana* > *E. sideroxylon*, with some variation in this rating according to planting time and techniques. Linear regression equations identified three significantly ($P<0.05$) different patterns of growth rate. Further subdivision according to EC range for growth rates of *E. camaldulensis* indicated, for the first planting, slower growth with increasing EC initially but compensatory growth later.

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*;
- avoid herbicide spray drift.

Where EC at 0 to 60 cm was below 2.5 dS/m *Chloris gayana* grew. In more saline areas on the site *Atriplex muelleri*, *Atriplex semibacatta*, *Enchylaena tomentosa*, *Flaveria australasica*, *Salsola kali* and *Trianthema portulacastrum* were found in 1987. The area of the tree site without *Chloris gayana* decreased from 40% in March 1987 to 23% in January 1989, indicating that reclamation measures were succeeding.

Publication(s):

Standley, J. and Cowie B.A. (1985), Studies on an area of dryland salting near Tangool, 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.

Standley, J., Cowie B.A. and Larsen, A.E. (1987). Studies on an area of dryland salting near Thangool, central Queensland. Part IV. Drainage and salinity in the tree study area 1984-87. Part V. Survival of trees 1984-87. In 'Landscape, Soil and Water Salinity. Principles, Processes, Management, Prevention and Case Studies'. Queensland Department of Primary Industries, Conference and Workshop Series, QC87003, pp B3-1 to 3-10; B4-1 to 4-18.

Standley, J. and Larsen, A.E. (1989). Studies on an area of dryland salting near Tangool, central Queensland. Part VI. Survival of trees, 1984-89; watertable and salinity, 1987-89. Queensland Department of Primary Industries, Brisbane.

Standley, J. (1989). Reclamation studies on an area of dryland salting near Thangool, central Queensland. Problem identification, drainage, measures, salinity monitoring and tree establishment, 1977 to 1989. Queensland Department of Primary Industries. Bulletin Series QB89006.

The effects of tree removal and afforestation on dryland salt distribution in the Murray-Darling basin

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Increasing dryland salinity is one of the now generally recognised consequences of tree clearing. Depending on the initial depth of the water table, the increase in the rate of recharge following clearing, and effects of geological structure, the lag between clearing and the expression of dryland salinity may range from a few up to possibly hundreds of years. Since substantial clearing has occurred in the Murray-Darling Basin (MDB) during this century, continued increases in the area affected by dryland salinsation can be expected if no ameliorative action is taken.

The processes leading to salinisation and the potential of afforestation for reducing salinisation are being investigated in a three-year project funded by the National Afforestation Program. It involves collaboration with several state, commonwealth and overseas agencies, particularly the state soil conservation authorities, Auslig, and Texas, A & M University. The project, which commenced in 1988, has the following objectives:

1. To identify areas of severe dryland salinity hazard within the MDB.
2. To predict the effects of different levels of afforestation on the expression of the salinity hazard.
3. To predict the time-course of the effects of reafforestation.
4. To develop a general methodology which can be applied to a range of land rehabilitation problems.

A variety of research techniques, relating to several levels of biological and physical organisation, are being used to address these goals. Key components include:

1. The use of geographic information systems at scales ranging from 0.0025° to 0.125° latitude and longitude (approximately 250 x 250 m to 11 x 11 km).
2. Remote sensing, particularly thermal imagery using AVHRR, for exploring water fluxes under various seasonal conditions and across bioclimatic gradients.
3. Electromagnetic induction (EM) to estimate salt concentrations in the landscape.
4. Vegetation hydrology using heat-pulse, ventilated chamber and stable isotope methods.
5. Plant growth modelling using non-linear functional responses of plants to water, radiation, nutrients, temperature and salinity.

A geographic information system is being used to assess dryland salinity hazard for the entire MDB at a resolution of 0.125°. The approach taken has been to use the relationship established by Greig and Devonshire (G-D 1981) which related stream salinity (S ppm) levels to the proportion of the catchment area underlain by sedimentary rock (R%) and covered with forest (i.e. >30 projected foliage cover, T %) and annual precipation (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, p 46). 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 approximately 140 sq km) which make up the Murray Darling Basin.

The assumptions made in applying the G-D 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 the component parts.

b. during periods of base stream flow the stream salinity levels reflect the groundwater 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.

As the G-D model was originally developed in central Victoria an analysis has been commenced to ratify spatial extension of the model to the MDB. For the Victorian catchments, upon which the G-D relationship is established, 'changes in vegetation categories since the (stream) records began would be small, if not negligible'. However, this is unlikely to be the case over the entire MDB particularly for the northern New South Wales - Queensland portion. Consequently while the catchment set used by G-D are likely to approximate a steady state equilibrium, evidence suggests that this is not the case for the MDB.

A series of 64 representative (i.e. exhibit the full spectrum of possible variability across the three G-D parameters) catchments encompassing the four states for which at least 10 years electrical conductivity data (a measure of the stream's total dissolved salts) is available and which contain no large areas of irrigation were selected.

The realtionship between stream salinity values and the stream salinity values predicted using the G-D relationship exhibit characteristics of a "frontier relationship" suggesting that, in contrast to the Victorian catchments upon which the G-D was developed, stream salinity values of the selected catchments are not all in equilibrium.

The interpretation of the "frontier relationship" for catchments below the frontier is: a) for those subjected to past clearing the salinity values can be expected to increase, b) those with no naturally occuring forest vegetation should slow a decline in stream salinity levels.

Determination of the dryland salinity hazard will provide an indication of the extent and severity that dryland salinity can be expected to progress to should no ameliorative action be taken. Furthermore, dryland salinity hazard can be used to prioritise ameliorative programs and target more intensive research efforts.

EM readings have been shown to account for some 70 to 80% of the variance in salt levels as measured in cores obtained by drilling, and the EM technique is therefore a powerful tool for carrying out rapid salinity surveys. With presently available equipment, measurements can be made down to 30 m below the soil surface, but the observations reported below are for integrated apparent conductivities to 5 or 7.5 m. Target areas for detailed EM surveys were identified on the basis of the salinity hazard mapping techniques described above or chosen to fall across bioclimatic gradients.

Salt loads have been found to be extremely variable, with apparent conductivities ranging from less than 10 to over 300 mS/m. This variation has been found to be significantly associated with position in the landscape at both small and large scales. Upper slopes of individual hills typically have lower salinities than their lower slopes and across the MDB, the mountain ranges generally have less salt than the low-lying plains.

Apparent conductivities of adjacent cleared and uncleared areas have been measured at many localities. Increases in conductivity were observed at some cleared sites where there was no evidence of water tables having yet risen close to the surface. This phenomenon was investigated by drilling in an arid woodland area in southern Queensland. Upward movement of salt, independents of movements in the permanent water table, was found to have occurred as little as 5 years after clearing, resulting in a concentration of salt centred at about 1 m below the soil surface. The duplex soils on which this phenomenon was observed comprise about 30% of the MDB, and the 'salt bulge' may have the potential to inhibit reafforestation even in recently cleared areas.

For the same southern Queensland site, a relationship between water use (as measured by the heat-pulse technique) and leaf area of trees has been derived. In summer, an average-sized poplar box may use 50 l of water a day. The information on water use is being integrated with existing models of vegetation dynamics, which include effects of salinity, radiation, temperature, nutrients, water availability, and competition, on growth responses. This work has the ultimate goal of allowing the prediction of tree growth and water use throughout the MDB.

Process models of the type described above are being linked to remotely sensed data relating to wetness, greeness and leaf areas, to derive regional water-balance components and predict the movement of salt in the landscape. This work is being carried out along a transect from Broken Hill to Tamworth. The transect spans the MDB and crosses its major bioclimatic gradients.

5. DATA BASES

Selector: Microcomputer assistance for selecting Australian tree and shrub species

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Select (RTDNSL 1988) was developed specifically for use within the environs of the Yass river valley in southern New South Wales for the tasks of providing native species recommendations for each of eight landscape habitats commonly found within the area or alternatively indicating the preferred landscape habitat for any one of some 60 native species climatically suited to the Yass district.

Although SELECT was developed principally to assist the Yass River Valley Revegetation Project to consistently make informed species recommendations for its members, interest and enquiries for SELECT have been received from all over Australia, along with requests that it be made available via a national electronic mail service (e.g. Viatel). Unfortunately, although the concept of SELECT remains valid its usefulness is limited to a) regions or areas with similar bioclimatic conditions as the Yass area, b) regions with similar landscape habitats. Consequently, in its current form, the value of SELECT is severely restricted because of these constraints. However, the interest generated by SELECT has confirmed the need for a package which can be used nationally.

The increasing interest in national tree planting schemes has cullminated in the launching of the one billion trees programme this year. Such programmes highlight the need for assistance in selecting the right species for the area or site and fulfilling the purpose intended. This is particularly so in light of the concern expressed that substantial resources could be wasted and enthusiasm shattered unless attention is given to selecting species well credentialled to succeed. Consequently the need has probably never been greater for a system for recommending species consistently in an informed manner. This background has been the catalyst for the creation of SELECTOR, a nationally orientated decision support system for assisting with the correct choice of native species.

The Natural Resources Conservation League, Victoria (NRCL) has operated a commercial nursery producing trees and shrubs for members (primarily farmers and public agencies) scattered across a large portion of south-eastern Australia. As a service to its members NRCL annually produces a booklet (Tree Planters Guide - for farms and public lands) to help identify appropriate species. This booklet has formed the basis for the data used by SELECTOR. In all, some 241 native species have included in the data base. Each species is classified according to each of the seven factors outlined below. Each factor then has a number of levels (from 5 to 26) to which each species is coded; within a factor, more than one level may be recognised for a species. On some occassions insufficient information is given for a species to be referenced to every factor. Obviously the provision of so many factor-level combinations does not guarantee the existance within the data base of a suitable species.

The factors and levels against which the species have been classified are aspects gleaned from the brief descriptions and details provided in the NRCL booklet. As the remarks etc. tend to be qualitative and not-exhaustive it cannot be inferred that every species has been considered against every level recognised. Subject to interest in SELECTOR the need to produce a more rigorous data base may be warranted. The factors and levels against which a species can be selected are:

Factor 1 - State

2) New South Wales
3) Victoria
4) Queensland
5) South Australia
6) Western Australia

7) Tasmania
8) Northern Territory
9) Australian Capital Territory

Factor 2 - Rainfall

1) Low
2) Low - Medium
3) Medium
4) Medium - high
5) High

Factor 3 - Soil conditions

1) Well drained
2) Wet/poorly drained
3) Marshy/saline
4) Moist soils
5) Banks of streams
6) Tolerant to wet conditions
7) Adapt to wet/saline conditions
8) Tolerant to periodic inundation

Factor 4 - Soil type

1) Sandy
2) Sandy coastal
3) Sandy loam
4) Loamy
5) Clay
6) Gravelly/rocky
7) Alluvial
8) Limestone
9) Acidic
10) Alkaline
11) Deep soils
12) Light soils
13) Wide range of soils
14) Suit better/rich soils
15) Lime tolerant
16) Heavy soils
17) Sandy soils
18) Poor soils
19) Granite soils

Factor 5 - Description

1) Small/low tree
2) Medium tree
3) Small/low shrub
4) Medium shrub
5) Spreading habit
6) Drooping habit
7) Dense growth
8) Prickly
9) Hardy
10) Slow growing
11) Fast growing
12) Deciduous
13) Ornamental
14) Spring flowering
15) Short lived
16) Tall tree
17) Large shrub
18) Climbing/sprawling habit

Factor 6 - Environment

1) Needs sheltered position
2) Prefers warmer climate
3) Responds to pruning
4) Needs moist summer
5) Cool country
6) Hill country
7) Frost tender when young

Factor 7 - Uses/features

1) Timber durable in ground
2) Used for poles/posts
3) Good timber
4) Firewood
5) Windbreak/windscreen
6) Shelter
7) Medium shelter
8) Shade
9) Stock shelter
10) Groundcover
11) Suitable for homestead/decorative
12) Erosion control/stabilization work
13) Drought resistant
14) Pest resistant
15) Catchment areas
16) Harbours beneficial wasp that attacks pasture pest
17) Cold hardy, frost resistant
18) Pest resistant timber
19) Provides emergency stock fodder
20) Yields good honey
21) Effective on irrigation areas
22) High altitudes
23) Attracts birds
24) Restricts stock traffic
25) Will grow in very hard conditions
26) Will stand coastal conditions

As example, say we were wanting to plant a species to provide shelter. Assume we are in New South Wales where the following conditions prevail:

State:	N.S.W.
Rainfall:	Low-medium
Soil conditions:	Wet/poorly drained
Soil type:	Wide range of soils
Description:	Tall tree
Environment:	Not important
Use:	Shelter

Entry of these contraints into SELECTOR leads to the selection of the species recognised as suitable for the conditions stipulated. For this particular example only one species meets the entire set of conditions:

Eucalyptus camaldulensis

SELECTOR requires an IBM PC or clone hosting MS-DOS and runs from a single floppy drive, a printer is optional. Plans are underway for the package to be commercially available.

6. REGENERATION TECHNIQUES

Plastic tree tube trial 1987-1989

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Summary

In autumn 1987 a trial was set up in Canberra to determine the effect plastic tree tubes had on the growth of three different tree species: *Eucalyptus mannifera* ssp. *maculosa, Quercus palustris* and *Pinus radiata*. The growth increase of trees in both 100 cm and 50 cm plastic tubes was compared to that of trees in wire mesh cages of the same sizes.

Analysis of the measurements taken after two years revealed that trees grown in 100 cm plastic tubes had increased in height significantly more than those grown in mesh cages. Height increase in the 50 cm plastic tubes was also greater than trees in mesh cages, though not by as much as the 100 cm tubes. The smaller plastic tubes showed the largest increase in stem diameter. The stem diameter increase of the trees planted in 100 cm plastic tubes was not significantly greater than those planted in wire mesh cages.

On removal of the plastic tubes in late winter 1989 there was an obvious difference between trees grown in the two sizes of plastic tubes. Those in the 50 cm tubes appeared to be quite sturdy and robust, whilst the stems of the trees grown in 100 cm tubes, in particular *Eucalyptus mannifera* ssp. *maculosea*, had trouble in supporting the large amount of foliage which had developed. Many of these trees had stems which bent over until the branches touched the ground.

Direct seeding in South Australia

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Introduction

The Woods and Forests Department has developed direct seeding techniques for a wide range of South Australian conditions. Currently we are able to successfully revegetate with trees and shrubs by this means in any country that receives a minimum of 300 mm/annum of rainfall, except for coastal sands (though we have a research project that is giving promising results for coastal sands). Research on seeding in areas of less than 300 mm/annum of rainfall is continuing in conjunction with the Arid Lands Botanic Gardens at Port Augusta. We have, however, done little work on non-wetting sands and the heaviest of clays but believe these sites are possible also.

The success of direct seeding is dependent upon having weed control for the 6-9 months after sowing. This is achieved mostly with residual herbicides such as simazine, oryzalin and oxy-flourfen. Seeding machines have an agricultural disc to remove herbicide contaminated soil and organic trash from the area in which seed is to be sown. The disc creates a continuous furrow in which cultivating and/or sowing tynes run - the type of tyne depending upon the species being used and the soil type. A press wheel follows.

Machine sown trials

Machine sown trial sites that were sown in 1989 and yet to be finally assessed include the following:-

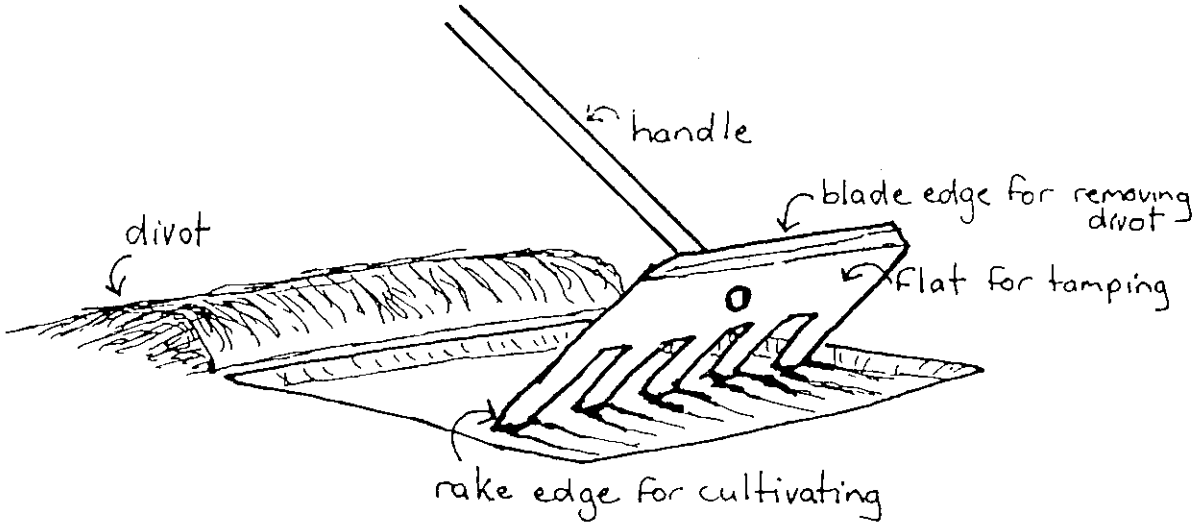
1. 450 mm p.a. rainfall, coastal sand.
2. 400 mm p.a. rainfall, inland but exposed clay loam ridge.
3. 340 mm p.a. rainfall, inland white sand.
4. 800 mm p.a. rainfall, loam.

Each site has the four herbicide combinations considered most appropriate for it, several machinery variations, a range of species, and bitumen/non bitumen mulch comparison (see below). Ripping and non-ripping comparisons are on sites 2 and 4.

Bitumen was included because promising results were achieved in 1988 when a thin layer (0.31 l/m^2) of AMCOO cutback bitumen was sprayed over the sown and pressed seed. The bitumen appears to hold the seed in place, give extra warmth, keep the topsoil moist, and may deter seed predation. AMCOO has the advantage over other bitumen products in that it can be applied with conventional spray equipment (but with large nozzles!) without coagulating. A single fan jet is used to cover the seed furrow. This means that only a small proportion of the total area is covered with bitumen making the operation much cheaper than with total coverage. The bitumen is currently costing about $100/ha.

Hand sown trials

Hand seeding is used when the site is too steep for machinery operation. It is not much more costly than machine sowing and is something that private landholders can easily do. Residual herbicides are still used. A 'spot' 2 m x 2 m is sprayed. A fire rake-hoe is used to remove a divot of herbicide contaminated soil from the centre of the spot. The 'rake' section of the rake-hoe is then used to cultivate the mineral earth, a 'pinch' of seed is thrown into the cultivated soil and the whole is tamped with the flat of the rake-hoe.



Hand seeding trials in 1988 and 1989 have not been finally assessed but indications are that a 3-4 fold increase in number of seedlings can be achieved on sites with high ant populations when seed is dipped in a slurry of permethrin insecticide. We used Coopex - R at the rate of 25 g per 100 ml of water. Seed is air dried before sowing. We believe that ants have been the cause of complete failure on some sites in the past.

Hand direct seeding trial sites are also being used to evaluate the movement of simazine on slopes, and the role of mulches; specifically gravel, bitumen and vermiculite. An assessment 10 weeks after sowing gave the following numbers of plants per 'spot'.

Mulch type	**plants/spot**	**Different at 0.05 level LSD**		
Vermiculite + bitumen	9.1	a		
Bitumen	7.4	a	b	
Gravel/course sand	4.9		b	c
No mulch	3.2			c

Native species transplanting and salvage

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Summary

In years gone by, the catch cry used to be "woodman spare that tree". Nowadays, the call may still be worth heeding in relation to salvaging young to intermediate aged native species of vegetation.

More experience is needed to find out which of our species can be successfully transplanted.

This report refers to successful transplants of several species in the Gosnells Golf Club area mainly, in 1988/89, during late August/September.

1. Origin of Stock Transplanted

1.1 *Callistemon lanceolatus* (Bottlebrush). These trees had originally been planted as nursery seedlings approcimately 4-5 years prior to relocation i.e. 1983/84.

Physical dimensions were approximately 3-4 m tall and girths about 15 cm, although some plants were multi-stemmed. Original spacing of 1-1.5 m had forced upright habit.

1.2 *Ficus hillii.* Two specimens had been front garden specimens at 69 Terence Street, Gosnells, with the usual buffalo grass lawn around the base. Each was of the order of 3-3.5 m tall and 15-20 cm d.o.b.

1.3 *Melaleuca nesophila.* Attempts were made to transplant several plants from a hedge type planting at the Gosnells Golf Club in 1989, which had been spaced at 1.5-2.0 m apart. Height of these was approximately 3.5 m with diameters up to 15 cm o.b. and often multistemmed.

1.4 *Pinus pinaster.* This tree had been windthrown during heavy winter storms in 1988. The root system on upwind side was completely exposed and downwind still in the ground but much bent. The whole tree lay on it's side for several weeks. During this time, the needle growth on the branchlets rotated through 90^{0} to grow vertically again. The tree had been planted approx 20-25 years previously and had attained a height of approximately 7-8 m with a girth of 0.5 m o.b.

1.5 *Eucalyptus lehmannii* (Dwarf Bald Island marlock). Located at the rear of 71 Terence Street, Gosnells, this tree had been windthrown in 1987/88. Upwind roots were exposed, diameter of the bole was 15 cm and height of bole approximately 3.5 m at the time of falling.

2. Transplant and Salvage Technique

2.1 The bottlebrushes were prepared for transplant by:

- lopping branches back to around 1.5 m height above ground level ensuring that tems retained included smaller laterals. Some of these were longer than lopped main stems.
- major roots were excavated and severed by axe approximately 0.5 m from the stem. The remainder of the root system was then lifted out by front end loader on a M/F tractor. As much soil as possible was taken with the transplant.
- a hole of suitable size to receive the lifted plant was made by a Bobcat. The new transplant was placed into the holes and earth replaced and firmly stamped. The operation was completed by copious watering to remove air pockets and consolidate soil. No stake supports were installed, due to weight of the plants concerned.
- during the first summer after transplanting in early September, watering was carried out at fortnightly intervals. Flowering was not upset by the move and all flowered on time.

2.2 Paper barks (melaleucas) were prepared in the same way. However, follow up watering was not effected adequately and all except one failed. The use of "Wettasoil" may also have had some effect, as did the absence of adequate small lateral branchlets.

2.3 *Ficus hillii* trees were prepared by severing all major lateral roots approximately 1.5 m from the stem and cutting the trunk back to around 1.8 m tall, retaining smaller branches where possible.

The whole tree was lifted out of the ground and transported in a trailer to the new site with the roots covered by a plastic sheet. Most of the soil fell away during removal. As in the other cases, a hole large enough for the root system was dug and the plant installed. A support stake was used in this instance because of shallow water tables. They were well watered in and during the ensuing summer at two weekly intervals.

2.4 *Pinus pinaster* (Maritime pine). The lateral branches on one side of the tree had to be lopped to allow a Bobcat bucket to get beneath the bole and lift it up to the vertical. A hole was made to accommodate the root system and backfilled when the tree and roots had been repositioned. Watering was done as for the other trees and earth firmed in by tractor wheels. A rope stay was attached to the bole and tied to a nearby tree. This tree has continued to live so far, but has not yet shown any epicormic shoots which is a feature of this species on occasions.

2.5 *E. lehmannii.* Similarly, the top limbs were cut away leaving smaller side branchlets. The root zone was opened and roots returned to their original position when the tree was lifted vertical. Soil was tamped back and well watered to remove air pockets.

A cement block was placed behind the bole to provide support for the stem. The sequel has been for profuse epicormic shoots to appear at the base of the trunk and on the retained upper shoots. There seems little doubt that this tree will continue to live and enlarge in size.

3. Photographs

General appearance of some of the trees transplanted can be observed from photos which are available from the author at the above address.

4. Conclusions

4.1 It is possible to successfully transplant young trees of bottlebrushes and *Melaleuca nesophila* up to 4-5 years of age, provided suitable preparation is undertaken prior to moving the plant.

4.2 Transplanting is obviously only feasible in winter months when growth is occurring.

4.3 Regular watering is essential after transplanting until new root systems are established.

4.4 Flowering sequences are not necessarily upset by the transplant.

4.5 Windthrown trees of other species can be salvaged depending on circumstances and value of the trees concerned.

Regeneration of salmon gum woodlands in the W.A. wheatbelt

R.J. Hobbs

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A project funded by World Wildlife Fund Australia.

Aim

To investigate and develop low-cost methods of promoting regeneration of tree and shrub species within degraded areas of salmon gum woodland on agricultural land.

Methods

1. Four blocks of degraded salmon gum woodland were selected for study in the Kellerberrin/Tammin area of the central wheatbelt of W.A.

2. Within each blocks, experimental plots, each 25 x 25 m were marked and the following treatments applied in May-June 1989:

    1) Control (no further treatment)
    2) Herbicide added (Tryquat)
    3) Scarification of soil surface
    4) Addition of seed of *Eucalyptus salmonophloia, E. salubris* and 6 understorey shrub species
    5) Combination of herbicide and seed addition
    6) Combination of scarification and seed addition

    Superimposed on these treatments were the following:

    1) Control (no further treatment)
    2) Fencing against stock
    3) Fencing against stock and rabbits.

3. Within each plot, a permanent transect 20 m long was established, and 5, 2 x 2 m quadrats set out at fixed locations along the transect. In each quadrat, percentage cover of native and non-native species was recorded, and the numbers of perennial seedlings counted in October 1989.

Preliminary Results

Virtually no perennial seedlings were found in any of the plots, except for occassional *Acacia* sp. and *Dampiera* sp. In one block several seedlings or vegetative regrowths of *Pittosporum phylliraeoides* were found, but abundance was not related to treatment. Further perennial regeneration will be monitored.

Ground treatments had clear effects on the abundances of non-native annual and perennial species (Table 1). Non-native species were abundant at all blocks except Nock's. Predominant weedy species were *Avena fatua, Lolium multiflorum, Hordeum leporinum* and *Mesembryanthemum* spp. Application of herbicide was effective in significantly reducing weed cover in all blocks. Scarification, on the other hand had no significant effect on weed cover at Riley's and Nock's, but increased weed cover significantly at Leake's and York's. Increase in weed cover with scarification is a predictable result of soil disturbance in these ecosystems. It thus seems that scarification cannot be used as a technique for preparing the seed bed because of its potentially stimulatory effect on weed growth. This study will continue for a further 2 years.

Table 1
Mean percentage cover of non-native species in experimental plots receiving different ground treatments.

Site	Control	Herbicide	Scarification
York's	25.1	6.3	60.8
Nock's	7.2	2.6	3.0
Leake's	13.5	8.6	33.3
Riley's	64.9	11.3	48.5

Weed control and rehabilitation of jam-York gum woodland in the Western Australian wheatbelt

R.J. Hobbs and J. Leone

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A project funded by World Wildlife Fund Australia.

Objective of project

To determine the effects of varying degrees of weed control on plant and animal community composition in remnants of degraded woodland in farmland in the W.A. wheatbelt.

Research Methodology

1. Select replicated areas of *Eucalyptus loxophleba/Acacia acuminata* woodland which are degraded and heavily weed-invaded.

2. Fence entire study blocks and, within each area, subject individual 5 ha areas to one of 3 treatments;

    1) Control

    2) One application of herbicide

    3) Three consecutive annual applications of herbicide.

3. Observe effects of weed control on plant community composition, soil seed stores and seed rain, and regeneration of native species.

4. Observe response of fauna to weed control, using pit traps to assess lizard abundances, and periodic surveys of invertebrates and ground feeding birds.

Progress to date

The project commenced in July 1989, and is funded initially for 3 years. Follwoing an initial survey using aerial photography and ground inspection, three sites near Kellerberrin were selected for study. Choice of site was constrained by the need to have areas >15 ha; the majority of woodland patches within the area surveyed were much smaller than this.

Each site was fenced; this involved only limited fencing since all sites had pre-existing fences on at least some boundaries. Within each site three 5 ha plots were delineated and marked, and assigned randomly to the three treatments.

Within each 5 ha plot, sampling grids and protocols were established as follows:

(a) For sampling of lizard populations, 2 grids of 12 pitfall traps (each 28.5 cm in diameter and 40 cm deep), arranged in a 4x3 grid. Pitfall traps to be opened 4 days and nights per month during October, November, December, February, March and April of each year. Each animal caught in traps recorded and measured, and lizard species marked for subsequent recapture estimates. November and December 1989 samplings trapped a total of 337 animals, comprising 17 lizard and 2 mammal species.

(b) For sampling of herbaceous vegetation, 2 sets of 10 quadrats, each 50 x 50 cm, placed at random in the vicinity of the pitfall grids. Within each quadrat, percentage cover of all species recorded during spring of each year. Pre-treatment recording carried out in October 1989. Also, following germination in autumn, numbers of herbaceous seedlings estimated from a 10 x 10 cm quadrat within each 50 x 50 cm quadrat.
In addition, to assess the overall variability of the herbaceous cover within each 5 ha plot, 10 standardised "grab" samples were taken during October 1989, sorted into species, dried and weighed.

(c) For sampling woody perennial regeneration, 5 transects, each 50 m long, through the 5 ha plot. Recording of all woody seedlings within a band 1 m either side of the transect, to be carried out in autumn 1990 and at regular intervals following treatment.

(d) For sampling seed rain, 2 sets of 5 seed traps located near vegetation quadrats. Traps consist of 10 cm petri dishes coated in bird-repellent gel (which stays sticky for long periods). Traps put out for 1 month periods during September - December of each year. Traps first positioned during November 1989.

(e) For sampling soil seed stores, 2 sets of 5 cores, each 10 cm in diameter and 5 cm deep, taken in each plot during late summer. Cores then transferred to seedling trays in the greenhouse, and watered frequently. Seedlings emerging identified and counted.

5. Herbicide applications will be carried out following germination of herbaceous species during autumn/winter 1990. Arrangements have been made to use spraying equipment owned by the Main Roads Department, W.A. to carry out herbicide applications. Choice of herbicide(s) to be used wil be made on the basis of trials conducted by Main Roads Department and Murdoch University. In addition CSIRO will conduct herbicide trials within the selected study areas during 1990.

Recordings of vegetation and faunal response to treatments will be followed during 1990-1992 as detailed above.

Direct seeding of roadsides (continued)

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Date commenced: **1988**
Expected completion date: **1992**

Aim
To establish a technique of direct seeding which allows the development of a broad spectrum of vegetation species along roadside areas acquired from adjoining developed farmland.

Value of site preparation techniques investigated
This programme has now been running for two growing seasons trialling two weed control techniques. The removal of 50 - 100 mm of topsoil has been successfully used in soils of a sandy or loamy nature. Its success is greatest in areas which have not been deeply cultivated in the process of crop production while under agriculture. Heavy soils and sites where the lower layer of duplex soils have been exposed were not successfully revegetated using this technique. The poor results may be due to a lack of a fine tilth upon seeding of sites with heavy soils. No post emergent weed control has been used at these sites. Germinant rates in plots with this type of weed control often exceed the equivalent of 10 000 per hectare where a seed application rate of 2 kg/ha or more is used.

Where herbicide treatment prior to seeding is used as a weed control technique, success of trial plots has been extremely limited. To date no herbicide treatment can be recommended. Further work is continuing to assess the suitability of herbicide control treatments using residual herbicides 12 months prior to seeding. These sites would then be spray topped with a contact or translocated herbicide 2-4 weeks prior to seeding to remove any new emergents. These trials are concentrating on the use of sulfometuron as the residual herbicide as the more common triazines have not provided the control desired to restrict growth of weeds for one full growing season.

Post seeding weed control
Trials are continuing to establish the impact of a variety of herbicides, used for narrow leafed grass control, on the growth of a broad spectrum of native species. To date this work has been restricted to glasshouse trials. A broad leaf selective is also being investigated for the control of wild radish, wild turnip, cape weed and Paterson's curse in revegetation plots.

Laboratory trials
Laboratory trials have been used to establish the quality of seed used in field trials. From this laboratory work it has become evident that many species require pretreatment prior to seeding. Some of these species, such as acacias, have been known to require pretreatment. Others, such as many Proteaceae, have very low germination rates. These species are often most expensive to obtain and thus some priority is being given to the completion of this work. Other species, such as verticordias, are considered unsuitable for direct seeding due to the lack of seed in seed heads, and thus planting from cuttings or nursery stock is recommended.

Monitoring
Plots are monitored quarterly to assess levels of germination and cover of weeds and germinants. Poorly established plots are abandoned after 12 months, but will be assessed after 48 months to check any progress beyond the 12 month assessment.

At present plots are established at some 20 locations in rural Western Australia.

Direct seeding demonstration trial - 1989

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A broadscale direct seeding demonstration trail was undertaken near Arthur River in the Great Southern Region of the South West of Western Australia during the winter of 1989. The project was a joint effort between the farmer and the Narrogin Research Branch of the Department of Conservation and Land Management. Three sites were chosen all on farmland currently running sheep and rotationally cropped with cereal species. Only 2 sites (0.35 ha and 0.75 ha) were seeded, the third site (1 ha) being inaccessible to farm machinery due to heavy rains in May. A variety of species were selected, mostly local on-site *Eucalypts, Acacias, Casuarinas* and an understorey component.

Low emergence rates (0.3 %, 0.6%) and low survival rates (0.3%, 0.4%) were probably due to the dryer than average seasonal rainfall, with only 70% of the average falling between June and December inclusive, and the lack of post sowing weed control. On site 1 this was compounded by sheep grazing and direct seeding on an already considered "difficult" site (due to the high clay content). On Site 2 a heavy infestation of pasture grasses, especially rye grass (*Lolium* sp.) occurred and a 32 per cent death rate of emergents was recorded. Final stocking rates were 404 and 479 stems per hectare.

The final site will be direct seeded early in 1990 with planning emphasis on post sowing weed control and increased farmer interaction.

Variable seed quality may affect saltbush establishment

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Large areas of soils in south west Australia which have become saline because of rising groundwater tables are being revegetated with halophytic species. Of particular agronomic importance are the saltbushes, *Atriplex* spp., which provide valuable grazing during the autumn feed gap. Establishment of saltbush stands is commonly achieved using a "Niche Seeder". This machine consists of opposed disks which form a raised mound into which a 'V' shaped channel or 'niche' is pressed. At intervals seed is dropped into the niche and covered with a dollop of vermiculite mulch.

Success of direct seeding using the niche seeder has been very variable. In some cases the cause of failure could be attributed to a range of factors including insect damage, weed competition, flooding and drought. Seed quality has, generally, not been considered as a problem by farmers and contract seeders.

Results from seed tests performed by the Seed Testing Laboratory at the Agriculture Department, South Perth, during 1988/89, indicate low quality seed may be the cause of failure in some instances. Seed quality results for the four shrub species most commonly sown on saline soil are shown in Figure 1. Seed quality is highly variable, ranging from 0 to about 80 per cent germination. For *A. undulata* (wavyleaf saltbush) and *Maireana brevifolia* (bluebush) a large proportion of the seed samples tested had germination rates of less than 5 per cent. This compares most unfavourably with wheat which had a 90 per cent germination rate or better for 90 per cent of the samples tested during 1988/89 (Fig. 2).

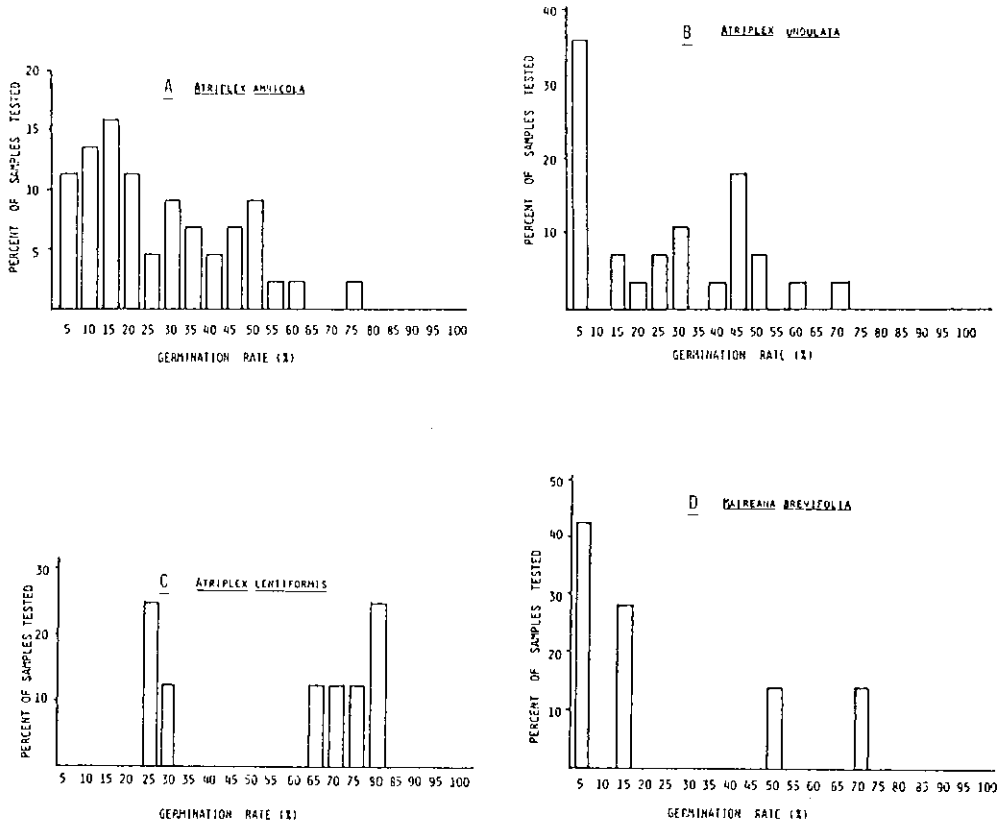

Figure 1: The distribution of germination rates for samples of seed tested through the Seed Testing Laboratory (Agriculture Department W.A.) during 1988/89.

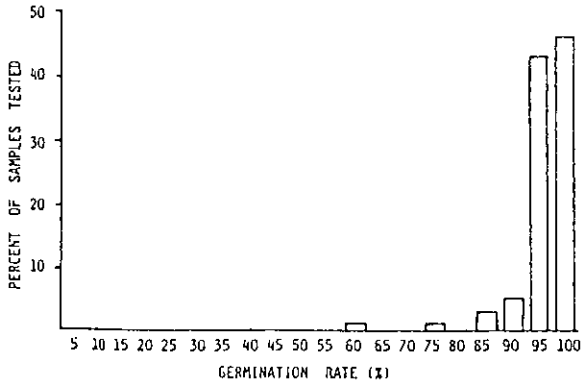

Figure 2: The distribution of germination rates for samples of non-certified wheat seed tested by the Seed Testing Laboratory (Agriculture Department W.A.) during 1988/89.

The effect of seed quality on the sowing required to achieve successful establishment can be large. For seed of *A. undulata* with a germination rate of 70 per cent a sowing rate of 0.1 kg/ha will ensure seed quality is not limiting establishment. If the germination rate is only 3 per cent the sowing rate to achieve equivalent establishment increases to 2.4 kg/ha. For seed of *A. amnicola* (which has a much larger seed) with a germination rate of 8 per cent a sowing rate of 6 kg/ha is recommended.

It is intended to have an extension campaign on the need for testing *Atriplex* seed quality before sowing. Using the germination results appropriate sowing rates can be determined to ensure poor seed quality is not limiting successful establishment.

7. REVEGETATION PROJECTS

Distributing plant nursery stocks to participants in a voluntary revegetation scheme.

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Revegetation schemes are concerned first with identifying suitable plant species for the habitats encountered in the area to be replanted. Then, for rural schemes involving private landholders, overall demands for plant species may be defined in advance sufficient to set a nursery's plant propagation priorities. However, due to the uncertainty of success when using many native plant propagation techniques and, the standard of nursery expertise in voluntary schemes, supplies of particular plant species may significantly undershoot or overshoot the numbers required during a planting season. To cope with the distribution of nursery stocks under these circumstances, a plant allocation model has been developed which maximally allocates the nursery stocks available at any one time given the competing and diverse requirements of landholders (Baird *et al.* in prep.).

The model has been developed and applied using data from the Yass River Valley Revegetation Project (Ive 1989; Ive *et al.* 1989). The computer program SELECT is able to identify 'right tree - right place' combinations for revegetation purposes (Ive 1988). However, when SELECT is used to assist with the task of allocating nursery stocks of plant species to suitable habitats, each landowner's planting request is processed sequentially. Therefore, as the number of participating landholders increases, say to 20, there is an increased likelihood that sequential allocation using SELECT will not achieve an optimal allcoation. The allocation model developed is designed to ensure an optimal and simultaneous allocation given any number of landholders. The model also recognises that, in voluntary schemes, it is desirable that plant allocation quotas be made available to participants in direct proportion to the level of voluntary contributions made. In addition, model design acknowledges that, for ecological reasons, a diverse mix of suitable species is often preferable to planting a pure stand of a single species.

'REVEG' is a prototype computer program which provides an interface to the mathematical programming model which facilitates efficient allocation of nursery stocks to landholders consistent with the habitats to be planted and the voluntary effort to propagate the stock while ensuring that no landholder's entitlement to plants is exceeded. Landholders' individual demands for plant species are expressed as 'plant allocation goals' which may or may not be met given the nursery stocks available. These demands by landowners for numbers of particular plant species (goal type 1), or particular species mixes (goal type 2), are most nearly met subject to (a), the suitability of the species demanded for the habitats present on landholders' properties, (b) each landholder's planting entitlement, and (c), the absolute numbers of each plant species available in the nursery. There is also provision for ranking the plant allocation goals. In practice this means priority in satisfying goals can be pre-defined. For example, it may be desirable for ecological reasons that certain plant allocation goals be satisfied before others, or that certain landholders' requirements be satisfied according to earned rights or entitlements.

REVEG is written in Microsoft QuickBASIC (Version 4) containing modules which interface to a commercially available mathematical programming package for IBM/IBM compatible microcomputers known as LP88 (Eastern Software Products Inc.). REVEG provides for interactive entry of the species-habitat suitability data and all model parameters including numbers of available nursery species; names of landholders, habitats and species; individual landholders' demands for species or species mixes; landholders' planting requirements; and (optional) weights on these species allocation goals. A report generator translates model output into a planting schedule for each landholder detailing the name and number of each species allocated and the habitats for which they are suitable. If required, an inventory of nursery stocks can be obtained after each run of the program.

The REVEG program represents only an initial stage in computer software development. Further field testing of the model and program is required, and should this prove to be successful, development of a computer package for more general use may be warranted.

References

Baird, I.A., Cocks, K.D. and Ive, J.R. (in prep.). Optimising allocation of plant nursery stocks to landholders in a voluntary revegetation scheme.

Eastern Software Products (1987) LP88 (Version 7.03). Linear programming for the IBM personal computer. User's Manual. Virginia: Eastern Software Products Inc., PO Box 15328, Alexandria Virginia 22309.

Ive, J.R. (1988). SELECT: a microcomputer package for selecting tee or habitat combinations. Research in Rural Tree Decline 4: 53-54.

Ive, J.R. (1989). Yass River Valley Revegetation Project. Tree Decline and Revegetation Newsletter 1: 39.

Ive, J.R., Baird, I.A. and Cocks, K.D. (1989). Mathematical programming for optimising landholder allocations of native species to diverse landscape habitats. Tree Decline and Revegetation Newsletter 1: 24.

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

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Completion of first stage

The first stage of the program ended in September of last year with the completion of David's MSc thesis entitled 'Eucalypt Re-establishment on the Northern Tablelands of N.S.W.'. It presents the results of research supported by A.S.R.R.F. and the New England Eucalypt Dieback Research Fund since 1984 on eucalypt establishment in dieback affected land on the Northern Tablelands.

The book and video arising from our work are progressing well. We are yet to raise the funds necessary to produce the video but the book is at the editing stage. A children's book on eucalypt regeneration has also been drafted and we are seeking money to publish it.

The next three years

The next phase of the Eucalyptus Regeneration Program will aim to reduce the cost of farm tree establishment through further refinement of direct seeding and natural regeneration techniques for our area. Also we shall experiment with a range of tree planting techniques (different ground preparation techniques, mechanical planting, different pot designs, and managing stock to encourage trees).

We will plant about 30 000 trees over the 10 properties involved (mostly the same as before). We shall continue the previous trials and have begun measurements on soil salinity on one property. We have been successful in attracting about $45 000 from Australian Special Rural Research Fund to fund salaries and the purchase of some equipment. This has been matched dollar for dollar by the farmers who are paying all the costs of tree establishment (fencing, seedlings etc.).

Publications 1989

Bailey, P. 1989. No rest for the natives. Good Weekend. 11.11 1989, pp 57, 62.

Curtis, D.J. 1989. Eucalypt re-establishment on the Northern Tablelands of N.S.W. MSc thesis, Dept. of Botany. Univ. of New England.

Curtis, D.J. 1989. What's to be done: the New England Experience. pp 28-31. In: Insects and Rural Tree Decline: in search of solutions. (B. Schur, ed) Denmark Environment Centre, W.A. Farmer's Federation, A.C.F.

Curtis, D.J. 1990. Regeneration naturally. Farm. January 1990, p 13.

Curtis, D.J. (in press). New England Dieback - where to now? Acres.

Curtis, D.J. (1990). Over-zealous clearing contributes to dieback. Country Leader 22.1.1990. (First of a series of about 12 articles to be published on the research in the Country Leader, over 1990).

Ford, H.A. (1989). The eastern state's experience. pp. 20-23. In: Insects and Rural Tree Decline (see above).

"Ribbons of Green" - a community tree planting project

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In 1989 Greening Australia WA embarked upon the planning of a project to promote broad spectrum revegetation in Western Australia. Launched in December 1988 the project was called "Ribbons of Green" and provided an opportunity for the people of Western Australia, particularly those who are Perth based, to participate as volunteers, sponsors or co-ordinators of a programme to establish a corridor of vegetation along the Great Eastern Highway, which extends from Perth in the west to Kalgoorlie in the east. The major sponsor for the project was Alcoa (Australia) who provided 150 000 trees and a project manager to progress the concept.

The "Ribbons of Green" programme was designed to promote revegetation as a project which involved the total community. District co-ordinators were appointed to develop the programme in the local area and Greening Australia, through Speakers Bureau, promoted the concept in city and country areas. Groups were addressed in areas from Kununurra in the north to Esperance and Kalgoorlie in the south and east. Other "Ribbons" were planted by community groups, beyond the reach of the Perth - Kalgoorlie project, at Katanning and in the Geraldton region. In all, 1200 volunteers planted the 150 000 plants on the Perth - Kalgoorlie ribbon between the towns of Northam and Merredin on 6 weekends. With the enthusiasm shown it would have been possible to plant another 150 000 without any trouble. Site preparation for the project was carried out by community groups, Local Government and State government authorities.

In 1990 it is planned to plant a total of 500 000 plants along "Ribbons of Green" in Western Australia. All plants are species common in the areas to be planted. In addition, seed collection sorties have yielded quantities of seed which will be used to propagate plants in pots or for direct seeding of areas to be revegetated. A thrust for 1990 will be the concept of growing plants for revegetation, from collection of the seed to the protection of the areas revegetated from weeds and fire after planting is complete. Planting will extend into the eastern wheatbelt and goldfields area of Western Australia in the 1990 autumn and winter, areas where results are not as assured but where revegetation is recognised as essential to the survival of agriculture and a necessary ingredient for rehabilitation of areas mined for gold in this region.

An essential ingredient to this project has been the community ownership of the project. This philosophy will be continued in 1990.

Planning priorities for trees in pastoral Tasmania

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Recognising that most of the resources involved in the application of trees to farming - finance, labour, knowledge, remaining trees and their seeds - are in limited supply, the discussion paper from which these notes are drawn seeks to rationalise the situation and draw the necessary compromises between urgency, practicability and cost effectiveness. In essence it is a review at a lay level, written to promote critical appraisal of Tasmania's revegetation philosophies and directions. None the less, the conclusions have wider relevance than the title suggests and may be extended to other parts of Australia where the circumstances are similar.

Excluding the establishment and management of stands primarily for wood production, which is generally considered not to be economically viable in these drier and naturally less fertile areas, there are four broad approaches to tackling the erosion of tree-dependent values in midland and coastal Tasmania: conservation, direct seeding, planting of natives and planting of exotics. These are treated here briefly in turn and followed by a recapitulation.

1. Conservation of remaining stands

The conservation, management and regeneration of substantial bush areas, on individual properties and on as wide a scale as possible throughout agricultural Australia, is an absolute priority. Here resides a most fundamental and flexible resource on which depends the continued establishment of native trees and the well-being of their genetics and ecologies, both *in situ* and in un-accustomed latitudes, to meet the farming needs of a changing future.

Here also is a paradox. Not only should conservation rate the highest priority but it is also the cheapest and quickest way of securing trees, with their benefits, as a going concern. The relative cost decreases, moreover, with increasing area enclosed; but ironically the more expensive alternative, planting, almost invariably takes precedence over protection.

As another directly practical consideration, from where are the seeds for new plantings and sowing to come if no-one takes care of the last stands on private property? Midland eucalypt seed is already scarce and can cost over a thousand dollars per kilogram to collect, to say nothing of any damage entailed in the process.

Ecological and genetic science are already in a position to suggest a rationale, if not a strategy, for this conservation, but it will need urgently to be translated into action.

It must be added that insects are having their way with the midland eucalypts, which are falling domino-like in a general order of increasing sclerophylly or decreasing palatability. Wind plays a similar final role in the coastal remnants; but in both situations the health of a number of relatively resistant understorey species gives some encouragement and an ecological lead for those engaged in rehabilitation.

2. Direct seeding of indigenous vegetation

Direct seeding is still in the experimental stage. There are several difficulties to be overcome before it can be recommended as a dependable technique in the Tasmanian midlands. In the meantime it makes good sense to persevere with collection and to place the bulk of seed in cool storage where it can be conserved for ten or more years, rather than allow it to dissipate naturally or spend it on large-scale attempts at direct seeding before reliable methods have been developed and proved. Species and provenance testing are high priorities for a proportion of the

seed, as is the establishment of seed production areas *ex situ*: that is in more salubrious localities where eucalypts can be expected to escape rural tree decline and to yield seed in relative abundance.

Sowing has been most successful on the least agriculturally improved sites, where indigenous species retain their competitive advantage and weed seed burdens are lower. Good results have been obtained for years in north-east coastal and island situations, where there are far less rigorous rainfall and temperature regimes than in the midlands, and where, characteristically, 'cocktails' containing larger seeded species e.g. *Casuarina* have been used.

Elsewhere there has been too much emphasis on eucalypts, and possibly also on seed drills. There seems little to commend drill sowing in preference to broadcasting, particularly for fine seed, at least until integrated weed control on pasture sites has been improved.

Though too frost tender for most midland sites, *E. globulus* commonly responds well in sowings. It has the largest seed amongst the indigenes and also shares some of the phenomenal 'get up and go' of *camaldulensis*. Sadly this latter tree is absent from Tasmania's natural suite of eucalypts, and its requirements for germination and early growth could be difficult to meet here in the field.

3. Planting of natives for shelter and land care

Putting aside their long seed-based traditions, Tasmanian graziers when turning to tree growing have opted for nursery seedlings: and the penance of planting. Certainly planting is the proven option for establishment, giving in one package the choice of which species, and where and in what arrangement to have one's trees: and the choice in recent decades has favoured natives, compromised into the narrowest of one, two and three row windbreaks based substantially on eucalypts.

There are some very real aerodynamic and cultural difficulties in using Australian natives in this way. Not the least of these arise from the accelerated lifestyles that they lead. Quite early in their lives in these harsh, isolated and altered conditions, eucalypts are seen to lose their crown density hrough the natural maturing process and through heavy insect and possum attack and increased exposure, to the extent that many soon succumb to decline. Added to this, management and regeneration of natives in such narrow enclosures and maintenance of basic density in areas of low carrying capacity are all potentially difficult. The situation would be improved by planting wider, multi-row belts incorportaing ecologically and aerodynamically balanced mixtures, but landowners gennerally are not ready to give up so much ground and also consider the cost of planting stock to be too high. Broad 'timberbelts' of the cheaper plantation species provide one alternative. Another is to plant ecologically and aesthetically fitting mixtures in block form as extensively as possible and link them with more functional narrow exotic windbreaks.

All this acknowledges the desirability of providing corridors for wildlife and gene flow, though with reluctance concerning the further encouragement of certain native quadrupeds.

Doubt exists also as to how eucalypts will perform in any of these arrangements in the future. The comfortable, conventional wisdom remains, to plant local provenances because "they have naturally adapted/evolved to suit the local environment", even though in our more modified agricultural areas this is now clearly fallacious. Given the ponderous evolutionary processes of trees and the prospects of atmospheric change accelerating into an altogether different time frame, the need to search out the most adaptable of species and provenances and thereby set up what might be termed quasi-ecologies becomes frighteningly pressing.

4. Planting exotics for a similar range of functions

The outstanding import is *Pinus radiata*; and despite its long proven versatility, this Monterey pine still has unfulfilled practical potential on the farm.

As a shelter tree it is quick, reliable, adaptable, wind and drought resistant, aerodynamically manageable, economical of land, remarkably free of pests and diseases on its own account and in respect of farm crops, not very aggressive and possibly marketable at the end of its useful life of 25 to 30 years. With the exception of its brief establishment phase it should, with some management, yield shelter of the highest quality, continuously. No other tree or selection of trees and shrubs can match this range of attributes. Furthermore, pine seedlings are the cheapest planting stock available. For comparable shelter projects in Tasmania, given the need for larger numbers of natives, pine may cost only one tenth to one twentieth of the outlay called for with native plants.

Pine has been promoted also for conventional woodlots on farms and for narrow-sense agroforestry, but its hydrological qualities in relation to soil salinity and stability have received less attention. These various benefits, real and potential, should adequately offset its low habitat value and limited aesthetic appeal, especially when it is integrated into the cultural landscape along with indigenous vegetation and with all due sensitivity.

Several exotics are possessed of an adaptability that is rare or unknown amongst Australian trees at home. The prime case, *P. radiata*, coming from two point sources in California with minimal selection or adaptive breeding, has been hugely successful over 18° of southern latitude. Other exotics, coniferous and deciduous, have been used widely in the past to support agriculture in Tasmania. In the present crisis it is crucial that there should be a return to a more eclectic attitude towards trees in agriculture.

Recapitulation

The conclusions to be drawn concerning trees and their values are that the most urgent, indeed desperate needs in the pastoral areas of Tasmania are (1) the conservation of substantial representative stands of woody vegetation and (2) the establishment of cost, time and function effective shelter; and that (3) this will require intellectual and material input from the far greater resources of mainland Australia and wood-production forestry.

The views expressed here are those of the writer personally. They are not necessarily endorsed by all professional foresters or the Forestry Commission. Their purpose is to stimulate thought, discussion and, it is hoped, a critical examination of the depth and direction of Tasmanian and national commitment to trees in agriculture.

Historically speaking, mistakes in large-scale tree planting are by no means rare. Characteristically the errors become evident a decade or more downstream. In the present situation of a fast declining indigenous resource and possible global climatic change it is vital as never before that we are right on course in our plans and programmes for the rural tree, and that this should not entail blindly pinning our faith on a single limited option, as appears almost to be the case in Tasmania at present.

A tree buffer zone around the town of Emerald to reduce chemical spray drift

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In recent years concern has increased about the level of chemical spray drift from adjacent cropland into the town of Emerald in Central Queensland.

As a component of a pollution control strategy, a biological buffer zone to surround the town has been recommended. The function of the buffer will be to intercept spray drift and to capture spray droplets and chemical residues.

The buffer will consist of extensive tree and shrub plantings to complement existing remnant vegetation around Emerald. Detailed site assessments are under way and suitable public and private land is to be recommended for the buffer reserve. A total of 187 ha of retained, regenerated or planted vegetation is to be included in the project.

The design of the planted sections of the buffer will include a progressive height variation across the buffer to capture various droplets and residues. The planting will consist of three main sections, the outer section will be primarily closely planted shrubs to four metres height to capture large droplets and dust. The middle section consists of wide spaced glaucous leaved trees to fifteen metres in height. This section will be the principal air filtering and chemical intercepting component of the buffer. Wide spacing will allow air movement through the trees rather than deflection over them. Glaucous leaf surfaces will enhance the fine particle capture potentials.

The inner sections of the buffer will be taller timber producing trees which will serve as an additional filter for droplets in air drifting over the filter trees.

The extent of effectiveness of this type of planting is not yet known. Evaluation of droplet capture and buffer effectiveness will be made as the plots grow.

Species selection for the plantings have primarily concentrated on suitable local species bearing in mind other benefits such as wildlife habitat, windbreaks, visual appearance and timber potential. Indigenous eucalypts, acacias, and casuarinas will be the primary species used in these plantings.

A full time project officer has been appointed to implement the planting and to promote community involvement and ownership of the buffer in Emerald.

Suggestions have been made to the Emerald Shire Council that the buffer become part of the town plan and that by-laws be adopted to protect the area from rezoning or redevelopment in the future.

8. NEWS AND VIEWS

Books

1. **Bush regeneration** - Recording Australian Landscapes $24.95
Robin A. Buchannan, NSW TAFE Student Learning Publications. Available from ABC and other large bookshops around Australia.

Many people across Australia are actively involved in the preservation and management of bushland in their local community. Until recently there have been no books on the subject to help these volunteers. Technical advice and direction has been sought from universities and government departments or passed on from more experienced volunteers.

"Bush Regeneration - Recovering Australian Landscapes", by the experienced Sydney bush regenerator and horticulture lecturer Robin Buchanan, will provide a good reference book for many community groups running bushland management projects.

The book has been written as a text for the NSW TAFE Bush Regenerators Course but will have a much wider audience than this. It will appeal to anybody interested in learning about this important new field of applied ecology. "Bush Regeneration" contains useful technical information on all aspects of bushland management, backed by well compiled case studies and supported by good introductory chapters on botany and ecology.

Bush regeneration has good colour photographs and well drawn graphs and diagrams, but I found that, except for chapter 8, the lack of visable table and figure captions awkward.

The book is not a complete review of the literature relating to the ecology and management of urban vegetation in Australia, nor the restoration of agricultural lands but I doubt if this was one of the author's aims. This would indicate that there are more scientific publications and technical reports available on both subjects than previously recognized and that reviews are necessary.

I do hope that this book enjoys the circulation and everyday use that it deserves and I commend Robin Buchannan for completing such an enormous undertaking.

2. **Urban Forestry Handbook**, by Richard Buchhorn, David Jones and David Robertson, Melbourne Region, Department of Conservation Forests and Lands, Victoria 1989, $12.00.

'Urban Forestry Handbook' is a regeneration techniques and planning manual for urban natural areas for use by anybody involved in their care and management. The name of the book is derived from the European and North American tradition of tree and park care in cities.

Techniques covered by the book include tree planting and care, weed control and fencing.

There is a very useful guide to costing bush associated projects as well as organizing management plans for urban areas. The authors use seven case studies of urban regeneration and forestry projects in Melbourne and three other Victorian urban centres to support these discussions. There are also clearly labelled sketches and black and white photographs where appropriate.

The book's focus on solving the problems related to managing urban bushlands in its main strength and it will be of great assistance to many community groups and reserve managers employed by government agencies.

Patrick Pigott

3. **"Guidelines for the Clearing and Maintenance of Roadside Vegetation by Local Government".**
Roadside Conservation Committee, W.A., 1989.

A small booklet which outlines road construction and clearing techniques to minimise the need for roadside vegetation destruction when upgrading of existing roads is undertaken.

Obtainable from Roadside Conservation Committee, PO Box 104, Como W.A. 6152.
Cost - single copy free; multiple copies - $2.00 each.

4. **A Conference/Workshop on "Nature Conservation - the Role of Corridors:"** was held at Busselton, Western Australia, on 11-15 September 1989.

A number of the papers submitted, and several of the workshops covered topics of interest to readers of this Newsletter. It is hoped that the full proceedings will be published by December 1990. A booklet containing a summary of the recommendations should be available by mid - March.

For information about either publication, contact:
Penny Hussey: Roadside Conservation Committee, PO Box 104, Como W.A. 6152.

Views

Two position papers containing interesting ideas and suggestions regarding remnant vegetation management have been sent in to us. While not strictly research, and so not suitable for printing in full in this Newsletter, we feel the points they raise might be of interest to many of our readers.

Copies of the papers may be obtained from the authors.

1. **Why not a 150% tax refund as a financial incentive to farmers to plant trees?**
Malcolm Campbell
Greening Australia (SA) Incorporated, GPO Box 9868,
Adelaide S.A. 5001

2. **WA's biggest nature conservation problem: land clearing in the south west. Proposals to reform the land clearance permit system in Western Australia**
Basil Schur
Australian Conservation Foundation, WA Project Officer
PO Box 142, Denmark W.A. 6333

Soil Conservation Conference

The 5th Australian Soil Conservation Conference, postponed from September 1989, will be held in Western Australia between Monday 19 and Friday 23 March. During the first three days, 10 Workshops will be conducted in the south-west and goldfields regions of W.A. These workshops are as follows:

Land Capability Assessment;
Erosion/Productivity and Prediction;
Stable Cropping Systems;
Dryland Salinity Management;
Vegetation Retention and Replacement;
Range Monitoring;
Information Systems;
Group Extension/Community Involvement;
Community Awareness and Education and Integrated Catchment Management.

The Vegetation Retention and Replacement workshop will be held at the Nanga Bush Camp near Dwellingup in the Northern Jarrah Forest. The first day will comprise a tour through part of the central wheatbelt and include visits to farm revegetation projects and discussions about the problems of managing remnant native vegetation in the area. The second day, also a bus tour, will include visits to reafforestation projects in the high rainfall Collie catchment and relevant discussions about resource management in these areas.

It is hoped that the conference will provide a good scientific and extension springboards for those involved in resource management for the 1990's; the Decade of Soil Conservation.

Patrick Pigott

Direct Seeding Conference

Rob Youl

Greening Australia, c/o National Herbarium,
Birdwood Avenue, South Yarra, Vic 3141

Of Mr Hawke's target over the next decade of one billion trees, six hundred million are to be established by direct seeding or as a result of natural regeneration. A conference in South Australia in May will help achieve this goal.

The conference is being organised by Greening Australia, with Federal Government sponsorship, for landcare professionals, farmers, mining industry technologists and others interested in revegetation.

Titled "Sowing the Seeds - Direct Seeding and Natural Regeneration", the conference will be held from May 22 to 25, at the Adelaide Convention Centre.

Direct seeding of Australia's native trees, shrubs and grasses is considered to be one of the most important technologies in the battle against land degradation.

It is also inexpensive, and a technology in which Australia has world leadership. Direct seeding means that trees and shrubs are planted with machines in the same way as farm crops and pastures. Every state has direct seeding projects, many of which are associated with rehabilitation after mining.

Natural regeneration is another useful and economical technique. Gemination from natural seedbeds can be enhanced and the resulting seedlings readily maintained. Surplus seedlings can be transplanted.

The objective of the conference is to distill current research knowledge and the practical know-how of scientists, farmers, miners and contractors. It will also point to new areas for research and development.

The conference will have a field day for inspection of large projects around Adelaide, plus demonstrations of the latest direct seeding techniques and equipment.

Although the conference is mostly for the benefit of Australia's tree-planting program, Greening Australia foresees it having great interest to overseas countries where Australian native species can help overcome land degradation problems.

For conference mailing list registration contact The Secretariat, Greening Australia Sowing the Seeds Conference, PO Box 232, Kensington Park, South Australia 5069. Phone (08) 31 1875; Fax (08) 332 8810.

For press inquiries: Geoff Wilson, Ph (03) 571 6209; Fax (03) 571 8502.

Roadside Conservation Committee (RCC)

Penny Hussey

Executive Officer, P. O. Box 104,
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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 1989/1990.

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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