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A study tour of south-west Western Australia and the Armidale Tablelands: Tree decline, revegetation and farm forestry
D.C. Close
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Dugald C. Close

Project B3: Silvicultural Systems

Cooperative Research Centre for Sustainable Production Forestry
GPO Box 252-12, Hobart, Tasmania 7001

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Executive summary

A study tour of south-west Western Australia (WA) and the Armidale Tablelands, NSW, was conducted for the benefit of the Natural Heritage Trust (NHT) project 'Revegetation to combat tree decline in the Midlands of Tasmania' being undertaken at the Centre. Tree decline and its underlying causes were investigated in both regions. Drought was associated with tree decline, although its effects were localised and species specific. On the Tablelands decline was associated also with agricultural land use, a factor commonly associated with rural tree decline (RTD). However, observation indicated that RTD in Tasmania was more severe than in south-west WA or the Armidale Tablelands.

Experience with revegetation on the Armidale Tablelands indicated that weed control, mound ploughing and watering had increased average survival of plantings from around 60 % (ten years ago) to over 90 % (current). Matching species to upper, mid, lower slope or flats was also essential. This is consistent with new recommendations for revegetation in the Midlands of Tasmania using best practice (Close and Davidson 2001). *Pinus radiata* nurse crops in south-west WA and the Armidale Tablelands benefited native plantings by ameliorating the microclimate through reductions in wind speed and increases in temperature. Such shelter was associated with recovery of predator numbers and improved control of insect pests. This finding has prompted the testing of *P. radiata* as shelter at the NHT demonstration trials in the Midlands.

The study tour confirmed that ectomycorrhizal fungi are low in abundance and diversity in revegetated compared to remnant or native stands and that their introduction is essential to successful re-establishment of native trees and shrubs. An expert in this area will be invited to assess ectomycorrhizal fungal diversity and abundance in Tasmanian revegetated and remnant sites and assist in raising awareness about this issue.

Salinity has been caused by clearing of native vegetation in both south-west WA and the Armidale Tablelands. Salinity in south-west WA is extensive but can be controlled by tree planting if in adequate numbers and with sufficient density. Given that one Midlands planting is in close proximity to a significant salt scald, monitoring salinity and of levels of the water table will be undertaken.

Farm forestry is an emerging industry in south-west WA and is being promoted as a viable economic enterprise alongside livestock and crop production. However, given the constraints of low temperature and rainfall in the Midlands, farm forestry may not be an economically viable option. It is recommended that revegetation with trees be managed for the purposes of livestock and pasture shelter (economic) and biodiversity, soil and water conservation (environmental).

Introduction

The limited success of revegetation programs, the low profile of farm forestry, salinity an emerging issue and a poor research base associated with severe tree decline in the Midlands of Tasmania, prompted a study tour of south-west Western Australia (WA) and the Armidale Tablelands, NSW. This report of the tour is divided into five sections: 1) tree decline – a nationwide phenomenon; 2) revegetation; 3) the importance of reestablishing ectomycorrhizal fungi; 4) managing salinity and; 5) farm forestry – a tool for managing salinity. The outcomes and benefits of the study tour are described.

Tree decline - a nationwide phenomenon

Whilst tree decline has been relatively well publicised and the subject of research on the Armidale Tablelands (Photo 1), and to a lesser extent in the Tasmanian Midlands (Photo 2), it is a nation-wide phenomenon. Severe tree decline is more recent in North Queensland (Fensham and Holman 1999) and in south-west WA (Wills et al. 2001a; b) (Photo 3) where drought is indicated as the catalyst. However considerable patchiness occurs on a local scale and some species are more susceptible than others. In south-west WA *Eucalyptus wandoo* (wandoo) and *E. gonphisophala* (tuart) but not *Corymbia calophylla* (marri), and on the Armidale Tablelands *E. nova-anglica* (New England peppermint), *E. blakelyi* (Blakely's red gum), *E. melliodora* (yellow box) and *E. viminalis* (manna gum) but not *E. pauciflora* (snow gum), *E. stellulata* (black sallee) and *E. caliginosa* (broad-leaved stringybark), are susceptible. Tree decline can occur in the absence of other causitive factors such as outbreaks of insect attack, or pathogenic diseases, and irrespective of whether the vegetation is in reserved native forest (Photo 4) or associated with agricultural land-use (A. Wills pers comm.) in an acquifer that has been drained because of drought (Wills et al 2001b). However, in particular cases, e.g. decline in *E. rudis* (flooded gum) that occurs in agricultural landscapes along water courses and drainage lines, it can be due to chronic damage by lerps and caterpillars that are in elevated numbers due to an imbalance with natural enemies induced by rural land use (A. Wills pers comm.).

Tree decline on the Armidale Tablelands does not occur in native forests (Morgan and Terrey 1999). Rather, it is associated with flat, good quality soil types that have been cleared for agricultural land and are typically managed as improved, fertilised pastures used for livestock production (Photo 1): such decline is referred to as rural tree decline (RTD). Rural tree decline is less severe, or does not occur, on slopes of lower soil quality where pastures are typically neither fertilised nor improved. Thus, RTD on the Armidale Tablelands is putatively caused by the combination of competition by trees for moisture with improved pasture, the effects of high intensity grazing and relatively low landscape positions that are subjected to low temperatures. Temperature differences of 10 °C have been measured in winter between flats and slopes only hundreds of metres apart (D. Carr pers. comm.). Very localised patches of dryland salinity may have contributed also to decline on some of these flats (D. Carr pers. comm.). Although large differences exist in the severity of RTD between land types, severe decline may be associated with extended drought in the late 1970's (C. Nadolny pers. comm.). Interestingly, levels of RTD are now considered less severe (D. Curtis pers. comm.). Many farmed areas have been farmed for over 100 years. Thus, isolated trees in decline in paddocks may well be well over 100 years of

Photo 1. Rural tree decline on the Armidale Tablelands.

Photo 2. Rural tree decline on a property called 'Woodland Park' in the Midlands of Tasmania.

Photo 3. Rural tree decline in south-west Western Australia

Photo 4. Tree decline in stands of *Eucalyptus wandoo* (wandoo) in reserved native forest.

Photo 5. Over 20 species of fungi fruit on this fallen log throughout the year (N. Bougher pers. comm.).

Photo 6. A highway strip planting where a gap has been caused by low temperature induced mortality of species not matched to the low temperatures. Cold air stratifies and flows through and into low-lying areas of the landscape, such as the gap in this planting.

age and trees decline with old age. Thus the scenario on the Armidale Tablelands is analogous to that in the Midlands of Tasmania, although more recent drought in Tasmania may explain the relatively greater severity of RTD at present. Drought-induced tree decline in both south-west WA and the Armidale Tablelands implicate drought as a major factor in decline in Tasmania. In addition as on the Armidale Tablelands, this is exacerbated by fertilised and improved pastures, grazing and cold in flatter areas.

Clearing and tree decline has led to rising water tables in both south-west WA and the Armidale Tablelands. This has caused patchy salinity on the Tablelands and a severe environmental problem in WA. Salinity and waterlogging causes tree decline in discharge areas of the landscape.

Observation of the relatively low level of decline on the Armidale Tablelands emphasises the extent of the problem in the Tasmanian Midlands. The Tasmanian Midlands has potentially an unrecognised environmental crisis associated with rural tree decline. This may well lead to salinity that although presently considered a minor problem, may develop into an environmental issue of considerable significance. This emphasises the importance and critical nature of revegetation programs and their successful outcome.

Revegetation – is it just as difficult elsewhere?

Revegetation programs in south-west WA appear to be more successful than those on the Armidale Tablelands and the Tasmanian Midlands for three main reasons: 1) the predictability of seasonal rainfall; 2) pasture and weed species are annual and; 3) mild temperatures. Generally, species are matched to average annual rainfall on the farm, sites are ripped and mounded six months prior to planting and weeds are knocked down after first germination following rain (D. Huxtable pers. comm.). This prescription, when followed correctly (!), typically results in over 95 % successful establishment (D. Huxtable pers. comm.). Possums are not an issue and insects not a major issue in revegetation programs (D. Huxtable pers. comm.). However, in some districts '22' parrots that chew the bark off seedlings and saplings are a serious pest. One study has indicated that little nutritional gain to parrots is provided (ample grain from the feeding of livestock is a more nutritious alternative) but that teenage 'vandal' parrots develop destructive habits out of 'boredom' (G Batty pers. comm.).

Revegetation in areas of tree decline on the Armidale Tablelands is largely constrained by factors similar to those in the Tasmanian Midlands. Given the low absolute temperatures experienced on the Tablelands, and the large temperature differences between slopes and flats, matching of species to site is absolutely critical (M O'Keefe pers. comm.) (Photo 6). Experience has shown that the 'shot-gun' approach to species planted is not ideal. Lower-slope/flats species are adapted to the colder temperatures and heavy soils whereas mid- and upper-slope species are adapted to milder temperatures and lighter, poorer soils. Sites contracted for revegetation to the non-profit-making community nursery are assessed prior to planting to allow selection of species best suited to the site (M. O'Keefe pers. comm.). Up to 70 % of plantings now comprise shrubs with tree numbers at densities of around 1000 stems ha^{-1}. The shrubs attract natural predators (insects and birds) of pest insects. Other factors such as the availability of a mound plough for site preparation and a watertanker to allow watering in of each seedling with 2-3 L of water (C. Nadolny pers. comm.) have enabled the community nursery to guarantee over 90% survival in plantings. In the absence of highly episodic insect pests, plantings are not damaged by herbivores (particularly possums). Further, summer grasses tend to dominate perennial pastures (C. Nadolny pers. comm), so browsing and competition for moisture and nutrition are not as severe as experienced in the Tasmanian Midlands. The lack of possums in both south-west WA and Armidale is attributed to the feral fox population.

A large scale experiment on the University of New England research farm has shown that > 20% pasture production occurs on paddocks sheltered by patchy, small shelterbelts. This is attributed to shelter from wind and cold air flowing down slope (C. Nadolny pers. comm.). Similarly, a leading farmer in the Kentucky district, where tree decline has been most severe and the landscape is largely treeless, has demonstrated that native plantings had greater survival and establishment when sheltered from wind and cold-air flow by a row of *P. radiata*, than when planted in isolation. Subsequent studies have shown that the *P. radiata*-induced altered microclimate can attract native birds and predatory insects and speed up ecological restoration compared to native plantings without *P. radiata* shelter (B. Jenkins pers. comm.).

The importance of re-establishing ectomycorrhizal fungi

In WA, soils with inherently low nutrient content can support large trees in woodlands of closed canopies, whereas agricultural crops grown on similar soils require constant nutrient application (Tommerup and Bougher 2000). Tree growth in such infertile systems is possible because of ectomycorrhizal fungi that make soil nutrients available to plant roots, enable efficient nutrient cycling within ecosystems and act to increase effective root area, thereby increasing acquisition of nutrients and soil water. However, the diversity and abundance of ectomycorrhizal fungi in revegetated areas are far below those in remnants or native bushland (Tommerup and Bougher 2000) (Photo 5). This may be a factor in the limited success of some revegetation programs. To counter this loss of endemic ectomycorrhizal fungi, CSIRO Forestry and Forest Products in WA have developed and maintained an extensive 'fungi-bank' analogous to a 'seed-bank' for the purposes of conservation. Ectomycorrhizal fungi therefore need to be re-established, along with trees and shrubs, in areas set aside for revegetation (Photo 7). Methods for doing this have been developed by CSIRO (e.g. Tommerup and Bougher 2002).

Salinity

Salinity is a major environmental issue in WA. Clearing of native vegetation for agriculture has increased recharge from < 0.1 mm yr^{-1} to > 10 mm yr^{-1} (N. Robinson pers. comm.). Increased recharge has caused the rising of salty watertables. Salinity is forecasted to affect up to 17 Mha of land in WA in the next 50 years. A NHT-funded project 'Putting trees in their place' has aimed to find the required distribution and density of plantings on farms required to control salinity. In medium rainfall areas (550-700 mm) plantings consist of *P. radiata* and *P. pinaster*. In low rainfall zones (350-550 mm), oil mallees (*Eucalyptus loxophleba* subsp *lissophloia*, *E. polybractea*, *E. kochii* subsp *plenissima* and *E. horistes*) are planted in rows of two to

Photo 7. Restoration revegetation where ectomycorrhizal fungi have been re-established along with native trees and shrubs.

Photo 8. Oil mallee hedge plantings established in low rainfall zones (350-550 mm) for salinity prevention and amelioration.

Photo 9. A grade bank which aims to move water to a natural drainage line. Trees are planted behind the bank to maximise utilisation of water that infiltrates the soil.

maximise edge affects (Photo 8). These form extensive root systems and lignotubers. Hedges have leaf area indexes (LAIs) of seven, typically giving an equivalent LAI of 0.5 across the paddock (N. Robinson pers. comm.). The project found that soil water was used from 5-10 m deep and 10-20 m laterally, depending on soil type. This work has led to the recommendation that alleys need to be 20-40 m apart (N Robinson pers. comm.). Such plantings are being established by farmers, particularly in discharge areas. Generally, alleys of a single booms-width are used to allow for continued wheat cropping or pasture production. To provide incentive for farmers to plant mallee hedges in recharge areas, industries based on eucalypt oil and biomass for energy production are being developed. Mallees have been selected for cineole content and can be harvested at age 5 years and then from coppice every 3 years. Another project is looking at alternative species for alley plantings in waterlogged discharge areas: Melaleucas show promise (D. Huxtable pers. comm.).

In addition to tree planting, earthworks are used to manage salinity. Contour or interception banks aim to intercept and hold water up-slope. Trees are planted immediately behind these banks to use the intercepted water (Photo 9). Grade banks typically have a 0.5 % grade and direct water from up slope to a salt lake, dam or natural drainage line.

Farm forestry

Farm forestry has been under development for the past 25 years in south-west WA and is an emerging industry in the medium rainfall region of 450-650 mm yr^{-1}(R. Moore pers. comm.: Photo 10). Farm forestry relies on thinning from > 1000 to approximately 150 trees ha^{-1} (at between age 3-7 years) and pruning prescriptions of up to 10 cm bole diameter, 50 % of canopy or 6 m height for high grade saw log by age 20 years. Species planted include *E. globulus* (Tasmanian blue gum), *E. saligna* (Sydney blue gum) (Photo 11), *E. caldocalyx* (sugar gum), *E. maculata* (spotted gum) and *E. microcorys* (tallow wood). The Master Tree Growers course run by the department of CALM every year for the past 10 years has contributed to the education of landholders and to the profile of farm forestry (G. Batty pers. comm.). At present incentive schemes are being offered whereby $700-800 ha^{-1} up front and crop share of 10 % of clearfell value are being offered to provide commercial incentive for salinity control (G. Batty pers. comm.). A mixed planting of *E. globulus* and *E. saligna* of 450 stems ha^{-1} in corridors of three rows with 4 m between rows running north-south to maximise light interception by pasture, dried out a discharge area within three years of planting. The farmer, David Jenkins, is a farm forestry innovator and worked with CALM in promoting and coordinating Master Tree Growers Courses with farmers in the district (Photos 12 and 13).

Dave Carr, species trialling officer, is running extensive farm forestry trials of many eucalypt species and provenances throughout NSW. These include trials based on slope stratification that compare the performance of different species at different slope positions.

Outcomes

1) The formation of, and exposure to, a large national contact network of people with interest in the project that the study tour was designed to benefit.

2) CRC Sustainable Production Forestry visiting scientist proposal for Dr Neale Bougher of CSIRO Forestry and Forest products for assessment of ectomychorrizal fungal populations in revegetated and remnant/native stands.

3) Salinity investigation in the Tasmanian Midlands. Salt could be close to but not necessarily at the surface at sites where revegetation programs have failed.

4) *Pinus radiata* now to be planted as a buffer/nurse crop around the new NHT plantings in the Midlands.

5) Increased consideration of economic return/long term uses of plantings.

6) CRC Sustainable Production Forestry Technical Report to increase the awareness of the study tour and outcomes from it.

Photo 10. The farm forestry industry has been developed over the past 25 years in Western Australia. This site is 5 km north of Busselton.

Photo 11. Fourteen year-old mixed rows of *Eucalyptus globulus* and *E. saligna* managed for high-grade timber on a farm in the 550 mm rainfall zone, near Bridgetown, WA.

Photo 12. Fifteen year-old *E. saligna* managed for high-grade timber by David Jenkins near Bridgetown, WA.

Photo 13. Small farm-scale mills allow value-adding of wood products.

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