Ecologically Sustainable Agriculture Initiative

Protection of threatened species in agricultural landscapes
Flora Species Final Report:

Eucalyptus strzeleckii K. Rule (Strzelecki Gum)

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Executive Summary

Eucalyptus strzeleckii occurs in the high rainfall, primarily diary production region of the Gippsland Plain Bioregion. *Eucalyptus strzeleckii* often persists as isolated trees in varying stages of dieback. Little natural recruitment has been observed for this species and removal of livestock is often not sufficient to promote regeneration. The aim of this study was to determine those factors limiting recruitment of *E. strzeleckii* in the agricultural landscape.

Successful seedling establishment is strongly dependent on seed production of mature trees and seed supply during this study was found to be limiting. However, when seed supply is not limiting, access to bare ground is essential for germination and establishment. This research also supports observations elsewhere that intense intra-specific competition or allelopathic interactions with the parent tree limit recruitment to or beyond the canopy drip-line. During the first year of establishment competition from exotic pasture and declining soil moisture limited seedling establishment. It appears that a one-off removal of competition just prior to germination may be sufficient to enable some seedlings to successfully establish to the end of their first year (November 2004), by which time many seedlings may have grown over the top of the surrounding pasture. Adequate soil moisture in the early stages of establishment is also clearly important. Further monitoring of the experimental sites will be required to determine whether seedlings established after one disturbance event are able to persist in the long-term.

General Introduction

"Threatened Species and Farming" is a sub-project within the Ecologically Sustainable Agriculture Initiative (ESAI) undertaken by the Department of Sustainability and Environment and the Department of Primary Industries. This project addresses how agricultural practices might be modified to help conserve selected threatened species as part of working toward ecological sustainability. The project documents case studies of selected threatened species in four bioregions: the Victorian Riverina, Wimmera, Victorian Volcanic Plain and Gippsland Plain. The farms considered include examples from the meat, wool, dairy and grains industries. This case study focuses on Strzelecki Gum (*Eucalyptus strzeleckii).*

Native vegetation cover in south-eastern Australia has been significantly modified since European settlement, primarily to develop land for agricultural production (NLWRA 2001). In fertile, high rainfall landscapes, remaining native vegetation often persists as small isolated patches and, in the case of once wooded landscapes, as scattered paddock trees. For example in the West Gippsland catchment management area 24 % of the original forest persists (WGCMA 2003). The maintenance of native vegetation cover in these agricultural landscapes is important for the persistence of native biodiversity, reducing land degradation, providing shelter and drought fodder for livestock.

In this report we outline a research case study undertaken on contrasting native plant species in livestock production systems in southern Victoria. The case studies highlight two issues in the management of native vegetation in southern Australia. The first examines factors limiting recruitment of woody trees, an issue that has relevance throughout both forest and woodland landscapes. The second considers the role of grazing frequency and selectivity in determining the persistence of perennial native legumes, a functional group which has apparently been most impacted by grazing management in grassy vegetation.

Introduction

In once forested landscapes the gradual senescence of isolated trees and absence of natural recruitment is contributing to gradual tree cover loss. For locally rare eucalypt species, such as *Eucalyptus strzeleckii* in the Gippsland plains, these processes are potentially threatening it with extinction. While grazing is generally documented as the primary process inhibiting eucalypt establishment (Curtis 1990, Lawrence *et al*. 1998, Li *et al.* 2003; Dorrough and Moxham 2005, Stoneman *et al.* 1994; Yates *et al.* 2000a), particularly in exotic pastures that are intensively grazed (Li *et al.* 2003; Semple and Koen 2003), even in the absence of livestock grazing, recruitment by eucalypts in agricultural landscapes may be rare. It has been suggested that this may be due to intense competition from exotic pasture species, particularly where nutrients are high due to fertiliser application and livestock camping, and reduced water availability due to soil compaction (Yates *et al* 2000b). Indeed in some instances grazing may be required to create gaps for seed germination. .

Eucalyptus strzeleckii (Myrtaceae) is endemic to Victoria and listed as nationally Vulnerable. The species occurs in the high rainfall region of the Gippsland Plain Bioregion in south-eastern Victoria. This area has been extensively developed for agriculture, in particular dairy production. Isolated individuals and small stands of *E. strzeleckii* still persist in this landscape, however, surviving trees are often old and in varying stages of dieback. Considerable effort has been made to conserve this species locally including fencing of remnant trees and planting of tube-stock. Despite these efforts, little natural recruitment has been observed for this species (Carter 2003). Livestock grazing is the primary disturbance in this landscape but removal of stock is often not sufficient to promote regeneration. The aim of this study was to determine those factors other than grazing, that are limiting recruitment of *E. strzeleckii*. We examined whether seed supply, pasture competition, soil compaction, parent plant competition and soil nutrients limited recruitment of *E strzeleckii.*

Methods

Species Description

Eucalyptus strzeleckii (Strzelecki Gum) is a medium to tall forest swamp gum to 40 metres high, endemic to Victoria. It is an obligate seeder producing creamy flowers from September to November. It has rough, loose bark on the lower trunk and is smooth on the upper trunk and branches. Old decorticated bark sometimes persists about the base as loose, thin sheets or strips. *Eucalyptus strzeleckii* was described as a distinct species in 1992 having previously been considered a form of *E. ovata*. *Eucalyptus strzeleckii* is also closely related to *E. brookeriana* and differs in the glaucous new leaf growth on the outside of the crown (Rule 1992, Walsh & Entwisle 1996). *Eucalyptus strzeleckii* K. Rule (Strzelecki Gum) is nationally Vulnerable (Briggs and Leigh 1988). It is also vulnerable in Victoria (DNRE 2000) and listed as a threatened taxon on Schedule 2 of the *Flora and Fauna Guarantee Act* 1988 in Victoria.

Field Experiment

Three properties in south-eastern Victoria supporting populations of *E. strzeleckii* were selected for replicated field trials (Figure 1). Farm locations were representative of vegetation, and are located within paddocks used for commercial livestock production. Sites one and two are dairy enterprises and the third is used for beef production. All three properties are adjacent to waterways where stands of *E. strzeleckii* occur and isolated individuals extend onto surrounding floodplains and lower slopes. The farms occur on deep fertile loams where the annual rainfall usually exceeds 1000mm (Rule 1992). At each property an isolated adult *E. strzeleckii* was chosen for a replicated field trial.

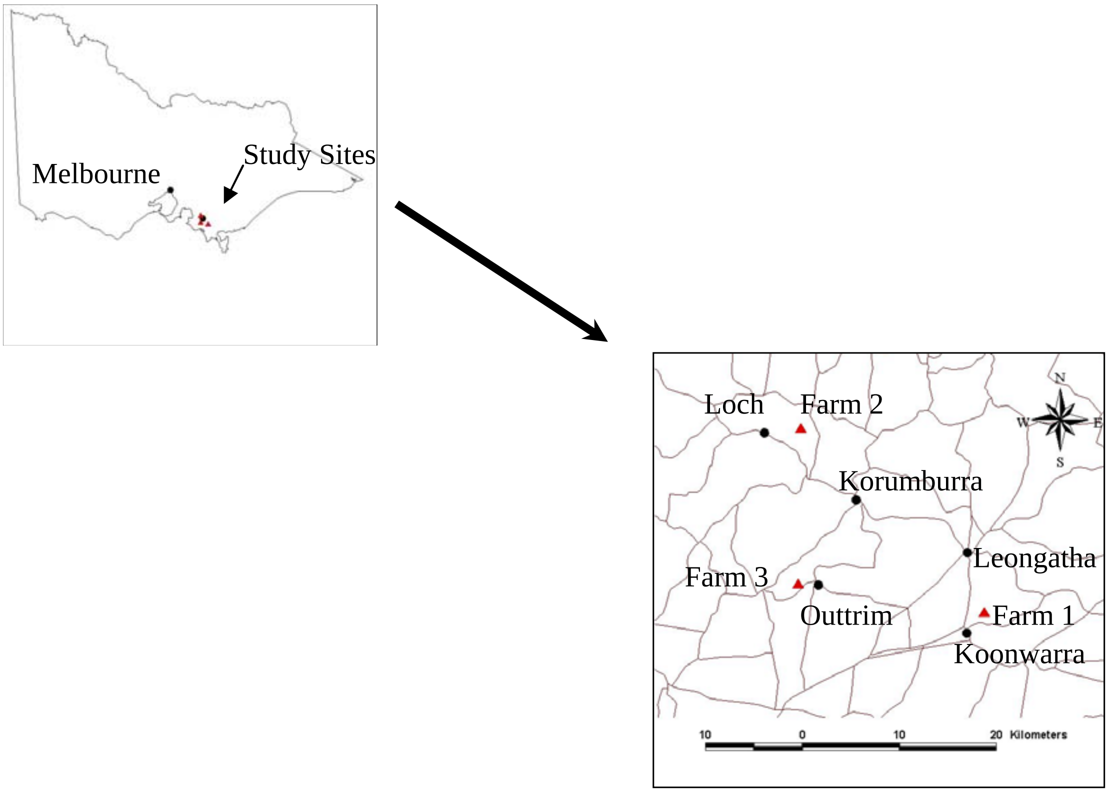

Figure 1. The location of the study farms in Victoria and closer in West Gippsland.

The plot preparation commenced at the start of autumn. The isolated tree was fenced off from stock and a randomised replicated field trial established (refer to Figure 2). Factors investigated included soil compaction (disturbed to a depth of 30cm/undisturbed), pasture competition (spraying once with roundup®/no spraying), seed supply (2g seed scattered over surface/no seed) and nutrient availability (1250g of raw sugar added over two applications/normal nutrient levels). To investigate parent plant competition the trial was applied at three distances from the parent tree canopy - at tree base, under the drip line and 2m away from the canopy. Each transect block measured 2m x 8m, containing the 16 treatments. Each treatment was applied to a 1m x 1m quadrat with an internal 50cm x 50cm quadrat where sampling was undertaken. Each transect block was separated by at least 2m, sometimes greater depending on the canopy of the adult tree. An external buffer of approximately 2m surrounds the field trial to limit stock grazing through the fence.

Base of Adult Tree

Tree Canopy
Transect 1

7	2	1	11	6	15	12	9
14	3	4	10	16	5	8	13

Transect 2
Canopy Drip line

11	4	12	7	3	14	6	8
9	16	15	13	1	5	10	2

Transect 3

1	12	16	3	7	6	11	9
5	14	2	4	8	13	15	10

Figure 2. Experimental layout for farm 1, displaying the adult tree and canopy cover in relation to the position of the replicated randomised blocks with treatments labelled 1-16.

Seed germination and survival
Data collection was undertaken bi-monthly, with the first collection in July 2003 and the last in November 2004. The number of germinants were recorded in each treatment plot along with percent cover of monocotyledons, dicotyledons, litter and bare ground. In each quadrat six individual seedlings were tagged (where possible). Seedling height (mm) and survival were recorded at each sampling time. If any marked seedlings died another was selected if present. A single measurement of soil moisture was made using a theta probe within each quadrat at each sampling sate.

Soil trials
To determine the effect of the nutrient treatments on soil nutrients, four quadrats were established adjacent to the experimental sites. These 50cm x 50cm plots (with a 50cm buffer zone around all quadrats) consisted of the following treatments:

1) Control
2) Nutrients removed via addition of 1250 grams of raw sugar, but vegetation intact.
3) Soil disturbance: all vegetation removed and soil disturbed with a mattock.
4) Soil disturbance and nutrients removed: combination of treatments 2 and 3.

Soil samples were taken from within each quadrat prior to the treatment establishment. Further soil samples were taken in November 2003.

Data Analysis

Initial analysis examined the impact of treatments on seedling survival. Seedling numbers were not normally distributed so were $\log_{10}$ transformed. Due to an unbalanced treatment structure in site three, a restricted maximum likelihood (REML) variance components analysis was undertaken, where a random model specifying the underlying design structure (date/site/transect/plot) was used. The seed addition treatment was not examined in the model because of an almost complete absence of seedling establishment from naturally dispersed seed. The soil nutrient treatments were also removed because preliminary analyses indicated that sugar addition at the dose applied had no effect on above ground vegetation or eucalypt establishment. Interactions between the main factors of date, distance from parent tree, disturbance and spraying treatments were examined.

The cover of monocotyledons, dicotyledons and litter were pooled to estimate total vegetation cover. An REML variance components analysis was undertaken on total vegetation cover where the underlying random design structure was (date/site/transect/plot) and fixed model was date*distance from parent tree*disturbance*spraying.

Soil moisture was examined using analysis of variance to examine differences between transects and sites over time. Due to the limited amount of data collected on soil nutrients and the effect of sugar addition no statistical analysis was undertaken, although means and standard deviations are displayed.

Results

Natural Regeneration

A total of eleven seedlings established by natural regeneration, eight seedlings died in the summer months and only one was still alive by the final sampling (November 2004). The majority of seedlings established in transect three. Only one seedling was observed in a treatment that had not either been disturbed or sprayed. Results suggest that, in this year at least, natural seed production was inadequate to ensure successful seedling establishment at all sites.

Plant growth, survival and soil moisture

The total number of seedlings varied between farms with much higher rates of establishment at farms one and two, particularly in transect three. Seedling numbers declined over time (Figures 4 & 7). The average seedling number was greatest in transect three (ie. furthest from the adult tree) (Figure 4). Most seedling mortality appears to have occurred between initial establishment and January 2004 (Figure 4 & 7). This partly coincides with a decline in available soil moisture and rainfall (Figures 3 & 5) and an increase in vegetation cover (Figure 6). Soil moisture peaked in September 2003 at close to 50% and declined to almost 10% by December 2003 and January 2004. Total vegetation cover in sprayed and/or disturbed plots increased by approximately 30% to 40% between September and December 2003.

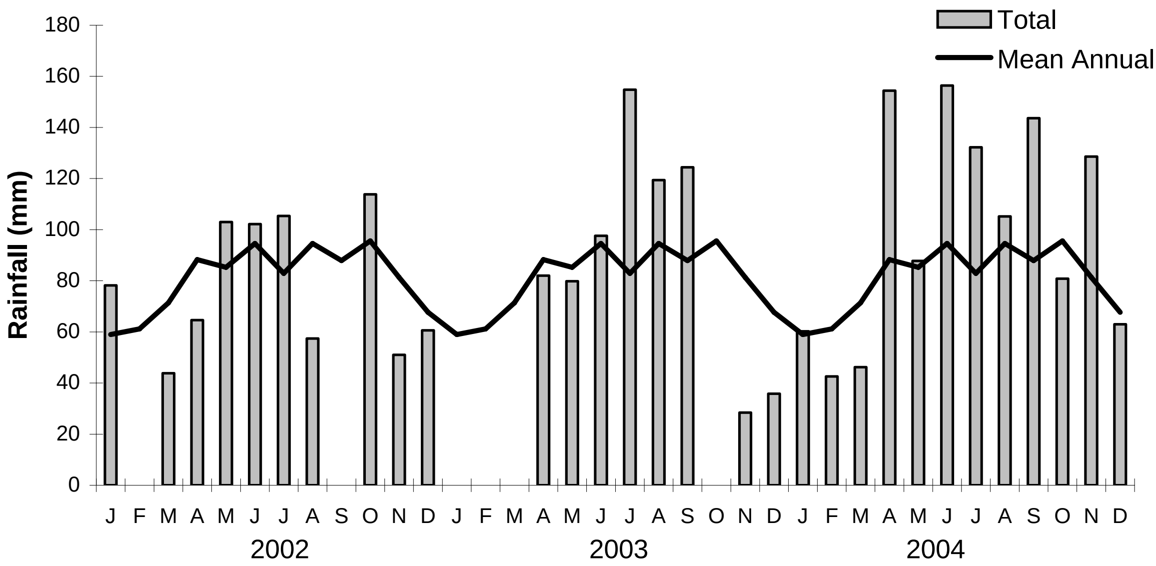

Figure 3. Total monthly rainfall (mm) for 2002, 2003 and 2004 (bars), and mean annual rainfall from 189 to 1957 (line). Care of the Australian Bureau of Meteorology.

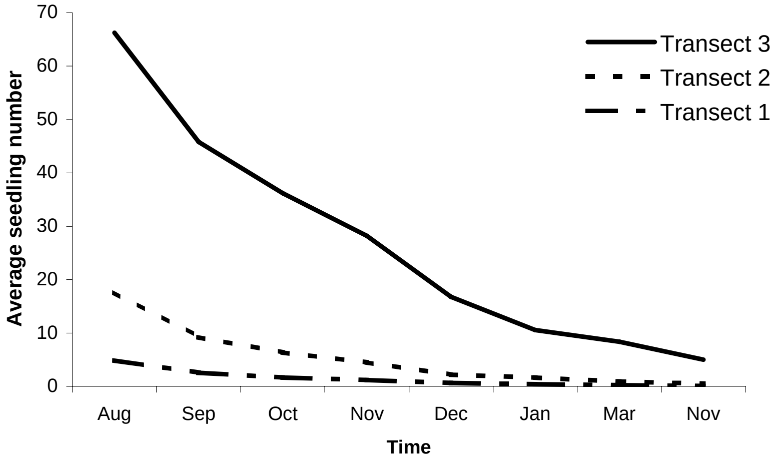

Figure 4. Average total seedling numbers in each of three transects over time.

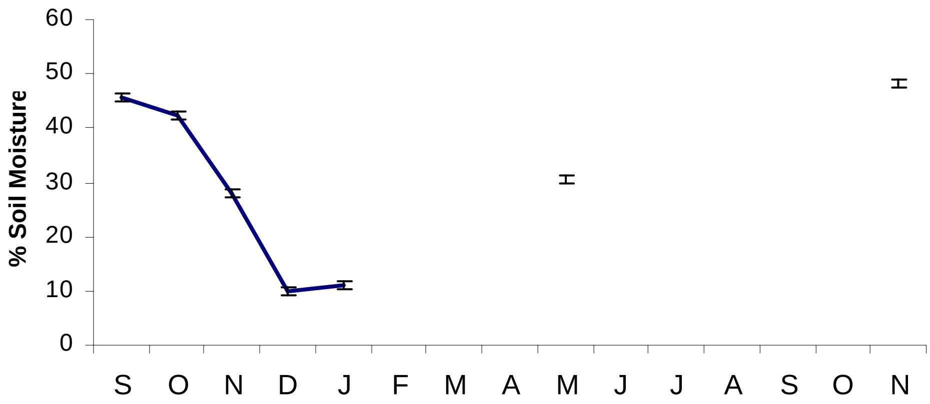

Figure 5. Percent soil moisture from 2003 to 2004.

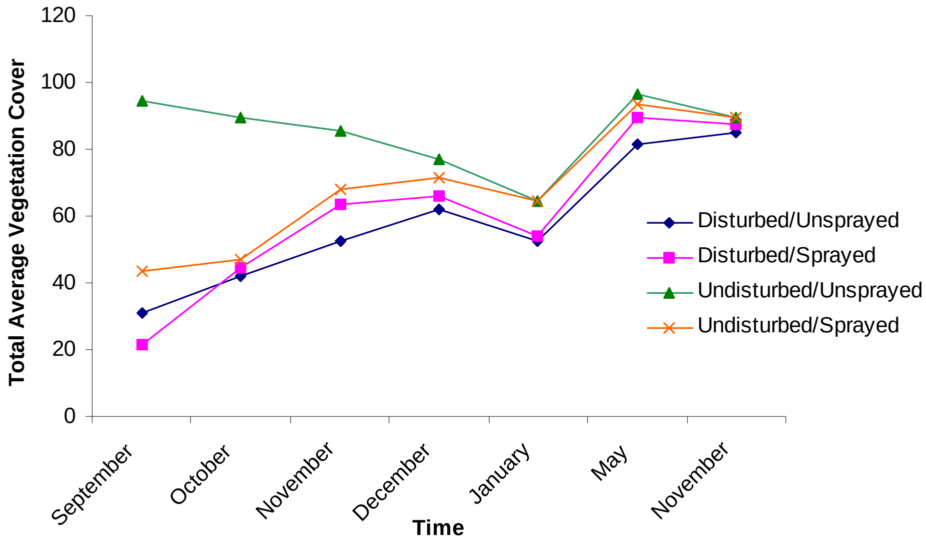

Figure 6. The effect of soil disturbance and spraying on average total vegetation cover in plots between September 2003 and November 2004. The standard deviation is shown.

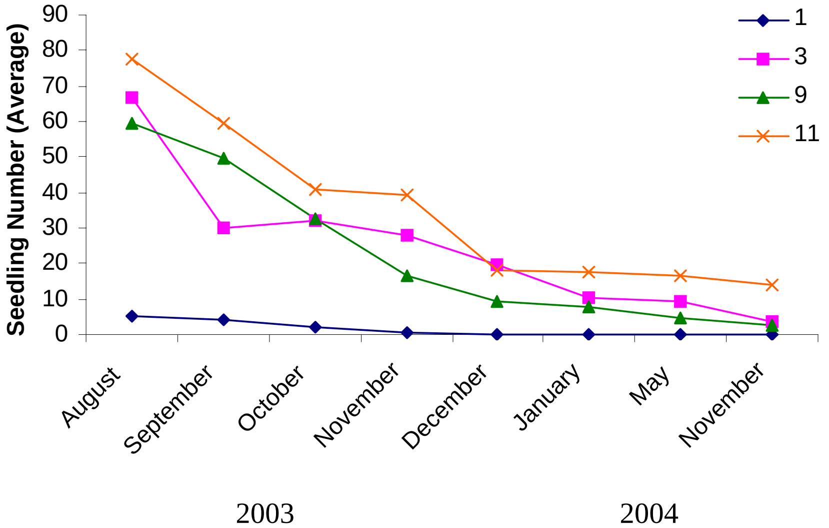

Figure 7. Seedling number across time displaying the different treatments – excluding sugar treatments. Where: 1 (unsprayed/undisturbed), 3 (unsprayed/disturbed), 9 (sprayed/ undisturbed), 11 (sprayed/ disturbed).

Seedling number and survival tended to be highest where vegetation was removed by spraying and / or disturbance (Figure 7). Treatments lacking either spraying or soil disturbance had little establishment even when seed was added.

Both soil disturbance and spraying had similar effects suggesting that compaction may not be a limiting factor in these environments (Figure 8). Either soil disturbance or spraying increases the number of establishing seedlings.

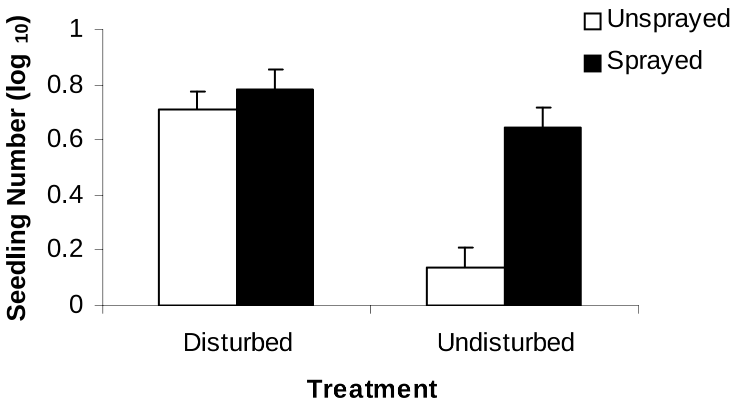

Figure 8. The effect of spraying and soil disturbance on the predicted number of seedling (log_{10}) per plot averaged over time and transects. The standard error of differences is shown.

Vegetation Cover
The cover of vegetation varied across time and throughout the study plots (Figures 6, 9 & 10). On average the cover of monocotyledons tended to increase over time while bare ground decreased. This was particularly evident at farms two and three.

There were significant effects of date, soil disturbance and spraying on total vegetation cover, although there was no effect of transect or sugar addition. In the undisturbed and unsprayed plots total vegetation cover gradually declined from almost 100% cover in September 2003 to approximately 75% in January and increased again to almost 100% by May and November 2004 (Figure 6, 9 & 10). Spraying and soil disturbance had similar effects on vegetation cover, leading to dramatic reductions in cover at the initial stages of the experiment. Vegetation cover in these plots gradually increased till December 2003 when cover was similar in all plots regardless of treatment.

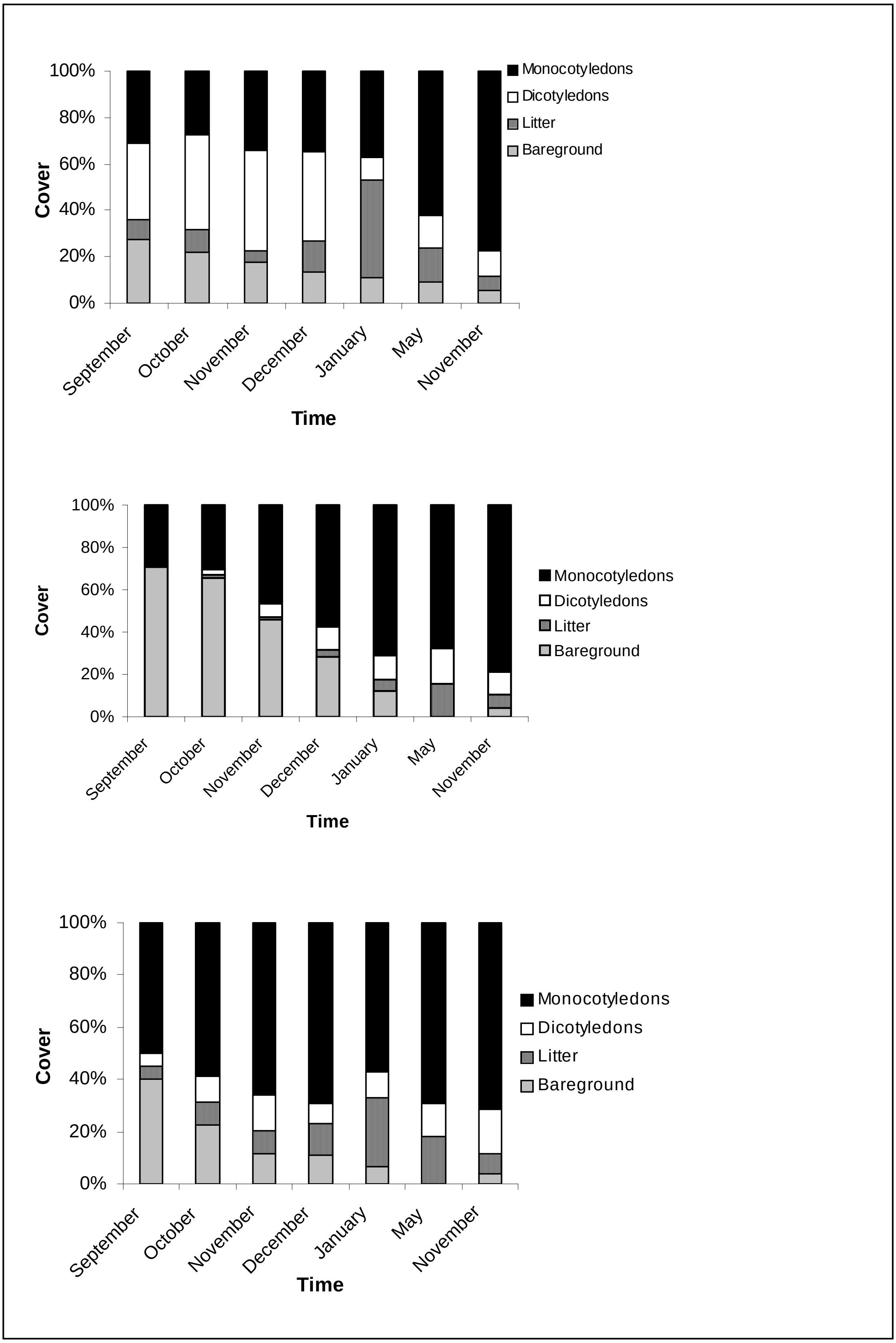

Figure 9. Percent cover of monocotyledons, dicotyledons, litter and bare ground across time averaged over all treatments at the three study locations.

Quadrat

Transect

Site

Figure 10. Time series photos showing vegetation cover. August 2003 (left), May 2004 (centre) and at end of the experiment in November 2004 (right), displaying three different scales; top = quadrat, middle = transect and bottom at the site level.

Soil Nutrients

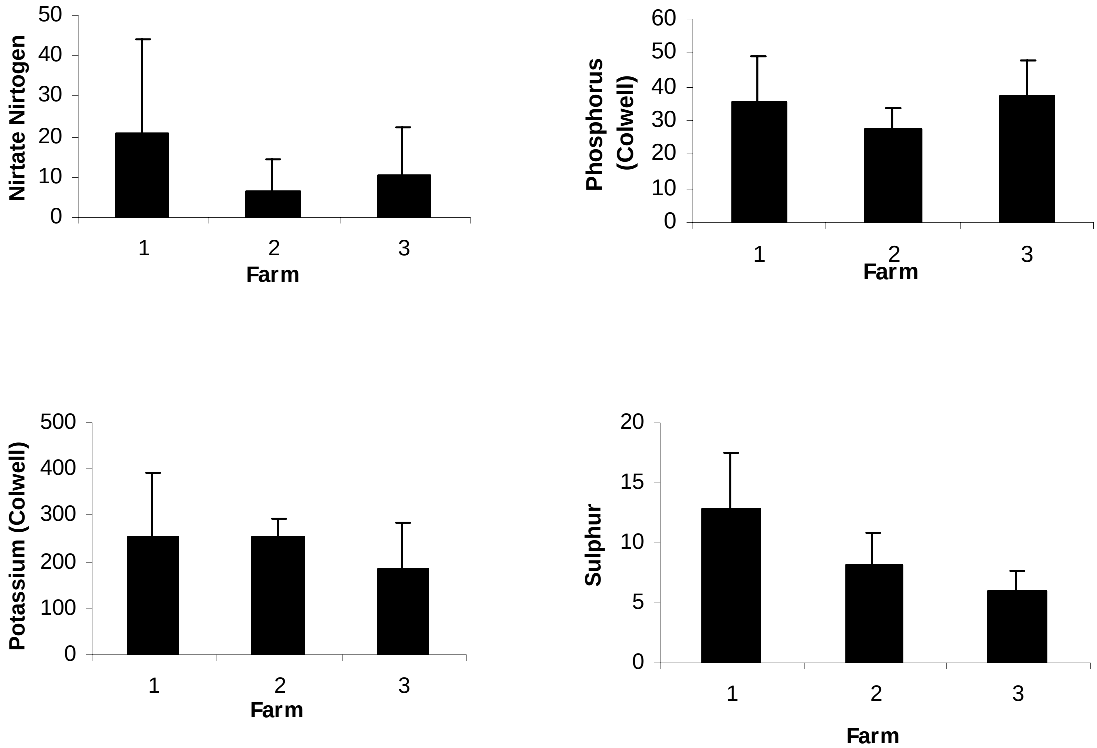

Figure 11. Graphical display of the levels of nitrogen, phosphorus, potassium and sulphur across the different farms.

There was no significant difference in nutrient levels across the three farms (Figure 11), although farms one and three tended to have higher phosphorous and site 1 higher sulphur.

Conclusion

Successful seedling establishment is strongly dependent on the health and hence seed production of mature trees. This research has indicated that seed supply, at least in the year this experiment was established, was a major factor limiting recruitment. If this pattern is general, even where adult trees are present, seed addition will be necessary for successful recruitment. Further research is required to examine spatial and temporal patterns of seed supply.

When seed supply is not a limiting factor this project has demonstrated the importance of access to bare ground for *E. strzeleckii* germination to occur, particularly at or away from the parent tree canopy. During the first year of establishment competition from exotic pasture limited seedling establishment. It appears that a one-off removal of competition just prior to germination may be sufficient to enable some seedlings to successfully establish to at least the end of their first year. Adequate soil moisture in the early stages of establishment is also clearly important. Further monitoring of the experimental sites will be required to determine whether seedlings established after one disturbance event are able to persist in the long-term.

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References

Briggs D.J. and Leigh J.H. (1988) *Rare or Threatened Australian Plants*. Australian National Parks and Wildlife Service. Canberra.

Carter. O (2003) Recovery Plan for *Eucalyptus strzeleckii* (Strzelecki Gum) 2004-2008. Department of Sustainability and Environment, Heidelberg, Victoria. Unpublished Report.

Curtis D (1990) Natural regeneration of Eucalypts in the New England region. In ‘Sowing the seeds – direct seeding and natural regeneration conference proceedings.’ (Greening Australia)

DNRE (2000) *Victorian Flora Information System Database*. Parks Flora and Fauna Division. Department of Natural Resources and Environment, Victoria.

Dorrough, J. and C. Moxham (2005). "Eucalypt establishment in agricultural landscapes and implications for landscape-scale restoration." *Biological Conservation* **123**: 55-66

Lawrence J, Semple WS, and Koen TB (1998) Experimental attempts at encouraging Eucalypt regeneration in non-native pastures of northern Victoria and central western NSW. *Proceedings of the Linnean Society of New South Wales*. **119** 137-154.

Li J, Duggin JA, Grant CD, and Loneragan WA (2003) Germination and early survival of *Eucalyptus blakelyi* in grasslands of the New England Tablelands, NSW, Australia. *Forest Ecology and Management.* **173** 319-334.

NLWRA (2001). *Australian Native Vegetation Assessment 2001*. Canberra, National Land and Water Resources Audit, Commonwealth of Australia

Rule K (1992) Two new species of *Eucalyptus* (Myrtaceae) in South Eastern Australia. *Muelleria*. **7** 497-505.

Semple WS and Keon TB (2003) Effect of pasture type on regeneration of eucalypts in the woodland zone of south-eastern Australia. *Cunninghamia* **8** 76-84.

Stoneman GL, Dell B and Turner NC (1994) Mortality of *Eucalyptus marginata* (jarrah) seedlings in Mediterranean-climate forest in response to overstorey, site, seedbed, fertiliser application and grazing. *Australian Journal of Ecology*. **19** 103-109.

Walsh NG, Entwisle TJ (1996) ‘Flora of Victoria, Volume 3, Dicotyledons: Winteraceae to Myrtaceae.’ Inkata Press, Melbourne.

WGCMA (2003) Draft West Gippsland Native Vegetation Plan. West Gippsland Catchment Management Authority, Victoria.

Yates CJ, Hobbs RJ and Atkins L (2000a) Establishment of perennial shrub and tree species in degraded *Eucalyptus salmonophloia* (Salmon Gum) remnant woodlands: effects of restoration treatments. *Restoration Ecology*. **8** 135-143.

Yates CJ, Norton DA and Hobbs R J (2000b) Grazing effects on plant cover, soil and microclimate in fragmented woodlands in south-western Australia: implications for restoration. *Austral Ecology*. **25** 36-47.