# GRASSTREE PROJECT MEETING

Report to Department of Conservation and Land Management

Wendy Colangelo (Editor)

June 1999

75 pp

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**Presentations**



**Abstracts**

# GRASSTREE PROJECT MEETING

Tuesday 22nd June 9.00 am in Building 311.118 (Boardroom)

## AGENDA

| | | |
|---|---|---|
| 9.00 | Introduction and overview | Byron Lamont |
| 9.10 | Aboriginal Fire: Its relevance to present day management of the Jarrah forest of South-Western Australia | David Ward |
| 9.30 | Grasstrees (Xanthorrhoea spp.) and the fire history of sites | Perry Swanborough |
| 9.50 | Mineral nutrient cycling in relation to fire (Progress Report) | Roy Wittkuhn |
| 10.10 | Biomass and water cycling in relation to season and fire (Progress Report) | Dylan Korczynskj |
| 10.30 | Morning Tea | |
| 11.00 | Histological Aspects: Update | Wendy Colangelo |
| 11.10 | Minesite rehabilitation | Jenny Richardson |
| 11.20 | Comparison of grasstree and conifer leaf aging Techniques. | Matthew Williams |
| 11.30 | Discussion | |
| | Light lunch provided finish by 1pm | |

Apologies from Lachie McCaw and Neil Burrows.

**Attendants to June 1999 Grasstree Meeting:**

| | |
|---|---|
| Byron Lamont (Chair) | Curtin University |
| David Ward | CALM/Curtin University |
| Jonathan Majer | Curtin University |
| Perry Swanborough | Curtin University |
| Wendy Colangelo | Curtin University |
| Dylan Korczynskj | Curtin University |
| Roy Wittkuhn | Curtin University |
| Matthew Williams | CALM/Curtin University |
| John McGraw | CALM |
| Jenny Richardson | ALCOA/Curtin University |

The next Grasstree Meeting will be held early December 1999.

# Introduction

## Staff

The first Grasstree Project Management Meeting was held on 24 June 1998 (Colangelo 1998). The research group met in December to review progress and set goals for 1999 (Burrows and Lamont 1998a). Since our first meeting, Dylan Korczynskyj was awarded the CALM PhD scholarship--he began in September but was not enrolled officially until Semester 1, 1999. He has taken on the task of biomass/water cycling in relation to fire with much enthusiasm. He has been instrumental in setting up a major trial on the effect of shade and extra water on subsequent growth (simulating the effects of fire). Chantal Burrows was awarded First Class Honours for her work on nutrient uptake patterns of the leafbases in relation to season and fire (Burrows and Lamont 1998b) and a manuscript on her results is near completion (Burrows, Lamont and Ward, ms). Her contract has now finished and we wish Chantal all the best in her new undertakings. Matt Williams (Senior Research Scientist, CALM) joined the team in Semester 1 to start his PhD part-time—his associate supervisor is Dr Ian Abbott (Senior Adviser, CALM). His topic is a comparison of grasstrees and conifers as bioindicators of past growing conditions and fire patchiness. Jennifer Richardson began her honours project part-time on the recruitment of *Xanthorrhoea* spp. in rehabilitated bauxite minesites—her associate supervisor is Dr John Koch (Principal Environmental Officer, ALCOA). Although grasstrees are a major understorey component of the jarrah forest understorey they are under-represented in the postmining vegetation, hence the interest in understanding their rehabilitation requirements.

Roy Wittkuhn has been fully occupied harvesting plants for nutrient analysis—because of the expected high costs of analyses he has been examining alternative ways of executing the work and has been negotiating with the Chemistry Centre (WA Govt) to undertake the analyses there himself. Producing enough ash for the fire simulation trial has also proved demanding. He has been assisted by several third year students to assess leaf mass accumulation over time to estimate their value as a source of nutrient release after fires at various time intervals. Wendy Colangelo has had little success in her search for a specific stain for lapachol (the reason for the postfire blackening of the leaf bases) and is now concentrating on when lapachol is deposited and the histological basis for the seasonal colour changes in the leafbases. Dr Perry Swanborough continues liaison with the Botany Dept at the University of WA—Dr Pauline Grierson has offered to examine one of our long unburnt plants for isotopes of nitrogen, as an expression of changing soil nutrient availability in the absence of fire. David Ward has continued his 'case study' investigation of the human history of John Forrest National Park as well as determining the fire history of grasstrees in scrub-heath in the Eneabba-Dongara area. His beautifully illustrated article with Rick Sneeuwjagt (fire manager, CALM) has now been published in the latest issue of Landscope (Ward and Sneeuwjagt 1999).

**Achievements**

Our manuscript on the effects of fire season and plant height on flowering of grasstrees (Lamont, Swanborough and Ward, in press) has now been accepted by the Australian Journal of Ecology, although it is unlikely to be published until 2000. David is about to resubmit a much more exhaustive manuscript to the Journal of the Royal Society of WA on the effect of plant height on flowering—second year students have helped with this study over the last five years. David has submitted for publication a manuscript with John Challinor (Principal Chemist, Chemistry Centre) on the basis of the leafbase colour change in response to fire (Ward and Challinor, ms). I have prepared a short manuscript based on results in Ward and Van Didden (1997) and Burrows and Lamont (1998a) for which we will be seeking comments soon (Ward, Lamont and Burrows, ms).

I have given oral presentations on the results to date at the International Ecological Congress in Italy (July, 1998) (Ward, Lamont and Burrows 1998), Botany Dept, University of Cape Town (Sept, 1998), and Faculty of Agriculture, University of WA (March, 1999) (abstract in the Appendix). I will do so again at the July 1999 meeting of the International Association of Vegetation Science at Bilbao, Spain (abstract in the Appendix). Chantal also presented a poster on her honours work at INTECOL (Burrows, Lamont and Ward 1998). I will present the same poster at the meeting of the International Association of Vegetation Science, as well as the August meeting of the International Botanical Congress at St Louis, USA. Perry will summarize our progress so far at a fire ecology meeting, Sturt University, NSW in July (BUSHFIRE99) and David will present a poster highlighting the management aspects (Ward and Sneeuwjagt 1999). I have offered an oral presentation on the jarrah forest fire history aspect of the grasstree work (Lamont and Ward 1999) and David a poster on the Dryandra Reserve work at the September meeting of the Australian Ecological Society in Fremantle. The offer of a $100 contribution to attendance costs to members of the group provided they prepare a poster still stands, although I appreciate that data collection is inadequate for most at this stage.

**Research issues**

Validation of the Ward technique for fire history determination is a major part of this project. That the alternating colour bands correspond to annual increments of growth is under study by Dylan—by showing how many leaves are produced seasonally/annually through direct tagging, and counting the number of leafbases in each colour category on a range of bands on the same tree, he will be able to show that they are consistent. It would be most informative if the tagged leaves themselves formed a band but we do not know how long it takes for the leaves to be pushed across the apex and down the side of the caudex where the bands form. From Dylan's work it is already clear that most leaves emerge in spring-summer (not winter-spring as we initially thought) while leaves appear to emerge throughout the year (unless the plant flowers). We need to know when leaves die and how long they live for. It is possible that the paler coloured leafbases died when the leaves were younger leaving insufficient time for the pigments to accumulate. David believes that the leaves dying in summer do so suddenly (they would have to be the autumn-winter formed ones), leaving insufficient time for complete withdrawal of the pigments, in contrast with leaves dying over winter.

Another concern is the decreasing likelihood of the crown burning the taller the plant. A study is required at sites burnt under a range of fire conditions and time since last fire—whether grasstrees were burnt or not in response to the extent of fire around their bases (an index of fire intensity) and height could be investigated—this may be a suitable activity to include under Matt's project (Lachie McCaw noted at our last meeting that CALM was to undertake a number of experimental summer fires that may be suitable?). We also need to look at the black bands more carefully to see if they can be used to determine season and intensity of fire. In the absence of such a study, we can assume that grasstrees up to 1 m high are sure to flower, and the likelihood decreases from there. In that case, to get the fire history of a site, assess the bottom metre of plants that say are 1, 2, 3, 4 m high—does David have any comments on this approach? David's current data could be checked to see if a height correction is required as in Figure 1 overpage. Wendy is looking at leafbases burnt at intervals after fire to se if the lapachol is deposited immediately after the fire or develops over time.

In view of the ecological implications of varying intervals between fires it is becoming clear that we need to document these in a running sequence rather than just giving number of fires per successive decade. This will be of particular value for feeding into fire response models (Enright et al. 1998).

This year we were disappointed that we were unable to arrange an autumn fire at Mundaring (the autumn fire at Yanchep went exceptionally well). We believe that a greater priority should be given by the Mundaring Office of CALM to execute a suitable fire for us in 2000 so that our work can be extrapolated to the jarrah forest as well as the Coastal Plain.

1. Accept all records for a plant height ≤ 1 m as correct.
2. For each decade get mean fires/decade for all records ≤ 1 m height.
3. Do a linear regression for each decade with records in the 1-4 m height region.
4. for each value in the 1-4 m height region, add the difference between the expected value from the best fit line and the value obtained from the mean in the 0-1 m region:

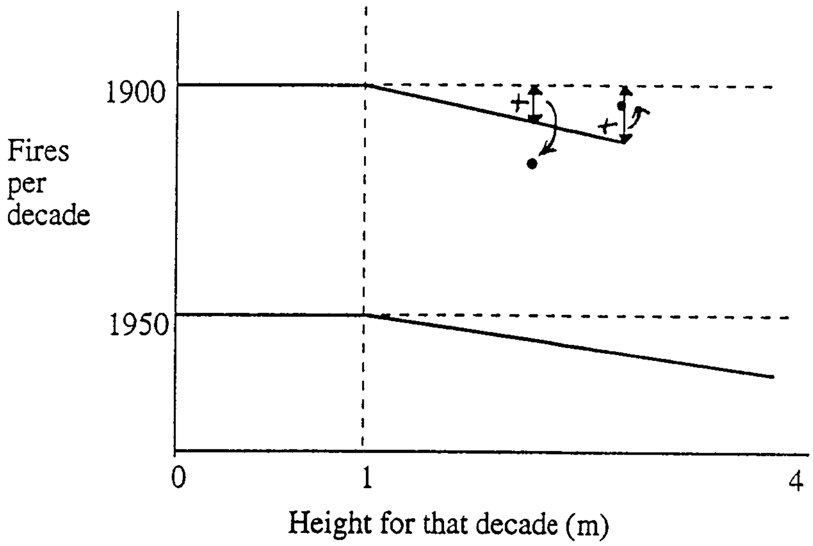



Figure 1. Graphical technique to apply a correction to the possibility of reduced incidence of fire bands on grasstrees with increase in their height.

**Future research prospects**

Our current funding base lasts until mid-2001 (Dylan's scholarship lasts until early 2002)–this assumes that the new administrative arrangements proposed for CALM do not affect our contract. If we believe that there are issues remaining that are worth pursuing beyond then, we need to appreciate that ARC applications for 2001 have to be submitted by late February 2000. We keep returning to the need for a population biology study of grasstrees, possibly as a PhD project, funding for which should be explored—is CALM interested? Adrian Wayne (Research Officer, Manjimup Office, CALM) raised the possibility of research on grasstrees as habitat for mammals as well as smaller animals—they are favoured resting sites for the rare ring-tailed possum. I have put in a preliminary application to Wilson Tuckey (at his invitation) to use grasstrees and eucalypts as data banks of growing conditions over the last 500 years (once clearfelling has taken place such venerable plants will no longer be available to obtain this sort of information)—copy included in the Appendix. Since there is no provision for research in the RFA, I will not hold my breath on this one!

I commend the team for its diligence and achievements over our first year and look forward to even greater progress in the next now that many teething problems have been solved.

Prof Byron Lamont

22 June 1999

Contribution to Grasstree Project Meeting
School of Environmental Biology
Curtin University
22 June 1999

# Aboriginal Fire: its Relevance to Jarrah Forest Management

by David Ward
Senior Visiting Research Fellow

The Grasstree Project Team at Curtin University, under the leadership of Professor Byron Lamont, is investigating ways in which grasstrees (*Xanthorrhoea* spp) can yield insights into both fire history and fire ecology. As results start to flow in, they will be presented at scientific conferences, and published in scientific journals.

However, it is important that we realise that the process must not stop there. If we wish to make a real contribution to the management of ecosystems in the southwest corner of Australia, and further afield, then we need to promote and communicate our results to the point where they are incorporated into land management policy and practice. Communication with managers, policy makers, and the general public calls for different skills from those required in writing a scientific paper. The challenge is to capture attention and inform without sacrificing scientific truth.

Models and metaphors are effective ways of getting a message across. They rely on an understanding of the "mental mapping" process. There is strong evidence from both psychologists and from practical experience that humans understand new ideas best when they are clearly linked to old ideas. It is easier, and more effective, to extend an existing mental map, than it is to create an entirely new one.

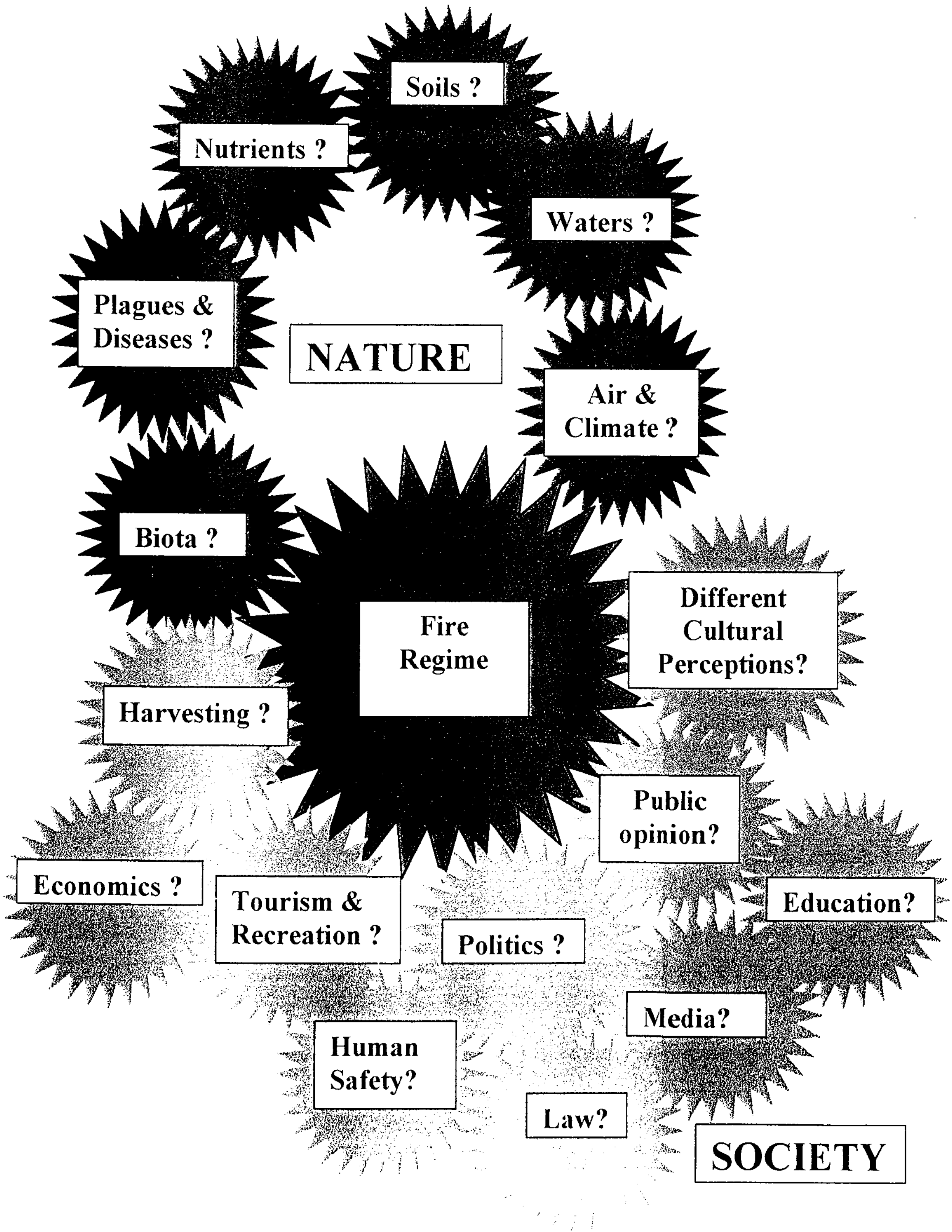
I present a model which shows how an understanding of fire links both to nature and to human society. A turn of any cog will affect other cogs. On the other hand, if any cog is locked, the others will be unable to turn. While I may (with some justice!) be accused of presenting a mechanistic, Newtonian, clockwork model, I believe that this model is helpful in thinking about environmental issues connected to fire. If anyone hungers after a bit of chaos, then we could remove some teeth, at random, from various cogs. Unpredictable slippage may then occur, and that may be closer to reality.

As a hypothetical example, suppose (*NB only suppose!*) that we found that summer burning offered a number of benefits to the flora (such as better seed germination and the inhibition of a certain pathogen or pest), then introduction of a policy change would run into a legal barrier, which prevents widespread burning in summer. There would be a need to free up the legal cog. This could be achieved through education and use of the media to change public opinion. This in turn would lead to a change in political thinking, and subsequent change in the law, so enabling a land management agency to change its policy and practice. In a multi-cultural society, research into differing cultural perceptions of fire would also help the process along. *(As an historical aside, it is interesting to note that the ban on summer burning was introduced in 1847 as the result of several years of political lobbying by a vociferous minority of British settlers at York, aided by the then media, the "Perth Gazette".*

*Their reasoning was narrowly economic, and their perceptions culturally biased. They ignored the opinions of the then Noongar majority, and those Europeans who understood some of the benefits of fire to flora and fauna. See Ward 1998.)*

**A Tentative Model of some Interactions between Fire, Nature & Society**

(By no means exhaustive)



The above model can also be used in a structured search for key research questions. Our team is currently addressing the interaction between fire and nutrient cycling (Roy Wittkuhn's PhD proposal) and between fire and plant growth (Dylan Korczynskiy's PhD proposal). It would clearly be useful to our team if we established communications with other researchers looking at other fire interactions, both in nature and society. Where we see gaps in the research, we could propose research topics to suitable parties, within Curtin, or at other universities. For example, I believe that Murdoch University has initiated a course called "Social Ecology" under the leadership of Dr Dora Marinova. They are interested (personal communication Dr John Phillimore) in ideas for student research projects.

I welcome ideas on how we could develop communication and co-operation with other organisations, and stimulate research by others in areas where we lack resources or expertise.

-oOo-

**References**

Ward, David (1998) Fire, Flogging, Measles & Grass: Nineteenth Century Land Use Conflict in South-Western Australia. Department of CALM, Perth.

# Grasstrees (*Xanthorrhoea* spp.) and the fire history of sites

**Perry W Swanborough, Byron B Lamont, Chantal L Burrows and Wendy Colangelo.** School of Environmental Biology, Curtin University of Technology, GPO Box U1987, Perth WA 6845, Australia.

**Abstract**

Grinding away the charcoal surface of grasstree stems reveals alternating white (winter) and brown (summer) banding interrupted by black bands which signify the passage of fire. The banding is therefore a reliable historical record of a site's fire history. Fire frequency in the Perth region has declined from three or four fires per decade in the mid-nineteenth century to zero or one fire per decade in recent times. The black bands are associated with accumulation of a lapachol-like compound. Persistent grasstree leaf bases indicate a temporary decrease in magnesium content following fire. A study of fourteen sites in the Perth region showed that incidence of grasstree flowering is influenced by the season of fire, with only 1% of plants flowering following winter fire and 75% flowering after summer fires. Plants flowering after summer fires produce larger inflorescences and higher fruit densities than plants flowering after fires in other seasons.

**Introduction**

This paper is a synthesis of results obtained by the Grasstrees Research Group at the School of Environmental Biology, Curtin University of Technology. Among our research interests is the validation of a recently-proposed non-destructive means of ageing grasstrees (*Xanthorrhoea* spp.), and interpreting the results to gain reliable fire histories of sites where other records are unavailable. We are also interested in the water relations, nutrient cycling, flowering and fruiting responses of grasstrees in response to fires of various intensities occurring in each season of the year.

**Validation of the new ageing technique**

Lamont and Downes (1979) observed that alternate expansion and contraction of the apices of *Kingia australis* R.Br. and *Xanthorrhoea preissii* Endl. produce regular longitudinal changes in stem diameter and morphology each year. The diameter fluctuations which are a response to apical growth and the highly seasonal climate of their south-western Australian habitat enable accurate estimation of age and vertical growth rates of individual plants. However, a limitation is that the fluctuations are lost as the lower stem expands with age through secondary growth (Staff and Waterhouse 1981). Another limitation is that plants must be harvested, but it is recognized that the conservation value of old grasstrees is high.

Following the study by Lamont and Downes (1979), a grasstrees ageing technique was developed by Ward (1997) who discovered that the annual fluctuations on the caudex of *X. preissii* stems correlated with coloured bands on the exterior of the mantle formed by the remnant leaf bases. The stem of a grasstree characteristically has a thick coating of charcoal and weathered material which when removed reveal the coloured bands. Once revealed, black bands against the regular sequence of light and dark brown bands may be seen. We have found that the black bands are associated with a lapachol-like compound which is not present in the other bands. It was proposed by Ward (1997) that the regular bands represented annual growth cycles (light brown or cream - winter/spring growth; and dark brown - summer/autumn growth) and that the black bands signified fire. It is therefore possible to age grasstrees and reconstruct site fire history for at least 200 years prior to data collection. Additionally, the non-destructive nature of the technique is an important advantage. The growth rates determined by this technique were equivalent to those obtained by Lamont and Downes (1979) in similar locations.

The width of the annual increments calculated from the caudex fluctuations were not significantly different from those calculated from the colour bands for three stems studied by Burrows (1998) confirming that the stem fluctuations and the colour bands correlate and that the colour bands represent annual growth increments, though the widths of the coloured bands were slightly wider than those measured from the stem fluctuations. This was probably due to post-harvest shrinkage of the caudex and spreading of the remnant leaf bases when adjacent leaf bases were previously removed using a hot air gun.

The strong correlation of the colour bands with the stem fluctuations confirms that they are produced during equivalent periods of growth. Lamont and Downes (1979) have previously confirmed that the stem fluctuations are annual increments. It is therefore suggested that the combination of one light brown band and one dark brown band is the equivalent of one year's growth as demonstrated with the peak and the trough of the stem fluctuations, although the reverse correlation was observed in one stem from the Amphion forest block studied by Burrows (1998) for reasons not yet known.

The alternating colours of the growth bands may be due to strongly seasonal growth, characteristic of the flora of southwest Australia. Tree stem growth is limited to a single growing season each year due to the strong Mediterranean-type climate typical of the jarrah forest region (Burrows *et al.* 1995). The winter/spring growth flush seen within many habitats is a response to water availability and warm growing conditions over these seasons. Slow growth at the end of autumn and beginning of winter produces a narrow band of dark wood followed by a wider band of faster grown lighter coloured wood in *Eucalyptus marginata* (Burrows *et al.* 1995). Most leaf development and associated stem expansion occurs in the winter/spring growing season (Lamont and Downes 1979) and winter/spring flush and expansion of the caudex occurs in *K. australis* (Lamont 1981). Delta $^{13}C$ ratios in leaf bases indicate that caudex peaks correspond to the lower temperatures of the winter/spring months. Therefore it is suggested that for the less seasonally restricted growth of *X. preissii*, (Twaddle *et al.* 1978; Lamont and Downes 1979; Lamont 1981) the light and dark brown bands represent winter/spring and summer/autumn growth respectively.

**Validation of the technique for determining fire history**

Lamont and Downes (1979) attempted to determine fire history by dating the incidence of floral remnants on *X. preissii* and *K. australis* stems. Floral remnants were considered to be an indication of fire history due to the association between fires and flowering among grasstrees (Lamont *et al.*, in review), although not all burnt grasstrees flower, and unburnt grasstrees sometimes do flower. Another potential problem with attempting to interpret fire history from floral remnants is that sampled plants may have escaped burning due to patchiness of fire. Low intensity fires may burn through a forest without igniting the wood on standing trees or stimulating grasstrees to flower (Anon. 1994). The technique of Ward (1997) allows the fire history of a site to be determined by dating the occurrence of the black bands on *X.preissii* stems and cross-referencing between associated plants. It is likely that the technique is highly accurate as grasstree leaves are highly flammable when dry so that even low intensity fires will be recorded as a black band, although tall grasstrees may still escape fires at frequently burnt sites. However, reliable conclusions could be drawn by sampling from a wide range of age classes.

Burrows (1998) found black bands on stems from sites in the Gyngoorda and Poison Gully blocks known to have been burned consistently throughout this century, but found no black bands on a stem from the Amphion block which has not been burned for at least 60 years, further supporting the conclusion that black bands signify fire. Ward (1997) has shown that fire history inferred from the bands agrees with fire records for the sites he studied. Studies of banding on grasstree stems may serve to supplement incomplete fire history records for the majority of Western Australian ecosystems and be useful for determining how variation in fire frequency has shaped vegetation over periods for which historical records do not exist (Bradstock *et al.* 1997). The common assumption that the presence of long-lived dominant species suggest lengthy fire cycles, and that resprouting or abundant seedling regeneration indicates relatively short fire cycles (Fox 1998) could also be assessed.

Fire frequency in the Perth region has declined from three or four fires per decade in the mid-nineteenth century to zero or one fire per decade in recent times.

**Dynamics of leaf-base nutrient contents after fire**

Burrows (1998) studied the dynamics of several nutrient concentrations in persistent *X. preissii* leaf bases and found that after fire, Mn and Mg concentrations within the innermost cm section of leaf bases declined and subsequently recovered to pre-fire levels (eg. Figure 1). In contrast, Ca and Zn concentrations increased after fire before decreasing to pre-fire levels. Although the fire effect on nutrient content was not apparent in the outermost cm of the leaf bases, regular seasonal fluctuations in the concentrations of Ca, K, Mg, S and Mn corresponding to the annual cycle of alternating bands (light brown/cream , dark brown) indicated that the seasonal banding pattern reflects seasonal changes in nutrient uptake. The concentration of calcium in grasstree leaf bases is likely to be a reliable indicator of past nutrient cycling due to being non-mobile and leaching-resistant in plant tissues (Sutcliffe and Baker 1974) and its consistent concentration dynamics in leaf bases (Burrows 1998). The contrasting post-fire changes in Ca and Mg concentrations might be due to inhibition of Mg uptake by the increase in Ca concentration.

Aside from the fire and seasonal effects on nutrient content, a long-term increase in leaf base nutrient concentrations was observed by Burrows (1998). According to Raison *et al.* (1985), prescribed fire rotations of 12 years are necessary for natural replenishment of nitrogen between fires, and 20 years to replace losses of phosphorus. During fire, nutrients are lost by volatilisation, leaching and particulate movement (Hingston 1985) so the long-term increase in leaf base nutrient concentrations could be explained by the historical decline in fire frequency in the Perth region. Hall (1994) suggested that the short –term protection afforded by fuel reduction burning may come at a long-term loss to productivity, but site nutrient dynamics is just one of many issues relevant to fire management.

**Effect of season of burn on subsequent flowering and fruiting**

In a recent study (Lamont *et al.*, in press), the responses of flowering and fruiting to fires in different seasons were assessed for fourteen populations of *X. preissii* in the Darling Range near Perth. Each plot in each graph in Figure 2 represents a random sample of 200 plants stratified into 5 height classes. The percentage of plants flowering in each height class was plotted against the corresponding mean height of the height class for each of the populations. It is readily apparent that in all four seasons of burn, flowering frequency increased with plant height class, but only 1% of plants flowered following winter fire (Figure 2d) and 75% flowered after summer fires (Figure 2b). Plants flowering after summer fires produced larger inflorescences and higher fruit densities than plants flowering after fires in other seasons (Lamont *et al.*, in review).

## Work in progress by the Grasstrees Research Group

Wendy Colangelo (Research Assistant) is investigating staining techniques for the identification of lapachol-like compounds at the micro-anatomical scale. These techniques will allow study of the movement and distribution of these compounds in leaf bases extracted from the black (fire) bands. Dylan Korczynskyj (PhD student) is studying water relations, leaf initiation and leaf growth in *X. preissii* following fires in different seasons. A study of how additional irrigation affects growth and water status of *X. preissii* has been initiated. Perry Swanborough (Research Assistant) is investigating correlations between variables associated with bands and the $^{12}C/^{13}C$ ratio. We hope to find consistent $^{12}C/^{13}C$ responses after fire. Roy Wittkuhn (PhD student) is studying biomass accumulation and nutrient dynamics in leaves, caudex and roots following fires at different times of year. This work will complement the previous nutrient results of Chantal Burrows.

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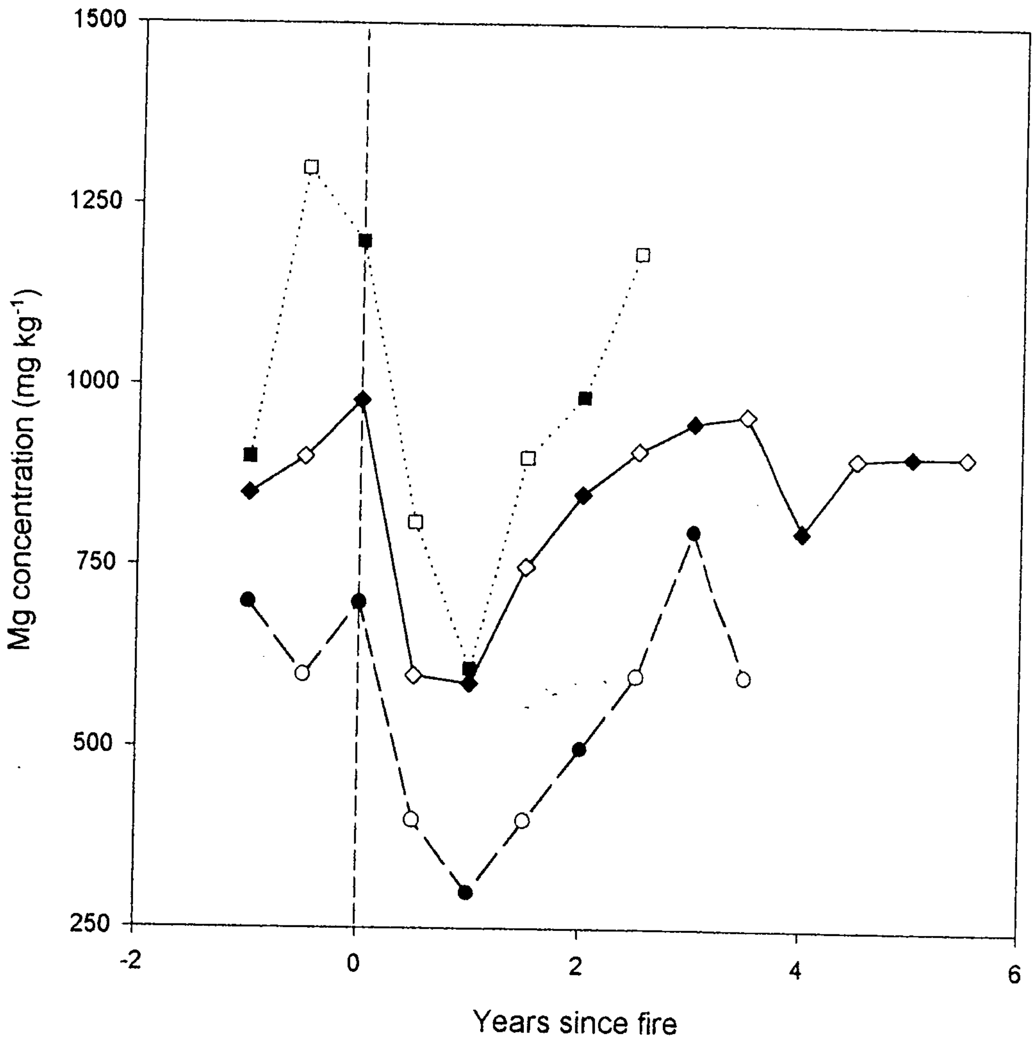
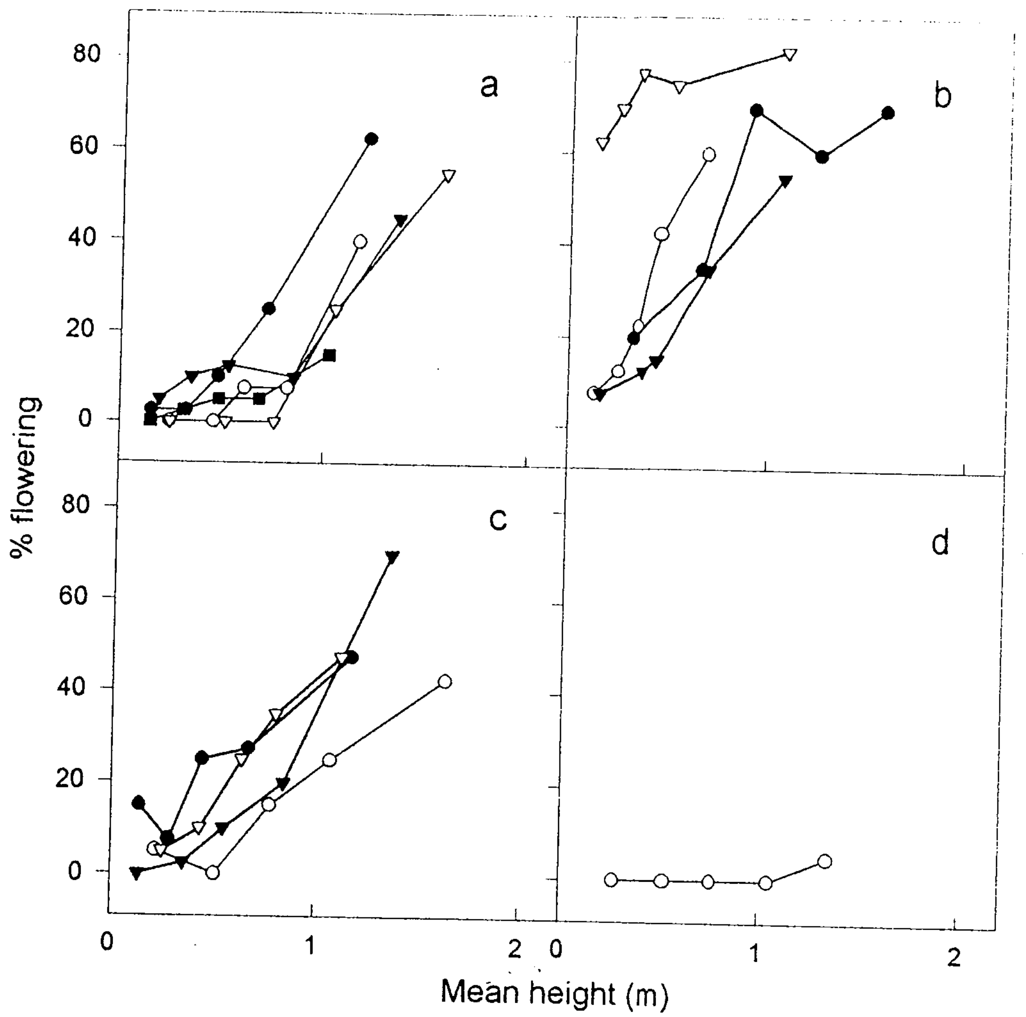
**Figure captions**

Figure 1. Dynamics of magnesium concentration in the innermost one cm of *X. preissii* leaf bases from a stem at Gyngoorda (32° 35′ S, 116° 28′ E) following burning. Data shown are for an 1892 fire (squares), a 1984 fire (circles) and mean values for 20 fires over 100 years (diamonds). Closed and open symbols indicate summer/autumn- and winter/spring –initiated leaves respectively.

Figure 2. Relationships between flowering frequency of grasstrees and height for sites previously burned in a, spring; b, summer; c, autumn and d, winter. Filled circle = flowered in 1995; open circle, closed triangle and closed square = flowered in 1996 and open triangle = flowered in 1997.

Figure 1. Mg dynamics after fire




80
60
40
20
0
80
60
40
20
0
% flowering
a
b
c
d
0
1
2
0
1
2
Mean height (m)

**Results of $^{12}C/^{13}C$ work so far**

The $^{12}C/^{13}C$ ratio is an integrative indicator of the historical water use efficiency (WUE) of a plant or plant part (Swanborough 1998). In short, low $^{13}C$ concentrations (more negative delta) indicate a history of less-limiting water availability compared with less negative delta values.

Figure 3 shows delta values for the outer (5$^{th}$) cm of leaf bases from a stem from the Gyngoorda block, for the time period 1900 to 1944. Figure 4 shows subsequent delta values from 1945 to 1987, and includes values for the innermost (1$^{st}$) cm of leaf bases from 1967 to 1987.

Points to note about the graphs:

Figure 3 shows a shallow decline in delta from 1900 to about 1940. However, the early '40s show a sudden increase in delta. Figure 4 shows the continued decline in delta from the values of the early '40s. The corresponding delta values of both 1$^{st}$ and 5$^{th}$ cm shown from 1967 to 1972 indicate that variation in delta along the entire length of a leaf base is typically low. It is clear from both graphs that there is no consistent seasonal pattern in the delta values, but the consistent decline in the values requires interpretation. Possibly long-term reduction in competition as a consequence of logging is resulting in increased water availability to grasstrees (despite long-term decreasing rainfall), but this is speculation. I will attempt to obtain logging records to investigate this hypothesis. On both graphs, fires are indicated on the time axis by asterisks (*). There appears to be no consistent pattern of response of delta subsequent to fires.

Work in progress:

I intend to compare delta values to corresponding band widths. Perhaps delta is a good indicator of season to season growth rates. I will do more delta measurements for 1$^{st}$ cm Gyngoorda leaf bases back from 1967 so that 1$^{st}$ cm values can be compared with 5$^{th}$ cm values for a longer interval. I will also measure delta for our Amphion block stem, so that delta values for this long-term unburnt site can be compared with the Gyngoorda (burnt) site values. The Amphion measurements will include $^{15}N$ so that we can start investigating nitrogen isotope discrimination also.

**Reference**

Swanborough, PW (1998). What stable isotopes can tell us. *In* Grasstree Project Meeting , July 1998 Report. School of Environmental Biology, Curtin University of Technology.

Figure 3. Delta 13C, Gyngoorda stem

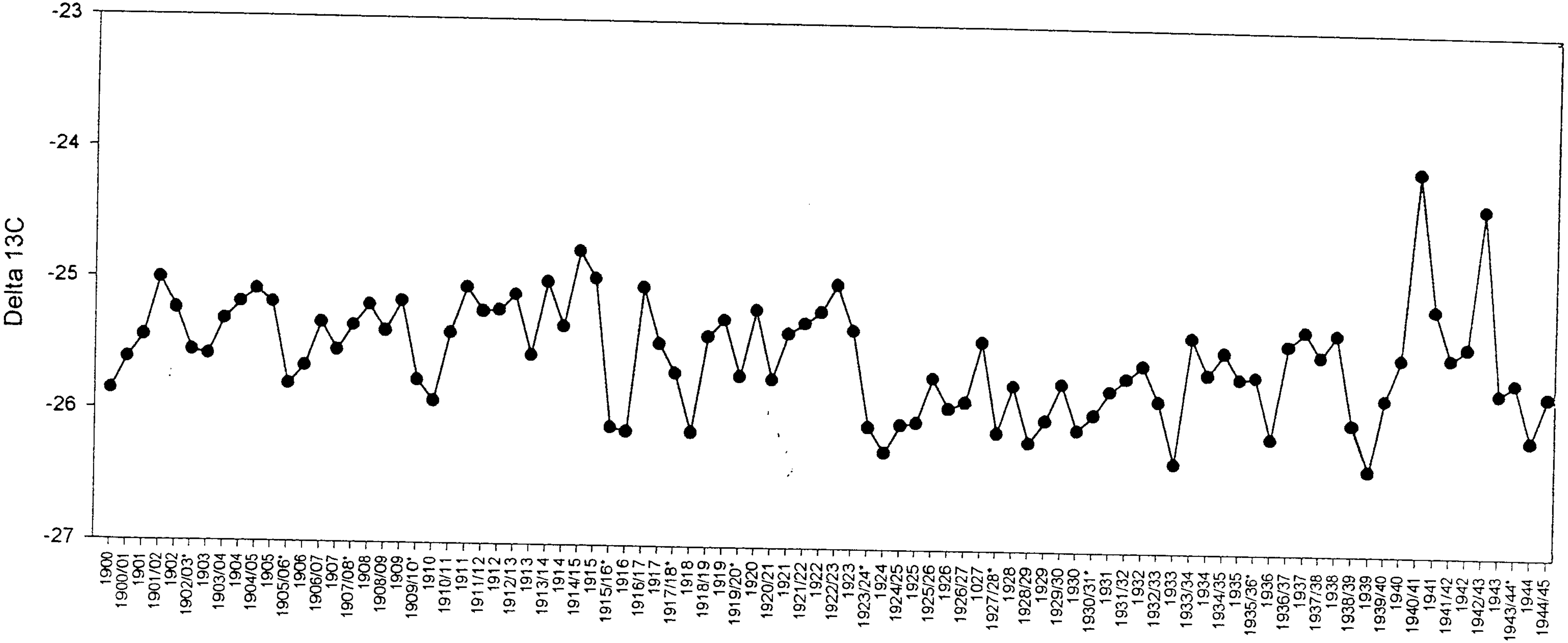
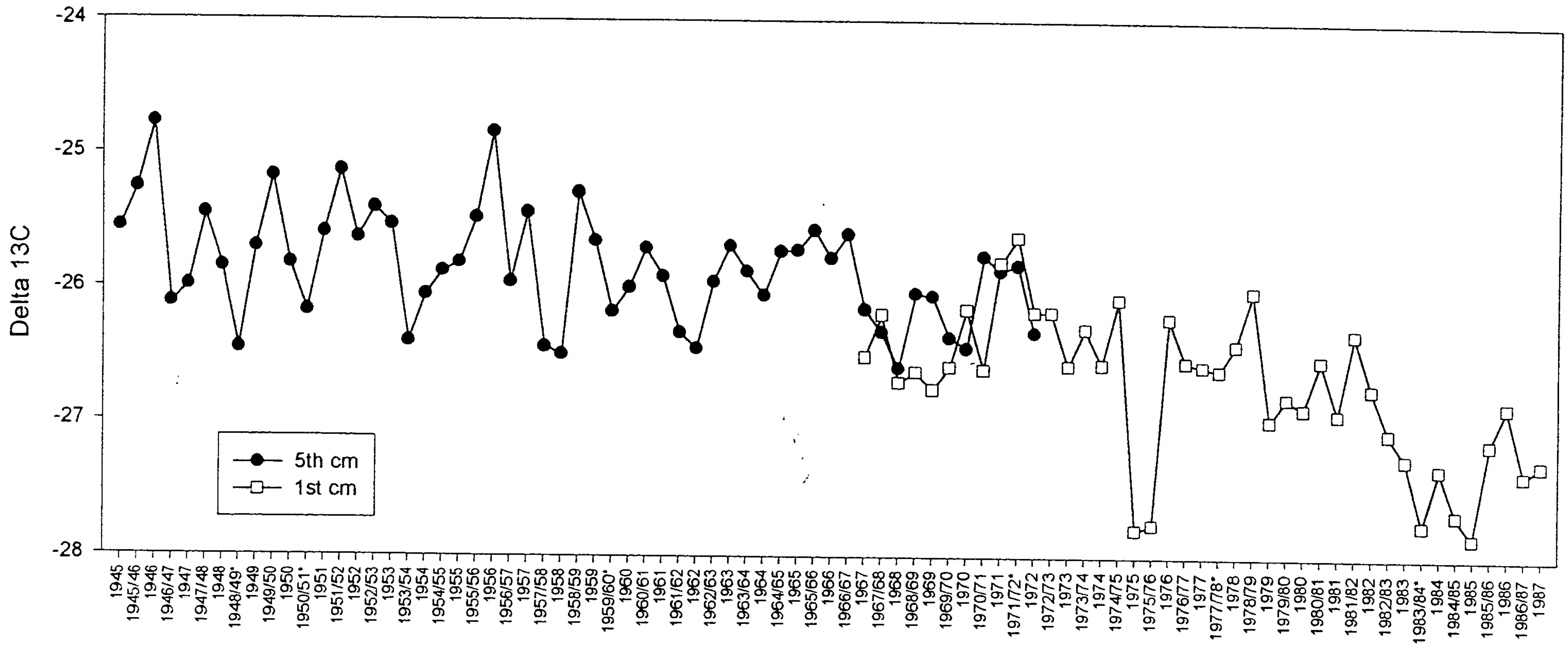


Figure 4. Delta 13C, Gyngoorda stem



# Grasstree Project Meeting

22 June 1999

Roy Wittkuhn - PhD candidate

*Overview of the experiments I am conducting*

There are 4 main experiments:

1. Monitoring of Nutrient Allocation Experiment
2. Fuel Age/Biomass Experiment
3. Nutrient Leaching - Skirts and Bases
4. Fire Simulation Experiment

## Monitoring of Nutrient Allocation Experiment

- The largest experiment that I am undertaking.
- This experiment monitors nutrient concentrations and total nutrient loads in the respective plant parts: leaves, caudex, roots and inflorescence.
- Plants are monitored at sites burnt in spring and autumn, and also at control (unburnt) sites.
- Plants are monitored at sites in Yanchep and Mundaring (two different sites to cover any site effects).
- Soils are also periodically sampled and analysed.
- The objective of this experiment is to find out whether there are any patterns of nutrient allocation with:

  - the passage of fire (burnt compared with unburnt - the first sample one month after fire)

- time since a fire (if there are differences between burnt and unburnt, do they persist?)
- season of burn (are more nutrients mobilised by the fire or absorbed by the plant for the different seasons of burn? Other factors: moisture availability, temperature).

- The other objective is to see which nutrients are showing patterns of accumulation, and to compare this with Chantal Burrow's work on dead leaf bases.
- Special area of interest: inflorescence formation and development (what happens to nutrient allocation, especially in the leaves).

### Fuel Age/Biomass Experiment

- Small experiment, designed to link with the *Nutrient Leaching - Skirts & Bases* experiment.
- Aim: to determine the biomass and nutrient load which is locked up in the skirt of the plant and to determine a relationship between the biomass of dead and live leaves and the fuel age (or time since burn).

  Linked with the *Nutrient Leaching - Skirts & Bases* experiment, I will test the hypothesis that the dead leaves on the skirt leach small amounts of nutrients, and try to quantify this and comment on the significance of it to the growth and nutrition of the plant. I may also expand somewhat to determine combustibility of the plant given a particular fuel age, and argue the evolutionary significance of the skirt as a combustion key rather than a nutrition key.
- Design: Green and dead leaves are harvested from four plants at six sites of fuel ages 0.5, 2.5, 4.5, 6.5, 9.5 and 13.5 years. This is duplicated with the study sites being at Mundaring and Yanchep.
- Biomass of green and dead leaves is averaged at each site, and plotted to obtain a relationship of green leaf biomass with fuel age, and dead leaf biomass with fuel age.

### Nutrient Leaching - Skirts & Bases experiment

- This experiment is the other half of the *Fuel Age/ Biomass* experiment.

- Aim: to determine the amount and nature of nutrients that leach out of leaf blades and leaf bases, and to determine if this plays a significant part in the nutrition of the plant.

  This experiment also covers one of Chantal Burrow's recommendations in her honours thesis which is to see whether nutrient leaching from the leaf bases is significant, since it could cloud the interpretation of results if the nutrition pattern is studied on old grasstree stems.

### Fire Simulation Experiment

- Conducted in conjunction with Dylan Korczynskij.
- Aim: to identify the fire effect(s) which influence leaf emergence (Dylan) and nutrient allocation (Roy).
- Design: There are 8 treatments which are made up of a combination of the following:

| | | |
|---|---|---|
| + shade | + water | + ash |
| - shade | - water | - ash |

  These 8 treatments were replicated 6 times, giving a total of 48 study plants.

- After one year of growth, I will harvest plants and determine the nutrient allocation in each of the plants, to test for the most influential fire effect on nutrient allocation and concentration.

## *Progress to Date (very much in brief)*

### *January*

- submitted my candidacy
- liaison with CALM Mundaring for autumn-burn site

*February*

- Liaison with CALM Wanneroo for autumn-burn site
- Began dieback testing on soil from possible autumn-burn sites.
- Plant harvests at Mundaring sites - Mundaring Spring Burn (MSB) site and Mundaring Control (MC) site.

*March*

- Plant harvests at Yanchep sites - Yanchep Control (YC) site and Yanchep Spring Burn (YSB) site.
- Completed all dieback testing - none of my sites dieback infected.
- Searched and finalised sites for FUEL AGE/BIOMASS experiment in Mundaring - CALM liaison.

*April*

- Collected green and dead leaves from plants for FUEL AGE/BIOMASS experiment in Mundaring.
- Dried and weighed all green leaf material and most dead leaf material. This experiment remains in limbo at present.
- Liaised with CALM Wanneroo for sites for FUEL AGE/BIOMASS experiment.
- Yanchep Autumn Burn (YAB) site burnt on 22 April. Set up study plot 1 week after burn.
- Took soil samples from YAB site.
- Met with Dave Allen from the Chemistry Centre of WA to negotiate analysing my thousands of samples.

*May*

- With Dylan and Perry, set up the FIRE SIMULATION EXPERIMENT: clearing vegetation, clipping plants, began making ash. This took up most of May.

- Harvested plants from YAB and YSB site.

*June*

- Harvested plants from YC site (first week).
- Made more ash for the FIRE SIMULATION EXPERIMENT.

## *The Rest of the Year*

*July*

- Harvests at MC and MSB sites.
- Collection of green and dead leaves for FUEL AGE/BIOMASS experiment at Yanchep.
- Analysis of all FUEL AGE/BIOMASS data.
- Have all ash made for FIRE SIMULATION EXPERIMENT so that the experiment can be implemented.

*August*

- Begin analysis of plant material and soils at Chemistry Centre of WA. This will be ongoing throughout the length of my studies.
- Design NUTRIENT LEACHING - SKIRTS & BASES experiment.

*September*

- Implement NUTRIENT LEACHING - SKIRTS & BASES experiment.
- Collect next plant samples from Yanchep and Mundaring.

*October*

- Conduct nutrient analyses at Chem Centre.

*November*

- Conduct nutrient analyses at the Chem Centre.
- Begin writing up the results for the FUEL AGE/BIOMASS and NUTRIENT LEACHING experiments.
- Next plant samples from Yanchep and Mundaring.

*December*

- Continue writing the paper for FUEL AGE/BIOMASS and NUTRIENT LEACHING.
- Continue with nutrient analyses at Chem Centre.

### *Setbacks for 1999*

- No autumn burn in Mundaring.

  Solution: will have to wait until next year for the burn. This presents problems with data analysis and presentation. I would welcome any ideas on this matter.
- Illness: I have just had tonsillitis which has come at a particularly bad time, and will probably put me back 2 weeks.
- The slow nature of negotiation on costs of nutrient analyses.

# Biomass and water cycling among grasstrees, relative to fire and season

SUMMARY OF PROGRESS BY DYLAN KORCZYNSKYJ

Since the December Grasstree Project Management meeting my work has broadened encompassing previously mentioned plans. During March I fulfilled the Universities requirement of submitting an Application for Candidacy, which primarily consists of a detailed document outlining every aspect of my proposed study. Although time consuming this provided an opportunity to clarify the direction in which my work will take, including a time frame. My candidacy was approved in May.

The order in which I have initiated new work has largely been determined by uncontrolled events, eg. changes in season and flowering spike initiation. Below is an outline of my work to date, and where possible, accompanied by a brief account of my results.

## Leaf Production & Biomass

Regular visits to each study site to monitor leaf production has continued and also expanded to include monitoring of a new autumn burnt site in Yanchep. Unfortunately, a comparable site in Mundaring was unable to be burnt, so it is our hope to establish such a site in 2000.

Figures 1 and 2 show the patterns of leaf production that are emerging. It is clear that a spring fire enhances the flush of new growth during spring/early summer among *X. preissii* on both the coastal plain and Darling Plateau. A gradual convergence of growth rates through summer into autumn and then winter is also apparent, with intermittent fluctuations consistent for both the burnt and unburnt plants. What is of particular interest is the apparent relationship between these fluctuations and rainfall. Using Figure 2 as an example, it can be seen that immediately following the data collection on the 18$^{th}$ March there was a rain event of 31mm. This resulted in an increase in leaf production among the control plants and a rapid slowing of the declining leaf production rate of the burnt plants. A second larger rain event (50.2mm) on the 15$^{th}$ April further emphasises the positive effect water availability has on leaf production rates.

From Figure 2 the autumn burn site can be seen to be responding to the recent fire event with an elevated leaf production rate compared to that of the control and spring burn site.

**FIGURE 1.** ***Xanthorrhoea preissii*** **leaf production rates and daily rainfall on the Darling Plateau (Mundaring). n=6, ±SD.**

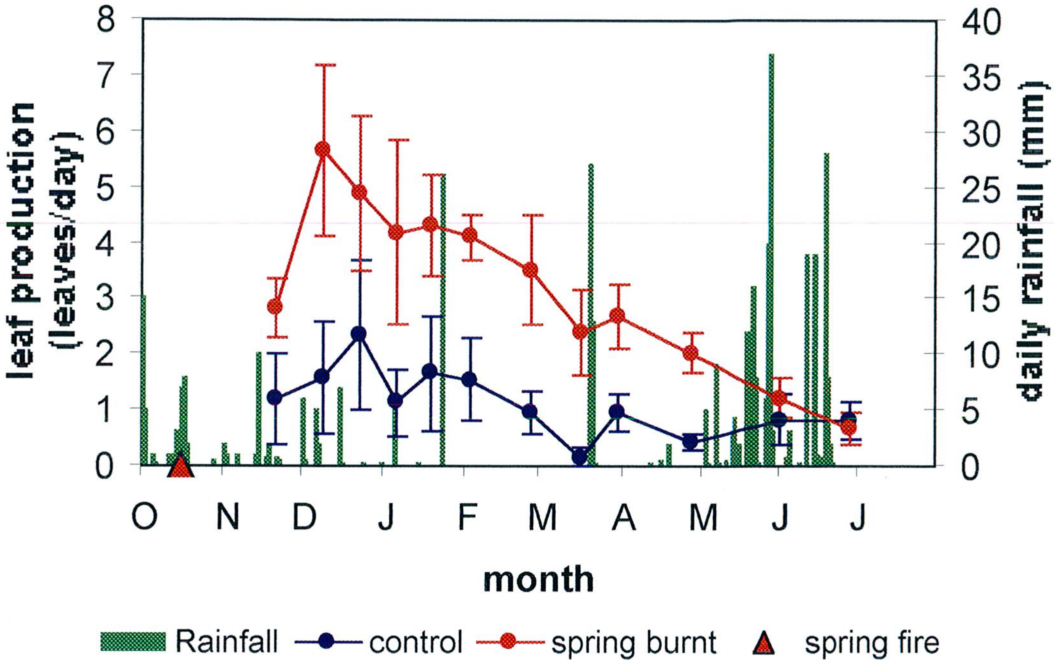
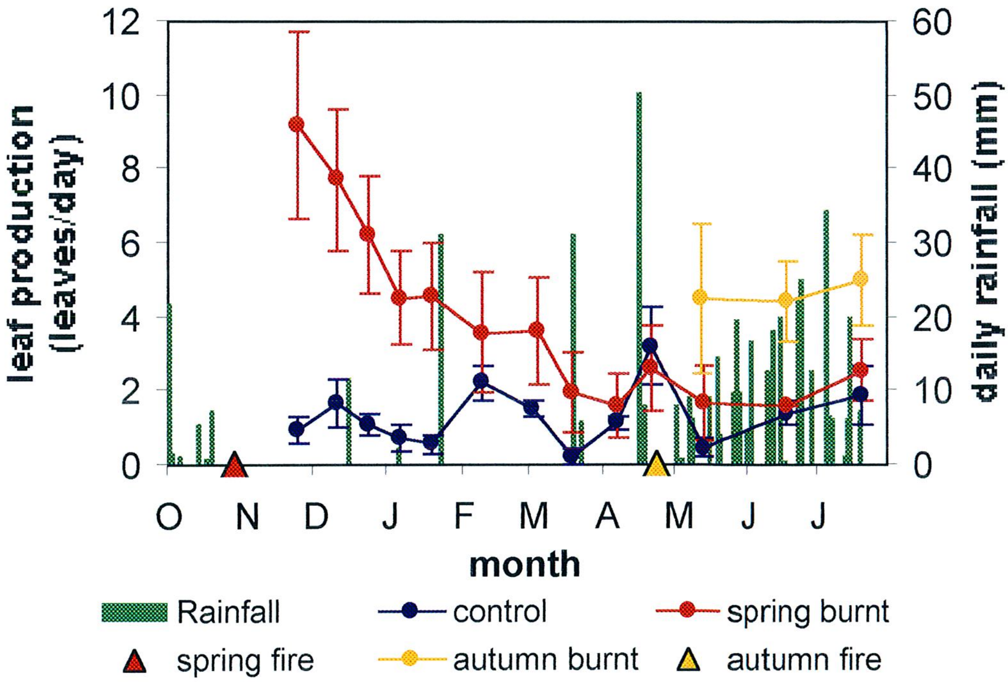



**FIGURE 2.** ***Xanthorrhoea preissii*** **leaf production rates and daily rainfall on the Coastal Plain (Yanchep). n=6, ±SD.**



## Water Cycling

Water relations work has been carried out on a regular basis as a means of monitoring the water status of *X. preissii* and interpreting the soil water availability at all four sites. The fifth autumn burn site has recently been included in this work.

From a general perspective water potentials have not differed significantly between the control and burnt sites since monitoring commenced, plants from both sites recover well overnight before becoming more stressed during the day. Midday water potentials for the control plants tend to be marginally more negative than those from the burnt sites, which may be a consequence of having a greater amount of transpiring foliage (ie. A mature crown of leaves). The lowest midday water potentials tend to reflect the respective periods during which each site experienced its driest weather.
Leaf water content is measured as a second index of plant water status. For both the Yanchep and Mundaring sites the spring burnt plants show a constantly higher predawn and midday water content. The Mundaring plants experienced their lowest midday leaf water content during the hottest summer period (February), while the predawn low lags until April corresponding more closely with the driest period and lowest water potentials. The midday and predawn leaf water content for the Yanchep plants do not appear to be out of phase, with the lowest values for both coinciding with the driest period.

Preliminary analysis of grasstree water cycling tends not to reveal an obvious difference between control and burnt plants, as was hypothesised. The 1998/99 summer was relatively mild, and offers a possible explanation for the lack of separation between the water status of plants at each site over this period. It is hoped that more light can be shed on this matter during the coming summer.

## Flowering

During March Roy Wittkuhn identified a newly initiated flowering spike while dissecting a series of grasstrees. In April after examining a number of plants I found that leaf widening, deformation and bifurcation of the plants growing apex was becoming a common occurrence in the burnt plants at Yanchep and to a lesser extent Mundaring. This was attributed to the initiation of a flowering spike hidden deep within the plants apex. A number of the plants monitored for leaf production began to exhibit this unusual growth pattern, and are now being treated separately from those that appear to have had no change. New plants were tagged to maintain replicate numbers for both flowering and non-flowering treatments.

It is my intention to record the development of the flowering spikes, while monitoring plant water status and leaf production.

## Experimental field work

Two field experiments have been established to identify the importance of fire effects and herbivory on grasstree growth.

### Fire Effects

This experiment is being carried out on the Coastal Plain, in conjunction with Roy Wittkuhn. It involves simulating a series of factors associated with a post-fire environment that are suggested to influence leaf production (Dylan) and nutrient allocation (Roy). A combination of the following have been applied to 48 (6 replicates/8 treatments) plants:

- +/- shade, represent the opening of the canopy following fire,
- +/- water, representing an increase in available water following fire due to reduced transpiration, and
- +/- ash, representing the nutrient rich ash bed created during a fire.

All plants and the surrounding vegetation out to a radius of 3m have been clipped back to simulate the "pruning effect" of fire. After one year of growth leaf biomass will be determined for each plant and the relative effect of each treatment will be assessed.

### Herbivory

Carried out at the control site at both Mundaring and Yanchep, this experiment aims to identify the effect animal herbivores (eg. kangaroo, parrot) have on subsequent leaf production. The following treatments have been applied to a total of 24 plants per site:

- Once off herbivory,
- Herbivory attack every 4 months,
- Herbivory attack every 2 months,
- Herbivory attack every month,
- Herbivory attack every month with leaf pieces left covering the growing apex, and
- Control – no herbivory.

Clipping back the entire plant crown has been used to simulate a herbivory attack. These treatments will be applied for one year, at the end of which accumulated leaf biomass will be determined.

## New Root Growth

We have recently observed the initiation of new roots from directly above the existing mature roots. As an area of relatively rapid growth and one that may play an important role in water cycling during the following summer, I feel that it is an important process to investigate and assess its effect on leaf production. A series of plants from each of the Yanchep sites have had young roots carefully excavated, measured and then buried, in an attempt to monitor their growth rates. I hope to continue applying this technique until summer, at which point total new root biomass will be determined.

## Conclusion

Despite the necessity to adjust my works priorities, the inclusion of work on new roots and the growth of the field experiments to a larger scale, I have been able to maintain my proposed time schedule. The coming spring/summer will be a particularly busy period as the grasstrees flower, leaf production increases and watering of experimental plants commences, however with sufficient preparation I cannot foresee any significant problems.

# GRASSTREE PROJECT MEETING

## Histological Update

by Wendy Colangelo

We are all aware of the occurrence of coloured bands on the grasstree (*Xanthorrhoea* spp.) stem. The cream bands depict winter/spring growth and the brown bands summer/autumn growth. The black bands coincide with CALM recordings of fire.

My part in the Grasstree project is a histological one. To determine the anatomical basis and origin of the difference in colouration between the three bands of leafbases. My aim is to section leafbases from the three different bands and to determine difference in colouration at the light microscope level and where that accumulation occurs.

my research time trying different embedding techniques including wax, GMA and Little work has been done on the anatomy of leafbases in grasstrees. I have spent all of preboiling fresh leafbases.

Wax embedding was not successful as the leafbases were harder than the wax and it was unable to penetrate the waxy outer surface of the leafbase.

GMA embedding has not been successful as half my sections of leafbases are still floating in GMA, after 12months infiltration period.

I have successfully sectioned the leafbases after initially preboiling them in distilled water for 30 minutes, then sectioning using the sledge microtome.

PHOTOS (Refer Grasstree Meeting Report December 1998).

These photographs show the leafbases taken from the fireband have an accumulation of material/substance in the xylem/phloem vascular arms. The photographs show that the fireband leafbase stained with toluidine blue stained blue in the vascular arms. Gahan (1984) noted that tannins stain blue using toluidine blue.

Further, the fireband leafbases stained with safranin and fastgreen stained red which O'Brien and McCully (1981) cite as giving additional evidence to the substance being a tannin.

Unfortunately, after conferring with a variety of plant and animal histologists it appears that histological staining will not be able to give a more concise determination of what is accumulating in the vascular tissue other than it being a tannin.

I then decided to look at the question of what it is from the chemical analysis by Challinor. Using gas chromatography the cream and fire bands were found to differ in only one compound which Challinor tentatively identified as a lapachol-like substance.

An extensive and ongoing literature search was undertaken to get information on lapachol and possible techniques I could adapt to histologically give evidence of the presence of lapachol in the fire band and possibly to a lesser extent in the brown band.

Some relevant information about lapachol.
Lapachol is a naturally occurring quinone or plant pigment. Lapachol has 2 aromatic rings fused to the quinone nucleus and is therefore classified as a napthoquinone.

Quinone pigments are a form of phenolic compounds (Harborne,1973), which tend to be water soluble. Several important groups of polymeric materials in plants including tannins and lignins are polyphenolic. Polymeric phenols such as tannins and lignins are easily oxidized and converted to quinones (Lindsey,1974). This suggests a relationship between my positive staining of tannins in the burnt leafbase and Challinor's identification of a lapachol-like compound.

I am currently attempting to adapt histochemical tests specific for the identification of napthoquinones to my histological work. If I can find a stain that is specific to napthoquinones which then stains my sections where they previously showed the presence of tannins it will give the closest supporting evidence to Challinor's work.

Thomson (1971) cited that leucomethylene blue was a useful spray for the detection of napthoquinones on paper and thin layer chromatography, the quinone appearing as blue spots on a white background.

Reduction to a colourless stain with easy restoration of the original colour on oxidation, is characteristic of quinones. I have found two protocols for making leucomethylene blue. The first used zinc dust as the reducing agent to clear the methylene blue. This stain had a short shelf life of a few days. However, on my initial trial I observed that the leucomethylene blue did not stain the blocked vascular arms blue in the preboiled fireband sections. Preboiled sections failed to take up the blue stain and remained brown as they appear in the unstained state. One explanation of this failure could be that boiling has altered the chemistry of the napthoquinone, so I need to test this stain on unboiled fresh sections. Using frozen sections is also a possibility.

I am currently using another method of making the leucomethylene blue using sodium dithionite as the reducing agent rather than zinc which may be more stable and last longer.

If this technique is successful then additional evidence has been provided to the question of what is accumulating in the vascular tissue and causing the difference in colouration to be a napthoquinone, possibly lapachol. In addition, histology has shown where the compound is accumulating.

Regardless of the success of using the leucomethylene blue stain, duplicate leafbase samples have been taken from the stems used by Chantal Burrows namely, Gyngoorda, Amphion and Poison Gully. The different bands and representative years have been sampled to duplicate my initial findings of colour accumulation in the vascular tissue of the fire band.

Also Roy and Dylan have collected fresh leafbases immediately after fire. I intend to cut serial sections to determine presence and extent of "lapachol".

**HONOURS PROJECT: 1999 - 2000**

**Project Sponsor: ALCOA**

**Industry Researchers:** Ward, S.C., Koch, J.M., Hantler, L., Morald, T.

**University Supervisor:** Lamont, B.B., Curtin University.

**Student Researcher:** Richardson, J.

**Location:** Alcoa's mines at Huntly, Willowdale and Jarrahdale.

**Project Title:** Establishment, survival and growth of *Xanthorrhoea spp.* on rehabilitated bauxite mines in Western Australia.

**Background information:**

Alcoa's objective is to establish a self-sustaining forest ecosystem, planned to enhance or maintain water, timber, recreation, conservation and/or other nominated forest values defined in the CALM Regional Management Plan for the Northern Forest Region.Ward, Koch & Nichols (1990)

Grasstrees (*Xanthorrhoea preissii* and *X. gracilis*) are major important floristic and structural components of the Northern Jarrah Forest.Seeds are relatively plentiful and germination and field establishment rates are high. However,there appears to be a high mortality rate of seedlings in the re-habilitated bauxite mines in the years following the initial establishment (J. Koch personal communication).

An Alcoa environmental research project commenced in 1980 showed that there were 54% of seedlings alive after one year and 30% surviving after 16 years (J Koch personal communication).

Alcoa has four dedicated permanent studies, which contain grasstrees of known ages. These were set up in the years 1980, 1986, 1992, and 1998. There are also more than 100 permanent vegetation plots where grasstree numbers have been recorded on two occasions and which could be remonitored to provide additional data points. These range from years 1990 to 1998.

Grasstree mortality rates could be correlated with other vegetation parameters which have been measured in these plots (density and cover of all plant species).

# Current Study

**Location:**

4 sites at Huntly (2 dieback free, 2 dieback present)
[2 stockpile soil, 2 direct return soil]

4 sites at Willowdale (2 dieback free, 2 dieback present)
[2 stockpile soil, 2 direct return soil).

**Design:**

Two three factorial experiments with eight replications per treatment.

**Statistics:**

Analysis of variance using SAS.

**Start Date:**

1/5/1998.

**End Date:**

1/5/2008. Student involvement to end 1/12/2000

**Method:**

There will be three main treatments, each of which will be applied at two levels. The treatments are:

Grazing: a) protected by a 70 mm chicken mesh enclosure
b) no protection.

Competition: a) understorey and overstorey removed
b) no removal

Shade: a) covered with 70% shadecloth
b) no shade protection.

Individual treatment plots are 1.6 x 1.2 m.One half of each plot was planted with 25 g (1517 seeds) of *X. preissii* and the other half was planted with 30 g (2714 seeds) of *X. gracilis.*

**Progress:**

The 1998 plots were planted with specific numbers of the seeds of *X.preissii and X. gracilis* .In September, 1998. these plots were thinned to approximately 50 plants per plot. The harvested seedlings were counted, measured for leaf length and leaf number. Some seedlings were potted-up, using 'Pixie Mix' potting compost, and kept under 70% shade house conditions and given regular water.

**Field-work schedule:**

1998 - plot monitoring September, November,

1999 - plot monitoring February, July, October.

2000 - plot monitoring February.

Monitoring dates for old plots yet to be decided.

On each field trip the location and number of surviving seedlings are mapped, together with the spread and identity of any competition plants. Soil is collected for analysis and is tested for soil moisture at the same time as other field work..

**Reports Due:**

27/10/99: CALM for collector's licence renewal

1/5/2000: for Alcoa.

Nov 2000.: Thesis due

**General Aim:**

The aim of the project is to determine what factors cause the demise of, and what factors promote, the survival of *X. preissii* and *X. gracilis* seedlings.

A secondary aim is to gain an understanding of root development and the histological changes in the leaf between juvenile and mature plants.

# <u>General Aim:</u>

The aim of the project is to determine what factors cause the demise of, and what factors promote, the survival of *X. preissii* and *X. gracilis* seedlings.

**<u>Project aims:</u>**

1. **Determine field establishment rates of these two species.**
2. **Identify factors affecting survival rate (eg: competition, grazing, drought, shade etc.).**
3. **Measure growth rates and plant morphology changes over the project time period.**

3.1. **Correlation between Xanthorrhoea performance and soil parameters.**

4. **Examine root growth and morphology.**
5. Soil Analysis.
6. Soil Micro-organisms.

**Project aims:**

1. **Determine field establishment rates of these two species.**

Ho Establishment rates are the same for of *X. preissii and X. gracilis.*

Ha Establishment rates not are the same for of *X. preissii and X. gracilis.*

Ho Establishment rates for *X. preissii* are the same at each location.

Ha Establishment rates for *X. preissii* are not the same at each location.

Ho Establishment rates for *X. gracilis* are the same at each location.

Ha Establishment rates for *X. gracilis* are not the same at each location.

Ho Establishment rates for *X. preissii* are the same for all treatments.

Ha Establishment rates for *X. preissii* are not the same for all treatments.

Ho Establishment rates for *X .gracilis* are the same for all treatments.

Ha Establishment rates for *X. gracilis* are not the same for all treatments.

2. **Determine survival (mortality) rates from 1 to 9 years [approx].**

Utilise data already collected by Alcoa and supplement with a current survey.

Correlation with other vegetation and soil attributes.

**3. Identify factors affecting survival rate (eg: competition, grazing, drought, shade etc.).**

Ho Survival rates are the same for of *X. preissii and X. gracilis.*

Ha Survival rates not are the same for of *X. preissii and X. gracilis*

Ho Survival rates for *X. preissii* are the same at each location.

Ha Survival rates for *X. preissii* are not the same at each location.

Ho Survival rates for *X. gracilis* are the same at each location.

Ha Survival rates for *X. gracilis* are not the same at each location.

Ho Survival rates for *X. preissii* are the same for all treatments.

Ha Survival rates for *X. preissii* are not the same for all treatments.

Ho Survival rates for *X. gracilis* are the same for all treatments.

Ha Survival rates for *X. gracilis* are not the same for all treatments.

**4. Measure growth rates and plant morphology changes over the project time period.**

The height and leaf number of two plants are recorded from each aspect of the soil profile. ie. Ripline. North facing and South facing slopes. (Six plants from each plot for each species).

Ho The seedling heights of *X. preissii and X. gracilis* are the same.

Ha The seedling heights of *X. preissii and X. gracilis* are not the same.

Ho The seedling heights of *X. preissii and X. gracilis* are the same for all treatments.

Ha The seedling heights of *X. preissii and X. gracilis* are not the same for all treatments.

Ho The seedling heights of *X. preissii and X. gracilis* are the same for all the sites.

Ha The seedling heights of *X. preissii and X. gracilis* are not the same or all the sites.

Ho The seedling heights of *X. preissii and X. gracilis* are the same for each part of the soil aspect.

Ha The seedling heights of *X .preissii and X. gracilis* are not the same for each part of the soil aspect.

A similar set of hypotheses can be compiled with regard to leaf numbers.

## 4.1. Correlation between Xanthorrhoea performance and Soil parameters

(Survival rates, leaf height and number of leaves correlated with soil pH, conductivity, nutrients, organic content, texture and moisture).

## 5. Examine root growth and morphology.

**5.1.** Some of the *X. preissii* seedlings had been maintained under shade-house conditions & have now been transplanted into my garden for observation. Selected area is woodland, Bassendean sand with high organic content, & strong root competition.
A watering regime has not yet been decided. All plants have been labelled but height & leaf number have not yet been measured & recorded. Root tubers were present on some samples taken from Sampson, Diamond & Thylacine sites. Scale drawings & macro photos were obtained of eight specimens from Diamond site prior to trans-planting.

**5.2.** Transplanting of other potted seedlings to CARROLL tubes is under consideration.

**5.3.** Seedlings will be harvested at trials end for examination.

Seedling sources will be:

A: plants from the field

B: plants from the garden trial

C: plants from shade-house trials

Specimens will then be:

A: photographed

B: scale drawings done

C: used for the herbarium collection

D: used for mycorrhiza analysis

**5.4.** Anatomical studies have been commenced to determine morphological characteristics of mature and juvenile leaves and roots in both species. Specimens have been fixed in GMA and are yet to be sectioned and stained.

## 6. Soil Analysis

Soil samples have been collected from each of the eight trial sites. Samples were collected from depth 0-10 cm and 10-20 cm both from the top of the ridge and the bottom of the ripline with four replicates at each site. Proposed analysis on these samples are: texture, nutrient analysis, pH, conductivity, and organic content. Soil moisture will be measured at the time of each field trip.

This data, when correlated with seedling establishment, may give some indication as to whether soil type has an influence on establishment and soil moisture, and whether the ripline profile has a bearing on survival of seedlings.

## 7. Soil Micro-organisms

Four of the sites are designated as Dieback-affected and four sites are classified as Dieback-free.

Four sites had direct return top soil and four sites had stock pile top soil. *Xanthorrhoea* species are known to be susceptible to *Phytophthora cinnamomi* . This study would be incomplete without establishing the status of this micro-organism at the *Xanthorrhoea* trial sites.

Ho: *Phytophthora cinnamomi* is present at all the trial sites.

Ha: *Phytophthora cinnamomi* is not present at all the trial sites.

Abbott & Robson(1977) and Burndrett & Abbott (1991) found an association between vesticular-arbuscular mycorrhiza and *Xanthorrhoea* species seedlings when grown in inoculated soil. They found that the infection process was slow to establish compared with some other Jarrah forest species.

Ho: Mycorrhizas are present in the roots of *X.* spp. at all trial sites.

Ha: Mycorrhizas are not present in the roots of *X.* spp. at all trial sites.

## Materials and Methods:

**Soil Analysis:** **Methods Used**

| Soil Analysis | Methods Used |
|---|---|
| pH: | 100 mL deionised water / 20 g air dried soil, shaking machine at 200 rpm. overnight. HAS. Beckman pH meter. |
| Conductivity: | 100 mL deionised water / 20 g air dried soil, shaking machine at 200 rpm. overnight. Philips conductivity meter. |
| Organic matter: | Carbolite Furnace pre heated to 600$^0$C 10 g soil / 2 hour duration |
| Nutrient Analysis: | CSBP Laboratory |
| Textural Analysis: | Dry sieving method. |

**Micro-organisms:**

Consultation with Ian Colquhoun, Snr. Research scientist at Alcoa.

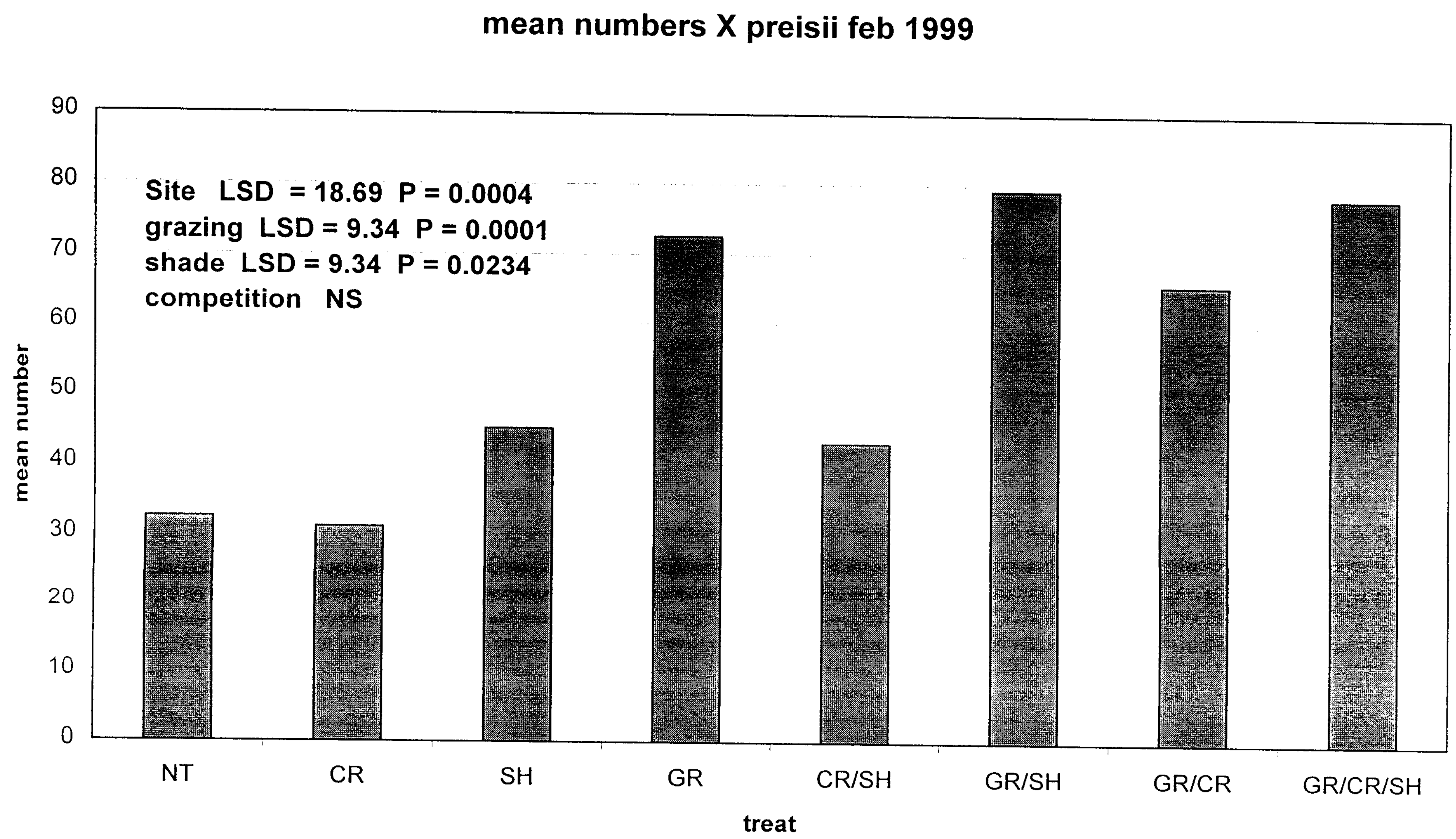
Alcoa will test samples for dieback.

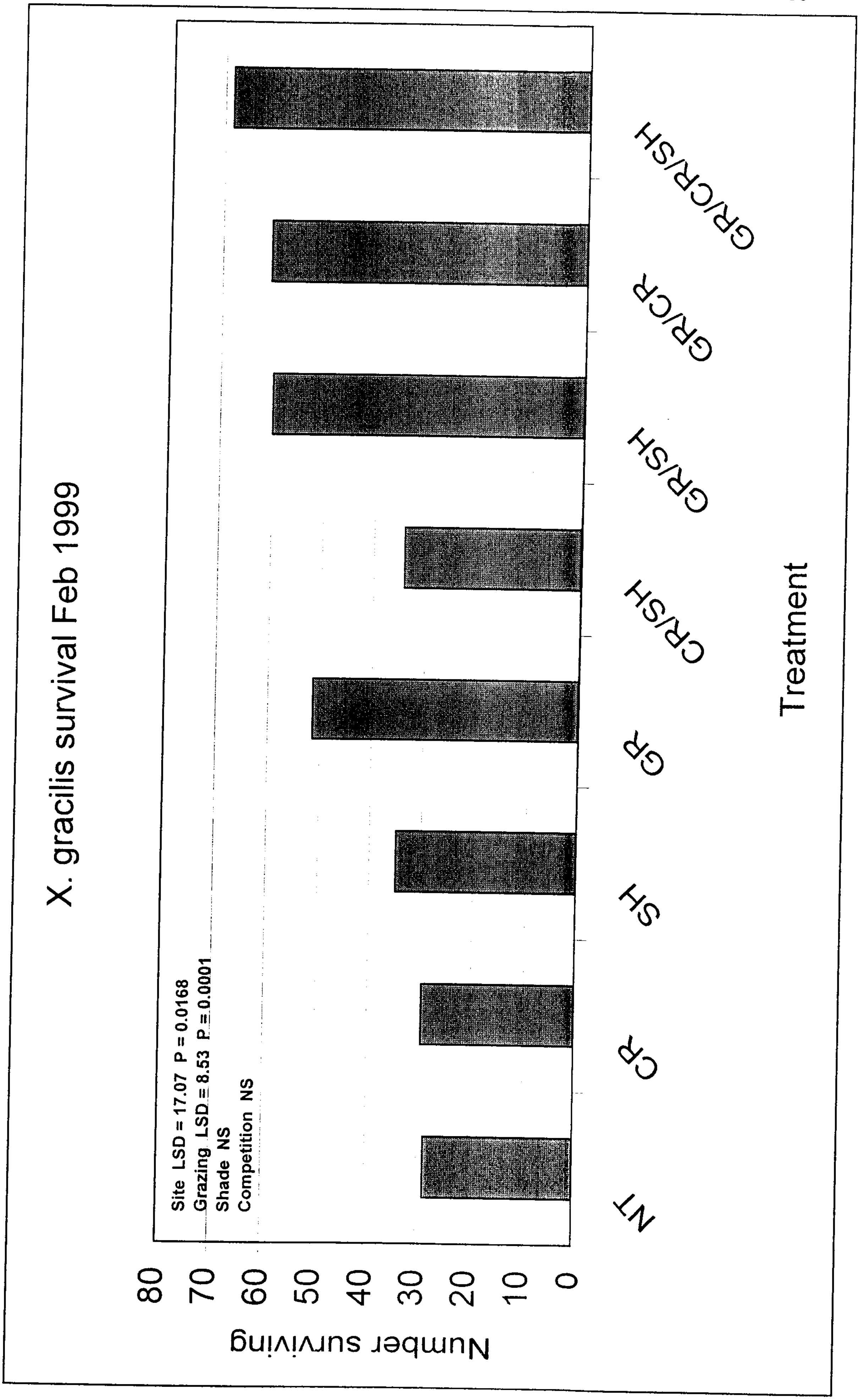
Subject to a research grant approval, specimens for mycorrhizal infection will be screened by the team at Murdoch using genetic tagging methods.

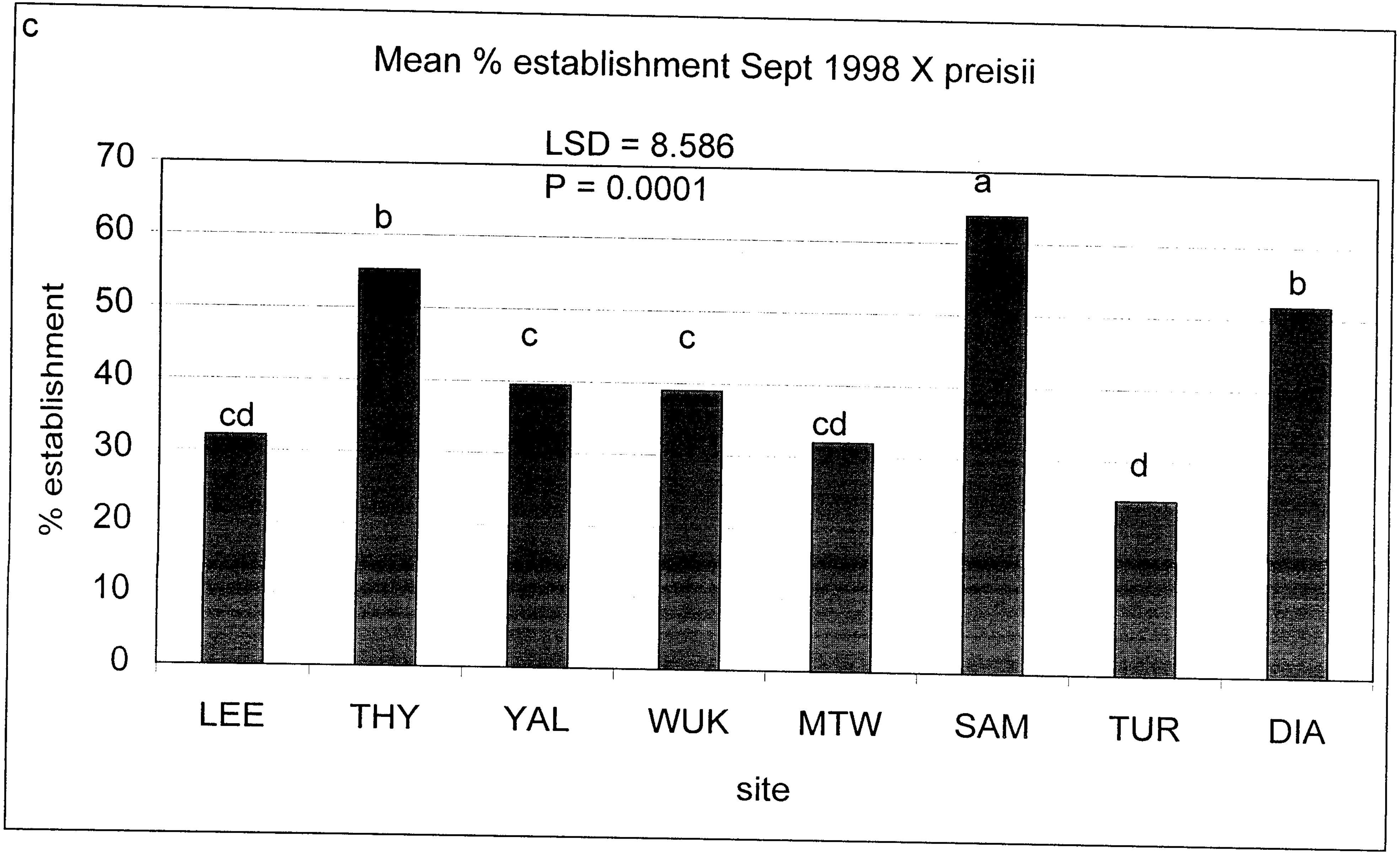
**Histology:**

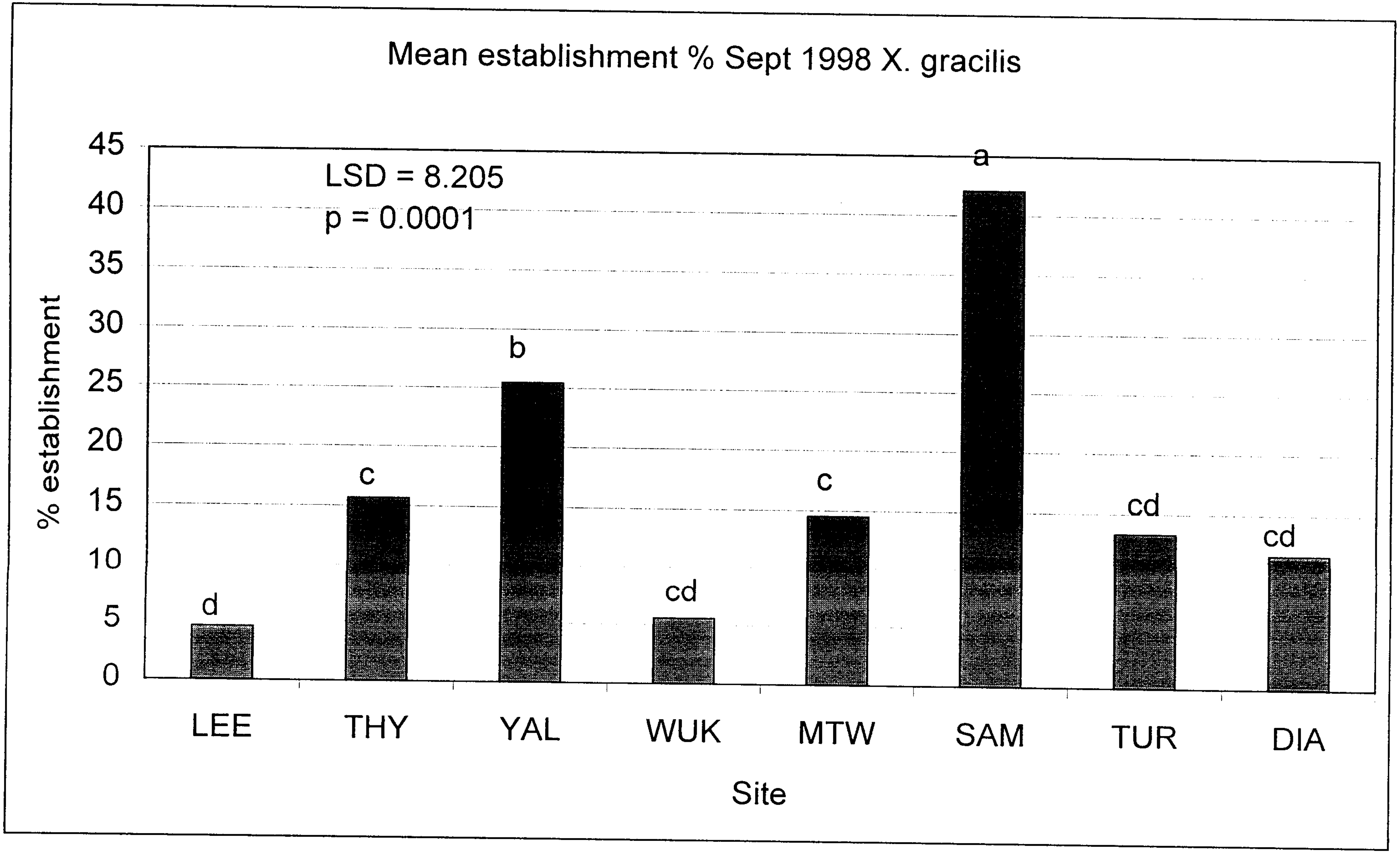
Specimens have already been fixed following protocol laid down by John Kuo , EMC, UWA.

Samples are yet to be baked, sectioned and stained.

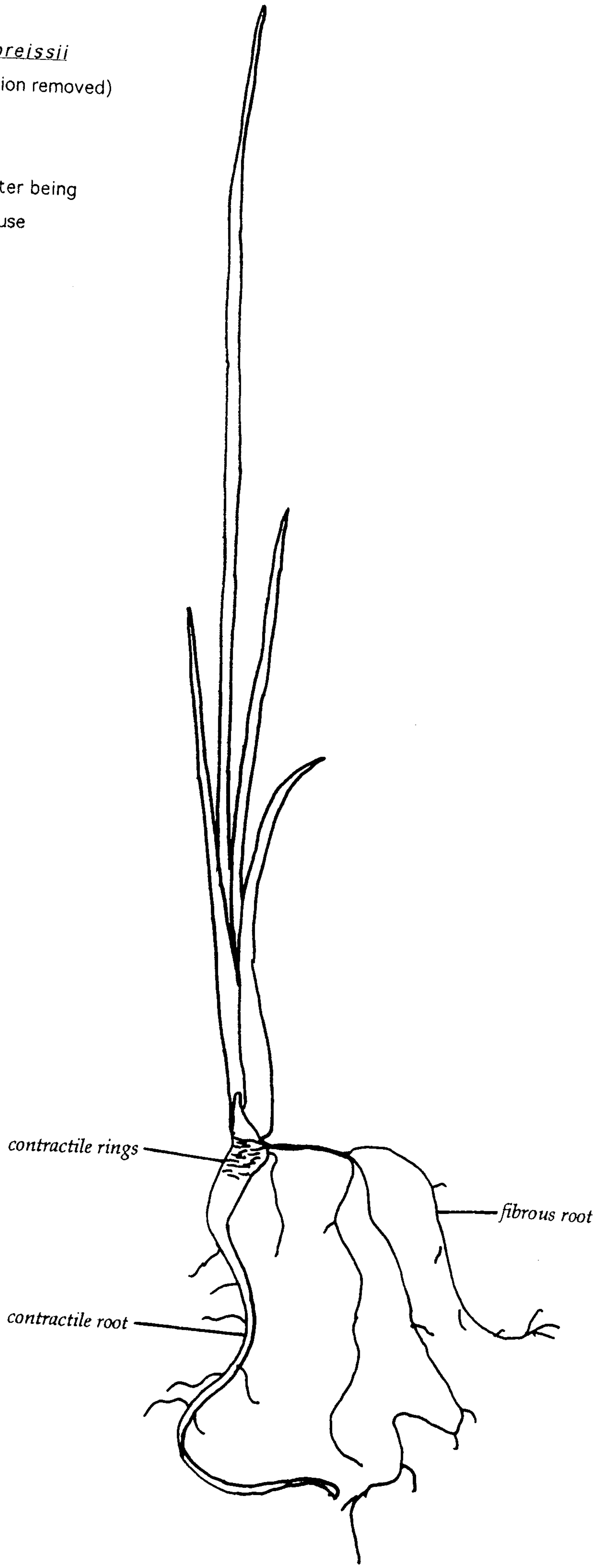

mean numbers X preisii feb 1999
Site LSD = 18.69 P = 0.0004
grazing LSD = 9.34 P = 0.0001
shade LSD = 9.34 P = 0.0234
competition NS
mean number
0
10
20
30
40
50
60
70
80
90
NT
CR
SH
GR
CR/SH
GR/SH
GR/CR
GR/CR/SH
treat


X. gracilis survival Feb 1999
Site LSD = 17.07 P = 0.0168
Grazing LSD = 8.53 P = 0.0001
Shade NS
Competition NS
Number surviving
0
10
20
30
40
50
60
70
80
NT
CR
SH
GR
CR/SH
GR/SH
GR/CR
GR/CR/SH
Treatment


c
Mean % establishment Sept 1998 X preisii
LSD = 8.586
P = 0.0001
% establishment
70
60
50
40
30
20
10
0
cd
b
c
c
cd
a
d
b
LEE
THY
YAL
WUK
MTW
SAM
TUR
DIA
site


Mean establishment % Sept 1998 X. gracilis
LSD = 8.205
p = 0.0001
% establishment
45
40
35
30
25
20
15
10
5
0
d
c
b
cd
c
a
cd
cd
LEE
THY
YAL
WUK
MTW
SAM
TUR
DIA
Site

*Xanthorrhoea preissii*
Diamond (competition removed)
Seeded 19/5/98
Collected 8/10/98
Drawn 17/4/99 after being
kept under shadehouse
conditions.
Scale x 1

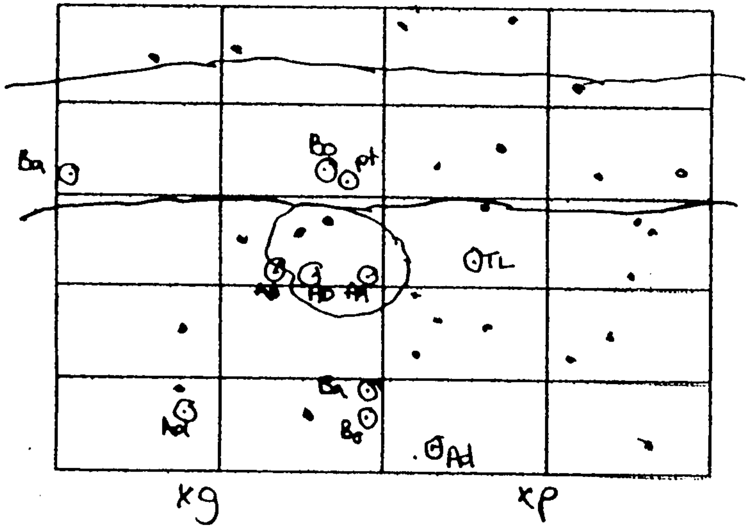


MINE SITE : Thylacine Rd

DATE : 25.2.99

N ▲

NO TREATMENT

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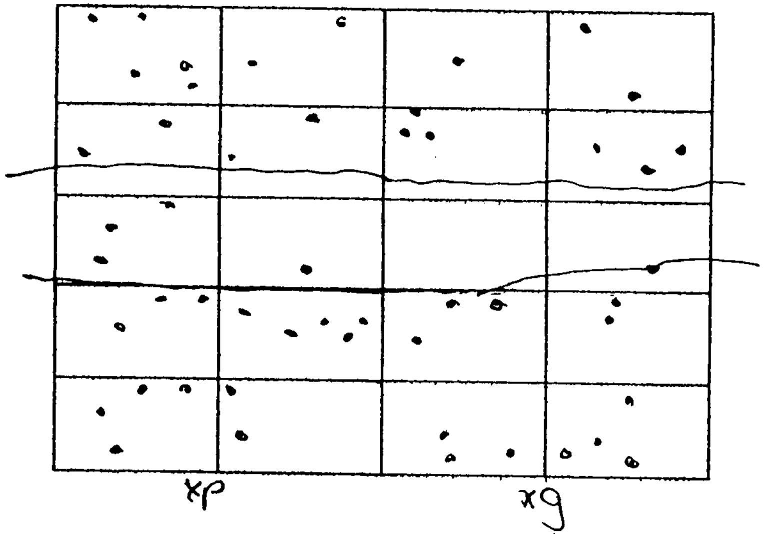
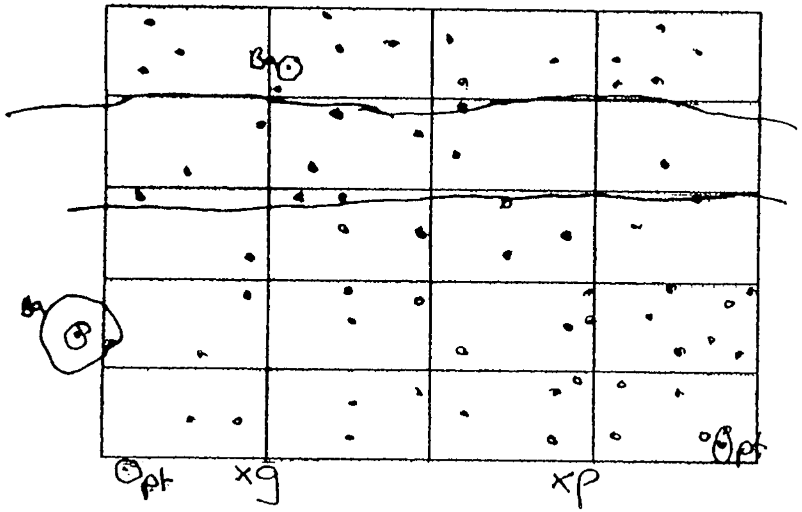
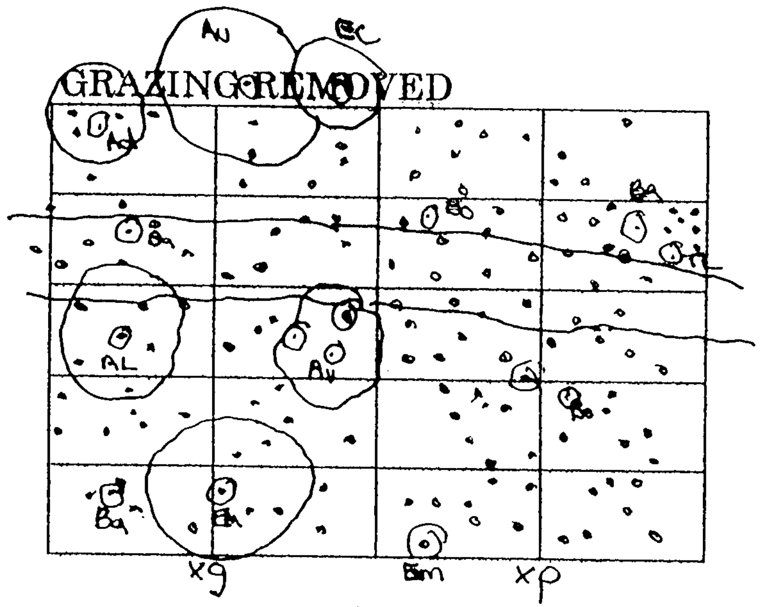



SHADED




GRAZING REMOVED



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# PROJECT TIMETABLE

## ASSIGNMENT / ACTIVITY

**DATE:**

| | |
|---|---|
| 14th May,1999 | Submit Project Design |
| End May,1999 | Conduct pH. and conductivity tests on current samples completed. |
| 22nd June, 1999 | Quantitive Biology exam. |
| July, 1999 | Field Work ie:<br>Collect regular soil samples for analysis from Leena Rd. site<br>Collect soil moisture samples from all sites.<br>Collect Dieback samples from all sites<br>Map, count and measure seedlings from all sites.<br>Map, count and measure seedlings from home garden.<br>Harvest seedlings from sites where numbers are plentiful, to examine root morphology. |
| Aug, 1999 | Data processing. |
| Sept, 1999 | Commence writing literature review. |

| | |
|---|---|
| Oct, 1999 | <u>Field work ie:</u><br>Collect soil moisture samples, all sites.<br><br>Map, count and measure seedlings, all sites.<br><br>Map, count and measure seedlings, garden.<br><br>Harvest seedling from sites where numbers are plentiful, to examine root morphology. |
| 5 Nov, 1999 | Seminar summaries due. |
| 12 Nov, 1999 | Literature review due. |
| November, 1999 | Data Processing. |
| December, 1999 | Holiday. |
| January, 2000 | Data entry. |
| February, 2000 | Commence Statistics unit.<br><br><u>Field work ie:</u><br>Collect soil moisture samples, all sites.<br><br>Map, count and measure seedlings, all sites.<br><br>Map, count and measure seedlings, garden.<br><br>Harvest seedling from sites where numbers are plentiful, to examine root morphology.<br><br>Harvest seedlings for mycorrhizal screening. |
| Mar, 2000 | Data entry and data analysis. |
| April, 2000 | Data entry and data analysis. |
| May, 2000 | Data entry and data analysis. |

| | |
|---|---|
| June, 2000 | Statistics Unit completed. |
| | Seminar Summaries due. |
| July, 2000 | Complete analyses. |
| | Commence write up. |
| Aug, 2000 | Histology. |
| Early Sept, 2000 | First Draft of Thesis. |
| Nov, 2000 | Seminar and Thesis Submission. |

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# GRASSTREES AND WOODY PLANTS AS BIO-INDICATORS OF PAST GROWING CONDITIONS AND THE PATCHINESS OF PAST FIRES.

*Brief description of the proposed research*

*Matthew Williams*

*April 1999*

## Summary

This project will relate past growth and records of past fires, as revealed by the stems of grasstrees, to other information about past growing conditions. The project will determine if there is correspondence ("cross-dating") between the growth bands found on grasstree stems and the annual growth rings of trees. Native conifers (principally *Callitris* spp) have clear, easily dated and measured annual growth rings and so provide a solid benchmark against which to date grasstree bands. This will provide independent confirmation of the annual nature of the growth bands. To achieve these aims, sites will be selected where grasstrees and native conifers co-occur.

Such sites are expected to occur from the outer wheatbelt through to areas beyond the Goldfields and into the Great Victoria Desert. Other tree species occuring at the same sites that may also provide records of past growth and past fires (such as mallees) will also be investigated.

Comparison of grasstree growth bands with tree rings will also allow assessment of the usefulness of the growth bands in reconstructing past growing conditions using the established methods of dendrochronology. Incidental to this work, preparing the grass tree stems for band-width measurement will enable fire histories to be constructed for the study sites. These will then be compared with satellite images to determine the relationship between fire intensity/patchiness/scale and the frequency that grasstrees burn. Similarly, comparison of fire histories between sites will enable the scale of past fires to be estimated. Ultimately, this will enable reconstruction of not only past fire frequency, but other parameters such as spatial scale.

The project will address the following specific research questions:

**Do the widths of grasstree annual growth bands correspond with the annual ring widths of nearby trees?** Other parameters, such as density variations and stable isotope ratios will also be compared.

**How does fire intensity and fire patchiness relate to the frequency of fire scarring in grasstrees?** In a burnt area only a proportion of the grasstrees will actually burn. What proportion this is depends upon a number of factors, primarily fire intensity and patchiness. However, a number of other parameters, such as grasstree height and years since previous fire, may cloud this relationship. It will be possible to establish and quantify the nature of this relationship by examining grasstrees in a number of burnt areas for which fire intensity and patchiness is well known or can be reconstructed (eg from aerial photographs). Incidental to this study, fire histories and grasstree chronologies can be constructed for these areas. By using the relationship, intensity of past fires can be estimated.

## Proposed work schedule

Year 1: The first six months will be spent reviewing the literature and producing a detailed research proposal. Field work, consisting of one or two trips to collect material, will begin in the second half of this year. It is expected that examination of field sites will commence in areas of most reliable and highest annual rainfall, subsequently progressing to more arid areas. Software and sampling equipment will also be purchased in year 1.

Years 2,3,4: Will consist of obtaining more samples, with 2 - 4 collecting trips each year. Sometime during this time I will seek to visit the Laboratory for Tree-ring Research, Tuscon Arizona, to discuss the progress of the research.

Year 5: Writing up. This will be done primarily in my own time.

**Estimated resources needed**

*Staff*

I propose to allocate 0.4 FTE to this project. By re-arranging my work schedule this project can be accommodated with minimal impact on my biometrical services to the Division:

| **Allocation of time to Divisional duties** | **Current** | **Proposed** |
|---|---|---|
| **Task** | **FTE** | **FTE** |
| 1. Joint (major) projects with other Divisional staff | 0.20 | 0.20 |
| 2. Consulting services to CALM and Divisional staff | 0.20 | 0.20 |
| 3. Research into new and improved methods | 0.20 | - |
| 4. Conservation of butterflies | 0.20 | 0.05 |
| 5. Administrative duties | 0.20 | 0.15 |
| 6. Dedicated to this project | - | 0.40 |
| **TOTALS** | **1.00** | **1.00** |
| **Additional time commitment by me** | **-** | **0.15** |

*Equipment*

Each field trip is estimated to cost $1500 – $3000, depending on destination.

Software needed to store and analyse ring widths can be obtained for around $500. The same software can be used for grasstree band width data.

Other equipment (tree corers, consumables) are estimated to cost $1000 each year.

Esimated expenses:

| **Year** | **1** | **2** | **3** | **4** | **5** |
|---|---|---|---|---|---|
| Field work | $ 3 000 | 5 000 | 5 000 | 5 000 | - |
| Other Travel | - | - | 3 000 | - | - |

| | | | | | |
|---|---|---|---|---|---|
| Software | $ 500 | - | - | - | - |
| Other | $ 1 000 | 1 000 | 1 000 | 1 000 | 1 000 |
| **TOTALS** | **$ 4 500** | **6 000** | **9 000** | **6 000** | **1 000** |

**Department of Conservation and Land Management**

CALM**Science** Division

**Science Project Concept Plan**

1. *Project title* **GRASSTREES AND WOODY PLANTS AS BIO-INDICATORS OF PAST GROWING CONDITIONS AND THE PATCHINESS OF PAST FIRES.**

2. *Aims*

   1. To establish correspondence ("cross-dating") between the growth bands found on grasstree stems and the annual growth rings of trees.

   2. Assess the usefulness of grasstree growth bands to reconstruct past climate and growing conditions (using band widths, stable isotope ratios, etc).

   3. Quantify the relationship between fire intensity/patchiness and the frequency of grasstree burning, thus reconstructing past fire regimes.

   A more detailed description of the project is attached.

3. *Proposed period of the project*

   1 July 1999 – 30 June 2004.

   Fieldwork will be conducted during the first four years of the project, with writing-up to be completed during year 5. The bulk of the writing-up will be done during my own time.

4. *Staff (FTEs)*

| | **Year 1** | **Year 2** | **Year 3** | **Year 4** | **Year 5** |
|---|---|---|---|---|---|
| **Scientist** | 0.4 | 0.4 | 0.4 | 0.4 | 0.1 |
| **Technical** | - | - | - | - | - |

5. *Indicative Operating Budget ($)*

| | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 |
|---|---|---|---|---|---|
| **Consolidated Funds (CALM)** | $4000 | $5500 | $6800 | $5500 | $500 |
| **External Funds (Curtin Uni)** | $500 | $500 | $2200 | $500 | $500 |
| **Total** | $4500 | $6000 | $9000 | $6000 | $1000 |

6. *Proponent* Matthew Williams *Date* 6 April, 1999

# GRASSTREES, PAST BURNING PRACTICES AND NUTRIENT UPTAKE PATTERNS IN SOUTHWESTERN AUSTRALIAN FORESTS

Following the lead of Lamont and Downes (1979), David Ward in CALM has developed a technique for ageing grasstrees (*Xanthorrhoea* spp) based on alternating colour banding patterns among the persistent leaf bases, which correspond to seasonal fluctuations in stem diameter. In addition, young leaf bases are blackened by fire and show up at intervals along the full length of the trunk. Initial results for 159 grasstrees spread through eucalypt forest/woodland in southwestern Australia indicate frequent burning by Aborigines in the period 1750-1860 (2-4 fires per decade) with a gradual decline to the present of 0-1 fire per decade. The decline in mean fire frequencies and increased variability coincided with abandonment of traditional Aboriginal burning practices through imprisonment and disease, attempts at fire exclusion by the new Forests Department, and later, a contraction in prescribed burning, and finally, financial and public pressures which coincided with a reduction in the incidence of managed fires. In the past, lowland flats and valley floors were much more frequently burnt than the ridges and uplands at Dryandra State Forest.

As part of the validation of the technique, we examined variation in nutrient composition of the leafbases over 100 years (400 samples analysed for 9 nutrients) in one individual (with 20 black bands) and over 60 years in another with no black bands (unburnt for 60 years). The outermost cm of leafbase showed that the concentration of most nutrients (Ca, K, Mg, S, Mn) fluctuated seasonally, with most showing a winter/spring peak. The innermost cm of leafbase best showed the effects of fires with rises (Mg, Mn), falls (Ca, K, Zn, Cu) and no effects (N, S) at the time of fire, and rises (Ca, K, Zn), falls (Mg, Mn) and no effects (S, B) by the next summer, taking 3-4 years to return to base levels. Over the longer term, the concentration of most nutrients fell ( N, K, S), probably as a result of leaching, although there may be some biological meaning in nutrients (Ca, Mg, Mn, B) which did not always follow this trend.

At present, we are exploring the potential of the technique to detect changes in growing conditions and plant cover over the last 250 years (using stable isotopes), and possible factors controlling band width changes (water, light and nutrient availability changes in response to fire and forestry practices, and herbivory).

Abstract of oral presentation to the Dept. of Soil Science + Plant Nutrition, Faculty of Agriculture, University of WA. 19 March 1999.

B. Lamont

Prof Byron Lamont

talk

Prof Byron Lamont

Aboriginal versus European burning practices in southwestern Australia as revealed by grasstrees

Byron Lamont, David Ward and Chantal Burrows

Early European visitors to Australia often reported Aborigines burning the 'bush'. Some researchers claim that the aversion of the British to wildfire resulted in an exaggeration of their occurrence and impact, while others that Aboriginal burning had such a profound effect on the landscape that the biota has never recovered. Since grasstrees (Xanthorrhoea spp) are long-lived and survive fire, we took advantage of a convenient new method of ageing them and determining their fire history over the last 250 years. In the 80 years prior to European settlement, and for the next 30 years, fires occurred at 2-4 per decade in eucalypt forest. The ensuing decline in mean fire frequencies and increased variability coincided with abandonment of traditional Aboriginal practices through imprisonment and disease, attempts at fire exclusion by the new Forests Department and later, a contraction in prescribed burning, and finally, financial and public pressures which reduced the incidence of managed fires. Current fires among grasstrees average 0-1 per decade. Both extremes must have had, or be having, a major impact on the vegetation.

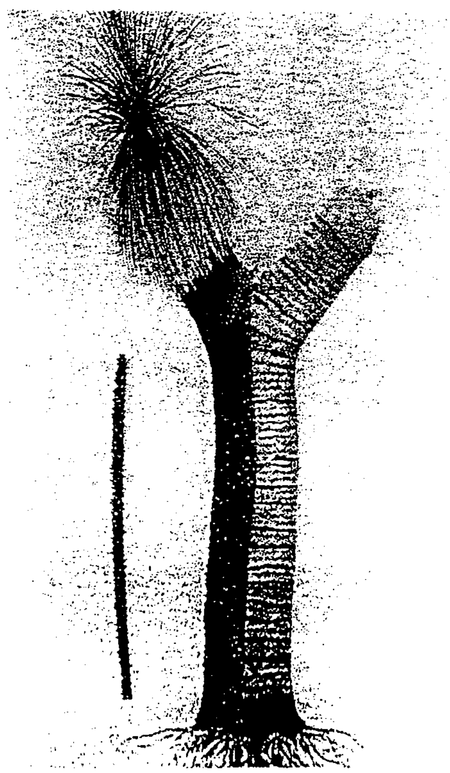
Abstract for oral presentation at July 1999 meeting of the International Association of Vegetation Science

Draft Poster for BUSHFIRE99, Albury, NSW, July 1999

# Aboriginal Fire:
## Its Relevance to Present Day Management of the Jarrah Forest of South-Western Australia

David J. Ward[1] & Rick Sneeuwjagt[2]

Research has shown that fire history can be reconstructed from fire marks on long-lived grasstrees (*Xanthorrhoea* spp.) (Ward & Van Didden 1997)



[1] Senior Research Scientist, CALMScience, Kelmscott, Western Australia 6111 & Senior Visiting Research Fellow, School of Environmental Biology, Curtin University, Western Australia 6102
[2] Manager, CALMfire, Como, Western Australia, 6152

# Australian grasstrees reveal contrasting fire regimes before and after European settlement

Byron B. Lamont

*School of Environmental Biology, Curtin University of Technology, Perth, WA 6845, Australia*

David Ward

*Department of Conservation and Land Management, Kelmscott, WA 6111, Australia*

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Early European visitors to Australia often reported Aborigines burning the 'bush'. Some researchers claim that the aversion of the British to wildfire resulted in an exaggeration of their frequency and impact, while others that Aboriginal burning had such a profound effect on the landscape that the biota has never recovered[5]. Since grasstrees are long-lived and survive fire, we took advantage of a convenient new method of ageing them and determining their fire history over the last 250 years. In the 80 years prior to European settlement in 1829, and for the next 30 years, fires occurred at 2-5 per decade in the dry eucalypt forest region of southwestern Australia. The ensuing decline in mean fire frequencies and increased variability started with demise of the Aboriginal inhabitants and uncontrolled logging. From 1920, attempts at fire exclusion followed later by prescribed burning programs proved difficult to maintain. Financial constraints, plus complaints about smoke haze, resulted in further reductions in managed fires to current levels of 0-1 per decade. Both extremes must have had, or be having, significant impacts on the biota.

Abstract for Meeting of the Aust Ecological Soc, Sept 1999

Research proposal to Wilson Tuckey



## Prelogging history of karri forest lots to be clearfelled under the RFA for the first time

It is likely that under the WA RFA, areas of forest will be clearfelled for the first time. Such lots will contain very old individuals of some species – karri up to 400 years (Rayner 1992), grasstrees up to 500 years (Lamont and Downes 1979). These plants are a unique data bank of growing conditions during that period as a) individual annual increments of growth can be identified, and b) growth and chemical composition of the annual increments are sensitive to environmental conditions at that time.

The approach will involve thorough searching by local workers for the oldest trees before clearfelling. These will be studied on site (grasstrees) or harvested by local contractors (timber trees) sawn into discs at the base of the trees, and stored at a timber mill for analysis. Local workers will be trained to a) prepare the surfaces for analysis, b) identify annual growth rings and fire scars, and c) take samples for chemical analysis. The modern technique of stable isotope analysis will be used to determine past climates (H/D ratio), and local growing conditions, especially water availability and occurrence of fires ($^{12}C/^{13}C$ ratio). Preliminary work on the grasstree, *Xanthorrhoea preissii*, in jarrah forest indicates, for the first time, the ability of the C isotope technique to detect the impact of fire on growth.

There have been suggestions that the karri forest was inaccessible to Aborigines in contrast to the jarrah forest and so rarely experienced fires. This project will provide direct evidence for the first time, and enable comparison of past fire regimes with current management practices. Since clearfelling rotations will be short compared with the age of old trees, and harvesting of old trees would not be permitted from reserves, this opportunity will not arise again.

### Timetable

Considerable progress can be made in three years. Since the RFA will be in place for 20 years, there would be a case for extending the project to take into account continuing tree areas to be logged.

### Personnel

Current work on the fire history of grasstrees is based at Curtin University under the supervision of Prof Byron Lamont, and this proposal is a natural extension of it. CALM is fully committed to this program, and the input of Mr David Ward, who developed the ageing technique, Dr Neil Burrows, who is experienced with tree growth ring analysis, and Mr Matt Williams, who is using the same techniques on grasstrees and conifers in arid areas, could be (partly) seconded to the project. Input from the timber industry would be required, including planning personal, rangers and timber workers. Other research staff would be required.

**Budget**

Research officer @ $70 000 pa (including on-costs) x 3 to supervise day-to-day activities, train other workers, analyse and model the data and prepare material for publication. Cost: $210 000.

Equivalent of two (ex) timber workers to plan and undertake fieldwork and sample preparation: $45 000 (including on-costs) pa x 2 x 3.
Cost: $270 000.

Time allowance for Prof Lamont and three CALM personnel: $40 000 pa x 3.
Cost: $120 000.

Consumables, especially isotope analyses @ $8/sample, tree harvesting, transport and storage, and fieldwork travel: $30 000 x 3.
Cost: $90 000.

Total over three years: $690 000

(There could be some rationalization with the suggested "Population viability of understory species ..." project).