

Probability of grasstrees (*Xanthorrhoea preissii*) flowering after fire

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Manuscript received January 1997; accepted December 1999

Abstract

Balga grasstrees (*Xanthorrhoea preissii* Endl) are widespread in south-western Australia, and flower profusely after fire. At five separate sites, the probability of flowering after fire was related to grasstree height, with tall plants more likely to flower than short ones. Height is probably a surrogate for age. We discuss the implications of this finding for both grasstree conservation and the reconstruction of fire history from grasstree flowering events.

Keywords: grasstree, fire history, phenology, *Xanthorrhoea*

Introduction

Grasstrees (*Xanthorrhoea* spp) are notable Australian plants due to their ubiquity, large size, unusual appearance, longevity, and spectacular flower spikes following fire. In south-western Australia the grasstree *X. preissii* is significant to the indigenous Noongar people, who call these grasstrees 'balga'. In the past, Noongars obtained many useful products from them, including gum, fish spears, fire drills, and edible 'bardi' grubs, *Bardistus cerberus* (Moore 1884). Grasstrees have a special place in Noongar folklore in connection with fire (personal communication, N Nannup, CALM).

Although grasstrees are still plentiful in south-western Australia, personal observations (DW) suggest that at long unburnt sites there is little regeneration, and old plants are dying without replacement. For example, Amphion Block, in state forest near Dwellingup, has been protected from fire since 1931. The stems of many grasstrees at Amphion are encased by termite mud, and the protective leaf bases are rotting in the damp conditions under the vast thatch. Although deaths directly attributable to rot and termite invasion have not yet been demonstrated, study is needed to determine the effect of long fire exclusion on grasstree health and reproduction. An understanding of the effect of fire on the survival, flowering and seed production of *Xanthorrhoea* is necessary for the conservation of this charismatic genus (Gill & Ingwersen 1976). Just as not all rare species are endangered, so not all common species are ultimately secure.

Due to their long life, high flammability, wide distribution, and stem structure, grasstrees may also give useful insights into local fire history (Lamont & Downes 1979; Ward 1996). Fire history, in turn, can give valuable insights into the role of fire in the recent evolution of Australian flora, fauna and ecological processes (Gardner 1955; Enright *et al.* 1998).

Methods

Cohunu Nature Park lies about 20 km south of Perth city, on the face of the Darling Scarp. In January 1994 a wildfire completely defoliated trees to 30 m above ground and most grasstrees were burnt. The stem height from soil to lowest green leaf, and the presence or absence of a flower spike were recorded for a sample of 500 grasstrees, located by random walking across the site, with each grasstree tagged as it was measured to prevent re-measurement. The random walk ensured that grasstrees of all heights had an equal chance of appearing in the sample.

A further four burnt sites were visited. These were Brady Block, on the Brookton Highway about 20 km from Karagullen (burnt summer 1995, visited 1996); Kangaroo Gully, also on the Brookton Highway, about 12 km from Karagullen (burnt autumn 1996, visited 1997); Ashendon Road near Mundaring (burnt spring 1997, visited 1998), and Crystal Brook Reserve near Kalamunda (burnt summer 1997, visited 1998). At each of these sites a sample of 500 grasstrees was measured and examined for evidence of recent flowering. The sample was random with regard to grasstree height. Taller and shorter trees had an equal chance of being included.

Abortion of some flower spikes due to attack by moth larvae of the genus *Meyriccia* (personal communication, T Burbidge, CALM) was noted at all sites. Although a careful search was made on each plant, it is likely that the shrivelled remnants of some flower spikes were missed, especially on very tall plants, or where the spike had aborted at a very early stage. In some cases the remnant may have disappeared altogether. Future investigators should be aware of the activities of this moth.

Firstly, the data from the five sites were split into flowering and non-flowering subsets to compare the height distribution within and between each sub-set. Mood's median test (Mood 1950) was used to test the null hypothesis of no height difference between flowering and non-flowering grasstrees. Mood's non-parametric test is less sensitive than the Kruskal-Wallis test, but more robust to outliers. In this case the height difference

between the two groups was so large that sensitivity was not an issue, but there were a few unusually tall grasstrees.

The data were then recombined, sorted into height order, and split into sub-sets over the height range. For each site, this procedure gave 10 disjoint subsets of 50 observations each. For all sites pooled, the sorted heights were split into 50 disjoint subsets of 50 observations each. The median height (h) for each subset was compared with the proportion flowering (P) in that subset by a hemi-sigmoid model, where

$$P = \tanh(\alpha + \beta \cdot h) \text{ for } (\alpha + \beta \cdot h > 0)$$

The parameters $\alpha + \beta$ of this hemi-sigmoidal model were obtained by linear regression of the metameter P with h;

$$P = \sqrt{(1+P)/(1-P)}$$

This is similar to, but in this case gave a better fit than, the well known logit metameter

$$P = \ln \sqrt{P/(1-P)}$$

(Berkson 1944; Fisher & Yates 1957) which assumes the full sigmoidal model

$$P = \{1 + \tanh(f)\}/2$$

(Emmens 1940).

Results

The height distributions of flowering and non-flowering grasstrees are shown for the data pooled over five sites in Fig 1. Each sampling site showed a very similar pattern, except that the grasstrees at some sites were generally taller than at others (Table 1). The height difference between grasstrees at the five sites is probably due to different growth rates resulting from varying site conditions. For example, the Crystal Brook site is dry, stony, and water shedding. Its grasstrees are small both in stem diameter (unpublished observations) and height, suggesting slow growth. Measurements (n = 100) of leaf-base deposition in the two years since the last fire gave an approximate mean growth rate of only 9 mm year⁻¹. Allowing 20 years before the stem starts vertical growth (BL, personal observation), the median age for flowering grasstrees at Crystal Brook was just over 80 years, and for non-flowering grasstrees was about 42 years. Kangaroo Gully, on the other hand, is a moist and water gaining site, with deep alluvial loam and outcropping granite.

Table 1

Height of flowering and non-flowering grasstrees analysed by Mood's median test.

	Median Height (cm)		χ^2 value*	Significance**
	Flowering	Non-flowering		
Crystal Brook	57	20	64	<0.001
Cohunu Park	75	34	83	<0.001
Brady Block	104	40	101	<0.001
Ashendon Road	121	50	38	<0.001
Kangaroo Gully	190	80	151	<0.001
All sites pooled	97	47	290	<0.001

* 1 degree of freedom; ** Type I probability.

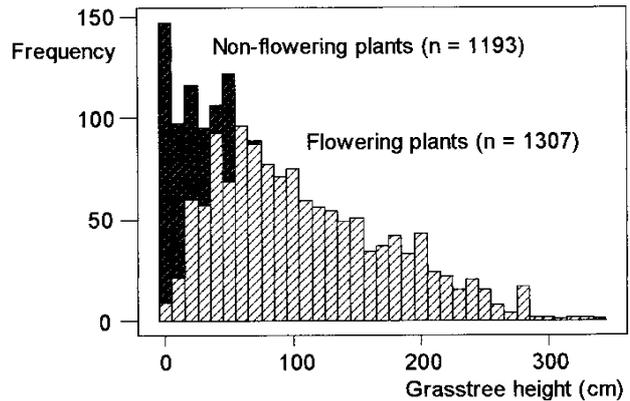


Figure 1. Frequency distributions for heights of flowering (light hatch, median = 97 cm) and non-flowering (dark hatch, median = 47 cm) grasstrees (all sites pooled).

The growth rate estimated from leaf-base deposition since the fire was over 21 mm year⁻¹, so the median age for flowering grasstrees was just over 110 years, and for non-flowering grasstrees was about 58 years.

The results of Mood's median test for grasstree heights at each site and for all sites pooled (Table 1) indicate that although the median height of both flowering and non-flowering grasstrees varies from site to site, we may conclude that there is a highly significant difference between the heights of flowering and non-flowering grasstrees at each site. The regressions used to fit the models are given in Table 2. The relationships between the probability of flowering and median grasstree height for each site, and for the pooled data, are shown in Fig 2.

Discussion

Parameters α and β for the fitted model $P = \tanh(\alpha + \beta \cdot h)$ obtained from linear regression of P and h; n = 10 for each sample and 50 for pooled sites.

	Regression	R ²	F	df	Significance*
Crystal Brook	$P = 0.258 + 0.013 \cdot h$	0.929	104.2	1,8	<0.001
Cohunu Park	$P = 0.193 + 0.008 \cdot h$	0.908	79.3	1,8	<0.001
Brady Block	$P = 0.124 + 0.007 \cdot h$	0.916	87.3	1,8	<0.001
Ashendon Road	$P = -0.170 + 0.008 \cdot h$	0.932	109.6	1,8	<0.001
Kangaroo Gully	$P = -0.294 + 0.007 \cdot h$	0.873	54.9	1,8	<0.001
All sites pooled	$P = 0.190 + 0.006 \cdot h$	0.851	274.5	1,48	<0.001

* Type I probability.

Since taller grasstrees are more likely to flower than shorter ones, this study points to the importance of conserving taller grasstrees as a seed source. The role of tall grasstrees in this respect would be diminished if they were likely to die as a result of fire, as suggested by Curtis (1998). However, Taylor *et al.* (1998) did not observe any deaths among *X. fulva* after fire, and in this study several deaths apparently due to fire were only seen at one site (Brady Block) which experienced a fierce summer fire following a long period unburnt. Unlike

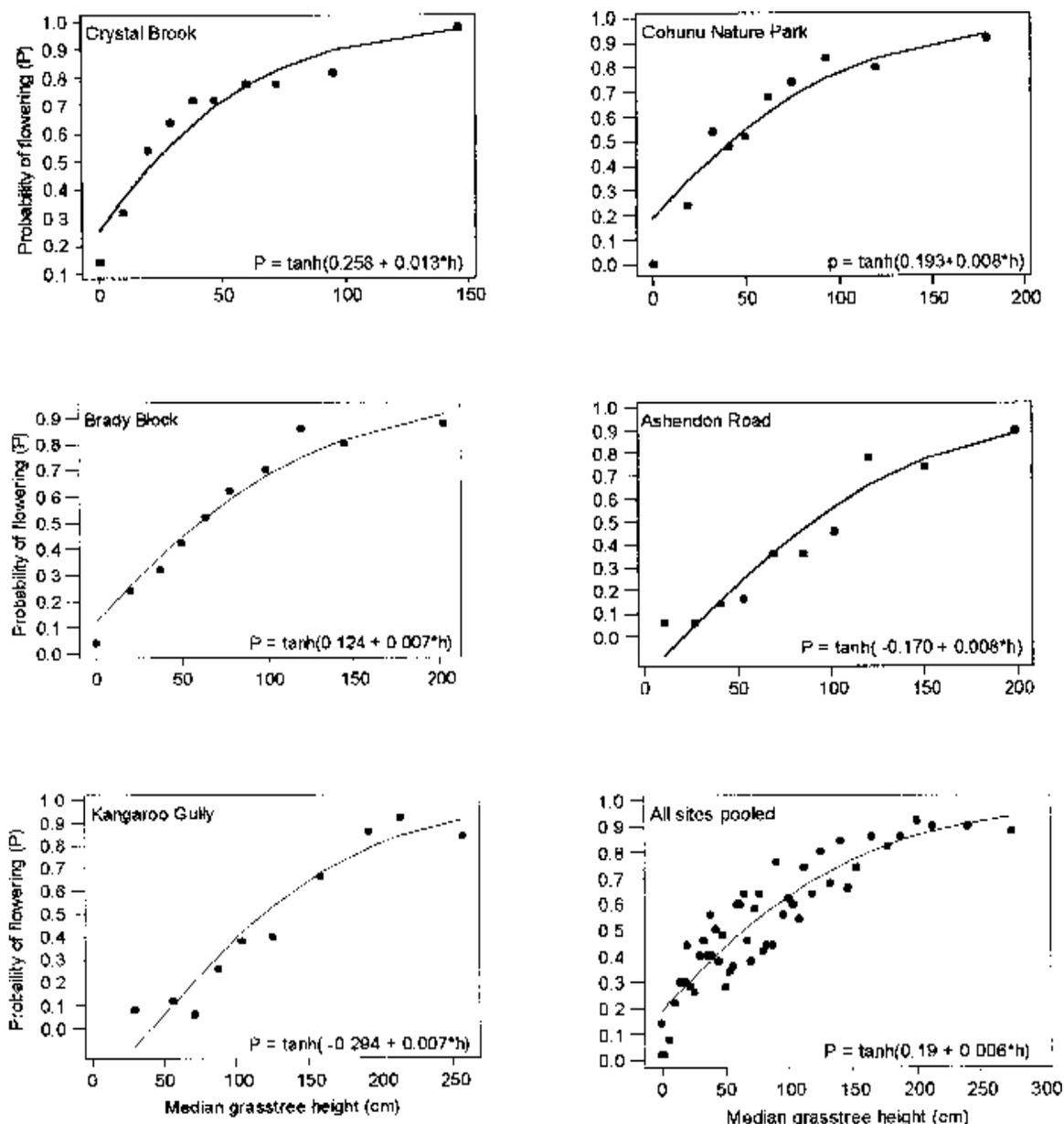


Figure 2. Models relating the probability of grasstree flowering to median grasstree height at five sites, and all sites pooled.

Curtis (1998), we did not find a general minimum height for flowering. At Crystal Brook, about 20% of plants flowered before their stems had emerged from the ground. However, at two sites (Kangaroo Gully and Ashendon) few flowered before the stems were 20 cm tall.

It has been suggested that short inter-fire intervals encourage flowering in *X. fulva* (Taylor *et al.* 1998). It also seems likely that frequent, light burning would protect old grasstrees from fierce, potentially lethal, fires which occur when thatch is allowed to build up over long periods. By promoting flowering, frequent burning would also promote seed production. Recent research into fire marks on grasstrees in south-western Australia suggests that, before European settlement, most were burnt every 3 to 4 years (Ward & Sneeuwjagt 1999).

Previous workers (Lamont & Downes 1979) used the growth rate and flowering history of grasstrees to reconstruct fire history back to pre-European times. Flowering events were identified by flower spike remnants close to swerves or forks in the stem. Since grasstrees usually have straight stems for the first metre or so above ground, with no evidence of flowering, it was concluded that fire frequency at the site examined was lower before European settlement than after. Our results now show that flowering history is an unreliable surrogate for fire history, due to the lower probability of flowering in shorter plants. Also, longitudinal sections of stems have shown that spike remnants are often engulfed by secondary growth of the stem, so that flowering events may be missed by external examination (BL, personal observation).

While grasstrees sometimes flower without the stimulus of fire, it is a common observation that fire causes prolific flowering (Specht *et al.* 1958; Baird 1977; Lamont & Downes 1979). Ethylene gas in smoke has been suggested as a flowering stimulus (Gill & Ingwersen 1976) although their results were equivocal. In this study it was noted that grasstrees outside the burnt area, but close enough to have been affected by smoke, sometimes flowered (also see Curtis 1998). A study of the effect of smoke on grasstrees stratified by height might give a clearer result.

Acknowledgements: We thank T Burbidge for identification of the moth larvae, and information on their habits. We thank biology students of Curtin University for their efforts in collecting field data, and M Williams of the Department of CALM for correcting one of us (DW) on the logit transformation.

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