

Heavy road traffic promotes flowering of the grasstree, *Xanthorrhoea preissii* – a preliminary investigation

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Abstract

Grasstrees are renowned for their ability to flower after fire. They are a popular species for ornamental landscaping and anecdotal observations indicate much higher levels of flowering of *Xanthorrhoea preissii* than occur among unburnt plants in nature. Also, unburnt grasstrees in nature reserves beside major roadways in Perth, Australia, appear to flower much more frequently than those some distance from the roadway. We chose a reserve site 6 km south of Perth with prolific flowering of grasstrees beside a busy intersection. We showed that plants within 10 m of the roadway were 2.5 times more likely to flower than those in the following 50 m. This is on a par with burnt plants in a nearby reserve and those in the median strip of a nearby road. Of those that flowered, roadside plants, adjusted for size (height), had 60% more spikes. Branching is induced by flowering, and roadside plants also had 60% more branches than those distant from the road without any difference in plant size. This means that the difference cannot be attributed to better growing conditions beside the road. Grasstrees have been shown to respond to the volatile hydrocarbon, ethylene, by flowering, and a major component of vehicle exhaust fumes is ethylene. We therefore hypothesise that prolific flowering by cultivated grasstrees in public places, and those beside busy roads, is a response to locally raised ethylene levels in the air. Much more remains to be known about this intriguing anthropogenic phenomenon.

Background

Most *Xanthorrhoea* species only flower sporadically in the absence of fire, but abundantly 9–12 months after fire (Curtis 1998, Taylor, Monamy and Fox 1998, Lamont, Swanborough and Ward 2000). There is some evidence that the causal agent is ethylene, routinely present in the smoke from bushfires or self-produced in response to damage (Gill and Ingwersen 1976, Margott 2015, He and Lamont 2018). Over the last decade we have noticed exceptionally high flowering among xanthorrhoeas growing in undisturbed gardens, parks, roundabouts, median strips and road verges compared with similar-sized plants in natural vegetation. This includes transplanted xanthorrhoeas as well as plants already present when infrastructure was later placed around them. For example, 20 of 50 plants transplanted (by Grasstrees Australia, pers. comm., Cockburn City Council) from a local population to the central median strip along Spearwood Av, west of Stock Rd in Spearwood, had flowered in the 2025 season. Such a high percentage is usually only seen after xanthorrhoeas have been burnt ($P = 0.2713$, Fisher's exact probability test, compared with our burnt study site, 2.5 km north of Spearwood Av). These plants did not appear to be managed in anyway. Stimulatory road edge effects are known among banksias and reduced competition and extra water and nutrients have been shown to account for greater size and fecundity of these plants (Lamont et al. 1994a, 1994b). At a growth rate of just 10–20 mm per annum, whatever their location, xanthorrhoeas cannot be considered competition-sensitive, and there is no obvious difference in sizes (as later shown formally here), indicating that access to resources (light, water, nutrients) and maladies (herbivores, pathogens, parasites) are matched whether near or away from the road.

This leaves vehicular traffic as a possible source of the apparent roadside stimulation of flowering. Dismissing these plants as sensitive to noise, night lights and vibrations leaves vehicular exhaust fumes

as a possible cause. Fossil-fuel powered vehicles emit a wide range of volatile organic compounds (Rybak and Olejniczak 2014). Ethylene (ethene) is a major component of the hydrocarbons present in the exhaust fumes of such vehicles, second only to toluene (Cai and Xie 2009), and sometimes even exceeding the levels of toluene (Fukusaki et al. 2021). In Australia, Duffy et al. (1999) recorded an average of 140 mg/km of ethylene released per car powered by unleaded petrol. No doubt, it would be considerably higher as vehicles decelerate towards, and accelerate away from, road intersections and roundabouts (Gregušková and Mičieta 2013). With regard to the possible role of ethylene in inducing flowering by xanthorrhoeas, it is noteworthy that Margott (2015) state that “motor vehicle exhaust is the largest contributor to urban ethylene levels”. Little is known about the pattern of decline in exhaust emissions as distance from the road increases. Carneiro et al. (2011) observed a linear decrease in the level of abortion of pollen grains of *Bauhinia blakeana* with increasing distance from the road, with an effect still detected at 120 m, whereas Gregušková and Mičieta (2013) emphasised the importance of the prevailing wind direction. Roorda-Knappe et al. (1998) recorded a curvilinear decrease in nitrogen dioxide levels with distance from the roadside with greater levels downwind.

While the spent spike is usually replaced by a single extension of the caudex (monopody) it is occasionally replaced by two (rarely three) branches. It is the act of flowering that induces axillary buds adjacent to the spike to shoot with one to three eventually surviving (Fig. 1c).

Thus, if exhaust fumes do indeed promote flowering, then, over time, roadside plants should have more branches at any time as well as more spikes in a given flowering season. We can hypothesise that over some years, a roadside effect will result in more flowering, thence more branches, and thence more spikes in the current season as a cumulative effect. We therefore hypothesised that xanthorrhoeas beside busy roads and intersections have more branches and flower spikes the closer they are to the roadway as they are more likely to receive higher levels of ethylene (assuming it does not reach supraoptimal levels, Lamont 2024). Since xanthorrhoeas are more likely to flower with increasing size this may need to be taken into account as the age of plants in a given population varies greatly (Ward and Lamont 2000).

Methods

Unburnt site. Choice of site was based on the following criteria: 1) the road carries continuous traffic throughout the day (preferably near intersections where exhaust fumes will be greatest), 2) the site has not been burnt for at least five years, 3) the presence of at least 3–4 plants of *Xanthorrhoea preissii* within 10 m of the edge of the road that have flowered in the current season, 4) xanthorrhoeas continue to be present uninterrupted throughout a further 50 m or more area from the road, 5) at least 25 plants have flowered in the potential study area in the current season but their location in relation to the roadway is irrelevant (see 3), 6) the xanthorrhoeas present have established naturally and have never been pruned, watered or fertilized (mowing to control weeds is acceptable), and 7) the site is accessible and permission can be obtained to undertake the study as required. Scores of potential sites were inspected along main highways up to 40 km north and south of Perth during April 2026. Reasons for

rejection encompassed all of these criteria, especially insufficient xanthorrhoeas in flower or too far from the road.

Redmond Reserve is situated on the SW corner of Stock and Winterfold Rds, and bounded by Redmond Av to the west and housing to the south, in the suburb of Hamilton Hill. Traffic lights are positioned at the boundary and heavy traffic is continuous throughout the day, somewhat heavier on Stock Rd than Winterfold Rd and local only along Redmond Av. The reserve is almost rectangular at 85 x 75 m. It is remnant open low woodland bearing *Banksia menziesii* (in particular) and *B. attenuata*, with a few *Eucalyptus marginata* trees (Fig. 1a,b). The only conspicuous shrub, 1-m tall *Allocasuarina humilis*, formed a sparse understorey with a fringing herb layer of annual exotic grasses. The most conspicuous species is the grasstree, *Xanthorrhoea preissii*, with 143 plants (we assessed all present) scattered throughout the reserve, sometimes in clumps of 4–6 over ~ 3 x 3 m. All were in the open, except 11 under the crown of *E. marginata* and one under *B. menziesii*. The site is flat rising slightly away from Stock Rd and would receive little to no runoff; the soil is deep Bassendean sand with much litter around the plants. There was some evidence of mowing and mulching, especially around the road perimeters and between the most exposed grasstrees. The site had not been burnt for at least 20 years with no natural recruitment evident, although scores of perhaps 2-year-old native shrubs planted by ‘friends’ of the reserve were present.

Burnt site. There were extensive fires along the wide road reserve (50–120 m on the west side of Stock Rd in Spearwood-Coogee in the 2024-5 summer period – we have not been able to find out its cause). We chose a site 100 m south of the Stock Rd-Barrington Rd interesection in Coogee and 4 km south of Redmond Reserve that reached an equivalent distance from the road as the Redmond Reserve. This possessed a dense, pure stand of *X. preissii* with a few plants beneath scattered, 30-m tall *Eucalyptus gomphocephala* (Fig. 1d). The grasstrees became closer spaced as one moved away from the road with local clumping of up to eight trees. Plants were in the open other than ten or so beneath the trees near Stock Rd. The orange tinge to the sandy soil, and presence of this eucalypt, indicated that Tamala limestone was present at depth although there was no outcropping. The road was raised 3 m above the start of the reserve that was flat but sloped for a distance of 8 m to start of the vegetation with a 1:20 gradient to the road from the other direction. Two cleared firebreaks ran parallel with the road, removing 12 m of vegetation along the transect.

Measurements. As traffic was heavy in both directions at Redmond Reserve we decided to measure the distance of any plant to the nearest road edge, ignoring the minor Redmond Av, with a cloth measuring tape. While we measured distance from the road at the Barrington Rd site, we did not use these data in our analysis as grasstrees were absent from the area where the roadside effect was most apparent at the Redmond Reserve plus the spatial interruption caused by the firebreaks. Plant stature was measured to the apparent location of the true apex. Since flowering is size dependent (Ward and Lamont 2000), we rejected plants less than 25 cm above the ground (and later adjusted the data for plant size). The number of branches, indicated by the separate clusters of leaves if stems were not obvious, and the

current season's spikes were counted (while inflorescences are composed of spikes and short supporting scapes we refer to them as spikes here).

The data were sorted into distance from the road, and the means taken for each successive group of ten plants, to give 14 classes. Flowering increases with increasing stature at a decreasing rate with an asymptote at about 2 m (Ward and Lamont 2000). To adjust for this biasing effect, the number of spikes was divided by the square root of plant stature to adjust for the effect of variations in plant size on the probability of flowering. We did not adjust for number of stems: by using absolute number of spikes per plant this takes into account historical, as well as present, causes of flowering (see Background). Spike numbers were plotted against distances from the road and standard curves applied, accepting the one that gave the highest coefficient of determination (R^2) as available from the statistics package, <http://vassarstats.net>.

For comparisons with the burnt population, the numbers of flowering and non-flowering plants were compared between a) the plants showing a roadside effect on flowering (there was a clear break in the data), b) plants in the rest of the population, and c) burnt plants. To avoid the problem of lack of a normal distribution due to the large fraction of non-flowering plants, the second response trait assessed was the number of spikes produced by the flowering plants adjusted for stature. Fisher's exact probability test was applied to the three groups to show statistical significance, and then pairwise comparisons undertaken to see where the differences lay. For the quantitative data, one-way ANOVA was applied to show statistical significance, and then Tukey's HSD test between the three pairs (<http://vassarstats.net>).

Results

The Redmond Reserve data for 142 plants separated into 14 distance classes showed a strong power-function relationship with number of spikes adjusted for plant stature, accounting for 68% of variance (Fig. 1). The data were clearly divisible into two groups: the first 20 plants were within 10 m of the roadside and produced 1.15 spikes per plant on average. The remaining 122 plants were at a distance of 11 to 63 m from the roadside with a mean of 0.27 spikes per plant. There seemed to be a minor shading effect, with the 12 grasstrees under trees not flowering ($P = 0.0507$, Fisher's exact probability test, compared with the remaining 130 plants), when the best fit curve indicated that an average of one *xanthorrhoea* in four was expected to flower at the average shaded-plant distance of 18.4 m from the roadside.

Summaries of mean parameters for the three situations show that the unburnt roadside plants produced 2.5 times more spikes than unburnt plants remote from the roads, whereas the slightly higher flowering of the burnt plants was non-significantly different from the roadside plants by Fisher's test (Table 1). Separating out the flowering plants revealed that the roadside plants produced 60% more spikes than the non-roadside plants when the data were adjusted for plant stature (and even more when they were not), and 90% more than the burnt plants. The roadside plants had 60% more stems than the non-roadside plants, and 2.4 times those of the burnt plants, which did not include roadside plants. The SDs were 50–

70% of the means. While 70% of roadside plants were multibranched, 56% of non-roadside plants were and 17% of burnt plants. Although the roadside plants were on average 10% taller than the non-roadside plants, this was not significant by Tukey's test. The unburnt plants were on average 1.67 times taller than the burnt plants, supporting the need to adjust flowering by stature (as a covariant). Unburnt plants remote from the road varied much more in size than the other two groups.

Interpretations and future research

The flowering data (Fig. 1) can be interpreted in two ways: 1) an initial steep decline from a mean of two spikes per plant at the road edge, to one spike per three plants at 15 m and one spike per ten plants at 50 m, or 2) the existence of two groups: a roadside group to 10 m with a mean of one spike per plant, and a non-roadside group with one spike per five plants. Certainly the disjunction is clear and might represent a critical level of flower-promoting, exhaust-fume ethylene (Gill and Ingwersen 1976) beneath which its stimulatory effect is negligible as its concentration continues to fall with increasing distance from the road. Remarkably, the 45% of plants flowering in the former matches those of the burnt plants in a natural population 2.5 km south of Redmond Reserve (50%), and those planted in a 1-m wide median strip in the middle of a busy road 4 km south of Redmond (40%) (Table 1). All contrast with the 18% flowering among the non-roadside plants. Reflecting its history of closeness to vehicular traffic, the roadside plants also had significantly more branches than the non-roadside and burnt plants, as branching requires flowering to stimulate axillary bud burst (Fig. 1c). The fact that the mean stature of xanthorrhoeas in both groups is non-significantly different indicates that there is no increased resource effect associated with the roadway, unlike that reported for banksias elsewhere in southwestern Australia (Lamont et al. 1994a,b). This means that adjusting for plant size was precautionary rather than necessary and certainly adjusting made negligible difference to the trends (not given here). This initial survey supports all our hypotheses, **confirming a positive roadside effect on flowering in terms of number of spikes and branches without increasing plant stature**. Further evidence is required to confirm these patterns at other sites to improve confidence in the generality of the trends. Suitable data already exist – for Emu Swamp Reserve in Ballajura and the Triangle Reserve in Inglewood, collected in 2024-5.

Another aspect worth considering as a link to the roadside work is pursuing the anecdotal evidence that smoke drift from fires may induce flowering (this phenomenon is noted in Lamont, Wittkuhn and Korczynskyj 2004). To formalize this, one or more burnt sites containing xanthorrhoeas at least partly surrounded by natural vegetation matched other than remaining unburnt are required. The fraction of flowering in the burnt patch would be compared with those of grasstrees at certain compass directions (as the location of smokedrift will depend on the direction of winds at the time of the fire) and distances from the edge of the fire. Here, smoke drift will simulate the vehicle exhaust fumes. As both should contain ethylene, and if ethylene is the transducer for promoting flowering, then at least some locations should show enhanced flowering..

The next challenge is to move from observational to experimental approaches. This might include placing a generator(s) in the middle of a stand(s) of xanthorrhoeas and monitoring flowering in all radii.

Monitoring of windspeed and direction would seem essential too. Applying smoke (from a smoke generator as used by beekeepers or those preparing 'smokewater') directly to plant apices is needed. Doing the same with ethylene (available as cylinders as ethephon) is the ultimate treatment. This could get tricky as a) one has to avoid contamination between treatments, b) treatments should be interspersed to minimize gradients in variables not under study, c) different concentrations are needed in the absence of knowledge of the optimal levels, and d) replication at different sites is also required.

Declarations

Acknowledgements

This study is part of a larger project examining the role of vehicular exhaust fumes on inducing flowering of grasstrees and the more general question of the role of fire in promoting flowering among grasstrees. It is being conducted in association with Notre Dame University, Fremantle (Dylan Korczynskj, Lucy McGrath) and the ARC Training Centre for Healing Country, Curtin University (Giancarlo Chiarenza, Stephen van Leeuwen). Two other equivalent unburnt sites have already been assessed (Emu Swamp Reserve, Ballajura, and Triangle Reserve, Inglewood) involving assistance from the Friends of Inglewood Triangle (City of Stirling). Comprehensive environmental and morphological data were collected from these reserves (girth of caudex, length of spikes, weather conditions beneath plants, density of grasstrees, canopy cover, soil physical and chemical properties) to show that these are not alternative explanations of the trends also supported at these two sites. Further assistance is anticipated from Grasstrees Australia, Middle Swan in identifying burnt and unburnt sites. Wireless Hill Reserve experienced a widespread fire in September 2026 and is under consideration for studying the possible effect of smoke on flowering as hundreds of balgas are present there. Other suitable sites for field trials are sought and the advice and assistance of others would be welcome.

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Table

Table 1 is available in the Supplementary Files section.

Figures

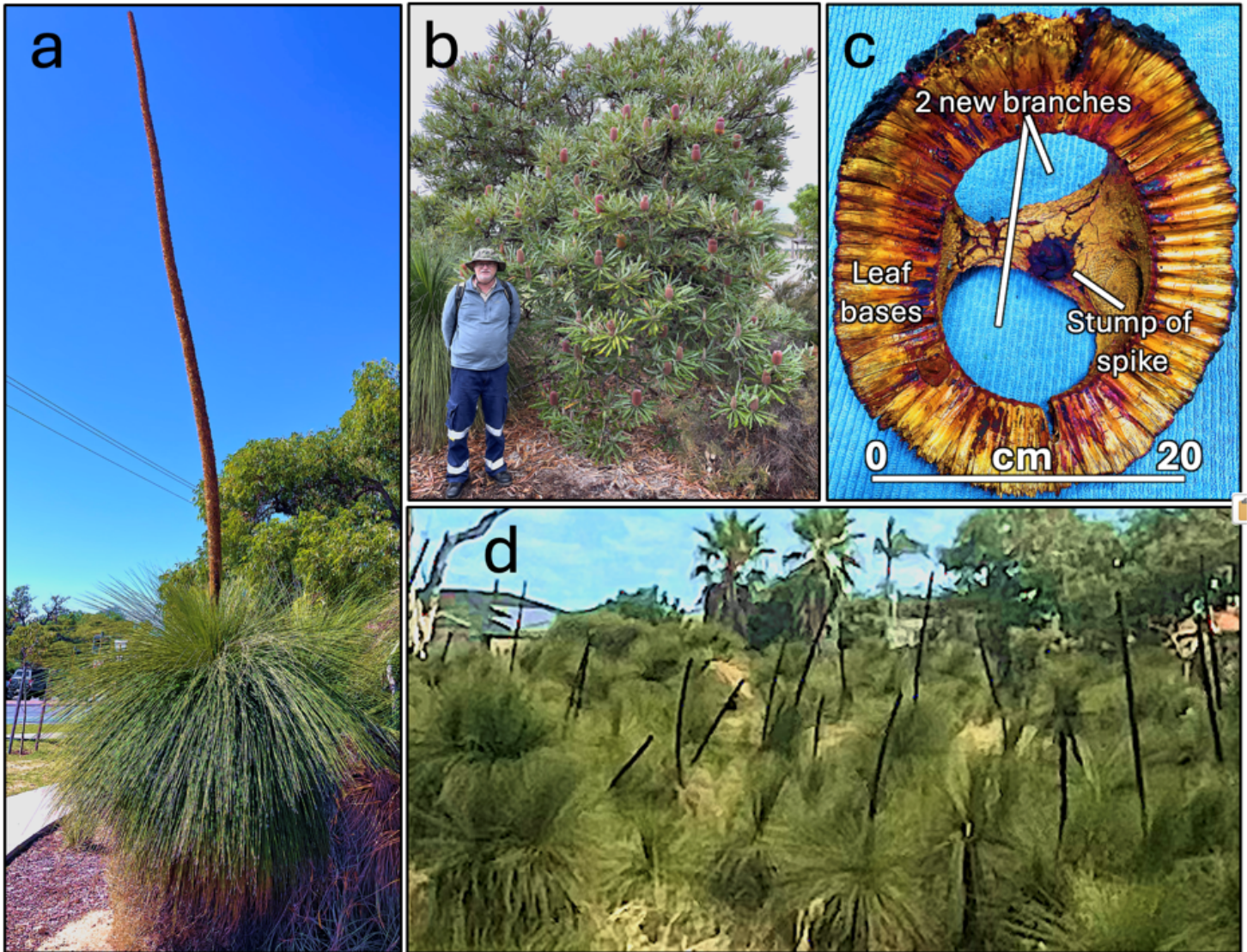


Figure 1

a. *Xanthorrhoea preissii* bearing a 4.66 m long spike near Winterfold Rd, Redmond Reserve, Hamilton Hill, April 2026. Note *Eucalyptus marginata* in the background. **b.** *Banksia menziesii*, an indicator species at Redmond Reserve, April 2026, with co-worker, Philip Groom. **c.** Sheathing leafbases of *X. preissii* with true caudex removed to show stump of flower and two spaces representing location of new branches arising diametrically opposite the stump. **d.** Dense stand of *X. preissii* at Barrington Rd site burnt in the 2024-5 dry season with 50% flowering in response, photographed in April 2026 when many spikes had fallen to the ground. Undamaged spikes were 3–4 m long with one recorded at 4.8 m.

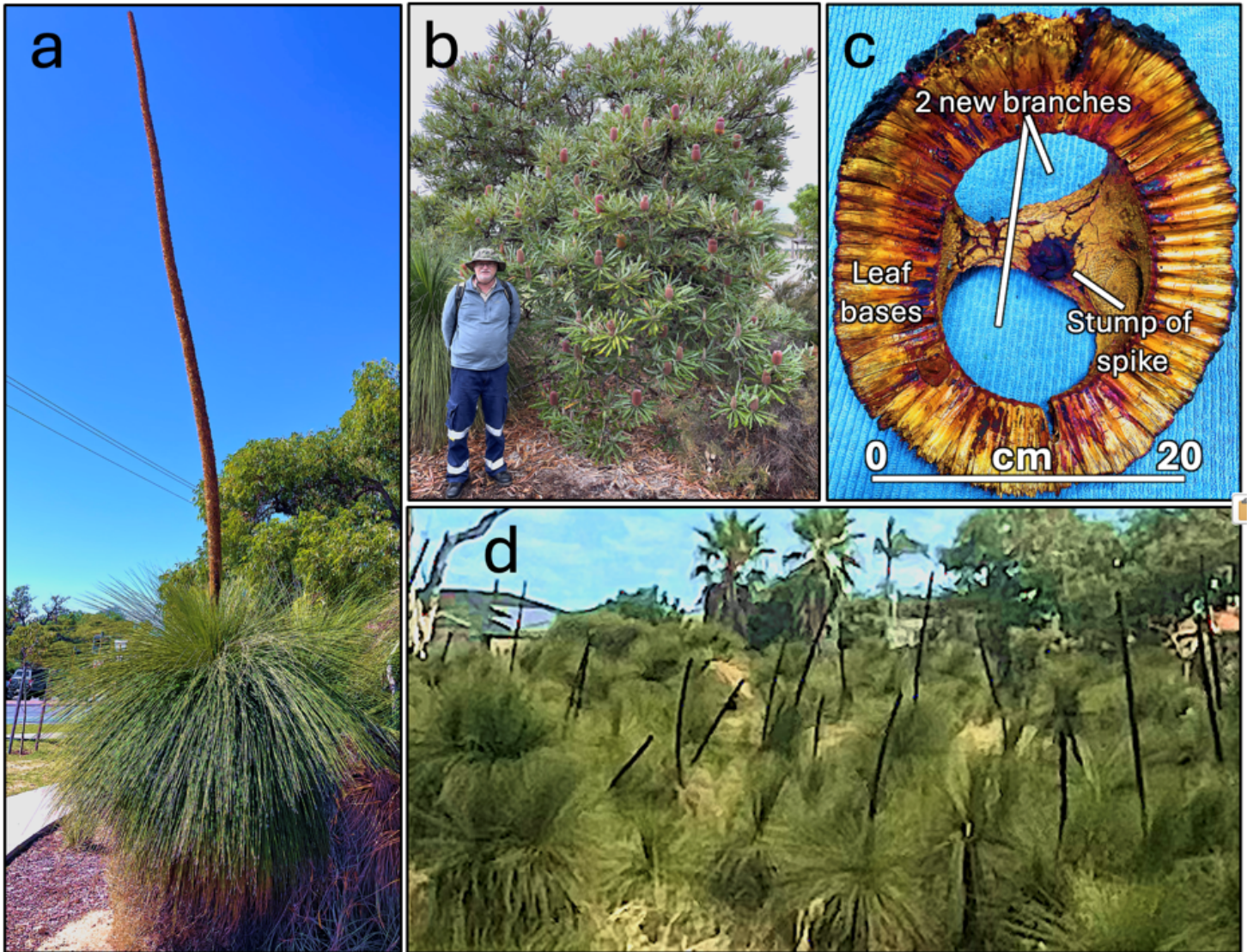


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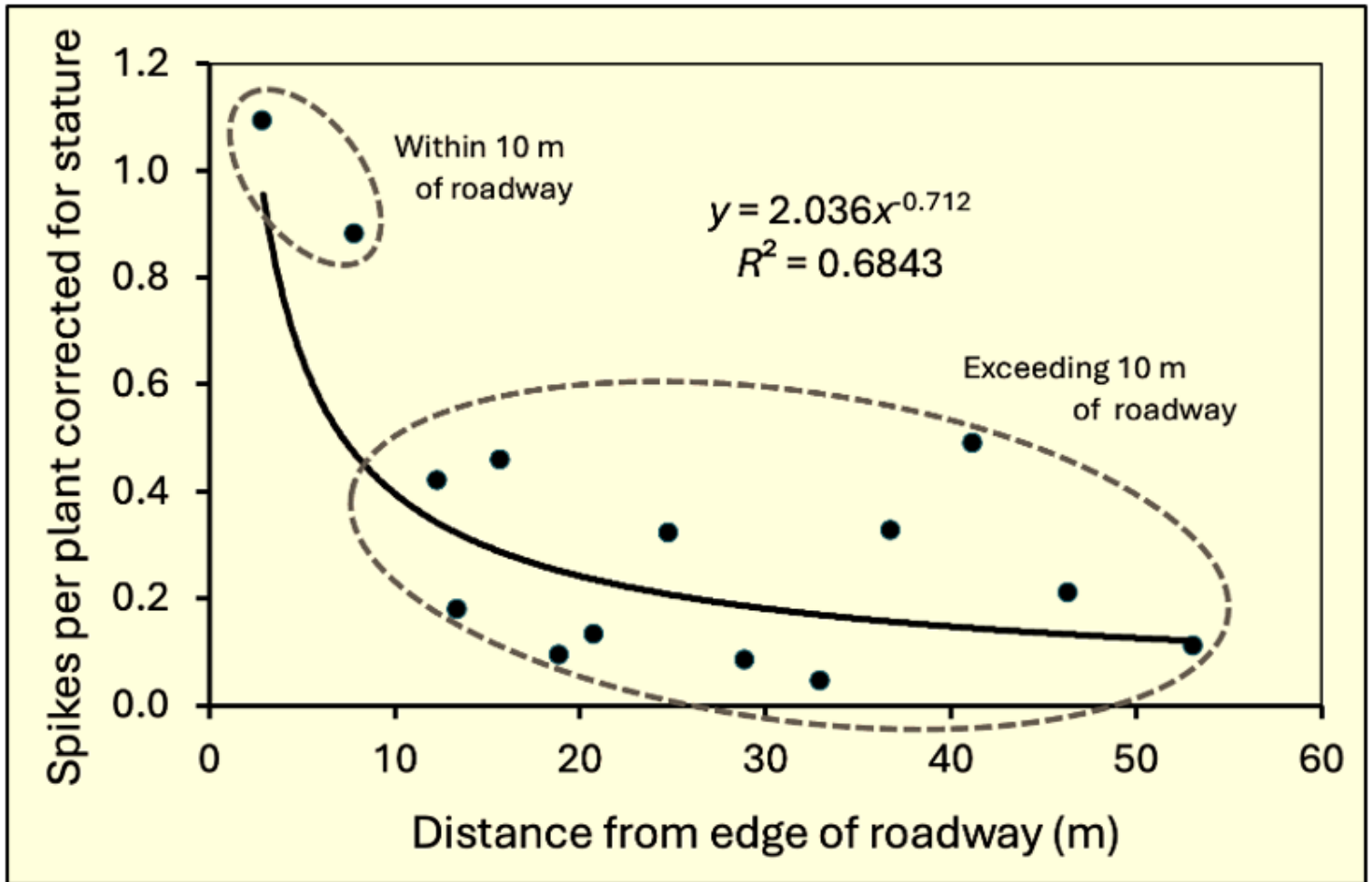


Figure 2

Fig. 1. Spikes per xanthorrhoea relative to distance from edge of the roadway with each coordinate representing the mean for each successive group of ten plants. The best fit line has been added and the plants showing a roadedge effect have been circled along with the plants not showing an edge effect.

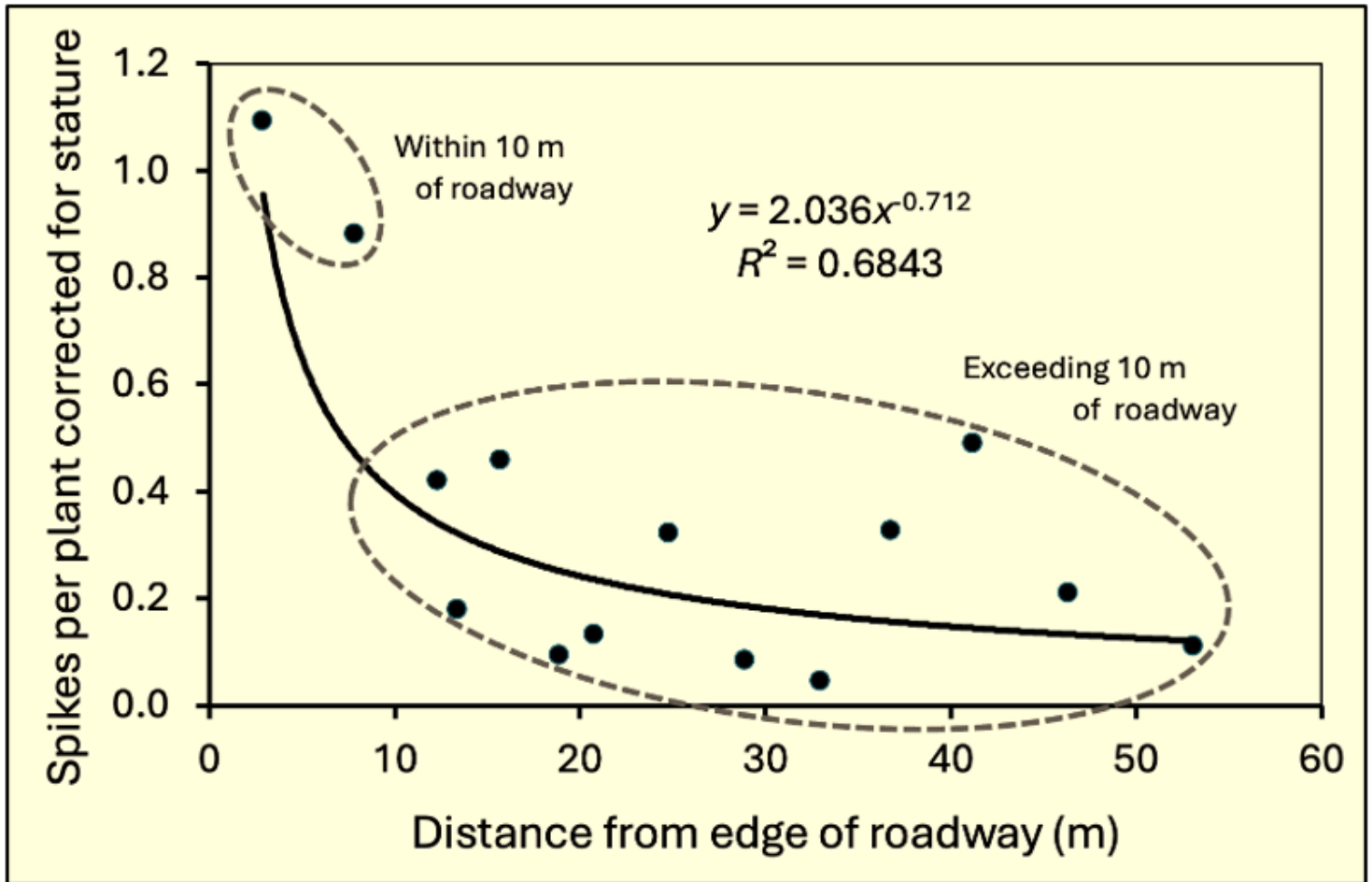


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Supplementary Files

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- [Table1.docx](#)