Population Dynamics and Fire Response of Two Rare Shrubs in Brisbane Eucalypt Forests

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Abstract

Understanding how eucalypt forest flora respond to fire allows the implementation of a planned burn program that best suits the ecosystem, including threatened species. We report on the dynamics and response to low-intensity planned burning of two rare shrubs that grow in Brisbane eucalypt forests on metamorphic hills (Regional Ecosystem 12.11.5). A population of the Vulnerable *Notelaea lloydii* at Changing Mountain on the western side of Brisbane has been stable for the last seven years. All plants burnt in low-intensity fires in 2021 survived and rapidly regrew to over half their pre-fire height within a year. However, no seedlings of *N. lloydii* have been seen. The species' Vulnerable status is supported. The Critically Endangered *Zieria gymnocarpa* is restricted to the Belmont Hills area in eastern Brisbane. The numbers of *Z. gymnocarpa* in a 100 m^2 monitoring transect have dropped significantly from 248 in 2015 to only 34 plants in April 2022. The population decline was initially recorded in the dry period between 2015 and March 2016. *Zieria gymnocarpa* regenerated vegetatively after an August 2016 fire via coppice shoots at the base of stems and root suckers. Plant numbers a year after fire were similar to pre-fire density. However, the population has subsequently continued to decline and no seedlings have been seen during any survey. Further assessment is needed to estimate the population density across the species' entire range and to investigate ways to promote its numbers. Given its small distribution and documented decline, we support the Queensland *Nature Conservation Act 1992* status of Critically Endangered and suggest *Z. gymnocarpa* also be listed as Critically Endangered under the Federal *Environment Protection and Biodiversity Conservation Act 1999*.

Keywords: *Notelaea lloydii*, *Zieria gymnocarpa*, fire management, monitoring, subtropical eucalypt forest

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Introduction

South East Queensland contains nearly a third of Queensland's threatened species, due to the variety of habitats and extent of vegetation clearing (Williams & Clouten, 2021). Appropriate fire and weed management is a critical aspect of conservation land management, including the preservation of threatened species. Monitoring changes in flora abundance over time and their responses to management actions allows ongoing refinements. The purpose of this study was to monitor populations of two rare shrubs of Brisbane eucalypt forests, to observe dynamics over time and their response to planned burning carried out by the Brisbane

City Council for ecological and hazard reduction purposes.

Notelaea lloydii Guymer, Oleacaeae, is a tall shrub with narrow opposite leaves and black berries (Figure 1; Guymer, 1987). It is endemic to South East Queensland, growing from Somerset Dam to south of Beaudesert (Halford, 1998). A recent assessment found the shrub is threatened by potential clearing for urban expansion and is only known from five locations with 30 or fewer individuals, plus several scattered plants along roadsides (Manwaduge et al., 2020). *Notelaea lloydii* has a Vulnerable status under both the Queensland *Nature Conservation Act 1992* (NC Act) and Federal *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

Zieria gymnocarpa (J.A.Armstr.) P.I.Forst., Rutaceae, has a Critically Endangered status under the Queensland NC Act but is not listed under the EPBC Act (Figure 2; Forster, 2020). It is a shrub with warty opposite leaves occurring as 3-leaflets. Crushed leaves have an odour best left unsampled. They have tiny white flowers. *Zieria gymnocarpa* is restricted to a 3.5 km diameter section of eucalypt forest at Belmont Hills and adjacent Mt Petrie, in eastern Brisbane.

The original collection of *Z. gymnocarpa* was at Belmont in September 1887 by J. H. Simmonds (Forster, 2020). The shrub was previously considered a subspecies of the more widely distributed *Z. furfuracea* but was recently upgraded to its own species, *Z. gymnocarpa* (Forster, 2020).

The populations of *N. lloydii* and *Z. gymnocarpa* assessed in this study grow in Regional Ecosystem 12.11.5, which is eucalypt forest on metamorphosed sediments on hills dominated by *Corymbia citriodora* subsp. *variegata* with *Eucalyptus siderophloia*, *E. crebra*, *E. propinqua* and/or *E. acmenoides*.

FIGURE 1. *Notelaea lloydii* at Changing Mountain.

FIGURE 2. *Zieria gymnocarpa* at Belmont Hills.

Methods

Notelaea lloydii and *Z. gymnocarpa* populations have been monitored since 2015, including before and after planned fires, as part of a broader vegetation monitoring program run by the Brisbane City Council. The monitoring began in 2008 and is undertaken in March or April each year (Williams & Collins, 2022). Each transect is 25 m long by 4 m wide (the narrow width is used to help with the accuracy of recounts) and is permanently marked by a post at each end. All woody plants, including seedlings and root suckers, are counted within the transect. A coordinate is recorded for individual woody plants (i.e. a distance along the transect and a measurement out from the central tape), unless they occur in large numbers clustered together. Where many plants are clustered, plant counts are made within segments of the transect – e.g. plants counted between 0 and 2 m along, then between 2 and 4 m along, etc.

Notelaea lloydii plants grow as well-spaced, distinct multi-stemmed shrubs, and the position along and out from the centre of the transect was recorded for each plant. Due to the significance of *N. lloydii* and their scattered distribution, several plants that grow adjacent to the 25 m × 4 m transect were included. *Notelaea lloydii* plants were monitored in three transects at Changing Mountain Reserve, near Lake Manchester, in the west of Brisbane. The locations of transects, plus dates of surveys and recent fires, are presented in Table 1. One of the Changing Mountain transects, Transect 90, has been surveyed in most years since 2015. Transects 108 and 109 were established prior to planned burns in 2021. All three transects were burnt in late July to August 2021, with average scorch heights (i.e. dead leaves from radiant heat) ranging from 2 to 4 m, which is considered low intensity.

Table 1. Transect details, including dates of the most recent fires and of monitoring surveys. "X" indicates a survey in a particular year. All surveys were undertaken in March to April, so that a survey occurred before a burn of the same year. That is, the 2016 survey at Belmont Hills was completed before the 2016 fire and the 2021 surveys occurred before the 2021 fires at Changing Mountain.

Transect No. & Reserve	Latitude Longitude	Recent fire	2015	2016	2017	2018	2019	2020	2021	2022
Notelaea lloydii Transects:										
90, Changing Mountain	27.509865°S 152.778913°E	2021 August	X	X	X	X	X		X	X
108, Changing Mountain	27.508196°S 152.774132°E	2021 August							X	X
109, Changing Mountain	27.505886°S 152.796452°E	2021 July							X	X
Zieria gymnocarpa Transect:										
73, Belmont Hills	27.513324°S 153.124071°E	2016 August	X	X	X	X	X			X

Zieria gymnocarpa was monitored in a single transect at Belmont Hills, which was initially surveyed in March 2015. This transect was purposely positioned within the core population of *Z. gymnocarpa* so that it could provide an indication of population dynamics. These plants grow as small multi-stemmed plants clustered together. Most of these plants were counted within contiguous 2 m segments of the transect, with a precise position along the transect only recorded for large, isolated plants. The transect was burnt in August 2016, producing an average scorch height of 2 m, which is considered a low intensity.

Results

Notelaea lloydii

The only *N. lloydii* plant growing in Transect 109 was not burnt in the July 2021 fire, due to the burn's patchiness, and remained alive in April 2022. Every burnt *N. lloydii* plant in the other two transects (five in Transect 90 and four in Transect 108) survived by regrowing from subsoil coppice shoots emerging from the base of the stems. The regrowth shoots had returned to over half their pre-fire heights within a year of fire (Figure 3). The number of stems per plant increased as a result of the fires. In Transect 90, stem number increased from an average of five per plant to well over 10 stems. In Transect 108, it increased from an average of 3.25 to 5.5 stems. No seedlings of *N. lloydii* have been observed during any survey, including the post-fire surveys, even though mature fruit have been seen.

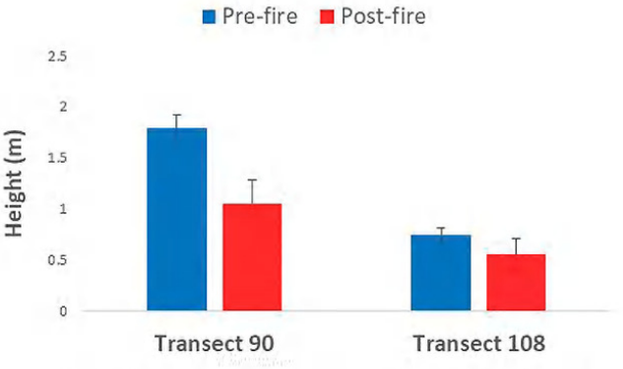

FIGURE 3. The average pre-fire and regrowth height at eight months post-fire (±1 standard error) of *N. lloydii* plants burnt in August 2021.

Zieria gymnocarpa

The numbers of *Z. gymnocarpa* have dropped drastically from their original 2015 count of 248 to only 34 remaining in April 2022 – i.e. only 14% have survived the last seven years (Figure 4). Specifically, *Z. gymnocarpa* numbers dropped from 248 in 2015 to 182 in March 2016, which was one of the driest periods of the last 15 years in Brisbane. *Zieria gymnocarpa* plants regenerated after an August 2016 fire from coppice shoots from the base of the plant and from root suckers away from the original stem base, which caused a drop in plant height (Figures 4 and 5). The *Z. gymnocarpa* population number was

roughly stable before the fire (182 in 2016) and a year after the fire (173 in 2017), but the population has further declined steadily since (Figure 4). The surviving plants have not grown beyond their average height at one year after the 2016 fire. While several plants have flowered, no *Z. gymnocarpa* fruit or seedlings have been seen at any time, including after the fire, or during the high rainfall in 2022.

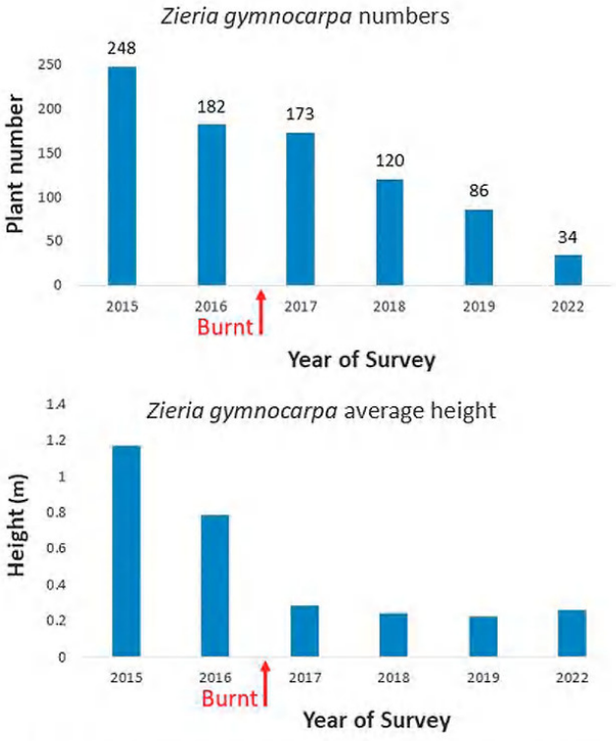

FIGURE 4. The number (top) and average height, ±1 standard error (bottom graph), of *Z. gymnocarpa* in Transect 73 at Belmont Hills.

FIGURE 5. *Zieria gymnocarpa* regrew from sucker shoots emerging along the roots.

In contrast to *Z. gymnocarpa*, the other common shrub in Transect 73, *Acacia disparrima*, has remained fairly stable, with a minor drop between 2019 and 2022 (Figure 6).

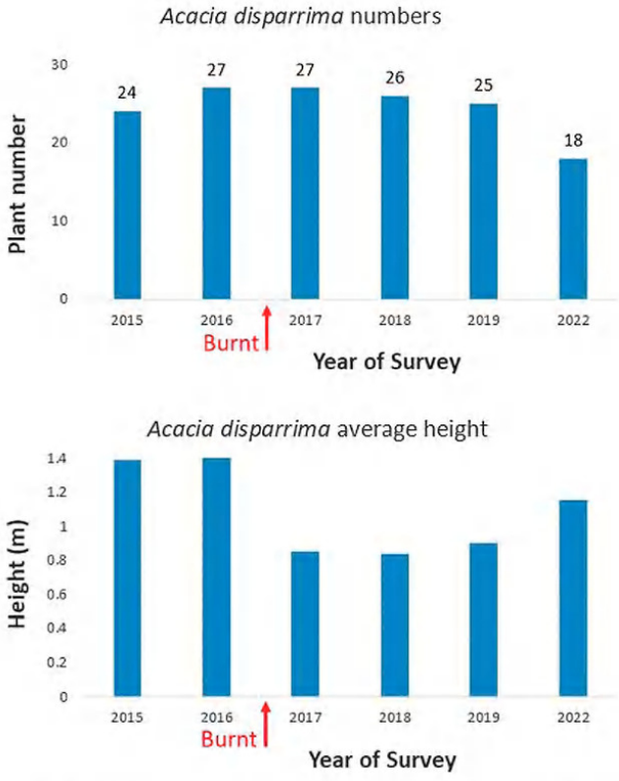

FIGURE 6. The number (top) and average height, ±1 standard error (bottom graph), of *Acacia disparrima* in Transect 73 at Belmont Hills, as a comparison with *Zieria gymnocarpa*.

Discussion

While these results are only based on three transects in one location of *N. lloydii*, and only one transect at the single known location of *Z. gymnocarpa*, they provide a snapshot of the dynamics of these two rare Brisbane bushland shrubs. The results confirm a previous observation by Halford (1998) that *N. lloydii* survives fire by vegetatively resprouting from the base of stems. We found 100% survival of burnt and unburnt plants, and rapid post-fire regrowth, indicating the sample population of *N. lloydii* at Changing Mountain appears to be stable and tolerant of low-intensity fire. However, no seedlings have been seen, and recruitment of *N. lloydii* may have been inhibited by a dense *Lantana montevidensis* ground layer in the area (Williams & Collins, 2022).

Based on the International Union for Conservation of Nature criteria (IUCN, 2022), the current status of Vulnerable at the state (NC Act) and Federal (EPBC Act) levels is supported for *N. lloydii*. That is, the species has a total extent of occurrence of between 5000 and 20,000 km^2, and has severely fragmented populations within the highly developed South East Queensland region. There is evidence of a decline in habitat quality on the basis of weed abundance, i.e. *Lantana montevidensis*.

In contrast to *N. lloydii*, the sample population of *Z. gymnocarpa* has undergone a significant decline in the last seven years. The relative stability of the associated *A. disparrima* indicates there is an issue selectively affecting *Z. gymnocarpa* rather than all woody plants in the area. It is particularly concerning because the species has such a limited known distribution (around 7 km^2).

The initial recorded drop in *Z. gymnocarpa* numbers occurred during a dry year when several *Zieria* plants were observed with dead leaves. It was independently noted that *Z. gymnocarpa* plants in an adjacent location also looked to be suffering from dry conditions and produced few fruit (G. Leiper, pers. comm., 17 May 2022). Multiple rare *Zieria* species in New South Wales have also dropped in number during droughts of recent decades (G. Wright, pers. comm., 12 May 2022). However, some of those species of *Zieria* have subsequently germinated massive numbers of seedlings (e.g. >1000 seedlings) after the high rainfall of recent years, including in sites burnt in the 2019 fires (Brown & Richards, 2022).

The lack of seedling recruitment by *Z. gymnocarpa* is unusual for a species of *Zieria*. Most *Zieria* species are fire-killed obligate seeders, a functional group that tends to produce more seedlings than do species that vegetatively regrow after fire, such as *Z. gymnocarpa*. For example, the Endangered obligate seeder *Z. bifida* of the Sunshine Coast hinterland recruited 188 seedlings from 19 pre-fire adult plants following a single fire (R. Thomas, pers. comm., 1 April 2015). *Zieria baeuerlenii* is another of the few species of *Zieria* that resprout after fire, which also shows population fluctuates linked to drought and has very limited, if any seedling recruitment (K. Coutts-McClelland, pers. comm., 27 May 2022). Therefore, the lack of seedling recruitment is not unusual for a resprouting shrub, especially one that can spread slightly via root suckers, and multiple *Zieria* species show strong fluctuations in population numbers, especially in dry years.

Using the IUCN criteria (IUCN, 2022), the current Queensland NC Act status of Critically Endangered is supported for *Z. gymnocarpa* and it is recommended it also be listed as Critically Endangered under the Federal EPBC Act. This is because the species has an extent of occurrence of approximately 7 km^2, which is at the lower end of <100 km^2. The Belmont Hills transect data presented in this paper show a significant population decline in the last decade (i.e. potentially an 86% decline within seven years). The population is fragmented by being split by the Gateway Motorway.

Further assessments will need t o be made to evaluate the population density of *Z. gymnocarpa* across its entire range at Belmont Hills and Mt Petrie. Small treatments, such as burning small patches in wet years, can be trialled with the aim of promoting plant numbers via well-spaced root suckers and/or seedlings. Germination and vegetative propagation trials and planting of resulting plants would be worthwhile.

The regional ecosystem in which these two rare shrubs grow (RE 12.11.5, eucalypt forest on metamorphic-derived soils on hills) is one of the most widespread across South East Queensland. These data highlight the variability of plant responses in this dominant vegetation type and the benefit vegetation monitoring makes to understanding population dynamics across the region.

In conclusion, monitoring of two rare shrubs of Brisbane eucalypt forests has found one species (*N. lloydii*) to be stable in the Changing Mountain (western Brisbane) area, including after low-intensity fire; while another, more restricted shrub (*Z. gymnocarpa*) to be declining in density in recent years.

These data highlight the absence of *N. lloydii* seedling recruitment, which may be linked to the abundance of the weed *Lantana montevidensis*, and also to rapid regrowth after fire and tolerance of at least occasional low-intensity burning. Further assessment of other *N. lloydii* populations, after a sequence of fires and after germination trials to assess seed dormancy, will increase our understanding of the dynamics of this species.

Additional assessment of the *Z. gymnocarpa* population is needed to understand the current number of plants in its only known population, as well as the role of burning, such as in moist conditions, in promoting further vegetative spread or seedling recruitment.

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Eleanor Collins is an ecologist interested in fauna and flora management, including suitable fire management. She has been involved with the Brisbane City Council vegetation monitoring program for over a decade.

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Chandra Wood is a land management professional with interest in managing fire for conservation at the urban interface.

Mel Cooper and Craig Hardie have many years of experience managing bushland and fire in Brisbane.

Kelli Messer is a Brisbane City Council employee with over 30 years' experience in protected area management. She has worked mostly in the West Region of Brisbane, managing both planning and delivery outcomes relating to fire management, recreation and conservation management in key conservation reserves. Kelli is currently part of the Environment Centres team.