

Vegetation Change Over 50 Years in Eucalypt Forest on North Stradbroke Island

Paul Williams¹, Dave Kington², and Eleanor Collins¹

Abstract

Detailed vegetation surveys on North Stradbroke Island (known by Traditional Owners as Minjerribah) by University of Queensland botanists in 1967 provided a rare and valuable opportunity to assess vegetation composition and structure changes over the last 50 years. The eucalypt forest assessed is dominated by scribbly gum (*Eucalyptus racemosa*), representing Regional Ecosystem 12.2.6. It is the most widespread forest on the island and is also abundant on Moreton and Fraser Islands, as well as the Cooloola Coast, so that this evaluation is relevant to a broad area. At the forest site, located south of Brown Lake, a previously continuous ground cover of kangaroo grass (*Themeda triandra*) has all but disappeared, while other herbaceous plants and species richness have declined. Large shrub and small tree densities have dramatically increased, particularly *Allocasuarina littoralis* and *Leptospermum trinervium*. Eucalypt crowns have been damaged and several trees are dead. The forest south of Brown Lake was burnt by intense fires in 1965 and 1995, but was not burnt in the extensive January 2014 wildfire. The study site may have experienced other fires which have not been documented, but was long unburnt by the time of the 2016 survey. We suggest that the dramatic loss of grass and herb cover, shrub and small tree thickening, plus crown damage, resulted from irregular, high-intensity fires. The re-establishment of regular, low- to moderate-intensity fires during periods of good soil moisture is likely to reduce crown damage, maintain shrubs at a healthy density and promote native grasses.

Keywords: eucalypt forest, wildfire, cultural burning, burning regime, planned burning, vegetation condition, kangaroo grass, *Themeda triandra*

¹ Vegetation Management Science, PO Box 32, Malanda, QLD 4885, Australia
(paul@vegetationscience.com.au)

² QYAC/QPWS Joint Management, Sturt Street, Dunwich, North Stradbroke Island, QLD 4183, Australia

Introduction

North Stradbroke, known by the Traditional Owners as Minjerribah, is a sand island east of Brisbane, 11 km offshore from Cleveland. Eighteen regional ecosystems (REs) are mapped across the island, dominated by eucalypt forests, wetlands and heaths (Stephens & Sharp, 2009). The most abundant eucalypt forest is RE 12.2.6, *Eucalyptus racemosa* on sand dunes and plains, while the mallee-heath RE 12.2.10 of *Eucalyptus planchoniana*, *Corymbia gummifera*, *E. racemosa* and *Banksia aemula* is abundant across the island's central ridges (Queensland Herbarium,

2019). These communities are abundant on nearby islands and the Cooloola Coast. Many large trees on the island have been dated as several centuries old, and traditional, low-intensity burning is thought to have preserved these old trees (Ngugi et al., 2020).

University of Queensland staff (Professors Trevor Clifford and Ray Specht) and students undertook botanical surveys on North Stradbroke Island in the mid to late 1960s, with further research through the 1970s and into the 1980s. They surveyed eucalypt forests and heaths south of Brown Lake and north of Blue Lake, and mallee-heaths on Mt Hardgrave,

This work is licensed under a Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International Licence. Individual articles may be copied or downloaded for private, scholarly and not-for-profit use. Quotations may be extracted provided that the author and The Royal Society of Queensland are acknowledged. Queries regarding republication of papers, or parts of papers such as figures and photographs, should be addressed to the Secretary of The Royal Society of Queensland (rsocqld@gmail.com).

describing them as characteristic representations of habitats of the inland sand dunes of the island (Clifford et al., 1979). Their survey results were written up in scientific articles and also as a book (Connor & Clifford, 1972; Clifford et al., 1979). Their vegetation surveys provide a valuable baseline for the assessment of vegetation change over time.

Fire is an important element in eucalypt forest dynamics. Specht et al. (1984) describe the 1965 fire in the Brown Lake area as a “ground and crown fire”. Connor & Clifford (1972) refer to two fires over four years, apparently prior to their 1967 survey – presumably the 1965 wildfire and an earlier patchy fire. The Brown Lake study site was burnt again in February 1995 (Paul Smith, pers. comm., 2020). No other fires have been documented in the Brown Lake site, but it is possible that one or more undocumented fires have occurred since 1965. However, the site did not burn in the January 2014 wildfire and appeared to have been unburnt for well over 10 years by 2016, based on little charcoal and the abundance of dense fire-sensitive species (e.g. *Allocasuarina littoralis*).

An awareness of vegetation change helps guide discussions about ideal composition and structure, and possible factors governing dynamics. While management should not automatically strive for some past vegetation condition, it should appreciate that broad changes in structural and species dominance patterns, and the appearance of canopy dieback, are essential factors for defining a healthy ecosystem, for understanding how forest communities function and for determining management objectives.

Methods

The University of Queensland (UQ) botanists produced fine-scale vegetation maps and descriptions for the ecosystems on the south side of Brown Lake (Connor & Clifford, 1972; Clifford et al., 1979). The UQ vegetation maps and associated vegetation descriptions were produced from a 1967 survey of two hundred 2×1 m quadrats, arranged in a grid across a $625 \text{ m} \times 400 \text{ m}$ area containing a mixture of open eucalypt forests and heathy sedgelands (Connor & Clifford 1972; Clifford et al., 1979). All species present within each of the 2×1 m quadrats were recorded, to produce a table of species’ frequency of occurrence (i.e. percentage of quadrats

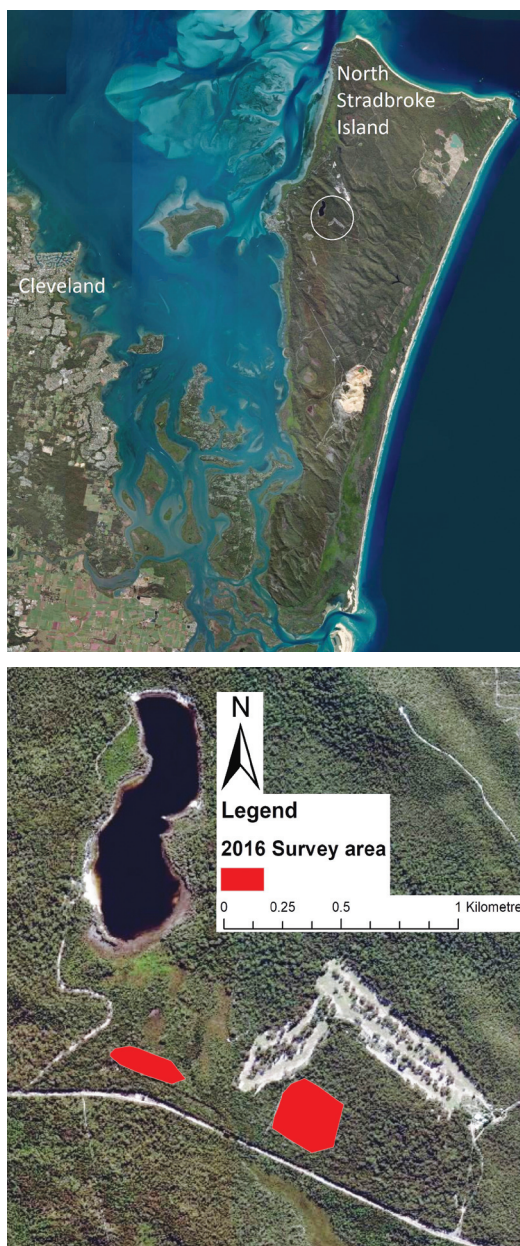
in which each species was present) across the area (Clifford et al., 1979). Vegetation types (eucalypt open forest and closed heath/grassland communities) were determined and mapped across the area based on the species information across the two hundred quadrats.

UQ distinguished three heathy sedgeland swamps and three eucalypt forest communities for the area south of Brown Lake, each differing in frequency of different key species. The three eucalypt forest communities were scribbly gum (*Eucalyptus racemosa*) with an understorey of kangaroo grass (*Themeda triandra*) and the small legume shrub *Phyllota phyllicoides* (Community E); a forest dominated by blackbutt (*E. pilularis*) and scribbly gum with a kangaroo grass understorey (Community F); and a forest dominated by blackbutt and scribbly gum, with kangaroo grass and *Phyllota phyllicoides* only rare in the understorey (Community D).

In February and April 2016, approximately 50 years after the initial UQ assessments, a resurvey was undertaken on the south-east side of Brown Lake. The 2016 assessment resurveyed, as closely as possible, the areas described in 1967 as eucalypt open forest with kangaroo grass (combining UQ Communities E and F of Clifford et al., 1979), which are south of the golf course (27.5004° south; 153.4401° east). This vegetation is RE 12.2.6, which is the most widespread forest ecosystem on the island. Since the original UQ surveys, a few tracks have been pushed through and a golf course built in the general area near Brown Lake. We repeated the 1967 survey method of recording species frequency within 2×1 m quadrats. In 1967, a total of 200 quadrats was sampled across six communities. We surveyed 50 quadrats to assess the eucalypt open forest areas dominated by kangaroo grass in 1967. The 50 quadrats were spread over an area 900 m wide, dissected by a wet heath, to ensure best possible overlap with the original 1967 survey area (Figure 1). Although it is difficult to know the precise boundaries of the initial UQ study site, our 2016 quadrat survey probably includes an extension of about 150 m east of the initial UQ boundary, to ensure adequate coverage of the eucalypt forest area and to compensate for the forest lost to the golf course development. Photos were taken of the site from a helicopter, and an overall assessment of the condition of the sites was made on the ground (e.g.

examining vegetation structure and crown health). Comparisons in species frequency of occurrence data and an evaluation of the descriptions provided by UQ were made to determine change over time.

Figure 1. Map of North Stradbroke Island (top, survey area circled) and 2016 survey area (below).



Results

Dramatic vegetation changes have occurred in the eucalypt forest on the south-eastern side of Brown Lake over the last 50 years. There were considerable differences in the frequency of occurrence data for common species in the open eucalypt forests in 2016 compared to 1967 (Table 1).

Note: The 1967 data are an average of records from the two grassy open eucalypt forest communities E & F described in Clifford et al. (1979), where only data from the most common species were published. Therefore, the 1967 records are presented as a blank space against some species, as we cannot be certain that their occurrence was zero.

Species with large changes between 1967 and 2016 are highlighted in bold. No alien species were recorded.

The majority of the six most abundant species in either 1967 or 2016 surveys changed in occurrence (Table 1). Two woody plants (*Allocasuarina littoralis* and *Woollsia pungens*) and the sedge *Lomandra multiflora* increased in frequency by 2016 (Figure 2). Other species that increased in frequency by 2016 were the sedge-like ground layer plant *Baloskion tetraphyllum*, as well as the shrubs *Acrotriche aggregata* and *Leptospermum trinervium*.

The largest reduction in frequency was of kangaroo grass, which declined from being present in every quadrat in 1967 to only 6% of quadrats in 2016. Furthermore, kangaroo grass was only represented by a few small, spindly tufts in those few 2016 quadrats, rather than healthy grass tussocks.

Other species that declined in occurrence between 1967 and 2016 included bracken fern (*Pteridium esculentum*) which nearly halved, and the small shrubs and herbs *Boronia rosmarinifolia*, *Bossiaea heterophylla*, *Hibbertia acicularis*, *Leucopogon* sp., *Phyllota phyllicoides*, *Pimelea linifolia*, *Sowerbaea juncea* and *Strangea linearis*. The small trees *Allocasuarina torulosa* and *Banksia aemula* also decreased in frequency of occurrence.

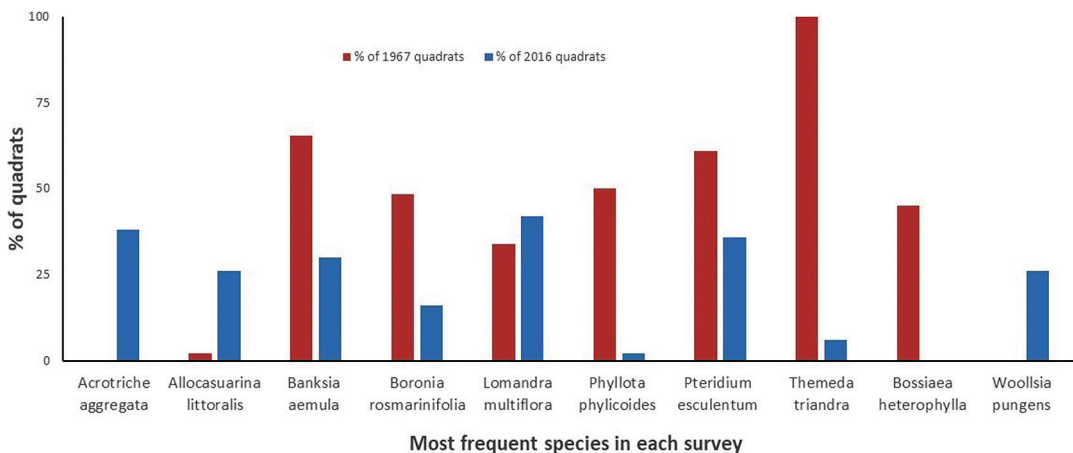
There was a dramatic decline in species richness between 1967 and 2016. The mean species richness per quadrat (2 m²) in 2016 was 4.9 species. This is one-third of the species richness (15 species, per 2 m²) recorded by Connor & Clifford (1972) as an average from their quadrats surveyed in 1967.

Table 1. The percentage frequency of occurrence within 50 quadrats of all species in eucalypt forest in 2016, compared with their frequency in 1967.

Family	Species	1967 quadrats (%)	2016 quadrats (%)
Apocynaceae	<i>Parsonsia</i> sp.		4
Casuarinaceae	<i>Allocasuarina littoralis</i>	2	26
	<i>Allocasuarina torulosa</i>	17	2
Cupressaceae	<i>Callitris rhomboidea</i>		2
Cyperaceae	<i>Fimbristylis</i> sp.		14
	<i>Lepidosperma laterale</i>		2
Dennstaedtiaceae	<i>Pteridium esculentum</i>	61	36
Dilleniaceae	<i>Hibbertia acicularis</i>	39	4
Elaeocarpaceae	<i>Elaeocarpus reticulatus</i>		10
	<i>Tetratheca thymifolia</i>		2
Ericaceae	<i>Acrotriche aggregata</i>		38
	<i>Leucopogon</i> sp.	36.5	6
	<i>Woollsia pungens</i>		26
Euphorbiaceae	<i>Ricinocarpos pinifolius</i>		10
Fabaceae	<i>Bossiaea heterophylla</i>	45	0
	<i>Daviesia umbellulata</i>		2
	<i>Dillwynia retorta</i>		2
	<i>Phyllota phyllicoides</i>	50	2
Hemerocallidaceae	<i>Dianella</i> sp.		10
Lauraceae	<i>Cassytha</i>		8
Laxmanniaceae	<i>Lomandra longifolia</i>	40.5	2
	<i>Lomandra multiflora</i>	34	42
	<i>Sowerbaea juncea</i>	9.5	0
Myrtaceae	<i>Angophora leiocarpa</i>		6
	<i>Austromyrtus dulcis</i>		6
	<i>Corymbia intermedia</i>	4.5	10
	<i>Eucalyptus pilularis</i>	10	2
	<i>Eucalyptus planchoniana</i>		8
	<i>Eucalyptus racemosa</i>	19	18
	<i>Leptospermum trinervium</i>	2.5	22
	<i>Ochrosperma lineare</i>	4.5	6
Poaceae	<i>Eriachne pallescens</i>		2
	<i>Themeda triandra</i>	100	6

Family	Species	1967 quadrats (%)	2016 quadrats (%)
Proteaceae	<i>Banksia aemula</i>	65.5	30
	<i>Persoonia virgata</i>		6
	<i>Strangea linearis</i>	26	0
Restionaceae	<i>Baloskion pallens</i>		2
	<i>Baloskion tetraphyllum</i>	3.5	22
	<i>Empodisma minus</i>		6
	<i>Leptocarpus tenax</i>		4
Rutaceae	<i>Boronia rosmarinifolia</i>	48.5	16
	<i>Zieria smithii</i>		2
Sapindaceae	<i>Dodonaea triquetra</i>		4
Schizaeaceae	<i>Schizaea bifida</i>		8
Thymelaeaceae	<i>Pimelea linifolia</i>	40	0
Xanthorrhoeaceae	<i>Xanthorrhoea johnsonii</i>	30.5	22
Other plants	Herbs unidentified		14

Figure 2. The change in frequency of occurrence (percentage of quadrats) between 1967 and 2016 for the most common species in each survey.



The original UQ quadrat data were complemented by observations of vegetation structure. The vegetation described by Connor & Clifford (1972) and Clifford et al. (1979) as open eucalypt forest with a kangaroo grass ground layer was by 2016 a forest with very dense shrubs and small trees, and almost no grasses (Figure 2). By 2016, the forest

contained a number of dead trees and dead trunks with coppice shoots (Figures 3, 4 and 5). It was estimated from a recent aerial photo that approximately 13 trees per hectare have a badly damaged crown or are dead. Several trees have old fire scars, so the crown-damaged and dead eucalypts probably represent damage from the 1965 and/or 1995 fires.

Figure 3. In 2016, the eucalypt forest had dense shrubs (top) with a ground layer dominated by leaf litter and *Austromyrtus dulcis* (bottom); this is in contrast to the description of an open forest with an abundant kangaroo grass layer in 1967.



Figure 4. Photo taken on 28 April 2016 from a helicopter looking north-east across the Brown Lake study area (top); and a recent aerial image (bottom). Several dead eucalypt trunks can be seen, as can the darker-green *Allocasuarina littoralis* trees. The dead eucalypt trunk (circled) is the eucalypt with coppice shoots shown from the ground in Figure 5.



Figure 5. An example of the many dead trunks in the area, apparently killed by the 1995 wildfire. This eucalypt, with coppice shoots, is the one marked by a black circle in Figure 3.



Discussion

The change in vegetation composition and structure to the south of Brown Lake since 1967 has been considerable. Clifford et al. (1979) reported kangaroo grass dominating the ground layer of open eucalypt forest, with 100% presence within their eucalypt forest 2×1 m quadrats. This equates to a well-grassed, open forest. The UQ description of the site as an open eucalypt forest reflects that of locals, including Greg Litherland (pers. comm., 2016) who recalls his father being able to drive a Bedford truck through the open eucalypt forest south of Brown Lake in the 1950s. Westman & Rogers (1977) also describe a scribbly gum open forest with blady grass, wire grass (*Aristida* spp.) and kangaroo grass in their 1973 survey south of

Point Lookout. In their study of forest biomass, grasses and other herbs contributed a third of understorey living biomass (equal to both shrubs and tree saplings). Therefore, it is apparent that open eucalypt forest with native grasses and scattered shrubs was once widespread across North Stradbroke Island. This open, grassy forest structure has disappeared from the Brown Lake site and is currently rare on North Stradbroke Island.

Specht et al. (1984) stated that kangaroo grass was frequent at their site near Brown Lake in 1976 (note that this was 11 years after the 1965 fire) but had almost disappeared by 1984 (19 years after the fire). Specht et al. (1984) also documented a decline in kangaroo grass biomass from 11 g/m^2 in 1976 to only 1 g/m^2 in 1984 (in the unfertilised control part of their experiment). By 2016, there remained only a few very thin and scattered kangaroo grass tufts.

Specht et al. (1984) found that the loss of native grasses near Brown Lake was associated with an increase in shrub and small tree biomass, primarily *Allocasuarina littoralis* and tea tree (*Leptospermum trinervium*). They recorded that *Allocasuarina littoralis* and other shrubs regenerated by seedlings following the 1965 fire, with *Allocasuarina littoralis* increasing in frequency of occupancy six-fold between 1968 and 1984. The post-fire *Allocasuarina littoralis* seedlings progressively grew to form a mid-stratum layer that, with the eucalypt canopy, “slowly suppressed the ground layer” (Specht & Specht, 1989). This smothering of the ground-layer plants in the Brown Lake eucalypt forest resulted in a progressive decline in species diversity following the 1965 fire: from around 26 species per 10 m^2 after four years; to around 23 species after 11 years; and around 18 species after about 18 years (Specht & Specht, 1989).

Considerable crown damage and some tree death is apparent south of Brown Lake, presumably as a result of the intense 1965 or 1995 fires. An island-wide assessment after the 2014 wildfire found widespread eucalypt canopy damage and tree death, as well as high densities of shrub and small tree recruitment, with limited grass cover (Williams et al., 2016). The presence of healthy trees, several centuries old, scattered across the island suggests that preservation was provided by traditional, low-intensity burning by Aboriginal people (Ngugi et al., 2020). The loss of regular burning allows the development of high fuel

loads and intense wildfires, which can damage tree crowns.

In summary, the process of vegetation change near Brown Lake appears to be that intense fires in 1965 and 1995 promoted the recruitment of many shrub and small tree seedlings which, during long intervals between fires, grew to form a dense mid-stratum that shaded out grasses and herbs, clogging the previously open forest structure and reducing species diversity. The intense fires also damaged eucalypt crowns and killed some trees. It appears probable that the promotion of a dense shrub layer is likely to form a fuel ladder that promotes the scorching of the canopy in future fires, unless the burns are skilfully implemented at times of good soil moisture.

The proposed mechanism of vegetation change is that intense fires during dry conditions damage

grasses, while promoting dense shrub and small tree recruitment. The shrubs and small trees grow into dense ladder fuels that shade grasses and can draw flames into the canopy to damage eucalypt crowns. This promotes further dense shrub recruitment, which grows into dense thickets during subsequent long fire intervals, perpetuating the cycle. The loss of native grasses makes early-season, low-intensity fires more difficult to implement.

We propose that fire intervals in RE 12.2.6 should typically be every two to six years (rather than the currently recommended seven to 25 years; Queensland Herbarium, 2019), with mosaic burning creating some longer unburnt patches. Burning must be implemented while there is good soil moisture and mild weather conditions, using spot ignitions and slowly ignited, short drip-torch lines, to ensure fire intensity remains low to moderate.

Acknowledgements

We are grateful to the many people who provided insight into the study site and island ecology, especially Darren Burns, Graeme Bulley, Greg Litherland and Paul Smith. This study was made possible following a request by Quandamooka Yoolooburrabee Aboriginal Corporation (QYAC) for a joint management fire strategy, with QPWS, for Naree Budjong Djara National Park. We thank Angela Arthington for providing very helpful advice as PRSQ editor, and two anonymous reviewers who improved the manuscript greatly with their detailed comments.

Literature Cited

- Clifford, H. T., Specht, R. L., & Specht, M. M. (1979). *The vegetation of North Stradbroke Island, Queensland*. University of Queensland Press.
- Connor, D. J., & Clifford H. T. (1972). The vegetation near Brown Lake, North Stradbroke Island. *Proceedings of The Royal Society of Queensland*, 83, 69–82.
- Ngugi, M. R., Knight, J., Hua, Q., Dowling, R., Kington, D., & Burns, D. (2020). Ageing culturally significant relic trees in southeast Queensland to support bushfire management strategies. *Ecological Management & Restoration*, 21, 147–150.
- Queensland Herbarium. (2019, April). *Regional Ecosystem Description Database (REDD)* (Version 11.1). Queensland Department of Environment and Science.
- Specht, R. L., Clifford, H. T., & Rogers, R. W. (1984). Species richness in a eucalypt woodland on North Stradbroke Island, Queensland – the effect of overstorey and fertilizer, 1965–1984. In R. J. Coleman, J. Covacevich, & P. Davie (Eds.), *Focus on Stradbroke* (pp. 267–277). Boolarong Press.
- Specht, R. L., & Specht, A. (1989). Species Richness of Sclerophyll (Heathy) Plant Communities in Australia: The Influence of Overstorey Cover. *Australian Journal of Botany*, 37, 337–350.
- Stephens, K. M., & Sharp, D. (2009). *The Flora of North Stradbroke Island*. Queensland Herbarium; Environmental Protection Agency, Brisbane.
- Westman, W. E., & Rogers, R. W. (1977). Biomass and Structure of a Subtropical Eucalypt Forest, North Stradbroke Island. *Australian Journal of Botany*, 25, 171–191.
- Williams, P., Kington, D., Burrens, D. & Collins, E. (2016). Vegetation Condition Assessment on North Stradbroke and Peel Islands. In D. Kington, P. Williams, E. Collins, D. Burns, & G. Bulley (Eds.), *Fire Management Strategy for the Indigenous Joint Management Areas (IJMAs) on North Stradbroke Island and Peel Island* (Appendix 3).

Author Profiles

Paul Williams is a plant ecologist interested in land management, especially appropriate fire regimes.

Dave Kington is a fire ecologist with extensive experience in fire management within South East Queensland forests.

Eleanor Collins is an ecologist interested in fauna and flora management, including suitable fire management.