Size of *Eucalyptus resinifera* trees, and sap-trees used by Yellow-bellied Gliders, in the Tumoulin Forest Reserve in north Queensland

Katharine Jessup[A], *John W. Winter*[B], and *Donald C. Franklin*[C]

[A]SIT Study Abroad, 1 Kipling Road, Brattleboro Vermont 05302, United States of America

[B]Threatened Species Program, Department of Environment and Science, 83 Main St., Atherton Qld 4883, Australia, and College of Marine and Environmental Science, James Cook University, 14–88 McGregor Road, Smithfield Qld 4878, Australia

[C]Research Institute for the Environment & Livelihoods, Charles Darwin University, Darwin NT 0909, Australia, and Ecological Communications, 24 Broadway, Herberton Qld 4887, Australia. Email: *eucalypt@iinet.net.au*

Abstract

The diet of the Vulnerable Yellow-bellied Glider (*Petaurus australis* unnamed subspecies) in north Queensland includes sap obtained from *Eucalyptus resinifera* (Small-fruited Red Mahogany), this being a critical resource obtained from a small percentage of trees. Past logging might have depleted resources for the gliders. In the Sawmill Gully area of Tumoulin Forest Reserve, an area temporarily reserved for the gliders, we show that most *E. resinifera* are less than 70 cm in diameter. Smaller size classes are all well-represented including saplings, but very few trees are greater than 1 m in diameter, suggesting that the forest is recovering from logging. Thirty-two glider sap-trees in the area had a mean diameter of 60.4 cm with a strong preference by gliders, relative to availability, for trees more than 60 cm in diameter. Recruitment of more *E. resinifera* to larger size classes may increase options for gliders, but more logging may deplete them.

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Introduction

The Tumoulin Forest has been heavily exploited for timber since European settlement of the area (Toohey 1991), with *Eucalyptus resinifera* (Small-fruited Red Mahogany; known locally as Red Stringybark; Fig. 1) a key resource that was widely used for construction. The forest also provides key habitat for the Wet Tropics population of the Yellow-bellied Glider (*Petaurus australis* unnamed subspecies), a population that is listed as Vulnerable under both Commonwealth of Australia (EPBC Act 1999) and Queensland legislation (DERM 2011). Concerns about further impacts of logging on the Tumoulin population, which is already likely to be stressed by loss of connectivity with other populations as a result of loss of habitat to land clearing nearby (Winter *et al.* 2004), contributed to declaration by the Queensland Government of the part of the Tumoulin State Forest occupied by the taxon as Tumoulin Forest Reserve in 2010. However, the reservation status is legally temporary and must be resolved by December 2025, and thus the longer-term future of glider habitat there remains to be resolved.

Yellow-bellied Gliders consume invertebrates and carbohydrates (nectar, pollen, honeydew and sap) (Smith & Russell 1982) but the relative importance of these dietary items varies regionally (Carthew

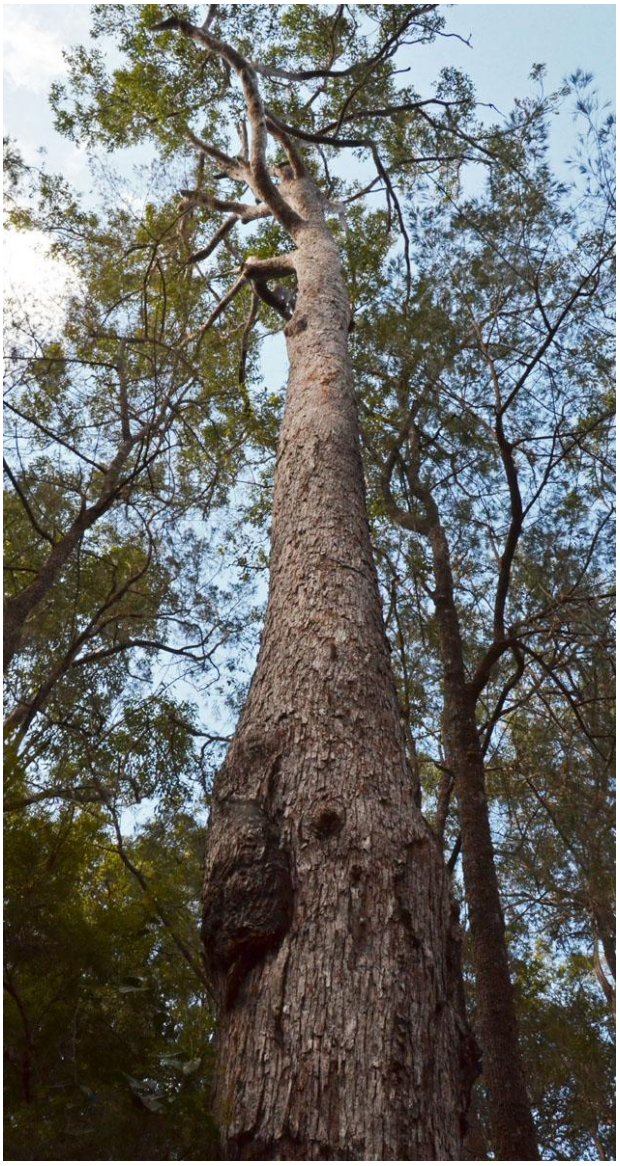

Figure 1. In north Queensland, *Eucalyptus resinifera* (Small-fruited Red Mahogany) is a tall tree of moist upland forests.
Photographed in the Tumoulin Forest Reserve by Don Franklin.

et al. 1999; Goldingay 2000) across a range that extends from north Queensland to western Victoria. A feature evident throughout the species' range is its ability to incise trees with its strong teeth to obtain sap, with the north Queensland population making especially heavy use of this resource (Smith & Russell 1982; Quin *et al*. 1996). Most populations consume sap from a variety of tree species (mainly eucalypts) (reviewed by Wallis & Goldingay 2014), whereas the populations at the two extremities of their geographical range are dependent on a single tree species; the population in Renwick Forest, far western Victoria, on *Eucalyptus viminalis* (Carthew *et al.* 1999) and the north Queensland population on *Eucalyptus resinifera* (Russell 1984; Quin *et al.* 1996; Bradford & Harrington 1999; Goldingay & Quin 2004) (Fig. 2). Further, only about 1% of *E. resinifera* trees are used (hereafter "sap-trees"), family groups at Nitchaga south of Ravenshoe using an average of 4.9 sap-trees over the course of a year (Goldingay & Quin 2004). Exploited trees appear to be those in which sap-flow is particularly strong (Goldingay 1987). Sap is used episodically (documented in populations elsewhere: Craig 1985; Goldingay 1986) and limited evidence suggests that it is used as a 'fall back' when other sources of carbohydrates are scarce (Kavanagh 1987; Mackowski 1988; Goldingay 1991). All these factors point to the likelihood that a few individual trees provide a critical resource for each family group especially in north Queensland, and that these should be protected from logging; this is believed to be true elsewhere in the species' range even where more than one tree species is exploited (Eyre & Goldingay 2003, 2005).

Figure 2. Yellow-bellied Glider and scars created by the species to obtain sap from the trunk of *Eucalyptus resinifera* (Small-fruited Red Mahogany).
Photo taken in the Tumoulin Forest Reserve by Don Franklin.

In this study, we examine the size profile of *E. resinifera* trees in a section of the Tumoulin Forest Reserve with a history of logging, and compare this with the size profile of sap-trees used by Yellow-bellied Gliders in the same area. Our results are used to consider two issues: the possible influence of past logging on the population structure of *E. resinifera*, and size selectivity of sap-trees by Yellow-bellied Gliders relative to tree availability. Both have implications for the future of the forest, its inhabitants and its management.

Methods

Study area and species

The study was conducted over *c.* 60 ha in the Sawmill Gully area (17°33'57"S, 145°29'37"E) of Tumoulin Forest Reserve (Fig. 3) in the Wet Tropics bioregion of north Queensland. As its name implies, the area hosted a small-scale sawmill at the northern extremity of the study site. Detailed information on the logging history of Tumoulin Forest Reserve is not available, but the Tumoulin Forest as a whole has a chequered history of heavy logging involving a variety of timber species (Toohey 1991). The sawmill extracted trees selected by Queensland Department of Agriculture Fisheries and Forestry rangers under the guidelines of The Forestry Act 1959. However, in the early 1990s, when observations on the gliders commenced Alfie Morris, Forest Ranger based in Ravenshoe, in liaison with Jane Blackwood arranged an unofficial ban on logging within the study site. The sawmill closed in or about 2000 and logging was no longer an option when the area was converted to Forest Reserve in 2010. The study area is known to support a population of Yellow-bellied Gliders with 32 sap-trees having been documented within it (see Results). It comprises moist to wet, tall sclerophyll forest at 1,050 to 1,100 m above sea level (ASL) with *E. resinifera* a frequent component. It is mapped as a mix of Regional Ecosystems 7.12.22a and 7.12.21a with more of the former and a smaller area of 7.8.8a (Table 1).

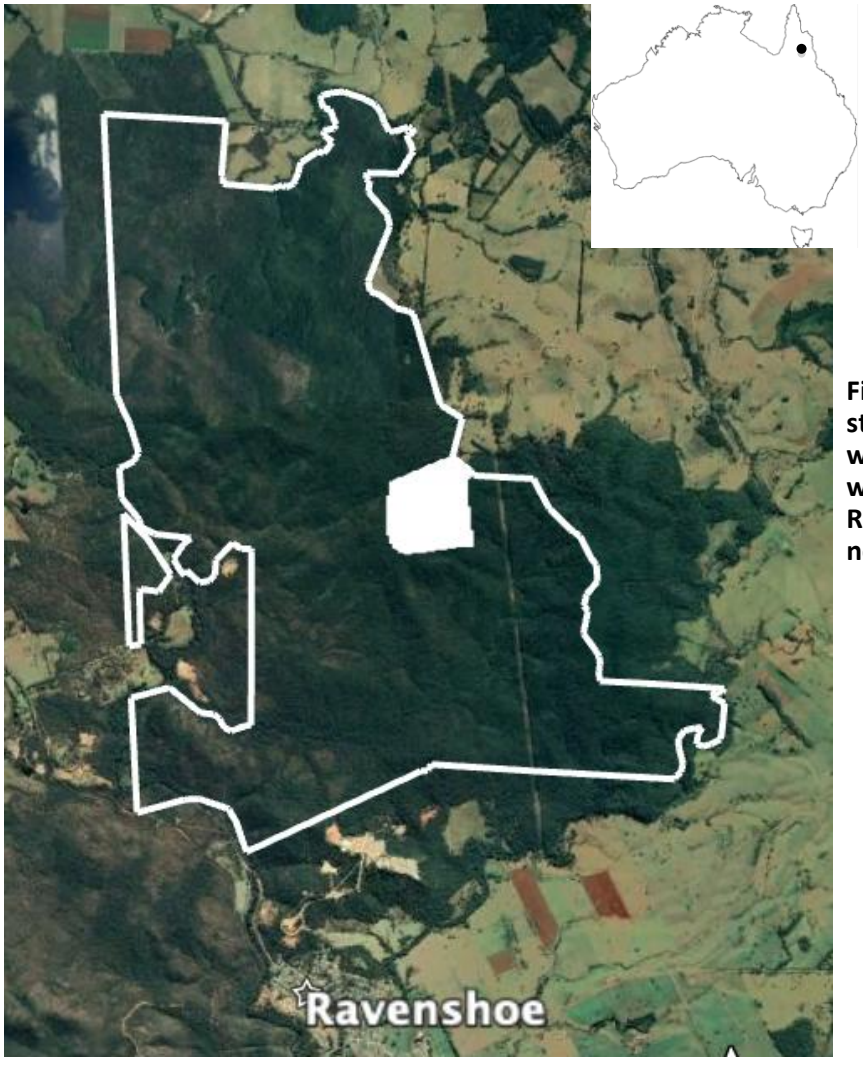

Figure 3. Sawmill Gully study site (shaded white) on Smith Rd within Tumoulin Forest Reserve (white outline) north of Ravenshoe.

Table 1. Mapped regional ecosystems (REs)* in the Sawmill Gully study area.

RE number	Description (DEHP 2016)	Geology
7.12.22a	"*Eucalyptus resinifera*, *Eucalyptus acmenoides*, *Corymbia intermedia*, *Eucalyptus cloeziana*, *Syncarpia glomulifera* tall open forest to tall woodland with *Allocasuarina torulosa* and *Callitris macleayana*. Uplands and highlands of the moist rainfall zone."	rhyolite – Glen Gordon Volcanics
7.12.21a	"*Eucalyptus grandis* tall open forest and woodland."	rhyolite – Glen Gordon Volcanics
7.8.8a	"*Eucalyptus tereticornis*, *Corymbia intermedia*, *E. reducta*, *Angophora floribunda* tall open forest and tall woodland with *Allocasuarina torulosa*. Uplands and highlands ... of the moist rainfall zone"	basaltic colluvium ("krasnozem and prairie soils" [DEHP 2016])

* from Queensland Globe, *https://qldglobe.information.qld.gov.au/*, viewed 12 Sept. 2019

In north Queensland, *Eucalyptus resinifera* is an upright, single-trunked tree to 45 m tall confined to a narrow band in the ranges mostly above 600 m ASL and with high rainfall (though not in rainforest) (DC Franklin unpublished). It occurs on a variety of geological substrates where soils are well-developed. Its bark is fibrous and furrowed becoming slabby on older trees, being reddish or red-brown or grey-brown with red-brown underbark. With straight trunks and high quality timber, *E. resinifera* is a preferred species for logging (e.g. Hornburg *et al.* 2012).

Field methods

The size profile of *E. resinifera* was determined in April 2012 by measuring the diameter at breast height (DBH) with a DBH tape of 400 live trees (including saplings) arranged in 20 zig-zag transects (McDonald *et al.* 1998) of 20 trees each. Starting points for transects were spread widely through the study area where there was an abundance of *E. resinifera*. For each transect, a compass bearing corresponding with abundant *E. resinifera* was selected to establish a centre line for the transect. The nearest *E. resinifera* on or on either side of the transect line was first chosen for measurement, then the next nearest was chosen that was on or on the opposite side of the line and measured, the process being repeated until 20 trees had been measured.

Over many years, sap-trees used by Yellow-bellied Gliders throughout their north Queensland range have been searched for by Queensland Parks and Wildlife Service and volunteers contributing to the monitoring and management of the taxon (John Winter unpublished data). More intensive monitoring of sap-trees within Sawmill Gully commenced in 1991 and throughout the rest of Tumoulin Forest Reserve in 2010 (Jane Blackwood and John Winter unpublished data). When found, sap-trees were geolocated (usually with a GPS), their DBH measured, and the records databased.

Data analysis

The 32 sap-trees used by Yellow-bellied Gliders in the Sawmill Gully study area were extracted from the Wet Tropics sap-tree database for comparison of diameters with the 400 trees measured along transects. To compare median diameters, we used the non-parametric Mann-Whitney U-test. To compare cumulative frequency distributions of diameters, we used the Kolmogorov-Smirnov test, which is also non-parametric and thus not dependent on the data being normally distributed.

Results

Most *Eucalyptus resinifera* trees (96.25%) in the Sawmill Gully area were less than 80 cm diameter, and 34% were less than 30 cm with an abundance of young saplings (Fig. 4). In contrast, no sap-tree (all of which were *E. resinifera*) was less than 30 cm diameter. Just over 40% of sap-trees were in the 60-70 cm diameter range. The median diameter of sap-trees was 53% greater than that of transect trees (Table 2), the difference being highly significant ($U = 2802$, $P << 0.001$). The two sets also differed significantly in their cumulative frequency distribution ($P < 0.001$). These trends remained the

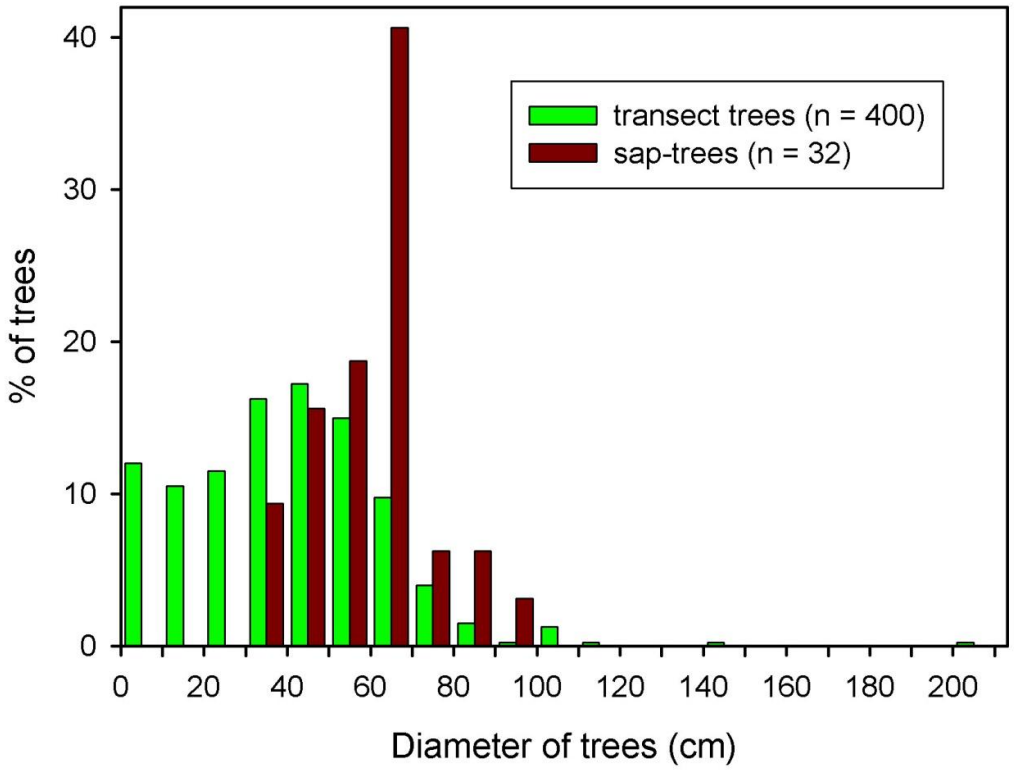

Figure 4. Size profiles of *Eucalyptus resinifera* in the Sawmill Gully area of Tumoulin Forest Reserve in 10 cm diameter classes.

Table 2. Summary data (n and diameter) of *Eucalyptus resinifera* trees in the Sawmill Gully area of Tumoulin Forest Reserve.

Parameter	Transect trees	Sap-trees	Transect trees sub-set*
n	400	32	256
minimum (cm)	2	35	30.5
maximum (cm)	210	91.5	94
mean (cm)	40.6	60.4	51.1
median (cm)	40	61.25	49.75
10^{th} percentile (cm)	9	43	35
90^{th} percentile (cm)	68.25	73	70

* 30–100 cm diameter

same though weaker when only those transect trees in the diameter range of 30-100 cm (the observed size class range of sap-trees) were included in the comparison (Table 2, Fig. 5), the median diameter of sap-trees being 23% larger than that of transect trees (difference: U = 2546, P < 0.001) and their cumulative frequency distributions also differing (P < 0.005).

Discussion

The forest in Sawmill Gully has the hallmarks of one recovering from heavy logging, which ceased about 30 years ago, having an abundance of trees in all size classes up to 70 cm diameter including saplings, and very few large (old) trees (one with a diameter of over 2 m). It is to be expected that loggers will prefer moderate to large trees for the volume and size of timber they yield, and in

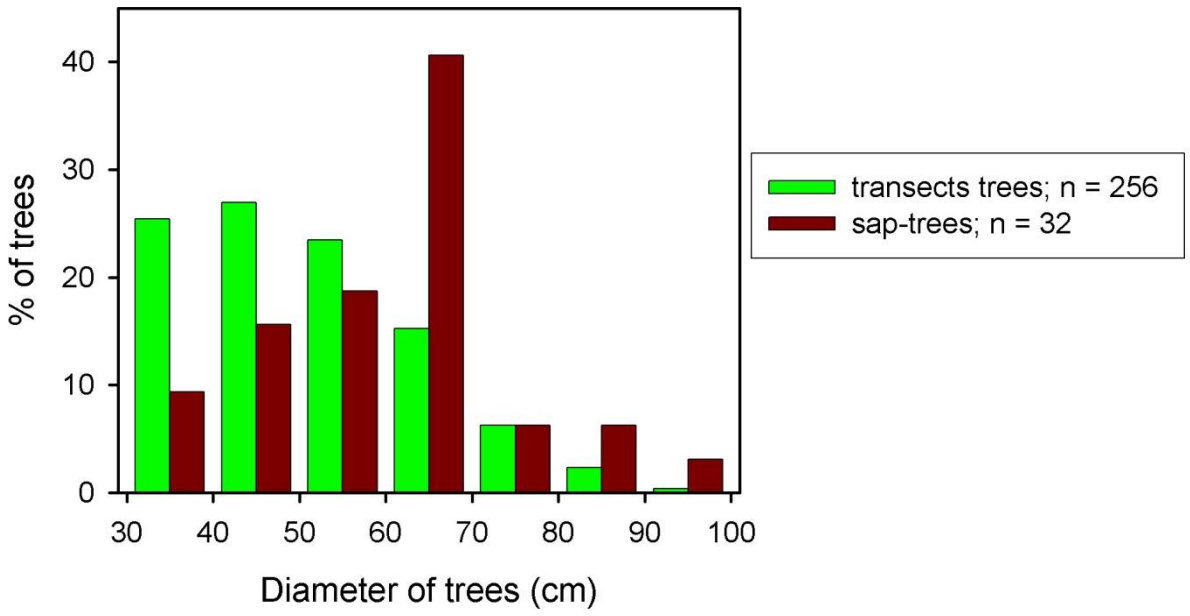

Figure 5. Size profiles of *Eucalyptus resinifera* in the Sawmill Gully area of the Tumoulin Forest Reserve in 10 cm diameter classes with transect trees restricted to diameter classes represented among sap-trees.

montane wet sclerophyll forest in northern New South Wales stand-average tree diameters were negatively correlated with the intensity of logging (McLean *et al.* 2015). It is unclear why the few large trees remain in Sawmill Gully; they might have been defective for timber production, or could have been left as habitat trees. In forest at Nitchaga Creek, which is 30 km to the south and also has a history of logging, Goldingay and Quin (2004) found that *E. resinifera* more than 5 m tall had an average diameter of 50.2 cm; this appears similar to diameters found in this study.

With an average diameter of 60.4 cm, the sap-trees used by Yellow-bellied Gliders in the Sawmill Gully area were smaller than those (also all *E. resinifera*) at Nitchaga (80.5 cm; Goldingay & Quin 2004) and the Mt Baldy Forest 30 km to the north of Sawmill Gully (76.6 cm; Bradford & Harrington 1999), but larger than *E. resinifera* sap-trees in south-east Queensland (50.9 cm; Eyre & Goldingay 2005). Relative to the proportions of available *E. resinifera*, Yellow-bellied Gliders showed a strong preference in Sawmill Gully for sap-trees larger than 60 cm diameter, a resource that is relatively scarce. Preference by the gliders for larger sap-trees than the average available is well documented (Kavanagh 1987; Goldingay & Quin 2004; Eyre & Goldingay 2005).

In any forest occupied by Yellow-bellied Gliders, only about 1% of available trees are used by them to obtain sap (Goldingay 1987; Bradford & Harrington 1999) but the few that are used are used persistently (Quin *et al.* 1996). Gliders make 'test' cuts on a wider range of trees than are used (Goldingay 2000). Sap-trees have higher sap-flow rates than non-sap trees (Goldingay 1987), grow on more fertile and productive sites (Kavanagh 1987; Eyre & Goldingay 2003), and may be the most vigorous trees in a stand (Craig 1985; Mackowski 1988). This evidence, along with preference for trees larger than 60 cm diameter in Sawmill Gully, suggests that trees that are optimal for extraction of sap are scarce. With time, regrowth of the Sawmill Gully forest will likely lead to recruitment of more trees into larger size classes, improving sap-feeding options for the gliders. Conversely, further logging risks depleting options for them and this is, we believe, a valid argument for long-term exclusion of logging from the Tumoulin Forest Reserve. The argument may be elucidated by improvement to our still-limited understanding of selection of sap-trees by Yellow-bellied Gliders.

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