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Short note

The influence of cattle grazing on tree mortality after drought in savanna woodland in north Queensland

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Abstract Live and dead trees were measured in macropod-grazed and cattle-grazed *Eucalyptus* woodland in north Queensland following a severe drought between 1992 and 1994. ANCOVA revealed no effect of grazing treatment on the proportion of drought death. Twenty-seven per cent of all tree species were killed by the drought and the value ranged from about 4% for *Corymbia dallachiana* (Benth.), K.D.Hill & L.A.S.Johnson to 29% for the dominant species *Eucalyptus xanthoclada* Brooker and A.R.Bean, although differences were non-significant. There was also no significant difference in mortality between poles (<10 cm d.b.h.) and trees (>10 cm d.b.h.). The study highlights a natural (as in pre-European), catastrophic structural collapse of tropical eucalypt woodland. Presumably the dramatic declines in basal area as a result of drought are recovered during successive relatively wet years by thickening events, although clearly this severe drought and its after-effects warrant further study.

Key words: dieback, drought, *Eucalyptus*, grazing, savanna woodland, tropics.

> On the plain we observed that more than half the box trees had died within the last three years, and that they had not been killed by bush fires, as the old timber which lay on the ground was not scorched.
>
> A. C. Gregory, 11 November 1856 in the vicinity of the Peak Range, central Queensland (Gregory 1884).

INTRODUCTION

The effect of drought on native vegetation has been exploited as a means of studying the differential moisture tolerance of plant species in temperate Australia (Pook *et al.* 1966; Ashton *et al.* 1975; Hnatiuk & Hopkins 1980; Kirkpatrick & Marks 1985). The effect of prolonged drought on vegetation in the Australian tropics has not been quantified. Eucalypt woodlands throughout large areas of northern Australia have supported herds of cattle (mostly *Bos indicus*) since European settlement. Cattle grazing reduces ground cover, and lower ground cover decreases water infiltration (Gifford & Hawkins 1978; Johns *et al.* 1984). Thus, grazing may reduce the amount of water reaching the root zone of trees. Alternatively, grazing may increase available moisture by reducing competition from the herbaceous layer, as suggested by established models of tree–grass coexistence in savanna (see Jeltsch *et al.* 1996 for references).

Areas that have been long ungrazed by cattle are rare, and opportunities to test the impact of grazing on tree densities and death are limited. However, a lava flow in north Queensland protects areas of savanna woodland from cattle and provides a unique opportunity for comparison (Fensham & Skull in press). After the drought of 1992–94 I compared tree densities and death, between cattle-grazed and macropod-grazed grassy eucalypt woodland. Specifically I investigated whether: (i) cattle grazing exacerbates drought death of trees; (ii) drought death preferentially affects individual species of trees; (iii) drought death preferentially affects individual size classes.

METHODS

Study area

Sites were located in and around a large basalt lava flow, the Great Basalt Wall, 70 km WNW of Charters Towers (20°00′S 145°20′E). This study area is more fully described in Fensham and Skull (in press). Eleven sites were chosen where cattle had grazing access. Five sites were in 'pockets' of woodland that were inaccessible to cattle. Common wallaroos (*Macropus robustus*) were able to cross the lava and graze the woodland throughout the study area. All sites were evergreen, savanna woodland dominated by *Eucalyptus xanthoclada* Brooker and A.R.Bean on ferrosols, with less than 5% surface rock cover formed on deeply weathered Tertiary basalt substrate.

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Rainfall records from 1881 were obtained from Charters Towers where the mean annual rainfall is 658 mm (Clewett *et al.* 1994). The 1992–1994 drought is the most severe over its duration, although droughts between 1897–1905 and 1931–35 extended over longer periods.

Field methods

Sampling was conducted during April 1995. At each site, eight 20 × 10 m plots were located at 50 step intervals along a random compass bearing. In each plot the diameter at breast height (d.b.h.) of all live and dead trees with height (H) greater than 2 m were measured. Tree death was assumed where no live shoots were evident and where bark was peeling away from the trunk. Dead trees without bark were not measured.

Table 1. ANCOVA comparing mortality between (a) grazing treatment, tree species and their interaction with pre-drought basal area as the covariate; and (b) species and size-class with pre-drought stem density as the covariate

Source of variation	df	*F*	*P*
(a) Grazing × species			
Grazing	1, 26	2.74	0.110
Species	1, 26	0.00	0.961
Basal area	1, 26	0.60	0.446
Grazing × species	1, 26	0.77	0.387
(b) Species × size class			
Species	1, 26	1.88	0.177
Size class	1, 26	1.04	0.314
Stem density	1, 26	2.41	0.127
Species × size class	1, 26	0.77	0.861

Analytical methods

The data were tabulated according to four species categories *E. xanthoclada*, *Corymbia erythrophloia* (Blakely) K.D.Hill & L.A.S.Johnson and *Corymbia dallachiana* (Benth.), K.D.Hill & L.A.S.Johnson and 'other species'. Trees were allocated into two girth classes: poles (≤10 cm d.b.h.) and trees (>10 cm d.b.h.). Multi-stemmed trees were treated as one individual and assigned to the class of the largest stem. Mean values across plots for each site were used as the unit of analysis. ANCOVA, within the Generalized Linear Model (GLM) procedure that caters for unbalanced designs, was employed to analyse treatment effects after arcsine transformation of the dependent variable. The first test examined the effect of grazing treatment (macropod-grazed *vs* cattle-grazed) and species (the dominant *Eucalyptus xanthoclada vs* the sub-dominant *Corymbia erythrophloia*) and their interaction on mortality (the proportion of dead tree basal area compared to live and dead basal area) with total basal area as a covariate. The second test examined the effect of species (*E. xanthoclada vs C. erythrophloia*) and size class (poles *vs* trees) and their interaction on mortality where total stem density was the covariate. When a size class of a species category was not present at a site it was assigned a missing value.

Table 2. Summary of mean (SE) dead trees and mortality for individual species and species groups according to (a) basal area; (b) <10 cm DBH stems; and (c) >10 cm DBH stems

	Macropod-grazed (n = 5)		Cattle grazed (n = 11)	
	Dead trees	Mortality (%)	Dead trees	Mortality (%)
(a) Basal area ($m^2.ha^{-1}$)				
Eucalyptus xanthoclada	16.93 (8.58)	25.8 (13.0)	13.10 (3.05)	29.7 (5.7)
Corymbia erythrophloia	0.00 (0.00)	0.0 (0.0)	0.96 (0.54)	24.3 (8.9)
Corymbia dallachiana	0.21 (0.11)	10.3 (6.9)	0.02 (0.02)	1.5 (1.1)
Other species	0.97 (0.79)	17.9 (12.0)	0.03 (0.03)	25.0 (15.1)
(b) <10 cm DBH stems ha^{-1}				
Eucalyptus xanthoclada	1.25 (1.25)	8.3 (7.5)	21.59 (14.11)	27.4 (10.2)
Corymbia erythrophloia	0.00 (0.00)	0.0 (0.0)	11.93 (4.57)	42.4 (10.6)
Corymbia dallachiana	2.50 (1.53)	50.0 (25.9)	1.14 (0.76)	4.7 (2.8)
Other species	11.25 (6.96)	8.6 (4.2)	1.14 (1.14)	25.0 (15.1)
(c) >10 cm DBH stems ha^{-1}				
Eucalyptus xanthoclada	10.00 (8.52)	9.0 (7.1)	32.39 (17.87)	23.5 (8.1)
Corymbia erythrophloia	0.00 (0.00)	0.0 (0.0)	4.55 (2.81)	27.3 (11.1)
Corymbia dallachiana	1.20 (1.25)	12.5 (11.2)	0.00 (0.00)	0.0 (0.0)
Other species	3.75 (3.75)	25.0 (22.4)	0.00 (0.00)	Void

Mortality is calculated so that a species missing from a site has a missing value and not a zero value.

RESULTS

There were no significant effects of grazing and tree species, or their interaction, on mortality as a result of drought death (Table 1). There were also no significant effects of species, size class or their interaction on the mortality of stems (Table 1). There was no effect of the covariates original basal area or stem density on mortality (Table 1).

Table 2 presents the basal area values and mortality according to species and grazing category. Drought reduced total basal area by 27%. This varied between 28% for the dominant species *E. xanthoclada*, 16% for the sub-dominant *C. erythrophloia* and 4% for the relatively infrequent *C. dallachiana*.

DISCUSSION

Drought had reduced tree basal area by more than a quarter in the grassy *E. xanthoclada* woodlands of the Great Basalt Wall. This may be a conservative estimate of mortality, because many of the trees that were recorded as live during this study had entirely lost their crown foliage and may not survive. The impact of the drought occurred regardless of pre-drought tree density or basal area and grazing effects. This study cannot rule out the possibility that heavy grazing by cattle affects drought mortality because the grazing treatment only covered from light to moderate utilization. It is also possible that grazing has a greater impact on the moisture status of soils with poorer structure than the ferrosols at the Great Basalt Wall. However, this study demonstrated that considerable mortality can occur as a result of drought in tropical eucalypt woodland regardless of cattle grazing. Gregory (1884) observed tree mortality prior to settlement which was probably the legacy of a drought event.

Mortality for the three dominant species varied considerably (Table 2), although differences were not significant. Drought had no preferential effect on pole-sized trees compared to larger trees, a result that contradicts the findings of Scholes (1985) from African savanna. For those parts of the tropics without high rainfall or a reliable wet season, dieback appears to be a natural catastrophic mortality event. It is probable that the decline in basal area after drought is matched by a thickening during relatively wet periods. Clearly the extent of the collapse in tropical woodlands as a result of the recent drought and the effects on ecosystem dynamics warrant further study.

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