TREE DENSITY EFFECTS ON YIELDS OF HERBAGE AND TREE COMPONENTS IN SOUTH WEST QUEENSLAND MULGA (*ACACIA ANEURA* F. MUELL.) SCRUB

I. F. BEALE*

ABSTRACT

The effect of tree density on total tree basal area and yields of tree foliage, tree litter and herbage were investigated at two sites in the south western Queensland mulga zone. Reduction in tree density increased herbage yield, but decreased tree foliage and litter yields, and total tree basal area. Relations are shown between herbage yield and total tree basal area. Some community management factors are discussed.

INTRODUCTION

The mulga (*Acacia aneura* F. Muell.) association in Australia occurs as a major component of about 492 million hectares, defined as Acacia Low Woodland Type by Perry (1970a). Some 22 million hectares of south west Queensland support mulga. This tree is used as supplementary feed for sheep and cattle in drought periods. Though this practice has been followed for many years (since 1886—Everist, 1949), little has been done to quantify the effect of tree management on the ecosystem (e.g. Wilcox, 1960, Perry, 1970b).

Tree characteristics have been expressed in various ways and related to herbage production for other communities. Tree basal area has been used by some (e.g. Gaines, Campbell and Brassington, 1954; McConnell and Smith, 1965; Jameson, 1967; Clary, 1969). Others have used tree canopy cover (e.g. Ehrenrich and Crosby, 1960; Pond 1961; McConnell and Smith 1965, 1970; Jameson 1967). Walker, Moore and Robertson, (1972) have used a quantity derived from tree and shrub biomass, designated percentage thinning, and related this to herbage yield in southern Queensland *Eucalyptus populnea* communities.

The mathematical relations proposed by these workers to describe such community inter-relations are varied, but all agree with the generalisation of Halls (1970) that herbage production is inversely related to tree density.

Wilcox (1960) reported yields of tree litter for a mulga community in Western Australia. Leaf (phyllode) and seedpod production did not exceed 60 lb/ac (53 gm/m^2), with seed production less than 2 lb/ac (0.18 gm/m^2). Workers in other communities have derived relations between tree litter and herbage production (e.g. Gaines, Campbell and Brassington, 1954; Pase, 1958), but the quantities of litter involved are much greater than those reported by Wilcox (1960). Litter yields given by Bray and and Gorham (1964) are also much larger. Slatyer (1972) noted that woody perennials tend to shed most leaves when new growth is commenced after water stress is removed. Wilcox (1960) previously observed that this occurs with mulga.

Everist (1949) mentioned the need for estimation of the growth rates of edible portions of the mulga tree. Burrows and Beale (1970) found that leaf weight is related to stem circumference, and this relation could be used to estimate community leaf yields.

This paper summarises results of studies in south west Queensland aimed at evaluating the effect of different mulga tree densities on productivity of the plant communities.

* Department of Primary Industries, Charleville Pastoral Laboratory, Charleville, Queensland 4470. Present address: 233 Braiden Hall, C.S.V., Fort Collins, Colorado, U.S.A.

MATERIALS AND METHODS

Two experiment sites were established, the first 140 km south-east of Charleville (Boatman site), and the second 110 km west of Charleville (Monamby site). Soils are red to red-brown fine sandy loams to loams (Isbell et al 1967). Topography is gently undulating.

Tree populations initially were 5570/ha at Boatman and 1946/ha at Monamby. The latter site had, in addition, a population of low woody shrubs (*Eremophila* spp.).

Mean rainfall is 460 mm for Boatman, and 380 mm for Monamby. The closest rainfall recording sites to the plots were approximately 10 km distant.

Tree populations were thinned in 1963 at Boatman and 1965 at Monamby. At both sites, experimental design was a randomized block of three tree thinning treatments (40, 160 and 640 trees per ha), with seven replications. Plot size was 0.4 ha at Boatman, and slightly larger at Monamby due to the includion of 11 m borders around the 0.4 ha experimental areas. Trees were located by grid, marked and the excess felled. Debris was left on the plots. In each plot 16 trees were randomly selected for stem measurements, initially diameter but since 1968 circumference, taken at 30cm above ground level with a flexible steel tape.

Stem circumference was used to estimate the amount of leaf per tree in the manner of Burrows and Beale (1970), using a revised set of estimation tables provided by M. L. Dudzinski (1970, pers. comm.). Basal areas were calculated from stem measurements by assuming circular trunk sections.

Tree litter yields were calculated from collections in 10 bins per plot, located randomly along one diagonal. Collection area was 0.56 m^2/ha. The bins were emptied every 12 months, and the material dried and weighed.

Sampling sites for herbage yield were located by randomised grid techniques. Initially 10 quadrats (0.4 m^2) were taken per plot, but since 1971 ranked-set sampling (Halls and Dell, 1966) has been used, with 4 sets per plot (12 quadrats). Sampling intervals were approximately 3 months till 1970, when harvests were approximately monthly. Herbage samples since 1969 were sorted into component species. Species present included *Aristida* spp., *Neurachne mitchelliana*, *Danthonia bipartita*, *Digitaria* spp., *Sida* spp., *Trachymene* spp., *Halorrhagis ondontocarpa* and *Cheilanthes sieberi*.

RESULTS AND DISCUSSION

Both Boatman and Monamby sites showed the effect of tree density on foliage reserve, yield increasing with greater tree density, and also with time, for all densities (Table 1). However, yields per tree were greatest in the least dense treatments.

Lower tree foliage yields were indicative of smaller trees. Increases in tree size after thinning were reported by Benzie and Cross (1959), and Della-Bianca (1969). Everist (1949) implied that this effect of scrub density on mulga tree size could be observed in the field.

Tree litter yields were much more variable with season than were those for foliage (Figure 1), though higher yields were usually associated with more dense tree stands. Bray and Gorham (1964) mentioned such variations in litter yield between seasons. Slatyer (1972) noted that woody perennials tend to shed litter after water stress is removed, and this effect in mulga (also observed by Wilcox 1960) may be influential in the variation in litter yields from season to season. This could not be confirmed here as litter yields were estimated annually. Litter production at Monamby was comparable with that reported by Wilcox (1960) in Western Australia, with Boatman yields generally larger.

Herbage yields responded in the manner reported by Jameson (1967) being inversely related to tree density, with the lower tree density treatments producing sig-

TABLE 1
Effect of tree density on foliage yields per tree

	Foliage per tree (g)			F Value	Necess. diff for signif.	
	Trees per ha					
	40	160	640		5%	1%
Boatman						
1966	3741	3041	2268	12.29**	648	908
1967	4188	3501	2481	20.69**	582	815
1968	4745	3919	2781	27.20**	582	817
1969	5291	4415	3107	35.58**	568	796
1970	5391	4536	3172	42.31**	530	743
1971	5970	5020	3640	43.19**	811	1110
Monamby						
1966	2341	2176	2087	0.56	N.S.	N.S.
1970	4044	3842	2954	9.69**	574	805
1971	4480	4230	3260	11.47**	863	1182

** $P < 0.01$.

nificantly more herbage (Figure 2). At a number of harvests at both sites, herbage yields from 40 and 160 tree/ha plots were not significantly different. Herbage response to season was also marked. A peak yield of 203 gm/m² was obtained in the summer of 1971 at Boatman. This is higher than that reported for native pastures in the mulga zone by Ebersohn (1970).

Total tree basal area integrates both tree number and size, and is one measure of the effect of tree canopy cover on understorey components (Perry, Sellars and Blanchard, 1969; Anderson, Loucks and Swain, 1969). Total tree basal areas and yearly increases are shown in Figure 3. It is evident that a range of basal areas are encountered, even though plots were thinned initially to similar tree densities in each treatment replicate. The largest area (6.6 m²/ha) is in contrast with 215 sq ft/ac (49.5 m²/ha) for ponderosa pine (Pase, 1958).

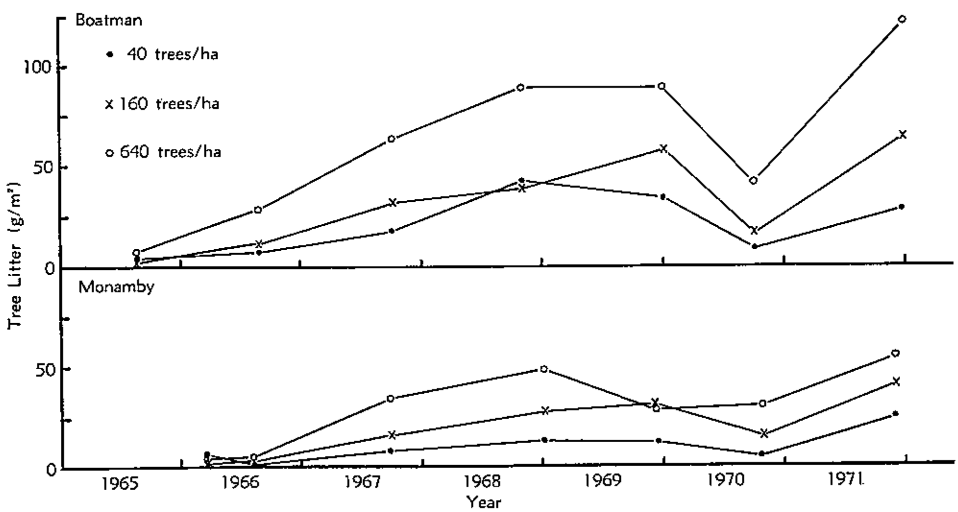

FIGURE 1
Tree litter yields (g/m²)

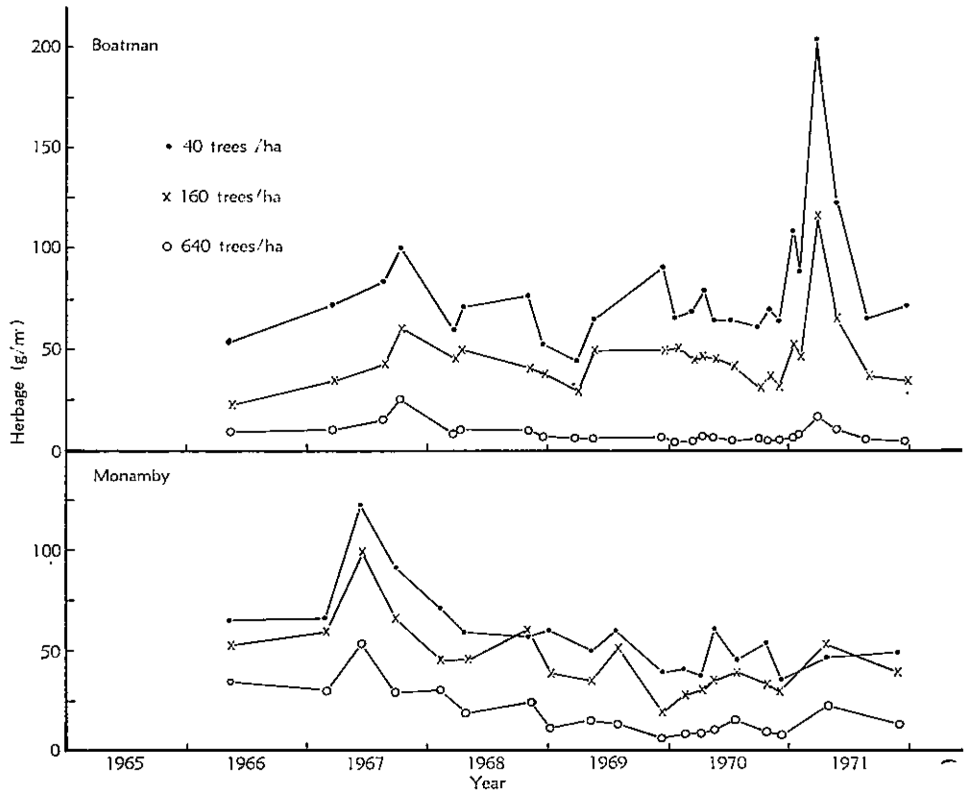

FIGURE 2
Herbage yields (g/m^2)

The relation between tree basal area and herbage yield has been examined for both mulga sites (using data from occasions when both yields and tree measurements were made at the same time). Relations of the form $Y = A + BR^X$ (X = tree basal area, m^2/ha; Y = herbage yield, gm/m^2; A, B, R = coefficients) for four sampling times are shown in Figure 4, and their coefficient values are given in Table 2, with their standard deviations.

Curvilinear relations were also shown between herbage yield and tree basal area by Pearson (1964), Jameson (1967) and Clary (1969). Walker, Moore and Robertson (1972) found similar responses of herbage yield to percentage thinning (based on plant biomass) in *Eucalyptus populnea* communities. They showed different responses to time of year and to rainfall. The data used in Figure 4 were all obtained in early summer. Thus the different lines were probably in response to seasonal conditions, but the lack of accurate rainfall records makes confirmation of this difficult.

As noted previously, total tree basal area at these two sites was low in comparison with other forests. From Figure 4, it is evident that small increases in tree basal area reduce herbage yield, with the rate of reduction greatest in the range of 0 m^2/ha to 1.5 m^2/ha. Trees in the 40 tree/ha plots have shown growth in this range since 1966 (Figure 3).

Pearson (1964) noted that management of timbered country is a compromise. For forestry, the aim is maximum timber yield; for grazing use, maximised grass yield necessitates removal of trees. While the former case does not apply to mulga as com-

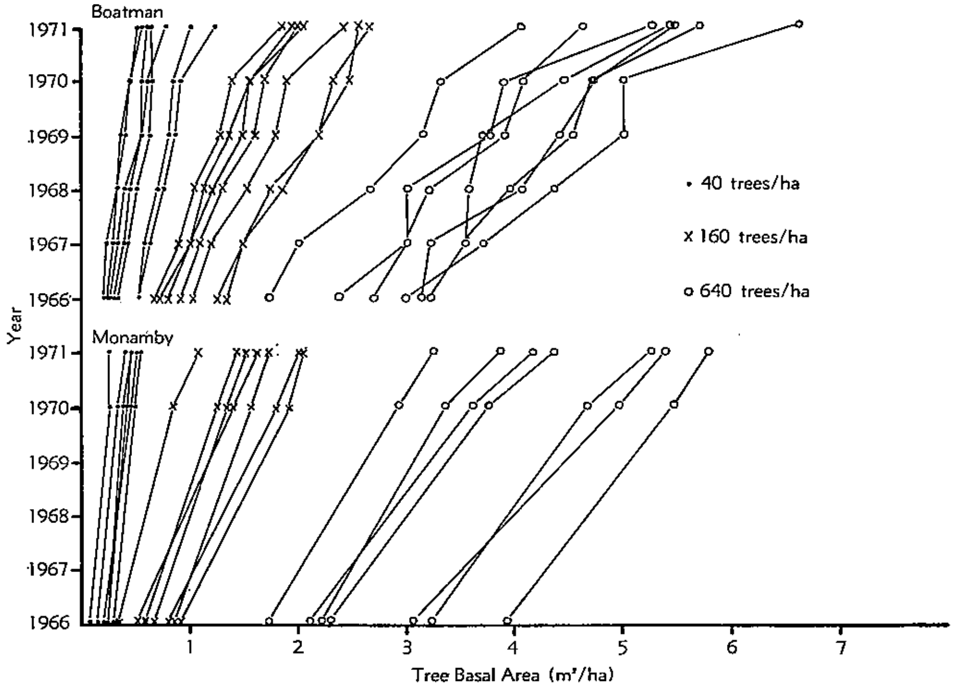

FIGURE 3
Tree basal area change with time.

TABLE 2
Coefficients for the relation between herbage yield (gm/m²) and tree basal area (m²/ha) at Boatman and Monamby sites

Site	A	B	R	F Value
	Coefficients			
Boatman 1967	4.86 (24.81)*	123.47 (19.24)	0.531 (0.192)	25.20**
Boatman 1969	−0.339 (13.048)	138.610 (16.58)	0.511 (0.126)	40.20**
Boatman 1970	−1.485 (14.349)	86.378 (12.686)	0.579 (0.174)	23.18**
Monamby 1970	5.279 (11.455)	70.079 (15.009)	0.461 (0.227)	11.83**
Composite of Boatman (1967, 1969, 1970) and Monamby 1970	0.363 (9.478)	104.86 (8.836)	0.546 (0.098)	70.54**

* Figures in brackets are standard deviations of the coefficients.
** $P < 0.01$.

mercial timber, it can be equated with drought fodder production. Management of such shrubs is complicated by a lack of quantitative data on the role of browse and herbage in the nutrition of animals in the region (domestic and native). Wilson (1969) concluded that browse does not play an important role in animal production, but this has not been confirmed for mulga.

The rapid drop in herbage production with basal area increases in the range 0-1.5 m²/ha (Figure 4) suggests that where grass production is important, severe reductions in basal area of trees are necessary to maintain this production—i.e. almost complete clearing. Walker, Moore and Robertson (1972) showed maximum production at about 6 mature trees/ha, and up to 360 shrubs/ha. They do not mention the effect of woody plant growth on herbage production. The rate of increase in basal area at Boatman and Monamby has been fairly rapid since 1966 (Figure 4), which suggests that for sustained maximum herbage yield, tree density should be kept low.

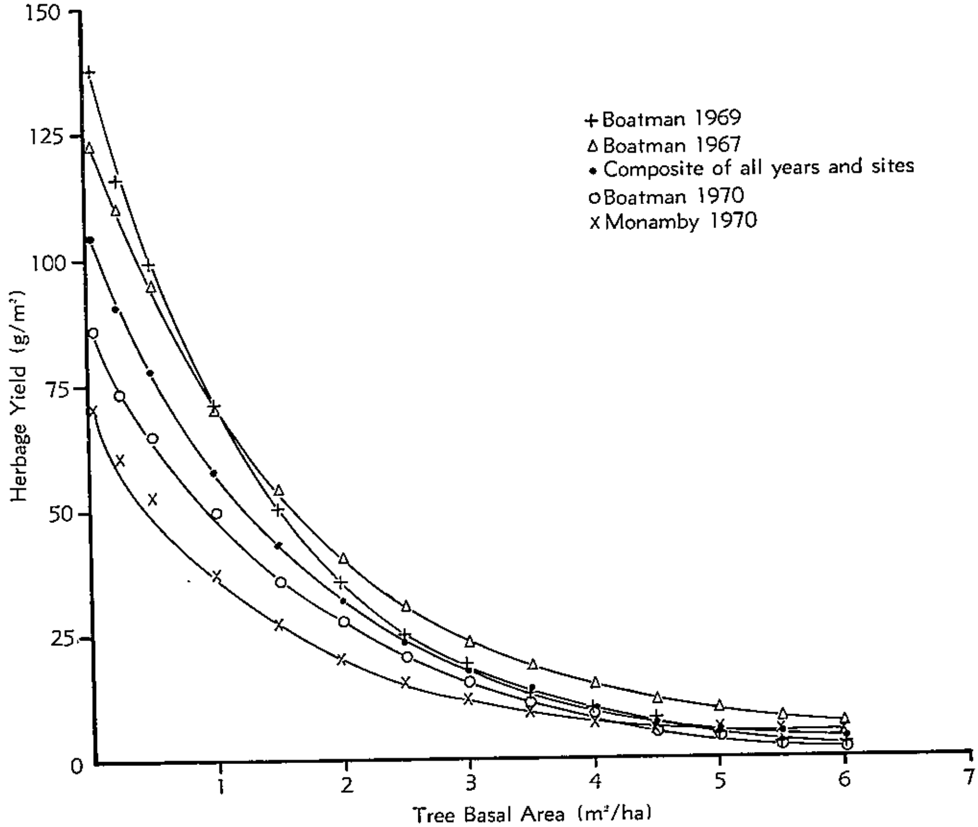

FIGURE 4

Relation between herbage yield (g/m²) and tree basal area (m²/ha).

Clearing of mulga scrubs for drought feeding, and then managing for grass production may be worthwhile in terms of animal production. Management problems include the potential regrowth of woody weeds and maintenance of pasture species. Everist (1949) suggested that grazing manipulation affects mulga regrowth. Other woody species were not so affected, and Moore (1969) suggested that fire may be a useful tool in their control, though he noted difficulty in obtaining sufficient fuel on degraded ranges. Grazing management can have a large influence on such range degradation, so establishing criteria for long-term stability is necessary.

The relation between tree density and leaf yield (Table 1) shows that the drastic thinning necessary for maximum pasture yield greatly reduces the amount of leaf available. Thus management for such yield for drought supplementation involves maintaining high tree densities (and consequent low herbage production).

This suggests that optimum management of mulga scrublands may involve cleared areas for herbage production, and areas of high tree density reserved for supplementing animals during periods of drought. Such a scheme could help reduce the effect of overgrazing induced by uncontrolled scrub feeding (Christian, 1956). However, evaluation of costs is necessary before such a scheme is undertaken. Long-term research is needed in such areas, to show whether any management practice is sound or just theoretically sound but practically imperfect.

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