GROWTH AND SURVIVAL OF MULGA (*ACACIA ANEURA F. MUELL. EX BENTH*) IN WESTERN NEW SOUTH WALES

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ABSTRACT

Growth and survival of mulga (Acacia aneura) *were monitored at Wanaaring and Cobar in western New South Wales. The effects of rainfall and grazing on the growth of mulga, white cypress pine* (Callitris columellaris) *and turpentine* (Eremophila sturtii) *were also examined at Cobar.*

The mulga population density at Wanaaring fluctuated greatly and there was an overall decrease in tree numbers over 14.6 *years of observation. At Cobar mulga density was little affected by grazing and severe drought. Grazing retarded growth of mulga and white cypress pine but not turpentine.*

Periods of regeneration of mulga occurred at Wanaaring. At Cobar grazing and rainfall did not significantly affect regeneration of mulga, pine and turpentine. Appreciable regeneration of white cypress pine and turpentine, and slight increases in the number of mulga trees occurred.

The practical implications of these findings are discussed.

INTRODUCTION

Mulga is widespread over much of western New South Wales, north of latitude 33°S and west of 147°E longitude. The average annual rainfall of this area falls between 150 and 400 mm. Mulga community development is greatest in the summer dominant rainfall area north of latitude 32°S.

Mulga may occur as dense, almost monospecific stands, or scattered as clumps in other communities dominated by either bimble (poplar) box (*Eucalyptus populnea*), red box (*Eucalyptus intertexta*), ironwood (*Acacia excelsa*) or white cypress pine (*Callitris columellaris*).

On some properties mulga has been harvested for use as fodder and fuel and in structural work. Regeneration was either deliberately or unintentionally prevented. In other areas dense mulga regeneration has occurred during the past 15 to 20 years. These new stands are useful as drought fodder but their density often precludes the growth of grasses and forbs (Anon, 1969).

In the 1940's there was general concern that mulga was dying out in parts of western New South Wales. Earlier, Ratcliffe (1938) came to the same conclusion after his investigations in arid parts of South Australia. Condon (1949) reported widespread mulga death in the West Darling and suggested that work be undertaken to investigate this problem.

As a result, studies to determine the effect of rainfall on the growth and survival of individual mulga trees were commenced at Wanaaring. Later, the effects of rainfall and stocking on growth, survival and regeneration of mulga, white cypress pine and turpentine (*Eremophila sturtii*) were investigated at Cobar. These two sites are representative of the communities in their respective regions and climatic regimes.

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MATERIALS AND METHODS

(a) *Growth increment and population study at Wanaaring*

In order to obtain a measure of growth rate, tree survival and population change, studies were initiated on "Lenroy" Station, 40 km north of Wanaaring. A mantle of siliceous gravel covered the surface of the neutral red earth (Northcote Gn 2.12) at this site which has a slope of ½-1 %.

All trees within the boundaries of a 0.04 hectare plot were tagged in October 1956. The position of each tree was noted and its height measured with a staff to the top of the highest living branch. Heights of all trees within the plot were then measured after 13, 29, 36, 41, 67, 94, 126 and 175 months had elapsed. Regeneration and deaths in the community were noted on each occasion and new seedlings were tagged. Rainfall was also measured in an attempt to relate this to growth and survival. Livestock had unrestricted access.

(b) *Regeneration and growth increment study at Cobar*

The site was a contour furrowed area, with slope of 1-3 %, 12 km south of Cobar. The soil was a shallow, stony, slightly acid dark reddish brown clay loam (Northcote Um 1.43).

Experiment 1

Trees were tagged and heights measured in September 1964 in a mixed community containing mulga, white cypress pine and turpentine seedlings which had been divided into grazed and protected sections 15 months earlier. Homogeneity tests on the height distribution of the grazed and protected populations of all three species when measurement began revealed that although the fit was only fair, it was sufficiently close for comparison.

The grazed section was set stocked as is the practice on most district properties. The grazing rate varied between one sheep per 1.7 to 2.8 hectares.

Heights of plants were again measured in October 1966, June 1969 and March 1972, and average annual height increments calculated. Statistical tests were carried out to determine the degree of association between height increment, grazing and rainfall.

Experiment 2

In order to assess the effects of rainfall and grazing on regeneration, all trees and seedlings in each of four 30.5 metres square plots were tagged and counted in October 1964, October 1966, June 1969 and March 1972. The species present were mulga, pine, turpentine, budda (*Eremophila mitchellii*), spine bush (*Acacia colletioides*) and bimble box.

(c) *Rainfall*

Rainfall data for the Wanaaring site appears in Table 2. Since continuity of the Wanaaring records is poor after 1969, rainfall data from "Lenroy" and adjacent "Mooreland Downs" were used for 1970/71. Pertinent Cobar data are given in text (biii).

RESULTS

(a) *Wanaaring growth increment population study*

(i) *Population dynamics*

The total population consisted of four sub-populations—the original, a second after 29 months, a third after 67 months, and a fourth after 175 months. An overall decrease in the number of trees on the plot occurred despite this subsequent regeneration (Figure 1).

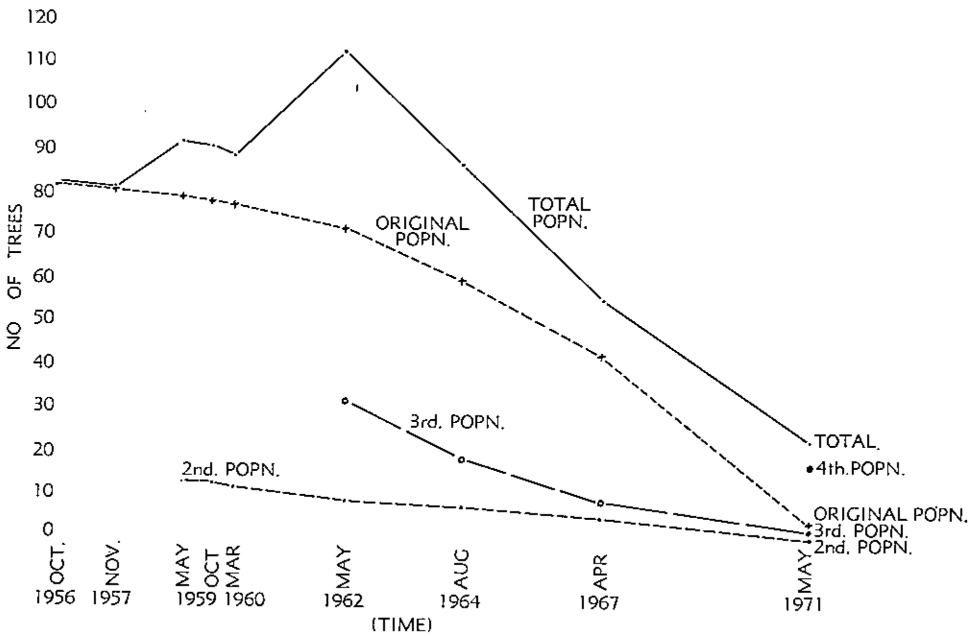

FIGURE 1
Fluctuation in Number of Mulga Trees in Total and Component Populations at "Lenroy", Wanaaring (1956–1971).

Eighty-two trees (2050 trees/hectare) were present originally and after 175 months, 23 trees (575/hectare) remained. A maximum of 113 trees (2825/hectare) was present at 67 months, but of these only 6 survived till 175 months. Four of these were present in 1956.

The major decrease in tree numbers, almost linear with time, began after 67 months and the decrease would have been more drastic but for the appearance of the fairly small fourth population.

(ii) *Survival of trees as related to original height*

Trees were divided into two height classes, those initially less than 1 metre and those initially more than 1 metre.

TABLE 1
Tree deaths in each measurement period, expressed as a percentage of the population in each class at the previous recording—"Lenroy" Wanaaring

(a) *Original population.* Original height class	period (months) 0–13	13–29	29–36	36–41	41–67	67–94	94–126	126–175
< 1 metre	2.04	4.17	2.17	0	6.67	16.67	40.00	85.71
> 1 metre	0	0	0	3.03	6.25	16.67	12.00	95.45

(b) *Total population.* Original height class	period (months) 0–13	13–29	29–36	36–41	41–67	67–94	94–126	126–175
< 1 metre	2.04	2.08	1.69	1.72	0	25.61	44.26	44.12
> 1 metre	0	0	0	3.03	6.25	16.13	11.54	91.30

Original Population

Of the 4 trees which survived the full period, 3 were between 0.41 and 0.60 metres high and one was more than 1 metre high initially. There were highly significant differences between the two height classes in variation in the proportion of deaths over time (Table 1) (X^2 (7d.f.) = 25.21). The greatest variation was in the 94-126 month period, when there was a much higher death rate of the "less than 1 metre" trees than of those initially more than a metre high.

No relationship was found between deaths and rainfall for either height class.

Total Population

The two height groups again varied with respect to death over time (Table 1) (X^2 (7 d.f.) = 50.05). The period 94-126 months was the largest contributor to variation, with a large percentage death in the less than 1 metre class. Again there was no correlation between death and rainfall.

In this total population, 19 of the 23 trees remaining after 175 months were originally less than 1 metre high. This was to be expected, as most trees present at this time belonged to the fourth population of regenerating trees and were thus less than 49 months old.

(iii) *Growth of trees*

TABLE 2

Rainfall and mean height increments in each measuring period—"Lenroy" Wanaaring

time period (months)	mean increment (m)	mean annual increment (m)	rainfall in period (mm)	mean annual rainfall (mm)
0–13	+0.025	+0.023	73	67
13–29	−0.030	−0.023	448	336
29–36	+0.018	+0.031	144	246
36–41	+0.060	+0.045	73	102
41–67	+0.088	+0.041	643	297
67–94	+0.281	+0.125	629	279
94–126	+0.004	+0.002	420	158
126–175	+0.607	+0.149	943	231

A positive height increment occurred in each period except 13-29 months when a decrease in mean height occurred (Table 2).

This decrease was mainly in trees less than 1.20 metres in initial height (48 trees less than 1.20 metres and 4 trees more than 1.20 metres lost height). The mean annual height increment exceeded 0.10 metres only in the periods 67-94 and 126-175 months.

The mean height increment and rainfall were related significantly ($F = 8.42$), with rainfall explaining 58% of the variation in mean increments.

There was considerable variation in height increments between trees within periods. In the 13-29 month period, for example, height increments of trees varied from + 0.74 to — 1.01 metres. No relationship was found between height increment in each period and initial height of trees.

For the total population, the mean monthly height increment in a winter period (29-36 months) was 0.0026 metres, and in a summer period (36-41 months) was 0.012 metres. Mean monthly rainfalls for these periods were 21 mm and 15 mm respectively.

(b) *Growth increment and regeneration study at Cobar*

Experiment 1

(i) *Growth out of sheep grazing range*

TABLE 3

Number of mulga trees on unstocked and (in brackets) stocked plots at four dates at Cobar

Height of trees / Date	0–1 m	1–2 m	2–3 m	3–4 m	4–5 m	5–6 m
September 1964	44 (28)	1 (0)	0 (2)	0 (2)	1 (0)	0 (0)
October 1966	37 (28)	8 (0)	0 (1)	0 (2)	1 (1)	0 (0)
June 1969	22 (23)	16 (2)	6 (3)	1 (0)	0 (4)	1 (0)
March 1972	0 (19)	25 (4)	15 (2)	1 (3)	4 (3)	1 (1)

TABLE 4

Number of pine trees on unstocked and (in brackets) stocked plots at four dates at Cobar

Height of trees / Date	0–1 m	1–2 m	2–3 m	3–4 m	4–5 m
September 1964	18 (11)	3 (0)	0 (0)	0 (0)	0 (0)
October 1966	12 (11)	8 (0)	1 (0)	0 (0)	0 (0)
June 1969	7 (10)	6 (1)	6 (0)	2 (0)	0 (0)
March 1972	3 (6)	7 (3)	6 (2)	1 (0)	4 (0)

TABLE 5

Number of turpentine bushes on unstocked and (in brackets) stocked plots at four dates at Cobar

Height of bushes / Date	0–1 m	1–2 m	2–3 m	3–4 m
September 1964	8 (70)	3 (10)	0 (0)	1 (1)
October 1966	8 (67)	3 (13)	0 (1)	1 (0)
June 1969	5 (46)	6 (33)	0 (3)	1 (0)
March 1972	3 (27)	7 (49)	1 (4)	1 (1)

The most significant aspect of the distributions of the mulga populations was that grazing generally kept the major portion of the population in the classes below 1 metre in height (Table 3). Nevertheless, of the 28 grazed trees which were initially less than 1 metre high (the measured grazing height of sheep), 9 trees managed to increase in height to such an extent that the top of the tree was out of grazing reach of sheep after 7.5 years of observation to March 1972. On the other hand, all of the 44 ungrazed mulgas which were initially less than 1 metre high had attained heights of more than 1 metre by 1972.

Of the 11 grazed pines less than 1 metre high initially, 5 managed to attain heights of more than 1 metre by 1972, whilst 15 of the 18 ungrazed pines initially less than 1 metre high exceeded this height after the same period (Table 4).

Although the turpentine samples differed in size (70 grazed to 8 ungrazed) proportionately the same number of plants in each population (43 to 5) exceeded a height of 1 metre after 7.5 years, indicating that sheep had little effect on plants in the grazed area (Table 5).

(ii) *Height increments over 7.5 years*

The mean annual growth rates of both ungrazed mulga and pine differed significantly at the 5% level (Paired t test; t = —3.78 and —2.98 respectively with 2 d.f.) from those of the grazed plants of these species (Table 6). The difference be-

TABLE 6

Mean and (in brackets) range of annual height increments of trees from September 1964 to March 1972 at Cobar

Species	Height Increment: Grazed	Height Increment: Ungrazed
	m	m
Mulga	0.12 (−0.008 to +0.43)	0.23 (+0.09 to +0.51)
Pine	0.09 (+0.02 to +0.26)	0.22 (+0.05 to +0.56)
Turpentine	0.07 (−0.05 to +0.22)	0.08 (−0.008 to +0.17)

tween the growth increments of ungrazed and grazed turpentine was not significant ($t = -1.00$).

This result confirms that turpentine is little affected by grazing.

Grazing reduced the growth of mulga to 53% of the growth possible under ungrazed conditions, and pine to 39% of growth without grazing. The growth rates of ungrazed mulga and pine were substantially the same; turpentine grew much more slowly and produced only one third of the mean annual height growth of the other two species.

Growth of mulga, pine and turpentine trees was not uniform and a large range of height increments existed. Even under grazed conditions large increments were possible for mulga trees with their tops within reach of sheep (Table 6).

(iii) *Effects of rainfall*

Rainfall between September 1964 - October 1966, October 1966 - June 1969 and June 1969 - March 1972 was 417 mm, 887 mm, and 1024 mm respectively. The first period included the worst drought on record and the second period included a drought of almost equal severity.

The effects of rainfall during the three observation periods on the mean annual growth increments of grazed and ungrazed mulga, pine and turpentine were difficult to isolate statistically. However, some effect of rainfall on height increase was indicated for mulga and pine but little effect on turpentine growth was suggested.

Experiment 2

(iv) *Species regeneration*

TABLE 7

Number of plants of 6 species on 4 regeneration plots at each observation—Cobar

plot number	grazing treatment	observation date	mulga	pine	turpentine	budda	bimble box	spine bush
1	ungrazed	Oct. 1964	19	4	8	—	—	—
		Oct. 1966	19	4	8	—	—	—
		June 1969	19	3	12	—	—	—
		March 1972	21	4	11	—	—	—
2	ungrazed	Oct. 1964	14	4	—	1	—	—
		Oct. 1966	14	4	—	1	—	—
		June 1969	15	7	—	1	—	—
		March 1972	17	29	—	1	—	—
3	grazed	Oct. 1964	22	1	80	2	2	1
		Oct. 1966	22	1	93	5	2	1
		June 1969	23	2	90	2	2	1
		March 1972	24	4	111	7	2	1
4	grazed	Oct. 1964	6	27	2	—	—	—
		Oct. 1966	6	27	2	—	—	—
		June 1969	7	27	2	—	—	—
		March 1972	5	66	5	—	—	—

Pine and turpentine increased considerably on some plots and mulga increased to a lesser extent on three of the four plots (Table 7). Association between regeneration of mulga, pine, turpentine or budda and rainfall was not significant. Grazing and regeneration were not significantly associated for any of these species. The number of bimble box seedlings or spine bushes did not increase.

DISCUSSION

(a) *Wanaaring growth increment and population study*

The high initial number of trees on the study site was most likely due to the favourable seasonal conditions of 1955 and early 1956. The dry period in 1957 caused very few deaths but probably affected the growth of trees in the following period (13-29 months) when most trees initially less than 1.20 metres high lost height. This dieback was most likely due to grazing by sheep superimposed on slow growth in a period of feed scarcity. This is substantiated by the fact that most taller trees (out of reach of sheep) increased in height in the same period. Alternatively, there may have been a chance heavy grazing of the area by sheep or native fauna just prior to the 29 month measurement.

Following the good rainfall of late 1958 and early 1959 a second population of trees became established. In the following two periods there were slight decreases in tree numbers which corresponded with lower mean monthly rainfalls. In the fifth period, following good rainfall in late 1961 and early 1962, the third population became established, boosting tree numbers to the maximum achieved during the trial. Subsequent lower rainfall resulted in tree numbers declining.

The drought of 1964, 1965 and early 1966 took heavy toll of trees. Of the surviving trees from the original population, 40% died in this period and a further large number were severely set back and were recorded at the 126 month measurement as being "sick". Most of these latter trees (39 out of 43) died between 126 and 175 months, with both young and old trees similarly affected. This mass death can be compared to that described by Lange (1966). Following the drought, tree numbers were very low, until good rains stimulated growth of the fourth population.

From the above observations it is evident that regeneration of mulga takes place after periods of good rainfall and when soil is moist for long enough to stimulate germination and soil moisture storage is sufficient for plants to establish. When dry periods return, there is rapid dying off due to competition for moisture and possibly increased grazing pressure. It appears, therefore, that the total population is a fluctuating one, with a tendency to decrease to some unknown low level.

The failure to find a statistical correlation between deaths and rainfall in any period indicates a "delayed reaction" effect of rainfall on survival, whereby trees die back (lose height) in a dry period but may not die until the following measurement period. This effect was most noticeable in the last two measurement periods, where trees lost height between 94 and 126 months but did not die until after the 126 month measurement. Dying back and reshooting was a common feature of the growth of trees, with trees eventually dying after a succession of severe setbacks from dry periods.

Summer growth rates about 4 times that of winter lend support to the observations of Slatyer (1962), who noted that very little growth occurs in the winter.

The highlight of this study was the discovery that the population was a fluctuating but gradually decreasing one with relatively few regeneration periods. Regenerating populations were short-lived due to seasonal conditions and the effects of grazing. The practical implications are that spelling after these periodic regenerations is necessary in this area to enable young plants to take full advantage of the seasonal conditions to become well established and grow beyond sheep grazing height.

(b) *Cobar regeneration and growth increment studies*

Removal of the grazing constraint caused a delayed but marked spread in the distribution of an initially grouped population.

The growth rates of mulga, pine and turpentine were most variable. Large height increases per unit time were not associated with any particular height group. Trees with leaders initially well within the range of grazing sheep made large height gains and extended leaders beyond sheep reach despite heavy grazing and drought. This suggests that mulga populations in the Cobar area (356 mm long-term average annual rainfall) are less vulnerable to destruction by grazing than those in Queensland discussed by Holland and Moore (1962).

Absent at Cobar was the catastrophic mulga death shown at Wanaaring during the 1964-1966 drought and described by Lange (1966). This may be due in part to the contour furrowing on the study site improving the soil moisture regime. However, indications are that it is not the case, since on nearby unfurrowed sections of the same property with similar slopes and soils, death was not prominent amongst regenerating or mature mulga trees during the same period. Also, the density of trees at the Wanaaring study plot was much greater than at Cobar. The increased competition for moisture at the higher tree density and the lower long-term average annual rainfall at Wanaaring (271 mm) probably also affected mulga growth and death. On this basis, catastrophic death, even under heavy stocking, would appear only to be a feature of the more dense stands in the drier parts of the mulga zone of New South Wales.

Regeneration studies at Cobar, although so far of short duration (7.5 years), have revealed that quite marked increases in pine and turpentine and, to a lesser extent, budda and mulga seedlings can occur rapidly, as happened between June 1969 and March 1972 after several good seasons. Regrowth of these less desirable species which are associated with mulga in many areas has caused great concern in the Cobar district. The above results show that the nature of a community may change markedly in a short time and indicate that the transition from a viable grazing enterprise to an uneconomic one can be of short duration.

The effects of grazing on pine were marked—particularly during feed stress periods. Nevertheless, almost 50% of the pines with leaders initially within reach of sheep managed to grow to above this height during the observation period.

Turpentine was neglected by sheep, in line with observations elsewhere by pastoralists and ourselves.

The relative palatabilities of mulga, pine and turpentine are well illustrated by the percentage of plants of each species initially less than 1 metre in height which have exceeded that height after 7.5 years; 32% mulga, 45% pine and 61% turpentine.

The fact that mulga and pine achieved annual height increments almost there times as great as turpentine is fortunate in that with sympathetic management these species should compete favourably with turpentine.

The practical implications of this work lie firstly in its indication that mulga populations at Cobar such as the studied population, may be maintained under grazing and secondly in its illustration of the speed with which regeneration and growth of noxious species, such as turpentine, can occur despite grazing. Unless some other means of controlling regrowth is used, an open woodland can, in a short time, become dense scrub of little pastoral value.

Although some shrub affords protection for soil against erosion, grass and herbage cover is essential. Ground cover is notably absent in dense shrub regrowth communities and so the soils especially on slopes, are predisposed to erosion.

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