REGENERATION AND SPATIAL PATTERNS OF *ACACIA ANEURA* IN SOUTH WEST QUEENSLAND

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ABSTRACT

Seed production from mulga in south west Queensland is adequate for regeneration. During summer, high soil temperatures (in addition to moisture deficits) may be a major factor limiting germination. Appreciable regeneration is occurring in both lightly stocked and unstocked areas, with or without summer rain. In experimentally thinned mulga scrubs, there was no significant difference in the number of seedlings regenerating under canopies of 40 *and* 160 *trees/ha; but significantly fewer seedlings regenerated under* 640 *trees/ha canopies and in plots cleared of all trees.*

The spatial patterns of mulga at one site are described and illustrated. All size classes (seedlings, <5 cm diameter and >5 cm diameter at 30 *cm height) exhibit strongly contagious distributions.*

Environmental conditions in south-west Queensland favour continual recruitment in mulga populations, as well as intermittent mass regeneration. Previous reports of only spasmodic regeneration occurring in mulga are due to stock browsing and killing seedlings in all but the most favourable seasons, rather than to an actual failure of seed to germinate and establish.

INTRODUCTION

Concern at the poor regeneration of mulga (*Acacia aneura*) has been expressed in New South Wales (Beadle 1948; Condon, 1949), South Australia (Jessup, 1951; Hall, Specht and Eardley, 1964; Lange, 1966), Western Australia (Beard, 1968), and in certain parts of the Northern Territory (Chippendale, 1963; Condon, Newman and Cunningham, 1969). In Queensland, Everist (1949), and Holland and Moore (1962) did not consider poor regeneration a problem, and a later study (Burrows and Beale, 1970) concluded that densities of young plants (<5 cm stem diameter at 30 cm height) were inadequate for future reserves only on the driest site receiving <250 mm mean annual rainfall. However, the increasing practice of clearing large tracts of mulga for drought feeding could lead to poor mulga regeneration in Queensland.

In view of the importance of mulga as a stabilising factor in the pastoral areas, a study of seedling regeneration was undertaken in three diverse habitats in south west Queensland since 1965. Factors of importance in determining the extent of regeneration (seed yields, germination responses, seedling survival ability) were studied in greater detail. The results are related to seasonal rainfalls and densities of parent trees. The spatial distributions of mulga were examined, to develop an understanding of regeneration patterns.

MATERIALS AND METHODS

(i) *Seed Yield*

An area of 0.4 ha on the Charleville Experimental Reserve was characterised by recording the number of mulga trees in three size classes (<5 cm, 5-10 cm, >10 cm diameter at 30 cm height). In October 1971, 96 tins (individual surface area 0.06 m^2) were randomly placed under canopies of trees then bearing pods, and seed and pod yield measured when they fell in November-January.

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(ii) *Germination*

Temperature and germination interaction were measured over a range of constant and alternating temperatures from 7 to 45°C. Seed was germinated on moist filter paper in petri dishes in the dark after scarification with boiling water (Preece 1971b). Germination was recorded when the length of the radicle exceeded the diameter of the seed. All germination experiments were replicated and terminated at 14 days.

The effect of moisture stress on germination was investigated at 25°C by imbibing seeds in aqueous solutions of polyethylene glycol (mol. wt. c. 20,000). The concentrations of polyethylene glycol required were obtained from a calibration curve kindly provided by Prof. J. R. McWilliam.

All seed used was collected from a single tree in November 1966 and had been stored in a dry cabinet in the laboratory prior to testing in January-February 1972.

(iii) *Seedling Survival*

Forty insulated plastic pots (20 cm × 20 cm) were lined with polythene, and each filled with 7 kg of oven dry soil (acid red earth—Gn 2.11) for which the soil moisture characteristics were known (Christie 1970). The pots were wet to field capacity (F.C. = 13% moisture), and sown with 2 pre-germinated mulga seeds. After maintenance at F.C. for seven days and thinning to one seedling/pot, each container was allowed to dry out and moisture loss was recorded by daily weighings. Survival of seedlings was recorded at 11, 14, 24 and 40 days after the —15 bar soil moisture tension had been reached. Survival was gauged for each time interval by re-wetting the eight replicates to F.C. and observing if turgidity was regained and active growth resumed within two days. At each watering date two additional pots were sampled to check uniformity of soil moisture distribution.

Daily recordings were made of relative humidity and maximum and minimum temperatures within the plant house during the course of the study. The pots were laid out on slatted benches in a randomized block design, which was completely re-randomised every three days. Soil temperature was recorded at 4.30 p.m. each day in two control pots.

(iv) *Population Studies*

The number of mulga trees in four classes (seedlings*, <5 cm diameter, 5—10 cm diameter and >10 cm diameter, measured at 30 cm height) were recorded in July 1965 and October 1969 for a 9.15 km section of the Humeburn belt transect (for details of site and method see Burrows and Beale, 1969).

The density of mulga over 12 ha of a virgin scrub was also recorded at "Monamby" Station, 100 km W of Charleville, in 1964. The area was then experimentally thinned to densities of 40, 160 and 640 mulga trees/ha respectively in replicated 0.40 ha plots. The plots have been undisturbed since thinning and were inaccessible to domestic stock (Beale, 1971).

In November 1971 density of mulga regrowth (all <5 cm diameter at 30 cm height) was recorded in 100 m × 2 m belt transects placed across a diagonal of each plot. The number of mulga plants (<5 cm diameter) present in adjacent non-enclosed virgin scrub was recorded at the same time in 160 randomly positioned 1 m × 0.5 m quadrats.

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* Seedlings are defined for the purpose of this study as being < 10 cm tall, often with one of the pinnate leaves still present. If there is evidence of the seedling having been previously browsed, it is placed in the < 5 cm diameter class.

Regeneration has also been followed for a shorter period in a clearing trial at Charleville, basically similar to that at "Monamby". Initial mulga density was 3775 trees/ha and replicated 0.5 ha plots experimentally thinned to 0, 40, 160 and 3775 trees/ha were established in September 1970. The plots were inaccessible to domestic stock. In March 1972 seedling regeneration was recorded in 3 random 100 m × 2 m transects placed across each replicate.

(v) *Spatial Patterns*

For purposes of analysis, the first 8.7 km segment of the Humeburn belt transect (Burrows and Beale, 1969) was divided into 256 contiguous 34 m × 2 m quadrats. Density of mulga in three size classes (seedlings, <5 cm diameter and >5 cm diameter at 30 cm height) was used as a measure of class abundance. A further group was distinguished by combining the densities of the three size classes, thus permitting an examination of the species as a whole.

The methodology employed in the study was that of conventional pattern analysis (Greig-Smith 1961, 1964). The calculation of variance and correlation coefficient values was carried out by Dr J. Walker, CSIRO Woodland Ecology Unit, using the CSIRO CDC3600 computer.

RESULTS AND DISCUSSION

Reasonable seed yields can be expected in Queensland (Table 1), especially when the current production is considered together with population size class distribution (Burrows and Beale, 1970). Notably all trees of apparent reproductive size do not necessarily set seed in any one year (cf Preece, 1971a).

TABLE 1
Mulga seed production on the Charleville experimental reserve

Site Characterisation (0.40 ha)			Seed and Pod Yield		
Tree diameter	No. of trees	No. of trees bearing pods	Seed/bearing tree (kg)	Seed/ha[a] (kg)	Pod/ha[a] (kg)
<5 cm	83	0	0	11.45 ±1.27	39.92 ±4.26
5–10 cm	90	0	0		
>10 cm	50	21	0.22		

[a] Results are in the form x ± tSx (P < 0.05).

TABLE 2
Regeneration of Mulga in three widely separated communities

		Tree Density (Mulga trees/ha)	Mulga regeneration* (Plants/ha)	Stocking Rate (Sheep/ha)
(i)	Humeburn (1965–1969)	410	904	0.2
(ii a)	Monamby (1965–1971)	40	2335 a	0
		160	1880 a	
		640	955 b	
(ii b)	Monamby (1965–1971)	1946	247	<0.2
(iii)	Charleville (1970–1972)	0	251 b	0
		40	555 a	
		160	491 a	
		640	141 c	
		3775	66 d	

* Values in any one column (for each site only) not followed by the same letter are significantly different (P < 0.05). Analyses performed on $\log_{10}$ transformed data.

Elsewhere little quantitative information is available about seed yield from mulga. At no time did seed fall in Western Australia exceed 2 kg/ha/yr (Wilcox, 1972). At Koonamore, in South Australia, seed is rarely set (Osborn, Wood and Partridge, 1935). Further north, Jessup (1951) noted that mulga seeds abundantly in good years.

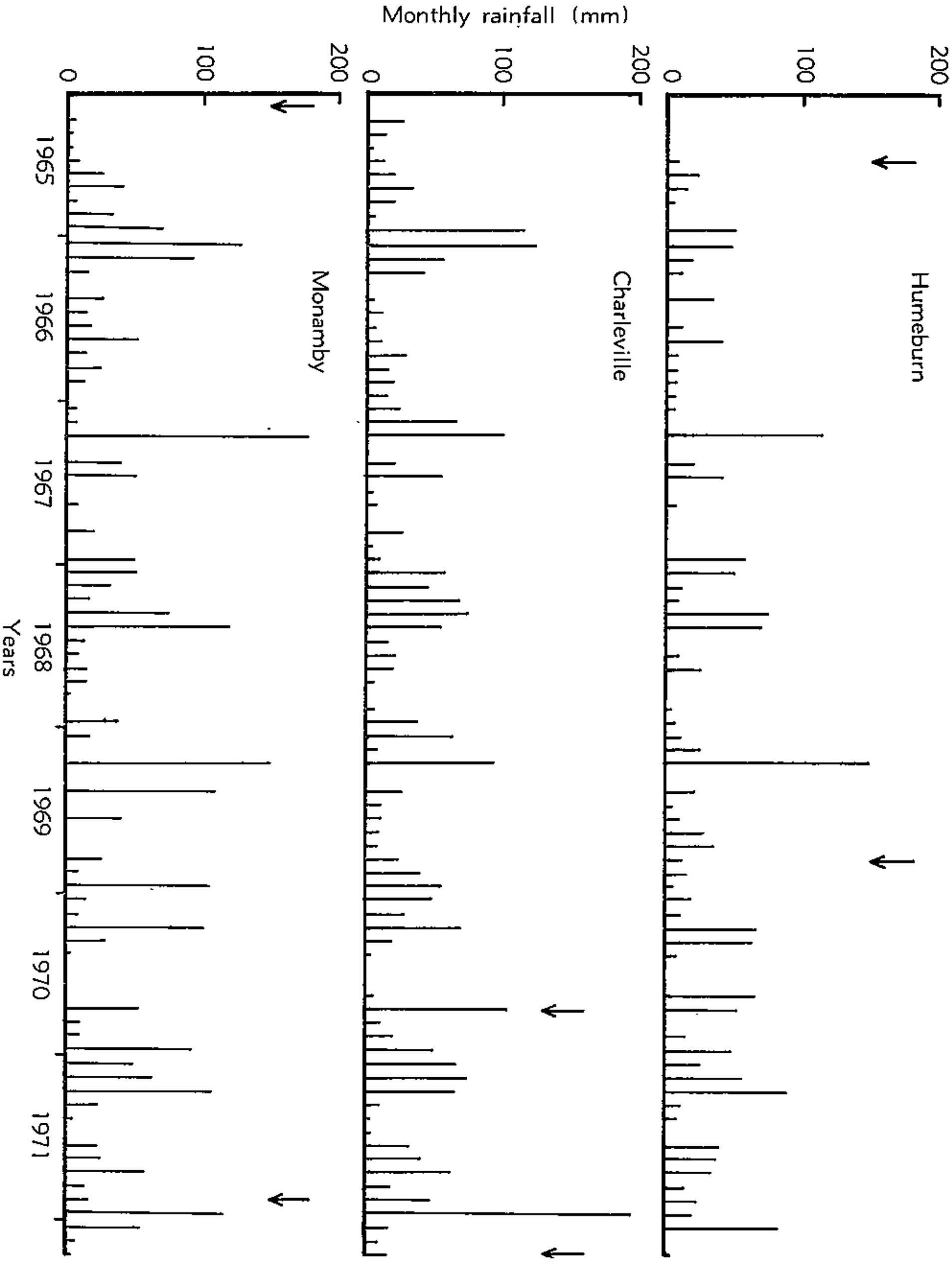

FIGURE 1

Rainfall at the seedling regeneration study sites (March 1965-March 1972). Humeburn and Monamby readings were obtained c.10 km from the plots. Time of plant counts at each site is indicated by arrows.

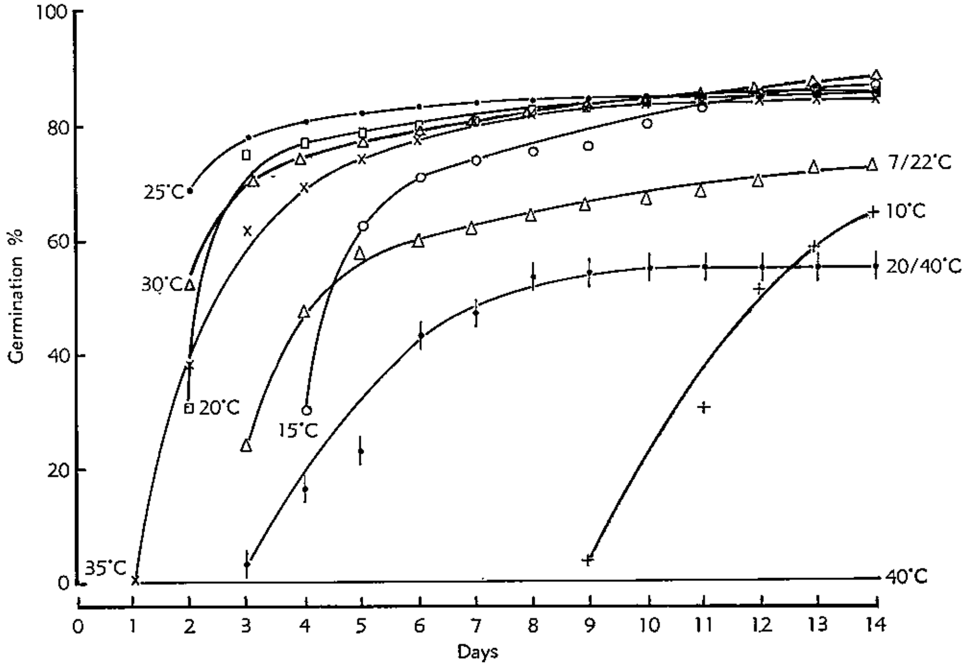

FIGURE 2

Effect of temperature on mulga germination. All tests were carried out in the dark at constant temperature apart from two alternating regimes—7/22°C (12 hr/12 hr) and 20/45°C (20 hr/4 hr).

Appreciable mulga regeneration at Humeburn, Monamby and Charleville (Table 2) has occurred in the absence of heavy summer rain (Figure 1). Earlier Melville (1947), Everist (1949), Hall et al (1964), Perry (1966) and Preece (1971b) implied that summer rain is essential for regeneration. For this reason, temperature requirements for mulga germination have been further explored in the present studies. The results (Figure 2) confirm Preece's (1971b) estimates of optimum values but also reveal pronounced suppression of germination in a 45°C/20°C (4 hour/20 hour) alternating regime, and complete suppression at a constant 40°C.

When these responses are compared with the temperature regimes found in mulga soils (Figure 3), it is difficult to visualise large scale germination occurring in summer unless there is a prolonged period of rainy weather, and consequent lower soil temperatures. On the other hand, it is apparent that germination (admittedly at a slower rate) is possible during most of the cooler months. This possibility is further enhanced by the apparent ability of the seed to germinate under osmotic drought (Figure 4).

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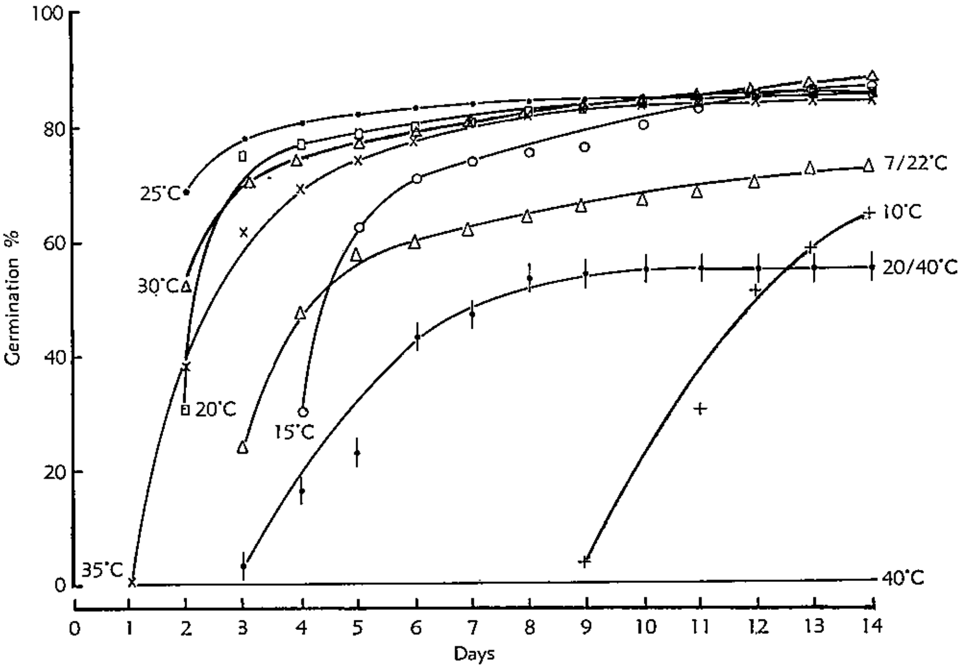

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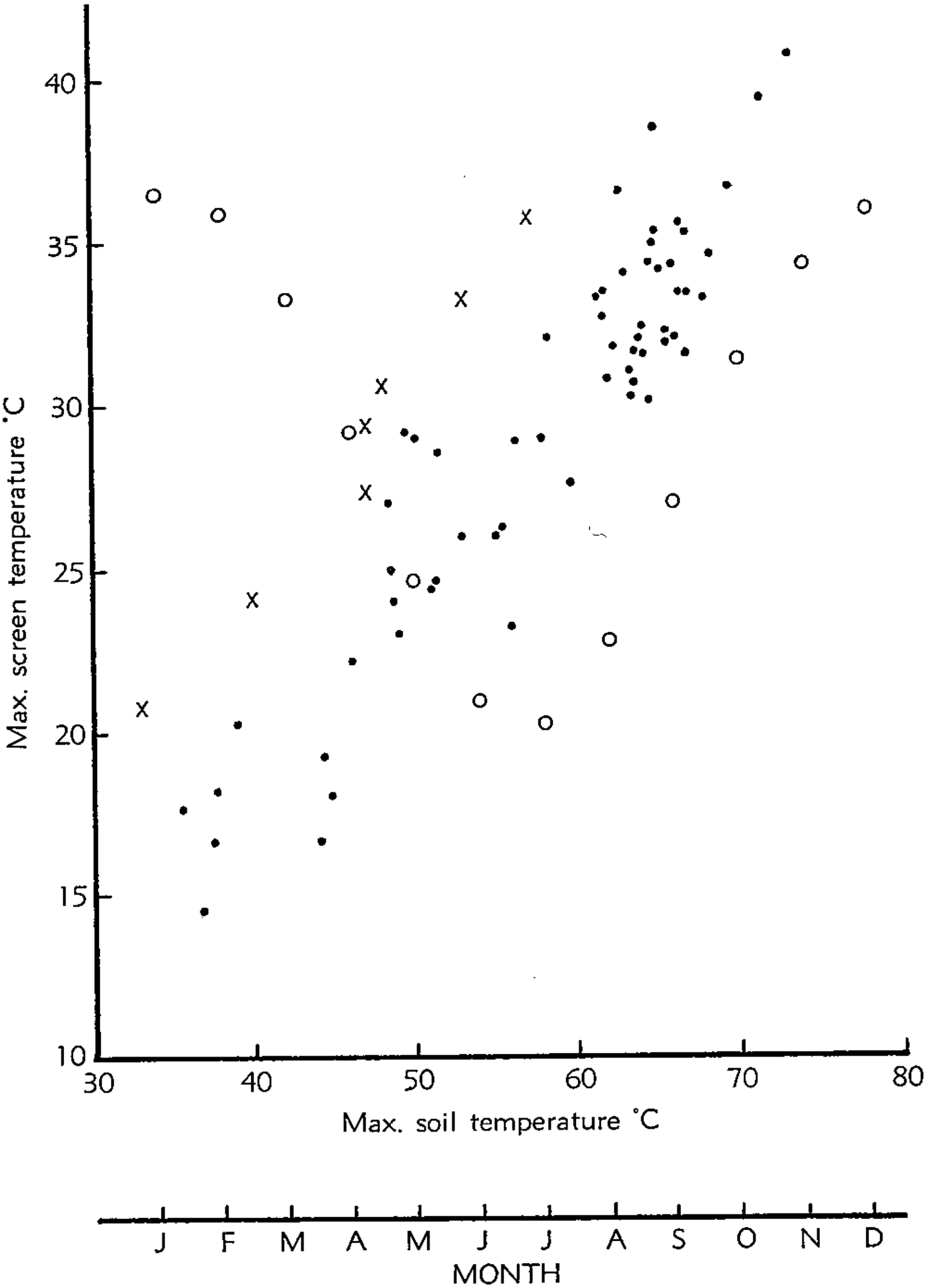

FIGURE 3

The relationship between maximum screen temperature and maximum soil temperature on mulga soils. Sources: (x) Preece (1971b) and meteorological data for Alice Springs: (·) Turner (1965). Data represented by (x) are 3 monthly means and include rainy and rainless periods. Data represented by (·) are for cloudless days at least 1 week after last rain. Mean monthly maximum screen temperatures for Charleville (o) are also indicated.

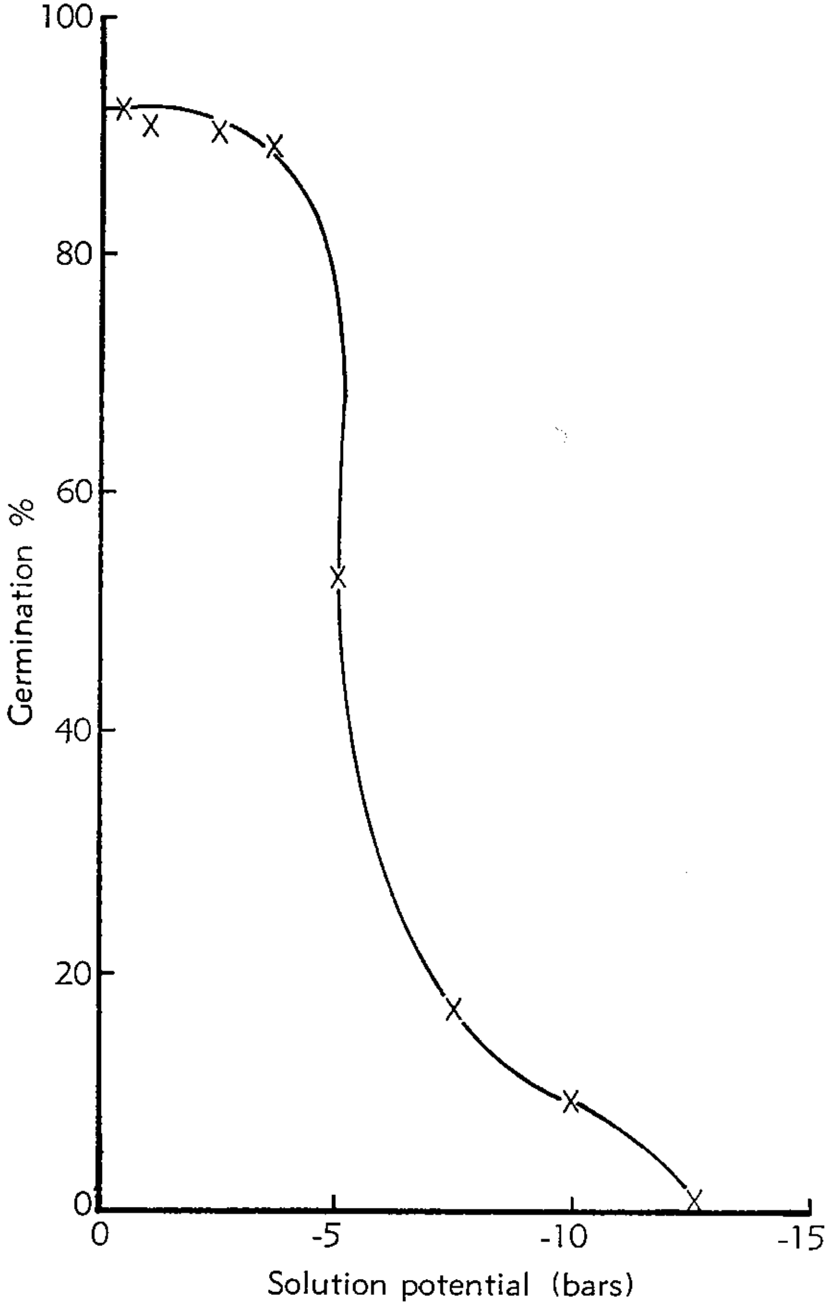

FIGURE 4

Effect of moisture stress on the germination of mulga at 25°C. Osmotic "drought" from aqueous solutions of polyethylene glycol (m wt 20,000) of known potential (bars). The polyethylene glycol was not dialysed (cf McWilliam, Clements and Dowling 1970).

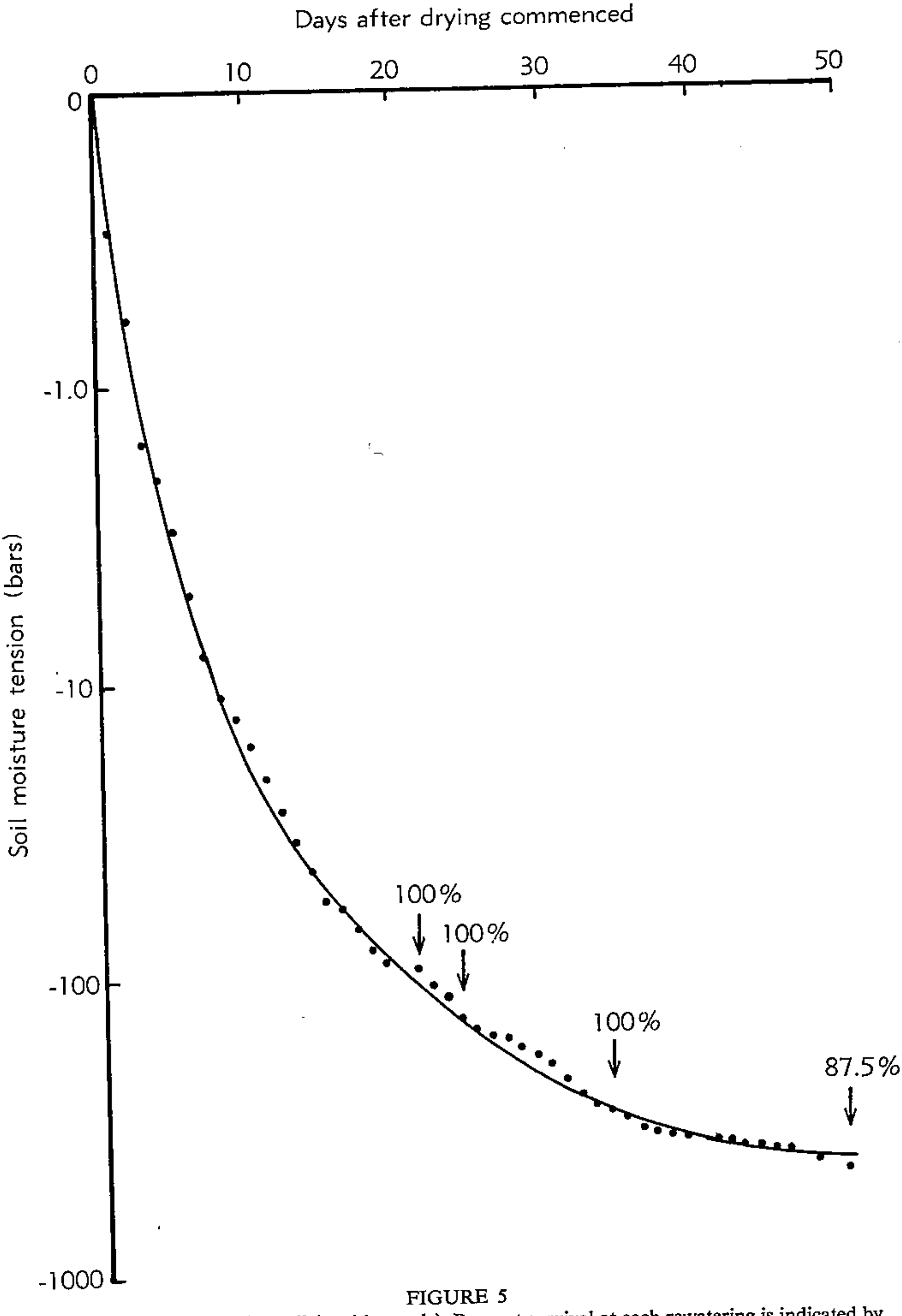

FIGURE 5
Seedling survival in a drying soil (semi-log scale). Per cent survival at each rewatering is indicated by arrows.

Regeneration of mulga has been observed in both lightly stocked and enclosed areas (Table 2). None of the sites were burnt since monitoring began. Two of the sites (Monamby and Charleville) had a large amount of litter on the soil surface. Beadle (1959), and Moore and Biddiscombe (1964) have stressed that a major reduction in soil organic matter will lead to reduced regeneration, through a loss of soil nutrient reserves (cf Charley and Cowling, 1968).

Litter modifies the microenvironment, especially through maintaining milder soil temperatures and reducing evaporation (Rickert, 1970). Unfavourable seasonal conditions are considered the most important factor limiting regrowth (Melville, 1947), but under light stocking rates and a favourable microhabitat this conclusion does not hold in Queensland.

An optimum balance between maintaining adequate drought reserves (mulga trees) and ground forage production would require a mulga tree density of about 160 trees/ha (Everist, 1949). However, Beale (1971) has shown that this tree density still depresses potential ground forage yields. Data in Table 2 indicate that mulga at >640 trees/ha prior to clearing could quickly revert to thick scrub, whatever the final tree number left standing, unless fire and/or heavy stocking, designed to prevent this, is imposed.

TABLE 3

Scales of spatial pattern (indicated by crosses) in shrub density for various size classes in a Mulga community

Species	Block Size 1	2	4	8	16	32	64	128	Mean Number per Quadrat*
1. Acacia aneura (>5 cm)			x				x		0.4
2. Acacia aneura (<5 cm)		x				x			5.2
3. Acacia aneura (seedling)		x			x		x		3.3
4. Acacia aneura (combined)		x					x		8.9

* Basic quadrat size 34 m × 2 m.

The strong evidence of contagion in mulga communities of the Northern Territory (Anderson, 1970) is also apparent in south west Queensland (Table 3), where growing is not a distinctive characteristic of the community. Two major scales of spatial pattern are evident at Humeburn, at block size 2-4 and block size 32-64 (Table 3). Because of the large basic unit (34 m × 2 m), both patterns could be attributed to variation in environmental factors (cf Kershaw 1963). In this area a major environmental factor (especially governing seedling distribution) is considered to be microtopography (Burrows and Beale, 1969). However, due to the large units involved, soil type and slope would override microtopographical influences. A recurring large scale pattern such as this is implicit in the recognition of run-off, run-on, relationships in mulga lands (Slatyer, 1961; Newman and Condon, 1969).

The associations between the various size classes were examined using the correlation coefficient r. The only significant relationship recorded was a positive one between the <5 cm diameter class and the seedlings ($P < 0.01$). Regeneration is therefore occurring within similar sites from year to year, and competition from existing young plants is not precluding new regeneration. Under mass germination, a thinning out process would be expected rather than one of continual recruitment.

The correlation analysis revealed no strong relationship between large *A. aneura* trees and juvenile or seedling trees. This confirms the earlier findings from inverse association analysis of this site (Burrows and Beale, 1969), and suggests that seedlings of *A. aneura* have a distribution somewhat independent of mature seed trees (cf Everist, 1949).

The actual density of seedlings in October 1969 at Humeburn was 475 ± 116 plants/ha. Rainfall records for the period show that these seedlings could only have become established following August/September rainfall (Figure 1). Habitat variables were not recorded to correlate with size class distributions. Almost all the seedlings were found in small depressions or in sites with a reasonable grass or litter cover.

It is clear from these studies that conditions necessary for the germination and establishment of mulga seedlings in the mulga lands of south west Queensland are not as rigid as previously supposed (Everist, 1949). Regeneration in this area would be much more frequent than that predicted in north western New South Wales (Preece, 1971b). Nevertheless the present observations are confined to "protected" sites and it is probable that previous observations of only intermittent regeneration in mulga (Melville, 1947; Everist, 1949; Hall, Specht and Eardley, 1964; Beard, 1968) are from areas where heavy stocking intensity (sheep, rabbits) has suppressed regeneration in all but the most favourable seasons.

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