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STUDIES IN THE DYNAMICS AND CONTROL OF WOODY WEEDS IN SEMI-ARID QUEENSLAND

1. Eremophila gilesii

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SUMMARY

Eremophila gilesii, **a woody pioneer species, is very responsive to disturbance in the mulga communities of south-western Queensland. Under present management it is increasing in density. The ability of the plant to invade areas cleared of mulga trees is demonstrated.**

Ploughing out stands of *E. gilesii,* **slashing at ground level, and applying any one of many common herbicides as a high-volume foliar spray were effective methods of killing the plant. A 1% a.i. 2, 4, 5-T ester-diesel distillate combination was particularly effective. The plant is periodically attacked by a wingless grasshopper (***Monistria pustulifera***), and when insect populations are high, large areas of** *E. gilesii* **are killed.**

The feasibility of applying a previously hypothesized grazing management technique to prevent future regeneration of *E. gilesii* **from seed is demonstrated.**

I. INTRODUCTION

Woody weeds are recognized as a major problem in the semi-arid grazing lands of eastern Australia (Interdepartmental Committee 1969; Moore 1969; Moore 1971). It is appreciated that a good knowledge of plant ecology is a prerequisite to successful control in such environments (Burrows 1972*a*), but, in Queensland, at least, much research has been directed towards chemical and mechanical eradication (Johnson 1964; Purcell 1964, 1966; Robertson 1965, 1966). These techniques are useful in reducing stands in grazing lands, but often hard to justify on economic grounds where large areas are involved.

Lack of long-term population studies makes it difficult to assess the problem status of many woody weeds. Are present populations increasing, decreasing, invading or merely thickening up? Answers to these questions are basic to sound ecological management of the communities. *Eremophila gilesii* F. Muell. is one of the shrubs which is causing particular concern in the mulga region of south-western Queensland. This paper records changes in the population of the plants since 1964 and details preliminary investigations into its control.

II. METHODS

Population dynamics.—The density of *E. gilesii* over 12 ha of a virgin *Acacia aneura* scrub (1924 ± 147 trees/ha) was recorded at "Monamby" station, 100 km west of Charleville, in June 1964. Number and position of woody plants present in 28 randomly placed 100 m x 0·8 m belt transects were noted. The area was then experimentally thinned to densities of 40, 160 and 640 *A. aneura* trees/ha respectively in 0·40 ha plots. There were seven replicates of each treatment. The plots have been undisturbed since thinning and exclosed to domestic stock (Beale 1971).

In November 1971 density of *E. gilesii* was recorded in 100 m x 2 m belt transects placed across a diagonal of each plot. The number of *E. gilesii* plants present in the non-exclosed virgin scrub was recorded at the same time in 160 randomly positioned 1 m x 0·5 m quadrats.

Density of *E. gilesii* has also been followed at three additional sites since 1965 (Burrows 1972*a*). This information, supplemented by 1972 readings where available, is repeated here.

Chemical control.—The following chemicals were tested in a randomized block design: 1% a.i. 2,4-D amine in water; 1% a.i. 2,4,5-T amine in water; 1% a.i. 2,4,5-T butyl ester in diesel distillate; 0·1% a.i. picloram + 0·4% a.i. 2,4-D amine (as Tordon 50D) in water; 0·1% a.i. picloram + 0·4% a.i. 2,4,5-T amine (as Tordon 105) in water; and diesel distillate alone. A non-ionic surfactant was added to all treatments in which water was the carrier. Chemicals were applied as high-volume sprays to thoroughly wet the bushes. There were also two control treatments to correspond to the two application times, March 11, 1970, and March 21, 1970, when moisture content of the treated plants was 36% and 123% dry-weight basis respectively.

Efficacy of treatment was measured by percentage dead in April and July 1970.

Mechanical control.—Slashing treatments were simulated by removing bushes at ground level ⅓ height or 2/3 height with hand clippers in March 1970. Treatments were applied to three height classes (7–15 cm, 15–30 cm and > 30 cm) in a randomized block design. There were five bushes for each of the six replications in each height class. Thirty untreated 'controls' were also recorded for the three height classes.

The effect of ploughing out *E. gilesii* was investigated using a 3-disc plough over an area in which plant position and number had previously been determined. Steel posts were placed at the extremities of the treated area to enable exact re-positioning of transects when examining regeneration.

Biological control.—It was postulated (Burrows 1972*a*) that strategic heavy stocking with sheep could substantially reduce fruit set and hence future regeneration of *E. gilesii* stands. To test this hypothesis, feeding trials were first carried out with three penned sheep to observe if any deleterious effects on the animals resulted from consumption of *E. gilesii* flowers and leaves. Secondly, an area carrying 69,200 ± 5,900 *E. gilesii* bushes/ha was fenced and stocked at the equivalent of 12 sheep/ha for 6 weeks from September 17, 1971. The *E. gilesii* stand had commenced to flower following 32 mm rain on September 13, 1971. At the completion of the trial the number of fruits on 40 randomly chosen bushes in adjacent stocked and unstocked stands was recorded. Bushes counted were > 30 cm high, as it had been shown that flowering was appreciably less in bushes below this height (Burrows 1971).

Finally, observations were made on biological control due to the activity of a natural predator, *Monistria pustulifera* (a wingless grasshopper). Several large infestations occurred in the Charleville region in the late summer of 1969-70.

III. RESULTS

Population dynamics.—Although no *E. gilesii* plants were recorded in the 1964 Monamby counts (Table 1) it is possible that occasional small plants may have been present outside the transects. In 1971 the *E. gilesii* stand at Monamby was at an early stage of colonization. This is reflected in the high standard errors for treatment means.

TABLE 1

DENSITY OF *Eremophila gilesii* ON FOUR SITES IN SOUTH-WESTERN QUEENSLAND FROM 1964 TO 1972
Mean density per hectare (± S.E.)

Site	1964	1965	1966	1967	1969	1970	1971	1972
Humeburn transect* ..	n.a.	447 ±86	n.a.	n.a.	1,001 ±194	n.a.	n.a.	n.a.
Lanherne exclosure* ..	n.a.	n.a.	44,375 ±7,500	48,900 ±5,625	n.a.	54,060 ±7,660	n.a.	n.a.
Maxvale exclosure* ..	n.a.	n.a.	20,780 ±2,810	37,190 ±6,875	n.a.	11,875 ±3,125	n.a.	9,218 ±2,812
Monamby (1924 *A. aneura*/ha)	0	n.a.	n.a.	n.a.	n.a.	n.a.	0	n.a.
Monamby (640 *A. aneura*/ha)	0	n.a.	n.a.	n.a.	n.a.	n.a.	5,570 ±5,500	n.a.
Monamby (160 *A. aneura*/ha)	0	n.a.	n.a.	n.a.	n.a.	n.a.	4,565 ±2,645	n.a.
Monamby (40 *A. aneura*/ha)	0	n.a.	n.a.	n.a.	n.a.	n.a.	1,840 ±1,830	n.a.

* Adapted from Burrows (1972*a*).

n.a. Not available.

Chemical control.—Results of the chemical screening trial (Table 2) are given for April and July, but there were no changes in the July readings when the plots were re-recorded in December (9 months after treatments were applied). There were no deaths in the marked control bushes over the period of observation.

TABLE 2

CHEMICAL CONTROL OF *Eremophila gilesii*

Treatment	Percentage dead April 30		Percentage dead July 31	
	Trans. Mean*	Equiv. Mean	Trans. Mean*	Equiv. Mean
1. 2, 4, 5–T Ester (a)	1·6	100·0	1·6	100·0
2. 2, 4, 5–T Ester (b)	1·6	100·0	1·6	100·0
3. Picloram/2, 4, 5–T (a)	1·5	98·7	1·6	100·0
4. Picloram/2, 4–D (a)	1·3	95·0	1·5	99·0
5. 2, 4–D Amine (b)	1·1	76·3	1·6	100·0
6. 2, 4, 5–T Amine (a)	1·1	76·0	1·6	100·0
7. Picloram/2, 4–D (b)	1·0	75·2	1·4	97·4
8. 2, 4–D Amine (a)	0·6	31·8	0·8	51·4
9. 2, 4, 5–T Amine (b)	0·6	29·4	1·6	100·0
10. Diesel distillate (b)	0·5	20·8	0·8	56·0
11. Picloram/2, 4, 5–T (b)	0·4	16·7	1·3	94·7

Necessary differences for significance—

April: Treatments 1, 2, 5% = 0·25; 1% = 0·35. Treatments 3–11, 5% = 0·5; 1% = 0·7.
1, 2 ≫ 5, 6, 7, 8, 9, 10, 11.
3, 4 ≫ 8, 9, 10, 11.

July: Treatments 1, 2, 3, 5, 6, 9, 5% = 0·2; 1% = 0·3. Treatments 4, 7, 8, 10, 11, 5% = 0·4; 1% = 0·6.
1, 2, 3, 5, 6, 9 ≫ 8, 10, 11.
4, 7 ≫ 8, 9.

a Treatment applied 11–3–70.

b Treatment applied 21–3–70.

* Arc sine transformation.

Mechanical control.—Results of these treatments are summarized in Tables 3 and 4.

TABLE 3

MECHANICAL CONTROL OF *Eremophila gilesii* BY SLASHING
Percentage kill in each height class (mean of six replicates)

Height Class	Treatment				Height Class
	A	B	C	D	
7–15 cm	100	30	3·3	0	7–15 cm
15–30 cm	96·6	3·3	3·3	0	15–30 cm
>30 cm	100	3·3	0	0	>30 cm

Treatment A: Plant cut off at ground level.
Treatment B: Plant cut off at one-third actual height.
Treatment C: Plant cut off at two-thirds actual height.
Treatment D: Control—plant left intact.

TABLE 4

MECHANICAL CONTROL OF *Eremophila gilesii* BY PLOUGHING

Height Class	No. of Bushes in Sampled Area	Equivalent No. per Hectare	Recovery 6 Months After Treatment (%)
0– 7·5 cm	65	20,250 ± 3,125	0
7·5–15 cm	87	27,125 ± 3,000	0
15 –30 cm	105	32,750 ± 3,875	0
>30 cm	47	15,875 ± 2,125	0
Total	304	95,000 ± 6,375	0

Biological control.—In pen studies sheep were unaffected where flowers of *E. gilesii* comprised their full diet. They showed a ready acceptance of the flowers in preference to the leaves. Green leaves were largely unacceptable to sheep even when mixed in varying proportions with lucerne chaff. On the other hand, sheep consumed up to 75% by weight of dry leaves when these were mixed with lucerne chaff. These preliminary observations were obtained before the field trial (Table 5) was commenced.

TABLE 5

EFFECT OF HEAVY STOCKING WITH SHEEP ON FRUIT SET IN *Eremophila gilesii*

Sample Area	No. of Fruits per Bush*	Height of Bushes Sampled (cm)
Stocked area	2·2 ± 0·9	49·3 ± 4·1
Unstocked area	111 ± 32	48·6 ± 3·5

* Results are in the form $\bar{x} \pm t S \bar{x}$ ($P < 0{\cdot}05$).

IV. DISCUSSION

Eremophila gilesii is known to be increasing in density, in areas where it occurs, both under light stocking and where stock are excluded (Burrows 1972*a*). The data for the Monamby site (Table 1) show that *E. gilesii* also has a remarkable capacity to invade areas cleared of *Acacia aneura* (mulga) scrub. This finding is in agreement with the observations of Everist (1954) and Holland and Moore (1962), but differs from that of Burrows (1971). From spatial pattern studies at Humeburn, Burrows concluded that *E. gilesii* was not invading areas cleared of mulga scrub. Conflicting results such as these are most likely due to differences in stocking rate. The Humeburn site has been grazed continuously by sheep, whereas Monamby has been completely exclosed to domestic stock since clearing.

Smith (1957) noted that *E. gilesii* is often found on sheet-eroded areas, while the apparent absence of this plant from virgin mulga scrub (Table 1) agrees with the earlier observation of Everist (1954). Thus it seems that *E. gilesii* (now with a proven capacity to invade) has many of the attributes of a pioneer species which is particularly responsive to disturbance. The evidence confirms the conclusions that populations of *E. gilesii* will continue to increase in density under existing management in mulga lands (Burrows 1971, 1972*a*).

It is apparent that most of the common arboricides (2,4,5-T, 2,4-D, picloram mixtures) are effective against *E. gilesii* (Table 2). These results contrast with non-susceptibility to 2,4-D and 2,4,5-T reported by Smith (1957). Rates of application used in the present screening were high, and this could account for the difference in the findings reported.

The data from Table 2 suggests that there is little advantage in spraying *E. gilesii* when bushes are actively growing (second spraying) compared with an inactive growth stage (mean of five common treatments—active growth 97% kill, inactive growth 89·5% kill). However, these results could be misleading. Although the plants were more or less dormant at the first spraying, 62 mm of rain were received 4 days later and leaf growth resumed quickly (Burrows 1972*a*, Fig. 3). Conditions for translocation of herbicide were therefore favourable within a short period of application, and it is likely that physiological responses of the plant were very similar for each application.

A herbicide rate of application trial will be necessary before any particular chemical spray can be recommended. However, the present results indicate that a 2,4,5-T/diesel distillate spray could have the most promise. Diesel distillate alone was reasonably effective, but a double application would probably be required to give full control.

The simulated slashing treatments show that the plant is easily killed by defoliation at ground level (Table 3). In contrast to other problem species such as *Eucalyptus* spp., *Acacia harpophylla,* and *Eremophila mitchellii, E. gilesii* does not appear to sucker from roots or underground buds. Nevertheless, use of a tractor-driven slasher is unlikely to be as successful in practice as this initial trial might suggest, because high kills would only be obtained if the tops of all plants were removed at ground level.

In view of the above findings it is not surprising that mechanical control by ploughing (Table 4) is also a completely effective method of killing *E. gilesii.* Both ploughing and slashing treatments tend to leave ideal seedbed conditions for the germination and establishment of *E. gilesii,* as well as other plants. It is possible that this situation could be exploited in any control programmes undertaken on a practical scale.

The fact that penned sheep will consume much greater quantities of dry than of green leaves suggests that the unpalatable factor in *E. gilesii* is volatile and may be dissipated by drying. Chippendale and Jephcott (1963) earlier observed that *E. gilesii* is not palatable to cattle although it is sometimes lightly grazed in dry times. In the present studies there was no evidence of scouring or other deleterious effects in sheep fed flowers or leaves.

The hypothesis (Burrows 1972*a*) that heavy stocking with sheep could effectively prevent fruit set in *E. gilesii* has been confirmed (Table 5), but whether this technique could be applied on a large scale is debatable. Substantial flexibility in stock numbers would be required as well as additional fencing to confine stock to the area being treated. Also, to obtain complete eradication the treatment would have to be applied following each flowering until the present population had died. However, the trial has demonstrated that in this semi-arid environment even a difficult problem species may be manipulated by soundly based management techniques.

Abundant evidence (e.g. Dodd 1927; Huffaker and Kennett 1959) suggests that host-specific insects have often comparable roles in the control of the same host species in exotic conditions as they have in regions where both host plant and parasite evolved and are endemic. The evidence refutes the common suggestion that only exotic species can have such striking and fundamental impact (Huffaker 1968; Ueckert, Polk and Ward 1971).

In south-western Queensland, Smith (1957) reported the wingless grasshopper *Monistria pustulifera* occasionally caused death of *E. gilesii.* During the present studies *M. pustulifera* infestations were particularly numerous throughout 1969–70.

Fig. 1.—Left, completely defoliated and ringbarked bushes of *Eremophila gilesii* following attack by the wingless grasshopper *Monistria pustulifera*: "Wallal", Charleville, March 1970. Right, same area, March 1972.

The habit of the grasshoppers was largely sedentary. The fully winged form was usually rare, but became more prominent as the population density increased to a high level. *E. gilesii* bushes were first stripped of leaves, then any regrowth and branch tips were removed. Finally the bark was removed from the stems (Figure 1). In all bushes where this final stage of attack was reached, no regrowth was observed 9 months later. Peak activity of the insect was reached in March–April 1970, although the first insects were observed in December 1969 and an odd individual was still evident in August 1970.

Seasonal conditions favouring the build-up of the grasshopper are not understood. However, there is little doubt that the effect on *E. gilesii* can be devastating. In excess of 500 ha of dense bush was completely killed within a 15 km radius of Charleville in 1970 and large infestations were again apparent in the 1971–72 summer.

The foregoing studies have shown several methods that could be developed to control *E. gilesii*. It is apparent that chemical and mechanical control techniques could be effective, but costly. Economic considerations suggest that the long-term control of *E. gilesii* probably depends on both biological control and ecological management. The important role played by this shrub in nutrient cycling in the infertile mulga ecosystem has been demonstrated (Burrows 1972). Removing the shrubs without consideration of what species, if any, will take their place could lead to further deterioration in the grazing value and stability of this ecosystem (Burrows 1971*a*). These factors should be appreciated before any control methods are applied in practice.

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REFERENCES

BEALE, I. F. (1971).—The productivity of two mulga (*Acacia aneura* F. Muell.) communities after thinning in south-west Queensland. M. Agr. Sc. thesis, University of Queensland.

BURROWS, W. H. (1971).—Studies in the ecology and control of green turkey bush (*Eremophila gilesii* F. Muel.) in south-west Queensland. M.Agr.Sc. thesis, University of Queensland.

BURROWS, W. H. (1972*a*).—A study of the phenology and germination of *Eremophila gilesii* in semi arid Queensland. Proc. U.S.-Australia workshop, "Plant morphogenesis as the basis for scientific management of rangelands", Berkeley, California. *Misc. Publs U.S. Dep. Agric.* (in press).

BURROWS, W. H. (1972*b*).—Productivity, litter fall, and nutrient distribution in an arid zone shrub (*Eremophila gilesii*) community in south-west Queensland. *Aust. J. Bot.* (in press).

BURROWS, W. H. (1972*b*).—Productivity of an arid zone shrub (*Eremophila gilesii*) community in south-western Queensland. *Aust. J. Bot.* 20:317-29.

CHIPPENDALE, G. M., and JEPHCOTT, B. P. (1963).—Topfeed—The fodder trees and shrubs of Central Australia. *Ext. Art. Anim. Ind. Div. North. Terr. Admin.* No. 5.

DODD, A. P. (1927).—The biological control of prickly pear in Australia. *Bull. Coun. Scient. ind. Res., Melb.* No. 34.

EVERIST, S. L. (1954).—Turkey bush in Wyandra and Quilpie districts. *Maranoa Grazier* 15/1/1954.

HOLLAND, A. A., and MOORE, C. W. E. (1962).—The vegetation and soils of the Bollon district in south-western Queensland. *Tech. Bull. Div. Pl. Ind. C.S.I.R.O.* No. 17.

HUFFAKER, C. B. (1968).—Insects as competitive herbivores. In: "A practical guide to the study of the productivity of large herbivores." (Ed. F. B. Golley and H. K. Bueschner). (Blackwell: Oxford).

HUFFAKER, C. B., and KENNETT, C. E. (1959).—A ten-year study of vegetational changes associated with biological control of Klamath weed. *J. Range Mgmt* 12:69-82.

INTERDEPARTMENTAL COMMITTEE (1969).—"Scrub and timber regrowth in the Cobar-Byrock district and other areas of the Western Division of N.S.W. Report of the Interdepartmental Committee." (Government Printer: Sydney).

JOHNSON, R. W. (1964).—"Ecology and control of brigalow in Queensland." (Queensland Dept. of Primary Industries: Brisbane).

MOORE, C. W. E. (1969).—Application of ecology to the management of pastoral leases in north-western New South Wales. *Proc. ecol. Soc. Aust.* 4:39-54.

MOORE, R. M. (1971).—Trees and shrubs in Australian sheep grazing lands. *In* "Plants for Sheep in Australia. A Review of Pasture, Browse and Fodder Crop Research 1948-70." (Ed. J. H. Leigh and J. C. Noble). (Angus and Robertson: Sydney).

PURCELL, D. L. (1964).—Gidyea to grass in the central west. *Qd agric. J.* 90:548-58.

PURCELL, D. L. (1966).—Chemical control of sandalwood and butterbush in gidyea country. *Qd agric. J.* 92:364-9.

ROBERTSON, J. A. (1965).—Chemical control of *Eremophila mitchellii. Aust. J. exp. agric. Anim. Husb.* 5:299-304.

ROBERTSON, J. A. (1966).—The effect of basal injections of 2,4,5-T on mature trees of *Eucalyptus populnea. Aust. J. exp. agric. Anim. Husb.* 6:344-9.

SMITH, L. S. (1957).—Report on Charleville turkey bush (*Eremophila gilesii* F. Muell.) in south-western Queensland. Queensland Dept. of Agriculture and Stock unpublished report. File No. 57/28247.

UECKERT, D. N., POLK, K. L., and WARD, C. R. (1971).—Mesquite twig girdler: a possible means of mesquite control. *J. Range Mgmt* 24:116-8.

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