Observations on the re-establishment of native shrubs in the Northern Marginal Lands of South Australia

By R.J. French and J.S. Potter.

Observations on the germination and persistence of perennial native shrubs on bare scalded land in a 220 to 280 mm annual rainfall area are reported.

The seed was collected from natural stands and was tested for its viability. Contour furrows were used to trap water and prevent seed being blown or washed away.

Successful establishment only occurred in moist winters when daily maximum air temperatures were about 15°C and evaporation less than 4 mm per day.

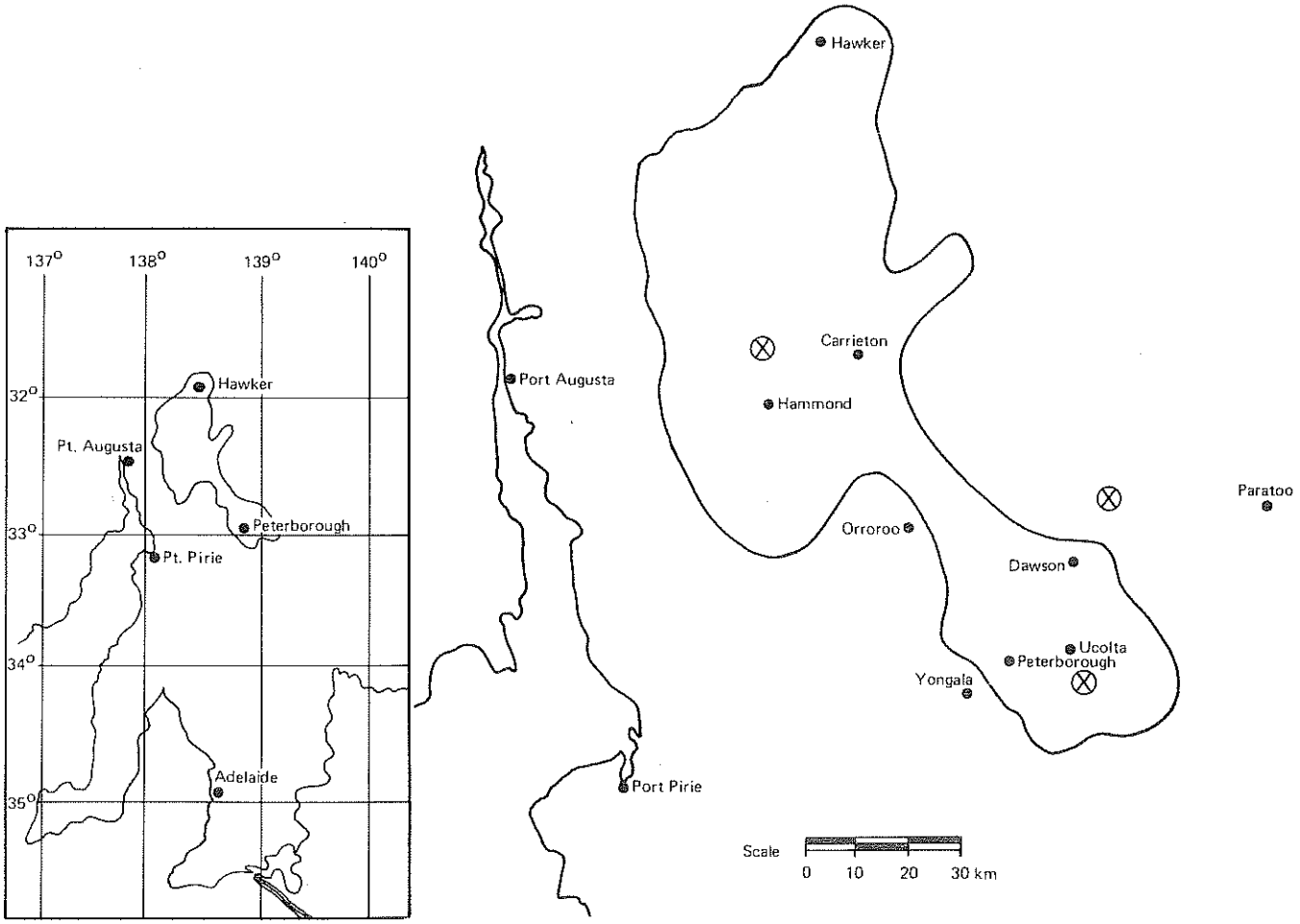
Atriplex vesicaria was the most successful species in permeable soil. *A. nummularia* and *Kochia pyramidata* were more suitable for hard scalds where furrows collapse after a few years.

In South Australia is a belt of country referred to as the Northern Marginal Lands (Anon 1939), see figure 1. The average annual rainfall within this area ranges from 220 to 280 mm. The original vegetation was a low shrub community of saltbush *(Atriplex vesicaria)* and bluebushes *(Kochia sedifolia, K. pyramidata).*

During the 1870's much of this land was cleared and sown to wheat. A succession of above average seasons gave immediate excellent harvests (Blackburn and Baker 1952; Meinig 1962), but droughts in the 1880's, coupled with a fall in soil fertility, reduced yields to as little as 300 kg/ha. Eventually wheat growing was abandoned in most of the area.

Raising sheep for wool production became the main agricultural pursuit, the sheep living mainly on sporadic growth of ephemeral herbs and grasses. In good seasons, stocking rate was as high as 1.2 sheep/ha. In dry seasons, the country was severely overgrazed because surplus sheep

Figure 1: Maps showing (a) the location of the Northern Marginal Lands in South Australia and (b) the towns within this area. The experimental sites are shown as ⊗.



R.J.F., Department of Agriculture, Adelaide, South Australia.
J.S.P., Department of Agriculture, Adelaide, South Australia.

were difficult to dispose of. Overgrazing led to erosion and the development of bare scalded areas which became virtual waste land. Eventually stock numbers were reduced to the present low levels of 0.2-0.25 sheep/ha, but even at these stocking rates nothing regenerated naturally and the scalded areas continued to be the focal point for water and wind erosion.

In 1956, it was decided to investigate means of re-establishing vegetative cover on scalded land. The work was based on the following assumptions:

1. The vegetative cover should be perennial if erosion was to be arrested and grazing was to be continued.
2. Native shrubs would be the best species to use. *Atriplex vesicaria* appeared to be the original vegetation on the scalded land.
3. Some cultivation would be essential to trap water and hold seed on these bare areas. Contour furrows would be the best approach (Tideman 1955).

Our hypothesis was that native shrubs could be re-established on scalded land, and that *A. vesicaria* would give the best results.

Investigational procedure

Sites

The sites selected were:

1. Dawson — annual rainfall 230 mm, altitude 340 m. The site was on an extensive area of flat scalded land (slopes of less than 0.5 per cent) subject to flash floods. The soil (a desert loam) had a hard, sheet-eroded, scald surface over a friable clay subsoil.
2. Ucolta — annual rainfall 280 mm, altitude 520 m. The site was a sheet-eroded area, with a slope of 5 per cent, situated among low hills. The soil was a stony, hard setting, sandy loam surface over a friable clay.
3. Hammond — annual rainfall 250 mm, altitude 310 m. The site was bare land with a 3 per cent slope. The soil was a fine textured, well structured, permeable clay loam with small stones on the surface.

Long term climatic data are given in table 1. Some of the towns are just beyond the boundaries of the Northern Marginal Lands (see figure 1), but they are the nearest official recording centres. The temperatures of the region are probably 1 to 2°C above those given for Yongala. Daily rainfall was recorded at or near the experimental sites from 1956 to 1961; the monthly totals are shown in table 2.

Sowing

Germination tests were made on the seed before sowing. Twenty-five viable seeds were hand-planted per 20 m of furrow. Seeds were sown in June 1956, and in May and August in both 1959 and 1960 (see table 2) in freshly ploughed contour furrows which were 15 cm deep and 1.5 m apart. The plots were fenced soon after the initial sowing in 1956.

A. vesicaria was sown at each site in three seasons, viz. 1956, 1959, 1960. Two other perennial shrubs found in remnant communuties within the region, *K. sedifolia* and *K. pyramidata,* together with *A. nummularia* which grows in western New South Wales, were sown in 1959 and 1960.

Assessment

The success of the species was judged by their:

1. Ability to germinate and to set seed.
2. Ability to persist from sowing until March 1973.

From 1956 to 1961, the experimental sites were inspected five or six times each year. After 1961, inspections were less frequent; sometimes 18 months elapsed between observations.

Table 1: Mean climatic data for Northern Marginal Lands of South Australia.

	Months												Annual
	J	F	M	A	M	J	J	A	S	O	N	D	
Rainfall (mm)													
Hawker	18	19	15	20	31	41	32	33	26	21	22	20	297
Peterborough	21	18	17	22	32	35	33	38	33	28	25	23	325
Paratoo	17	18	16	13	22	21	15	18	19	19	21	20	218
Temperature (°C)													
Yongala — Mean daily													
Maximum	30.6	29.5	27.1	21.4	16.8	13.4	12.4	13.4	17.8	21.7	25.5	28.3	
Minimum	13.2	12.9	10.8	7.2	4.5	2.9	2.3	2.1	4.0	6.2	9.1	11.4	
Evaporation (mm) — (Aust. tank)													
Mean daily Orroroo	9.7	8.6	7.0	4.5	2.4	1.9	1.5	2.8	3.8	4.9	6.9	8.4	

Table 2: Recorded rainfall (mm) and planting, germination and seed setting times at experimental sites.

Site	Year	J	F	M	A	M	J	J	A	S	O	N	D	Annual
Dawson	1956	4	32	98	31	31	$28(P_1)$	$62(G_1)$	14	16	25	2	(S_1) 0	343
	57	0	10	9	2	0	28(G)	26	13	0	0	0	(S_1)24	112
	58	25	78	(G) 20	16	19	0	24	46	18	(S_1)43	61	7	357
	59	56	15	37	0	$16(P_2)$	0	26	$2(P_3)$	10	9	10	17	198
	60	9	13	0	10	$44(P_4)$	0	21	$(G_4)31(P_5)$	$38(S_1)$	0	$28(G_5)$	22	216
	61	5	0	4	51	7	3	4	20	8	0	31(G)	6	139
Peterborough	1956	39	10	32	47	54	$55(P_1)$	$73(G_1)$	36	57	30	15	(S_1) 0	464
	57	1	2	17	6	5	46(G)	38	33	21	43	12	$22(S_1)$	244
	58	33	14	23	17	22	1	46	89	$57(S_1)$	57	77	11	448
	59	30	17	37	2	$26(P_2)$	4	27	$14(P_3)$	21	18	12	17	225
	60	21	15	4	31	$90(P_4)$	18	69	$64(P_5)$	$79(G_4)$	6	$37(G_5)$	12	446
	61	1	9	7	60	8	15	35	41	22	6	61(G)	16	282
Hammond	1956	3	2	19	13	60	$35(P_1)$	53	9	(G)19	34	8	(S_1) 0	256
	57	0	1	11	4	9	22	19(G)	24	11	21	0	$39(S_1)$	157
	58	11	4	23	10	25	0	29	60	$58(S_1)$	53	36	6	314
	59	12	24	27	0	$10(P_2)$	3	31	$7(P_3)$	14	13	11	4	156
	60	11	11	5	12	$56(P_4)$	11	46	(S_1) $32(P_5)$	$69(G_4)$	2	$26(G_5)$	0	280
	61	8	6	6	45	3	6	13	31	35	2	22(G)	19	196

P = planting; G = germination; S = setting of seed by bushes.
The inferior figures, 1-5, refer to five times of planting. The absence of figure means that the germination or seed setting could not be related to a specific planting time.

The soils' wilting points (15 bar content) and some field moisture contents were determined to give an idea of moisture availability. At Dawson, soil moistures were measured in May and August 1959, March and October 1960, and June and October 1961. At the other two sites, measurements were made only in May and August 1959.

Results

The occasions when the native shrubs germinated and set seed are recorded in table 2. The viabilities of the seeds used are listed in table 3. Wilting points and the wettest and driest moisture contents recorded at the sampling dates are given in table 4.

The sown seeds germinated well after the 1956 planting, failed to germinate after both 1959 plantings and gave a limited germination after the 1960 plantings. Seedlings usually established themselves and subsequently set seed.

Germinations within the experimental areas were also observed in June-July 1957, February 1958 (Dawson only), and November 1960 and 1961. The seed probably came from bushes previously established by sowing. However, only those seeds which germinated in June-July 1957 grew into mature bushes.

Figures 2 to 6 illustrate the trend in establishment and persistence of perennials during the 17 years.

Furrows at Dawson slumped readily and were no longer effective in pounding water or holding seeds after five years. They were still effective for holding both water and seed at Ucolta and slightly effective as a seed trap at Hammond after 12 years.

Table 3: Germination percentages of seed collected and used in the 1959 and 1960 plantings.

Species	Percentage germination
Atriplex vesicaria	
green seed	24
newly matured seed	64
one year old seed from under bush	34
A. nummularia	
green seed	10
one year old seed from under bush	34
Kochia sedifolia	
newly matured seed	60
K. pyramidata	
one year old seed from under bush	75

Table 4: Wilting point (15 bar) and selected moisture contents at the three experimental sites.

	Depth (cm)	Wilting point (%M)	Driest (%M)	Wettest (%M)
Dawson	0-15	14.7	1.8	5.9
	15-30	16.9	4.3	8.0
	30-60	16.9	6.8	8.0
Ucolta	0-15	8.1	2.7	7.2
	15-30	12.5	6.6	9.9
	30-60	18.7	12.1	10.0
Hammond	0-15	20.7	5.3	11.2
	15-30	23.1	9.2	11.1
	30-60	23.9	11.7	14.3

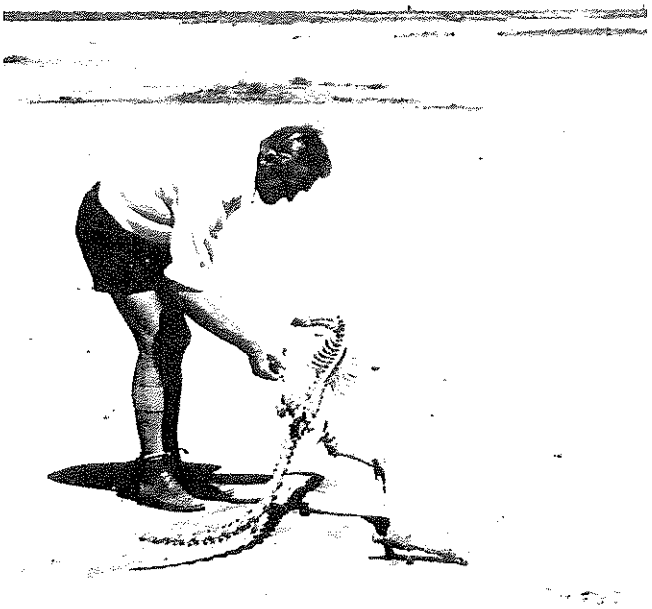
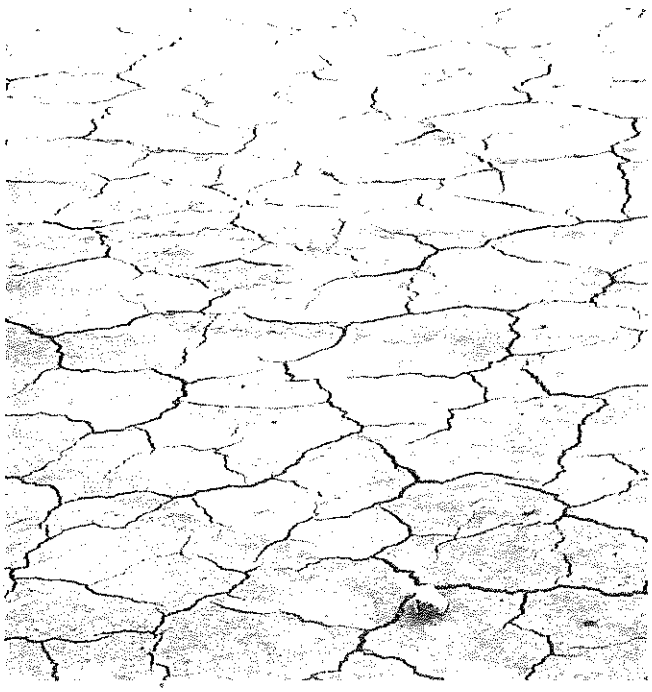


Figure 2: Bare scalds are waste land; they provide no grazing and act as focal points for erosion. Above, typical scalded land. Below, a close view.



Discussion

The results suggest that successful establishment of *A. vesicaria* is most likely only after favourable winter rains when the maximum daily air temperatures are about 15°C and evaporation rates are less than 3 to 4 mm per day. The temperature is similar to the lower optimum germinating temperature determined by Burbidge (1945). Outside these weather conditions, germination may occur but seedlings rarely survive.

Examination of the rainfall for the three winter months (June-August) shows that germination is most likely when the rainfall in two of the three months is greater than the 7th decile (this is the rainfall amount which is not exceeded by the driest 70 per cent of values). At the Paratoo official recording station, near Dawson, the 7th decile values for June, July and August are 27, 20 and 23 mm respectively. Data from the Dawson experiment suggest that a 25 mm rain or several rains of 12 mm close together are required for germination with further rains of 12 mm or more in the following month for establishment.

Three further conditions are needed to ensure establishment. Firstly, a source of viable seed must be available at the beginning of winter (June). This source can be reduced by low germination percentages (see variations with age of seed in table 3), and by removal by wind or runoff from summer thunderstorms, as at Dawson in February 1958. Secondly, competition from ephemerals must not be too great. In 1958 annual grasses such as spear grass (*Stipa* spp.) and wild oats (*Avena* spp.) grew vigorously at Ucolta, while at Hammond annual grasses and a wealth of annual herbs (e.g. species of *Goodenia, Minuria, Bassia*) were produced. No perennial bushes established that year despite good rainfall. Thirdly, the furrows or any other cultivation technique, e.g. small pits (Young 1969), need to remain effective for some years to trap seed and increase water intake. The present trend in the pastoral areas of South Australia is to prefer pitting to contour furrowing because the operation is simpler to apply, has a lower cost per hectare and it increases the area of land on which to trap seeds.

The ability of species to germinate and persist varied on the different soils. *A. vesicaria* bushes grew best on the friable soil at Hammond. They increased in number and size for about 7 years after sowing and reached a density of 1-2

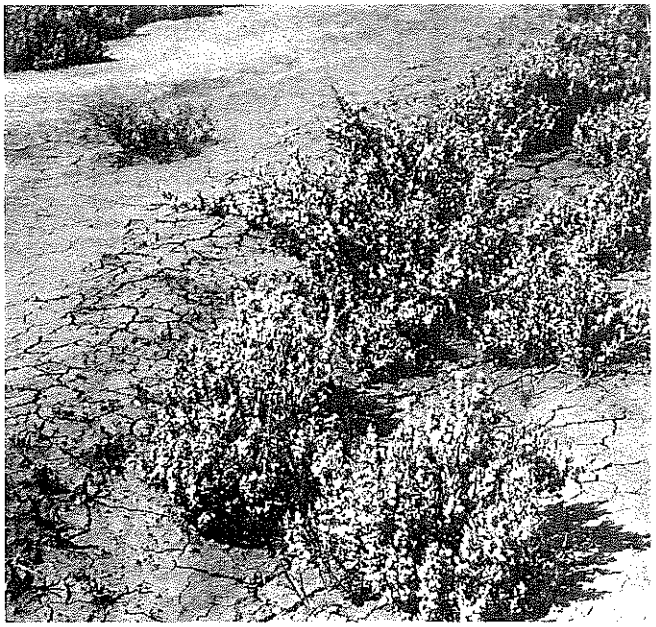
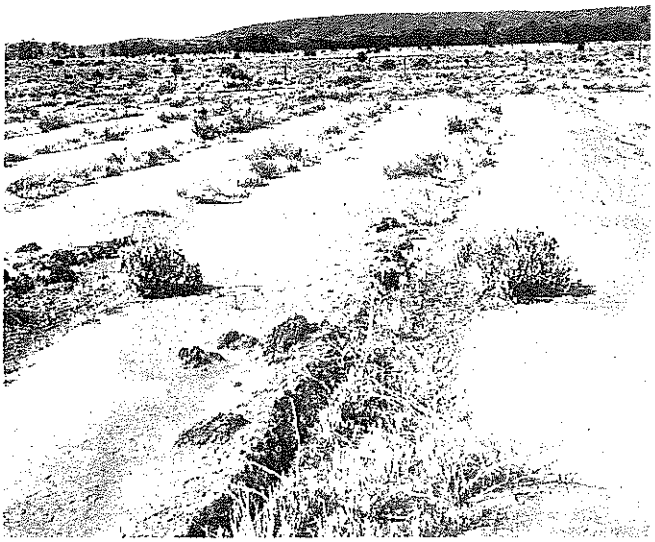
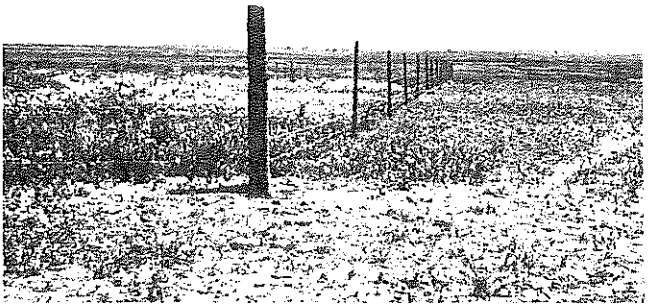
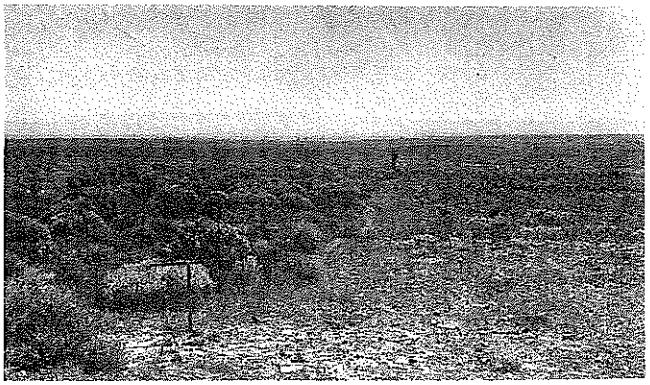


Figure 3: Progressive stages of growth of *Atriplex vesicaria* seeded in June 1956 on bare scald, Dawson. Above, October 1958. Below, October 1961. These plants died in the 1967 drought and the area reverted to bare scalds.







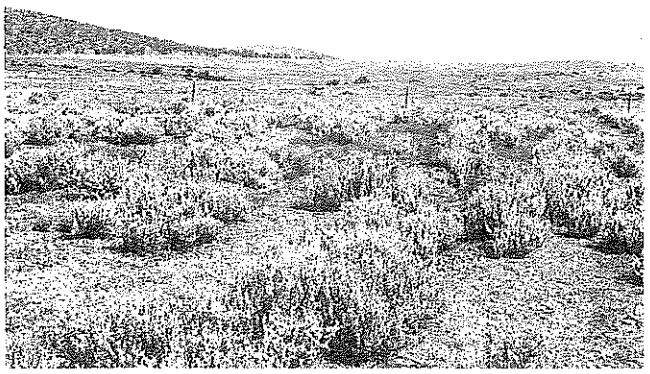


Figure 4: Establishment of *Atriplex vesicaria* – sown June 1956 on permeable soil at Hammond. Top, ungrazed ephemeral growth on plots in October 1958. Middle, mature stand of *A. vesicaria,* March 1973 – two years after the fence had been removed. Note the bushes that have established following spread of seed from the plots. Bottom, showing density of bush on plots March 1973. The position of the furrows can still be discerned.

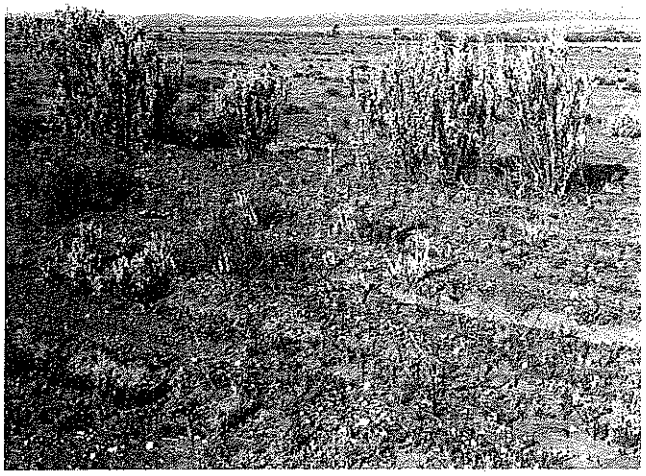


Figure 5: Revegetation plots Ucolta, March 1973, showing persistent furrows and established plants of *A. vesicaria* (small foreground) and *A. nummularia* (tall bushes) – seed sown 1960.

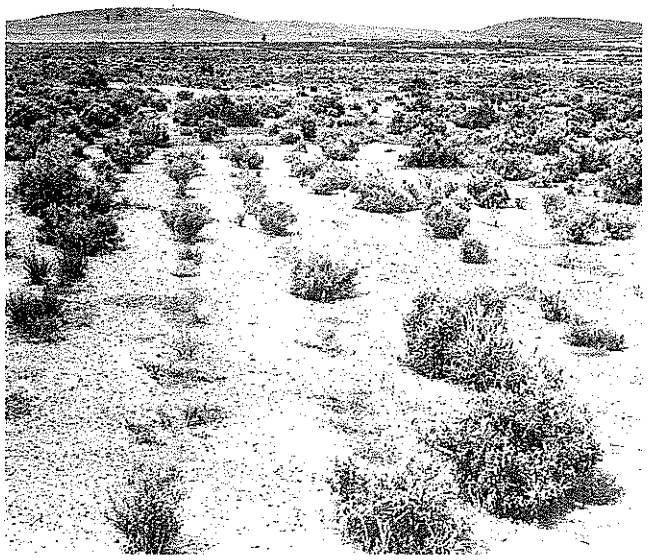


Figure 6: *Kochia pyramidata* successfully established by natural spread of seed on bare scalded land at Dawson, five years after the soil surface was pitted with a disc pitter. The area was not fenced and was periodically grazed.

bushes/m^2. The stand of bushes was still excellent in 1973 and most were seeding, even though the fence had been removed two years previously and the bushes were now subject to normal paddock grazing. Bushes had also established outside the experimental site following spread of seed from the plots (see figure 4b).

A. vesicaria did not persist on the hard scald at Dawson. It grew successfully and set seed for 4-5 years, but all bushes died in the severe drought of 1967, 9 years after sowing. The death of these bushes is of interest because *A. vesicaria* is normally drought resistant and has grown successfully for about 30 years on soil which rarely wets to a depth of more than 30 to 35 cm, and where the soil water tension exceeds 15 bars for a greater part of the year (Osborn *et al.* 1932; Jackson 1958; Carrodus and Specht 1965).

Although moisture measurements were few, they indicate the magnitude of soil dryness. Moisture contents from Ucolta and Hammond indicate that *A. vesicaria* can persist where the soil below 15 cm depth is only 50 per cent of the 15 bar content for much of the year. At Dawson, however, the subsoil was even drier (between 25 and 50 per cent of the 15 bar content). The extreme dryness together with the 1967 drought eventually killed the bushes. Thus erosion on the scalded areas at Dawson, has drastically reduced the soil's capacity to absorb rainfall. Contour furrows restore the water intake, but this advantage is lost when the furrows collapse and a surface seal redevelops.

The establishment of other species was limited; only a few plants grew from the sowings in August 1960. This limited success may be due to sowing at the end of the critical June-August period, but Burbidge (1946) has shown that both *Kochia* spp. can germinate at higher temperatures than *A. vesicaria*. Hence the poor establishment may be due to other factors, e.g. loss of seed by wind or insects.

A. nummularia and *K. pyramidata* have both persisted and set seed at all sites, even on the hard scald at Dawson where *A. vesicaria* failed. It appears that these plants are more suitable for colonising such soils (see figures 2 to 6). A few plants of *K. sedifolia* persisted at the friable Hammond site, but results with this species are inconclusive.

Observations on these experimental sites will be continued, the changes being recorded by photographs taken from fixed points.

Conclusions

The observations suggest the following requirements for establishing native shrubs in the Northern Marginal Lands of South Australia.

1. The species should be suited to the soil type. Our observations suggest that *A. vesicaria* is best for permeable soils. *A. nummularia* and *K. pyramidata* are best for hard scalds where furrows collapse after a few years. The hypothesis is therefore only partially supported.
2. Viable seed should be sown in winter (June) into freshly prepared contour furrows or pits. Germination and establishment are likely when two of the three winter months have rain greater than the 7th decile value.
3. The area should be protected from stock until the bushes are well established and dense enough to give good cover. This may take up to seven years.

Acknowledgments

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