REVIEWS *(continued)*

Area, distribution and weed potential of *Eragrostis curvula* (Schrad.) Nees in New South Wales

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Summary

A questionnaire survey of the area and distribution of African lovegrass (*Eragrostis curvula* (Schrad.) Nees) in 123 shires in New South Wales revealed that the plant occupied 45 000 ha of land and occurred in 56 shires and on 644 properties. Five shires had more than 1000 ha, and 54 properties were heavily infested. The plant was present on roadsides, railway land and river banks in 53, 21 and 15 shires respectively; from these situations it spread to adjacent rural land used for agricultural production.

***Eragrostis curvula* (consisting of a number of naturalized strains) was considered to be an unpalatable weed on the south coast and northern, central and southern tablelands. It has the potential for further spread within favourable environments and there is a strong argument for its control in these areas in New South Wales.**

Introduction

Leigh and Davidson (1968) described African lovegrass (*Eragrostis curvula* (Schrad.) Nees) as a perplexing pasture species because it is regarded as a valuable plant for animal production and soil conservation on the one hand and as an unpalatable weed on the other.

At present there are seven agronomic types of *E. curvula* in New South Wales: robusta (blue, green, intermediate); chloromelas (tall, short); conferta; and curvula (Leigh and Davidson, 1968; Johnston and Aveyard, 1977). The types are identified only with difficulty; the differences are based on leaf colour and size, stalkiness, habit, plant height, chromosome number and inflorescence characteristics. Clear definition of all genotypes will not be possible until the taxonomy of the genus has been revised (Leigh and Davidson, 1968).

Eragrostis curvula has been reported to be one of the highest producing grasses in the summer rainfall temperate and cool subtropical regions of southern Africa and of North and South America (Leigh and Davidson, 1968). It has also persisted over a wide range of conditions in Australia and shown promise as a pasture grass (Leigh and Davidson, 1968; Leigh and Mulham, 1964; Squires and Myers, 1970).

Because of its drought tolerance, warm season performance and adaptability to a range of soil erosion situations, *E. curvula* has shown potential for soil conservation. Johnston and Aveyard (1977) screened 70 accessions, selecting 16 on their ability to protect the soil during summer when cool season species are dormant.

Factors which indicate that *E. curvula* may be a potential weed include: low palatability, low crude protein content (Voigt *et al.*, 1970), susceptibility to frost damage and ability to invade and dominate native and introduced pastures. For example, in New South Wales, *E. curvula* has invaded and dominated *Phalaris aquatica* pastures south of Braidwood, *Lolium perenne* pastures near Bega and native grass pastures near Cooma (Campbell, unpublished data). Many landholders in the northern and southern tablelands and south coast consider it to be a weed. Thus we need to know the present area and distribution of the plant so that, should it be classifiied as a serious weed eventually, plant administrators could make decisions on control measures, containment policies, subsidy schemes and research priorities with a clear picture of the area infested.

In 1970, information on the area and distribution of *E. curvula* in New South Wales was limited, the only accurate assessments being for a small area near Tenterfield (Auld and Scarsbrick, 1970) and for points of introduction and chance spread throughout the State (Leigh and Davidson, 1968). Thus in 1981 a statewide survey was initiated to assess more thoroughly the area and distribution of *E. curvula.*

Methods

A mail questionnaire survey was carried out in 1981-82 seeking information from weed control bodies in 123 shires in New South Wales. Repeated requests were made until answers were obtained from all shires. The 'shires' included the A.C.T. and 11 'city' shires, for example City of Greater Lithgow. Weed officers answered 11 questions and provided a map of the shire showing infestations. Information for some shires was obtained from agronomists, weeds field officers and soil conservation officers.

The survey method was chosen because it has proved to be successful for other weeds in New South Wales (Campbell, 1977) and was faster, cheaper and more practical than some other methods, for example those of Smith (1975) and Cuthbertson (1978).

In the survey, the only types of *E. curvula* that could be identified with any degree of certainty were the curvula-type and the short chloromelas-type. However, no distinction was made between them in the survey in case other types were also present. In 1981, identification problems were overcome by lecturing to weed officers and showing live plant specimens, and by sending them a description and a seedhead encased in plastic. Many weed officers also had identification assistance from agronomists and botanists.

The area of land infested with *E. curvula* was assessed from records kept by inspectors, from their knowledge of their shires, from special surveys, or from indications of infestations on shire maps. The degree of infestation was classified according to density: class 1 – dense infestation; class 2 – scattered patches with isolated plants interspersed; and class 3 – scattered plants only.

Results and discussion

Area and distribution

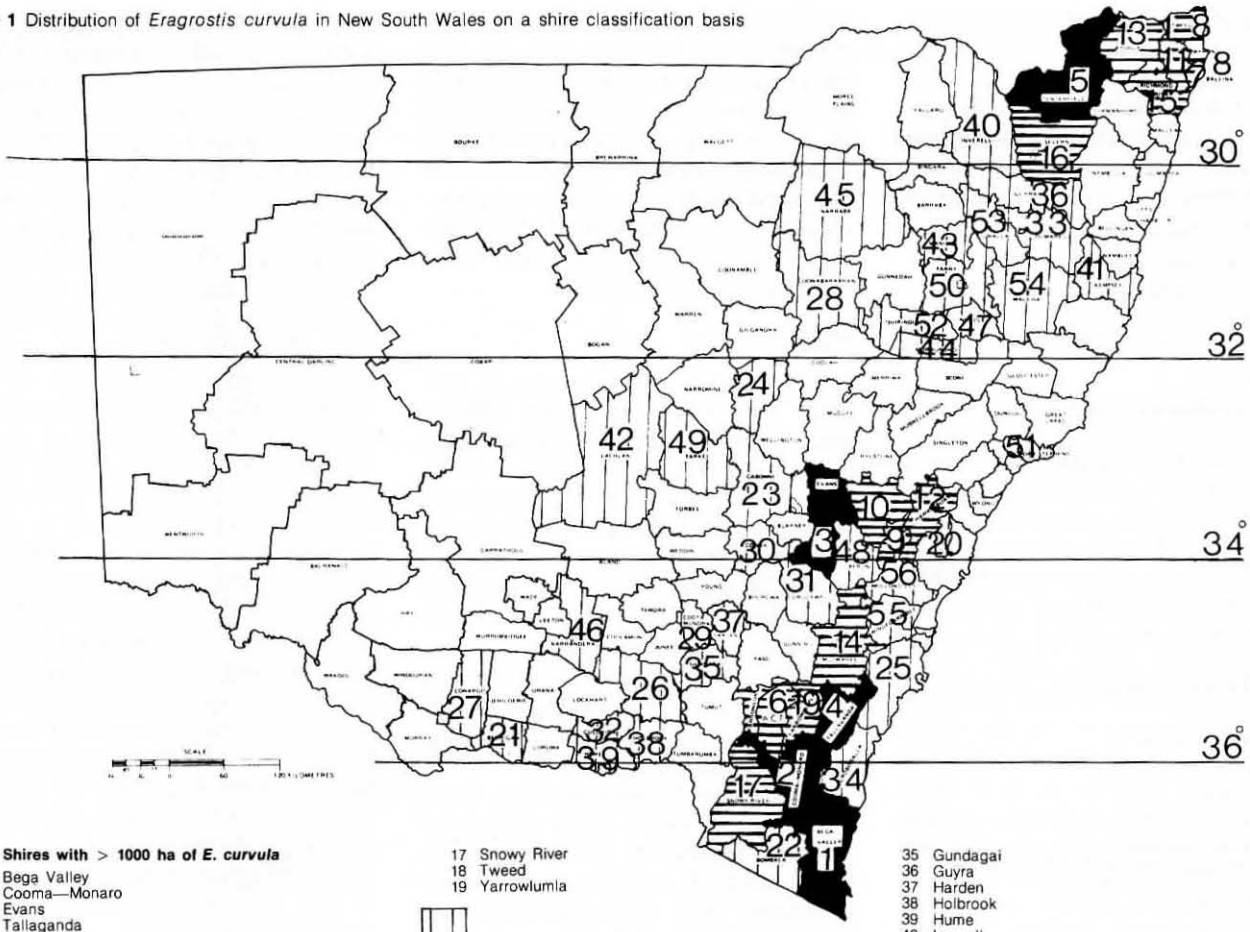
Although this survey shows that *E. curvula* is widely distributed in New South Wales, mainly on the coast and tablelands (Table 1, Figure 1), the total area occupied (45 000 ha) is small compared with that occupied by other pasture weeds, for example: *Nassella trichotoma* L. – 680 000 ha or *Hypericum perforatum* L. var. *angustifolium DC.* – 188 000 ha (Campbell, 1977). Of the 56 shires with *Eragrostis curvula*, only 15 had class 1 infestations and only five of these had 100 ha or more (Table 1). Similarly, 19 shires had class 2 infestations, and only seven of these had 100 ha or more. Of the 56 shires infested only 19 had a total infestation of 100 ha or more.

The earliest record of *E. curvula* in New South Wales was from the N.S.W. National Herbarium where plants collected at Cowra and Richmond were identified in 1900 (Leigh and David-

Table 1 Area of land and number of properties infested with *Eragrostis curvula* in the shires of New South Wales

Shire	Area infested (ha)				Number of properties infested			
	class 1	class 2	class 3	Total	class 1	class 2	class 3	Total
A.C.T.	10	50	500	560		3	15	18
Ballina			270	270			1	1
Baulkham Hills			20	20				
Bega Valley	1 500	1 000	5 800	8 300	14	10	20	44
Berrigan		1	1	2				
Bombala	1	1	10	12	1	2	5	8
Byron			270	270			1	1
Cabonne			1	1				
City of Blue Mountains	10	50	150	210				
City of Dubbo			1	1				
City of Greater Lithgow	10	30	90	130			4	4
City of Lismore			200	200			1	1
City of Shoalhaven			10	10				
City of Wagga Wagga			1	1				
Conargo			1	1				
Cooma–Monaro	200	5 500	12 000	17 700	20	30	80	130
Coonabarabran			1	1				
Cootamundra			1	1				
Cowra			1	1				
Crookwell			1	1				
Culcairn			1	1				
Dumeresq		10	20	30			10	10
Eurobodalla			1	1				
Evans		200	900	1 100		20	46	66
Gundagai			1	1				
Guyra			2	2				
Harden			1	1				
Hawkesbury		40	60	100			10	10
Holbrook			1	1				
Hume			20	20			2	2
Inverell			10	10				
Kempsey			1	1			1	1
Kyogle			270	270			1	1
Lachlan			1	1				
Manilla			21	21				
Mulwaree	20	20	200	240			4	4
Murrurundi			25	25				
Narrabri			1	1			1	1
Narrandera			1	1				
Nundle			25	25				
Oberon			1	1				
Parkes	5	20	20	45				
Parry			20	20				
Port Stephens			2	2				
Quirindi			20	20				
Richmond River			270	270			1	1
Severn	50	100	300	450	3	6	20	29
Snowy River	50	50	80	180	4	4	6	14
Tallaganda	100	200	1 000	1 300	7	4	30	41
Tenterfield	400	6 000	6 000	12 400	2	50	160	212
Tweed			240	240			1	1
Uralla			5	5				
Walcha			3	3			5	5
Wingecarribee	4	3	60	67			2	2
Wollondilly	40	25	8	73	3	4	10	17
Yarrowlumla	100	200	80	380			20	20
TOTAL	2 500	13 500	29 000	45 000	54	133	457	644

Figure 1 Distribution of *Eragrostis curvula* in New South Wales on a shire classification basis



Shires with > 1000 ha of *E. curvula*

1 Bega Valley
2 Cooma—Monaro
3 Evans
4 Tallaganda
5 Tenterfield

Shires with 100 to 1000 ha of *E. curvula*

6 A.C.T.
7 Ballina
8 Byron
9 City of Blue Mountains
10 City of Greater Lithgow
11 City of Lismore
12 Hawkesbury
13 Kyogle
14 Mulwaree
15 Richmond River
16 Severn
17 Snowy River
18 Tweed
19 Yarrowlumla

Shires with < 100 ha of *E. curvula*

20 Baulkham Hills
21 Berrigan
22 Bombala
23 Cabonne
24 City of Dubbo
25 City of Shoalhaven
26 City of Wagga Wagga
27 Conargo
28 Coonabarabran
29 Cootamundra
30 Cowra
31 Crookwell
32 Culcairn
33 Dumeresq
34 Eurobodalla
35 Gundagai
36 Guyra
37 Harden
38 Holbrook
39 Hume
40 Inverell
41 Kempsey
42 Lachlan
43 Manilla
44 Murrurundi
45 Narrabri
46 Narrandera
47 Nundle
48 Oberon
49 Parkes
50 Parry
51 Port Stephens
52 Quirindi
53 Uralla
54 Walcha
55 Wingecarribee
56 Wollondilly

son, 1968). Since then over 100 lines of *E. curvula* have been assessed in experiments for their value in pastures and soil conservation; Leigh and Davidson (1968) recorded 13 sites and W. H. Johnston (personal communication, 1982) four sites in New South Wales where various strains had been sown. Leigh and Davidson (1968) also recorded that *E. curvula* had become naturalized, outside the controlled experimental areas, in nine situations in New South Wales by 1968. The survey reported here shows the plant has now become naturalized in 56 shires.

Almost all (53) of the infested shires had roadside infestations of *E. curvula* and, in 36 of these, roadsides were classed as the main problem area for control of the weed (Table 2). Other situations in which *E. curvula* occurred were: railway land, river banks and intermittently grazed land (mainly abandoned mines, forests, travelling stock routes, cemeteries, school playgrounds and national parks). *E. curvula* occurred on rural land in 26 shires which included infestations on 644 properties (Table 1). However, only 54 of these properties had class 1 infestations. This compares with 3794 properties infested with *Nassella trichotoma* in New South Wales, 283 of them having class 1 infestations (Campbell, 1977).

The spread of *E. curvula* in New South Wales has proceeded along a number of pathways. In Bega Valley Shire, the plant has spread from roadsides to adjacent cultivated paddocks, a pathway common in southern Africa (Leigh and Davidson, 1968). *E. curvula* was first noticed in the Bega Valley in 1945 (E. Cochrane, Candelo, personal communication, 1982) but was not considered a problem until it began to spread after dry years in the 1960s and 1970s. Thus it appears to have spread over an estimated 8300 ha in 37 years. *E. curvula* infests 8000 km of roadsides in shires controlled by the Far North Coast County Council but is not considered to be a weed because it has been present for 40 years and has spread only to farm tracks, school playgrounds and other areas where traffic has destroyed competing species. The greater spread of *E. curvula* on the south coast than on the north coast may be due to lower rainfall on the south coast than on the north coast and thus less competition from existing pastures, and/or to the predominance of sandy textured soil (derived from granite) on the south coast which favours its growth and spread (Leigh and Davidson, 1968) more than the heavier soils of the north coast.

On the southern tablelands *E. curvula* (first recorded at Cooma in 1948) infests 60 km of roadsides on the highway from Cooma to Michelago. During the last 34 years it has spread from these roadsides to approximately 17 700 ha of the adjacent paddocks

Table 2 Occurrence of *Eragrostis curvula* in shires in New South Wales

	Number of shires
Occurrence in:	56
Declared noxious in:	18
Shires with infestations of:	
1000 to 20 000 ha	5
100 to 1000 ha	14
10 to 100 ha	14
<10 ha	23
Shires with infestations on:	
roadsides	53
intermittently grazed land[1]	28
railway land	21
arable rural land[2]	20
non-arable rural land[2]	16
river banks	15
Shires with the main problem of control on:	
roadsides	36
intermittently grazed land	5
railway land	4
arable rural land	5
non-arable rural land	1
river banks	5

[1]crown land, national parks, travelling stock reserves, abandoned mines, quarries, water catchment reserves, etc.
[2]rural land — occupied by landholder.

(Figure 2). Its spread has been favoured by sandy textured granite soil, dry conditions and lack of competition from the unploughed native or naturalized pastures.

In the Krawaree Valley south of Braidwood, *E. curvula*, sown by a landholder near the headwaters of the Shoalhaven River, spread downstream over an estimated 50 km in 20 years, infesting river banks and some adjacent pasture paddocks. The plant has also infested the banks of the Murrumbidgee, Bega, Abercrombie and Macquarie Rivers.

The first record of *E. curvula* from the Tenterfield Shire was in 1939 (Leigh and Davidson, 1968); by 1969 it had spread from the original infestation near the railway station to all roadsides radiating from the town and to many adjoining paddocks (Auld and Scarsbrick, 1970). Between 1969 and 1978 the area infested approximately doubled (B. A. Auld, personal communication, 1982).

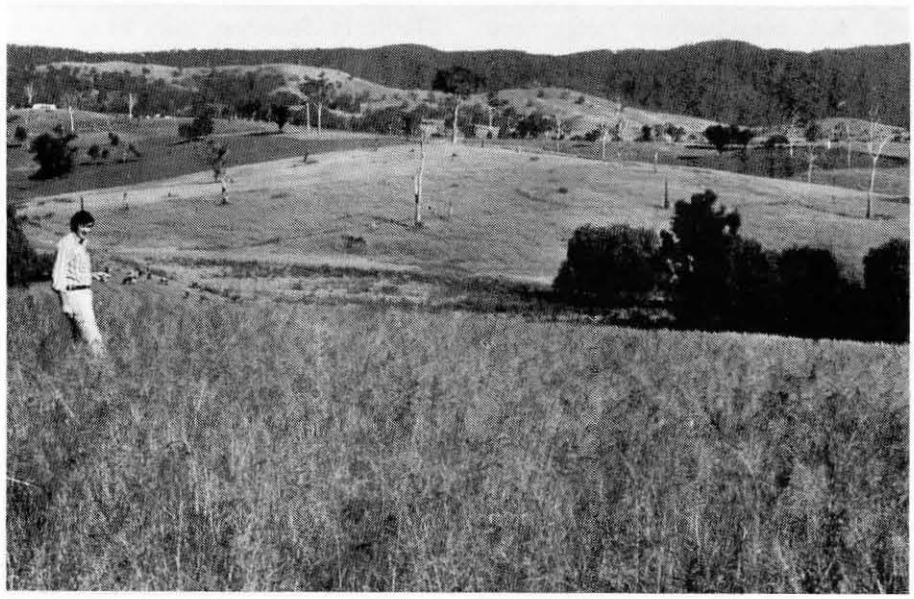
On the other hand the plant has been in the Cowra, Narrabri, Condobolin, Deniliquin and other districts for many years without spreading, presumably due to unfavourable environments. Unless the biology and ecology of a plant is studied (Quinlivan, 1972) the full potential of its spread cannot be assessed accurately. At present the indications are that the plant can spread further, at least within the environments that have already proved to be suitable. As there are large areas on the south coast and northern, central and southern tablelands that are free of the weed but have a similar environment to areas already infested, the potential for spread in New South Wales must be regarded as high.

Weed potential

In 12 of the 56 infested shires, *E. curvula* was rated by weed officers amongst the ten most important weeds, but in only five shires was it rated in the first three. (By comparison, *Nassella trichotoma* was rated in the three most important weeds in 24 out of the 38 shires in which it occurred (Campbell, 1977).) *Eragrostis curvula* has been declared noxious in 18 shires in New South Wales; four of these shires had over 1000 ha, five had 100 to 1000 ha; two had 10 to 100 ha and seven had less than 10 ha.

In one heavily infested shire, Bega Valley, dairy cattle avoid the plant, grazing associated pasture species which gives *E. curvula* a competitive advantage. Beef cattle also avoid the plant in the Tallaganda Shire and graze associated *Phalaris aquatica*. In a heavily infested paddock in this shire, *Eragrostis curvula* had 90% ground cover in early summer 1979, growing to a height of 70 cm which almost covered the *Phalaris aquatica*; in the winter of 1980 it had 95% brown frosted tissue and a crude protein content of 3.6%. On the other hand *Eragrostis curvula* had some value at Deniliquin for sheep meat production when irrigated and supplied with nitrogen fertilizer (Squires and Myers, 1970). It has also been used for beef production in Oklahoma, U.S.A. where, over three years, steers gained an average of 0.44 to 0.49 kg beast^{-1} day^{-1}; the higher weight gain on a palatable selection and the lower on an unpalatable strain (Voigt *et al.*, 1970). The pastures were fertilized annually with 60 kg ha^{-1} of urea. Palatability was associated with low lignin:cellulose ratio, tallness, late heading and wide leaf. In west Texas, experiments have shown that by correct animal management an unpalatable strain of *E. curvula* can be made productive. Cotter *et al.* (1981) grazed decadent stands of *E. curvula* with 3.8 steers ha^{-1} using an eight paddock rotational system with 2 to 5 days grazing per paddock and 39 kg ha^{-1} of fertilizer nitrogen per year. No paddock was regrazed until leaf length was 20 to 25 cm and grazing was foregone in autumn (to allow plants to store food) and winter, which meant reserve pastures were necessary to maintain the system. Liveweight gain varied from 0.2 to 0.6 kg steer^{-1} day^{-1}. Cotter *et al.* (1981) noted that it was essential to use enough livestock to get the needed utilization.

Eragrostis curvula is not considered to be a weed in South Africa, however, Leigh and Davidson (1968) recorded that a curvula-type named Ermelo was probably the most unpalatable plant ever recommended as a pasture species in that country. They stated that 'it has all the vigour of a weed; with appropriate husbandry it might be a valuable pasture, without this it might be an embarrassment'. Thus the evidence



Heavy infestations of *Eragrostis curvula* near Candelo in the Bega Valley Shire. Infested areas are the lighter areas in the foreground, midground and hills in the background.

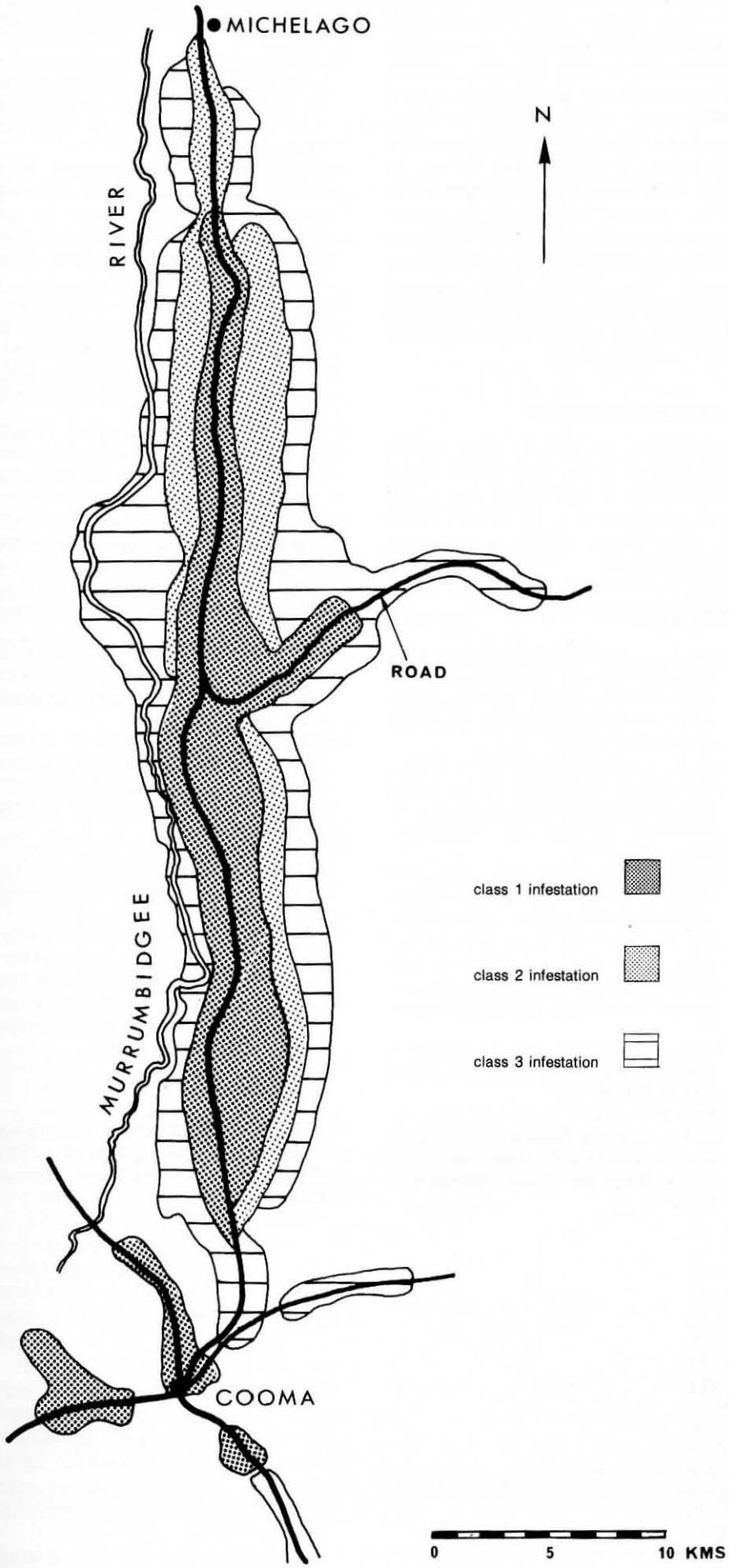


Figure 2 Spread of *Eragrostis curvula* from the roadsides to paddocks in the 60 km between Cooma and Michelago on the southern tablelands of New South Wales.

from U.S.A. and South Africa indicates that with an appropriate grazing strategy the plant may not be a weed but may be used for animal production. However, forcing animals to graze unpalatable grasses, for example *Nassella trichotoma*, is generally not successful over large areas or in heavy infestations, because in periods of abundance animals avoid the weed and in periods of scarcity they overgraze useful species (Campbell, unpublished data).

To overcome this problem a search for more palatable strains of *Eragrostis curvula* has begun in South Africa (Kruger and Grunow, 1982) and Australia. As a result a new strain of *E. curvula*, a conferta-type, has recently been submitted for registration as a pasture species in New South Wales (W. H. Johnston, personal communication, 1982). This strain was shown in grazing trials to be more palatable than many other strains of *E. curvula* (Johnston and Aveyard, 1977). However, if it is released as a pasture species, animals will have the choice of a much wider range of alternatives than other strains of *E. curvula*. Thus its palatability should be compared with that of widely distributed pasture species in New South Wales to ensure that it will not be ignored by grazing animals and become another weed in these situations. It must be remembered that *Nassella trichotoma* is grazed in Argentina in preference to other closely-related grasses (Connor, 1960) but has become a major weed in New South Wales because animals refuse to graze it, selecting the more palatable pasture species available here. Irrespective of the possible value of the conferta-type, the problem of the types already established in the 56 shires in New South Wales remains.

Control

At present *Eragrostis curvula* can be controlled on arable land by ploughing, sowing improved pasture, spelling from animals for a year and removing any re-infestation. On non-arable land scattered plants can be removed by chipping. Recent research has indicated that the herbicide tetrapion can remove selectively *E. curvula* from *Phalaris aquatica*, native perennial grasses and *Pennisetum clandestinum* which will assist control on both arable and non-arable land (Campbell, unpublished data). Registration of the herbicide for these purposes is currently in progress. Replacement of *Eragrostis curvula* on roadsides, railway land, intermittently grazed land and riverbanks, a major problem in its

control, could be achieved by using tetrapion for selective removal of *E. curvula* from native perennial grasses and broadleafed plants which are common in these situations. Other methods would also need to be used to stop its spread, for example aerial sowing or direct drilling of improved pastures after herbicide treatment and the use of road-making equipment free of *E. curvula* seeds.

Conclusion

This survey shows that naturalized strains of *E. curvula* are widely distributed in New South Wales but occupy a relatively small area compared to other major pasture weeds. They are unpalatable and have the potential to spread in regions where the environment favours their growth. This indicates that *E. curvula* is a weed in New South Wales that falls into Category B in the classification of weeds by Amor and Twentyman (1974). Category B is a proclaimed species that should be controlled by governments and by local government as follows: assisting landholders through research, extension, hiring of equipment and loans; suppressing the weed on public land; and organizing containment in regions where local opinion is strongly in favour of enforced control. This could be accomplished under the present weed administrative system in New South Wales.

It would require, in addition to activities already in progress: research by government bodies into the biology and ecology of the weed and its control by grazing management, extension of information by the New South Wales Department of Agriculture on the danger of the weed and methods of control, and special control programmes initiated by local government weed authorities in shires where the weed is already widespread or where it is a potential threat.

Statewide control of the naturalized strains of *E. curvula* would incur expenses to some local government weed control authorities and to some landholders but, because the areas infested are relatively small, immediate control could prove to be a sound investment, keeping in mind the potential spread of the plant. In that respect, it may be wise to reflect on the fact that Cross (1937) warned that *Nassella trichotoma* was a potential weed in 1937. Had control been enforced then it could have saved New South Wales annual production losses of $11.8 million and a control bill of $24.4 million (Vere and Campbell, 1979).

Acknowledgements

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