CLONCURRY BUFFEL GRASS (*CENCHRUS PENNISETIFORMIS*) IN NORTH-WESTERN QUEENSLAND

T. J. HALL*

ABSTRACT

Cloncurry buffel grass (Cenchrus pennisetiformis) *is currently the only introduced pasture grass with the ability to increase carrying capacity and stabilize beef cattle numbers in the Isa Highlands region of north-western Queensland. A morphological description is presented. Its origin, present and potential distribution, and soil characteristics as well as other factors influencing establishment and natural spread are discussed. A map showing existing large Cloncurry buffel areas, localized areas with potential for further spread, and country suited to Cloncurry buffel in selected localities, has been produced.*

INTRODUCTION

White or slender buffel grass (*Cenchrus pennisetiformis*) first appeared in the Cloncurry district of north-western Queensland some 50 years ago. It has subsequently spread along parts of the frontages of all major rivers and watercourses in the district, replacing lower yielding and poorer quality native grasses.

Now known in Queensland as Cloncurry buffel, there is a strongly held opinion that the grass has substantially increased the carrying capacity of country which it has invaded. Its presence has also helped stabilize beef cattle numbers, according to local graziers and others associated with it in the area. At present, Cloncurry buffel and to a lesser extent Birdwood grass (*C. setiger*, previously *C. setigerus*) are the only introduced grasses showing any promise for improving pasture yield and quality in the Isa Highlands region as described by Perry *et al.* (1964).

It has now been in the area long enough and has spread widely enough to enable some assessment to be made of the areas to which it is suited. This paper, after describing the grass and examining its origin, seeks to do this.

MORPHOLOGICAL DESCRIPTION

C. pennisetiformis, originating from India, tropical Arabia and North Africa, differs little in general appearance from commercial cultivars of *C. ciliaris*. There is, however, a difference in degree of union of the inner bristles of the involucre. In *C. pennisetiformis* these are united for a distance of 1 to 3 mm above the base but in *C. ciliaris* they are joined only at the base (Gardner 1952). *C. pennisetiformis* is often distinguished by paler involucres (Gardner 1952) and wider spacing of the spikelets on the rachis (Humphreys 1974). DeLisle (1963) in his comprehensive treatment of the genus *Cenchrus* regarded *C. pennisetiformis* as a synonym of *C. ciliaris* while Vickery (1975) maintains the distinction between the two species on the basis of the connate inner bristles of *C. pennisetiformis*.

The fascicle of *C. setiger*, the other important pasture species of this genus, is more compact and is harder than that of *C. ciliaris*. The bristles of the former are rigid, broad and flat, in contrast to the rather soft hair-like ones of *C. ciliaris* and *C. pennisetiformis*. Identification keys for the three species are provided by Gardner (1952) and Vickery (1975).

ORIGIN

The origin of Cloncurry buffel in north-western Queensland is uncertain. Humphreys (1967) credits this to three plants of Cloncurry buffel which resulted

* Queensland Department of Primary Industries, Cloncurry, Qld. 4824.

from a seed lot received from the Roebourne area of Western Australia by Mr. A. M. Morrison in 1926; these were grown by Mr. Morrison on Maronan Station, situated 65 kilometres south-east of Cloncurry on the Fullarton River. However, this claim becomes doubtful when Humphreys further states that the grass had spread to the denuded town common by 1928. It is unlikely that three plants could have provided the impetus for such spread in two years, particularly as there was no effective rainfall at Cloncurry during the 1927-28 wet season (Everist and Moule 1952). In addition, the Fullarton River flows north-east, away from the Cloncurry River catchment.

Discussions with long term residents of the district support the doubt that Maronan station was the sole source of Cloncurry buffel in the area. Mr. D. J. J. Paterson of Ashley Farm, Cloncurry, and formerly a drover in the district, first noticed Cloncurry buffel around the Afghan camel camp on Coppermine Creek at Cloncurry in 1928. In his opinion the seed came from rotting camel saddles which had been abandoned following the closure of major copper mines and the replacement of camel trains by road and rail transport. Mr. Paterson has maintained an interest in Cloncurry buffel grass from the late 1920s, and during his droving trips north of Cloncurry he used to spread seed which he carried in match boxes. His recollection is that the grass was well established on Coppermine Creek and at the railway trucking yards, near the present golf course, by 1930.

Another resident of the area is Mr. J. T. Spreadborough of Ilkley Station, who formerly worked on Oorindimindi, a property adjoining Maronan. He believed that Birdwood grass, of which Mr. Morrison obtained twelve plants out of the 1926 seed lot (Humphreys 1967), was more common than Cloncurry buffel grass on Maronan until the mid 1950s. This is confirmed by Mr. G. H. Muller, the present owner of Maronan, who found some Birdwood grass but only scattered Cloncurry buffel plants on the property when he acquired it in 1954.

Mr. Muller hand harvested and spread seed of Cloncurry buffel over Maronan for six years with disappointing results; however, since the 1960s the grass has spread rapidly from the isolated clumps that did establish along watercourses. With a run of above average rainfall years between 1971 and 1976, it has spread away from the creeks into hilly country. This observation is in line with those of other property owners in the district, where widespread movement of the plant from the fertile alluvial flats to poorer country over the recent wet years has been noticeable.

Mr. Spreadborough is another who is of the opinion that 1930 was a critical time in the spread of Cloncurry buffel grass around Cloncurry. He considers it became particularly noticeable around the town and in the district after the 1930 drought.

Certainly *C. pennisetiformis* was at Cloncurry in 1934, being collected there in that year by S. T. Blake (Queensland Herbarium records), and at Byrimine Station, 90 km north-east of Cloncurry, in 1936. Also in 1936, S. L. Everist observed the grass growing profusely in the Cloncurry railway reserve (Marriott and Everist, Q.D.P.I. files 1954). In February 1937, Everist and Smith (Queensland Herbarium records) reported that Cloncurry buffel was "very common along banks of the Cloncurry River".

By 1954 the main concentrations of Cloncurry buffel were around Cloncurry, along channels and flood plains of the Cloncurry River, and along Butcher Creek. Smaller areas were present along the Dugald, Leichhardt and Corella rivers (S. Marriott, Q.D.P.I. files). As none of these watersheds has direct connection with the Fullarton River or the Maronan area, this lends credence to the suggestion that the major centre of origin of *C. pennisetiformis* in the north-west may well be Cloncurry township rather than Maronan Station. Afghan camel harness is believed to be the origin of *C. ciliaris* cv. West Australian in the north-west of Western Australia (Marriott 1955) and a similar source is possible for Cloncurry buffel.

During the 1950s the value of the plant had been recognized, and it was actively spread under the guidance of Mr. S. Marriott, even to the extent of full cultivation and sowing of locally harvested seed by a number of landholders, especially on Australian Estates properties. This active planting is no longer being carried on because of the expense involved, and because rapid natural spread has taken place in country where cultivation is impossible.

PRESENT DISTRIBUTION

Extensive areas of Cloncurry buffel occur throughout the Cloncurry and Quamby Land Systems (Perry *et al.*, 1964) on the eastern side of the Isa Highlands. The grass has spread progressively from fertile alluvial river and creek levees, across frontage woodlands, into stony undulating country.

In the eastern half of the Isa Highlands, all main watercourses support large areas of Cloncurry buffel. Some of these include the Fullarton, Williams, Cloncurry, Corella, Dugald, Leichhardt and Burke rivers, as well as Tommy and Butcher creeks. Levees and frontages of these watercourses support buffel stands of varying densities extending for distances of a few metres to several kilometres from their banks. Many hollows and smaller watercourses in hilly country in this portion of the Isa Highlands also carry patches of buffel. Some stony hills adjacent to well established Cloncurry buffel stands on frontage country near Cloncurry are covered with the grass at the expense of spinifex (*Triodia pungens*).

Significant areas of Cloncurry buffel occur throughout the western half of the Isa Highlands, on creek flats, where property owners have planted seed. Patches occur from Wills Creek in the south, around Mount Isa and north to Fiery Creek near Gregory. If not continually grazed, these established areas will be important seed loci for future colonization.

Cloncurry buffel does not grow over gravelly *Aristida contorta* and *Enneapogon polyphyllus* ridges or on steep skeletal soils. Also, the deep brown and grey-brown cracking clays (Ug5.3, Ug5.2 Northcote 1965) supporting *Astrebla* spp. and *Iseilema* spp. in the south-east of the region and *Dichanthium* spp., *Eulalia fulva* and *Astrebla* spp. in the north, are not suited to Cloncurry buffel. Consequently, spread into these communities is not expected.

DISTRIBUTION IN RELATION TO SOILS

In 1958, D. I. Sillar associated spread of Cloncurry buffel grass with high phosphate soils. He also indicated that those near Cloncurry were on dolomitic and calc-silicate rock formations (Q.D.P.I. files). Establishment, growth, drought survival and herbage production of *C. ciliaris* are favoured by high phosphate and alkaline reaction soils (Humphreys 1967, Christie 1975). Both of these factors appear to promote the rate of spread of Cloncurry buffel. The phosphate rich and neutral to alkline frontage soils were first colonized. In Highlands country Cloncurry buffel appears to establish more readily on limestone or calcareous ridges than on other geological types. Deep, light textured soils in geological formations of the Isa Highlands region of the Georgina Basin (Smith 1972) containing phosphatic and calcareous parent material are considered suited to Cloncurry buffel.

The limestone formations of the middle Cambrian era in north-western Queensland have been described (Öpik 1960, Smith 1972) and mapped (Carter *et al.* 1961, Smith 1972). Russell (1967) reports phosphatic lower middle Cambrian formations being present under a wide expanse of the Georgina Basin. The Beetle Creek and Thorntonia limestone formations are two phosphate bearing formations which outcrop across the Isa Highlands. A survey of existing areas where Cloncurry buffel has colonized indicates that the adaptation of the plant is to soils of moderate to high phosphorus status and slightly alkaline reaction.

Potassium does not appear to be a limiting nutrient for Cloncurry buffel growth in the region. Dense stands occur on low potassium soils of both high and marginal phosphate status. In the latter instance spread is slow.

Cloncurry buffel is particularly well adapted to alluvial flats of creeks radiating from regions containing phosphatic rock material. Such soils have acid extractable (BSES) phosphorus levels greater than 30 ppm. Natural spread onto and over loamy red earths with an alkaline reaction but with lower phosphorus levels has occurred in above average rainfall years, provided adequate external seed supplies have been available. Colonization has also occurred on lower phosphate soils beneath the canopy of some tree species, particularly *Eucalyptus argillacea, E. terminalis* and *E. pruinosa*, and in disturbed soil areas along roadsides.

POTENTIAL DISTRIBUTION

Consideration of known Cloncurry buffel distribution in conjunction with Land System maps (Perry *et al.*, 1964, Christian *et al.*, 1954) and soil maps (Isbell *et al.*, 1968, Northcote *et al.*, 1968) has led to the definition of three zones along the eastern margin of, and within, the Isa Highlands region of north-western Queensland where Cloncurry buffel occurs and is potentially suited.

Zone I (Figure 1): Existing large dense areas of Cloncurry buffel. It includes the following landscapes and major soils:—

1. The Cloncurry River frontage country, where buffel first became dominant, which is described by Northcote *et al.* (1968) as gently undulating alluvial plains with many old levees and infilled channels and classified as map unit My95. Dominant buffel soils on Northcote's (1965) classification are deep loamy red earths (Gn2.12, Gn2.13) with brown earths (Gn2.42, Gn2.43), deep sands (Uc5.21) and loams (Um5.22).
2. Other rapidly colonized stream levees and flood plains which occur in map unit My91. Dominant soils are deep loamy red earths (Gn2.12) with associated red earths (Gn2.15, Gn2.13, Gn2.43) and occasional deep sandy red earths (Gn2.11, Gn2.12) and deep uniform loams (Um5.52).
3. Subsequent spread of buffel has been into adjacent undulating and hilly country (map unit Mo34). Main buffel soils are shallow to moderately deep loamy friable red earths (Gn3.12) with smaller areas of the alkaline form (Gn3.13) and occasional loamy red earths (Gn2.12, Gn2.15).

At present there are 860 000 ha of grazing country containing large dense areas of Cloncurry buffel grass mapped as Zone 1. On soil variants within the zone, Cloncurry buffel dominance may be displayed on from 5 to 75 per cent of local areas. The area of dense Cloncurry buffel in this Zone is estimated to be 150 000 ha.

Zone II (Figure 1): Localized areas of Cloncurry buffel with potential for further spread.

Landscapes in Zone II vary from alluvial plains and stream levees (map unit Mx33) to gently and strongly undulating country with rock outcrops (map units include Fa38, Qa27, Mu13 and Fa21). Throughout this zone, soils similar to those carrying dense Cloncurry buffel stands in Zone 1 occur; they are not as extensive and are mostly limited to hollows and narrow creek flats. Small stands of Cloncurry buffel have established on sandy red earths (Gn2.11), loamy red earths (Gn2.12, Gn2.13) and shallow loamy sands (Uc4.22, Uc4.11, Uc4.12) in this zone. These patches will provide seed producing nuclei for further spread. There are 730 000 ha of mainly Highland country in Zone II. Within local areas, from 1 to 15 per cent of the country is suited to some degree of Cloncurry buffel colonization although stands normally will not be as dense as those occurring in Zone I. At present there is estimated to be 4 000 ha with some Cloncurry buffel out of a potential area of 36 000 ha.

Zone III. Areas containing country potentially suited to Cloncurry buffel in selected localities.

Landscapes in this zone range from gently undulating plains with shallow drainage lines to moderately and strongly undulating lands with limestone or dolomite outcrops and steep scree slopes (map units include My93, Od13, Oa19, Fz25, Fa39, Mz34). Suitable Cloncurry buffel soils are on "run-on" areas along water courses, creek levees and valley floors where deep loamy and gravelly red earths (Gn2.12, Gn2.13, Gn2.22) red friable earths (Gn3.12), loams (Um1.43) and sandy red earths (Gn2.15) occur. Similar soils in Zone I and in parts of Zone II support Cloncurry buffel grass.

There are 1.3 million ha mapped as Zone III; however, the area potentially suited to Cloncurry buffel is estimated at less than 1 per cent.

Small patches of Cloncurry buffel occur outside the three zones in isolated areas too small to be mapped separately.

Rainfall throughout the three zones is strongly summer dominant and increases from south to north. Some mean annual rainfalls are—Cloncurry 470 mm, Dajarra 372 mm, Mount Isa 391 mm and Lorraine Station 558 mm. There are no climatic restrictions to Cloncurry buffel growth throughout the region; however, establishment and spread are favoured by above-average rainfall seasons.

Analytical data of surface soils from sites in existing Cloncurry buffel areas and potential Cloncurry buffel country are shown in Table 1.

STRATEGIES FOR PROMOTION OF SPREAD

Commercial cultivars of *C. ciliaris* have been planted on properties in the Cloncurry district, but their performance has been considerably inferior to that of Cloncurry buffel. With the exception of cv. West Australian, which has spread over a few hectares, there has been negligible spread of other cultivars on the Dugald River frontage at "Granada" in more than 15 years. In the meantime, Cloncurry buffel has spread over more than 6 000 ha with the assistance of strip plantings. On the other hand *C. ciliaris* has proved superior to *C. pennisetiformis* in other buffel growing areas of Queensland where the two species have been planted. The reasons for this different regional adaptation have not been identified.

Cloncurry buffel has spread rapidly by natural means in Zone I, particularly during the above average wet seasons commencing in 1970, without widespread hand seeding. Full potential spread in this zone will be achieved by natural means and doesn't require extensive hand broadcasting of seed.

In parts of Zone II and throughout Zone III there are no seed producing colonies; consequently, these will have to be deliberately established if spread is to be hastened. Plantings could be made into selected micro-habitats such as beneath the canopy of *Eucalyptus* trees, where soil fertility is greater than in the inter-tree spaces (Ebersohn and Lucas 1965, Hall unpublished) and in protected locations around logs. On a levee of the Dugald River, at Granada Station, colonization between planted strips was such that after nine years the original plantings were no longer obvious (Bishop *et al.* 1974). It is anticipated that colonization of the creek levees in Zones II and III could take longer than this. The abovementioned authors attributed lack of spread of Cloncurry buffel in the first four years to a need to accumulate reserves of viable seed in the soils; a similar situation could apply to Cloncurry buffel spread on suitable soils of the Highlands. A major force for proliferation of Cloncurry buffel is a run of good seasons. It is important to have seed producing nuclei established when such seasons occur.

Cloncurry buffel seed dispersal from established colonies would be assisted by wind, running water, and cattle movements. On some soils surface disturbance will be required to encourage establishment and subsequent spread. Cloncurry buffel has established readily along many kilometres of roadsides in gravelly soils where the surface has been loosened by machinery, but has not yet spread onto adjoining undisturbed areas. Cultivation has been necessary for satisfactory establishment of

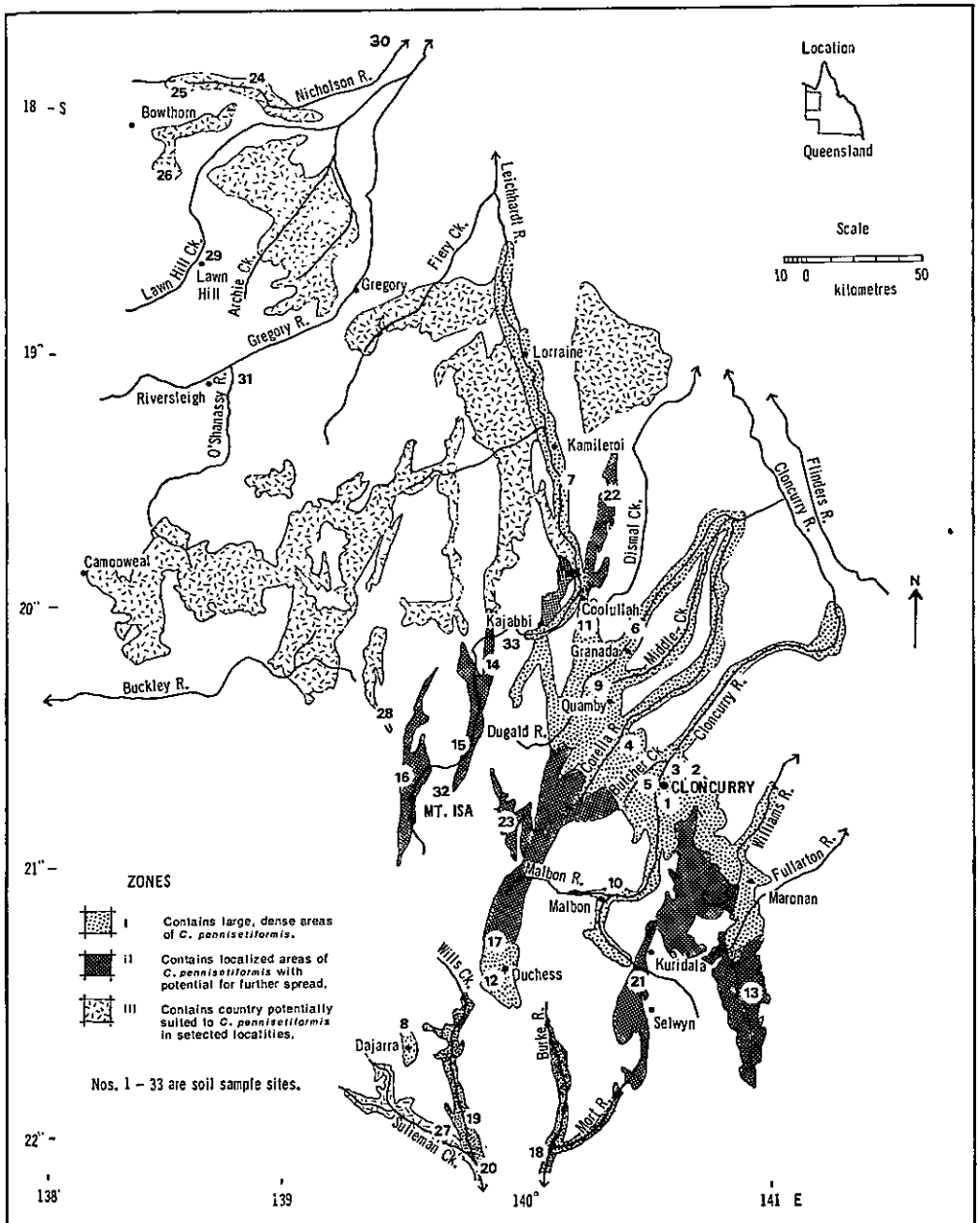

FIGURE 1

Existing areas and potential spread of *C. pennisetiformis* in north–western Queensland

TABLE 1

Surface soil chemical analysis data from existing and potential areas of C. pennisetiformis

Location	Map Zone	pH	Extr. P‡ ppm	Nitrogen		K	T.S.S.	Cloncurry buffel presence and remarks
				Total N%	$NO_3 - N$ ppm	m.equiv. %	%	
1. Cloncurry River frontage 0-10 cm	1	7·0	39		8		0·038	Dense and widespread.
30-45 cm		6·9	49		5		0·030	
75-90 cm		8·5	160		10		0·071	
2. Cloncurry Town Common*	1	8·3	31	0·09		0·65		Dense and widespread.
3. Rocky Outcrop Cloncurry Railway Reserve*	1	7·5	175	0·14		1·75		Dense and widespread.
4. Corella River frontage—"Carsland"	1	6·9	120			0·79		Dense and widespread.
5. Ridges—on Cloncurry River frontage	1	6·5	41		2	0·27	0·006	Dense under trees, scattered in inter-tree spaces.
6. Dugald River frontage—"Granada"†	1	7·1	175		Low (4 to 6)	0·90		Dense and widespread.
7. Leichhardt River alluvium—"Kamilaroi"††	1	6·8	68	0·033			0·010	Dense and widespread.
8. Creek Flat—"Stanbroke"—Dajarra**	1	7·3	105		V. low (< 3)	0·80		Dense patches and spreading.
9. Hollow in ridge country—"Patricia Vale", Quamby	1	7·8	47		3	0·45	0·012	Dense and widespread.
10. Malbon River—"Devoncourt"*	1	8·2	175	0·10		0·70		Dense, associated with Birdwood grass.
11. Leichhardt River frontage—"Coolullah"	1	7·2	175	0·09		1·48		Dense and widespread.
12. Creek flat—"Ashover", Duchess**	1	6·6	120	0·03		0·73		Spreading down creeks.
13. McKinlay River terrace—"Percol Plains"	2	7·1	109	0·09		0·96		Widespread.
14. Leichhardt River flat—5 km north of Lake Julius	2	7·9	64		4	0·64	0·016	No buffel present.
15. Creek flat 38 km south of Lake Julius	2	7·1	120		3	0·57	0·010	No buffel present.
16. Spring Creek flat 20 km NNW of Mount Isa	2	7·1	28		4	0·69	0·013	Clumps under trees, Birdwood grass present.

17. Creek flat—"Bushy Park", Duchess**	2	6·6	39		V. low (< 3)	0·64		Spreading down creeks.
18. Burke River levee—"Windsor Park"	2	7·7	120 33‡‡		10	0·88	0·010	Dense stands and spreading.
19. Wills Creek frontage—"Buckingham Downs"	2	7·1	79 21‡‡		6	0·48	0·012	Dense areas and scattered clumps in favourable microhabitats.
20. Wills Creek frontage—"Two Rivers"**	2	6·9	175	0·09		1·66		Patches and spreading.
21. Creek flat—"Farley", Kuridala**	2	7·7	136	0·20		1·60		Dense and spreading.
22. Hollow in ridge country—"Boomarra"	2	8·7	120 18‡‡		21	0·29	0·026	Dense down hollow, throughout woodland.
23. Creek flat—Mary Kathleen**	2	6·7	175		High (26-50)	0·63		Dense close to water course only.
24. Nicholson River frontage—Doomadgee Mission	3	6·8	19		16	0·37	0·024	Scattered plants.
25. Nicholson River frontage—"Bowthorn"	3	6·5	9		3	0·29	0·010	Under trees, very slow to spread.
26. Musselbrook Creek—"Bowthorn"	3	6·7	13		2	0·32	0·006	Mainly under trees and spreading.
27. Sulieman Creek frontage—"Buckingham Downs"	3	7·2	64 31‡‡		9	0·61	0·011	Scattered clumps in some areas.
28. Hollow in highlands 30 km NNW of Mount Isa	3	6·6	5		2	0·43	0·006	Scattered plants.
29. Creek flat—"Lawn Hill"**	§	8·1	115		Med. (7-25)	0·52		Dense patches.
30. Nicholson River frontage—"Escott"	—	6·2	13		9	0·76		Buffel and Birdwood grass, negligible spread.
31. O'Shanassy River frontage—"Riversleigh"**	—	6·3	190		V. low (< 3)	0·70		Dense patches.
32. Disturbed soil 10 km east of Mount Isa	—	9·0	120 7‡‡		12	0·45	0·021	Dense buffel; negligible in undisturbed adjacent country.
33. Creek flat 13 km west of Kajabbi	—	7·4	120		2	0·46	0·008	No buffel present.

* Soil samples collected by F. C. West (1955, Q.D.P.I.).
** Soil samples collected by D. I. Sillar (1957-60, Q.D.P.I.).
‡ BSES extraction (Kerr and von Stieglitz, 1938).
‡‡ Bicarbonate extraction (Colwell, 1963).
† Champ, Sillar and Lavery (1961).
†† Hubble and Beckmann (1957).
§ Areas too small or narrow to map separately.

C. ciliaris on a range of soils, particularly those with a neutral to acid reaction (Norman 1961, Brzostowski 1962, R. J. Jones cited by Humphreys 1967). However, full cultivation is not appropriate in this area and advantage should be taken of roadside disturbance.

Exclusion of stock at strategic times will be necessary for establishment, seeding and spread, in Zone III and parts of Zone II. At present Cloncurry buffel stands in the Highlands country are continually grazed and consequently rarely grow higher than about 20 cm. For most of the year the tussocks are grazed down to 10 cm or less and consist mainly of stems with very little leaf material. This contrasts with the situation on frontage country in Zone I. Here cattle select the new shoots of Cloncurry buffel which appear before growth commences in the native perennials, such as *Chrysopogon fallax*, *Dichanthium* spp. and *Bothriochloa* spp. Later, as new growth becomes available from the natives, stock concentrate on this, thereby relieving the pressure on the Cloncurry buffel and allowing it to seed. As the season progresses, stock return to the Cloncurry buffel, which is then heavily utilized for the remainder of the year. This grazing pattern allows seed to build up and seedlings to establish. In the Highlands alternative pasture species—*Triodia pungens*, *Aristida* spp. and short lived annuals such as *Enneapogon* spp.—are less palatable, and stock graze the Cloncurry buffel at all times.

Some work on pelleting Cloncurry buffel seed with basic superphosphate and lindane for control of seed harvesting ants has been done in this environment (Champ *et al.* 1961); however, no particular seed treatment is considered necessary.

Although the potential area of Cloncurry buffel is relatively low compared with the total area of light textured soils in north-western Queensland, it should be remembered that Cloncurry buffel areas currently take the brunt of stocking pressure. Therefore the grazing benefit from Cloncurry buffel is considerably higher than may be assumed from its area alone.

ACKNOWLEDGEMENTS

I am grateful to Mr. G. R. Lee and other colleagues who have assisted with the preparation of this paper, to the Agricultural Chemistry Branch of the Queensland Department of Primary Industries for conducting soil analyses, and to the Australian Meat Research Committee for financial support to conduct field surveys.

REFERENCES

BISHOP, H. G., WESTON, E. J., and SILLAR, D. I. (1974)—Spread of Cloncurry buffel grass (*Cenchrus pennisetiformis*) on a river levee in north-western Queensland. *Queensland Journal of Agricultural and Animal Sciences* **31**: 253-61.

BRZOSTOWSKI, H. W. (1962)—Influence of pH and superphosphate on establishment of *Cenchrus ciliaris* from seed. *Tropical Agriculture, Trinidad* **39**: 289-96.

CARTER, E. K., BROOKS, J. H., and WALKER, K. R. (1961)—The Precambrian mineral belt of north-western Queensland. Department of National Development, Bureau of Mineral Resources, Geology and Geophysics Bulletin No. 51, Volumes I and II.

CHRISTIAN, C. S., NOAKES, L. C., PERRY, R. A., SLATYER, R. O., STEWART, G. A., and TRAVES, D. M. (1954)—Survey of the Barkly Region, Northern Territory and Queensland, 1947-48. C.S.I.R.O. Land Research Series No. 3.

CHAMP, B. R., SILLAR, D. I., and LAVERY, H. J. (1961)—Seed harvesting ant control in the Cloncurry district. *Queensland Journal of Agricultural Science* **18**: 257-60.

CHRISTIE, E. K (1975)—A study of phosphorus nutrition and water supply on the early growth and survival of buffel grass grown on a sandy red earth from south-west Queensland. *Australian Journal of Experimental Agriculture and Animal Husbandry* **15**: 239-59.

COLWELL, J. E. (1963)—The estimation of phosphorus fertilizer requirements of wheat in southern New South Wales by soil analysis. *Australian Journal of Experimental Agriculture and Animal Husbandry* **3**: 190-97.

DELISLE, D. G. (1963)—Taxonomy and distribution of the genus *Cenchrus*. *Iowa State Journal of Science* **37** (3): 259-351.

EBERSOHN, J. P., and LUCAS, P. (1965)—Trees and soil nutrients in south-western Queensland. *Queensland Journal of Agricultural and Animal Sciences* **22**: 431-35.

EVERIST, S. L., and MOULE, G. R. (1952)—Studies in the environment of Queensland—2. The climatic factor in drought. *Queensland Journal of Agricultural Science* **9**: 185.

GARDNER, C. A. (1952)—*Flora of Western Australia*. Government Printer, Perth, Western Australia.

HUBBLE, G. D., and BECKMANN, G. G. (1957)—The soils of some western Queensland properties of Australian Estates Company. C.S.I.R.O., Division of Soils, Divisional Report 6/56.

HUMPHREYS, L. R. (1967)—Buffel grass (*Cenchrus ciliaris*) in Australia. *Tropical Grasslands* **1**: 123-134.

HUMPHREYS, L. R. (1974)—*A guide to better pastures for the tropics and sub-tropics*. Wright Stephenson and Company (Aust.) Pty. Ltd.

ISBELL, R. F., WEBB, A. A., and MURTHA, G. G. (1968)—Atlas of Australian soils. Explanatory data for sheet 7, North Queensland. C.S.I.R.O., Melbourne University Press.

KERR, H. W., and VON STIEGLITZ, C. R. (1938)—The laboratory determination of soil fertility. Bureau of Sugar Experiment Stations, Queensland, Technical Communication No. 9.

MARRIOTT, S. (1955)—Buffel grass. *Journal of the Australian Institute of Agricultural Science* **21**: 277-78.

NORMAN, M. J. T. (1961)—The establishment of pasture species with minimum cultivation at Katherine, N.T. C.S.I.R.O., Australian Division of Land Research and Regional Survey Technical Paper No. 14.

NORTHCOTE, K. H. (1965)—A factual key for the recognition of Australian Soils. Second edition, C.S.I.R.O., Australian Division of Soils, Divisional Report 2/65.

NORTHCOTE, K. H., ISBELL, R. F., WEBB, A. A., MURTHA, G. G., CHURCHWARD, H. M., and BETTENAY, E. (1968)—Atlas of Australian Soils. Explanatory Data for Sheet 10,Central Australia. C.S.I.R.O., Melbourne University Press.

ÖPIK, A. A. (1960)—*The geology of Queensland*. Editors: Hill, D., and Denmead, A. K., Melbourne University Press.

PERRY, R. A., SLEEMAN, J. R., TWIDALE, C. R., PRICHARD, C. E., SLATYER, R. O., LAZARIDES, M., and COLLINS, F. H. (1964)—General report on lands of the Leichhardt-Gilbert area, Queensland, 1953-54. C.S.I.R.O., Land Research Series, No. 11.

RUSSELL, R. T. (1967)—Discovery of major phosphate deposits in north-west Queensland. *Queensland Government Mining Journal* **68**: 153-57.

SMITH, K. G. (1972)—Stratigraphy of the Georgina Basin. Department of National Development, Bureau of Mineral Resources—Geology and Geophysics. Bulletin III.

VICKERY, JOYCE W. (1975)—*Flora of New South Wales*. No. 19. Gramineae, Supplement to Part 1. Part 2. New South Wales Department of Agriculture.

(Accepted for publication January 5, 1978)