I

INTRODUCTION

The importance of the Gramineae, both as a vital resource in the rural industry and as the dominant family in the herb layer of many communities, has been thoroughly emphasised by agriculturalists and botanists.

On the New England tableland, as elsewhere in temperate Australia (Walley, 1970a), most research has, however, concentrated on exotic grasses introduced for pasture improvement, and though by far the greater area is dominated by native species, there is a disproportionate knowledge of their botanical and agronomic attributes. The need for more information on indigenous grasses received economic emphasis during the exceptionally dry years on the tableland from 1965 to 1968, when properties which had relied on pastures of introduced species were severely affected by the drought conditions, forcing the owners to ajist their livestock or send them out to graze grasslands on roadsides and stock routes.

Most of the recent Australian research on native grasses is in the fields of taxonomy and grassland ecology (particularly with regard to the effects of pastoral management - e.g., Biddiscombe, 1953, and Williams, 1968). The progress of native grassland research is somewhat hampered by a lack of ecological studies applying floristic skills to the occurrence and structure of community types (such as the survey of the western plains of New South Wales by Beadle, 1948), and the problems experienced by agronomists in utilising the results of taxonomic research for the correct identification of species in native communities.

The aim of this thesis is to provide a link between taxonomy and agronomy for ecological research on grasses and grasslands of the New England region. The need for a stronger connection between the two disciplines was illustrated in a recent publication on the Tenterfield area (Auld and Scarsbrick, 1970), in which a pasture dominant, *Sporobolus elongatus*, was not only incorrectly identified as *S. africanus*, but the authors employed the now invalid name of *S. capensis*.

The major part of the project involved the construction of keys to the grasses of New South Wales and New England employing characters suitable for field determination with, at the most, the assistance of a handlens. Preliminary to such a task, it was necessary to acquire a comprehensive understanding of the Gramineae, of its Australian genera, and in particular to become familiar with local and State species. With the guidance of Vickery's census of the native grasses of New South Wales (Vickery, 1953), the original descriptions were studied, and in most cases translated from the Latin, and representative specimens were examined.

While making observations on New England grasses, the author became curious as to the nature of the grasslands at the time of European settlement. Though squatters pioneered the region, few of their impressions of the pastures have survived, and probably very little was ever recorded.

The grass flora, on the other hand, can be deduced in some detail for the second half of last century by an analysis of the Gramineae in Flora Australiensis, by Bentham and Mueller (1878). This analysis forms a basis of comparison with subsequent reports on grasses found in the area, culminating in a complete, current list. The central portion of the thesis presents a key to the known New England grass flora, with brief descriptions of the genera and species and a discussion of their occurrence and distribution.

As a supplement to Roe's preliminary survey (Roe, 1947), a limited quantitative assessment was made of selected communities relatively protected from primary production. It is hoped the report may facilitate further ecological studies on the grasslands of the region.

II

DESCRIPTION OF NEW ENGLAND REGION

Introduction

Various authorities have defined different boundaries of New England to suit particular interests. The present study is concerned with the grasses and grasslands of a natural pastoral unit whose borders may be justified in terms of topography, geology and climate to achieve a degree of uniformity in these features throughout the region. Thus altitude is used as a guide rather than an absolute criterion, and wherever extensions of the complex of New England ranges and plateaux project beyond the outline of the granite bathylith or exhibit climatic characteristics diverging from the main tableland climate, those areas have been excluded from the region. In the former category are the Nandewar Range to Mount Kaputar and the Liverpool Range to the Warrumbungles. Climatic disqualification applies to the stretch of tableland north of the State border, which has a warmer winter than the New South Wales portion.

The most pronounced disagreement on the delimitation of the region centres around the western boundary. The western slopes lack a clear topographic demarcation, and rather than impose a natural border, an artificial boundary has been drawn along meridian 151°E and thence north-east in a straight line to the Queensland border. By this definition the region encloses a marginal atypical strip along the foothills of the north-west slopes which exhibits a warmer climate than the rest of the region and includes grass species that are absent from the higher tableland plateau. This discrepancy is correlated with the inclusion of the Inverell district within the New England region, since it shares some marginal floristic and climatic attributes with the north-western edge. The incorporation of Inverell and the lower north-west slopes partly contravenes the basis of delineation stated above, but some degree of imprecision is considered an inevitable consequence of adopting an arbitrary western border where no clear and satisfactory natural boundary is available.

The following section discusses the definition of the borders in more detail, and the region thus specified for the subsequent floristic and ecological study is compared with earlier concepts of New England. The topography is described and main river systems draining the area are noted. The distribution of geological formations is illustrated and related to soil types of the region. Climatic conditions in the area are reviewed, and the vegetation is discussed with particular reference to forest formations and dominant tree species. The concluding section summarises principal features of the description.

Definition of Area

The settled tableland district north of the Liverpool Plains was loosely called "New England" in the 1830's by the early English squatters, who recognised its similarity to parts of their home country (Walker 1966).

The Act of 1839 which established the Pastoral District of New England, defined its boundaries in relation to Mount Werrikimbe as the south-east corner, the southern border lying at latitude $31^{\circ}12'$S and the eastern border being a line north from Mount Werrikimbe along longitude $152^{\circ}14'$E. The western border was vaguely expressed "as to include the tableland", while the northern boundary was specified "indefinite" (Walker, 1966). Under the Act, a Crown Lands Commissioner was appointed, and he fixed his headquarters on the site of the future town of Armidale. In 1839 the northern limit of settlement was not far past Armidale, and "New England" denoted the southern part of the tableland, beyond which the plateau continued as "Beardy Plains" (Campbell, 1922) in honour of two bearded bushmen who acted as guides for squatters exploring the northern parts.

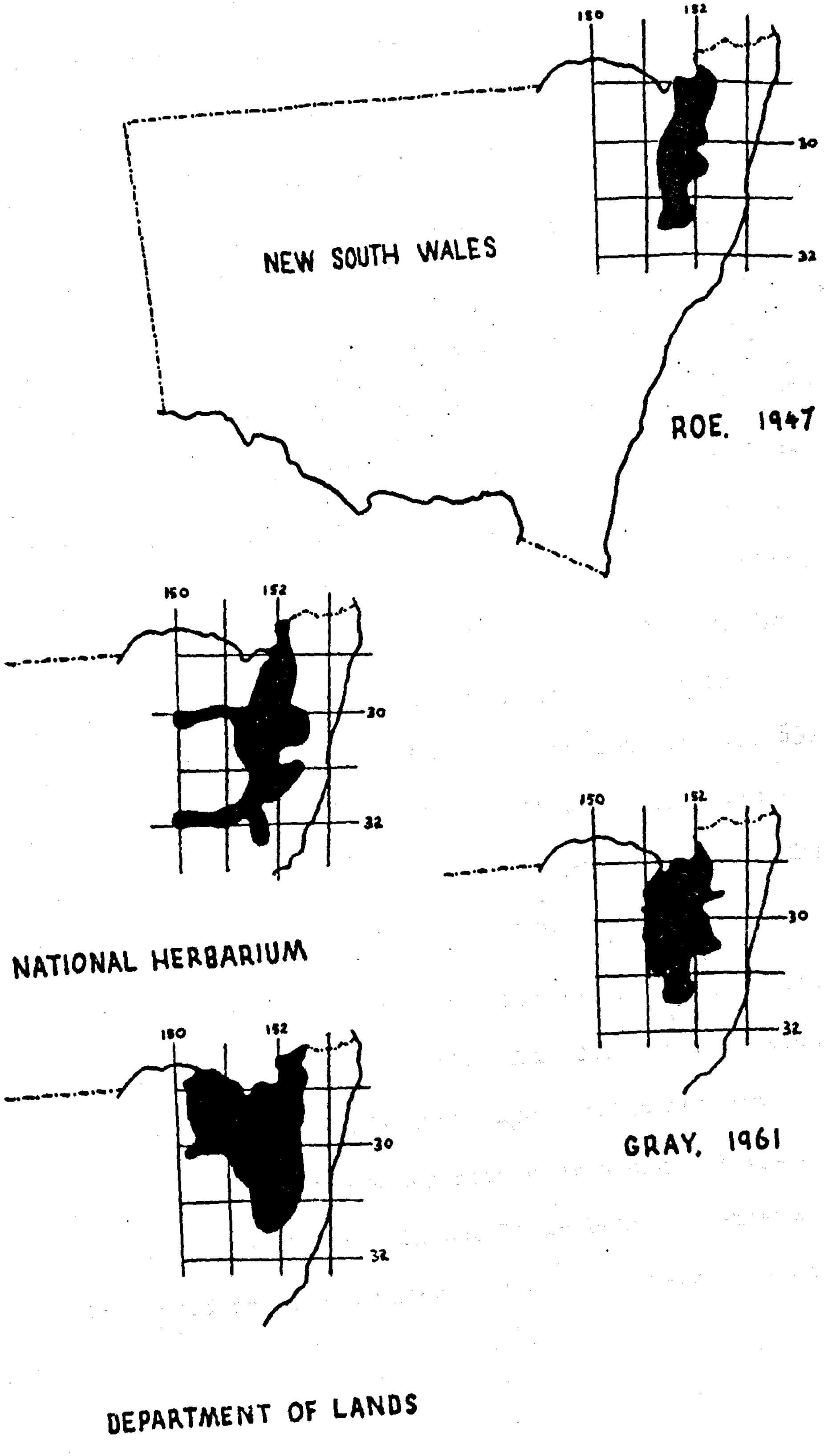
Governor Gipps, in 1840, placed New England between parallels 26° and 32°S, which embraced the Darling Downs, but in 1843 the northern boundary was officially set at 29°S and the other borders maintained as stated above, with the south-east corner adjusted from Mount Werrikimbe to nearby Mount Seaview (Campbell, 1922). The region has more or less retained these boundaries ever since, conforming to the State border in the north, the escarpment on the east, and the vicinity of parallel 31°30'S in the south. The definition of the western border, however, has remained open to interpretation, and as Turner pointed out in 1895, ".....its exact geographical limits have...been the cause of considerable controversy".

As illustrated in Fig. 1, there are still differences of opinion over the demarcation of New England, particularly with regard to its western edge. A map of the region drawn by the Department of Lands in 1946 for the Premier's Department of the New South Wales Government, shows the western limit extended past Bingara almost as far as meridian 150°E, and on the eastern side it includes small areas of coastal country below 1,000 ft, such as Tabulum. This is the broadest view of New England and perhaps the most artificial, since it involves an area in the north-western sector that lies below 1,000 ft and has a climatic affinity with the western plains.

The National Herbarium in Sydney adopts the 2,000 ft contour as the boundary line (except in the north), which produces narrow westerly extensions along the Nandewar and Liverpool Ranges to Mount Kaputar and towards the Warrumbungles respectively, and a southerly projection to include Barrington Tops. Fig. 1 illustrates the unusual tentacled shape resulting from this approach, and

FIG. 1

FOUR CONCEPTS OF NEW ENGLAND



though it forms a natural unit in the biogeographical divisions of New South Wales employed by the National Herbarium, its extremities are too remote from the central pastoral area of the region for the purposes of the present study.

In his preliminary survey of the natural pastures of New England, published in 1947, Roe's interpretation of the region is presented as a narrow strip of tableland bounded on the west about the 3,000 ft contour. Such a border forms a natural boundary in the northern part using the contour as a guide, but in the south the western slope is more gentle at that altitude, and a border further west is favoured. The limits proposed by Gray (1961) agree with this view of the south-western margin and, in the author's opinion, come closer to an acceptable definition of the region, though the validity of his western line based on topographic features is questioned. The western border adopted by Spencer and Barrow(1963) is slightly west of Gray's boundary in the north-west, but swings east to within a few miles of Uralla in the south-east sector. They give no particular reasons for their delineation.

The main area of controversy lies between Inverell and Watsons Creek (11 miles NNW of Bendemeer). This line is traversed by the Nandewar Range, which spreads into rugged hills between Kingstown and Barraba and extends a northern spur along the 151°E meridian. There is a natural break in the Range between Barraba and Bingara which could provide a boundary to the western edge of the tableland, or the border could be drawn along the northern spur. The author has chosen the latter alternative, but as the spur approaches Inverell it merges with undulating plains which separate the Range from an escarpment boundary proceeding north north-west of Inverell. In contrast to the well-defined eastern escarpment, the north-west decline is somewhat irregular, with contours that do not readily lend themselves to adoption as criteria for a straightforward boundary.

In the absence of clear topographic discontinuities, the western border, for this study, is marked by meridian 151°E between Watsons Creek and the Macintyre River, thence a straight line to Maidenhead, where the Beardy River joins the Dumaresq. Marginal country linking the western plains with the north-west slopes is included in this demarcation, and consequently several western grasses extending inside the north-west boundary, but unknown on the tablelands, are incorporated in the New England flora (see Chapter VII).

From Maidenhead, the State border beteeen New South Wales and Queensland is taken as the northern limit of New England, as is customary. Near Wylie Creek, north-east of Stanthorpe, where the Dividing Range is narrow and flattened, the eastern boundary proceeds south from the State border, following the edge of the scarp and lying generally between the 2,000 and 3,000 ft contours. This border, drawn in Fig. 2, was determined with the assistance


2b
GEOLOGY
Basaltic
(red)
Granitic
(clear)
Sedimentary
(blue)
x Localities of
Sample Areas (Ch.IX)
Serpentine

2a

VEGETATION, RAINFALL AND TEMPERATURE RANGE

Rainforest And Closed Canopy

Standard Average Rainfall (inches)

Avge. Jan. & July Temps.

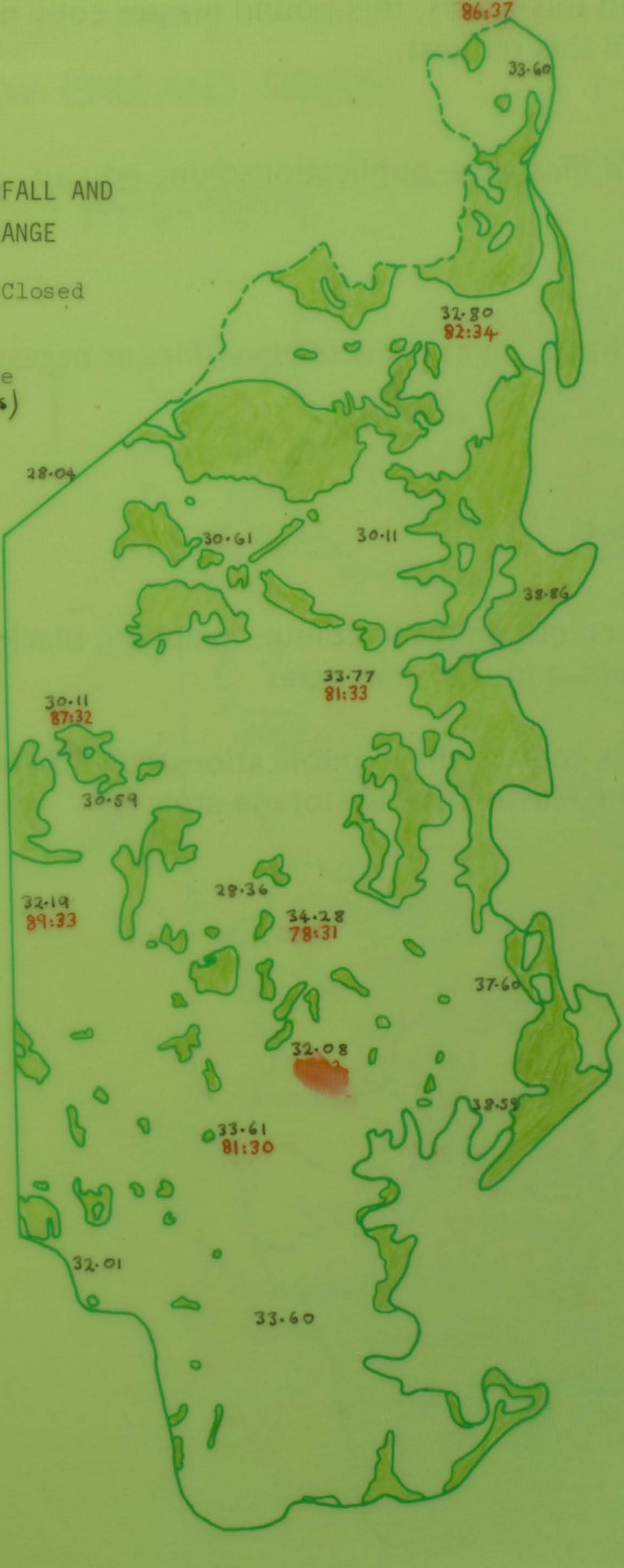
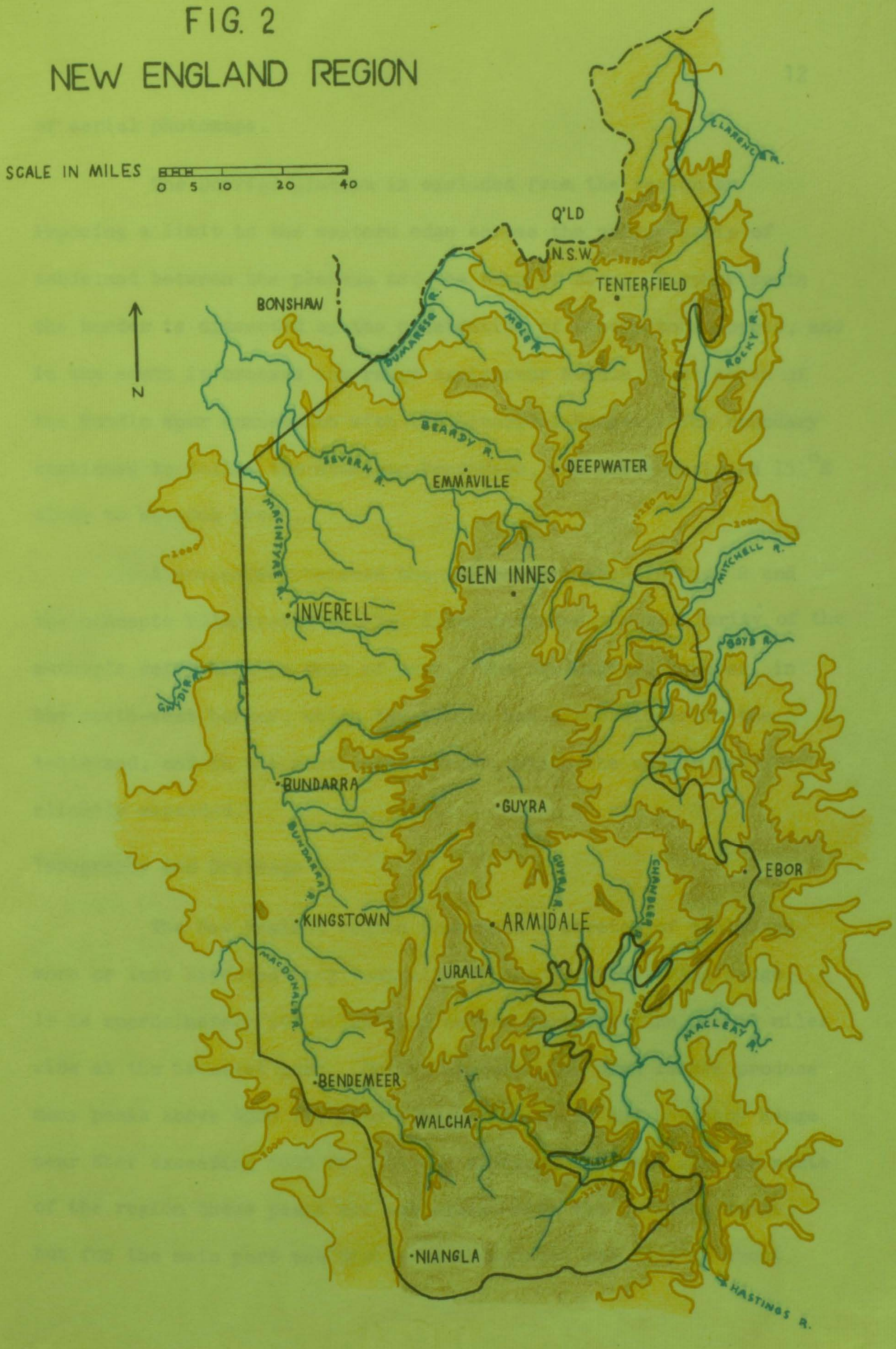


FIG. 2
NEW ENGLAND REGION



of aerial photomaps.

The Dorrigo plateau is excluded from the region by imposing a limit to the eastern edge across the narrow strip of tableland between the plateau and the town of Ebor. Further south the border is dissected by the penetration of precipitous gorges, and in the south it crosses the range again near Nundle, just north of the Nundle spur connection with the Liverpool Ranges. The boundary continues to follow the scarp to Bendemeer, and meets meridian 151°E close to Watsons Creek.

A comparison between the region described in Fig. 2 and the concepts illustrated in Fig. 1 demonstrates the similarity of the author's definition to that of Gray. The two differ, however, in the north-west border, which the author has drawn closer to the tableland, and in the north-east corner, which the author has slightly expanded.

Topography and Drainage

The New England region comprises a stretch of tableland more or less bisected longitudinally by the Great Dividing Range. It is approximately 200 miles long on the northern line and 90 miles wide at the broadest part. On the eastern side high ranges produce many peaks above 4000 ft, with some mountains of the Doughboy Range near Ebor exceeding 5000 ft. In the northern area and extreme south of the region these peaks are associated with the Dividing Range, but for the main part the Divide is indistinct and lies at about

3500 ft.

The eastern border follows the coastal side of the Great Divide in the north and along the edge of a conspicuous escarpment south of the Gibraltar Range, often characterised by steep gorges. Rugged mountains re-appear in the Moombi Range in the south and the Nandewar Range on the west, and in the north-west some steep declines occur, but the remainder is generally undulating to hilly country dotted with isolated peaks.

The tableland plateau consists of a narrow strip from the north-east extremity passing through Tenterfield and Deepwater to Glen Innes, where it broadens to the east and descends to the Inverell plains on the west. An area of plateau spreads east between Glen Innes and Armidale, and a second large segment extends south of Armidale through Walcha to the border. The western side slopes gently between the Divide and boundary as far north as Emmaville, and a narrow crescent of foothills stretches from the Inverell district along the north-west border. The main pastoral centres occur around the principal towns.

Beyond a line between Guyra and Ebor the eastern fall forms part of the Clarence River catchment area, comprising in particular the Boyd, Mitchell and Rocky Rivers. South of that line the tableland is drained by watercourses feeding the Macleay River, such as the Chandler, Guyra and Apsley Rivers, and further south by creeks leading into the Hastings and Manning

Rivers. West of the Divide there are four major river systems, beginning with the Macdonald River passing through Bendemeer which flows into the Namoi. On the slopes west of Armidale the Bundarra River flows north before swinging west into the Gwydir, and the Macintyre River of Inverell also flows north to be joined by the Severn River which rises near Glen Innes before leaving New England in the north-west. Two smaller streams, the Beardy and Mole Rivers, drain the slopes west of Tenterfield and feed the Dumaresq River, which forms part of the State boundary.

Geology and Soils

The geological history and principal features of the region have been discussed by Voisey in his inaugural lecture (1955) and the relevant chapter in New England Essays (1963), and will be considered only briefly here. A recent map of the geology of New South Wales prepared by the state Department of Mines (1962) provides the basis for Fig. 2b, which illustrates the main rock types of the region and its periphery. The areas of volcanic and granitic rocks are reproduced faithfully, but the various sedimentary formations have been grouped into one classification to simplify the geological picture.

The New England bathylith of granite dominates the region and its distribution approximates the borders defined earlier. The igneous material is a complex of different granite types which intruded during the late Permian into Palaeozoic sediments and are associated with elevation and folding of the sediments. Porphyries are common on the western side of the Divide and granite and granodiorite prevail in the east.

The Palaeozoic sediments are chiefly slates, phyllites and a few schists, there being a low degree of metamorphism in general. After the Permian upheaval there followed a relatively quiescent period in the Mesozoic characterised by erosion of sediments which revealed the bathylith in several places and depressed surface relief. A lake formed in the Armidale district towards the end of the Mesozoic and early Tertiary sediments were deposited.

Later in the Tertiary, probably the Oligocene, successive volcanic flows from fissures poured basalt over the greater part of the area, sometimes to a total depth of over 1000 ft. Subsequent earth movements near the close of the Tertiary era uplifted the bathylith to its present position.

Extensive erosion has destroyed most of the basalt, leaving a few sheets north of Inverell and in the Ben Lomond - Guyra and Armidale-Uralla districts. In addition, scattered residuals of basalt cap many flat-topped hills throughout the area. The weathering and erosion has exposed early Tertiary lake sediments, much of the granite bathylith and the surfaces of various Palaeozoic sediments, thereby creating the landscape as it now stands.

There is a close correlation between the geological formations and the distribution of major soil groups in the region, as demonstrated by the soil maps published by Jessup (1965) and Northcote (1966). On the strip of basalt separating the two main masses of exposed granite and on the residual basaltic outcrops, black earths, chocolate soils, red earths and a few lateritic profiles have developed. In the Inverell district euchrozems of the Amarina family occur on colluvium and alluvium derived from basalt, and they are generally deeper and contain fewer stones than the red chocolate Aperta family in the Guyra association. The lateritic Gooramadda family in several tableland localities also occurs on basaltic colluvium or alluvium, and bears ferruginous and ferro-manganiferous nodules in the A_2 horizon.

Solodic and podsolic soils have developed on most sedimentary and granitic parent materials. These are characterised by stronger profile differentiation with an eluviated A_2 horizon and lower fertility and surface clay content than the basaltic soils, though the nutrient status of soils on sedimentary rocks varies with contrasting layers of parent material. Banyo and Nillimuk families are important soils on porphyry and indurated sediments, and tend to be more fertile than the Jeramatta, Baratook and Champoon families, or areas dominated by granite outcrops and skeletal sedimentary soils.

Analytical data for four representative profiles on the three types of parent material have been abstracted from Jessup

TABLE I

Soil Profile Data (Published by Jessup, 1965)

Soil	Gleyed Solodic		Grey-Brown Podsolic		Red Chocolate		Black Earth	
Family	Jingella		Champoon		Aperta		Daalkoo	
Parent Material	Sedimentary		Granodiorite		Basalt		Basalt	
Location	Rockvale		Uralla		Chiswick		Inverell	
Depth	0-4"	7-15"	0-11"	21-30"	0-3½"	13-24"	0-1½"	16-26"
Horizon	A_1	B_1	A_1	B				
pH	6.6	8.3	6.3	6.0	6.4	6.5	6.9	7.8
Clay %	27	41	6	42	32	84	84	83
Organic Matter* %	8.1	4.3	1.9	5.9	13.6	13.0	12.1	11.0
Nitrogen %	0.235	0.052	0.058	0.050	0.326	-	0.249	0.112
Phosphorus %	0.024	0.011	0.014	0.035	0.121	-	0.040	0.025
Total Exch. Cations **	20.2	10.5	5.7	19.5	43.8	48.3	99.4	98.2

* Loss on ignition

** m-equiv./100g soil

(1965) and presented in Table I. The moderately high rainfall in the region maintains acidic to neutral conditions in at least the surface horizons, with pH increasing with depth for solodics and black earths. The comparative Table emphasises the sandy texture of the poorer soils and their lower levels of organic matter and exchangeable cations. Understandably, the basaltic soils are the most suitable for cultivation and pasture improvement.

The influence of topography is reflected in the occurrence of podsolic soils on hill-slopes where the rate of leaching creates an acidic profile low in bases and soluble salts, which drain to valley sites displaying solodic soils. As Jessup (1965) pointed out, rainfall effectiveness declines in a westerly direction and this drop in leaching potential promotes solodic profile formation irrespective of topographic features on the western side of the region with a corresponding diminution of podsolic soils. For basaltic soils on the tableland, the leaching differential down a slope has resulted in the formation of catenas with chocolate soils on the higher sites, prairie soils lower down and wiesenbodens in the valleys.

Spencer and Barrow (1963) measured growth response of a Phalaris-subclover pasture over a two-year period to test the nutrient status of New England soils. They reported general deficiencies in phosphorus, nitrogen and sulphur. Deficiency in phosphorus caused the main limitation on growth and was evident over 90% of the area, particularly on podsolic and solodic soils. Sulphur deficiency was also widespread but was not noticeable until the second year of growth.

Climate

The climate of New England is cool to mild temperate with a predominantly summer rainfall. The average annual precipitation for most of the region is from 30 to 33.6 inches, but near Ebor and Glen Elgin it rises to over 38 inches (Williams, 1963, and Woolmington and Warner, 1965, have reported over 60 inches near Point Lookout), and towards the north-west plains falls to 28 inches. Rainfalls for a number of centres published by the Commonwealth Bureau of Meteorology (1966) are included in Fig. 2a. These figures are standard averages over a period of 30 years from 1931 to 1960.

Surveys of the Macleay, Clarence, Gwydir and Macintyre and Severn River Valleys prepared by the New South Wales Water Conservation and Irrigation Commission (1966-1968), show that the wettest months of the year are December to April, with a second peak in June-July. Reference has already been made above to the decreasing effectiveness of rainfall across the region from east to west. Roe (1947) pointed out that variability of monthly rainfall is consistent throughout the year, and that once in ten years the annual rainfall is below two thirds of the mean. Consecutive dry seasons are relatively common, as experienced during the recent dry years since 1964. Although the majority of the rain falls in the summer months and autumn, Begg (1959) found that the greatest soil moisture stress occurred during the same period, the maximum soil moisture being attained in winter and spring. The advantage of winter soil moisture levels favourable for plant growth is off-set however, by low winter temperatures and frosty conditions which severely limit the growth of native grasslands.

Monthly maximum and minimum temperatures published in the Surveys of River Valleys (cited above) indicate that the coldest month is July and the warmest weather occurs in January. The average maximum January temperature and the average minimum July temperature for eight sites are shown in Fig. 2a. Temperature range is relatively constant on the tableland, the winter average minima falling to 30°F at Uralla and increasing northwards to 34°F at Tenterfield and, north of the border, 37°F at Killarney (just beyond the north-east corner of the region). The minima in individual years can fall well below the mean, however, as evidenced by the unusual minima of 16°F for Armidale and 10°F for Walcha on a couple of days in 1970. The low temperatures are associated with winter frosts and occasional snow falls. In the Armidale and Guyra districts frost occurs on average on 100 to 165 days of the year and snow can be expected at any time between June and October (Davies and Warner, 1963; Water Conservation and Irrigation Commission, Water Resources of the Macleay Valley, 1968), and in some years, such as 1970, light snow falls are registered in May.

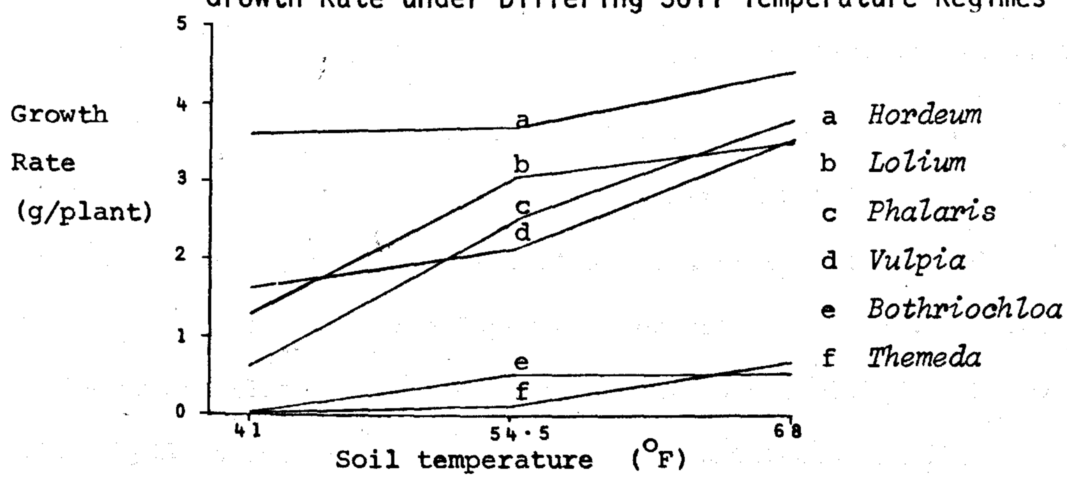
Overall, the severity of winter conditions decreases towards the north and north-west parts of the region, and summer temperatures increase from east to west. The average maximum January temperature ranges from 78°F at Guyra to 87°F at Inverell and 89°F at Bundarra, and one would expect it to be higher along the north-west border which lies at a lower altitude and has a drier climate.

Winter soil temperatures were recorded by Davies and Warner (1963) in the Guyra - Ben Lomond district. The measurements were taken on basaltic peaks 4,630 to 4,920 ft above sea level with readings at the soil surface and 2½ inches below. At the higher altitude, average daily minima at the surface fell below freezing point for three winter months and mean ground daily minima were reduced to 34 and 35°F. At the lower site daily minima were slightly higher, the lowest below-surface daily means being 38 and 37°F in July and August. Meteorological records from the C.S.I.R.O Pastoral Research Station at Chiswick, ten miles south of Armidale, show that mean overnight (4.30.a.m.) soil temperature taken 1 inch below the pasture fell to 36.2°F in July, 1963, and to 40.3°F in August of the same year. The July mean is lower than the July mean minimum recorded by Davies and Warner at 4,630 ft, though the elevation at Chiswick is close to 3,300 ft. Winter soil temperature during the day does not rise very high on the basis of a mean July soil temperature of 40°F at four inches below the surface reported by Agyare (1967).

Soil temperatures in the vicinity of 40°F could be expected to limit plant growth, as Blackman (1936) discovered with English pastures dominated by *Lolium perenne*. Davidson (1969) considered the influence of root/leaf temperature differentials on root/shoot ratios for several grasses, and permitted some of the data obtained during the study (Davidson, 1970) to be presented in Fig. 3. The curves represent the top-growth of both native and introduced grasses under varying soil temperature regimes with constant ambient temperature. The trial was conducted for a period of three months. The growth of winter annuals (*Vulpia* sp., *Hordeum leporinum*) and the introduced temperate species (*Lolium perenne, Phalaris tuberosa*) at 41°F soil temperature contrasts with the dormancy of native species such as *Bothriochloa macera* and *Themeda australis*. Even at a soil temperature of 54.5°F the growth rate of the native species is severely limited, whereas introduced European species are approaching maximum spring productivity.

FIG.3.

Growth Rate under Differing Soil Temperature Regimes



The cold winters probably exert the major climatic influence on the indigenous New England flora.

Vegetation

Apart from the marginal and sporadic intrusion of rainforests along the eastern edge of the region, eucalypts are the dominant trees of New England vegetation. Areas of forest and woodland with a more or less closed canopy have been drawn from aerial photomaps and illustrated in Fig. 2a. The following summary of forest types and the principal tree species has been adapted from Williams (1963; 1970). [An ecological study of the region to assess potential land use was commenced by Jessup in 1950, but the results of the vegetation survey have not yet been published.]

In the high rainfall areas near Point Lookout and the Gibraltar Range there are patches of wet sclerophyll forests dominated by *Eucalyptus obliqua* L'Hér., *E. fastigata* Deane and Maiden, and *E. viminalis* Labill. The greater part of the forest coverage, however, consists of dry sclerophyll forests and woodlands.

The dry sclerophyll eucalypt forests are confined to podsolic, solodic or skeletal soils with marked nutrient deficiencies and usually consist of stunted trees with a well-developed xeromorphic shrub layer and few grasses among the herbs on the forest floor. Bogs and fens are often associated with dry sclerophyll forests at high altitudes in mountainous granite country. Peppermints such as *E. acaciiformis* Deane and Maiden and *E. radiata* Sieb. ex DC., stringybarks such as *E. caliginosa* Blakely et McKie and *E. youmanii* Blakely and McKie, and gums such as *E. dalrympleana* Maiden ssp. *heptantha* L. Johnson and *E. deanei* Maiden, characterise dry sclerophyll on the eastern side. Forests west of the Divide are commonly dominated by gums (e.g. *E. bancroftii* Maiden and *E. dealbata* A. Cunn. ex Schau.), stringybarks (e.g. *E. youmanii* and *E. macrorhyncha* F. Muell), and the peppermint *E. andrewsii* Maiden. On the western side cypress pine (*Callitris endlicheri* (Parl.) F.M. Bail.) is frequently encountered on rocky hill-sides, and the silver-leaf ironbark (*E. melanophloia* F. Muell.) dominates patches of the north-west slopes.

The woodlands have a grassy herb stratum with few shrubs, and grade imperceptibly into more open savannah vegetation, which has generally arisen from deliberate clearing by pastoralists. In woodland communities on fertile basaltic soils, *E. viminalis* is a common component, associated with *E. pauciflora* Sieb. ex Spreng. (and often also *E. stellulata* Sieb.ex DC.) at high altitudes. On the podsolic and solodic soils the woodlands are frequently dominated by *E. blakelyi* Maiden and *E. melliodora* A. Cunn. ex Schau., with associated species such as *E. bridgesiana* R. T. Baker, *E. conica* Deane and Maiden, *E. andrewsii*, *Angophora floribunda* (Sm.) Sweet, and *E. albens* Benth. appearing at lower elevations. *E. caliginosa* is a characteristic ridge species, especially on skeletal soil, and *E. nova-anglica* Deane and Maiden is common in valley woodlands on the eastern side of the Divide.

Trees of the savannah are generally remnants of former forests and woodlands; *E. melliodora, E. blakelyi, E. viminalis* and *Angophora floribunda* are frequently encountered. The grassland communities and their dominant species are discussed in detail in subsequent chapters.

The vegetation map, Fig. 2a, shows that most of the region is savannah or open grassland. Forested areas prevail on the ranges and rugged hill-slopes along the eastern boundary as far south as Armidale, the hilly north-west decline around Emmaville, and on the Boonoo Boonoo plateau north of Tenterfield. Patches of woodland and forest lie between Armidale and Inverell and are usually associated with hilly topography. Virtually all the vegetation communities are utilised for pastoral interests. Even the rocky hills, rugged mountains and areas left in a forested condition because the poverty of the soil does not warrant the expense of clearing, are lightly stocked.

Summary

The New England region is defined by the State border in the north, the escarpment in the east (approx. $152^{\circ}15'$E), the narrow neck of tableland near Nundle in the south, the escarpment in the south-east as far as meridian 151°E, on the west by the same meridian to the Macintyre River near Graman, thence a straight line to Maidenhead at the junction of the Beardy and Dumaresq Rivers. The region is approximately 200 miles long and 90 miles wide at the broadest part through Armidale, and lies between 2,000 and 4,000 ft with several peaks approaching and a few exceeding 5,000 ft.

Most of the region is undulating to hilly with rugged ranges and a steep escarpment on the eastern edge, and a steep decline on the south-west and north-west borders. The Great Dividing Range more or less bisects the tableland, watercourses on the eastern side chiefly leading into the Clarence and Macleay Rivers, and the western drainage feeding the Namoi, Gwydir, Macintyre and Dumaresq Rivers.

A granite bathylith dominates the geology of the area, with a strip of basalt from Inverell to Glen Innes and down to the Armidale-Uralla district. Many Palaeozoic sediments are exposed in the north-west and south-east sectors and in the vicinity of Bundarra. Podsolic and solodic soils of moderate to low nutrient status have developed on granite and sedimentary material, whilst more fertile chocolate, red earth and black earth profiles occur on basaltic parent material.

The New England climate is cool to mild temperate with an average annual rainfall between 30 and 33.6 inches over most of the region. It has a predominantly summer rainfall with a second and smaller peak in mid-winter. Average winter temperature minima fall to around freezing point and summer mean maxima range from 78 to

89°F. Rainfall decreases towards the north-west and summer temperatures increase westerly. The severity of winter conditions is the most distinctive feature of the climate.

Savannah and open grasslands cleared for grazing are the prevailing vegetational forms. Dry sclerophyll forests on poor soils, and woodlands on basaltic and solodic soils, are associated with ranges, steep slopes and rocky hills along the eastern boundary and north-west decline, and occur in patches in the western districts. Various *Eucalyptus* species and *Angophora floribunda* are the dominant trees of the region, the most common eucalypts being *E. blakelyi*, *E. viminalis*, *E. melliodora* and *E. caliginosa*. *Callitris endlicheri* is frequently encountered on rocky slopes in the western half.

SECTION A

HISTORICAL PERSPECTIVE

III

NEW ENGLAND GRASSLANDS

IN THE NINETEENTH CENTURY

The present state of New England grasslands is largely a function of the vegetation as it existed at the time of European settlement and the impact of pastoral management during the last one hundred and fifty years. Considerable changes have probably occurred since the days when the pioneers first drove their flocks onto the tableland, but in order to understand these changes it is necessary to know something of the structure and floristics of the grasslands of that period. The principal sources of information on this subject are the writings of early squatters and the tutor William Gardner, all with very little or no botanical training. The following study is severely limited by a dearth of informed, original material.*

Explorers

The first explorers to reach New England were Oxley and his party, who ascended the range near the present township of Limbri in 1818. After some "precipitous travelling", Oxley reported that the top country was "well clothed with grass" and displayed "a great number of fallen trees [which] was in some measure accounted for by the men observing about a dozen trees on fire near this [aboriginal] camp, no doubt the more easily to expel the opossums, rats, and other vermin which inhabit their hollows."[I] Continuing

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* For this chapter only, the practice of using footnotes has been adopted in accordance with the accepted conventions for referring to historical documents and secondary sources.

I. John Oxley, *Journal of Two Expeditions into the Interior of New South Wales*, London, 1820, pp. 287, 289-290.

east, he crossed the Apsley River a few miles south of the spot where Walcha now stands,[2] and wrote, on 8 September:"...we proceeded through the finest open country, or rather park, imaginable: the general quality of the soil excellent..."[3] The firing and burning by aborigines receives further attention later in the chapter; as for Oxley's park-like countryside near Walcha, the description undoubtedly influenced the tableland's first squatter, who re-discovered the region in 1832.

The journals of two other explorers who reached the Peel River add little to the record. Cunningham's expedition in 1827 approached the tableland from the south, but the rugged nature of the range diverted him to the north west.[4] His northward progress remained west of the tableland through lightly-timbered, occasionally very open country with "patches of plain", drought-stricken but well-grassed, the drought resistance of the native grasses by the Macintyre River deserving his commendation.[5] The return journey

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2. Subsequent references to townships in this chapter denote the site of the town rather than the township itself.
3. Oxley, *op. cit.*, p. 291.
4. Mrs. C.B. Marriott, *Early Explorers in Australia*, London, 1925, p.550; Marriott quotes Cunningham's journal where he observes; "...the country to the north-east and east appeared lofty, broken and submountainous, the ranges thickly wooded and seemingly grassy, yet the abrupt character of their western acclivities obliged me to abandon the design of proceeding northward from Peel's River."
5. Marriott, *op. cit.*, pp.556-558; Cunningham comments in his journal: "We were surprised to observe how wonderfully the native grasses had resisted the dry weather on the upper banks of this dried watercourse. They appeared fresh and nutritive, affording abundance of provision..."

from the Darling Downs took him across the Dumaresq River about thirty miles west of Tenterfield, but he was no longer interested in the ranges and travelled south-west to rejoin his trail near Warialda, noting "good grass" periodically in his journal.[6] Thomas Mitchell made two expeditions, in 1831 and 1846, which passed close by the tableland on the western side. His remarks on species found and collected are of little value to the student of New England vegetation.[7]

Pioneer Squatters

The interval of fourteen years between Oxley's discovery and the advent of pastoral settlement is explained by Campbell as being due to the inaccessible nature of the eastern and southern margins, and the indifferent pasturage of the granite belt confronting pioneers from the west.[8]

In 1832 the first pioneers ventured onto the tableland; they were Hamilton Collins Sempill and Edward Gostwych Cory.[9] Sempill brought his Hunter Valley flocks up the Nundle spur and

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6. *ibid.*, pp. 574-577.
7. T. Mitchell, *Three Expeditions into the Interior of Eastern Australia*, 2 vols., London, 1838, Vol. I, and T. Mitchell, *Journal of an Expedition into the Interior of Tropical Australia*, London, 1848.
8. J.F. Campbell, "Discovery and Early Pastoral Settlement of New England", *Royal Australian Historical Society, Journal and Proceedings*, Vol. 8.(1922) p.246.
9. R.B. Walker, *Old New England*, Sydney, 1966, p.11.

settled at Walcha, while Cory, displaced from his runs on the Liverpool Plains by the Australian Agricultural Company, ascended the Moombi ranges and established himself at Gostwyck. In 1840 there were sixty six stations scattered loosely over the tableland and by 1848 the best grazing land in New England was already occupied, the next eight years adding only ten new stations, most of them situated in the rough country of the eastern highlands.[10] These early holdings were mainly taken up by squatters seeking " a more or less abundant supply of grass and water which could be obtained there for the starving flocks of the lowlands during times of drought"; the majority resided on their southern properties and sent experienced bushmen to look after their New England runs.[11]

There were several reasons for the reluctance of squatters to occupy the tablelands. Many were landowners in the Hunter Valley and preferred to build homesteads there rather than risk unnecessary capital improvements on squattages with insecure tenure.[12] The frosty winters and difficulty of access also militated against permanent occupancy in the early stages of settlement.[13] The handfull of pioneer squatters who did live on

10. *ibid.*, p. 42
11. Campbell, *op. cit.*, p. 234.
12. *ibid.*, p. 238
13. *ibid.*, p. 234.

their runs record in their diaries and letters many details and trials of the squatting life, but unfortunately (for our purposes) they concentrated on economic problems, home cultivations for subsistence cropping, building huts and fences and chasing stray cattle; pasture evaluation was largely overlooked, and in practice remained the day-to-day responsibility of the hired shepherd.[14]

From the few references to the vegetation in the available records, it is evident that Oxley's impressions of the Walcha country could have been applied to most of New England. John Everett, who with his brother George took up "Ollera" near Wandsworth, made the following notes in his diary in 1838; "There is plenty of grass in all directions and plenty of water. It is too open for cattle....Large flats with water running through them, open down-like plains....It is not densely wood, but more like open park scenery... the soil of some flats very good, no necessity for clearing".[15]

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14. A.V. Cane, *"Ollera" 1838-1900*, M.A. Thesis, Sydney University, 1949, pp. 55058; Correspondence of Thomas Tourle, *passim*, comprising letters written from Balala to England, 1839 to 1845, photocopy held by Mr. R. Hudson, Balala; *Memoirs of Edward and Leonard Irby* (1841 to 1845) [hereafter referred to as Irby Memoirs], typescript of book published by William Brooks, Sydney, 1908, *passim*.
15. J. Everett, diary, 1838, University of New England Archives. There is no reference to any date in the diary after a statement that he left Sydney, 11 November, 1838, on his way to New England.

On taking up his run at Strathbogie, Frederick Lamotte reported "fine open country, with small plains and beautiful ridges",[16] and Captain Henderson in 1851 also remarked on the "openness of the countryside and thinness of the wood."[17] This opinion is further supported by M. H. Marsh who acquired Salisbury station in 1840,[18] and by George Mundy on the occasion of his visit to Salisbury Plains in 1847. Mr. Mundy was by no means attracted to the tableland, however suitable it might be for grazing sheep:

> " The country we passed through latterly did not give us a very favourable idea of the soil of New England, its vegetation, or its scenery. The timber is poor in size and tiresome of aspect. Being lightly wooded, it is however well calculated for stock farming.[19]

> " Salisbury Plains is an undulating tract clear of trees and scrub, and clothed with good grass. Both pasturage and climate are admirably adapted to sheep farming. They are suitable also for breeding, but not for the feeding and fattening of horned stock."[20]

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16. F.C. Lamotte, letter dated 5 April, 1840, quoted in full by R.L. Dawson, "Outback from the Hunter, New South Wales, to 'New Caledonia' and the Severn River in 1840", *Royal Australian Historical Society, Journal and Proceedings*, Vol. 15 (1929),pp.44-46.
17. Captain Henderson, *Excursions in New South Wales*, 1851, p.244, quoted by Cane, *op. cit.* p. 24.
18. M. H. Marsh, *Overland from Southampton to Queensland*, London, 1867, p.55.
19. G. C. Mundy, *Our Antipodes; or, Residence and Rambles in the Australasian Colonies, with a Glimpse of the Goldfields*, 3 Vols., London, 1852, Vol. 2, p.33.
20. *ibid.*, p.36.

Observations on the grassland itself are meagre. Edward Irby wrote in a letter from Deepwater station in 1842: "The grass grows very differently here to what it does in England! At a distance it appears as though the ground were were well covered with it, but when you are walking you will perceive that half the surface is bare".[21] On a page of the Old Letter Book dated 1840, John Everett reported: "...those open grassy parklike tracts of which so much has been said characterise the secondary range of granite and porphyry...the grass was chiefly of the kind called oat or forest grass which grows in tufts at considerable distances from one another and which generally affords good pasturage."[22] These two extracts indicate the tussocky structure of the grassland, suggesting dominance by a caespitose perennial.

On the high ranges near the eastern edge of the tableland, however, the ground is described by Gardner as "covered with a thick sward of grass similar to the grass fields in England. Grass does not grow in tufts in that part of the country as it does in most parts of New South Wales..."[23] The eastern highlands were the last and least attractive areas to be settled, and remain generally lightly stocked and heavily timbered to the present day.

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21. Edward Irby to his mother, 1 November, 1842, in Irby Memoirs, *op. cit.*, p. 38.
22. J. Everett, Old Letter Book, University of New England Archives. The Book contains various jottings written from 1836 to 1849 including copies of business letters dated 1843 to 1848. A two-page account of the vegetation of New England dated 1840 appears among the business letters in between two letters to Mr. W. Dawes, one dated 14 April, 1847, and the other undated.
23. William Gardner, *Production and Resources of the Northern and Western Districts of New South Wales*, 2 Vols,1854,Vol.1,p.20. Microfilm, University of New England Archives.

The licenced holdings established by the squatters were "usually bounded by leading ridges, and embraced the valley or valleys lying between. They were briefly described as embracing all the land drained by a main stream and its tributaries".[24] The natural ridge boundaries were timbered and often rocky - "rough country" usually avoided by the shepherds.[25]

The grazing value of the New England grasslands in the pioneering days is difficult to assess. In 1840 Governor Gipps referred to the region as "a wonderful extent of comparatively flat land...one of the best grazing Districts in the Colony." [26] His description may have been influenced by reports from squatters during the succession of particularly good seasons in the late 1830's[27] and he probably overlooked the extremes of abundance and poverty characteristic of natural pastures in the tableland climate, but whatever his evidence the residents did not share his opinion without qualification. Though the grass was plentiful, the Everetts at "Ollera" found the rain caused it to become rank and tough and the winters were so severe that they labelled August "starvation month".[28] Despite the fact that runs were large enough to accommodate sheep

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24. Campbell. *op. cit.*, p. 241.
25. Edward Irby to his mother, 1 November, 1842, in *Irby Memoirs, loc. cit.*
26. Governor Gipps, in a despatch to the Colonial Secretary, 28 September, 1840. *Historical Records of Australia,* Series I, xx (1924), p. 841.
27. Cane, *op. cit.*, p. 24.
28. *Ibid.*

at one for every 4½ acres and allow them to select the most palatable grasses available,[29] feed quality was the limiting factor, and its limitations were most acute in winter as frosts "destroyed much of the herbage and the nourishing qualities of the grasses, which are found to be hard, dry and unfit for sheep."[30] Fluke, footrot and other diseases created additional hardships,[31] apart from the depredations by aborigines and native dogs.[32]

There is scarcely any reference to the prevalence of kangaroos in the early records of the region, when stock numbers were low, and one must assume that the squatters did not view them as a serious nuisance to the grazing industry. In the 1880's, however, there is evidence of large-scale slaughter of kangaroos, one property killing 10,000 in 1881 and another destroying 20,000 in four years.[33] It is unlikely that kangaroo shooting at this rate was a sudden innovation; more probably the marsupial population became a threat to productivity in the 1870's, or even earlier, and their slaughter gradually increased in severity. Their presence must be conceived in terms of a threat rather than an irresistible temptation to the sporting instincts of the settlers and their men, since graziers offered an incentive of 6d. a head for kangaroos and 3d. for wallabies.[34]

29. Walker, *op. cit.*, p. 31.
30. Gardner, *op. cit.*, p. 25.
31. Cane, *op. cit.*, pp. 63-65.
32. *ibid.*, pp. 37, 71-72
33. *ibid.*, p. 125.
34. *ibid.*

Cane suggests that aboriginal hunting had kept the animals in check, and that "as the years passed, the blacks died out and the kangaroos and possums multiplied till they began to have a serious effect on the grass."[35] This reasoning does not seem valid, however, since according to a report by the Commissioner for Crown Lands resident at Armidale in 1842, there were only five or six hundred aborigines on the tableland, or one person to every 22 square miles,[36] hardly a sufficient hunting force to control the kangaroo population, particularly when possums and small marsupials relatively easy to catch formed a large part of their diet.[37] It is more plausible to believe that the density of kangaroos was restrained by the availability of feed, and that the number of large marsupials remained more or less constant until their competition for grazing lands provoked the graziers to introduce control measures.

Quite early in the history of the region, the squatters turned to European grasses and legumes to try and improve what Campbell called "the coarse and sour characteristics of much of the pasturage".[38]

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35. *ibid.*
36. R.B. Walker, "The Relation Between Aborigines and Settlers in New England, 1818-1900",*Armidale and District Historical Society,Journal and Proceedings,* 4(1962),p.8. The Aboriginal population was beginning to decline during this period:I.C. Campbell, *The Relations Between Settlers and Aborigines in the Pastoral District of New England 1832-1860,* B.A. Hons. thesis, University of New England, 1969.
37. Walker, *Old New England, op. cit.,* p. 5.
38. Campbell, *op. cit.,* p. 241.

Marsh sowed the first white clover at Salisbury in 1841, and though many other English clovers and grasses were tried, white clover was the most successful.[39] Experimental use of lucerne began at "Ollera" in the late 1840's, and in the 1860's rye, cocksfoot, prairie grass and sheep's burnet were all sown for pasture.[40] The history of pasture improvement in New England is an absorbing study but must be left outside the scope of this thesis, save to mention that thirty years after their introduction, rye, cocksfoot and prairie grass could be singled out for their potential contribution to the productivity of New England pastures.[41]

Cultivation of commercial crops flourished briefly in New England when the tableland was envisaged as a possible granary for the Colony, and with the wheat came an influx of free selectors who challenged the holdings of the squatters and initiated a turning point in the pastoral industry. The Robertson Land Act of 1861 provided freehold farmers with security of tenure over a few hundred acres; selectors rushed in eagerly to accept the offer, but wheat farming was handicapped from the beginning by an unfavourable climate, low fertility soil in most areas, and insufficient capital to clear and prepare the ground properly and apply adequate fertilizer. Soil

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39. Marsh, *op. cit.,* p. 54.
40. Cane, *op. cit.,* p.24.
41. F. Turner, *Australian Grasses,* Sydney, 1895, p. xxxii.

depletion and competition from better and cheaper Adelaide flour forced the collapse of New England's wheat industry by the 1880's, with the exception of the Inverell area. The free selectors who survived were generally those who abandoned crops and grazed fine-woolled merinos instead; others turned to maize, oats, potatoes or fruit, or sold out to large pastoral interests. Contrary to the expectations of 1861, the principal beneficiaries of Robertson's farming scheme were the squatters, who utilised the Act to acquire their own freehold properties which were amalgamations of selections bought by members of their own families and by "dummy" farmers under contract. In the scramble for the best land, however, the original pastoral holdings were severely trimmed, and the transformation from squattages to properties was accompanied by a reduction in their overall grazing acreage.[42] Efficient utilisation and control of available pasture became an important aspect of property management, and shepherd supervision of flocks was discarded in favour of a more economic paddock retention system. Fencing became imperative, and for the first time the squatters sought to improve the existing natural pasture by clearing the timber and burning off the frosted winter herbage.

Clearing and Burning

The early writings of three pioneer squatters mention timber treatment only on a very small scale - ringbarking swampy areas and

42. Walker, *Old New England, op. cit.*, Chapters 5 and 6.

preparing home paddocks for cultivation.[43] On the Everett's property, extensive clearing of grazing land did not begin until the 1870's.[44] The trees were initially ringbarked, which provided only a short-lived improvement in grass quality[45] and allowed a crop of suckers and saplings to spring up which, if left unchecked, gave the countryside a bush-like rather than park-like appearance.[46] Burning the dry top growth of grass in late winter or early spring ensured a flush of green grass with the onset of warm weather, but this practice could also have detrimental results if poorly managed (see Section C).

There is no doubt that when the squatters arrived, grass fires were already a common occurrence, largely due to the careless attitude of aborigines.[47] The following two extracts indicate the prevalence of fires, their aboriginal origin, and their role in preventing brush growth in the open grasslands:-

> i) The great [summer] heat is sometimes increased by the burning grass, which is generally lighted by the aborigines carrying fire about with them; these fires, when there is a wind, will burn for days, but if there is no wind, there is almost always a dew at night, which often puts them out. The sight of fires at night is sometimes magnificent, as whole ranges of mountains are lighted up by them. They have a great effect on the character of the country, as they burn many of the young trees, and thus prevent the forest from being too thick. All the country, except when heavily stocked with sheep, is sure to be burnt at least every two or three years.[48]

43. Correspondence of Thomas Tourle, *op. cit., passim;* Irby Memoirs, *op. cit., passim;* Cane, *op. cit.*, especially p. 63.
44. Cane, *ibid.*, p. 97.
45. P. Wright, "Pasture Improvement in New England", *Armidale and District Historical Society, Journal and Proceedings*, 7 (1964), p.16.
46. Cane, *op. cit.*, p. 22, note (3)
47. A.R. King, *The Influence of Colonization on the Forests and the Prevalence of Bushfires in Australia,* CSIRO. report, Melbourne, 1963. p.2
48. Marsh, *op. cit.*, p. 413.

> ii) The country round three sides of the station is now on fire...It is generally supposed that these large fires are caused by the natives dropping their fire-sticks accidentally, and not from any design on their part of trying to burn the settlers out of their station. They sometimes burn the old grass off, in order that they may have a chance of killing kangaroos when they go to feed on the young grass that springs up, and also when they think they are likely to be pursued they fire it to prevent their tracks being seen.[49]

References to bushfires started by natives disappear from the records in the 1860's, probably because the aborigines were being brought within the authority of the white settlements.

In a note published in 1848, Mitchell also emphasised the utility of fires for aboriginal game-hunting and stressed their value in eliminating shrub and sapling growth in the grasslands. He added: "The squatters, it is true, have also been obliged to burn the old grass occasionally on their runs."[50] The extent to which pioneer squatters capitalised on the pasture response to aboriginal fires is a matter of conjecture, but it would appear that as the grazing industry developed the squatters adopted burning for their own purposes. The letters and diaries for the first two decades of the pioneers cited previously make no reference to deliberate burning off, but by the end of the century it was an established procedure,[51] and is still a common feature of natural pasture management, despite its deleterious effects on soil properties and pasture quality if

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49. Edward Irby to his father, 6 December, 1842, Irby Memoirs, *op. cit.*, p. 41.
50. Mitchell, 1848, *op.cit.*, p. 413
51. P. Wright, *op. cit.*, p. 16.

carried out on an annual basis over a long period.

Botanists*

The first stage in the botanical investigation of New England grasslands was gathering information on the species present. The principal nineteenth century collectors in the region were C. Stuart, C. Moore, Perrott, W. Woolls and F. Turner. Stuart was a collector employed by the Botanical Department at Melbourne[52] and, through von Mueller, provided the bulk of New England grasses cited by Bentham in the Flora Australiensis. The brief discussion that follows is concerned with the common and dominant grasses of the area; the floristics are considered in detail in Chapter IV.

After Stuart, Turner made the next major contribution to botanical knowledge of the tableland, collecting widely and augmenting his material with specimens submitted by interested pastoralists. He published the first census of New England vegetation in 1903,[53] and in the Introduction to his book entitled "Australian Grasses" printed in 1895, he presents an assessment of New England as a grazing district, and specifies the common grasses and comments on

52. W. Woolls, "The Progress of Botanical Discovery in Australia", in *Lectures on the Vegetable Kingdom,* Sydney, 1879, p.52.
53. F. Turner, "The Vegetation of New England, New South Wales," *Proceedings of the Linnean Society of New South Wales,* 28 (1903), pp. 276-311.

* No record of collections made by Charles Frazier, the Government Collector with Oxley's expedition, has been located.

their value.[54] On the basis of his remarks, the grasslands towards the end of last century were dominated by the tufted perennials *Sorghum leiocladum, Themeda australis, Danthonia* spp., *Dichanthium sericeum, Poa* spp., *Chloris truncata, Agropyron scabrum,* and the summer annuals *Agrostis avenacea* and *A. aemula.*[55] He indicates that these grasses were allvaluable as forage, though *Themeda australis* was depressed by heavy stocking and the tussocky *Poa* spp. were palatable only when young, becoming hard and tough as they matured. Turner also cites the common occurrence of *Cynodon dactylon, Eragrostis leptostachya, Dichelachne crinita,* and reports the prevalence of *Paspalum paspaloides* in many damp places.

Around the turn of the century, Turner was not the only botanist to publish a number of vegetational studies on various regions of the Colony. R.H. Cambage wrote a series on the Native Flora of New South Wales, and in two parts of the series discussed the western slopes of New England and the Deepwater-Torrington flora.[56,57] Although his notes deal almost entirely with trees, shrubs and non-

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54. Turner, *Australian Grasses, loc. cit.*
55. Turner's scientific names were based on Bentham(Turner, *ibid.*, p.vi). Where nomenclatural changes have occurred, the currently accepted names are employed in this chapter. (The authorities for these names are provided in Table VII).The interpretation of the following names used by Turner are discussed in Chapter IV, pp.59-64: *Danthonia semiannularis* R.Br., *Poa caespitosa* Forst. var. *australis, Deyeuxia billardieri* Kunth., and *Deyeuxia forsteri* Kunth.
56. R.H. Cambage, "Notes on the Native Flora of New South Wales, Part ii". *Proceedings of the Linnean Society of New South Wales*,29(1904) pp.781-797.
57. R.H. Cambage, "Notes on the Native Flora of New South Wales. Part vi", *Proceedings of the Linnean Society of New South Wales*,33(1908), pp.45-65.

graminaceous herbs, Cambage does record *Themeda australis* as a common grass in the vicinity of Emmaville and Deepwater.[58]

J. H. Maiden published a species list of the Howell district in 1906 in which he mentions twelve grasses, but *Themeda australis* is the only one which coincides with the tufted perennial dominants in Turner's assessment.[59] The other perennials in Maiden's paper include *Eulalia fulva, Cymbopogon refractus, Capillipedium spicigerum, Arundinella nepalensis* (in moist situations), *Aristida vagans* and *Eragrostis parviflora.*

From the incomplete evidence of these few botanists, it is apparent that members of the tribe Andropogoneae contributed a significant proportion of the common tableland grasses, and that of these *Themeda australis* was perhaps the most prominent.

Discussion

The pioneers discovered that New England was characterised by a relatively stable grassland community of savannah woodland with a park-like appearance. At that time the pasture was dominated by caespitose perennials with a sparse ground-cover of decumbent species and annuals between the tussocks, apart from the high rainfall areas east of Armidale where the sward was more even.

The identity of the conspicuous dominant which John Everett

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58. *Ibid.*, p. 62.

59. J. H. Maiden, "The Botany of Howell (Bora Creek): A Tin-Granite Flora", *Proceedings of the Linnean Society of New South Wales*, 31 (1906), pp.63-72.

in 1840 called "oat or forest grass" (see p. 36) is uncertain, but there are several reasons for presuming that he referred to *Themeda australis*, now known as "kangaroo grass". *T. australis* was very common and occurred over most of the tableland: its companion species, *T. avenacea*, has been commonly called "tall oat grass", "oat kangaroo grass", and "native oat grass";[60] the inflorescence of *T. australis* with its lax, open habit and its spikelets bearing a long geniculate awn, is suggestive of *Avena* spp.; the inflorescence is distinctive, and might well have attracted the attention of a pioneer commenting on the vegetation, just as it had attracted Cambage during his trip to New England nearly seventy years later.

White settlement of the tableland upset two important features of the ecosystem which had operated for many centuries and helped shape the character of the vegetation. The incidence of casual bushfires was reduced due to the gradual "civilisation" of the aboriginal population, and the effect of marsupial grazing diminished.

The settlers also introduced a number of new factors into the ecosystem. Flocks of sheep created a steadily increasing ruminant grazing pressure, foreign herbage species were introduced, and some

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60. J. W. Vickery, "Gramineae", *Contributions from the New South Wales National Herbarium, Flora Series*, Sydney, No. 19, Part I(1961),p.63.

cultivation took place. The exotic species and efforts at farming had a limited effect. Weeds proliferated near settlements, and along with European grasses and clover were slow to invade natural pastures before soil fertility was improved or intensive grazing depressed indigenous species; the cultivation was confined to small areas near townships and homesteads and other suitable localities, and in most cases was eventually abandoned for economic reasons.[61] Growing flock numbers exerted the major impact on the grasslands, and as livestock density increased and the free selector scheme constricted station size, the graziers introduced ringbarking and clearing of timber to serve their pastoral interests. At about the same time they adopted late-winter burning to assist brush control and guarantee earlier and more accessible spring grass growth.

By the end of the century the tableland had changed from a park-like grassland grazed by marsupials and frequently but irregularly burnt, to a mixture of brush and savannah grazed mainly by ruminants and periodically burnt, often on an annual basis.

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61. In a recent report, only 14% of the New England area was sown to pastures and crops: *Soil and Pasture Research on the Northern Tablelands, New South Wales,* CSIRO and Department of Agriculture, Sydney, 1964, p.3.

S E C T I O N   B

G R A S S   F L O R A   O F   N E W   E N G L A N D

The floristic study of New England grasses is divided into three parts: a list of recorded species, a key to the species, and a discussion of their prevalence and distribution. Chapter IV traces the development of botanical knowledge of species occurring in the region from the publication of Volume VII of the Flora Australiensis in 1878 to the census taken by M. Gray (1961), and brings the grass flora up to date with a complete list of species found in New England. Chapter V discusses the construction of a key to New England grasses, which is presented in Chapter VI with brief descriptions and notes on distribution. A general discussion of the flora is given in Chapter VII.

IV

SPECIES OF GRAMINEAE IN NEW ENGLAND

There have been two censuses of the New England flora, one by Turner published in 1903 and the second by Gray in 1961. The earlier (1878) publication of the Flora Australiensis provides a starting point for a comparison of the grass flora in successive lists. Only 60 grasses were reported from New England in Bentham and Mueller's Flora, about one quarter of the Gramineae now recorded from the region.

The correct identities of grasses cited by Bentham, Turner and Maiden are discussed, and the contribution to our knowledge of the flora from each author is tabled. Recent additions and new records for the region are presented, and a full list of Gramineae from New England is given to conclude the chapter.

Bentham and Mueller

The first specification of grasses that occur on the New England tableland was presented in Bentham and Mueller's Flora Australiensis, Volume VII (1878), based largely on specimens collected by C. Stuart of Melbourne with a small portion attributed to Perrott of Armidale, W. Woolls and C. Moore. The species which Bentham cited from New England are listed in Table II, together with several grasses for which he ascribed a general New South Wales distribution (*Imperata cylindrica* var. *major*, *Themeda australis*, and most of the introduced grasses in the Table). The grasses are denoted by names currently in use, but where there has been a change from Bentham's nomenclature the superseded name is entered in parenthesis. The great majority of changes listed have been cited by Vickery (1953); in addition, Hubbard (1935), Vickery (1950a), Bor (1960), Blake (1969) and Clayton (1968) were consulted.

TABLE II

New England Grasses in Bentham's Flora Australiensis

Where nomenclatural changes have occurred, the name used by Bentham is written in square brackets.

* Introduced species.

See text.

Agrostis aemula R.Br.	[*Deyeuxia Forsteri* Kunth] #
Agrostis avenacea Gmel.	[*Agrostis scabra* Willd. var *elatior* Benth.] # [*Deyeuxia Forsteri* Kunth] #
Aristida ramosa R.Br.	
Aristida vagans Cav.	
Arthraxon hispidus (Thunb.)Makino	[*Arthraxon ciliare* Beauv. var. *australe* Benth.] P
**Briza minor* L.	
**Bromus mollis* L.	
Capillipedium parviflorum (R.Br.) Stapf	[*Chrysopogon parviflorus* Benth.] G
Cenchrus australis R.Br.	
Chloris truncata R.Br.	
Cymbopogon refractus (R.Br.) A. Camus	[*Andropogon refractus* R.Br.] G
**Cynodon dactylon* (L.) Pers.	
**Dactylis glomerata* L.	
Danthonia carphoides F. Muell.ex Benth.	
Danthonia longifolia R.Br.	
Danthonia pallida R.Br.	
Danthonia racemosa R.Br.	
Danthonia racemosa var. *obtusata* F. Muell.ex Benth.	
Deyeuxia gunniana (Nees) Benth.	[*Deyeuxia breviglumis* Benth.] P
Deyeuxia mckiei J. Vickery	[*Deyeuxia scabra* Benth.] # [*Agrostis scabra* Willd. var. *elatior* Benth.] #

Deyeuxia quadriseta (Labill.) Benth.	
Dichanthium sericeum (R.Br.) A. Camus	[*Andropogon sericeus* R.Br.] G
Dichelachne sciurea (R.Br.) Hook.f.	
Digitaria brownii (Roem. et Schult.) Hughes	[*Panicum leucophaeum* H.B.K.] E.
**Digitaria ciliaris* (Retz.)Koeler	[*Panicum sanguinale* L.]#
Digitaria ramularis (Trin.) Henrard	[*Panicum parviflorum* R.Br.]#
**Echinochloa crusgalli* (L.)Beauv.	[*Panicum crusgalli* L.] G
Echinopogon caespitosus C.E. Hubbard	[*Echinopogon ovatus* Beauv.] #
Enneapogon nigricans (R.Br). Beauv.	[*Pappophorum nigricans* R.Br.]EG
Entolasia marginata (R.Br.) Hughes	[*Panicum marginatum* R.Br.] G
Eragrostis brownii Nees ex Steud.	
Eragrostis elongata Jacq.	[*Eragrostis diandra* Steud.] E
Eragrostis leptostachya Steud.	
Eragrostis parviflora (R.Br.) Trin.	[*Eragrostis pilosa* Beauv.] E
Eragrostis trachycarpa (Benth.) Domin	[*Eragrostis nigra* Nees var. *trachycarpa* Benth.] E
Glyceria australis C.E. Hubbard	[*Glyceria fluitans* (L.)R.Br.] E
Glyceria latispicea (F. Muell.)Benth.	
**Holcus lanatus* L.	
**Hordeum leporinum* Link	[*Hordeum murinum* L.] E
Imperata cylindrica (L.)Beauv. var. *major* (Nees) C.E. Hubbard.	[*Imperata arundinacea* Cyr.] E
Isachne globosa (Thunb.) O. Kuntze	[*Isachne australis* R.Br.] P
Leptochloa decipiens (R.Br.) Stapf	[*Leptochloa chinensis* Nees] E
**Lolium perenne* L.	
**Lolium temulentum* L.	
Microlaena stipoides (Labill.) R.Br.	
Panicum bisulcatum Thunb.	[*Panicum melananthum* F. Muell.] P
Panicum effusum R.Br.	
Panicum obseptum Trin.	
Panicum simile Domin	[*Panicum bicolor* R.Br.] Ill
Paspalidium constrictum (Domin) C.E. Hubbard	[*Panicum flavidum* Retz. var. *tenuior* Benth.] # [? *Panicum gracile* R.Br.] #
Pennisetum alopecuroides (L.) Spreng.	[*Pennisetum compressum* R.Br] P

Phragmites australis (Cav.)Trin. ex Steud.	[*Phragmites communis* Trin.] P
**Poa annua* L.	
Poa sieberana Spreng.	[*Poa caespitosa* Forst.] #
Sorghum leiocladum (Hack.) C.E. Hubbard	[*Sorghum plumosum* Beauv.] E
Sporobolus elongatus R.Br.	[*Sporobolus indicus* R.Br.] #
Stipa pubescens R.Br.	
Stipa setacea R.Br.	
Themeda australis (R.Br.) Stapf	[*Anthistiria ciliata* L.] E
Tragus australianus S.T. Blake	[*Lappago racemosa* Willd.] E

Notation for nomenclatural changes.

G Species transferred to another genus.

P Name lapsing into synonomy because an earlier specific epithet takes precedence.

E Name incorrectly applied to the grass.

EG Genus only incorrectly applied to the grass.

Ill Specific epithet illegitimate because it is already occupied by another species.

As indicated by the notations to Bentham's species in Table II, a large number of the nomenclatural changes are the result of names being incorrectly applied to Australian grasses by early botanists, and then discarded in favour of more informed identifications. Most of the other changes are due to generic transfers or the establishment of precedence for an earlier specific epithet. Apart from these alterations, the inclusion of several names based on the species in Bentham's Flora requires more explanation.

Bentham gives a New England locality for *Deyeuxia Forsteri* Kunth based on specimens collected by Moore and Stuart. In her revision of the Australian species of *Agrostis*, Vickery (1941) places *D. Forsteri* in *Agrostis avenacea* Gmel., and includes in its synonomy seven of the ten species Bentham equates with *D. Forsteri*. She also cites Stuart's specimen under *A. avenacea* but omits Moore's. The remainder of Bentham's synonomy for *D. Foresteri* are arranged by Vickery under *Agrostis aemula* R.Br., with which she identifies Moore's specimen from New England. It is apparent, therefore, that Bentham's two New England representatives of *D. Forsteri* belong to *A. avenacea* and *A. aemula*.

Vickery's revision of *Agrostis* indigenous to Australia also indicated that a New England specimen described by Bentham as *Agrostis scabra* Willd. var. *elatior* Benth. in fact consists of a mixture of *A. avenacea* and *Deyeuxia mckiei* J. Vickery.

Bentham's *Deyeuxia scabra* Benth. was discarded by Vickery in her revision of the Australian species of *Deyeuxia* (Vickery, 1940), and his specimens re-grouped by her under *D. contracta* (F. Muell.) J. Vickery, *D. decipiens* (R.Br.) J. Vickery and *Agrostis rudis* Roem. et Schult. She also created a new species, *D. mckiei*, which included a New England grass collected by Stuart that Bentham cited under *D. scabra*.

A grass collected by Stuart from Clifton, west of Tenterfield, was classified by Bentham as *Panicum sanguinale* L. Hughes (1923) believed the specimen should have been identified as *P. adscendens* H.B.K. and placed it in *Digitaria marginata* Link [now correctly known as *D. ciliaris* (Retz.) Koeler...Blake, 1969]. However, according to Vickery (1961), in Australian literature no distinction was made between *Panicum sanguinale* and *D. ciliaris*, and there is no New England record of *D. ciliaris* in the National Herbarium, Sydney, though the species is widespread over most of the state, nor in the New England University Botany Department Herbarium. Without a check on the identity of Stuart's specimen, now in England, Hughes' opinion must be assumed correct.* Subsequent references to *P. sanguinale* from New England, beginning with Turner (1903), are deemed to refer to *D. sanguinale* (L.) Scop.

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* In a recent letter (1/12/1970), the Director of the Royal Botanic Gardens, Kew, confirmed that Stuart's specimen is *D. ciliaris*.

Bentham identified a grass collected from New England by Stuart as *Panicum parviflorum* R.Br., a taxon with which he equated *P. ramulare* Trin. and *P. striatum* R.Br. Following Stapf's revision of *Panicum* (Stapf, 1920), Hughes reviewed the species enumerated under the genus in the Flora Australiensis (Hughes, 1923) and transferred Bentham's Series Digitarieae to *Digitaria* Hall. In her appraisal of *P. parviflorum* she re-established *P. striatum* as *D. striata* (R.Br.) Hughes and placed some material in a new species, *D. diminuta*, but Stuart's New England grass was retained in *D. parviflora* (R.Br.) Hughes. Vickery (1950c),decided, however, that *P. striatum* and *D. parviflora* were conspecific, and also considered Bentham's material in relation to *D. ramularis* (Trin.) Henrard, which Hughes had ignored or overlooked. This brought to light a specimen collected by Woolls from Parramatta that Hughes had kept in *D. parviflora* but which really belonged to *D. ramularis* Vickery (1950c). She made no mention of the New England specimen in her report, but since specimens of *D. parviflora* in the National Herbarium, Sydney, have all been collected from coastal districts, the author presumes that Stuart's grass, if collected on the tableland, was also *D. ramularis*. Dr. Vickery does not recollect examining Stuart's specimen and the assumption lacks confirmation.*

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* Clarification was sought from the Royal Botanic Gardens, Kew, and the Director reported agreement between Stuart's specimen and material of *D. ramularis* (Taylor, 1/12/1970). He further indicated that Stuart may have also collected *D. parviflora* from New England.

Mueller sent Bentham a specimen of *Echinopogon* collected by Stuart from New England for inclusion in the Flora which Bentham identified as *E. ovatus* Beauv. Hubbard examined Australian representatives of the species in 1935 and placed Stuart's specimen in a new species, *E. caespitosus* C.E. Hubbard. *E. ovatus* proper has been recorded from New England since Stuart made his collections.

There are two New England grasses collected by Stuart cited in Bentham under *Panicum flavidum* Retz. var. *tenuior* Benth. and *P. gracile* R.Br. The revision by Hughes (1923) re-arranged part of *P. flavidum* var. *tenuior* in the new combination of *Paspalidium jubiflorum* (Trin.) Hughes and part in *Paspalidium gracile* (R.Br.) Hughes var. *rugosum* Hughes. Her only reference to Stuart's New England material is included in localities for *P. gracile* var. *rugosum*, which is now considered identical with *Paspalidium constrictum* (Domin) C. E. Hubbard. Dr. Vickery inspected Stuart's specimen at Kew and placed it in *P. constrictum* (personal communication).

The large number of varieties that Bentham ascribed to *Poa caespitosa* Forst. indicates the uncertain taxonomy of the native *Poa* spp., a difficulty which has persisted until the recent revision of the Australian species of *Poa* by Vickery (1970).
He obviously had a wide range of material at his disposal, and it is most unlikely that Stuart would have overlooked the common New

England *Poa* (Turner, 1895) when collecting northern tableland grasses for Mueller and Bentham in the middle of last century. Two common native Poas are now known from the area, *P. labillardieri* Steud. and *P. sieberana* Spreng, and *P. costiniana* occurs sporadically on the tableland. From Bentham's comments on *P. billardieri* (Bentham's spelling) and his varieties of *P. caespitosa*, the author feels justified in deducing that he had access to the scabrous *P. sieberana* from New England localities and that he may also have examined specimens of *P. labillardieri* from New England and placed them in a variety of *P. caespitosa*.

Sporobolus indicus R.Br. has a northern tableland distribution in Bentham's Flora, based on a specimen collected by Stuart, but as Vickery points out in her list of naturalised grasses in New South Wales (Vickery, 1950a), *S. indicus* was erroneously applied to Australian material, particularly to *S. africanus* (Poir.) Robyns et Tourn. (referred to *S. capensis* Kunth by Vickery) which was an early introduction from South Africa. It is evident, however, from Bentham's description of *S. indicus* ("panicle very narrow, 3 to 8 in. or even longer, continuous throughout or when long often much interrupted") and from his group of synonyms, that he applied *S. indicus* to material representing the native *S. elongatus* R. Br. as well as the introduced *S. africanus*. Turner (1891a), distinguished a var. *elongatus* from *S. indicus*, but though he gives a coastal distribution for the species he fails to note the occurrence of the variety. On the basis of material held in the New South Wales National Herbarium and the herbarium of the New England University Botany Department, *S. elongatus* is common on the northern tableland while *S. africanus* is mainly a coastal grass. The only exception is a specimen of *S. africanus* collected at Walcha in 1900 by A.R. Crawford. There seems little reason to doubt, therefore, that the New England grass Bentham called *S. indicus* was in fact *S. elongatus*.

Turner The locality citations in Bentham's Flora, in the light of the above discussion, indicate a botanical knowledge of 60 species and varieties of Gramineae from New England in 1878. The next steps in the growth of understanding of the grass flora of the region were taken by F. Turner who, unlike Bentham or Mueller, spent considerable time in the area and travelled widely throughout the district. His two important contributions to the floristics of New England are contained in his book "Australian Grasses" (1895) and his census of "The Vegetation of New England, New South Wales" (1903).

Turner's discussion of New England pastures in the Introduction to "Australian Grasses" mentions the most common or conspicuous grass species, of which the following four are additional to Bentham's New England grasses as presented in Table II: *Deyeuxia billardieri* Kunth, *Danthonia semiannularis* R.Br., *Dichelachne crinita* Hook., and *Paspalum distichum* L. [now known as

P. paspaloides (Michx.) Scribn. (see Bor, 1970, p.494)].The erroneous identification of the first two species requires clarification.

In her revision of the Australian species of *Agrostis*, Vickery (1941) transferred Kunth's *Deyeuxia billardieri*, based on *Agrostis billardieri* R.Br., back to *Agrostis*. *A. billardieri*, however, only occurs in coastal areas, and it would appear that Turner was mistaken in his identification. The anomaly is resolved by consulting Turner's illustration and description of *D. billardieri* in "Australian Grasses". The specific description is drawn entirely from Bentham and Mueller (1878) and stipulates the lemma as "quite glabrous", but the accompanying drawings of the spikelet and the floret both show a conspicuously hairy lemma. His discussion of the grass notes its similarity to *D. Forsteri* (syn: *A. avenacea*) and draws attention to its distinctive "reddish inflorescence". It would appear that Turner's identification was in error, and that the grass that he had in his possession was *Agrostis aemula* R.Br.

The question of the true identity of material referred to *Danthonia semiannularis* by Turner is a considerable problem. Vickery states in her revision of the Australian species of *Danthonia* (Vickery, 1956, p.290): "Bentham's description of *D. semiannularis* in the Flora Australiensis applies to species allied to *D. caespitosa* rather than the true *D. semiannularis*. Examinations of the specimens cited by him and of others named by him as *D. semiannularis* showed that they included *D. caespitosa*, *D. purpurascens, D. pallida, D. duttoniana, D. alpicola, D. setacea, D. laevis, D. semiannularis, D. acerosa* and *D. occidentalis*." Of these, *D. purpurascens, D. laevis* and *D. pallida* occur in New England. Turner's preface to "Australian Grasses" acknowledges reference to Bentham's nomenclature, and presumably he was able to distinguish *D. pallida* from Bentham's description. The earliest record of *D. laevis* from New South Wales is 1911, and most of the collections of the species have been made since 1930, so it seems unlikely that Turner held any specimens. Hence the implication of Vickery's observation is that Turner attributed *D. purpurascens* to *D. semiannularis,* and this view gains credence in the light of Stuart's collection of *D. purpurascens* from New England (Vickery, 1956).

However, since Bentham presupposed that *D. linkii* Kunth was conspecific with *D. semiannularis,* Turner may have identified material of the *D. linkii* group as *D. semiannularis,* viz. *D. linkii, D. richardsonii* Cashmore, and the less common *D. monticola* J. Vickery. It seems certain that *D. semiannularis* does not occur in New England, having been collected only from the Sydney district, but since his collection has not survived, it is impossible to determine the identity of specimens inspected by Turner which led him to decide erroneously that *D. semiannularis* was a common New England grass. With some justification we can presume that his conclusion was based on famialiarity with one or more of the following species: *D. purpurascens, D. laevis, D. linkii* and *D. richardsonii*. Since Stuart collected New England specimens of *D. purpurascens* (which is not mentioned in the Flora Australiensis under a species known at the time), *D. purpurascens* is the most likely identity of Turner's *D. semiannularis,* particularly in view of the fact that the popular interpretation of "semiannularis" by early botanists was the character of two rows of hairs on the lemma (Vickery, personal communication).

Turner's census of the New England District (1903) lists 93 grasses, 84 of them indigenous. It is evident that he relied on Bentham for the foundation of his census, since all the grasses cited by Bentham for New England appear in his list in the same order in which they occur in the Flora Australiensis. Turner's contribution to knowledge of the grass flora of the tableland is presented in Table III, which lists grasses in his census that are additional to Table II and those discussed in "Australian Grasses". Nomenclatural changes have been determined by reference to Jackson (1895), Vickery (1953, 1961), Blake (1968), and Hubbard (1968).

TABLE III

New England Grasses in Turner's Census, 1903, Not Recorded in Bentham, 1878, or Turner, 1895.

Where nomenclatural changes have occurred, Turner's name is inserted in square brackets.

* Introduced grasses

\# See text.

Agropyron scabrum (R.Br.)Beauv.	
**Agrostis gigantea* Roth	[*Agrostis alba* L.] E
Alloteropsis semialata (R.Br.) Hitchc.	[*Panicum semialatum* R.Br.] G
Amphibromus neesii Steud.	
Arundinella nepalensis Trin.	
**Avena fatua* L.	
Bothriochloa bladhii (Retz.) S.T. Blake	[*Andropogon intermedius* R.Br.] P
Bothriochloa macera (Steud.) S.T. Blake	[*Andropogon affinis* R.Br.] P
**Briza maxima* L.	
**Bromus sterilis* L.	
**Bromus unioloides* H.B.K.	[*Ceratochloa unioloides* D.C.] G
**Digitaria sanguinalis* (L.) Scop.	[*Panicum sanguinale* L.]
**Echinochloa colonum* (L.) Link	[*Panicum colonum* L.] G
Eriochloa procera (Retz.) C.E. Hubbard.	[*Eriochloa annulata* Kunth] P
Eriochloa pseudoacrotricha (Stapf ex Thell.) C.E. Hubbard ex.S.T.Blake	[*Eriochloa punctata* Hamilt.] E
Eulalia fulva (R.Br.) O.Kuntze	[*Pollinia fulva* Benth.] EG
Festuca asperula J. Vickery	[*Festuca duriuscula* L.] E
Hemarthria uncinata R.Br.	[*Hemarthria compressa* R.Br.] E
Hierochloe rariflora Hook. f.	
**Koeleria phleoides* Pers.	
Panicum decompositum R.Br.	
Panicum prolutum F. Muell. #	
**Phalaris canariensis* L.	
**Poa glauca* E.B. #	
**Poa pratensis* L.	(Attributed to Willdenow by Turner)
**Polypogon monspeliensis* (L.)Desf.	
Sehima nervosum (Rottl.)Stapf	[*Ischaemum laxum* R.Br.] E
**Setaria glauca* (L.)Beauv.	
**Setaria viridis* (L.)Beauv.	
**Vulpia bromoides* (L.)S.F. Gray	

Notation

G Species transferred to another genus.

P Name lapsing into synonomy because an earlier specific epithet takes precedence.

E Name incorrectly applied to the grass.

EG Genus only incorrectly applied to the grass.

Panicum prolutum appears in Turner's census for New England, but extant records give it a western plains, south and central western slopes distribution, not extending to the western slopes of New England. One suspects that either Turner was mistaken in including the grass in his census, or that his concept of "New England" was broader than the region defined by the author, and it is therefore omitted in subsequent discussion of the grass flora of the region. The true identity of *Poa glauca* E.B. is uncertain; the authority could refer to Ernst Betche (Vickery, personal communication), but the specimen in question, together with other grasses in Turner's census, has not survived.

Maiden A few years prior to the appearance of Turner's census, J. H. Maiden published "A Manual of the Grasses of New South Wales"(1898). Apart from writing botanical and taxonomic notes on each grass, he gives an indication of their value as fodder and includes a comment on their habitat and range. Frequently Maiden's distributions are expressed in very general terms such as "an interior species", or "from the coast districts to the tablelands" without any qualification of latitude. In a number of instances, e.g. in the case of *Stipa aristiglumis* F. Muell., he gives the range as "from the coast districts to the interior" and fails to mention whether the species persists on the intervening tableland or Dividing Range. For several grasses, however, the distribution clearly embraces New England, and four species in this category are not mentioned by Turner in his census.*

Maiden states that *Paspalum orbiculare* Forst. [referred to as *P. scrobiculatum* L. in his Manual] occurs from "Port Jackson to the Tweed, and westward as far as the Blue Mountains; also in New England and other tablelands". The only specimens of *P. orbiculare* in herbaria inspected by the author were collected on the north coast, and it would appear that Maiden was in error in extending its range to the tablelands.

Eremochloa bimaculata Hack. [*Ischaemum pectinatum* Trin.] is described by Maiden as "found on the northern rivers, extending to the tableland", a range which is confirmed by existing herbarium records. The same applies to *Hyparrhenia filipendula* (Hochst.)Stapf [*Andropogon lachnatherus* Benth. - Maiden: "it extends from the north coast to New England"], and *Sorghum halepense* (L.) Pers. [Maiden: "it is found as far west as New England"]

A further eight grasses, also omitted by Turner, are given a range by Maiden of either "from the coast districts to the tableland" or "from the tableland to the interior", but without a more specific distribution they cannot be considered as part of the New England flora on the basis of Maiden's Manual, even though they

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* Nomenclatural changes for species cited by Maiden were determined by reference to Vickery (1953, 1961).

were later collected from the New England district. These eight grasses are *Pseudoraphis spinescens* (R.Br.) J. Vickery [*Chamaeraphis spinescens* (R.Br.) Poir], *Cymbopogon obtectus* S.T. Blake [*Cymbopogon bombycinus* (R.Br.) Domin], *Chrysopogon fallax* S.T. Blake [*Chrysopogon gryllus* (L.) Trin.], *Themeda avenacea* (F. Muell.) Durand et Jackson [*Anthistiria avenacea* F. Muell.], *Aristida leptopoda* Benth., *Stipa mollis* R.Br. [*Stipa semibarbata* R.Br.], *Danthonia pilosa* R.Br. and *Chloris acicularis* Lindl.

A few years after Turner's census was taken, Maiden and Boorman visited the tin-mining town of Howell on the western slopes, and a flora of the area was published by Maiden (1906). He found only twelve grasses, but two of them had not then been recorded for New England; these were *Capillipedium spicigerum* S.T. Blake [*Andropogon micranthus* Kunth var. *spicigera* Benth.] and *Stipa verticillata* Nees. He also included *Echinopogon ovatus* in the Gramineae from Howell, but since Hubbard (1935) cites a specimen of *Echinpogon* from Howell collected by Boorman in January, 1906, under *E. intermedius* C.E. Hubbard, the author presumes that Maiden's grass in the Howell flora is the same species.

Gray Half a century elapsed between Turner's census and the second floristic study of New England, published by M. Gray in 1961. Gray listed 179 species and varieties, including three species of whose taxonomy he was uncertain, one being the native tussocky *Poa*. Those grasses in his census which had not previously been recorded for New England are presented in Table IV, together with species given New England localities in revisions of Australian members of genera, or publications of new species, prior to Gray's census. In particular, Hubbard's revision of *Echinopogon* (1935), Vickery's revisions of *Festuca* (1939), *Deyeuxia* (1940), *Agrostis* (1941), *Danthonia* (1956),new species in Vickery's taxonomic studies of Australian grasses (Vickery, 1950c), and new species in Blake's studies on Queensland grasses (1941) and Australian Andropogoneae (1944).

TABLE IV

Grasses in Gray's Census Not Previously Recorded for New England by Bentham, Turner or Maiden

* Introduced
# See text.

Agropyron repens (L.) Beauv.
Agropyron scabrum var. *plurinerve* J. Vickery
Agrostis hiemalis (Walt.) B.S.P.
**Agrostis tenuis* Sibth.
Agrostis venusta Trin.
**Aira cupaniana* Guss.
**Alopecurus pratensis* L.
Amphipogon strictus R.Br.
**Anthoxanthum odoratum* L.
Aristida calycina R.Br. — [*Aristida* sp.aff. *A. calycina* R.Br. and *A. glumaris* Henrard] #
Aristida caputmedusae Domin
Aristida echinata Henrard
Aristida jerichoensis Domin ex Henrard var. *subspinulifera* Henrard
Aristida leptopoda Benth.
Aristida personata Henrard
Aristida warburgii Mez
**Arrhenatherum elatius* (L.) J. et C. Presl
**Avena sativa* L.
Bothriochloa biloba S.T.Blake

Bothriochloa decipiens (Hack.) C.E. Hubbard
**Brachiaria advena* J. Vickery
**Bromus brevis* Steud.
**Bromus diandrus* Roth
**Bromus madritensis* L.
**Catapodium rigidum* (L.) C.E. Hubbard
Chloris divaricata R.Br.
**Chloris gayana* Kunth
Chloris ventricosa R.Br.
Cymbopogon obtectus S.T. Blake
Danthonia eriantha Lindl.
Danthonia induta J. Vickery
Danthonia laevis J. Vickery
Danthonia linkii Kunth
Danthonia monticola J. Vickery
Danthonia pilosa R.Br.
Danthonia richardsonii Cashmore
Deyeuxia acuminata J. Vickery
Deyeuxia brachyathera (Stapf) J. Vickery
Deyeuxia imbricata J. Vickery
Deyeuxia parviseta J. Vickery
Dichanthium setosum S. T. Blake
Dichelachne rara (R.Br.) J. Vickery
Digitaria coenicola (F. Muell.) Hughes
Digitaria coenicola var. *ramosa* J. Vickery
Digitaria diffusa J. Vickery [*Digitaria* sp.] #
Digitaria diminuta Hughes
Diplachne fusca (L.) Beauv.
Echinopogon cheelii C.E. Hubbard
Echinopogon mckiei C. E. Hubbard
Echinopogon nutans C.E. Hubbard
var. *major* C.E. Hubbard
Echinopogon ovatus (Forst.) Beauv.
Echinopogon phleoides C. E. Hubbard
**Eleusine tristachya* (Lam.) Lam.
Enneapogon gracilis (R. Br.) Beauv.
Entolasia stricta (R. Br.) Hughes
**Eragrostis cilianensis* (All.) Lutati
**Eragrostis curvula* (Schrad.)Nees [Incorporating *E. chloromelas* Steud.]
Eragrostis molybdea J. Vickery
Eragrostis philippica Jedw.
**Festuca arundinacea* Schreb.
Festuca eriopoda J. Vickery
**Glyceria maxima* (Hartm.) Holmb.
**Hyparrhenia hirta* (L.) Stapf
**Lamarckia aurea* (L.) Moench
**Lolium multiflorum* Lam.
**Lolium rigidum* Gaud.

Oryzopsis miliacea (L.) Benth. et
Hook.f. ex Aschers. et Schweinf.
**Panicum laevifolium* Hack.
Panicum queenslandicum Domin
Panicum queenslandicum var.
acuminatum J. Vickery
Paspalidium aversum J. Vickery
Paspalidium gracile (R. Br.) Hughes
**Paspalum dilatatum* Poir.
**Pennisetum villosum* R. Br.
Pentapogon quadrifidus (Labill.) Baill.
**Phalaris minor* Retz.
**Phalaris tuberosa* L.
**Phleum pratense* L.
**Poa compressa* L.
Pseudoraphis spinescens (R.Br.) J. Vickery
**Secale cereale* L.
Setaria australiensis (Scribn. et Merrill) J. Vickery
**Setaria geniculata* (Lam.) Beauv. var.
pauciseta Desv.
Stipa aristiglumis F. Muell.
Stipa mollis R. Br.
Stipa nervosa J. Vickery
Stipa nervosa var. *neutralis* J. Vickery
Stipa scabra Lindl.
Themeda avenacea (F. Muell.) Durand et Jackson
Tripogon loliiformis (F. Muell.)C.E. Hubbard
**Vulpia megalura* (Nutt.) Rydb.
**Vulpia myuros* (L.) Gmel.

In the light of Blake's clarification of the taxonomy of *Aristida calycina* and *A. glumaris* (Blake, 1969), Gray's specimen related to these two species is assigned to *A. calycina*. Mr. Gray permitted an examination of a grass labelled *Digitaria* sp. in his census, Sheet 2674 of his New England Survey, which the author identified as *D. diffusa* J. Vickery.

It would be misleading to assume that all the 92 grasses in Table IV represent new records for the area over and above those discovered at the end of the last century. Only 58 of Gray's additions to the flora are indigenous, the other 34 having been introduced or discovered during the interval between the two major censuses. Furthermore, approximately half of the new indigenous species listed represent grasses which could have been classified in Bentham's Flora under outdated or erroneous names in Tables II and III,if they had been collected in the area, and which have been described by taxonomists after Turner published the census of 1903. A large portion of examples of grasses in this group belong to new species established in revisions of genera and the other publications cited above (page 69). The remaining 25 to 30 grasses include a few indigenous species which have recently invaded the area or gone unnoticed by earlier botanists - for example, *Aristida echinata, Chloris divaricata* and *Amphibromus strictus,* but for the majority, Gray's survey confirmed the records of previous collections.

It is interesting to note that Gray failed to include in his census several grasses which were given a New England distribution in earlier studies and are still found in the region. *Leptochloa decipiens,* recorded by Bentham for New England, can be found growing in isolated localities on the eastern edge close to the escarpment. Turner included *Sehima nervosum, Hierochloe rariflora* and *Alloteropsis semialata* in his census, but only *A. semialata* has been collected from the tableland this century. There is no extant specimen to support Turner's claim that *Sehima nervosum* could be found at Kentucky (Turner, 1903) or even near Tamworth (Turner, 1891b), but a sheet dated 1891 and labelled *Hierochloe rariflora*, New England, held in the New South Wales National Herbarium, together with Maiden's comment (Maiden, 1896) on a note from Mr. Walker of Tenterfield, confirms the original range of *H. rariflora* as encompassing the northern tablelands. Maiden's New England distribution for *Hyparrhenia filipendula* and *Sorghum halepense* is substantiated by herbarium records of *H. filipendula* from the vicinity of Tenterfield and Glen Innes and the presence of *S. halepense* as a weed of settled districts on the tableland.

Recent additions to the flora

By means of examination of specimens stored in National Herbarium, Sydney, and the herbarium of the University of New England Botany Department, combined with personal collections and field studies in the region, it was found that many more grasses occur in a native or naturalised state in New England than appear in Gray's census or earlier publications. These additions to the published grass flora of the region are listed in Table V, together with some Panicoideae and Andropogoneae species for which New England localities were cited by Vickery (1961) but which were omitted by Gray. Details of an herbarium record for each species in the table are given in Appendix II. A sheet for each species is held in the New South Wales National Herbarium.

TABLE V

Additions to the Flora since Gray's Census

* Introduced

Amphibromus whitei R.Br.
Amphibromus sp. nov.
Aristida acuta S. T. Blake
Aristida ingrata Domin
Aristida jerichoensis Domin ex Henrard
Aristida muelleri Henrard
**Arrhenatherum elatius* var. *bulbosum* (Willd.)Spenner
**Avena sterilis* L.
**Bromus inermis* Leyss.
**Bromus macrostachys* Desf.
**Bromus molliformis* Lloyd
**Bromus racemosus* L.
**Bromus rubens* L.
**Bromus secalinus* L.
**Cenchrus ciliaris* L.
**Cenchrus pauciflorus* Benth.
Chloris acicularis Lindl.
**Chloris virgata* Swartz
Chrysopogon fallax S. T. Blake
**Cyndon hirsutus* Spent.
**Cyndon incompletus* Nees
**Cynosurus cristatus* L.
Dichanthium affine (R.Br.) A. Camus
Dichanthium tenue (R.Br.) A. Camus
**Digitaria ternata* (Hochst.)Stapf
**Digitaria violascens* Link
**Ehrharta calycina* Sm.
**Ehrharta erecta* Lam.
**Eleusine indica* (L.) Gaertn.
**Festuca rubra* L.
Heteropogon contortus (L.)Beauv. ex Roem. et Schult.
**Hordeum vulgare* (L.)
Leptochloa digitata (R.Br.)Domin
**Nassella trichotoma* Hack.
Oplismenus aemulus (R.Br.)Kunth
Oplismenus imbecillus (R.Br.) Roem. et Schult.
**Panicum antidotále* Retz.
**Panicum capilláre* L.
**Panicum laevifolium* Hack. var. *contractum* Pilg.
**Panicum maximum* Jacq.
**Panicum miliaceum* L.
Paspalidium globoideum (Domin) Hughes
**Paspalum urvillei* Steud.
**Pennisetum clandestinum* Hochst. ex. Chiov.
**Phalaris arundinacea* L.
**Phalaris coerulescens* Desf.
**Phalaris paradoxa* L.
**Poa bulbosa* L.
Poa costiniana J. Vickery
Poa fordeana F. Muell.
Poa labillardieri Steud.
Poa queenslandica C. E. Hubbard
Poa sieberana Spreng. var. *hirtella* J. Vickery
**Polypogon littoralis* Sm.
Potamophila parviflora R. Br.
Sacciolepis indica (L.) Chase
**Setaria italica* (L.) Beauv.
**Setaria pallide-fusca* (Schum.) Stapf et Hubbard
**Sorghum vulgare* Pers.
**Sporobolus africanus* (Poir.) Robyns et Tourn.
Stipa densiflora Hughes
**Stipa hyalina* Nees
**Stipa neesiana* Trin. et Rupr.
Stipa ramosissima Trin.
**Trisetum flavescens* (L.) Beauv.
**Triticum aestivum* L.
**Urochloa panicoides* Beauv.
**Zea mays* L.

More than half the grasses in Table V are introduced and most of the additions in the list are based on solitary records or a few collections from isolated localities, such as *Paspalidium globoideum, Chloris acicularis* and *Leptochloa digitata* on the western edge of the district, *Oplismenus* spp. in the high rainfall areas in the east, and some *Bromus* spp., *Poa bulbosa, Cynosurus cristatus* and *Sacciolepis indica* near township communities in the central tableland. Others listed are cereal grasses that have become naturalised in townships and along roadsides, and the Table is further augmented by the recent study by J. Vickery of the genus *Poa* (Vickery, 1970).

When cereal grasses and collections lodged with the National Herbarium, Sydney, prior to Gray's census have been accounted for, there remain nine species in Table V which are new records for the region. These grasses are listed in Table VI.

TABLE VI

New Records for the Region

* Introduced

**Bromus macrotachys*	
**Bromus rubens*	**Paspalum urvillei*
**Ehrharta calycina*	**Pennisetum clandestinum*
**Ehrharta erecta*	**Polypogon littoralis*
**Festuca rubra*	*Potamaphila parviflora*

Potamophila parviflora occurs against rocks in Salisbury Waters above Dangar Falls. Isolated plants of *Paspalum urvillei,* a common north coastal species, have appeared along the Grafton Road 20 to 30 miles east of Armidale. *Ehrharta calycina* was found growing in grassland 10 miles south of Guyra. The other grasses in Table VI have all been collected in the vicinity of Armidale township.

List of grasses in the region

The concluding section of this chapter presents a full list of New England grasses compiled from all the records studied, including recent additions to the flora. Table VII contains 256 grasses, but one would expect this number to increase as the result of further taxonomic studies and more exhaustive collections. *Stipa* is at present being examined by Mrs. J. De Nardi, and on her advice the *Stipa* spp., *S. scabra, S. variabilis, S. falcata* and *S. drummondii* have been lumped together for the time being as the *S. variabilis* complex.

Grasses introduced for trial to experimental stations in the region, such as *Festuca hookeriana* F. Muell to Glen Innes and *Panicum coloratum* L. to Inverell and *Setaria sphacelata* to Armidale University, which have not spread into the neighbouring grasslands nor occurred in roadside communities, have been omitted from the list. The Table does contain, however, several rare species which have only been recorded once or twice and have not been seen in recent years, such as *Nassella trichotoma* and *Hierochloe rariflora.*

TABLE VII

THE GRASS FLORA OF THE NEW ENGLAND DISTRICT

* Introduced

Agropyron repens (L.)Beauv.
Agropyron scabrum (R.Br.) Beauv.
Agropyron scabrum var. *plurinerve* J. Vickery
Agrostis aemula R.Br.
Agrostis avenacea Gmel.
**Agrostis gigantea* Roth
Agrostis hiemalis (Walt.)B.S.P.
**Agrostis tenuis* Sibth.
Agrostis venusta Trin.
**Aira cupaniana* Guss.
Alloteropsis semialata (R.Br.) Hitchc.
**Alopecurus pratensis* L.
Amphibromus neesii Steud.
Amphibromus whitei C.E.Hubbard
Amphibromus sp. nov.
Amphipogon stictus R.Br.
**Anthoxanthum odoratum* L.
Aristida acuta S.T. Blake
Aristida calycina R.Br.
Aristida caputmedusae Domin
Aristida echinata Henrard
Aristida ingrata Domin
Aristida jerichoensis Domin ex Henrard
Aristida jerichoensis var. *subspinulifera* Henrard
Aristida leptopoda Benth.
Aristida muelleri Henrard
Aristida personata Henrard
Aristida ramosa R.Br.
Aristida vagans Cav.
Aristida warburgii Mez
**Arrhenatherum elatius* (L.)J. et C. Presl.
**Arrhenatherum elatius* var. *bulbosum* (Willd.)Spenner
Arthraxon hispidus (Thunb.) Makino
Arundinella nepalensis Trin.
**Avena fatua* L.
**Avena sativa* L.
**Avena sterilis* L.
Bothriochloa biloba S.T. Blake
Bothriochloa bladhii (Retz.)S.T. Blake
Bothriochloa decipiens (Hack.) C.E. Hubbard
Bothriochloa macera (Steud.) S.T. Blake
**Brachiaria advena* J. Vickery
**Briza maxima* L.
**Briza minor* L.
**Bromus brevis* Steud.
**Bromus diandrus* Roth
**Bromus inermis* Leyss.
**Bromus macrostachys* Desf.
**Bromus madritensis* L.
**Bromus molliformis* Lloyd
**Bromus mollis* L.
**Bromus racemosus* L.
**Bromus rubens* L.
**Bromus secalinus* L.
**Bromus sterilis* L.
**Bromus unioloides* H.B.K.
Capillipedium parviflorum (R.Br.) Stapf
Capillipedium spicigerum S.T. Blake
**Catapodium rigidum* (L.)C.E.Hubbard
Cenchrus australis R.Br.
**Cenchrus ciliaris* L.
**Cenchrus pauciflorus* Benth.
Chloris acicularis Lindl.
Chloris divaricata R.Br.
**Chloris gayana* Kunth
Chloris truncata R.Br.
Chloris ventricosa R.Br.
**Chloris virgata* Swartz
Chrysopogon fallax S.T. Blake
Cymbopogon obtectus S.T. Blake
Cymbopogon refractus (R.Br.) A. Camus
**Cynodon dactylon* (L.)Pers.
**Cynodon hirsutus* Spent.

**Cynodon incompletus* Nees
**Cynosurus cristatus* L.
**Dactylis glomerata* L.
Danthonia carphoides F. Muell. ex Benth.
Danthonia eriantha Lindl.
Danthonia induta J. Vickery
Danthonia laevis J. Vickery
Danthonia linkii Kunth
Danthonia longifolia R.Br.
Danthonia monticola J. Vickery
Danthonia pallida R. Br.
Danthonia pilosa R.Br.
Danthonia purpurascens J. Vickery
Danthonia racemosa R.Br.
Danthonia racemosa var. *obtusata* F. Muell. ex Benth.
Danthonia richardsonii Cashmore
Deyeuxia acuminata J. Vickery
Deyeuxia brachyathera (Stapf) J. Vickery
Deyeuxia gunniana (Nees)Benth.
Deyeuxia imbricata J. Vickery
Deyeuxia mckiei J. Vickery
Deyeuxia parviseta J. Vickery
Deyeuxia quadriseta (Labill.) Benth.
Dichanthium affine (R.Br.)A.Camus
Dichanthium sericeum (R.Br.) A.Camus
Dichanthium setosum S.T.Blake
Dichanthium tenue (R.Br.)A.Camus
Dichelachne crinita (L.)Hook.f.
Dichelachne rara (R.Br.)J.Vickery
Dichelachne sciurea (R.Br.)Hook. f.
Digitaria brownii (Roem. et. Schult.) Hughes
**Digitaria ciliaris* (Retz.)Koeler
Digitaria coenicola (F.Muell.) Hughes
Digitaria coenicola var. *ramosa* J. Vickery
Digitaria diffusa J. Vickery
Digitaria diminuta Hughes
Digitaria ramularis (Trin.) Henrard
**Digitaria sanguinalis* (L.)Scop.
**Digitaria ternata* (Hochst.)Stapf
**Digitaria violascens* Link
Diplachne fusca (L.)Beauv.
**Echinochloa colonum* (L.)Link
**Echinochloa crusgalli* (L.)Beauv.
Echinopogon caespitosus C.E. Hubbard
Echinopogon cheelii C.E.Hubbard
Echinopogon intermedius C.E. Hubbard
Echinopogon mckiei C.E.Hubbard
Echinopogon nutans C.E.Hubbard var. *major* C.E.Hubbard
Echinopogon ovatus (Forst.)Beauv.
Echinopogon phleoides C.E.Hubbard
**Ehrharta calycina* Sm.
**Ehrharta erecta* Lam.
**Eleusine indica* (L.)Gaertn.
**Eleusine tristachya* (Lam.)Lam.
Enneapogon gracilis (R.Br.)Beauv.
Enneapogon nigricans (R.Br.)Beauv.
Entolasia marginata (R.Br.)Hughes
Entolasia stricta (R.Br.) Hughes
Eragrostis brownii Nees ex Steud.
**Eragrostis cilianensis* (All.) Lutati
**Eragrostis curvula* (Schrad.)Nees
Eragrostis elongata Jacq.
Eragrostis leptostachya Steud.
Eragrostis molybdea J. Vickery
Eragrostis parviflora (R.Br.) Trin.
Eragrostis philippica Jedw.
Eragrostis trachycarpa (Benth.) Domin
Eremochloa bimaculata Hack.
Eriochloa procera (Retz.) C.E. Hubbard
Eriochloa psuedoacrotricha (Stapf ex Thell.)C.E.Hubbard ex S.T.Blake
Eulalia fulva (R.Br.) O. Kuntze
**Festuca arundinacea* Schreb.
Festuca asperula J. Vickery
Festuca eriopoda J. Vickery
**Festuca rubra* L.
Glyceria australis C.E.Hubbard
Glyceria latispicea (F.Muell.) Benth.
**Glyceria maxima* (Hartm.)Holmb.

Hemarthria uncinata R.Br.
Heteropogon contortus (L.) Beauv. ex Roem. et Schult.
Hierochloe rariflora Hook.f.
**Holcus lanatus* L.
**Hordeum leporinum* Link
**Hordeum vulgare* L.
Hyparrhenia filipendula (Hochst.) Stapf
**Hyparrhenia hirta* (L.)Stapf
Imperta cylindrica (L.)Beauv. var. *major* (Nees)C.E.Hubbard
Isachne globosa (Thunb.)O.Kuntze
**Koeleria phleoides* (Vill.)Pers.
**Lamarckia aurea* (L.) Moench
Leptochloa decipiens (R.Br.)Stapf ex Maiden
Leptochloa digitata (R.Br.)Domin
**Lolium multiflorum* Lam.
**Lolium perenne* L.
**Lolium rigidum* Gaud.
**Lolium temulentum* L.
Microlaena stipoides (Labill.)R.Br.
**Nassella trichotoma* Hack.
Oplismenus aemulus (R.Br.)Kunth
Oplismenus imbecillis (R.Br.) Roem. et Schult.
**Oryzopsis miliacea* (L.) Benth. et Hook. f. ex Aschers. et Schweinf.
**Panicum antidotále* Retz.
Panicum bisulcatum Thunb.
**Panicum capilláre* L.
Panicum decompositum R.Br.
Panicum effusum R.Br.
**Panicum laevifolium* Hack.
**Panicum laevifolium* var. *contractum* Pilg.
**Panicum maximum* Jacq.
**Panicum miliaceum* L.
Panicum obseptum Trin.
Panicum queenslandicum Domin
Panicum queenslandicum var. *acuminatum* J. Vickery
Panicum simile Domin
Paspalidium aversum J. Vickery
Paspalidium constrictum (Domin) C.E.Hubbard
Paspalidium globoideum (Domin) Hughes
Paspalidium gracile (R.Br.) Hughes
**Paspalum dilatatum* Poir.
Paspalum paspaloides (Michx.) Scribn.
**Paspalum urvillei* Steud.
Pennisetum alopecuroides (L.) Spreng.
**Pennisetum clandestinum* Hochst. ex Chiov.
**Pennisetum villosum* R.Br.
Pentapogon quadrifidus (Labill.) Baill.
**Phalaris arundinacea* L.
**Phalaris canariensis* L.
**Phalaris coerulescens* Desf.
**Phalaris minor* Retz.
**Phalaris paradoxa* L.
**Phalaris tuberosa* L.
**Phleum pratense* L.
Phragmites australis (Cav.)Trin. ex Steud.
**Poa annua* L.
**Poa bulbosa* L.
**Poa compressa* L.
Poa costiniana J.Vickery
Poa fordeana F. Muell.
Poa labillardieri Steud.
**Poa pratensis* L.
Poa queenslandica C.E. Hubbard
Poa sieberana Spreng.
Poa sieberana var. *hirtella* J.Vickery
**Polypogon littoralis* Sm.
**Polypogon monspeliensis* (L.)Desf.
Potamophila parviflora R.Br.
Pseudoraphis spinescens (R.Br.) J. Vickery
Sacciolepis indica (L.)Chase
**Secale cereale* L.
Setaria australiensis (Scribn.et Merrill). J. Vickery
**Setaria geniculata* (Lam.)Beauv. var. *pauciseta* Desv.
**Setaria glauca* (L.)Beauv.
**Setaria italica* (L.)Beauv.
**Setaria pallide-fusca* (Schum.) Stapf et Hubbard
**Setaria viridis* (L.)Beauv.
**Sorghum halepense* (L.)Pers.
Sorghum leiocladum (Hack.) C.E.Hubbard

Hemarthria uncinata R.Br.
Heteropogon contortus (L.) Beauv. ex Roem. et Schult.
Hierochloe rariflora Hook.f.
**Holcus lanatus* L.
**Hordeum leporinum* Link
**Hordeum vulgare* L.
Hyparrhenia filipendula (Hochst.) Stapf
**Hyparrhenia hirta* (L.)Stapf
Imperta cylindrica (L.)Beauv. var. *major* (Nees)C.E.Hubbard
Isachne globosa (Thunb.)O.Kuntze
**Koeleria phleoides* (Vill.)Pers.
**Lamarckia aurea* (L.) Moench
Leptochloa decipiens (R.Br.)Stapf ex Maiden
Leptochloa digitata (R.Br.)Domin
**Lolium multiflorum* Lam.
**Lolium perenne* L.
**Lolium rigidum* Gaud.
**Lolium temulentum* L.
Microlaena stipoides (Labill.)R.Br.
**Nassella trichotoma* Hack.
Oplismenus aemulus (R.Br.)Kunth
Oplismenus imbecillis (R.Br.) Roem. et Schult.
**Oryzopsis miliacea* (L.) Benth. et Hook. f. ex Aschers. et Schweinf.
**Panicum antidotale* Retz.
Panicum bisulcatum Thunb.
**Panicum capillare* L.
Panicum decompositum R.Br.
Panicum effusum R.Br.
**Panicum laevifolium* Hack.
**Panicum laevifolium* var. *contractum* Pilg.
**Panicum maximum* Jacq.
**Panicum miliaceum* L.
Panicum obseptum Trin.
Panicum queenslandicum Domin
Panicum queenslandicum var. *acuminatum* J. Vickery
Panicum simile Domin
Paspalidium aversum J. Vickery
Paspalidium constrictum (Domin) C.E.Hubbard
Paspalidium globoideum (Domin) Hughes
Paspalidium gracile (R.Br.) Hughes
**Paspalum dilatatum* Poir.
Paspalum paspaloides (Michx.) Scribn.
**Paspalum urvillei* Steud.
Pennisetum alopecuroides (L.) Spreng.
**Pennisetum clandestinum* Hochst. ex Chiov.
**Pennisetum villosum* R.Br.
Pentapogon quadrifidus (Labill.) Baill.
**Phalaris arundinacea* L.
**Phalaris canariensis* L.
**Phalaris coerulescens* Desf.
**Phalaris minor* Retz.
**Phalaris paradoxa* L.
**Phalaris tuberosa* L.
**Phleum pratense* L.
Phragmites australis (Cav.)Trin. ex Steud.
**Poa annua* L.
**Poa bulbosa* L.
**Poa compressa* L.
Poa costiniana J.Vickery
Poa fordeana F. Muell.
Poa labillardieri Steud.
**Poa pratensis* L.
Poa queenslandica C.E. Hubbard
Poa sieberana Spreng.
Poa sieberana var. *hirtella* J.Vickery
**Polypogon littoralis* Sm.
**Polypogon monspeliensis* (L.)Desf.
Potamophila parviflora R.Br.
Pseudoraphis spinescens (R.Br.) J. Vickery
Sacciolepis indica (L.)Chase
**Secale cereale* L.
Setaria australiensis (Scribn.et Merrill). J. Vickery
**Setaria geniculata* (Lam.)Beauv. var. *pauciseta* Desv.
**Setaria glauca* (L.)Beauv.
**Setaria italica* (L.)Beauv.
**Setaria pallide-fusca* (Schum.) Stapf et Hubbard
**Setaria viridis* (L.)Beauv.
**Sorghum halepense* (L.)Pers.
Sorghum leiocladum (Hack.) C.E.Hubbard

*_Sorghum vulgare_ Pers.
*_Sporobolus africanus_ (Poir.)Robyns et Tourn.
Sporobolus elongatus R.Br.
Stipa aristiglumis F. Muell.
Stipa densiflora Hughes
*_Stipa hyalina_ Nees
Stipa mollis R.Br.
*_Stipa neesiana_ Trin. et Rupr.
Stipa nervosa J. Vickery
Stipa nervosa var. _neutralis_ J. Vickery
Stipa pubescens R.Br.
Stipa ramosissima Trin.
Stipa setacea R.Br.
Stipa variabilis Hughes complex
Stipa verticillata Nees
Themeda australis (R.Br.)Stapf
Themeda avenacea (F. Muell) Durand et Jackson
Tragus australianus S.T. Blake
Tripogon loliiformis (F. Muell.) C.E.Hubbard
*_Trisetum flavescens_ (L.)Beauv.
*_Triticum aestivum_ L.
*_Urochloa panicoides_ Beauv.
*_Vulpia bromoides_ (L.) S.F.Gray
*_Vulpia megalura_ (Nutt.) Rydb.
*_Vulpia myuros_ (L.)Gmel.
*_Zea mays_ L.

V

INTRODUCTION TO THE KEY TO NEW ENGLAND GRASSES

Prologue

When the author was appointed to teach grass systematics and correct student collections in 1966, there was no existing key to the grasses of the New England district or New South Wales. Available literature was confined to the keys in Bentham and Mueller, Vol VII (1878), and Moore and Betche (1893), both of which were out of date, Beadle's key to the grasses of the Sydney district and Blue Mountains (Beadle, Evans and Carolin, 1962), and finally Vickery's key to the grass genera in New South Wales with specific treatment of 34 genera (Vickery, 1961).

Beadle's key to the Sydney district has limited application to the Northern Tablelands or New South Wales as a whole, particularly with regard to indigenous species. For general usage it was necessary to employ it in conjunction with Black's key to the South Australian grasses (Black, 1960) in order to cover species found in the western districts of New South Wales which are often common to South Australia.

Vickery's key to New South Wales genera distinguished grasses within subfamilies and tribes, and followed the pattern of characters already established by Bews (1929) and, more especially, Hubbard (Hubbard, 1948). Students experienced considerable difficulty when using Vickery's key, largely because a large number of alternatives are often required to cover the range of characters embracing species with pronounced differences from the subfamilial or tribal type. This deterrent of multiple alternatives within initial couplets is compounded by the terminology and phraseology with which lead characters are expressed. A "natural" key was deemed more suited to botanists who already have a degree of familiarity with the Gramineae and its variable spikelet structure, as opposed to beginners using a key to acquire such a familiarity. This point is emphasised by the unusual appearance and difficulty of interpretation of florets in the Andropogoneae compared to the rest of the Gramineae - which always seems to be a stumbling block for student taxonomists.

Another awkward aspect of a "natural" key is that some distinguishing characters at the tribal level require microscopic examination for accurate detection, e.g. nervation of the florets in Festuceae and Agrostideae and the presence of 2 sterile lemmas in some Phalarideae, and are not amenable to field determination with a handlens.

Apart from these general problems associated with "natural" keys for use by people unskilled in grass taxonomy, there are several anomalies in the system. Thus, although spikelets of Panicoideae fall entire at maturity, the fertile floret of *Panicum* has a very fragile attachment to the rachilla and is often expelled before the spikelet has separated from the pedicel. Furthermore, *Isachne* contradicts the normal Panicoideae spikelet structure (as Vickery acknowledged), *Phalaris paradoxa* has obsolete sterile lemmas which complicates its successful keying to Phalarideae, and the absence of the lower glume in some Paniceae creates a difficulty in keying out on positive characters. These and other areas of confusion may be overcome by broadening the descriptions in the couplets and providing a general impression of spikelet appearance with contrasting shapes and textures in addition to nervation, spikelet arrangement, floret number and awn placement, and thus conforming with standard definitions of subfamilies and tribes. The result, whilst maintaining taxonomic validity, often produces intricate couplet paragraphs and hampers the task of identification by people untrained in tribal classification.

To avoid these difficulties, the author prepared a key to the grasses of New England based on artificial groups. This key was almost immediately set aside and another was drawn up along similar lines to identify the grasses of New South Wales. A debt to Dr. Joyce Vickery must be acknowledged for constructive comments on some sections of these two keys. The key to the grasses of New South Wales was planned to assist students preparing grass collections from anywhere in the State and a provisional edition was used for this purpose from 1967 to 1970. By marking these collections and conducting laboratory classes in grass taxonomy over a four-year period, the author has had an opportunity to check approximately 15,000 student identifications determined by the key, and thereby thoroughly test the validity and intelligibility of the couplets employed. This had provided ideal conditions for detecting errors and correcting them, discovering which characters are the most difficult to understand and interpret, and determining characters which are unsuitable for field examination. Information obtained by pinpointing mistakes in student usage has led to modifications which are incorporated in the key to New England grasses presented in Chapter VI and the key to New South Wales grasses tabled in Appendix I.

Artificial Key to New England Grasses

The following key is partitioned into three sections: a key to groups of genera, a key to genera within each group, and a key to species within each genus. The last section also provides a brief description of each species. The keys to genera are based on characters which should be discernible in the field with the naked eye or a handlens, but in many instances the distinction of species requires microscopic examination. The classification of the groups of genera has been designed for quick and fluent usage.

i Generic Key

A number of couplets in the key to the groups of genera are straightforward and describe simple characters, but the others should receive some comment, particularly as this section is probably the most important part of the key.

Couplet 2:2* extracts grasses with a compound spatheate panicle. Inflorescences with a solitary spathe enclosing the peduncle, as in depauperised specimens of *Heteropogon*, were excluded from Group II because the character is too general and unpredictable, and may occur more or less in the form of modified leaves of many grasses, e.g. *Hemarthria, Stipa* and *Holcus,* whilst a compound spatheate inflorescence does not easily admit misinterpretation. In the key to New South Wales grasses, *Spinifex* and *Zygochloa* have been placed in Group II on account of the numerous bracts in their inflorescences.

Couplet 3:3* relies on the ready determination of the number of fertile florets in the spikelet. [For the New England and New South Wales keys, a "fertile floret" is defined as a floret which contains an ovary or grain, and is usually distinguished by the presence of the fruit in mature spikelets.] Though the actual number of florets may be mistaken by an inexperienced taxonomist (especially when identifying species in genera of the Andropogoneae, some Paniceae, and the genus *Phalaris*), the presence of at least one fertile floret may be anticipated in nearly all spikelets (exceptions being found with dioecious or diclinous plants, some members of the Andropogoneae and species with barren and bisexual spikelets intermixed), and it is necessary merely to count more than 3 lemmas or more than I grain or ovary in order to place the grass under lead character 3*. The problem of correctly identifying the sterile lemma in Panicoideae grasses is overcome, and this advantage is maintained in subsequent couplets under lead character 3. The use of this character involves some repetition, however, in spikelets with 2 florets whose second floret may be sometimes fertile, as with *Arundinella nepalensis, Arrhenatherum elatius* and *Isachne globosa.*

The division into awned and awnless spikelets in couplet 4:4* is designed in part to avoid confusion with spikelets of such genera as *Eriochloa, Pseudoraphis* and *Hemarthria,* where the glume and/or lemma produces an acuminate point whose short bristle may be called an awn by subjective assessment. Vague cases of this kind rarely have a bristle point longer than 3 or 4 mm and are conveniently sorted into "awnless" character 4, together with spikelets possessing inconspicuous fine bristles such as those of some *Echinopogon* and *Deyeuxia.*

Couplet 7:7* , distinguishing terminal awns from dorsal or subterminal awns, places all awned spikelets from tribe Andropogoneae within "terminal awn" lead character 7. This arrangement was influenced by the difficulty of detecting the membranous lobes in some bifid lemmas from Andropogoneae and Stipeae and by the fact that the awn on bifid lemmas in these tribes arises between the lobes, whereas awns in or near the sinus of bifid and laterally compressed lemmas of grasses in Group VII always pass behind the lobes rather than between them, e.g. in *Echinopogon* and *Dichelachne.*

As with couplets 4:4*, and 9:9*, couplet 12:12* incorporates the term "conspicuous" or its adverb. This is deemed to mean that the character is noticeable with the naked eye at first inspection.

Most of the couplets employed in the keys to genera within the groups may be read without further comment, but in several cases a supplementary note is appropriate.

In Groups IV and V, members of the tribe Andropogoneae have not been distinguished from grasses in other tribes on the basis of their paired spikelets, which might be considered an obvious character to use. There are three reasons for this: (i) the pedicellate spikelet is often so reduced in *Bothriochloa* spp. that it may not at first be recognised as a spikelet; (ii) the density of the spikelets and hairiness of the racemes may conceal the paired condition, and (iii) students using keys employing this character have discovered obscure pairing of spikelets in many non-Andropogoneae grasses before they became acquainted with the general floral morphology of the Andropogoneae and could interpret the character accurately, by which time they no longer needed it. The nature of the three terminal spikelets of a panicle branch has been found to be a more reliable character for separating Andropogoneaceous grasses from other species, in terms of ease of distinction. It does have a disadvantage, however, with regard to those genera whose racemes readily fracture and fall away at maturity. The utilisation of the character in group V could lead to misidentification of one species, *Bothriochloa bladhii,* if the specimen being classified is too mature or has been roughly handled.

It is regrettable that the unusual pedicel and raceme rhachis structure of *Bothriochloa* and *Capillipedium* is often so difficult for untrained eyes to see and yet so necessary for the accurate separation of these genera. Vickery (1961) defined this character in terms of a "translucent middle line". It has been the author's experience, however, that the line of soft tissue is not always translucent, and may be more readily detected by its colour and/or textural difference.

In the discussion of couplets in the key to the groups, it was pointed out that the identification of sterile or staminate florets was carefully avoided in that key, but the keys to genera in Groups I, III, V, VI, VII, and X all use a couplet requiring the identification of one or two sterile lemmas. In each case, however, the sterile floret is clearly differentiated and no members of the tribe Andropogoneae are involved.

More than twenty genera key out more than once in the keys to genera. The majority of these repetitions are of genera whose members have an inflorescence structure ranging over two of the patterns employed (e.g. *Danthonia* and *Heteropogon*), or of genera which do not strictly conform to either "spikelets with 1 fertile floret" or "spikelets with more than 3 lemmas"(e.g. *Arundinella* and *Chloris*), or of *Phalaris*, where the sterile lemmas may be developed or suppressed, or of genera whose members may be awned or awnless (e.g. *Agrostis*, *Ehrharta* and *Festuca*). With many more genera involved, the generic key to New South Wales grasses contains further repetitions. The author has endeavoured to keep repetitions at a minimum; with very variable genera such as *Bromus*, however, some repetition is inevitable in an artificial key.

Where there has been a choice in key structure, the "short" key has been constructed in preference to a "long" key. This practice is endorsed by the conclusions of some general theorems proved by Osborne (1963) concerning the number and arrangement of taxa in any given key.

The authorities for genera classified in the New England and New South Wales keys are those given in Burbidge (1963).

ii Key to Species

Following the generic key, each genus and species is described briefly, and a key to species is provided where necessary. Common names, if any, are given, and for each introduced species the region or country in which it is indigenous is stated. An indication of the frequency of occurrence of each species is provided, together with a note on distribution. For the New South Wales key, the distributions were determined by examining boxes of herbarium sheets at the New South Wales National Herbarium.

In the section describing the species, the genera are grouped into tribes. A number of different tribal classifications exist in the taxonomic literature, both those based on traditional spikelet characters and gross morphological criteria as well as those incorporating biochemical, cytological and microscopic anatomical differences, whose utilisation in grass taxonomy is relatively recent (Bowden, 1965). Largely as the result of the anatomical work published by taxonomists such as Stebbins (1956), Reeder (1957) and Brown (1968), tribal systems have been devised which modify the more established classifications, re-arranging some genera and often creating new tribes or subfamilies. Though this modern approach has been applied to regional floras (e.g. Bor, 1960, 1970: Stebbins and Crampton, 1961) and even on a world basis (Prat, 1960: Decker, 1964), further research is required before taxonomists can reach a satisfactory agreement on any one system (see: Bor, 1960; Booth, 1964; Gould, 1968; Hubbard, 1968; Burbidge, 1964).

In the absence of an authoritative and comprehensive statement systematising the genera in the light of recent findings on a world basis, it was deemed advisable to adhere to the tribal classification adopted by the New South Wales National Herbarium (Vickery, 1961), which follows Hubbard (1959) and his earlier revision (Hubbard, 1948). In the case of genera which some taxonomists have placed in other tribes, the new tribal name is inserted in parenthesis.

Though specimens of all the New England species and almost all of the New South Wales species were carefully examined, invaluable assistance was obtained from taxonomic publications in the construction of certain keys to species. The keying of many introduced grasses from Europe was facilitated by Hubbard's book on the grasses of the British Isles (1968), particularly in the genera *Bromus, Glyceria* and *Agrostis*. Chippendall in Meredith (1955), Bor (1960, 1970) and Hitchcock (1950), were also consulted.

The preparations of keys to *Festuca, Poa, Danthonia,* *Agrostis, Deyeuxia* and *Amphipogon*, were influenced by revisions in these genera by Vickery (1939, 1970, 1956, 1941, 1940 and 1950b). In Andropogoneae, the keys rely heavily on Vickery (1961), and from the same publication assistance was received in keying out some Paniceae, especially *Digitaria* and *Paspalum*. The author is further indebted to Dr. Vickery for kindly permitting access to her unpublished keys to New South Wales *Panicum* and Australian *Paspalidium*. Her notes on *Agropyron* (Vickery, 1950c) and *Dryopoa* (Vickery, 1963) were also helpful, together with a comment on *Diplachne* (Vickery, 1950d).

Revisions in *Enneapogon* and *Triodia* by Burbidge (1941, 1953), in *Echinopogon* by Hubbard (1935), in *Aristida* by Henrard (1929, 1932) and in *Phalaris* by Anderson (1961), were of considerable assistance in the study and keying out of grasses in these genera. The confusion surrounding the use of *Phalaris tuberosa* in preference to *P. aquatica* was clarified by reading, with the permission of the Director, a letter from Bor to the Director of the New South Wales National Herbarium dated 10/1/1969.

The taxa employed for *Avena* were determined with reference to Malzew (1930) and Burfitt (1959), who favour the suppression of *A. ludoviciana* Durieu to a subspecies of *A. sterilis*. Before keying the species of *Stipa*, Hitchcock (1925), Willis (1957), Hughes (1921) and Vickery (1950c) were consulted. Blake (1941) and Clayton (1965) contained notes which were of assistance in preparing they key to *Sporobolus*, as were the notes by Morris (1934) with regard to *Amphibromus*. The distinction of species of *Aira* and *Glyceria* was facilitated by some comments by De Nardi (1970), whose generous help to the author is acknowledged elsewhere. Studies on Australian grasses by Gardner (1952) and Black (1960) were useful in a few genera, e.g. *Astrebla*.

Those texts and reports which were of particular value have been cited above, but many others were read and consulted which, though contributing to the author's general understanding of Gramineae, were not sufficiently helpful to the study of New England grasses to warrant specific mention.