VOL. 67 — 1943

TRANSACTIONS OF THE ROYAL SOCIETY OF SOUTH AUSTRALIA

INCORPORATED

ADELAIDE

PUBLISHED AND SOLD AT THE SOCIETY'S ROOMS
KINTORE AVENUE, ADELAIDE

Registered at the General Post Office, Adelaide,
for transmission by post as a periodical

CONTENTS

PART I

AN ECOLOGICAL STUDY OF THE VEGETATION OF EIGHT MILE CREEK SWAMP A NATURAL SOUTH AUSTRALIAN COASTAL FEN FORMATION

By CONSTANCE M. EARDLEY, B.Sc.,
Systematic Botanist, Waite Agricultural Research Institute

Summary

The vegetational study of this swamp was undertaken in February, 1942,in conjunction with a soil survey of the same area by Stephens (1943). The swamp is now being drained and cleared for settlement, and reports on the soil and vegetation were drawn up for the South Australian Lands Board. Stephens' paper (1943) on the soils appears in the current volume of this journal and is indispensably linked with the present one. The writer is indebted to Stephens for the data quoted on the physical properties of the soils and waters, also for the preliminary field work and mapping and the free use of these maps and soil profiles. Readers are referred to his paper for further necessary information on the soils and peats and for a map of the area.

AN ECOLOGICAL STUDY OF THE VEGETATION OF EIGHT MILE CREEK SWAMP A NATURAL SOUTH AUSTRALIAN COASTAL FEN FORMATION

By Constance M. Eardley, B.Sc.,
Systematic Botanist, Waite Agricultural Research Institute

[Read 9 September 1943]

Plates XXVII to XXIX

Contents

I INTRODUCTION

The vegetational study of this swamp was undertaken in February, 1942, in conjunction with a soil survey of the same area by Stephens (1943). The swamp is now being drained and cleared for settlement, and reports on the soil and vegetation were drawn up for the South Australian Lands Board. Stephens' paper (1943) on the soils appears in the current volume of this journal and is indispensably linked with the present one. The writer is indebted to Stephens for the data quoted on the physical properties of the soils and waters, also for the preliminary field work and mapping and the free use of these maps and soil profiles. Readers are referred to his paper for further necessary information on the soils and peats and for a map of the area.

Plant determinations were made by the writer, using the resources of the Adelaide University Herbarium and Mr. J. M. Black's private herbarium; the nomenclature of the South Australian plants is that of Black's "Flora of South Australia," pt. i (2nd Ed., 1943), pts. ii-iv (1924-1929) and annual "Additions."

The synonymy of the English and American plants given is less well-known to the writer, and many standard works of reference have had to be employed, with sometimes conflicting results; the significance of this will appear in the section on "The Aquatic Zone."

The specimens collected at Eight Mile Creek are deposited in the Herbarium of the Waite Agricultural Research Institute. No systematic determinations of algae were made, and the mosses present were not of much ecological importance.

II THE SWAMP AND ITS ENVIRONMENT

Eight Mile Creek Swamp is situated in the south-eastern corner of the State, within a few miles of the Victorian border, immediately behind the littoral dunes and sands. This part of South Australia is, for the most part, fairly flat country, and contains many swampy areas over a widespread region; it is the largest well-watered area in the State, and this is only partly due to precipitation.

The rainfall is a winter one and ranges from 25-33″ in the area bounded by Millicent, Mount Gambier, Cape Northumberland and Eight Mile Creek. Figures are available for Cape Northumberland, only ten miles away, which give a sufficiently accurate picture of the climate of Eight Mile Creek. They are as set out below in Table A, and were supplied by Stephens.

TABLE A Meteorological data, Cape Northumberland

Month	Rainfall (P) in inches	Evaporation (E) calculated from relative humidity and mean temperatures	P/E
January	0·87	4·4	0·20
February	0·99	4·8	0·21
March	1·12	3·9	0·29
April	2·05	3·0	0·68
May	3·16	2·1	1·50
June	3·93	1·6	2·46
July	3·90	1·4	2·79
August	3·50	1·8	1·94
September	2·51	2·3	1·09
October	1·92	3·2	0·60
November	1·40	3·7	0·38
December	1·28	4·4	0·29
Aver. Annual Totals	26·63	36·6	0·73

Great quantities of drainage water also reach this corner of the South-East, underground, from Victorian sources. Such water is sure to have an enhanced mineral content; indeed, it largely passes through limestone country and hence is alkaline and highly calcareous. Under these conditions it is not to be expected that the oligotrophic vegetation characteristic of an ombrogenous bog of low mineral content would develop.

The raised bogs or "Hochmoor" common in Europe are examples of ombrogenous bogs. They consist usually of a dense mass of *Sphagnum* and have a convex surface; they can be formed only in areas with a high P/E ratio, being watered by rainwater alone, which is low in soluble salts. The acid peat, normally formed from decaying plants under damp conditions, is not neutralised or made alkaline by ground-water draining into the bog. Drainage water is the cause of the alkaline reaction of peats of the topogenous or fen type.

Different plants characterise these alkaline or nearly alkaline fen peats. They are eutrophic species with high mineral requirements, and *Sphagnum* is notably absent. As soon as the peat is built up above the level of the alkaline ground water,

unmodified acid peats are produced, and colonisation by oligotrophic plants, like *Sphagnum*, may take place, as Godwin and Turner (1933) have shown at Calthorpe Broad in Norfolk.

None of the peats of Eight Mile Creek Swamp is more than slightly acid—most are neutral to alkaline (pH 5·8-8·8)—and they bear a fen vegetation, including many well-known cosmopolitan, eutrophic, swamp species. No *Sphagnum* was found; it is also absent from the acid bogs of the Mount Lofty Ranges. The only record of its occurrence in South Australia is in the lower South-East area now under consideration, in a locality within 40 miles of Eight Mile Creek Swamp (Crocker and Eardley, 1939). It is interesting to note that though this *Sphagnum* occurred mainly on open swampy depressions with some rushes and sedges, on soil having a pH value of 4·3 in the surface horizon, these flats were surrounded by a dense thicket of one or both of the identical tea-tree species forming the climax association on Eight Mile Creek Swamp, and the *Sphagnum* was found even among the dense stems of this thicket. Godwin and Turner (1933) also record *Sphagnum* in a fen scrub or "carr" formation in Norfolk.

Many of the swamps in the South-East have been greatly altered by drainage, clearing and cultivation. The swamp described here, and also one or two smaller ones of the same type (but not yet examined) further along the coast to the east, are among the last to remain in a virgin state.

Eight Mile Swamp extends about five miles along the coast and no more than two miles inland. Its waters come from precipitation, surface drainage and a series of spring ponds scattered about the swamp, which run over into creeks, of which Eight Mile in the centre is the largest emptying naturally into the sea. Another creek, Deep Creek, reached the sea at the same place *via* a long meander in the coastal barrier, but has now a shorter, artificial exit. None of the other creeks reaches the sea directly, and many, like Bone Creek at the east and Badenoch Creek at the west end, simply flooded out over the swamp, probably giving an abnormally high water level in their immediate neighbourhood.

Since 1937, many drains have been made leading these blind creeks to the sea or into the two largest, and ponds have had their overflows drained in the same way. The swamp is now becoming drier, as may be seen by comparing present conditions with those recorded by H. L. Fisk's traverses of 1938-40 (South Australian Lands Department). The period between his first survey and the present one—three and a half years—is too short to show successional changes in the vegetation, except by deliberate experiments, of which there were none, and few indications of such changes were obtained. According to Fisk, the elevation of the swamp is from four to ten feet above extreme high water mark and the coastal barrier up to ten feet above it, except in the eastern third where there are sand ridges at least thirty feet above sea level.

The peat has an average depth of five or six feet (1·5-1·8 m.), and it is formed in a trough running parallel to the coastline (see Stephens, 1943, fig. 7). The landward wall and floor of the trough consist of Miocene polyzoal limestone, and the seaward wall consists of fixed calcareous dune sand, changing to grey calcareous sand under the peat, where it overlies the limestone layer.

As yet, we have little clue to the possible age of this peat deposit, and there is no detailed knowledge of post-Pleistocene climatic changes here as there is for western Europe, but see Crocker (1941). Sometimes clayey peats or diatomaceous earths occur between the lowest peat and the Miocene limestone, which suggest a period of uneven, shallow inundation. The species found in the diatomaceous earth were identified by the Zoology Department of the University of Adelaide as belonging to the genera *Navicula*, *Cymbella* and *Synedra* (v. Mahony, 1912).

Nothing was seen in the peat profiles to suggest that its formation has been discontinuous, and the depth of between five and six feet (1·5-1·8 m.) is quite comparable with peat depths in the English fens and around the Norfolk Broads. Godwin's numerous *"Studies of the post-glacial history of British vegetation"* show that the depth of the fen peats is commonly of the order of two or three metres; Wicken Fen is one of the deeper peats and has 385 cm. (12½ ft.) of nearly pure peat (Godwin and Clifford, pt. iii, 1940). There are rare cases of much deeper peats in the fens, but they are due to special conditions (*e.g.*, "Old Decoy," a former river bed, has peat 625 cms. deep, Godwin and Clifford, l.c.). There is an intrusive layer of clay here in the seaward part of the fens, dividing the peat into upper and lower layers (Godwin and Clifford, pt. ii, 1939). Godwin here describes a cross-country section, 17 miles long, showing that the upper peat and the fen clay beneath are continuous for that distance; the depth of the upper peat was from two to five feet. Wicken Fen is outside the range of the fen clay and has a single layer of peat approximately twice as deep (Godwin and Clifford, pt. iii, 1940).

Godwin, who has correlated climatic history, forest zones and archaeological periods from work on English peats, considers that peat formation became general in the fens in the Atlantic climatic period, during Neolithic times—say 3,500 years B.C. (Godwin and Clifford, pt. i and ii, 1939). And though it would be rash to postulate similar rates of formation for the closely similar peats of Eight Mile Creek Swamp, it is reasonable to suppose that these latter peats were formed under climatic conditions at least as warm as those of the fens, and that therefore the growth rate of the constituent plants would not have been any slower on account of the temperature factor. Water is unlikely to be a factor limiting plant growth on a swamp—it controls the type of community, but all are dense. The conclusion is that our peats have probably formed at least as quickly as the English ones, and that, therefore, the Eight Mile Creek peat is probably younger than the slightly deeper ones of the fens, *i.e.*, does not date back as far as 3,500 B.C.

The reed-swamp vegetation of Eight Mile Creek is so like that of the Norfolk Broads, even to the extent of sharing important dominant species, as will presently be shown, that one does not hesitate to compare formation rates of this type of peat in the two places, with due regard only to the varying masses of material likely to have been formed under the two kinds of climate. Both places also have similar types of fen scrub ("carr" in England, "tea-tree thicket" in South Australia), but here one must also consider the possibility of differential rates of peat formation, on the one hand by *Rhamnus* spp. or an alder-willow-birch carr, and on the other hand by the evergreen Myrtaceous genera, *Melaleuca* and *Leptospermum*, of the South Australian tea-tree thicket. This is an important point, because tea-tree peat is the most plentiful type at Eight Mile Creek, and its rate of formation would be the critical one in assessing the age of the swamp. No literature has been seen dealing with relative formation rates of peats from different vegetation types, but the necessary information for such an analysis is accumulating.

Raised *Sphagnum* bogs of the ombrogenous type have usually a much deeper layer of peat than topogenous fens. They are not so well known in England, but Godwin et al. have studied a few profiles, *viz.*: (1) on the Somerset Levels by the Severn Estuary (Godwin and Clifford, pt. vi, 1941), and (2) at Tregaron in Wales (Godwin and Mitchell, 1938), which show about two metres of fen peat at the base, with three to six metres of *Sphagnum* peat above, giving a total depth of as much as 8·5 metres (about 28 ft.) at Tregaron. Godwin considers the latter peat older than that of the fens, but the deep Somerset peat roughly the same age.

Tansley (1939) reproduces two records of borings made by Osvald in raised bogs of the central limestone plain, at Athlone and Edenderry, in Ireland. In both, the upper layer of acid moss peat (*Sphagnum*) is about 4·5 metres thick, and below is a further 3·25-4·25 metres of alkaline fen and reed-swamp peat, *i.e.*, 8·75 metres (about 29 ft.) in all, even deeper than the Tregaron peat. Probably the depth of a fen peat is limited by the necessary condition of being within reach of ground water. With raised bogs there is not this limitation, and they grow higher and higher. Depths for peats of both types in Tasmania and the adjacent King Island were supplied by Stephens. They were just over 40 inches, except for a reed-swamp peat intermixed with clay, up to 65 inches deep. In South Australia, the Mount Compass acid peats probably attain a depth of eight feet in parts.

Eight Mile Creek Swamp was probably far too wet and impenetrable in the past for much human interference. Now that clearing has started, the almost solid tea-tree thicket is being rolled (pl. xxix, fig. 9), and the fallen débris is to be burnt *in situ*.

The vegetation was found to be an excellent guide in mapping the boundaries of the four important swamp-soil types. This is only logical, for they are all peats, and peats are essentially plant remains, depending for much of their individual character on the species of plant from which they are derived.

The swamp is probably a mature one, in equilibrium with the environmental conditions recently destroyed, and occurs in a region whose climatic climax is a sclerophyll forest dominated by *Eucalyptus* spp., though the surrounding country is now cleared and settled. On the seaward side, the swamp abuts normal coastal plant formations, and some mutual modifications may be detected.

III GENERAL OUTLINE OF THE VEGETATION

The vegetation of the swamp consists mainly of various tea-trees of the family Myrtaceae, with occasional Eucalypts, and a large selection of reeds, rushes and sedges. On the landward margin there are transition Eucalypt woodlands on transitional soils, also a certain amount of grassland probably subject to occasional inundation. The littoral vegetation on the seaward side has already been mentioned.

It will be shown that the Eight Mile Creek Swamp formation bears many resemblances to the alkaline fens of East Anglia in England. The most important environmental factors in swamp formations are: (1) the height of the water-table and its variations, (2) the mineral content and pH of the ground water, (3) climate, including rainfall.

The general trend of succession in fens is well established. First, the waters are gradually blocked up by the accumulation of aquatic plants which detain silt, making a suitable medium for the growth of reeds; these, in turn, build up the soil a little higher and are replaced by other plants, until finally a dry-land woodland is established. This process of "Verlandung" is usually arrested at some equilibrium point, but examples have been studied by Godwin and Turner (1933) at Calthorpe Broad; also by Pearsall (quoted by Tansley, 1939) at Esthwaite Water in the English Lake District, where progress along such lines was demonstrated by observations made at an interval of 15 years.

No such comparisons are available for Eight Mile Creek; it is expected that the gradual drainage of the area would speed up the process. The drying of the peat will naturally cause shrinkage or wastage and a sinking surface level. The drains which are always wet do not sink in this way, and, in the English fens, pumps often have to be installed to continue drainage. The course of natural succession in a fen may be seen either in time or space. It may also be seen by identifying the plant remains in the successive layers of peat.

If the terms "marsh," "fen," "bog," and "swamp" are accurately used (according to Tansley's definitions, 1939), Eight Mile Creek must be described as *swamp* and *fen* country. The points of importance for these designations are: (1) water régime, (2) amount of organic matter present, and (3) pH value of the soils.

There is strong correlation between the behaviour of the watertable at Eight Mile Creek Swamp and the different vegetation types. Godwin and Bharucha, pl. ii (1932), have demonstrated such a relationship very precisely in Wicken Fen, and conclude that the *maximum winter water level* is the controlling factor in the formation of fen scrub or "carr," which is only found on soil above winter water level. There is less information available about the water level changes in Eight Mile Creek Swamp, and they would be complicated by the recent drainage policy (but see Ward, 1941, for the seasonal fluctuation of the ground-water table in the South-East).

The swamp soils will be discussed in detail in connection with the associated vegetation, of which there are the following four main types:

(1) Dense *Tea-tree thicket*, about 14 feet high, the dominant and most widespread community on the swamp.

(2) A more open and lower *shrub* community with *low sedges* between the bushes.

(3) A *sedge meadow* (Weaver and Clements, 1929) of these same low sedges alone.

(4) Aquatic communities of *water plants*, together with *reed-swamps* marginal to the streams and ponds.

Besides these, the communities of the adjacent areas must not be neglected, they are:

(5) *Eucalypt woodland.*

(6) *Grassland.*

(7) *Littoral plants* of the more or less stabilised sands.

The first four communities form a series, and, in a normal hydrarch succession, would replace each other on decreasingly wet soils in the following order:— *aquatic communities* (4), *sedge meadow* (3), *shrub-and-sedge* (2), culminating in the *tea-tree thicket* (1) of the soils mainly above flood level. Here and there a stage is skipped, and, *e.g.*, *reed-swamp* (4) and *tea-tree thicket* (1) grow in juxtaposition beside a pond. The shrub-and-sedge zone (2) is definitely intermediate in character and position between the *sedge meadow* (3) and the *tea-tree thicket* (1), growing on an intermediate type of peat and usually fringing the tea-tree thicket.

These four swamp communities and the three adjacent formations will now be described in detail. In a later section, on the probable history of the swamp, evidence is brought forward to show that succession has proceeded in the reverse direction, in comparison with the classic type of hydrosere in which "Verlandung" is taking place.

Human interference with the swamp has been small until recently. The official drainage scheme began only in 1937; rolling and burning in 1941 and 1942 respectively—the burning not until after this vegetation survey. There was certainly some burning of the margins and probably clearing of the two main creek channels before this. One such recently burnt patch had been monopolised by three very similar native bushes of the family Compositae (*Senecio lautus*, *S. orarius* and *Erechthites prenanthoides*); *Cirsium lanceolatum* (Scotch Thistle) was an alien weed also invading here and elsewhere.

IV THE IMPORTANT SWAMP COMMUNITIES DESCRIBED

(Pl. xxvii; fig. 1, 2, 3, and 4)

(a) The Aquatic Zone.[1]

(i) *Nasturtium officinale—Potamogeton pectinatus* Association.

The hydrophytes (submerged and partly submerged aquatics) of the flowing streams and still ponds are mainly freshwater plants, though some have quite a tolerance for brackish water (*e.g., Ruppia, Phragmites communis, Triglochin procera, Potamogeton pectinatus*). *Ruppia*, indeed, has been found in an evaporating salt-lake (Wood and Baas Beeking, 1937).

The waters are generally calcareous and rarely saline. Representative samples of free water from various ponds, drains and creeks on the swamp gave pH values of 7·23, 7·63, 7·74 and 8·09, and the soluble salts ranged from 28·72 grains per gallon in Eight Mile Creek itself (a good domestic-purposes water) to values of 60, 74, 82 and 83 (still potable waters) in ponds and smaller creeks and drains; about half these salts were in the form of chloride (Stephens, 1943). No saline water was actually obtained for analysis, but an almost dry swamp at the east end had a decidedly saline soil; its vegetation will be considered in the next section on the sedge meadow. The soils of the reed-swamp themselves were so close to open water that their profiles were not examined, no doubt they consisted mainly of reed-peat (including *Triglochin* peat).

The dominant species was Water Cress (*Nasturtium officinale*), which occurred in great masses, as large as a rowing boat, from deep down in the water to the surface, often filling the stream. Local dominance was assumed by *Potamogeton pectinatus*, called "Water Mat." This is one of a group of closely related species of water plants which share a grass-like habit; they are practically indistinguishable when not in flower. *Ruppia maritima* and *Althenia Preissii* should undoubtedly be added to the group of "Water Mats," though rarely seen in flower in February, 1942.

The submerged aquatics were:

Nasturtium officinale.[3] Water Cress—introduced. **D.**[2]
Potamogeton pectinatus.[3] A Water Mat—very common. Local **D.**
Ruppia maritima.[3]
Althenia Preissii (now *Lepilaena Preissii*). Slender Water Mat.
Myriophyllum elatinoides. "Sheoak Weed," Water Milfoil.
Hydrocotyle vulgaris.[3] Marsh Pennywort (and half submerged).
Lilaeopsis? Not seen flowering. Large specimens in deep water—probably needs shallow water for flowering.
Characeae. "Set-net," stonewort (*Chara* or *Nitella*).
Eleocharis acuta (and half submerged).
Ranunculus rivularis? Not seen flowering.
Lemna minor.[3] Duckweed. A small surface plant in still waters.
Epilobium sp. Occasionally found quite submerged, but not flowering.
Various freshwater Algae.

---

[1] J. M. Black, 1943, makes the following relevant names changes:—*Phragmites communis* Trin. becomes *Ph. vulgaris* (Lamk.) Crép.; *Althenia Preissii* (Lehm.) Graebn. becomes *Lepilaena Preissii* (Lehm.) F. v. M.; *Scirpus lacustris* L. becomes *S. validus* Vahl.; the form *Eleocharis* is adopted in place of *Heleocharis; Cladium rubiginosum* (Soland.) Domin, of the "Additions" reverts to *C. glomeratum* R. Br. of the First Edition; *Carex pseudo-cyperus* R. Br. not of L., becomes *C. fascicularis* Soland. ex Hook. f.

[2] **D** = "dominant," when placed beside a plant name.

[3] = spp. found in England.

TABLE B* COMPARATIVE LISTS OF AQUATIC SPECIES IN SOUTH AUSTRALIA, IN EAST ANGLIA, AND IN NORTH AMERICA

EIGHT MILE CREEK SWAMP, SOUTH AUSTRALIA	DISTRIBUTION	EAST ANGLIAN FENS AND BROADS (ENGLAND) (v. Tansley, 1939)	NORTH AMERICAN SWAMPS (v. Weaver and Clements, 1929)
REEDSWAMP		REEDSWAMP	
Phragmites communis, Common Reed **D**	Cosmopolitan; persists in soil above water level	*Phragmites communis* **D**	*Phragmites communis*, Reed Bulrush **D**
Typha angustifolia, Cumbungi, Bulrush **D**	Cosmopolitan (v. discussion)	*Typha angustifolia*, Lesser Reedmace	*Typha angustifolia*, Cat-tail
		Typha latifolia, Greater Reedmace **D**	*Typha latifolia*, Cat-tail **D**
Triglochin procera, local **D**	An Australian endemic sp.	Small, unimportant spp.	*T. striata* R. & P. A small, unimportant sp.; also at Eight Mile Creek
Olearia (*ramulosa* ?), local **D**	Australia		
Cladium Mariscus, large sedge, but not tussock habit, local **D**	Cosmopolitan (v. discussion)	*Cladium Mariscus*, Saw Sedge **D**	*Cladium jamaicense* Crantz, closely related
Scirpus lacustris (*S. lacuster* in Black's Flora —now *S. validus*)	Cosmopolitan (v. discussion)	*Scirpus lacustris* forms., Bulrush **D**	*Scirpus validus* Vahl., Great Bulrush **D**
S. americanus Pers. (= *S. pungens* Vahl. ?)	America, Australia, Europe	*S. pungens* in Jersey	*Scirpus americanus* Pers.
Sium latifolium var. *uniwittatum*, Water Parsnip	An Australian var. of a European type	*Sium latifolium* and *S. erectum*	*Sium* spp.
Gahnia psittacorum	Australia	Cf., similar habit of great tussock-forming sedges, *Carex paniculata* and *C. acutiformis*	
Eleocharis acuta. Also sedge meadow	Southern hemisphere	*Elocharis palustris* R. Br. Similar habit and range	*E. palustris*, Spike Rush **D** } Sedge
Cladium articulatum	Australia		Cf. *Cladium jamcense*, in Aust. & N.Z. **D** } meadow
Carex pseudocyperus (now *C. fascicularis*)	Cosmopolitan (v. discussion)	*Carex pseudocyperus* and many other *C.* spp.	*Carex*, many spp. In sedge meadow
Juncus caespiticius *J. pallidus*; also drier habitats	Australia } Australia }	Many other *Juncus* spp.	*Juncus* spp.
Urtica incisa, also in thickets, Stinging Nettle	Australian form of cosmopolitan *U. dioica*	*Urtica dioica*, also in fen carr; almost same sp. as Australian plant	*Urtica dioica*, Stinging Nettle
Polygonum serrulatum	Australia and Old World	*P. lapathifolium*, Cornwall; also Australia	*Polygonum*, sp., floating, Smartweed
Epilobium glabellum and *pallidiflorum*, some quite submerged	Australia and New Zealand	*Epilobium*, other spp., some submerged forms. Willow-herbs	*Epilobium* spp.
SUBMERGED AQUATICS		SUBMERGED AQUATICS	
Nasturtium officinale, naturalized **D**	Northern Europe and Asia. Widely naturalized. Native *Nasturtium* spp. occur in Australia and America also	*N. officinale*, Common Water-cress	*N. officinale*, naturalized
Potamogeton pectinatus, sub- **D** } Same	Cosmopolitan	*Potamogeton pectinatus* forma **D**	*Potamogeton pectinatus*
Ruppia maritima } grass-like	Cosmopolitan. Various forms exist	*Ruppia maritima*	*Ruppia maritima*
Althenia Preissii } habit	Australian sp. Others in W. Mediterranean		
Myriophyllum elatinoides	Australia, New Zealand, South America	*Myriophyllum*, other spp. Water Milfoil	*Myriophyllum*, other spp.
Hydrocotyle vulgaris	Australia, Europe, Africa	*H. vulgaris*. Great habitat range in fen. Sometimes **D**	*Hydrocotyle*, other spp.
Lemna minor, Duckweed	A cosmopolitan family	*Lemna minor* and other cosmopolitan *Lemnaceae*	*Lemna minor*
Ranunculus rivularis ? (4)	Australia, New Zealand	*Ranunculus fluitans* and *R. circinatus*	*Ranunculus* spp., (e.g., *R. aquatilis*), v. closely related to English and other S. Aust. forms
Lilaeopsis (*Crantzia*) ? (4)	Australia, New Zealand, South America		
Characeae. Not studied	*Chara* and *Nitella* are cosmopolitan	*Chara*	*Chara*
Algae. Not studied	Many types are cosmopolitan	Algae	Algae

(4) Not in flower.

* Identical or closely related spp., in the two or three countries are indicated by underlining.

(ii) *Phragmites communis—Typha angustifolia* Association.

Surrounding the open water of ponds or banking that of the creeks and rapidly invading the clear channels, is the well-known *reed-swamp* formation; some of its members can grow submerged, but normally they stand well above the water surface. The dominants of the *reed-swamp* are the cosmopolitan *Phragmites communis* and *Typha angustifolia*. Important plants of the formation are:

Phragmites communis[3] (now *Ph. vulgaris*). Common Reed, Bamboo Reed. **D.**
Typha angustifolia.[3] Bulrush or Cumbungi (Australia), Reedmace (England), Cat's-tail (America). **D.**
Triglochin procera. Local **D.**
Olearia ramulosa. Water Cypress. Local **D.**
Sium latifolium var. *univittatum.*[3] Water Parsnip. Common here, but rare in South Australia.
Gahnia psittacorum. May be dominant around ponds. Parrot Sedge, Giant Sword Rush.
Eleocharis acuta.
Cladium Mariscus.[3] May be dominant around ponds. Pom-Pom Rush (Saw Sedge in England).
C. articulatum.
Scirpus americanus. Bayonet Rush.
S. lacustris[3] (*S. lacuster* in Black—now *S. validus*). Tooley Rush.
Carex pseudocyperus[3] (now *C. fascicularis*).
Juncus caespiticius.
J. pallidus. Pale Rush.
Urtica incisa. Stinging Nettle.
Polygonum serrulatum.
Epilobium glabellum, *E. pallidiflorum* } Willow Herb.
Cassytha glabella (occasional).
Mentha gracilis and *Mimulus* sp. or *Mazus* sp. Small ground plants, occasional on the bank.

Many of these plants are quite at home in a drier environment than a reed-swamp, often with an altered habit of growth. The list probably does not account for all the Cyperaceae and Juncaceae to be found in this habitat, which would repay more intensive study. The striking thing about reed-swamps is the cosmopolitan nature, not only of their general appearance, but of the constituent species, many of which are identical in widely separated parts of the globe, and others merely closely-related variants. This applies also to other types of aquatic communities (Wood and Baas Becking, 1937).

Eight Mile Creek consists of swamp and fen country, obviously comparable to the English fens of East Anglia, and it will be of interest to set out the parallelism in the vegetation. Such close correspondence does not exist between land-plant formations, or even acid bogs of Australia and Europe (v. Wood and Baas Becking, 1937). Now refer to Table B, where some information on North American swamps is also included.

There are good examples of rapid spread of water plants, when introduced to new countries, which may help to explain the almost universal occurrence of the dominants in a given climatic zone, *viz.: Nasturtium officinale* (Water Cress), a European and Western Asiatic plant naturalised in America and the British Colonies; the North American *Elodea canadensis*, which spread with such spectacular rapidity in Britain in the second half of last century and is now found in most countries, often as a pest, though not yet recorded as spontaneous in South Australia; and *Eichhornia speciosa* (Water Hyacinth),

a native of Florida and South America, now a nuisance in Australia, India, etc. We believe *Phragmites* and *Typha*, etc., to be genuine natives, but something similar may have happened in the distant past; the possibility of seed transport by water-fowl may have some connection with this extensive distribution.

With species so widespread as this, one cannot avoid having doubts about their taxonomic identity, and a world-wide field and cabinet study of the species is needed, though the cosmopolitan nature of water plants is familiar from text books (Warming, 1909).

Some studies of this kind have been made on *Cladium Mariscus*, in Britain by Conway (1936-42), where it is common in certain localities only, *e.g.*, East Anglia, especially Wicken Fen; also by Blake (1943), with particular reference to forms from the Pacific region. *Cladium Mariscus* sens. lat. has a global distribution, many of the forms are now ordinarily known by other specific names and fairly well defined geographically. Blake, an Australian specialist on the Cyperaceae, is of the opinion that the Australian plant should also be considered a distinct species, as it is a further geographical form, and has published it as *C. procerum* S. T. Blake (1943). There is no doubt that these forms should be distinguished in some suitable way, but the method of giving them distinct specific names causes the ordinary worker to lose sight of the fact that this group of species exists and is much more closely interrelated than most others of the genus. In this particular case, a system of sub-specific geographical names would probably be workable. Hitherto the Australian form has been accepted as identical with the European one.

Scirpus lacustris L. is another example; the Western American form has been known as *S. validus* Vahl. for some time. Blake quotes the work of Beetle (1941 and 1942), who finds that the Australian form agrees with *S. validus* which has a circum-Pacific distribution, *S. lacustris* being restricted to Europe with a variety in Asia (Blake, 1943). Bentham and Hooker (1908) mention varieties of this species, but accept it as cosmopolitan.

Carex pseudocyperus is not now considered to include the Southern Hemisphere forms, and the Australian plant is to be known as *C. fascicularis* Boott.

Black (1943) accepts the last two changes, but not that of *Cladium Mariscus*. These problems of identity should be kept in mind when studying the comparative table of species (Table B). In the past, many of these names have been quoted as synonyms, which is not quite accurate.

Typha is also a taxonomically difficult genus, and Melvaine (1940) has published a revision of the New South Wales material, and comes to the conclusion that the Australian specimens are "not definitely identical" with the European, stressing the necessity for a good field knowledge of the habit. The present writer was not equipped with "a good field knowledge" of *Typha*, so followed Black (1st and 2nd Ed.) in naming the specimens. Black considers our *Sium* a variety of *S. latifolium*; and no critical work on *Phragmites* has been seen. *Potamogeton pectinatus* and *Ruppia maritima* are both known to have variants; these have not been studied in South Australia where water plants are relatively unimportant. There also appears to be close relationship between some of the aquatic species of *Ranunculus*.

In the other cases, the corresponding species are not quite so closely related, and for *Gahnia psittacorum* it is legitimate to make a comparison with the great tussock-forming sedges, *Carex paniculata* and *C. acutiformis*, composing the reed-swamp in some of the Norfolk Broads. Many of the

Cyperaceae run very much to type in different geographical areas. A further examination of the reed-swamp at Eight Mile Creek would probably group *G. trifida,* and perhaps *Cladium filum* (which are also large tussock sedges practically indistinguishable even when in flower) with *G. psittacorum,* both in this habitat and in drier ones.

The presence of *Olearia* (*ramulosa?*) in the reed-swamp is interesting; it is a bushy plant which often completely lines the sides of creeks and grows out into the centre, soon blocking the channel with a mass of roots in the water and leafy branches above it. This *Olearia* sp. is a small-leaved Composite and most unlike all the other members of the reed-swamp. Two *Olearia* spp. were found at Eight Mile Creek. Most species of this genus are very difficult to determine or distinguish, even when in flower.

Triglochin procera is endemic in Australia and occurs widespread in fresh and brackish waters of all the States. Small specimens have also been seen in an acid *Sphagnum* bog in South Australia. It has not a widely accepted common name, but belongs to the "Arrowgrass" genus, and is probably the largest and tallest of the genus, as the specific name indicates. The specimens found growing in the deep waters of Eight Mile Creek and its ponds are giants, with leaves long, narrow and ribbon-like, in a group growing straight up from the mud, in this case often 150-180 cm. below the surface of the water. There is a cylindrical flower-stalk in the centre bearing a dense spike of small flowers above water-level; the leaves stand out of the water and usually have their distal portions drooping over and floating on the surface. The average width of the leaves, as described in various floras, is about 1·2 cm., with a maximum of 3·2 cm. The specimens found had leaves fleshy below and up to 7·7 cm. broad, and flowering spikes 4 cm. in diameter. Intermediate sizes of *T. procera* were found, between the giants and the barely recognisable, moribund plants on the areas with a limey surface soil and saline peat. These apparently started to grow in a shallow, drying swamp and literally became stranded.

Triglochin has large, tough, fibrous rhizomes which present a great obstacle to cutting the waterways clear of vegetation. They may also form a very thick layer of plant remains, decaying, at first, as hollow tubes 2-3 cm. in diameter. Sods of such material had been cut out of Hitchcox Drain when enlarging it, and were locally called "hassocks." These rhizomes contain much starchy tissue and bear a great mass of fleshy roots below, some with tubers attached, and a coating of fibres from old leaf-bases on the upper side. The genus is cosmopolitan and not very large. Of the two British species, *T. maritima* grows in salt-marshes and has a rhizome and root system very like those of *T. procera* (Tansley, 1939). *Triglochin* spp. do not seem to be important in Britain or the United States, except for *T. maritima,* which has been recorded as an HCN-containing poison plant of damp meadows in the United States (Marsh et al., 1929). *T. maritima* is apparently a strictly coastal salt-marsh plant in Britain, and Godwin and Clifford, pl. iv (1940), found some *"Triglochin* clay" deposits among the peats of the East Anglian Fens, containing recognisable *Triglochin* remains. This was taken as evidence of the marine or tidal deposition of the clay. The Australian *T. procera* is certainly not an indicator of saline conditions.

The English "reed-grass" swamps, in which aquatic grasses like *Glyceria, Phalaris arundinacea* and *Molinia* are dominant, in place of the sedges and rushes, might be mentioned. Associations of this type are of doubtful occurrence in South Australia. Apart from the important dominants discussed earlier, the reed-swamps have a certain degree of geographical individuality in species and genera.

Pidgeon (1940) describes communities fairly similar to those at Eight Mile Creek Swamp for the early stages of brackish-water and freshwater-river successions in the coastal area of New South Wales.

(b) The Sedge Meadow and its Variations.

(Pl. xxviii; fig. 5, 6, 7 and 8)

Cladium junceum—C. glomeratum Association.

This area is generally evenly covered with a dense growth of one particular sedge, *Cladium junceum* (Blue Wire-rush), about 30-70 cm. high; sometimes with a small admixture of the almost indistinguishable *C. glomeratum* (*C. rubiginosum*) and, in places, the latter is the dominant constituent, but the meadow can properly be called a Cladietum. Weaver and Clements (1929) quote such a *sedge meadow* for North American swamps, dominated by an *Eleocharis-Carex-Juncus* complex; the Spike-rush here (*Eleocharis palustris* R. Br.) is similar in habit to our *Cladium junceum*. Pidgeon (1940) cites *C. junceum* as a dominant in one stage of brackish-water succession in the central coastal area of New South Wales, though she does not describe a pure meadow society of it; and Wood and Baas Becking (1937) record it as a peat-former in an acid bog (pH 4·0-4·5) at Mount Compass in South Australia. Tansley treats these marsh meadows under grassland, and also under reed-swamp, giving *Juncus effusus* L. as the dominant plant, with other *Juncus* spp. and sometimes *Eleocharis palustris* R. Br., as in North America.

The *sedge meadow* is the characteristic vegetation of Stephens' Milstead coarse fibrous peat soil type, the surface horizon obviously consisting mainly of the dark-brown, undecomposed mass of sedge rhizomes and roots, giving a springy surface. Lower down, the material is more decomposed, and the peat reaches a depth of 66 inches. The significance of the vertical sequence of the peat types will be discussed for all of them in the section on "The Probable History of the Swamp." The present vegetation differences are associated with the distinctive surface horizons, which alone will be given for each vegetation type (see fig. 2).

For the most part there are no other plants of importance in this very uniform *sedge meadow* (pl. xxviii; fig. 5 and 8), but there are three modifications of the main soil type to be described in due course.

The unmodified *sedge meadow* probably has the soil water-logged for a large portion of the year. The varying requirements of the alternative dominants have not been studied, though the indications are that *C. glomeratum* favours the low-lying areas with the lime surface, but it was also found in the *Gahnia*-tussock sedge meadow. One or other of them is so overwhelmingly important that further plants present are only incidental. The list (including modified areas) is as follows:

Cladium junceum
C. glomeratum (formerly *C. rubiginosum*) } either one of these is **D.**
Agrostis Billardieri, a Blown Grass.
Agrostis sp.
Chara (or *Nitella*). Local **D.**
Chenopodium ambiguum.
Epilobium sp.
Funaria, moss.
Gahnia trifida, Cutting "Grass"; with similar large tussock sedges not in flower. Local **D.**
Eleocharis acuta.
Juncus maritimus var. *australiensis.*

Lobelia anceps.
Luzula campestris.
Muehlenbeckia adpressa, a coastal species.
Olearia ramulosa.
Samolus repens.
Scirpus nodosus.
Selliera radicans, a very widespread ground plant in swamp communities.
Senecio sp. or *Erechthites,* closely resembling each other.
S. lautus.
Spiranthes australis Lindl. Swamp Orchid. (*S. sinensis* (Pers.) Ames in Black, 2nd Ed.).
Triglochin procera. Local **D.**
T. striata, a small plant.
Urtica incisa, Stinging Nettle.

At the east end of the swamp, where the *sedge meadow* meets the sandhills, is a small *Cladium Mariscus* society, whose habitat requirements are not understood, forming a thicket about 130 cm. high, with *Urtica incisa* all through it. Some *Agrostis* spp. and *Poa* spp. permeated most of the communities like a light web.

The first of the modifications is associated with the Hitchcox limey peat soil type (fig. 2), which is characterised by a surface layer of lime from two to six inches thick, overlying a coarse and fine fibrous peat. It seems very likely that some of this surface layer has been formed from the green algal freshwater plant, *Chara,* whose structure could still be detected in the snow-white incrustation covering some bare patches in the *sedge meadow* (pl. xxviii, fig. 6), or even on the ground between the sedges (pl. xxviii, fig. 5). *Chara* must grow submerged in water, and it is common in the South-East, to see it dried white and brittle in belts, like a layer of salt, around a receding pond or shallow swamp where the growth has been dense.

Green water-plants of many kinds can cause calcium or other cations to be deposited, usually on their surfaces, from a solution rich in bicarbonate, as they extract CO_2 from the water during photosynthesis, causing precipitation of the carbonate. Still waters are more suitable for this deposition than those of turbid streams. There are also bacteria which behave in the same way. *Chara* limestones are well known (for a South Australian occurrence v. Howchin, 1909), but their rate of formation must be slow; it has been calculated as one foot in about 2,500 years in Green Lake, Wisconsin (quoted by Twenhofel, 1932). *Chara,* as a rule, is found only in hard waters. Some of these calcareous surfaces of the Hitchcox limey peat contained the shells of small water-animals, which must also play a part in their formation. It would only be necessary to have frequent or constant flooding, in this region of alkaline waters, to get the right conditions for the deposit of calcareous matter such as this in an open area; consequently it is concluded that this soil type was formed under wetter conditions than those of the normal *sedge meadow.* These patches were dry in February 1942—a new state of affairs, probably due to the draining.

The second modification also occurs in this zone of wet soils with a limey surface; it is characterised by a spongy, brown, fine fibrous peat of a saline type. The limey surface was in the form of still-recognisable *Chara* remains, and there were a great many dwarfed dead plants of *Triglochin procera* here; the fibre-coated rhizomes of *Triglochin* have already been mentioned, and it is believed that this area has been under deep water, with what Fisk, in his survey of August, 1939, described as "a kind of water-lily or hyacinth" growing in "soupy" mud. This plant was *T. procera,* and it is suggested that the

decay of the thick growth of rhizomes and fibrous leaf-bases has produced this fine fibrous peat. In February, 1942, at the time of the vegetation survey, it had become just dry enough to walk on. The death of the *Triglochin* plants may simply have been due to drying or also to the effect of the accompanying rise in salt concentration. It is essentially a water plant.

The third modification is the type of *sedge meadow* dotted with numerous big tussock sedges of a Cutting Grass (*Gahnia trifida*) 1·3-1·5 m. high (pl. xxviii, fig. 7), and it is found on the *shallower* peats of the Milstead coarse fibrous variety and other types. In appearance it resembles the *shrub-and-sedge* community to be described later. Some of the non-flowering tussocks were suspected of being the closely similar *Cladium filum*, but its presence at Eight Mile Creek was never confirmed by fruiting specimens.

The *Chara* phase and the *Triglochin* phase occur (usually in the Cladietum glomerati) at the eastern end of the swamp, which received the floodwaters from Bone Creek before it was connected by a drain to the sea. The *Gahnia*-tussock *sedge meadow* is on obviously drier areas, mainly on the landward side of the swamp, and at times the low sedge gives way to grass sward between the *Gahnia trifida* clumps. This community is probably not one of the stages in the normal swamp succession. Moreover, it is within reach of the fires known to have been put in from the edge, for many years past, by leaseholders desiring to penetrate the swamp property and make use of what pasture was available. Sometimes small, open, dried-up winter swamps were seen here with the remains of either *Chara* or *Ruppia maritima*.

(c) The Tea-tree Thicket and included "Islands."

(Pl. xxix, fig. 9)

Leptospermum pubescens—Melaleuca squarrosa Association.

The *Tea-tree thicket* is the climax vegetation (under the swamp conditions) and covers a greater area than the other types (v. Stephens, fig. 1). It consists almost solely of two shrubs of practically identical habit and very even in height (about 4·5 m. or 15 ft.). They form a closed community so dense that one can hardly force a way between the thin, unbranched, vertical, woody stems; and there is little room or sufficient light for the growth of smaller plants in the thicket, or even for leaves on the two dominants, except at the top of the plants which have a continuous, nearly level canopy of foliage, broken occasionally by twigs of the larger-leaved Swamp Gum (*Eucalyptus ovata*).

The raw material of the *Tea-tree thicket* peat is the woody stems and small leaves of the two dominants. Apparently they are not very fibrous and decompose fairly quickly into a good, humified, fine black friable peat—the Badenoch friable peat—with which the *Tea-tree thicket* is constantly associated. This soil type is the best on the swamp and gives quite definite acid reactions in some of the horizons, the range being pH 5·8-7·8; the pH value falls regularly with increasing depth of peat. There is the suggestion of such a tendency in the related Orwell coarse and fine fibrous peat, but in the other types (uncomplicated by the presence of lime) there is only one pH value on the acid side of neutrality, and that occurs in the surface horizon of the Milstead coarse fibrous peat (sedge meadow). Any of these peats which have an acid reaction are probably not much exposed to the calcareous ground-water and, for other reasons also, it is assumed that the *Tea-tree thicket* grows on thoroughly well-drained soils only (v. fig. 1). The cause of the increase in acidity with depth of the peat may be connected with increasing humification (*i.e.*, an acid-producing process).

It is uncertain whether the stemmy habit of the *Tea-tree thicket* is due to the presence of a very thick crop of plants or whether each plant stools freely from the base. The latter is the case in the similar Rhamnetum at Wicken Fen near Cambridge (Godwin and Bharucha, pt. iii, 1936). In England a fen scrub of this type is called "carr"; at Wicken this carr is almost a pure community of two species of *Rhamnus*, the more important one being the Alder Buckthorn, *Rhamnus Frangula* L. (= *Frangula alnus* Miller). A more usual type of carr is that dominated by deciduous trees of the *Alnus* (Alder), *Salix* (Willow) and *Betula* (Birch) type, eventually changing over to woodland with *Quercus* (Oak), etc. (as at Calthorpe Broad, Godwin and Turner, 1933).

An analogous formation is described for hydroseres in North America by Weaver and Clements (1929) dominated by *Alnus*, *Salix* and *Populus* (Poplar). In our opinion, the *Tea-tree thicket* at Eight Mile Creek corresponds more closely with the Rhamnetum at Wicken than with the *Alnus-Salix-Betula* type of fen carr. The earlier comparison between the reed-swamp formations in South Australia and in the Fens and Broads of East Anglia revealed that the facies and the dominant species were practically the same. In this case there is no identity of dominant species, but still a similarity of facies; the two dominant species at Eight Mile Creek are evergreens of the family Myrtaceae, with particularly Australian affinities.

The occasional presence of *Eucalyptus ovata*, one of the dominants of the surrounding sclerophyll woodland, is clearly parallel to the occurrence of ordinary English woodland trees in carr, and illustrates the divergence of species between the two geographical regions the further one goes from the aquatic vegetation.

In the Tea-tree zone there are occasional small rises, the larger ones bear definite Eucalypt woodland (*e.g.*, "Timber Island"), and the smaller ones have *E. ovata* (White Swamp Gum) as the dominant. The two *Tea-tree thicket* species are relatively unimportant, the vegetation is more open, and the list of accompanying species obviously belongs to the Eucalypt woodland formation. These small patches, moreover, are associated with the fine, grey, sandy loam and flinty loam soil types common on the margins of the swamp, which will be dealt with later, and are no doubt relict areas as yet uninfluenced by the normally increasing swampiness of Eight Mile Creek. The present drainage policy (apart from clearing) would have ensured the survival of these islands. It would also, on theoretical grounds, have favoured the invasion by *Tea-tree thicket* of the shrub-and-sedge community, and finally the sedge meadow.

At present the swamp is being cleared for cultivation; the ordinary tractor-drawn scrub-roller is being used to smash down the *Tea-tree thicket* and leaves behind it an almost solid layer of prostrate, woody stems about two feet (60 cm.) deep. It is fairly easy to walk on this, and where re-growth has started, the normally repressed associated plants become frequent; the dominant Tea-trees sprout again also. This formidable layer of débris is eventually burnt. The list of associated plants is given below, together with that for the "islands" of Eucalypt woodland. The big sedges, *Gahnia* (two species) and *Cladium Mariscus*, are fairly common in the thicket, but cannot often attain their tussock or clump habit in such crowded conditions.

Tea-tree thicket:

Leptospermum pubescens. Silky Tea-tree (known earlier as *L. lanigerum*), **D**.
Melaleuca squarrosa. Bottle-brush Tea-tree. **D**.
Acacia myrtifolia.

Billardiera cymosa.
Cassytha pubescens.
Cladium Mariscus (base of stems long and scaly with leaf remains).
Correa sp.

Cyperaceae—various:
Eucalyptus ovata. Not dominant here.
Gahnia psittacorum. Not in the usual tussock form, constantly associated.
G. trifida. Not as a tussock.
Imperata cylindrica. Blady Grass (*I. cylindrica* var. *major* in Black, 1943.)
Leucopogon australis.
Muehlenbeckia adpressa.
Olearia glandulosa and *O. ramulosa.*
Phragmites communis. Ubiquitous in the swamp.
Pimelea macrostegia or *P. ligustrina* (not in flower).
Poa caespitosa. Hair-like grass permeating ground layer of 30 cm.
Pultenaea stricta.
Rubus parvifolius.
Senecio (*lautus* ?).
Sprengelia incarnata.
Swainsona lessertiifolia, scrambling on other plants.
Typha angustifolia. Marginal, next to Cladietum.

Eucalypt "Island (c.f. Eucalypt Woodland list):
Eucalyptus ovata, White Swamp Gum. **D.**
Leptospermum scoparium. A Tea-tree; sub-**D.**
L. pubescens
Melaleuca squarrosa } Not dominant here.
Exocarpus cupressiformis.
Imperata cylindrica. Blady Grass (= *I. cylindrica* var. *major,* in Black, 1943).
Helichrysum ferrugineum.
Pimelea glauca.
Olearia glandulosa.
Pteridium aquilinum. Bracken.
Correa sp., not in flower.

(d) The Shrub-and-Sedge Community.

(Pl. xxviii, fig. 8)

Leptospermum pubescens—Cladium junceum Ecotone.

This is a reasonably open shrub community 90-120 cm. (3-4 ft.) high, with the low sedge dominants of the sedge meadow in the spaces. Its intermediate nature between sedge meadow and Tea-tree thicket has been mentioned before, and the soil is the partly humified, intermediate type, Orwell coarse and fine fibrous peat, which has less of the coarse material produced by the sedges on the surface of the sedge meadow and a proportion of the fine black Tea-tree peat.

The dominant shrubs are dwarf *Leptospermum pubescens,* Silky Tea-tree (formerly known as *L. lanigerum* in South Australia) and *Melaleuca squarrosa,* Bottle-brush Tea-tree, the same two which form the Tea-tree thicket. These two do not crowd out other shrubs here, as in the Tea-tree thicket, and those most commonly present are further types of Tea-trees and large tussock sedges, together with quite a variety of plants not suited to very swampy conditions. Among these may be seen young White Swamp Gum trees (*Eucalyptus ovata*), which is probably unable to establish itself on the wetter phases. Some patches of unusually tall and dense *shrub-and-sedge*

vegetation were seen, which gave the impression of Tea-tree thicket in the course of development. The list of other plants present is given below.

Shrubs:

Leptospermum pubescens. **D.**
Melaleuca squarrosa. **D.**
M. gibbosa.
Leucopogon australis (probably not the almost indistinguishable coastal sp., *L. parviflorus*).
Gahnia trifida, *G. psittacorum* } Large tussock sedges.
Leptospermum scoparium. A tea-tree.
Olearia ramulosa.

Undergrowth:

Cladium junceum, *Poa caespitosa* } Continuous ground cover.
Leptocarpus Brownii, *Juncus maritimus* var. *australiensis* } In the *Cladium* stratum.
Agrostis Billardieri. Common.
Samolus repens.
Villarsia sp.

Other Plants which may be present are:

Acacia myrtifolia. A shrub.
Cassytha pubescens.
C. glabella.
Eucalyptus ovata. Young plants, White Swamp Gum.
Hakea nodosa. A shrub.
Logania ovata. A shrub.
Muehlenbeckia adpressa.
Phragmites communis. Found in many communities.
Sprengelia incarnata. A swamp plant, rare at Eight Mile Creek.
Typha angustifolia.

The actual swamp communities have all now been described, and a plant notably absent is the broom-like shrub, *Viminaria denudata,* so constant a member of the swamps of the large Fleurieu Peninsula region, south of Adelaide, and other parts of the State, including the South-East. There is clearly something unsuitable to *Viminaria* in this environment, perhaps the high soil pH value.

V ADJACENT AREAS

(e) Eucalypt Woodland

(Pl. xxix, fig. 10 and 11)

Eucalyptus vitrea—E. ovata Association.

This woodland or scrub is found around the landward borders of the swamp on grey loam or grey fine sandy loam soils containing more or less flint, and also on transitional shallow peats, peaty loams and the few brown loam soils. In the case of the peaty soils, the Eucalypt woodland is liable to include clumps of typical Tea-tree thicket on peat.

The islands of grey, sandy loam, bearing *Eucalyptus ovata* and scrub, which occur in the Tea-tree thicket, have already been described, and are, like the clumps of Tea-tree in the woodland just mentioned, a good demonstration of the relationship of *Eucalypt woodland* and Tea-tree thicket. *Eucalypt woodland* occurs on drier soil with much less organic matter than that of the Tea-tree thicket, which, of course, is a swamp peat.

There are only two important Eucalypts, *E. ovata,* the Swamp Gum, a pale-barked, smooth-branched tree, and *E. vitrea,* with a dark-brown, fibrous bark on trunk and limbs. *E. ovata* is also found on the swamp, but not *E. vitrea,* which is uncommon in South Australia and restricted to the South-East.

The trees are 6-12 m. (20-40 ft.) high, with shrubs and smaller plants forming an undergrowth of varying density. The plants in the Eucalypt woodland are given below—some clearly belong to the swamp communities.

Eucalyptus vitrea. **D.**
E. ovata. **D.**
Acacia melanoxylon. Blackwood, tree as tall as the Eucalypts. T.
A. pycnantha (a society probably due to burning). S.
Acaena Sanguisorbae. Bidgee-widgee.
Agrostis Billardieri.
Astroloma humifusum and other Epacrids.
Banksia ornata. S.
Bursaria spinosa. S.
Cassytha pubescens or *C. glabella* on tea-tree.
Casuarina stricta. 9 m. (30 ft.) high. Drooping Sheoak. T.
Cladium or *Gahnia.* Not in flower. S.
Dipodium punctatum. Hyacinth Orchid.
Epilobium pallidiflorum.
Exocarpus cupressiformis. Native Cherry. S or T.
Gahnia trifida. A Cutting Grass. S.
Hakea nodosa. S.
Helichrysum ferrugineum. S.
Hydrocotyle sp.
Imperata cylindrica. Blady Grass.
Leptospermum scoparium. Tea-tree. S.
L. pubescens. Silky Tea-tree. S.
Leucopogon australis, and perhaps *L. parviflorus,* the coastal species. S.
Loranthus pendulus. Mistletoe on Eucalypts and Acacia.
Muehlenbeckia adpressa.
Pelargonium australe.
Poa caespitosa. A hair-like, all-pervading grass.
Pteridium aquilinum. Bracken, common.
Scirpus nodosus.
Selliera radicans.

S = shrub, except small prostrate ones. T = tree.

(f) GRASSLAND (Pl. xxix; fig. 10, 11)

The *grasslands* occur on grey sandy loams with flint similar to those carrying Eucalypt woodland; the small amount of black clay soil in the swamp also carries grass. There is undoubtedly some natural grassland—for example, an area of grass beset with *Gahnia trifida* tussocks, 1-1·5 m. (up to 5 ft.) high; also the open, half-bare, grassy flats in the Eucalypt woodland; but some of the grassland is probably due to the clearing of the scrub. The grassland is marginal, occuring alternatively to the woodland; the reason for the presence of grassland rather than woodland is often clearly due to the shallowness of the soil or to occasional inundation.

The turf was composed mainly of *Themeda* sp. (Kangaroo Grass), *Danthonia* sp. (Wallaby Grass), *Agrostis* sp. and *Selliera radicans* (not a grass, but a common, small, creeping swamp plant), with perhaps very low sedges of the sedge meadow, some *Acaena Sanguisorbae* (Bidgee-widgee Burr) and the invading weed, *Cirsium lanceolatum* (Scotch Thistle), which

establishes itself wherever possible in the swamp. There would be more annual species of grasses in spring and early summer.

(g) LITTORAL (Pl. xxix, fig. 12)

Leucopogon parviflorus Association.

The coastal sands are calcareous, and, in places, flinty. At the east end of the swamp there are high dunes of unstabilised sand, but elsewhere the sands are fairly level, fixed, and slightly elevated above the beach. The vegetation is of the type common to such coastal situations in South Australia (Wood, 1937).

The most important plant is the shrub *Leucopogon parviflorus* (a plant with small, white, edible berries), found on both fixed sands and dunes. We believe it is generally replaced on the swamp by *L. australis*, but the two species are far too alike to be very sure.

The dunes have a less varied selection of the plants found on the fixed sands, together with a few characteristic ones, like the grey cushion-bush (*Calocephalus Brownii*) and the pioneer sand-binding grass *Spinifex hirsutus*. On the fixed sands, the sedge, *Scirpus nodosus*, is an important sand-binder, like the Sword Rush (*Lepidosperma gladiatum*). The associated sward-forming grasses, *Distichlis spicata* and *Sporobolus virginicus*, are also important surface stabilisers, and there are other small shrubs and tussock grasses.

Prior to 1937, Deep Creek had a meandering exit, passing through these coastal sands for some distance. A short, new channel to the sea has now been cut, but the old course remains, and in it grows much vegetation related to creeks rather than sands. Similarly there is an area with swampy swales of tall Tea-tree alternating with sandy rises. Probably the sands tend to invade the swamp in such places.

The lists of plants are as follows:

Dunes:

Leucopogon parviflorus. **D.**
Calocephalus Brownii. **D.**
Carpobrotus aequilaterus (Haw.) N.E. Br. (= *Mesembrianthemum aequilaterale* Haw.), Pigface.
Lotus australis.
Olearia sp. (not in flower — *O. axillaris* ??).
Pelargonium australe.
Pimelea serpyllifolia.
Poa caespitosa var. *Billardieri*. A maritime tussock grass with almost pungent leaves.
Polypogon monspeliensis.
Rhagodia baccata. Coastal saltbush.
Scirpus nodosus. An important dune sedge.
Sonchus megalocarpus. Native coastal Sow-thistle.
Spinifex hirsutus. Important sand stabiliser.
Swainsona lessertiifolia. Scrambling plant.
Tetragonia implexicoma. Coastal climbing spinach.

Fixed Sands:

Leucopogon parviflorus. **D.**
Scirpus nodosus. Sub-**D.**
Acaena Sanguisorbae.
Agrostis sp.
Anagallis arvensis.

Apium australe. Sea Celery.
Cakile maritima var. *edentula.* A strand plant.
Carpobrotus aequilaterus (= *Mesembrianthemum*).
Cladium junceum (sedge meadow plant).
Dichondra repens.
Distichlis spicata, *Sporobolus virginicus* } Associated sward-forming grasses.
Hydrocotyle hirta. Probably a swamp plant.
Lagurus ovatus. Common coastal grass.
Lepidosperma gladiatum. Sword Rush, common.
Muehlenbeckia adpressa.
Pelargonium australe.
Pimelea serpyllifolia. A coastal shrub.
P. sp., annual.
Poa caespitosa var. *Billardieri.*
Polypogon maritimus.
Salicornia (not in flower).
Samolus repens.
Scaevola microcarpa or *pallida* (not in flower).
Senecio lautus. Sometimes also a strand plant.
Solanum aviculare (rare).
Sonchus megalocarpus.
Sporobolus virginicus.
Stipa teretifolia. A coastal grass.
Swainsona lessertiifolia.
Sward-forming grass (not in flower).

VI THE WATER TABLE AND THE PLANT ASSOCIATIONS

The Lands Department surveys in connection with drainage plans of this area were made by Fisk in 1938-1940; there had been an earlier, not very detailed survey. Most of Fisk's water-levels were recorded in the months of June, July and October, and the ground-water levels in the South-East are known to be generally highest in August-September and lowest in April (Ward, 1941), so that Fisk's levels must be near the maximum for the season. The fall in water-level due to drainage could hardly have been very great at the time of his surveys.

Eight S.-N. contour sections were drawn across the swamp at intervals, from end to end, using Fisk's levels and water-level data, and indicating the vegetation types (two are reproduced in fig. 1). In none of these sections is the water level anywhere more than 22 cm. (8½ in) above natural surface level in the Tea-tree thicket (October 1938), and, for the most part, so far below this that the Tea-tree thicket soils can seldom have free water above them. All the other swamp communities show water at inundation levels in these sections, though the shrub-and-sedge community on the Orwell coarse and fine fibrous peat is seen to occur both in submerged and in fairly dry places. The water-level in the swamp has been a rising one, historically speaking, and these small parts of the Tea-tree thicket now subject to inundation may have grown up under drier conditions and might eventually succumb to this encroaching winter flood if at all prolonged.

The Cladietum on the Hitchcox limey peat, with its *Chara* and *Triglochin* patches, is submerged longer than any of the other vegetation types, except the reed-swamp—probably all the year round in most seasons. That it was seen dry in February, 1942, can only be due to the successful drainage. The Hitchcox limey peat and the brown, fine fibrous peat are soil types certainly formed under these conditions of flooding, and can be expected to change to some degree if the flooding stops.

TWO S.-N. SECTIONS OF THE SWAMP SHOWING TOPOGRAPHY, VEGETATION AND WATER LEVELS.

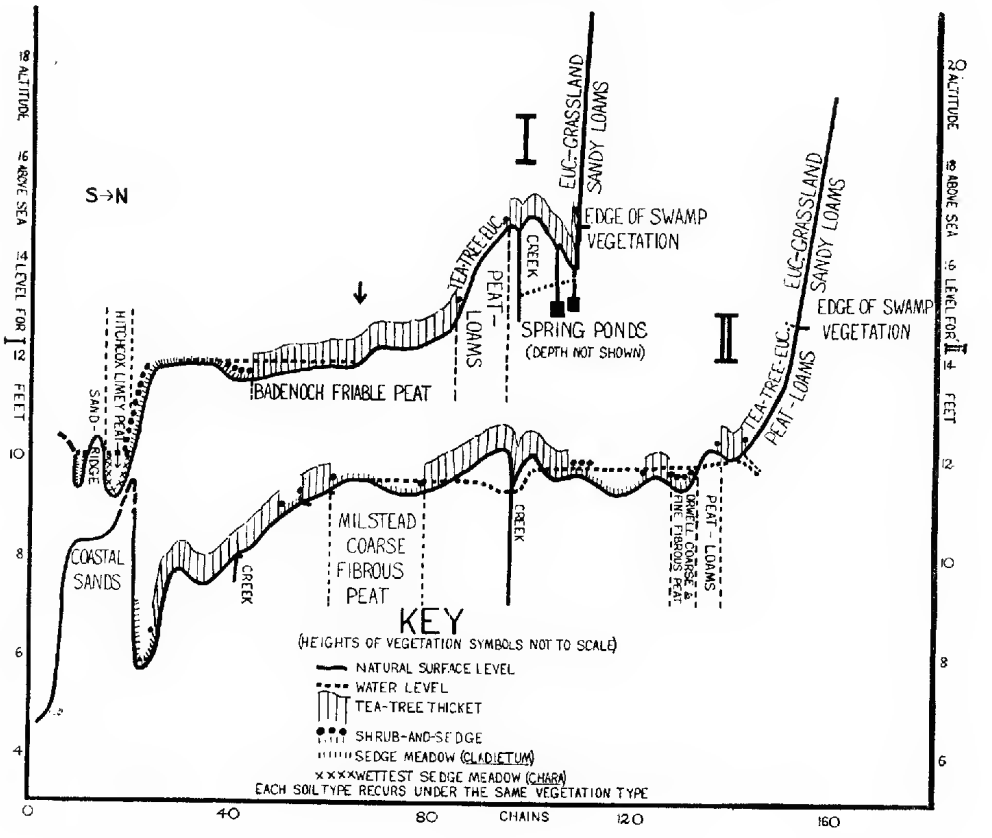

Fig. 1

No. I is 110 chains east of the mouth of Eight Mile Creek (v. map in Stephens', fig. 1) and almost parallel to the new drain from Bone Creek, which is 10-15 chains to the west. At the north end, the section passes through ponds at the source of Bone Creek; and at the south, through a little of the most swampy part of the whole area, showing the Hitchcox limey peat soil type carrying *Chara*.

The water levels were recorded by Fisk in June, 1939, and were the same in February, 1940. The arrow indicates the southern edge of a burnt patch, evidently limited by surface water. Only the swamp vegetation types are given in detail; the reed-swamp is always a narrow fringe and does not show on a plan of this scale.

No. II lies 30 chains east of the mouth of Eight Mile Creek and passes practically through Danger Point. In general level it is lower than No. I (exaggerated by two feet on the plan), but the trough shown behind the coastal sands is far less swampy than similar ones further east, and carries the normal Cladictum without *Chara*. Note the general occurrence of the Cladietum in submerged depressions and of the Tea-tree thicket on the slopes and higher ground. Water levels recorded July, 1940.

(Based on levels by H. L. Fisk, and soil map by C. G. Stephens.)

VII PROBABLE HISTORY OF THE SWAMP

An upper age limit of something less than 5,500 years has already been suggested for the swamp, after a consideration of the known age of the English Fen peats. Future local studies of peat pollens and climatic history will modify this figure. In the meantime, a tentative history of the area will be given.

During Pleistocene or Recent geological times, the sea has gradually retreated from the south-eastern portion of the State, leaving a succession of consolidated

calcareous or unconsolidated sandy ridges at various distances inland, parallel to the present coastline. These ridges represent old coastal dunes (Crocker, 1941). At some time before or after emergence of the land, the Eight Mile Creek springs were formed by faulting, and, as their waters accumulated on account of incomplete drainage, the area became first slightly swampy and then increasingly so.

From our present experience, it seems likely that the first swamp vegetation to colonise the region and leave peat remains would have been the driest of the swamp communities, viz., the Tea-tree, which may have replaced Eucalypt woodland or some other type of vegetation as the soil became wetter.

On this hypothesis, the whole of the swamp has been through an initial Tea-tree thicket stage, and one would expect to find Tea-tree peat at the bottom of all the peat profiles. On studying the section across the swamp in Stephens' fig. 7 (1943), one obtains a picture of the underlying beds of calcareous sand or Miocene limestone and an idea of the relationship between his four peat types and surface level. It is clear that the Hitchcox limey peat and the Milstead coarse fibrous peat occupy the lower levels of that section, and it is known that these areas were regularly under water in winter.

PROFILES OF THE FOUR SWAMP PEAT TYPES (after Stephens), showing the probable sequence of vegetation.

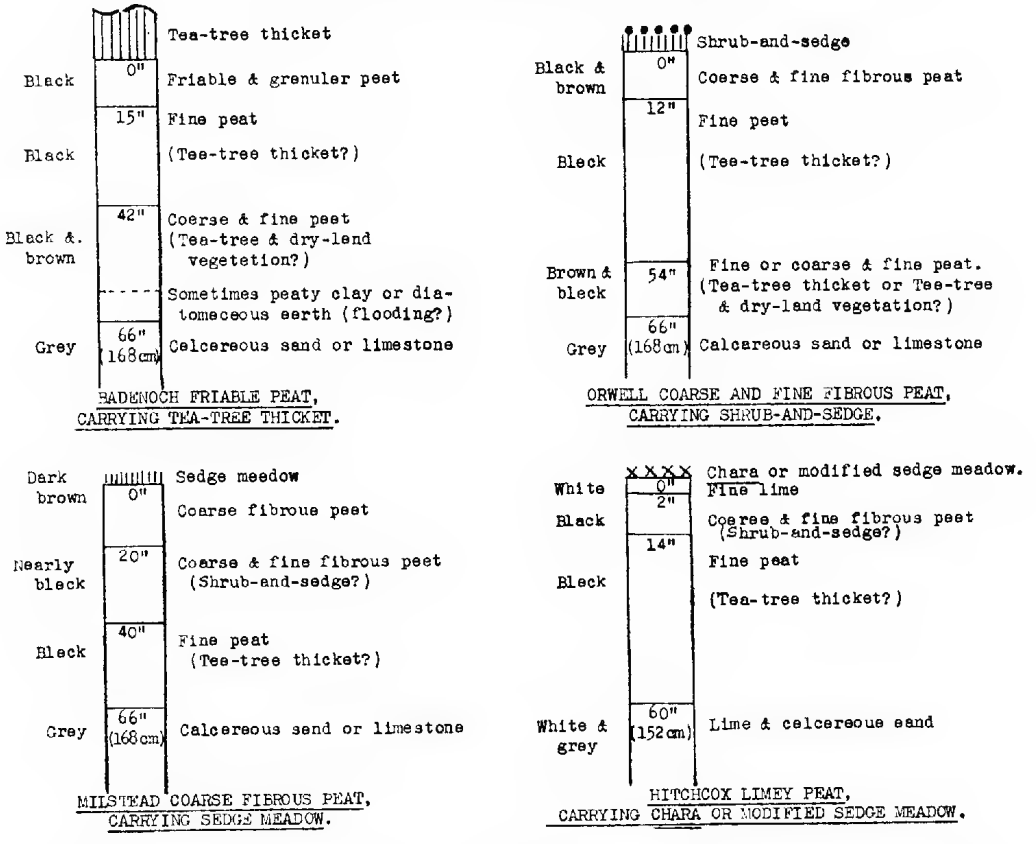

Fig. 2

The vegetation is not to scale; that probably responsible for forming the peat layers is given with a query; symbols as in Fig. 1.

Now, on examining Stephens' four soil profiles (fig. 2 herewith), which were named according to the nature of the surface horizon in each case, it is seen that at the bottom of the Milstead and Hitchcox peats there is black, fine peat. Our peats and vegetation types have not yet been correlated by the careful microscopic examination of detritus of the various peats, which is really necessary to identify them accurately; but this black, fine peat is almost certainly humified Tea-tree thicket remains. In the less swampy Badenoch and Orwell soils there is a more mixed peat at the bottom, and it is probably to be interpreted as the remains of a former vegetation changing over to Tea-tree thicket rather more slowly than in the case of the Milstead and Hitchcox peats, because the area was not so wet. A microscopic analysis of this mixed peat might give a clue to the nature of the former vegetation.

Returning to the Milstead and Hitchcox peats, above the basal black fine peat is coarse and fine fibrous peat. This is most likely the remains of a shrub-and-sedge community, representing the opening out of the Tea-tree thicket and more vigorous growth of sedges with increased flooding. Above this, the coarse fibrous peat of the Milstead soil type represents the establishment of the pure Cladietum on account of more frequent inundation; and the layer of lime typical of the Hitchcox limey peat must be due to almost permanent flooding, as already discussed, and is probably connected with the first arrival of the flood-waters of a blind creek at a low-lying spot, *e.g.*, the waters of Bone Creek.

In the same way, shrub-and-sedge has succeeded the Tea-tree thicket on the Orwell peat, while the Badenoch peat is still dry enough to carry the Tea-tree thicket and has a less humified surface horizon.

If this theory of the sequence of events is correct, one could probably destroy the intractable Tea-tree thicket by impeding the natural drainage and letting the spring waters accumulate—but it might take a long time, and, sooner or later, would establish a new Tea-tree area on the dry land of the adjacent parts, which have been described. Succession can take place in both directions in the plant sequence, and here we have an example of the reverse of the more usual type of succession in the hydrosere. If the above experiment of impeding the drainage were performed, there would be two opposing tendencies at work—one, the gradual rise of the water table, and the other, the natural rise of the soil level due to peat accumulation. As we have seen, the water has had some victories in the past, when the Hitchcox limey peat was formed; though, in general, the rise of soil level has prevailed.

VIII SUMMARY

A vegetation survey of a coastal swamp in the south-east corner of the State was made, in connection with the soil survey of the same area, prior to draining, clearing and settling it. Previous human interference has been slight, on account of the wetness of the soil and density of the vegetation.

The environment of Eight Mile Creek Swamp is described, and compared with that of acid, ombrogenous *Sphagnum* bogs and topogenous fens, with their distinct vegetation types, in other parts of the world. Some of the largest fenlands are found in East Anglia in England, and it is believed that Eight Mile Creek Swamp bears a very close relationship to these, on account of the similar alkaline ground water, peat types (Stephens, 1943), and especially the eutrophic vegetation types, which, in the wetter communities, involves identity of dominant species. On this basis, some comparison is attempted between the fen peats of a given depth and known age and the Eight Mile peats nearly as deep, 150-168 cm. (5-5½ ft.), and of unknown age. It is tentatively suggested that the South Australian peats are less than 5,500 years old.

There is very close correspondence between the four main peat soil types and their associated vegetation, which was safely used to map the soil boundaries.

The main factor limiting the extent of each type of swamp vegetation is the level of the water table; and the climax vegetation of the swamp is a closed Tea-tree thicket growing on the Badenoch friable peat, the best-drained of the peat soils, most of it being higher than winter water-level. It is also the commonest type, covering over half the total area. The vegetation and soils of three adjacent communities are also discussed. These are quite Australian in their floristic affinities and not cosmopolitan like the aquatic plants of the swamp.

The above seven vegetational units are described ecologically and floristically, and a detailed comparison is appended between the aquatic species at Eight Mile Creek and in East Anglia, together with some indication of further parallels in North America. The taxonomic implications of this are also touched upon.

As the swamp is poorly drained and supplied with water from several springs as well as the drainage from the surrounding country, it is believed that the history of the area is one of increasing swampiness, and the course of plant succession is discussed from this point of view, with additional evidence supplied from the sequence of distinctive peat types in the soil profiles. These peat types have been correlated with certain vegetation types on the experience gained with the surface horizons only; no attempt has yet been made to identify plant detritus in the peat. It would seem that succession has proceeded in the reverse direction to the well-known "Verlandung" cycle, beginning with climax Tea-tree thicket and ending with flooded sedge meadow and aquatic communities.

Profile sections of the swamp are discussed in relation to vegetation type and winter water-level.

IX ACKNOWLEDGMENTS

This account of the vegetation is due to Mr. Stephens' suggestion and is based on his cognate study of the soils (q.v. 1943). Assistance on many desired points of information has been received from: the University Zoology Department concerning diatoms, and the Geology Department in connection with *Chara* limestone; Mr. H. L. Fisk of the Lands Department, Mr. Rowland Hill of the Lands Board, and Mr. H. Willkie of the South-Eastern Drainage Board, the last three of whom have great personal knowledge of Eight Mile Creek Swamp. Professor J. G. Wood, of the Adelaide University Botany Department, has read the paper during preparation and suggested many important improvements. Finally, the work was carried out under the aegis of the Waite Agricultural Research Institute.

Bibliography

Bentham, G., and Hooker, J. D. 1908 Ed. "Handbook of the British Flora."

Bentham, G. 1863-1878 "Flora Australiensis." London

Black, J. M. 1922-1922 "Flora of South Australia." Adelaide; also subsequent annual "Additions", Trans. Roy. Soc. S. Aust.

Black, J. M. 1943 "Flora of South Australia," pt i 2nd Ed.

Blake, S. T. 1943 Trans. Roy. Soc. S. Aust., **67**, (1), 42-61

Conway, V. M. 1936-1938 New Phyt., **35**, **36**, and **37**

Conway, V. M. 1942 J. Ecol., **30**, 211-216

Crocker, R. L. 1941 Trans. Roy. Soc. S. Aust., **65**, (1), 103-107

Crocker, R. L., and Eardley, C. M. 1939 Tr. Roy. Soc. S. Aust., **63**, (2), 210-214

Godwin, H., and Bharucha, F. R. 1931-1941 Studies in the Ecology of Wicken Fen," pt. i-iv., J. Ecol., **19**, **20**, **24**, and **29**

Godwin, H., and Turner, J. S. 1933 J. Ecol., **21**, 235-262

Godwin, H., and Mitchell, G. F. 1938 New Phyt., **37**, 425-454

Godwin, H., and Clifford, M. H. 1939-1941 "Studies of the Post-glacial History of British Vegetation," pt. i and ii, Roy. Soc. Lond. Phil. Trans., Ser. B, **229**, 323-406; pt. iii and iv., l.c., **230**, 239-303; pt. vi, New Phyt., **40**, 108-132

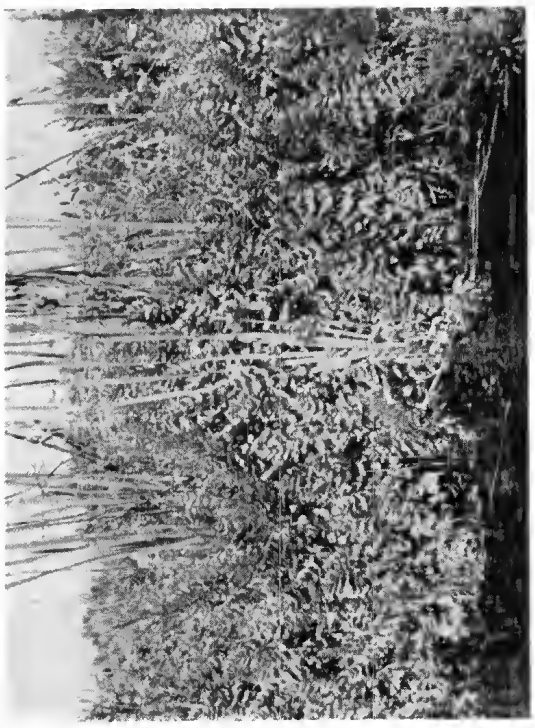

Fig. 2

Fig. 4

Fig. 1

Fig. 3

Fig. 6

Fig. 8

Fig. 5

Fig. 7

Fig. 10

Fig. 12

Fig. 9

Fig. 11

GODWIN, H. 1941 Proc. Geologists' Assoc., **52**, 328-361
HOOKER, J. D., and JACKSON, B. D. 1895- "Index Kewensis." Oxford
HOWCHIN, W. 1909 Trans. Roy. Soc. S. Aust., **33**, 253-261
MAHONY, D. J. 1912 Geol. Survey of Vict., Bull. 26. Dept. of Mines
MARSH, C. D., CLAWSON, A. B., and ROE, G. C. 1929 U.S. Dpt. Agr. Tech. Bull 113
MELVAINE, A. T., 1940 Contrib. N.S.W. Nat. Herb., **1**, (2), 83-93
PIDGEON, I. M. 1940 Proc. Linn. Soc. N.S.W., **65**, 221-249
SMALL, J. K. 1933 "Manual of the South-Eastern Flora." New York
STEPHENS, C. G. 1943 Trans. Roy. Soc. S. Aust., **67**, (2), 191
TANSLEY, A. G. 1939 "The British Islands and their Vegetation." Cambridge
TWENHOFEL, W. H. 1932 "Treatise on Sedimentation," 2nd Ed. London
WARD, L. K. 1941 "The Underground Water of the South-Eastern part of South Australia," Bull. No. 19, Dept. of Mines, S. Aust.
WARMING, E. 1909 "Oecology of Plants," English Ed. Oxford
WEAVER, J. E., and CLEMENTS, F. E. 1929 "Plant Ecology." New York
WOOD, J. G. 1937 "The Vegetation of South Australia." Adelaide
WOOD, J. G., and BAAS BECKING, L. G. M. 1937 Blumea, **2**, (4), 329-338

EXPLANATION OF PLATES

PLATE XXVII

Fig. 1 *Reedswamp* bordering Eight Mile Creek. The boat-oar points to a large plant of *Triglochin procera; Typha angustifolia* (Cumbungi or Bulrush) grows densely behind it.

Fig. 2 *Reedswamp* standing in water bordering Eight Mile Creek Channel; mostly *Sium latifolium* var. (Water Parsnip) flowering and growing 3 ft. above the water-surface, with some *Olcaria ramulosa* (Water Cypress) and the taller *Typha angustifolia.*

Fig. 3 *Reedswamp* fringing Deep Creek Pond, with some Tea-tree.

Fig. 4 *Reedswamp* around small spring at head of Eight Mile Creek. The white plumes are inflorescences of *Phragmites communis* (= *P. vulgaris;* Common Reed), and the clumped heads those of *Cladium Mariscus* (Pom-pom Rush) ; *Gahnia psittacorum* is also flowering. Tea-tree thicket surrounds the stream-side community.

PLATE XXVIII

Fig. 5 *Sedge meadow* (*Cladietum juncei*) on *Hitchcox limey peat soil type,* also characteristic of the closely related *Milstead coarse fibrous peat soil type.* The more shrubby communities are visible in the background.

Fig. 6 A recently flooded flat covered with dry, brittle, snow-white *Chara.* The surrounding *sedge meadow* looks identical with fig. 5, but is actually a *Cladietum glomerati;* at east end of swamp on *brown, fine, fibrous peat soil type.* Just visible in the background is a tussock-sedge society of *Gahnia trifida* in grassland; the soil is a shallow phase of the *Orwell coarse and fine fibrous peat type.*

Fig. 7 *Gahnia trifida* (Cutting Grass) in the *sedge meadow* (*Cladietum glomerati*) on shallow *Milstead coarse fibrous peat soil type.* The *Gahnia* tussock shrubland is common on the shallower peat soils of various types at Eight Mile Creek.

Fig. 8 *Shrub-and-sedge* on *Orwell coarse and fine fibrous soil type,* with sedge meadow (*Cladietum glomerati*) in foreground on shallow *Milstead coarse fibrous peat soil.*

PLATE XXIX

Fig. 9 *Tea-tree thicket* (*Melaleuca squarrosa* and *Leptospermum pubescens*). In the foreground is a layer of fallen débris 2 ft. thick, due to rolling. This is the dominant and widespread vegetation type on the swamp and the associated soil is the *Badenoch friable peat.*

Fig. 10 *Eucalypt woodland* with the rough-barked *Eucalyptus vitrea* (left) and the smooth, pale-barked branches of *E. ovata* (right). There is a winter swamp of sedge or grass turf in the foreground. At landward margin of swamp on *grey, fine, sandy loam soil with flint.*

Fig. 11 *Eucalypt woodland, Eucalyptus vitrea* only, on *grey, flinty loam soil,* at landward margin of swamp. The sward-covered winter swamp in the foreground is on *transitional swamp soil.*

Fig. 12 *Calcareous coastal sands,* the dominant shrub *Leucopogon parviflorus* forming a dense line near the sea.

GENERAL INDEX.

[Generic and specific names in italics indicate that the forms described are new to science.]

GENERAL INDEX

[Generic and specific names in italics indicate that the forms described are new to science.]