No. 20

The effects of agricultural land use change on the flora of three grazing marsh areas

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Abstract

The report outlines the changes that have taken place in the agricultural use of three areas of traditional grazing marshes and the consequences for wild plant life. It highlights the role of the actual watercourse as a refuge for plants, describes the effects of different forms of ditch management, and concludes by reviewing the prospects for wild plant conservation in the future. The areas studied were Romney Marsh (including the Walland Marsh), the Somerset Levels and Moors, and the Idle/Misson Levels of the Nottinghamshire, Humberside and South Yorkshire borders.

The report describes research carried out for the Nature Conservancy Council by the Institute of Terrestrial Ecology (Natural Environment Research Council). A 16-page full-colour booklet, *The effects of land drainage on grazing marsh flora*, illustrates certain aspects of this work.

1 Introduction

If history is any guide, grazing marshes will always be the centre of controversy. They occupy land which is so valuable for so many different purposes that there is bound to be a never-ending debate as to how far the marshes should be drained and how far grazing, cultivation, woodland or wildlife should be regarded as the dominant interest. The marshes have been the scene of some of the greatest civil engineering schemes of their day, and also of the bitterest clashes as to which kind of livelihood should prevail. The scope for reconciliation is just as limited today.

Successive reports of the Nature Conservancy Council have described the difficulties of preserving a place for wildlife among all the competing interests of the marshes. Experience shows that effective action can only come through research, monitoring, legislation, education and, most crucially of all, co-operation with those who actually manage the land and water on a day-to-day basis.

Successes there have been. Important precedents have been established at Amberley Wild Brooks in West Sussex, West Sedgemoor in Somerset, and the Halvergate Marshes in Norfolk. They have attracted considerable public interest and have been of relevance to rural land use policies generally. They have also tended to polarise attitudes – emphasising the role of legislation and such devices as compensation payments. The search is now on for ways of expanding the scope for collaboration at the practical level.

The words 'grazing marsh' conjure up a picture of flat land criss-crossed by ditches brim-full of water, with grass to the horizon grazed by sheep and cattle. A hay or silage crop may be taken. As well as acting as stock-proof barriers, the field ditches play a crucial role in removing surface water and regulating the high groundwater-table. Most of the marshes occur along rivers or the coast.

The marshes often represent a stage in the conversion of 'virgin' land into farmland, and traditionally they have been outstanding for their abundance and variety of plant life. To take one example, Amberley Wild Brooks on the east bank of the River Arun have been managed by farmers *for farming* over many centuries. Although only 360 hectares in size, the Wild Brooks still contain 400 different plant species – almost a quarter of the total British native flora. They include all five British duckweeds (Lemnaceae), all three British species of water-milfoil *Myriophyllum*, five out of the six British species of yellow-cress and water-cress (*Rorippa* and *Nasturtium* species), six out of the seven British water-dropworts *Oenanthe*, 14 out of the 21 British pondweeds *Potamogeton*, 19 species of sedges *Carex*, and 35 species of grasses (Nature Conservancy Council 1980, p. 46).

Amberley Wild Brooks are a model of the rich and distinctive wild plant life of such sites. What has been the fate of the grazing marshes found elsewhere, which have been much more directly affected by modern farming practices? How has the plant life of Romney Marsh (including the Walland Marsh) of Kent and Sussex, the Somerset Levels and Moors, and the Idle/Misson Levels of the Nottinghamshire, Humberside and South Yorkshire borders been affected by agricultural land drainage schemes (Figure 1)?

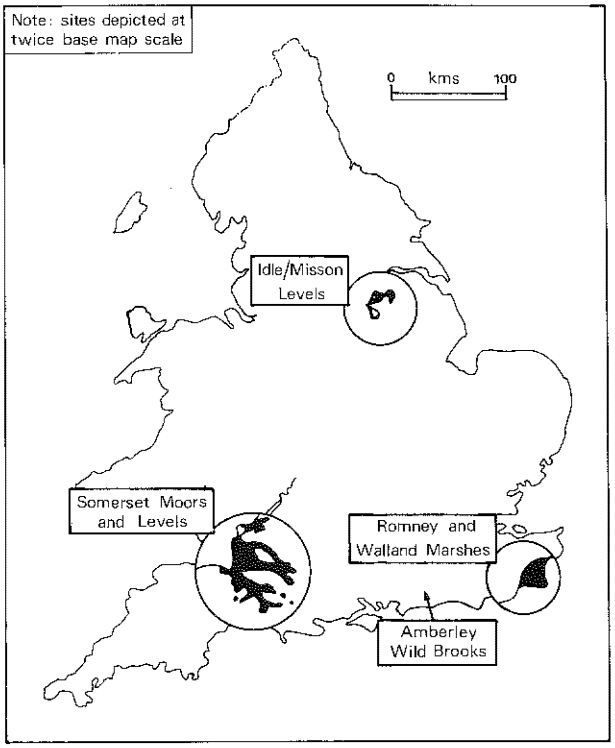


Figure 1 The study areas

The NERC Institute of Terrestrial Ecology has carried out a study of these three areas, designed to lay down baselines from which future changes in plant life, drainage regime and the pattern of agricultural land use and management might be measured. A search has been made for data which would make it possible to construct baselines for different points in time in the past. The ultimate goal has been to identify the influence of one type of change on another and the consequent scope for preserving and enhancing the biological interest of such 'wetland' areas for the future.

2 Changes in agricultural land use

When Whittlesea Mere was bright with water, one family of gipsies made a living by capturing for collectors the 'swallow tail', a very rare and beautiful butterfly that fluttered among its reeds and sedges, also the large copper butterfly equally rare. So it was in my young days; but now all is gone – reeds, sedges, the glittering water, the butterflies, the gipsies, the bitterns, the wild fowl, and in its place, as a result of an enormous and unprofitable outlay, a dreary flat of black arable land, with hardly a jack snipe to give it a charm and characteristic attraction.

(*Reminiscences of Albert Pell* (Mackay 1908). Pell lived between 1820 and 1907 and knew the East Anglian fens well.)

There is nothing natural about the origins of the grazing marshes in the three study areas. The early history of the Somerset Moors is one of forest clearance, punctuated by phases of woodland regeneration. Much of Romney Marsh was reclaimed from the sea in medieval times. The drainage pattern of the Idle/Misson Levels was largely determined in the seventeenth century by the Dutch water engineer, de Vermuyden, as part of a scheme to improve the drainage of the Isle of Axholme.

Once a regular regime of grazing was established, it tended to persist, despite the insistence of agricultural commentators that "the extraordinary productive power" of the soils would sustain huge crops of grain. William Cobbett saw fields "loaded with corn" in the course of his *Rural rides* through Romney Marsh in 1823, but it is clear from his account, and those of his contemporaries, that far greater importance was attached to the "numberless flocks [of Romney sheep] and herds [of Sussex cattle] fatting" on the grasslands. Cobbett described how there were grasslands for a great distance on both sides of the road between Appledore and Snargate (Cobbett 1953). An Assistant Tithe Commissioner commented in the 1830s on how ploughlands were always "badly farmed where grazing engrosses so much attention".

There have been only five occasions when field-by-field land-use data have been collected for the entire area of Romney Marsh (Figures 2–6).

Figure 2 Land use, after the Tithe Commutation Surveys, c. 1840 (Public Record Office, IR29/30)

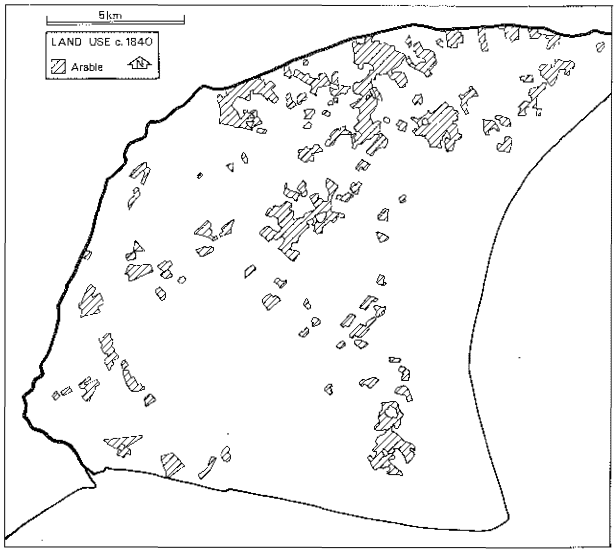


Figure 3 Land use, after the Ordnance Survey 1:25 000 maps and Parish Area Books, c. 1870 (British Library, Map Room)

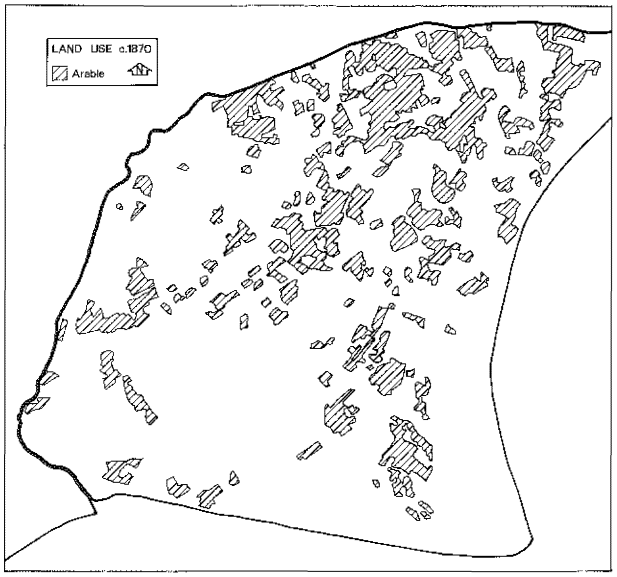
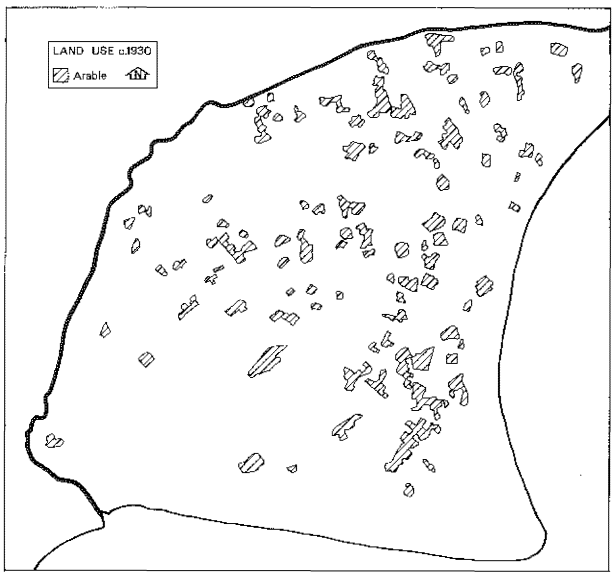


Figure 4 Land use, after the first Land Use Survey manuscript 1:10 560 maps, c. 1930 (Map Library, British Library of Political and Economic Sciences)



The first occasion was the Tithe Commutation Survey of 1837–44. The surveyors compiling the individual parish maps and apportionments recorded 88% of the agricultural land as being pasture or meadow. 80% of the land was described as pasture in the first large-scale survey carried out by the Ordnance Survey in the 1870s. A similar proportion was recorded as grassland in the annual returns made to the Board (later Ministry) of Agriculture from the late 1860s onwards for those parishes falling wholly within the Marsh. The depression in cereal prices acted as a further discouragement to arable farming. Except for a few brief years during and after the First World War, the area under tillage in Romney Marsh declined to as little as 7%, according to the agricultural census (Figure 7). Over 90% of the Marsh was described as grassland in the first Land Use Survey of the early 1930s.

Figure 5 Land use, after the Second Land Use Survey manuscript 1: 25 000 maps, c. 1960 (Department of Geography, King's College, London)

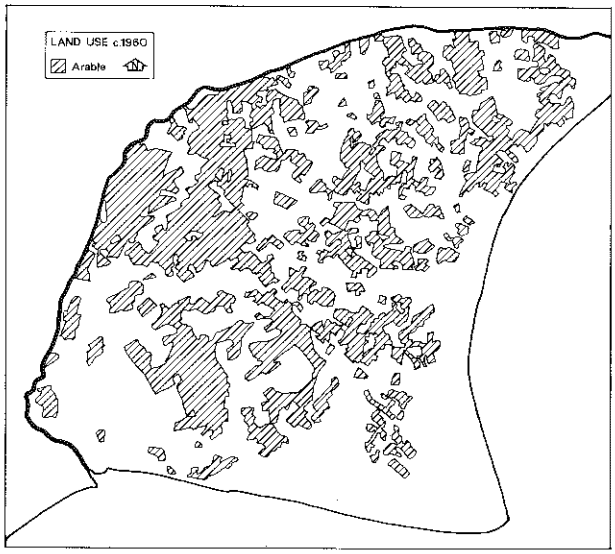
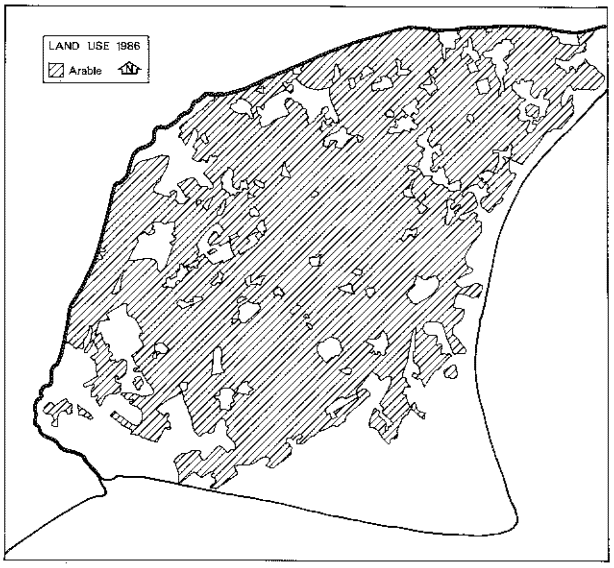


Figure 6 Land use, as recorded in 1986



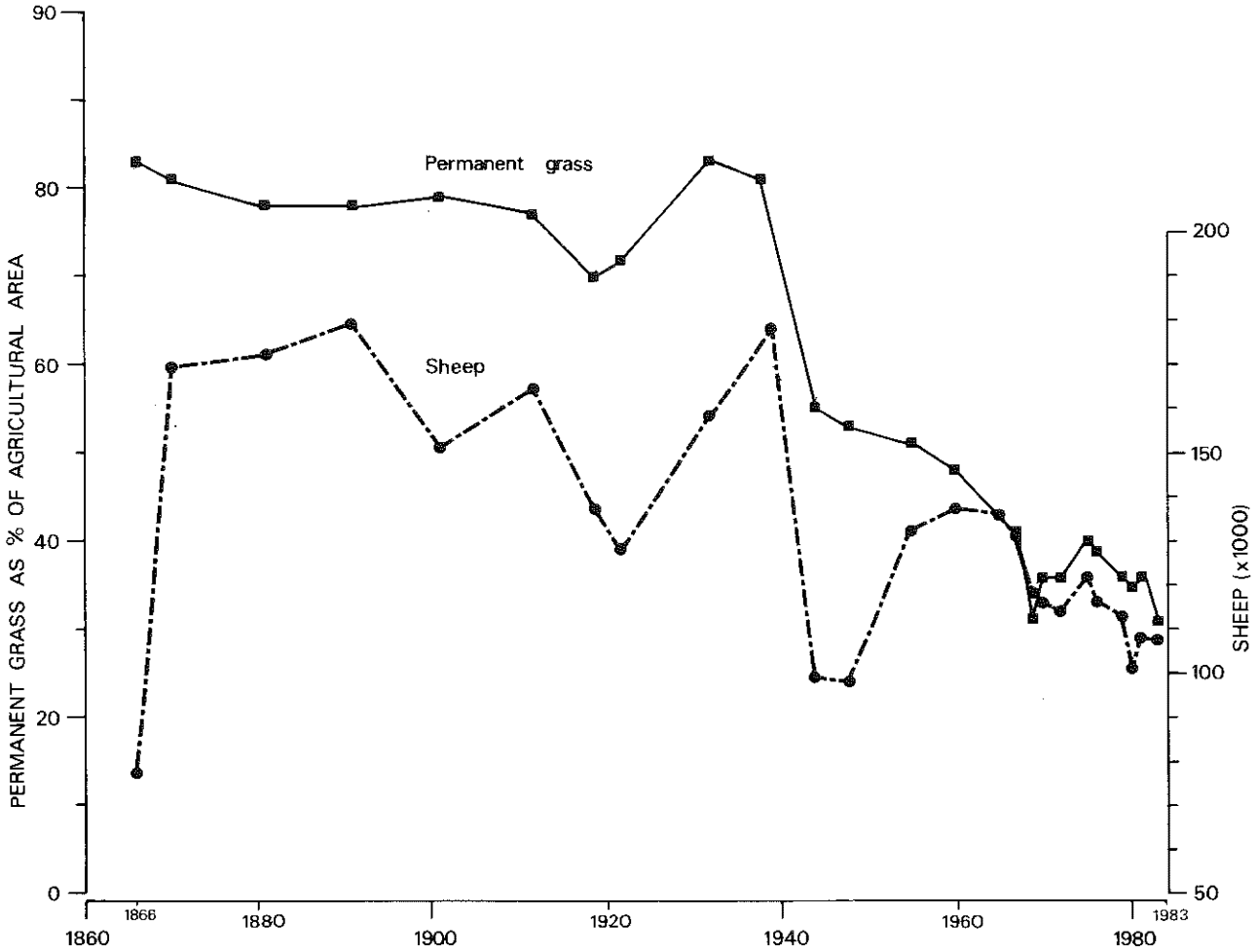


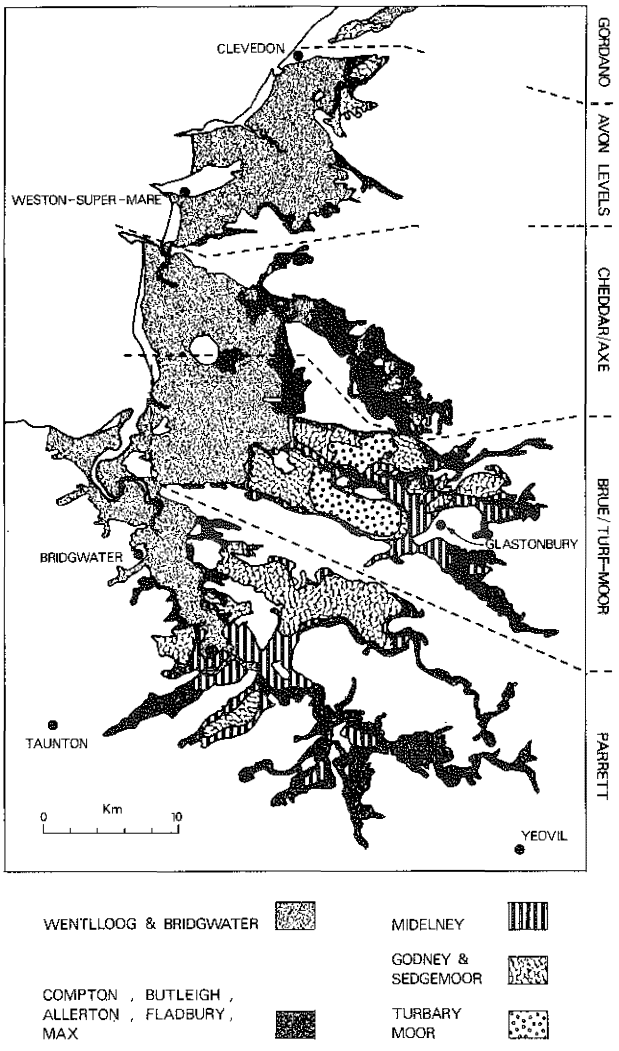
Figure 7 Changes in permanent grassland and sheep population, as indicated by the Annual Returns made to the Ministry (earlier Board) of Agriculture

When change comes to the grazing marshes, it tends to be dramatic. During the 1940s, plans to breach the sea defences of Romney Marsh as a deterrent to a possible enemy landing led to the evacuation of 40% of the sheep flock. In the event, the breaches were never made, and the absence of the sheep, together with the desperate need to grow more arable crops, resulted in the proportion of land under arable in the parishes wholly within the Marsh rising from 9% to 37%. The Second Land Use Survey, carried out about 1960, recorded 42% of the area as arable or temporary grass. A further marked change occurred in the late 1960s, when, according to the annual census of the Ministry of Agriculture, the area under permanent grass declined from 43% to 31% between 1965 and 1969. Only about a third of farmland was classified as permanent grassland in the early 1980s (Sheail & Mountford 1984).

There were striking variations in the scale and timing of drainage schemes. About 60% of Romney Marsh, 30% of the Idle/Misson Levels and 10% of the Somerset Levels and Moors were affected directly by field drainage schemes carried out between 1940 and 1980. Within each area, there have also been wide variations in the proportion of farmland affected (Figure 8), reflecting local drainage conditions, the nature of the soil and the character of the farming enterprise.

The complex relationship between decisions to embark on drainage schemes and those to change the agricultural use of land may be illustrated in respect of Romney Marsh (Figure 9). The experience of the post-war years indicated that, even where the soils were described by the Soil Survey as being free-draining/moderately well-drained, there was a risk of the potato and root harvests being badly disrupted on the newly ploughed land in a wet autumn. As an insurance against such weather, tile-drains were installed and ditches improved. The success that was achieved encouraged other farmers to follow, and the Internal Drainage Boards responded by making further improvements to the arterial drainage system. Together with the installation of new pumps, drainage entered a new phase in the late 1960s, whereby it became feasible to cultivate land where ploughing had previously been exceptional.

Large-scale changes in the land use of the Idle/Misson Levels did not occur until the late 1970s, when a pump drainage scheme was installed. Whereas earlier improvements to the drainage system had been designed primarily to reduce the risks to livestock from drowning and disease and to ensure that the hay crop could be taken more regularly (an average of one crop in three or four was lost), the 1970s' scheme was intended to improve both the productivity and the character of



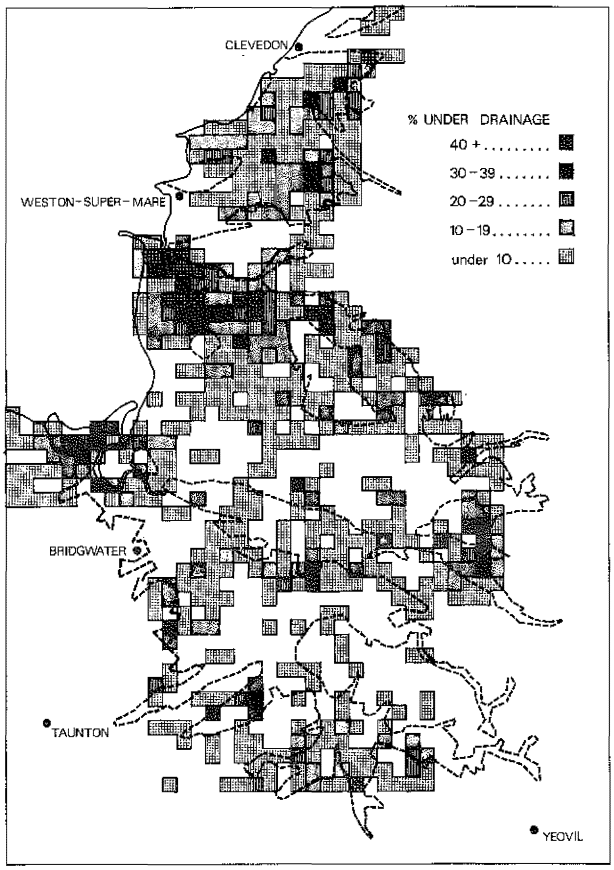
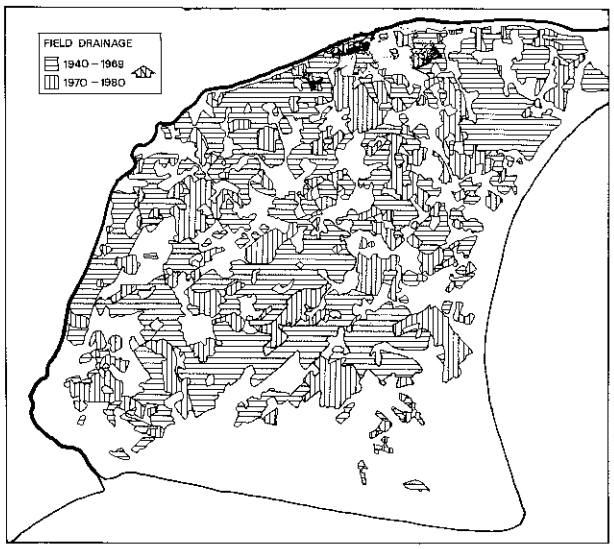


Figure 8 Somerset Levels and Moors: soil series and incidence of under-drainage between 1940 and 1980 (after Soil Survey of England and Wales, Soils of the Levels and Moors in Somerset and Avon Sheet 1:100 000 (1978) and Ministry of Agriculture, Fisheries and Food)



over 5,480 hectares of land, including the conversion of the previously grass-covered washlands to cereal, root and vegetable production. The degree of success achieved may be indicated by comparing information on land use collected during a survey of 1983 with that recorded by the Second Land Use Survey of the early 1960s. About 30% of the grassland recorded in the earlier survey had been ploughed by 1983. The area of grassland converted to arable was seven times greater than that recorded as arable in the early 1960s and as grassland in 1983 (Figure 10).

The changes to a predominantly arable form of farming heralded a regime far less sympathetic to the distinctive wildlife of the grazing marshes. The implications for plant life are recounted in the next chapter.

Figure 9 Extent and period of under-drainage schemes in Romney Marsh

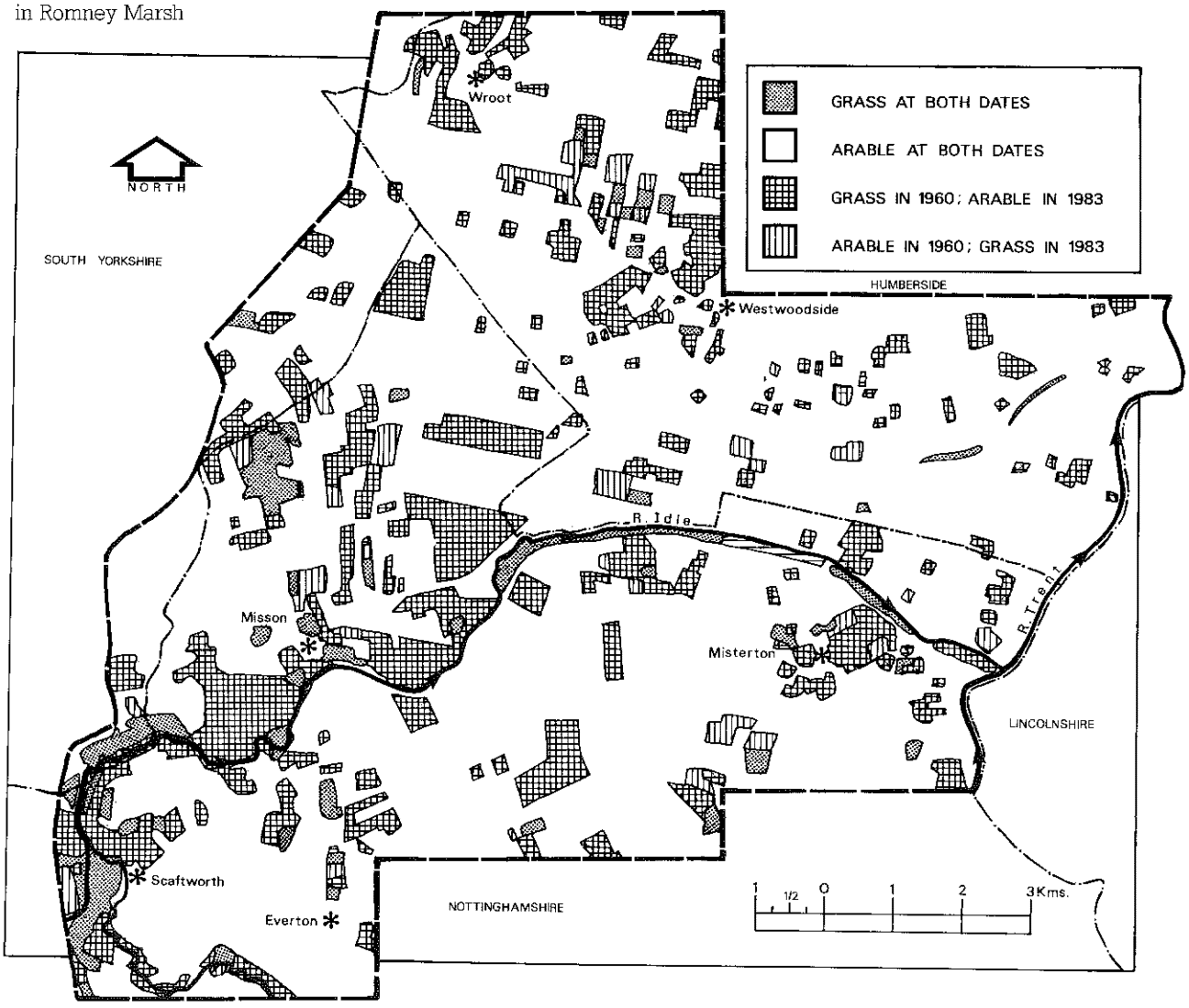


Figure 10 Comparison of grassland areas, as indicated by the Second Land Use Survey, c. 1960, and fieldwork in 1983

3 Changes in plant life

The great increase of interest in natural history during the nineteenth century led to many surveys of the local flora being made. A picture of the Somerset Levels and Moors at the turn of the century can be gained from Murray's *The flora of Somerset* and its supplement (Murray 1896; Marshall 1914) and from White's detailed survey in *The flora of Bristol* (White 1912). Over the following half century, a large amount of additional information was published in various journals or recorded on card indexes. As elsewhere in Britain, the publication of *Atlas of the British flora* (Perring & Walters 1962) stimulated a great deal of interest in a more systematic approach to recording the flora of different parts of Somerset. A tetrad mapping scheme initiated in the early 1960s formed the basis of a new flora of Somerset, which appeared in the early 1980s (Roe 1981).

Some of the most detailed records come from archival sources. Carr's flora of Nottinghamshire was never published. Now preserved in Nottingham museum, the manuscript provides a detailed insight into the status of plants in the Idle/Misson Levels over the 30-year period 1909–39 (Howitt & Howitt 1963). All too often botanists recorded only the name of the parish in which a species was found, irrespective of the size of that parish and the fact that it might include both high and low ground (Figure 11). Diaries, notebooks and herbarium specimens are particularly valuable where site descriptions and plant lists and material are located so precisely that it is possible to revisit the particular field or watercourse at the present day.

How far can trends in the population and distribution of species be deduced from these different sources? Not only were there marked differences in the way each data source was compiled, but there was considerable variation in the taxonomic skills and interests of individual botanists. The increase in status of some species may be more apparent than real; the plants may, until recently, have been overlooked or mistaken for other species. There are often differences in the thoroughness with which localities were surveyed. Few records were made for remote areas, such as West Sedgemoor, compared with those parts of the Somerset Moors closer to railway stations and main roads.

Despite these inherent problems of interpretation, a marked difference can be seen between the numbers of species which have experienced an increase, as opposed to a decrease, in status (Table 1). Aliens are conspicuous among those species which have increased. Fringed water-lily *Nymphoides peltata* was first recorded in the Royal Military Canal of Romney Marsh in the late 1950s

SIUM, L.

S. latifolium, L.

Native. Ditches and marshy places; very local, and decreasing. P. July—Aug.

1. In the ditches between Redriff and Deptford, *Doody MS.* 107. Ditches about Lewisham and Rushy Green, *M. & G.* 399. Marshes between Gravesend and Woolwich; ditch by a roadside between Eltham and Lee; river bank at Mary Cray, *Cooper, Fl. Met.* 52, 73, 77. Extinct in most, if not all of these stations.

2. About Northfleet, *Ibid.* 68. Ditch banks, Dartford, *de Crespigny.*

3. Faversham, *Jacob*, 107. (Ditches by the Rope Walk, very common; stream, Faversham, very common, *Cowell Fav.*)

8. Tonbridge town, *Forster, Tonbr.* 36.

9. Ditches near The Bottoms, Tenterden, *Prebble.* Ham Street, *Baker.* Cranbrook, *Clarke.* Near Appledore, *Marshall.*

10. Abundant in trenches by the roadside, between Ham Street and Ivychurch, and by the military canal, *Hanbury.* Near Appledore Station, *Herb. Mill.* Warehorne, *W. Jeffrey.*

First record, about 1700: "Sium majus latifolium."—*Doody, l.c.*

Figure 11 The entry for greater water-parsnip *Sium latifolium* in *Flora of Kent* by F J Hanbury and E S Marshall (1899) (Some records – for example "Near Appledore" – could refer to any location within a large parish. Others locate the site of the plants much more precisely.)

Table 1 Numbers of species showing a change in abundance

Romney Marsh				Somerset Levels and Moors				Idle/Misson Levels			
Increase in abundance and/ or distribution		Decrease in abundance and/ or distribution		Increase in abundance and/ or distribution		Decrease in abundance and/ or distribution		Increase in abundance and/ or distribution		Decrease in abundance and/ or distribution	
Marked	Slight	Marked	Slight	Marked	Slight	Marked	Slight	Marked	Slight	Marked	Slight
5	20	55	42	11	21	43	58	3	5	75	47
Totals 25		97		32		101		8		122	

and has become locally abundant in the Bridgwater and Taunton Canal in Somerset. *Elodea nuttallii* was first recorded in Romney Marsh in 1977 and in the Idle/Misson Levels in 1983. It occurred in 10% of the Somerset ditches surveyed in 1982.

The decline is most striking in the Idle/Misson Levels, where only eight species show signs of having increased their range and level of abundance. Over 120 species have become less common than they were in 1880. Even in the Somerset Levels and Moors, where habitat changes have been less extensive, 101 species have undergone a decline – a marked decline in 43 cases.

Botanists sometimes recorded the reasons for the decline of species (Figure 12); more usually they can only be guessed at. Many of those species experiencing a decline are normally found in acid bog or wet heathland vegetation. Wherever peat-cutting occurs, there is a risk of the species associated with acidic conditions being displaced as the lowering of the peat surface leads to flooding by alkaline ground water. The turf-moor and domed-*Sphagnum* areas of the Somerset Moors once contained 49 species which have now become nationally rare or very localised in their distribution.

Three-quarters of these have undergone a marked decline (Table 2). Raised-bog vegetation was once typical of much of the Idle/Misson Levels. A combination of peat-cutting and subsequent flooding by more mineral-rich water, together with drainage and conversion of pasture to arable, has now reduced this area to fragments adjacent to the Scaftworth Barrier Bank, parts of a bombing range, and localities where sand and gravel extraction have restored wet, acid conditions.

Rich fen habitats have also been converted to wet pastures, drained by ditches. Perhaps the most conspicuous of the species to have been

CYPERACEÆ.

CYPERUS *Linn.*

C. longus *L.* *Galingale.*
Native; now extinct.

S. This rare and beautiful sedge grew at Walton-in-Gordano in a small plot of wet marshy ground, believed to have been anciently a fish pond, and situated behind some cottages in the upper part of the village. Sole, in a MS. dated 1782, says of it: "Abundantly in a pond at Walton-in-Gordano, near Possit, Somerset, a village belonging to Sir Abraham Elton." Possit = Portishead. The plant continued to be plentiful until 1882; when, the ground having been sufficiently drained by digging some water channels, the occupier ploughed it and planted potatoes. The year following Mr. Fry and I found many stems along the intersecting ditches and some among the crop; but in consequence of the disturbance their development was much retarded and flowering delayed nearly two months. By 1887 the ground had become much less marshy: part was in cultivation; the remainder overrun by pigs and cattle. Notwithstanding the adverse human and bestial conditions, many plants of *Cyperus* were seen to be still in existence, none of which, however, seemed likely to flower. Some of these lingered on for a while in the moister portions of the place, disappearing finally about 1896. In 1897 we found the whole ground reduced to a mass of black mud by the trampling of animals, and "main nasty" as the tenant admitted. No sign of *C. longus* at this date, nor on subsequent visits. There can be no doubt that we have lost a very valuable species. Likely spots at the head of the Walton valley, near at hand, have been well searched, without result.

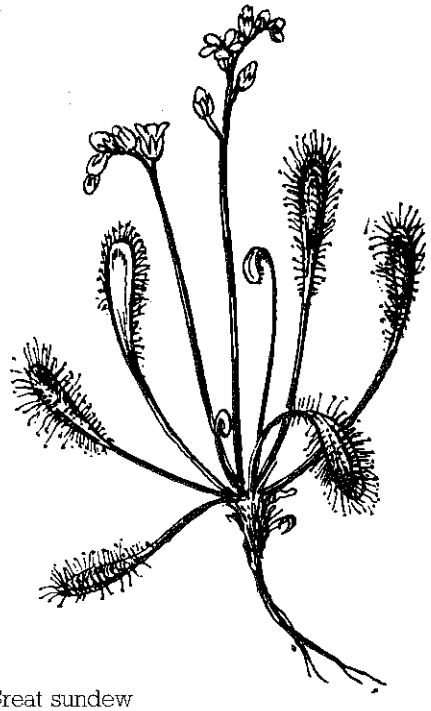
Three good sheets of Walton specimens, gathered in 1853, are in the Flower herbarium. And there is a fragment of "English Galingal" in the Somerset *Hortus Siccus* of Wm. Paine (1730), referred to under *Rumex pulcher*.

Figure 12 The entry for galingale *Cyperus longus* in *The flora of Bristol* by J W White (1912)

Table 2 Species of the raised bog and peat-cuttings of the Turbary Moors in Somerset which are today regarded as regionally or nationally rare

* Species displaying a decline in distribution and abundance. Dates represent dates of extinction or of the last known record.

Anagallis tenella
Andromeda polifolia* (1920)
Antennaria dioica* (1913)
Apium inundatum* (1957)
Baldellia ranunculoides*
Carex curta* (1791)
C. diandra*
C. dioica* (1855)
C. lasiocarpa
C. lepidocarpa
C. pulicaris*
C. serotina
Cicuta virosa* (1888)
Cladium mariscus*
Coeloglossum viride*
Drosera anglica* (1970)
D. intermedia*
D. rotundifolia
Eleocharis multicaulis
E. quinqueflora*
Frangula alnus
Hypericum elodes* (1922)
Lathyrus palustris*
Menyanthes trifoliata*
Myrica gale*
Narthecium ossifragum*
Osmunda regalis*
Parnassia palustris* (1782)
Pedicularis palustris*
Peucedanum palustre*
Pinguicula lusitanica*
P. vulgaris* (1928)
Platanthera bifolia
Potentilla palustris*
Radiola linoides*
Rhynchospora alba*
R. fusca* (1969)
Sagina nodosa* (1951)
Salix repens*
Schoenus nigricans*
Scirpus cernuus
S. fluitans*
S. setaceus
Scutellaria minor* (1914)
Sparganium minimum*
Thelypteris thelypteroides
Utricularia minor*
Vaccinium oxycoccus* (1920)
Wahlenbergia hederacea*



Great sundew
Drosera anglica

lost is great fen-sedge *Cladium mariscus*, which, in historical times, was so prominent as to give its name to extensive areas, including West Sedgemoor. Most botanists in the mid nineteenth century believed it had become extinct, as a result of large-scale drainage and the conversion of rich tall fen to pasture; in point of fact a very small population survives. The list of extinctions in these meadows is not, however, as long as in the raised bog vegetation because several species have managed to survive by the margins of the drainage channels, where the water has continued to be base-rich (Table 3).

In Romney Marsh, half the species which have declined were previously confined to pastures and their associated watercourses, and many of the remainder were generally commoner in grassland areas. One particularly interesting group of species, usually found in saltmarshes, occurred on peaty soils well beyond the tidal influence, where saline water is held in the organic layers. This combination of salinity and poor drainage meant that the land was generally left to pasture. Indeed, the sites had become important for those species which were otherwise being displaced by the construction of coastal defence works and tourist development along the coast. Over the last few years, ploughing has destroyed some of these grassland sites also.

To summarise, it is possible in many cases to correlate land-use changes with floristic change. Much of the botanist's interest has tended to focus on the dates of extinction of species which may always have been very localised. Particularly since the last war, even some of the most commonplace communities and species have undergone a marked decline in both their abundance and their distribution.

Some examples of increasing and declining plant species are given in Appendices 1 and 2.

Green-winged orchid
Orchis morio

Table 3 Species found in the old wet meadows of the Sedgemoor, Godney and Turbary peat series which are today regionally or nationally rare

* Species displaying a decline in distribution and abundance. Dates represent dates of extinction or of the last known record.

Bidens cernua*
Cirsium dissectum
Colchicum autumnale*
Cyperus fuscus
C. longus* (1896)
Dactylorhiza incarnata ssp. incarnata*
D. majalis ssp. praetermissa*
Genista tinctoria*
Gymnadenia conopsea var. densiflora
Juncus compressus*
J. subnodulosus
Lotus tenuis*
Myosurus minimus
Ophioglossum vulgatum ssp. vulgatum*
Orchis morio*
Polygonum minus
P. mite
Rumex maritimus*
R. palustris*
Samolus valerandi
Serratula tinctoria
Thalictrum flavum
Triglochin palustris
Valeriana dioica*

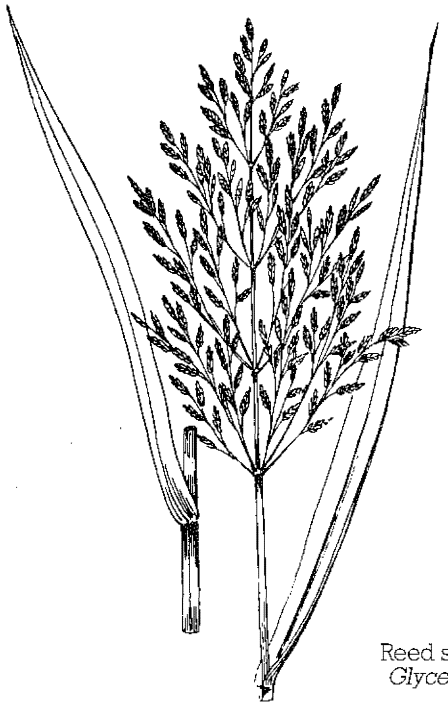
4 Where is the wildlife interest today?

Because it would have been impossible to survey all the fields in the three study areas, a random selection was chosen, which by its very nature represented the range of habitats in each area. A brief outline of the approach adopted is given in the Appendix, and more detailed information in Mountford & Sheail (1982, 1984, 1985).

The survey provided further confirmation that a large part of the grasslands had been destroyed or agriculturally improved. The meadows of the parish of Misson were well-known for the large number of fen violet *Viola persicifolia*. The authors of *A flora of Nottinghamshire* (Howitt & Howitt 1963) noted how these sites had survived until the last 10 years before they wrote as "rough mowing grass with *Sium latifolium*, *Valeriana dioica*, *Lysimachia vulgaris*, *Cirsium dissectum*, *Juncus subnodulosus*, *Calamagrostis canescens* and *Glyceria maxima*. Now they have been ploughed and re-seeded, and the *Viola* is lost, but the other plants can still be found along hedge and drain sides." Of the 200 random sites surveyed in the Idle/Misson Levels in 1983, only 39 were adjacent to grasslands of any kind. In most cases, they took the form of a narrow strip along the floodbank of a river or major drain.

The changed status of plant species in the Misson Fenny Fields is described in Appendix 3 and that of the old moat in Old Romney in Appendix 4.

In the Somerset Levels and Moors, half of the 240 survey sites had undergone some kind of agricultural improvement, for the most part by the application of fertilisers or herbicides. The fertilisers had the effect of encouraging perennial rye-grass *Lolium perenne* and other grasses. The herbicides had largely removed the broadleaved species. An analysis of the pasture quadrats indicated that there was a much greater degree of uniformity within the sample taken from the grassland sites than from either the bank or aquatic sites sampled. The grassland vegetation was composed mainly of species widespread and common in lowland grasslands generally. It did not include the regional or nationally rare species.



Reed sweet-grass
Glyceria maxima

Perennial rye-grass
Lolium perenne

These findings, together with the historical evidence, suggest that the watercourses have become the principal refuges for many of the rarer species. Even where the adjacent pastures were found to be species-poor, the banks might continue to represent the kind of flora once characteristic of the grasslands. They were affected less directly by applications of herbicides and fertiliser and were often still grazed.

The main attention of the nature conservationist is likely to be focussed on these artefacts of earlier systems of farming. The primary divisions of an analysis made of the 650 ditch samples, taken from the three study areas, represent those ditches which were for the most part dry and those which were found to contain water (Figure 13). The dry ditches account for over 20% of those sampled and are especially well-represented in the Idle/Misson Levels.

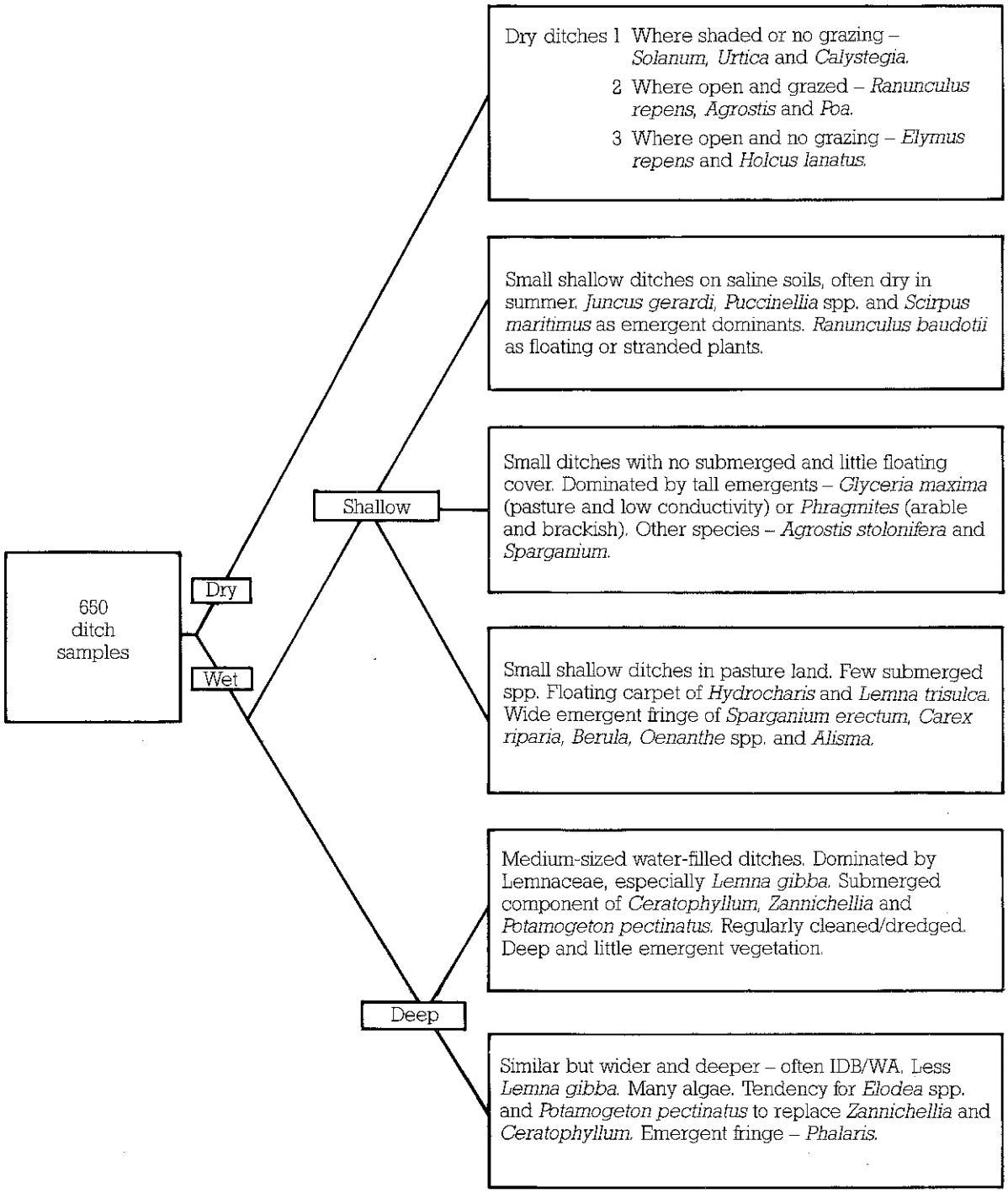


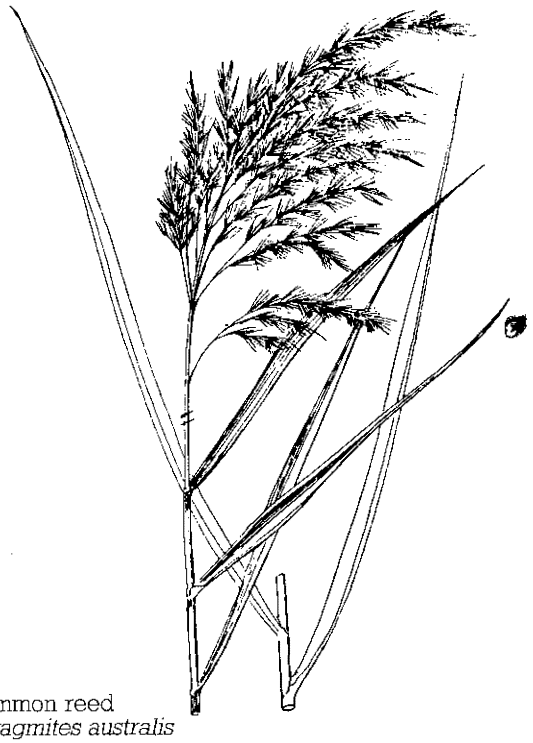
Figure 13 The primary divisions of the analysis of the ditches surveyed in the three study areas, 1981-83

The character of the dry ditches varies according to management and soil conditions. Three situations may be cited:

1 The shading effect of hedges planted on the ditch bank will lead to a mixture of coarse plants that can tolerate waterlogging and low light intensities (e.g. common nettle *Urtica dioica*, bittersweet *Solanum dulcamara* and hedge bindweed *Calystegia sepium*). This is particularly common in those parts of the Somerset Levels and Moors where stock-proof fences are still needed.

2 Where the dry ditches are an integral part of a pasture, grazed by sheep or cattle, the ditch vegetation may simply represent a moist-ground variant of what can be found elsewhere in the field, with creeping bent *Agrostis stolonifera* and creeping buttercup *Ranunculus repens* especially prominent.

3 In arable areas, the ditch may become colonised by rank grassland, made up for the most part of common couch *Elymus repens* and Yorkshire-fog *Holcus lanatus*. Such conditions are especially common in the sandy parts of the Idle/Misson Levels.



Common reed
Phragmites australis

Two groups of water-filled ditch may be distinguished, namely the shallow, narrow examples and the deeper drains, where a variety of submerged and floating aquatics often occur with considerable amounts of filamentous algae. The shallow ditches may be divided into three major types:

1 A small, but very distinct, group of shallow, occasionally summer-dry ditches. These are associated with the modified saltmarsh vegetation found on the saline soils, in which saltmarsh rush *Juncus gerardi*, saltmarsh-grass *Puccinellia* species and brackish water-crowfoot *Ranunculus baudotii* are commonly found. The ditches are almost entirely confined to soils of the Fairfield, Dowels and Appledore series in Romney Marsh, although somewhat similar ditch vegetation occurs along the tidal parts of the rivers flowing through the Wentlloog soil of the coastal fringe of Somerset.

2 Small ditches with little submerged or floating cover. The major components are the two tall grasses, common reed *Phragmites australis* and reed sweet-grass *Glyceria maxima*, in arable and pastoral areas respectively. Particularly where bent *Agrostis* and rush *Juncus* species are common, this represents a transitional stage towards terrestrial conditions. Ditches of this group are commonly found in all three areas.

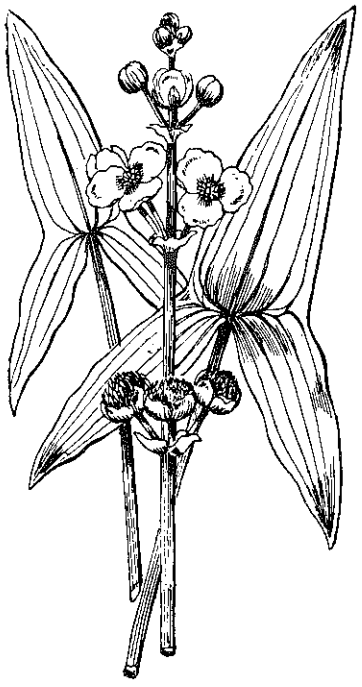
3 Pasture ditches with a floating carpet of frogbit *Hydrocharis morsus-ranae* and ivy-leaved duckweed *Lemna trisulca*. There are a few submerged species. Branched bur-reed *Sparganium erectum*, greater pond-sedge *Carex riparia*, water-dropwort *Oenanthe* species and water-plantain *Alisma plantago-aquatica* are especially common in the characteristically wide and varied fringe of emergent species. Representing one of the richest types in terms of species variety and the presence of rare or uncommon species, these ditches are commonly found in the Somerset Levels and Moors. They occur only in some parts of Romney Marsh and are very rarely encountered in the Idle/Misson Levels.

Greater pond-sedge
Carex riparia

The ditches with deeper waters represent the most intensively managed drains in each of the study areas. The high level of disturbance seems to override any other factor. The abundance of both filamentous algae and fennel pondweed *Potamogeton pectinatus* reflects the nutrient-rich character of the water. Two major types can be distinguished:

1 Ditches covered by mixed species of duckweeds, with emergent vegetation confined to a narrow fringe. Fat duckweed *Lemna gibba* is especially typical, but common duckweed *L. minor* is also very common. Greater duckweed *Spirodela polyrhiza* is a frequent component of the group in Somerset. Submerged species are both diverse and abundant; horned pondweed *Zannichellia palustris* and hornwort *Ceratophyllum* species grow in association with fennel pondweed. The emergent species are suppressed by the regular maintenance of the drains.

2 Major drains and canalised rivers, where algae are more abundant and the duckweed cover is reduced. Together with fennel pondweed, the alien *Elodea nuttallii* is very common in Somerset, where it may be displacing Canadian waterweed *E. canadensis*. A number of river plants, yellow water-lily *Nuphar lutea*, arrowhead *Sagittaria sagittifolia* and unbranched bur-reed *Sparganium emersum* are commoner here than elsewhere in the drainage network. Such species as shining pondweed *Potamogeton lucens* are almost confined to these larger waterways. There is only a narrow fringe of emergent species in the shallow water beside the steep, often flailed, banks. Reed canary-grass *Phalaris arundinacea* is the most abundant tall emergent.



Arrowhead
Sagittaria sagittifolia

There are striking variations, both *between* and *within* each of the study areas. In the Idle/Misson Levels, the primary analysis identified a group of 69 ditches, which were at least summer-dry, from 131 examples, which were truly wetland ditches. In the Somerset Levels and Moors, there were 50 dry ditches, compared with 190 water-filled examples. Although less than 15% of the ditches surveyed in Romney Marsh were dry in summer, a similar type of vegetation (but with common reed especially abundant) was found in a further 20% of those sampled. These took the form of shallow ditches in arable land, where the accumulation of reed stems and leaf litter was so marked that the succession to terrestrial conditions was already well advanced.

In practice, it is often difficult to distinguish the effects of one type of ditch attribute from another, and how each in turn is affected by wider environmental factors. The impact of distinctive soil types on the incidence of plant species is often modified by the movement of ditch water from one type to another, as a result either of natural flow or of pumping operations. A number of relationships can, nevertheless, be discerned in respect of:

altitude

depth of ditch

width of ditch

width of bank

freeboard

angle of slope of bank

pH of ditch water

turbidity of water

shade of ditch by species rooted on bank

management of ditch

neighbouring land use(s)

under-drainage of neighbouring land.

There is only room in this report to refer to some of the features of the ditch. Further details are given in Mountford & Sheail (1982, 1984, 1985). In the Somerset Levels and Moors, 35 species are more commonly found in deeper ditches and 39 in shallow ditches (with 20 of these particularly associated with generally dry ditches) (Table 4). The species list for the shallow and/or dry ones reflects two types of situation, namely:

1 a small number of rich sites where the ditch is a shallow depression in the waterlogged turf;

2 a much larger number of sites which are occupied by terrestrial species or where woody plants cast a dense shade.

If attention is turned to the other features of the ditches, 28 species in the Somerset Levels and Moors are found to show a preference for narrow ditches; they are mainly emergent swamp species. Forty-four are common at sites with low banks, compared with only 14 species where high banks exist. Five times as many species occur more frequently on sites with gently-sloping banks than in ditches with steeper banks.

It is noticeable that in all the study areas the ditches on the peaty soils have a much wider variety of bank and aquatic species than those on mineral soils. Freeboard also has a particularly significant effect. In arable land and where high steep banks make it difficult for livestock to reach the water, the ditch is usually covered with coarse tall emergents, which have displaced the more light-demanding species. Hedgerows and scrub growing on the banks can also have a marked shading effect. Fenced ditches have characteristically far fewer species in the water and on the banks than those where farm stock have access.

Table 4 Species and their relationship to the depth of water in drainage ditches in the Somerset Levels and Moors

Preference for shallow ditches (less than 0.25 m)

* Especially in dry ditches.

Marked preference

Anagallis tenella
Anthoxanthum odoratum
Atriplex prostrata*
Calystegia sepium*
Carex demissa
C. flacca
C. panicea
C. paniculata*
Cirsium palustre
Elymus repens*
Epilobium hirsutum*
Filipendula ulmaria*
Galium aparine*
Juncus acutiflorus*
Juncus subnodulosus
Lotus uliginosus
Lychnis flos-cuculi
Lysimachia nummularia
Lythrum salicaria
Plantago major*
Polygonum lapathifolium
Potamogeton coloratus
Potentilla anserina*
Pulicaria dysenterica*
Ranunculus acris
R. flammula
Rumex conglomeratus*
Sagina procumbens
Scirpus lacustris ssp. tabernaemontani*
Senecio aquaticus*
Solanum dulcamara*
Urtica dioica*
Valeriana officinalis*
Veronica beccabunga*
Viola canina

Slight preference

Baldellia ranunculoides
Callitriche stagnalis
Equisetum arvense
Hypericum tetrapterum

Preference for deeper ditches (more than 0.75 m)

Marked preference

Filamentous algae
Alopecurus geniculatus
Azolla filiculoides
Butomus umbellatus
Ceratophyllum demersum
Elodea nuttallii
Myosotis scorpioides
Myriophyllum spicatum
Nuphar lutea
Potamogeton berchtoldii
P. crispus
P. lucens
P. pectinatus
P. pusillus
Ranunculus penicillatus
Sagittaria sagittifolia
Scirpus lacustris ssp. lacustris
Scutellaria galericulata
Sparganium emersum
Spirodela polyrhiza
Wolffia arrhiza

Slight preference

Elodea canadensis
Festuca arundinacea
Galium elongatum
Glyceria fluitans
G. maxima
Hydrocharis morsus-ranae
Iris pseudacorus
Lemna gibba
Lycopus europaeus
Polygonum mite
Rumex crispus
R. sanguineus
Salix cinerea ssp. oleifolia
Veronica catenata

Improvements in arterial and field drainage have led to the elimination or redesign of many ditches. Over extensive areas of Romney Marsh, livestock no longer need access to watercourses now that mains supplies are available. The small, shallow dykes have become redundant where an under-drainage scheme has been installed. After the conversion of pasture to arable, it has been common for some dykes to be filled in so as to make it easier to use combine harvesters and other large machinery. In the Idle/Misson Levels, an estimated quarter of the ditches were eliminated between the revision of the Ordnance Survey 1:25 000 maps of 1948–51 and the survey of 1983. During the course of fieldwork, many of the surviving ditches were found to be dry in summer or made redundant as a result of the deepening of the main drains, leaving the field ditches as if they were 'dry hanging valleys'.

The proportion of land affected by field drainage schemes is lowest in the Somerset Levels and Moors. Only 45 of the 480 fields surveyed in 1982 which were adjacent to the sampled ditches had experienced a grant-aided scheme between 1940 and 1980. A survey was made of a further 35 ditches in 1983, where the 70 adjacent fields were known to have been affected by subsurface drainage. A comparison of the species complement of these ditches with that of the other sites sampled in 1982–83 suggested that subsurface drainage had led not so much to a distinctive ditch community as to an impoverished variant of the vegetation that existed on the sites prior to drainage. Of the 150 fields adjacent to ditches with eight or fewer aquatic species in a 20-metre length, 46 had been under-drained. Only 16 of the 116 fields adjacent to ditches with 15 or more aquatic species had experienced under-drainage. Four times as many species displayed a preference for the ditches and banks of land which had not been directly affected by a scheme.

Appendix 5 provides further information about the various types of watercourse in the three study areas and their plant communities.

5 Managing the plant life of ditches

Farm ditches are excavated expressly to drain the land. If neglected, even a deep, wide ditch may become so full of thick aquatic vegetation as to reduce the rate of flow, and therefore the efficiency of the ditch, by a theoretical 97% (Guscio, Bartley & Beck 1965). The farmer's choice of management technique, and the intensity and frequency with which it is deployed, will have a considerable impact on both the abundance and the composition of wildlife beside and within the watercourses.

The ditches of the grazing marsh can be regarded as the lineal descendants of the water-bodies and swamp margin of the original marshlands. From the earliest days of ecology as a science, it was realised that the adoption of certain management practices played a crucial part in preserving plant species and communities. In his vegetation survey of the Bath and Bridgwater districts published in 1907, Charles E Moss wrote of how "the upright-leaf and floating-leaf associations" in the Somerset Moors were "kept in position" by the ditching operations of farmers. But for their close attention to the management of the artificial watercourses, "the upright-leaf forms would eventually occupy the whole rhine, which would then become filled with humus and silt" (Moss 1907).

The vegetation cover of a ditch can change very quickly. Within five years, open water may become completely overgrown by tall emergent species. Where this happens, a survey made in any one year represents no more than "a single frame in a moving film". In order to help gauge the representativeness of records made of each site on the basis of a single visit, a quarter of the sites visited for the purposes of this study in the Somerset Levels and Moors in 1982 were resurveyed a year later and subsequently in 1984 and 1986. Similarly, in Romney Marsh, 30 watercourses, first examined in 1981, were resurveyed in 1982, 1983, 1984 and 1986.

When these time series are analysed and compared with the classification made on the basis of the original surveys, the stability of the vegetation is found to be very marked. Of the 60 Somerset sites examined, 36 of the 1983 sample fell in the same group as they had in 1982 and a further 16 were in very closely related groups. In only eight cases did the 1983 sample appear very different. Five of these sites had been dredged in the intervening period. Several had 'returned' to their original grouping by 1986.

A striking feature of these time series is the extent to which the rarer species were found in the vegetation with a history of recent management – including grazing by livestock. Many pasture banks have been grazed as an incidental part of normal farming operations. In the survey of the Somerset Levels and Moors, about three times as many plant species were confined to, or showed a preference for, ditch banks which were regularly grazed and subject to trampling. The several open-water species and many low-growing plants characteristic of the grazed sites require relatively high light levels and are eliminated wherever growth of reed is permitted.

The traditional form of management has been to adopt a 'little-and-often' approach, such as cutting by hand or the use of a bucket on the back of a tractor or heavier machine. This suppresses the tall emergents, coarse grasses and scrub that would otherwise become dominant. An alternative approach is to leave the ditches for longer periods of time, but then to carry out a much more radical form of management. On each occasion, there is a rapid change in vegetation, followed by a period of gradual recovery.

The long-term effect of regular maintenance may be to keep the ditch at the same stage in seral development. Although a large proportion of the annual production of the ditch is removed, there survive viable propagules (usually in the form of vegetative fragments) of most species, allowing almost identical vegetation to develop over the course of the ensuing months or years. Where the ditch is maintained on a 'little-and-often' basis, the differences in vegetation from one year to the next will be minimal. The differences will be more striking where management is more radical but less frequent. The most recently cleaned ditches will correspond with the open-water stage of a hydrosere and will support a more diverse vegetation. In areas where management work is carried out on a rotational basis, the ditches will include examples of a very wide range of vegetation.

Where grazing ceases, as a result either of the conversion of adjacent land to arable or of the erection of a fence between the pasture and ditch, cutting and cleaning operations become even more necessary. Catastrophic changes will come about in two ways:

1 where ditch cleaning is accompanied by the considerable enlargement of the ditch and the consequent removal of the substrate and steepening of the banks;

2 where management ceases altogether and succession is allowed to occur. The depth of the water decreases as a result of the accumulation of plant remains and the establishment of low emergents and ultimately of reed.

In both types of situation, only a small range of plant species is present. They have become increasingly common where grazing marshes have been converted to arable.

Four patterns of ditch management are described in Appendix 6.

Throughout the three study areas, there is plenty of evidence of what will happen if farmers decide that a traditional form of ditch management is obsolete and no longer worth using. Some of the new forms of management, adopted in order to eliminate all flooding and lower the water-table (as the first step in grassland improvement or the conversion of pasture to arable), can have just as dramatic an effect on plant life as if the watercourse were entirely removed.

6 Intensively farmed land and the prospects for nature conservation

Even where drainage channels survive, the vegetation of an increasing proportion is likely to change as farmers take up new crops and husbandry practices. The choice for nature conservation is one of losing the more demanding or distinctive forms of plant life or else of maintaining or reintroducing appropriate forms of land use and ditch management explicitly for the purposes of conserving wildlife communities. In view of the resources required, in terms both of investment and of loss of agricultural production, a much more precise understanding will be required of the impact of management practices on individual species and their communities.

From the ecologist a two-fold approach is required. In order to obtain a more detailed knowledge of the ecology of individual species affected by drainage and land-use changes, and especially of the processes that can affect the speed and manner in which species displacement and colonisation can take place, an experimental approach is required.

A trial has already been set up in Romney Marsh, whereby a ditch has been cleared of its dominant common reed and specimens of four species typical of shallow pasture ditches have been introduced. Because the ditch lies in arable land, the trial should provide the opportunity to separate the effects due to shade created by tall emergents (e.g. common reed) from other factors brought about by the conversion from pasture. The reeds are suppressed and the input of nutrients monitored. In the first three years, frogbit *Hydrocharis morsus-ranae*, tufted forget-me-not *Myosotis laxa* ssp. *cespitosa* and fool's water-cress *Apium nodiflorum* disappeared, despite the suppression of reed. Only tubular water-dropwort *Oenanthe fistulosa* survived and spread. Although all four species were well established a year after their introduction, the first three began to show signs of decline when the adjacent arable field was sown to a crop of rape after a long period under cereals. An algal bloom occurred in the same year. Two duckweed species, *Lemna minor* and *L. trisulca*, and a water-starwort, *Callitriche obtusangula*, were first recorded in 1983.

The second approach must be to acquire and compare a greater range of baseline data, derived from the past and present, for a wide range of wetland systems in order to monitor future trends more rigorously. Without this, it is easy to overlook both the dynamic qualities and the considerable variety of conditions encountered within each of the grazing marsh systems of lowland Britain. The relative importance of the ditch bank, as opposed to the adjacent fields, for the conservation of plant life is already clear. The further categorisation of ditch types is likely to highlight not only the constraints now imposed on sustaining a diverse and distinctive flora within modern farming systems, but the challenge presented to plant ecologists of creating from scratch such a flora explicitly for conservation purposes, based on a fuller knowledge of the ecology of the species involved and of the population dynamics of a grazing marsh system.

If this greater competence in the management of grazing marshes for nature conservation is to be achieved, taking account of the very complex interrelationships between drainage, land use and management on the one hand and botanical status on the other (Figure 14), there is an urgent need to relate the conclusions reached in respect of plant life to the concurrent changes taking place in the status of bird, mammal and invertebrate groups. Close collaboration is required both with agronomists, hydrologists and soil scientists and with those farmers and drainage engineers who actually manage the land and water-bodies in question. Without a greater appreciation of the techniques, findings and experience of these different disciplines and professions, there can be little prospect of answering the basic question, how does a specific form of drainage, applied at a specific point in time, in a specific place, on a certain type of soil, affect a particular kind of plant or animal life?

Fool's water-cress
Apium nodiflorum

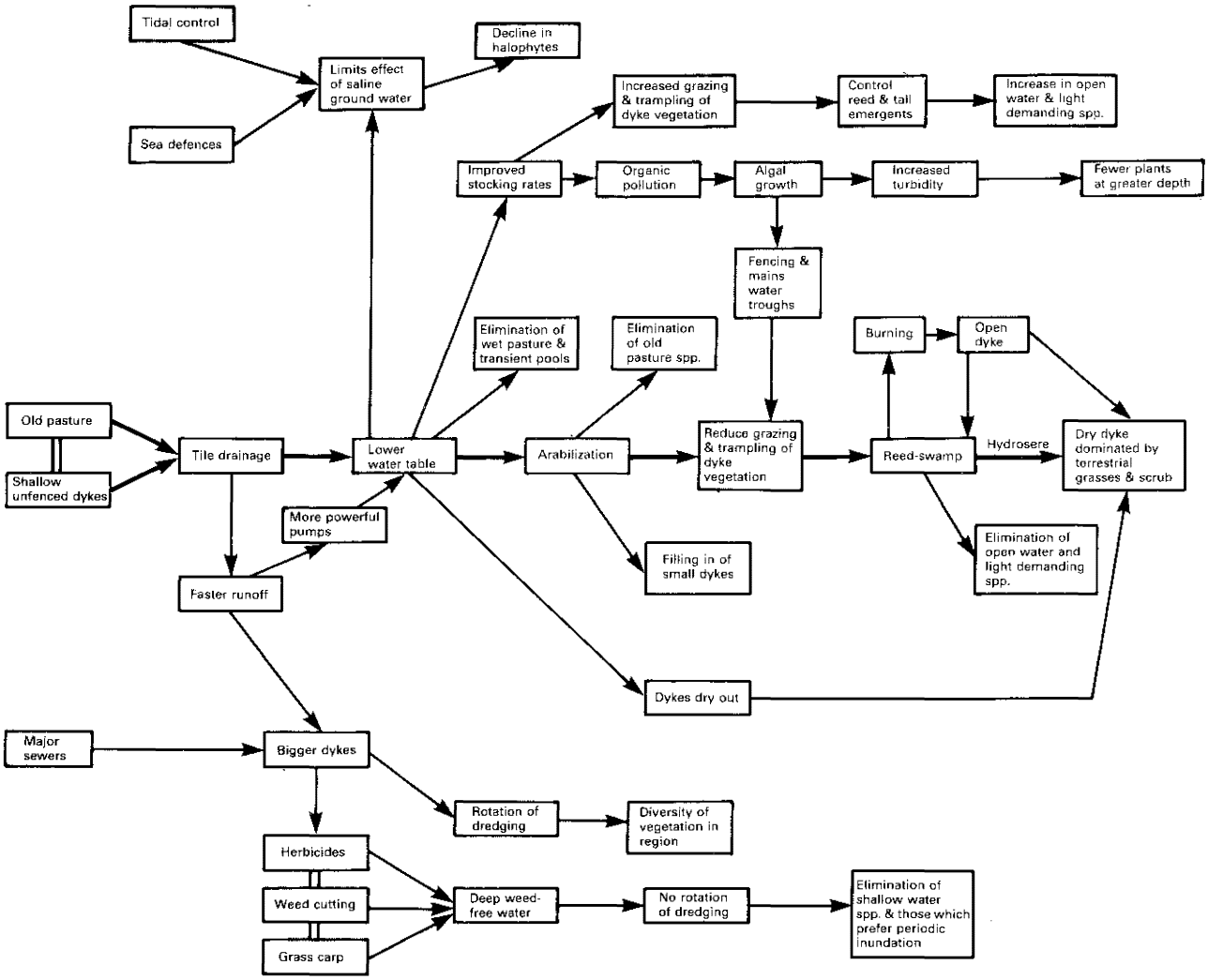


Figure 14 Interrelationships between drainage, land use and management on the one hand and botanical status on the other

7 Survey methods

A stratified random sampling approach was used for carrying out a present-day survey of Romney Marsh, the Somerset Levels and Moors, and the Idle/Misson Levels. In the case of the first two areas, the length of ditch was measured in representative areas of each soil type, and sites were allocated in proportion to the total number of ditches (i.e. calculated total lengths of ditches in the entire area of each soil series). The sites were located by using random grid co-ordinates, and 100-metre samples were recorded with an examination of both bank and water. Because there was no detailed information on the soils of part of the Idle/Misson Levels, random numbers were used to obtain pairs of National Grid co-ordinates, the aim being to survey those ditches nearest to the random grid intersections as plotted on Ordnance Survey maps. In all three areas further sites were surveyed, where earlier site-specific data were available.

For each site, three or four files of vegetation data were compiled. Plant lists and estimates of percentage cover were made for species rooted in the water of a 20-metre length of ditch and for a further 40 metres of either side. A third file of data was related to the banks of the 20-metre lengths, which were scored for the percentage cover of the component species. A fourth file was compiled where the ditch was adjacent to grassland; a 1-metre square quadrat was randomly thrown, and the species, plant height and percentage cover were recorded.

Two files of environmental data were also collected for each 20-metre length, one including such information as the dimensions of the ditch and banks and the other covering such aspects as soils, land use and management.

Both the vegetation and the environmental data were subjected to two related types of multivariate statistical analysis, namely an Indicator Species Analysis (ISA) (Hill, Bunce & Shaw 1975) and TWINSPAN (Hill 1979), as a means of classifying the vegetation types and identifying correlations between environmental factors and vegetation samples.

Acknowledgements

The study reported here depended for its success on the assistance and co-operation of numerous individuals and organisations. It is a pleasure to record here our thanks to them all. The authors of this report are alone responsible, however, for the selection and interpretation of the data used.

Throughout the duration of this project, Dr C Newbold (the Nature Conservancy Council's nominated officer) and his colleague, Mrs M Palmer, have been a ready source of advice, ideas and information. The regional staff of the NCC have ensured that relevant sources of information on each area were consulted – Messrs J M Schofield and P J Horton (South-East Region), Messrs R Williams and R Corms (South-West Region) and Dr M A Vincent (East Midlands Region).

The county recorders of the Botanical Society of the British Isles made available their files and records of plant distribution – Mr E G Philp (Kent), Captain R G B Roe (Somerset), the late Mr R C L Howitt (Nottinghamshire), Miss E J Gibbons (Lincolnshire) and Dr W A Sledge (South Yorkshire). Several other individuals who have conducted detailed studies of the particular areas also freely provided data – Dr F Rose (Kent), Dr W Latimer (Kent and Sussex), Mr and Mrs E G Burt (Kent and Sussex), Professor A J Willis (Somerset), Mr B Storer (Somerset), Mrs P A Wolseley (Somerset) and Dr J Hodgson (Idle/Misson Levels).

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The drawings of plants in this publication are reproduced mainly from *The flora of the Liverpool district*, edited by C Theodore Green (Liverpool, 1902). The drawing of fringed water-lily *Nymphoides peltata* is from *Illustrations of the British flora* by W H Fitch and W G Smith (3rd ed., London, 1892) and that of water fern *Azolla filiculoides* from *Flore descriptive et illustrée de la France* by H Coste (vol. 3, Paris, 1906).

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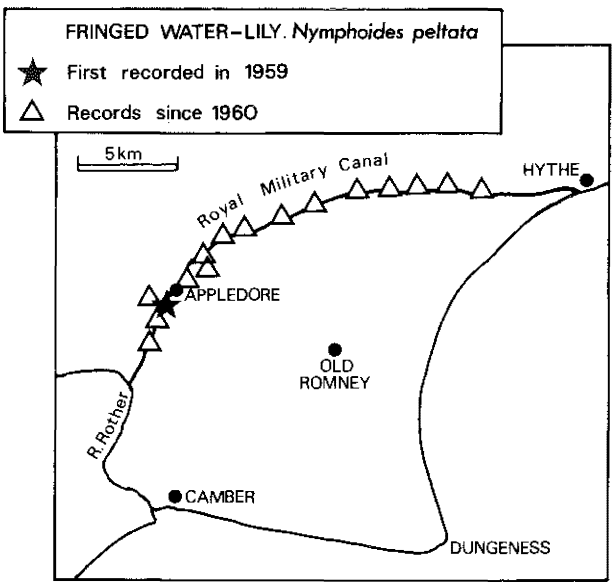
Appendix 1
Species with an increasing status

1 Fringed water-lily *Nymphoides peltata*

This rare and attractive relative of bogbean is a native species of still and slow-moving water, mainly in the Fenland basin. Very popular with gardeners and those planting ornamental waters, the plant has been introduced to many lakes and pools throughout Britain. It can be very invasive. Possibly through a combination of natural spread, deliberate introductions and the dumping of unwanted plants in watercourses, the fringed water-lily has become well established both in the Bridgwater and Taunton Canal in Somerset and in the Royal Military Canal of Romney Marsh, where it has to be cleared regularly in order to protect navigation and fishing. Whilst it is still very rare away from the canals, a recent survey indicated that it may be spreading into adjacent arterial drains, from which it could soon colonise a wide area. The plant has not yet been recorded in the Idle/Misson Levels, but the Chesterfield Canal would appear to provide suitable habitat.

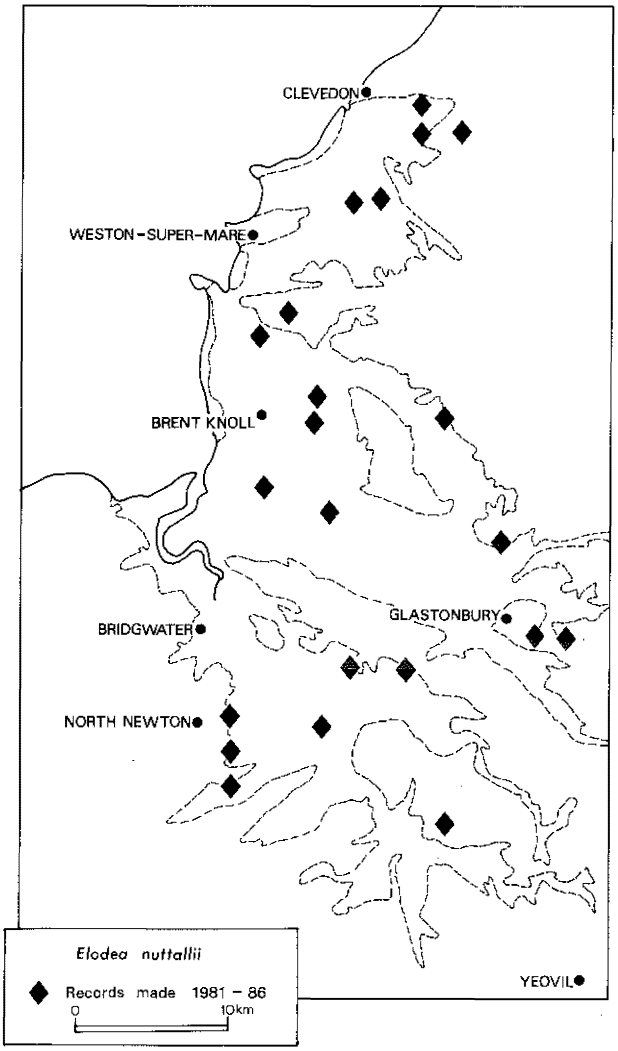
Fringed water-lily
Nymphoides peltata

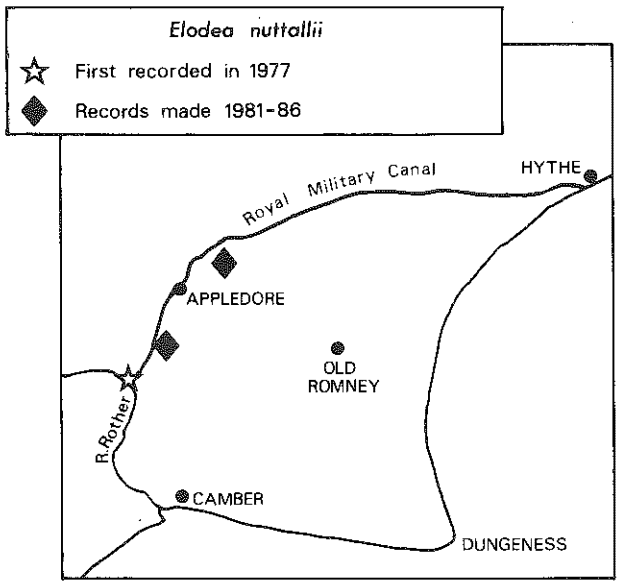


2 *Elodea nuttallii*

This close relative of Canadian waterweed *Elodea canadensis* was first found in Britain in the mid 1970s. There is some evidence that it is displacing *E. canadensis*. Within the Somerset Levels, it appears to be particularly common in deeper, wider and more nutrient-rich ditches, very often growing with fennel pondweed *Potamogeton pectinatus* and fat duckweed *Lemna gibba*. The species was first recorded by the lower part of the River Rother in Romney Marsh in 1977; plants have been recorded to the north, on or near the Royal Military Canal, during the 1980s. It was first recorded in the Idle/Misson Levels during fieldwork in 1983.

A popular oxygenating plant, it was probably thrown out, or escaped, from ornamental pools and aquaria. The species was probably mistaken for an odd form of *E. canadensis* for many years.



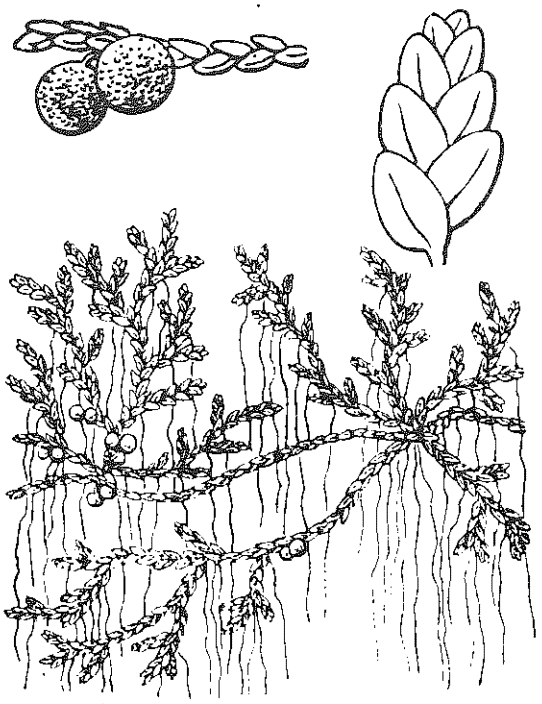


3 Water fern *Azolla filiculoides*

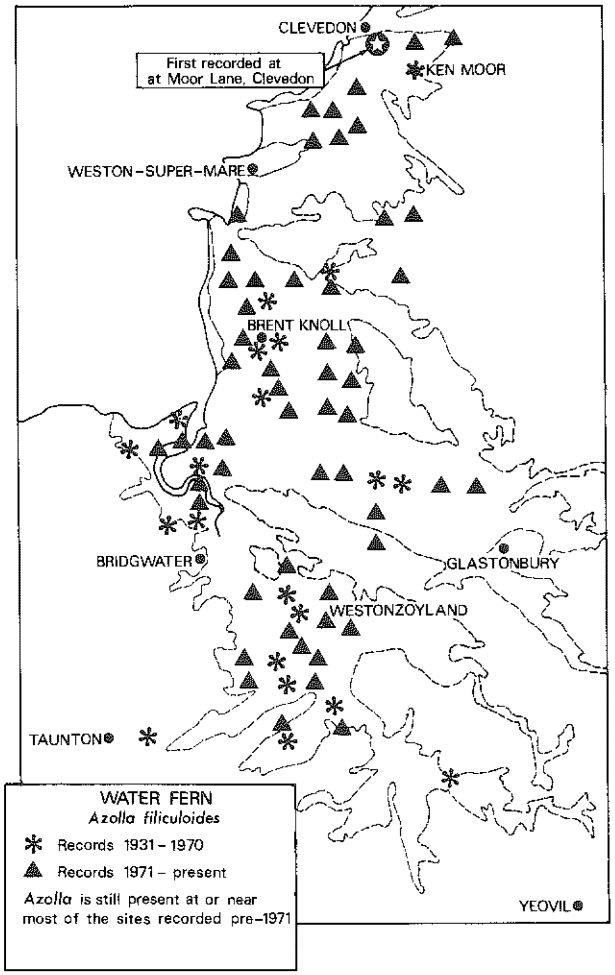
The water ferns or 'fairy moss' are popular in the aquarium or garden pond. They are the most buoyant of the free-floating aquatics and may, by shading the Lemnaceae, have a competitive advantage. The presence of a blue-green alga of the genus *Anabaena* in the leaf may help the plants to tolerate nutrient-poor waters.

The spread of the fern in the Somerset Levels and Romney Marsh can be traced from the records of Captain R G B Roe and Mr E G Philp respectively. It was first reported to have escaped from a pond at Clevedon Court in Somerset. From there, it was found on Kenn Moor and at Kewstoke, near Weston-super-Mare. Its recent spread to much of the Somerset Levels probably arises from further introductions (as at Westonzoyland in 1945 and Brent Knoll in 1946), as well as long-distance dispersal as a result of water movement and ditch-cleaning. Its inability to tolerate cold winters may account for the sudden 'crashes' observed; many botanists have noted how it will dominate a ditch in one year but be absent in the next. Through its ability to reproduce rapidly by vegetative means, recovery is fast, particularly after ditch-cleaning, when competition from tall emergents is reduced.

In Romney Marsh, its spread has been equally rapid. The species' distinctive appearance means that it is easy to recognise. It has not so far been found in the Idle/Misson Levels, where the colder winters may make it harder for the plant to spread and maintain itself.



Water fern
Azolla filiculoides

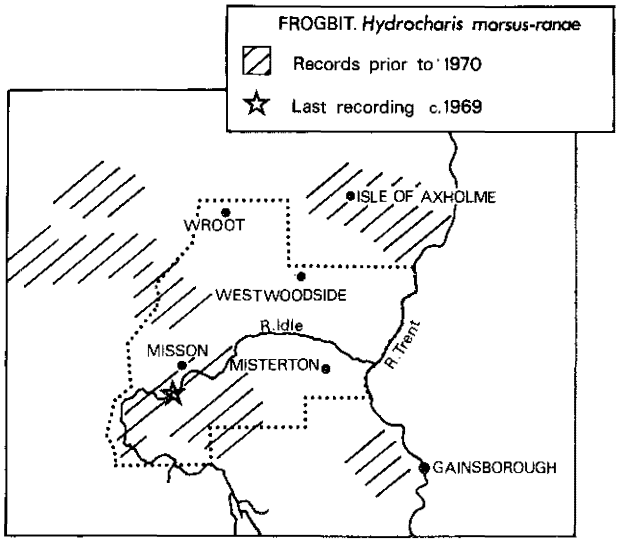


Appendix 2
Species with a declining status

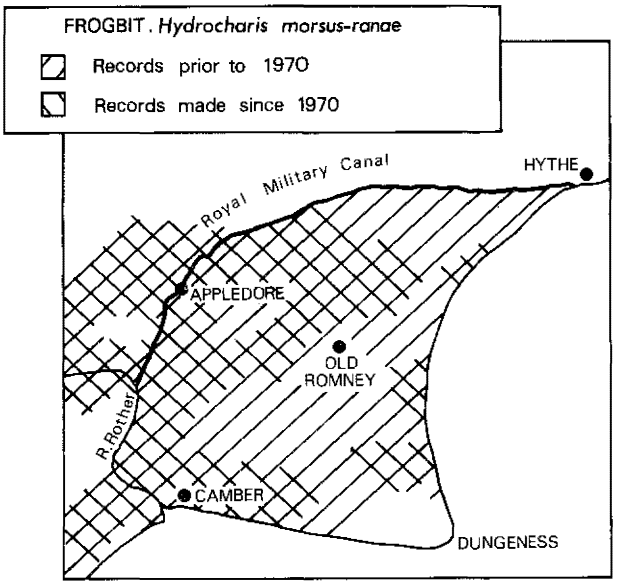
1 Frogbit *Hydrocharis morsus-ranae*

This plant is by far the best indicator species of the change from pastoral to arable farming. It prefers shallow, still water, with plenty of light. Frogbit is especially common in small pasture ditches, where stock suppresses the reed or sedge and where management work is never too radical. It is excluded from dry ditches, those colonised by tall emergents and large expanses of regularly cleaned open water prone to strong wind or water movement. In intensively arable landscapes, with few large open drains and the smaller ditches either overgrown or eliminated, frogbit may only survive in those marginal areas of the drains beyond the reach of machinery.

Frogbit is one of the most ubiquitous aquatic species in the Somerset Levels and Moors, with large populations wherever the land use is still predominantly pastoral. It is rarely encountered in the major drains and those watercourses draining the comparatively few arable areas, such as the Bleadon Level.



Frogbit
Hydrocharis morsus-ranae



This was also the situation until the last war in Romney Marsh. Botanists regarded the plant as so common that it did not warrant the making of localised records. Today, with most of the area under arable, the plant is only common in the ditches of the few fragments of pasture around Camber and in the Rother Levels. Elsewhere, it only occurs wherever a small patch of pastureland survives or where the fields have been grazed until very recently. Fieldwork from 1981 onwards revealed many examples of the rapid decline of the species once the pastures adjacent to the drainage ditches had been ploughed.

Frogbit may have been always an uncommon, but characteristic, species of the drains of the Idle valley. By the early part of the century, most of the sites where it was previously recorded had become too dry, overgrown or deeply dredged, and the plant was probably extinct by the early 1960s. It was last recorded in Everton Carr, in a linear pool which now survives as a damp sandy depression in a potato field.

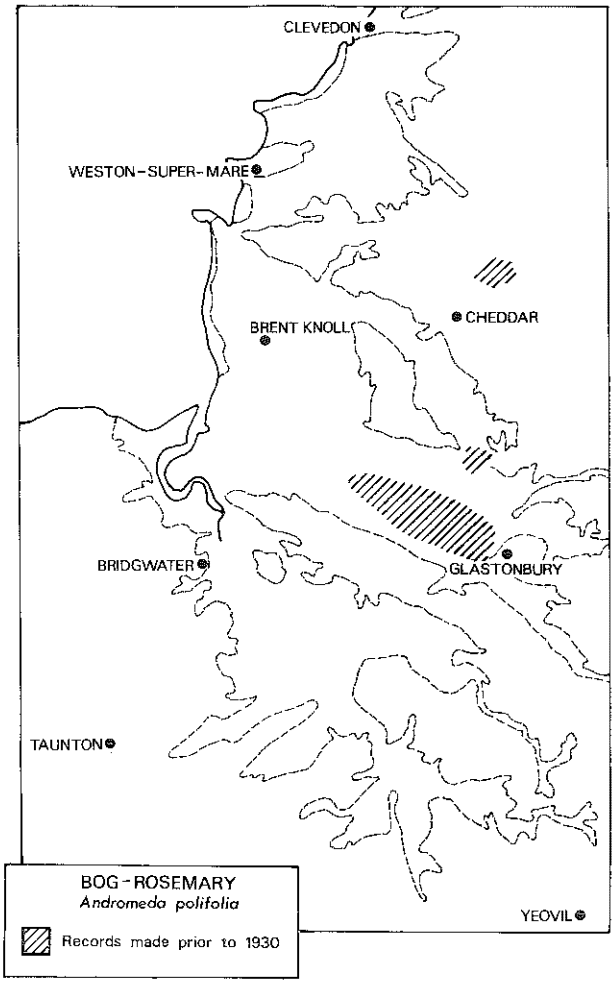
2 Bog-rosemary *Andromeda polifolia*

Bog-rosemary is now largely confined to raised bogs in Wales, northern England and southern Scotland. It was much more widespread at one time in southern England. Its presence, and indeed local abundance, on the drier parts of the 'primitive heathland' of the Turbary moors of Somerset was the subject of considerable comment among nineteenth-century botanists.

The plant was already very hard to find by the turn of the century. White (1912) recorded it among the heather alongside some of the main droves in Somerset, where the original peat surface still survived. It had disappeared by the time *The flora of Bristol* was published (White 1912). Together with other botanists, Charles Moss observed that it did not colonise abandoned peat-cuttings (Moss 1907). C I and N Y Sandwith saw the plant for the last time in 1920, south of the railway between Ashcott and Shapwick stations.

Bog-rosemary
Andromeda polifolia

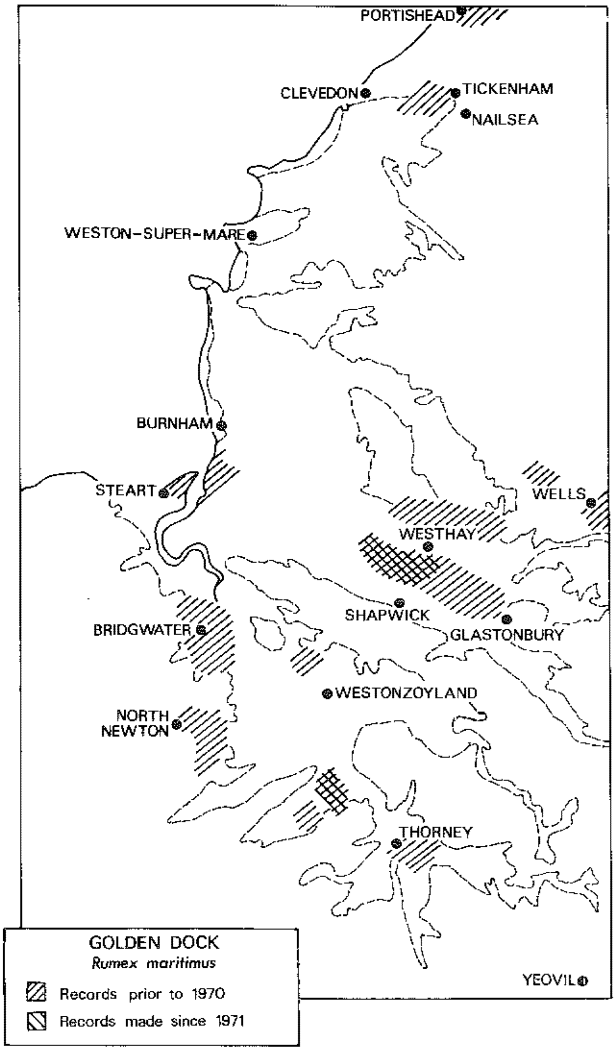
Although bog-rosemary survives near the Idle valley close to Thorne, Crowle and Goole, many of the sites described by earlier botanists have been destroyed as a result of peat-cutting, drainage or building development. There were some plants in the Wroot and Epworth areas between 1840 and 1893.



3 Golden dock *Rumex maritimus*

This dock is not simply a plant of the coast, as its scientific name might suggest. Its principal habitat is the wet ground exposed as a lake or pond dries up in warm weather. Here, a distinctive assemblage of plants occurs, with bur-marigolds *Bidens* species, celery-leaved buttercup *Ranunculus sceleratus*, red goosefoot *Chenopodium rubrum* and knotweeds *Polygonum* species especially common. Both golden dock and its close relative, *Rumex palustris*, can also be found in large numbers where spoil from rivers and ponds has been dumped or the peat cut. Lack of competition and efficient seed dispersal enable the species to establish themselves before the sward closes. The seeds remain viable for long periods and germinate when the soil is disturbed or exposed.

The stronghold of golden dock in the Somerset Levels and Moors is now the old peat cuttings around Shapwick and Westhay, where the species has always been common. White (1912) described it as "plentiful on the peat moors after any fresh cutting of the turf". It has disappeared, however, from Portishead, Nailsea, Tickenham, Knowle, Wells, Burnham, Steart, Bridgwater, Westonzoyland, North Newton, Glastonbury and Thorney. In these parts, the plant grew by ponds, along the edges of the tidal rivers, and locally in marshes where the trampling of livestock close to the water's edge

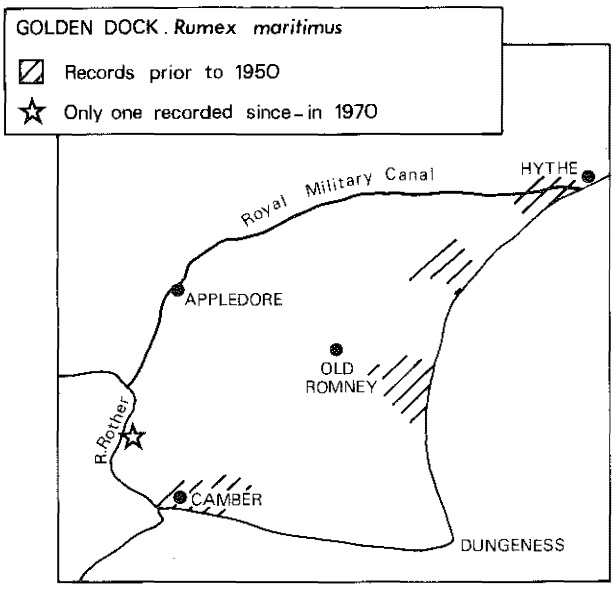


Golden dock
Rumex maritimus

reduced competition. Here, the fencing of the ditches and use of drinking troughs may have contributed to its decline.

In Romney Marsh, it has long gone from the areas of intensive holiday development along the coast between Camber and Hythe, surviving only in a wet corner of a field where the farmer is a keen botanist. Here, there is no peat-cutting to help maintain the population.

In the Idle/Misson Levels, golden dock is still found in small numbers over tracts of wet mud near the larger rivers. It has disappeared from the smaller sites. As in parts of Romney Marsh, the conversion of grazing land to cereals and the consequent withdrawal of livestock from the ditch edge have contributed to this decline.

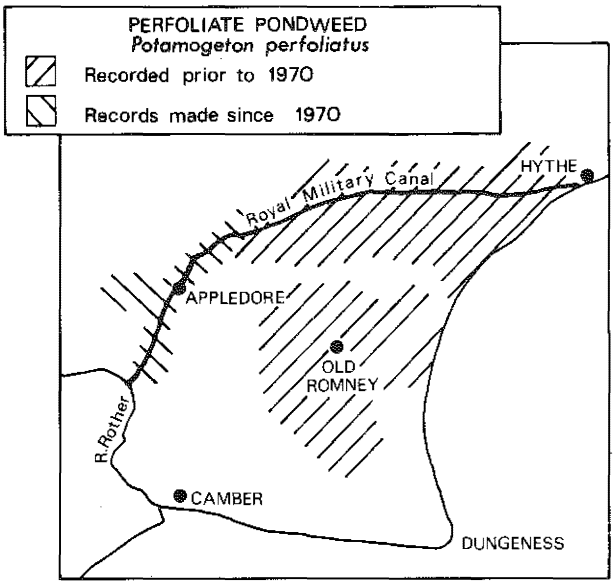


4 Perfoliate pondweed *Potamogeton perfoliatus*

This pondweed is closely associated with the larger drains, canals and canalised rivers, and it is far from clear why it has experienced a marked decline.

In Romney Marsh, the plant was once widespread and indeed common in the eastern part. Recent records are confined to the Royal Military Canal and adjacent main drains between Iden and Warehorne.

A combination of factors may be leading to the reduction of the pondweed populations. In addition to direct damage, some drains have been neglected and colonised by tall emergents to the detriment of the submerged flora. Many of the rivers and drains may carry a larger sediment load than they did in the ninteenth century. Algal populations have increased owing to the nutrient-rich run-off from farmland, leaving the water much murkier than previously. All these factors must reduce the amount of light reaching the submerged pondweeds.

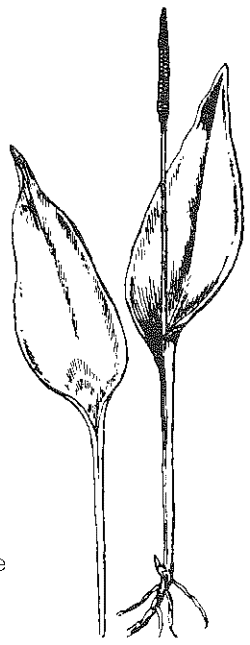


Perfoliate pondweed
Potamogeton perfoliatus

Appendix 3
The Misson Fenny Fields

When plant lists are available for the past from sites which can be accurately located, there is the opportunity to carry out case studies of wider trends in plant life. In the Idle/Misson Levels, surveys of the Misson Fenny Fields were carried out by Mr and Mrs R C L Howitt in 1952, 1954, 1955 and 1969, as part of a project to produce a new flora of Nottinghamshire (Howitt & Howitt 1963). There was often standing water on parts of the peaty meadows in winter and the ditches were permanently wet. The grasslands, which were formerly mown for hay and then grazed only in late summer, were improved by ploughing and reseeding in 1954. The installation of the pump drainage scheme in the late 1970s resulted in most of the land being used for arable crops.

The very rich fen flora, characteristic of short, damp turf and wet hay meadows and containing such national rarities as fen violet *Viola persicifolia* and marsh pea *Lathyrus palustris*, has been largely destroyed. Arable weeds have greatly increased.



Adder's-tongue *Ophioglossum vulgatum* ssp. *vulgatum*

In the Somerset Levels, many botanists recorded the plant in the Brue valley. It was also found from Berrow in the north to the River Yeo and the Bridgwater and Taunton Canal in the south. Murray (1896) called it a "locally common" species. Roe (1981) described it as "rare and decreasing".

There is little evidence within the Idle valley of any reduction in the range of the species. R C L and B M Howitt noted, however, that the use of aquatic herbicides in the carr drains from the early 1970s onwards had led to marked reductions in the populations of all the larger-leaved pondweeds. Some drains had become 'sterile'.

Species change in the Misson Fenny Fields

Species which have declined or disappeared since 1950

Baldellia ranunculoides
Carex acuta
C. panicea
C. vesicaria
Cirsium dissectum
Dactylorhiza majalis
  ssp. praetermissa
Hippuris vulgaris
Lathyrus palustris
Ophioglossum vulgatum
  ssp. vulgatum
Potentilla palustris
Rhinanthus minor
Samolus valerandi
Scirpus fluitans
Succisa pratensis
Valeriana dioica
Viola persicifolia

Species more widespread or abundant in 1983 than in 1950

Atriplex prostrata
Cirsium arvense
Elymus repens
Galeopsis tetrahit s.l.
Galium aparine
Phragmites australis
Polygonum aviculare s.l.
Urtica dioica

Species apparently as widespread in 1983 as in 1950

Achillea ptarmica
Calamagrostis canescens
Carex disticha
Lychnis flos-cuculi
Lysimachia vulgaris
Oenanthe fistulosa
Rorippa amphibia
Sanguisorba officinalis
Senecio aquaticus
Stellaria palustris
Thalictrum flavum

Information for the 1950s is derived from the surveys carried out by R C L and B M Howitt.

Appendix 4
The old moat, Old Romney

The kind of change taking place in Romney Marsh may be illustrated by reference to the old moat (TR 033254), north of the village of Old Romney. When Dr Francis Rose visited the site in September 1959, he recorded how the moat and surroundings were intensively grazed. A local farmer recalls that the grasslands were converted to arable and under-drained in the 1960s. During the early 1980s, crops of wheat covered most of the land.

The species list compiled by Dr Rose in 1959 suggests that the moat supported a characteristic pasture-dyke flora, made up of low-growing, light-demanding plants associated with water-logged soils or water margins. They included water forget-me-not *Myosotis scorpioides*, common marsh-bedstraw *Galium palustre*, gipsywort *Lycopus europaeus* and water-cress *Nasturtium officinale*. When the water-table was lowered and the pasture ploughed in the 1960s, these species were probably displaced by tall emergents. When surveyed in September 1981, the moat had been colonised by species of reed swamp and coarse, marshy vegetation, including hedge bindweed *Calystegia sepium*, bittersweet *Solanum dulcamara* and common sallow *Salix cinerea* ssp. *oleifolia*. The local rarities, rootless duckweed *Wolffia arrhiza* and soft hornwort *Ceratophyllum submersum*, had disappeared from the species list. A further visit in 1983 showed little change from 1981.

Common sallow
Salix cinerea ssp. *oleifolia*

Species lists for the old moat in Old Romney in 1959 and 1981

(A) denotes a strong trend in general distribution to arable dykes.

(P) denotes a strong trend in general distribution to pasture dykes.

1959 survey

Ceratophyllum submersum (P)
Nasturtium officinale (P)
Althaea officinalis (A)
Oenanthe aquatica
Galium palustre (P)
Myosotis scorpioides (P)
Callitriche stagnalis
Lycopus europaeus
Agrostis stolonifera
Wolffia arrhiza
Lemna gibba
Lemna minor

1981 survey

Salix cinerea ssp. oleifolia (A)
Rumex conglomeratus (A)
Althaea officinalis (A)
Epilobium hirsutum (A)
Calystegia sepium s.s. (A)
Solanum dulcamara (A)
Alisma plantago-aquatica (P)
Juncus inflexus (P)
Poa trivialis
Lemna minor
Lemna trisulca (P)
Sparganium erectum
Carex otrubae

Information for 1959 is derived from the surveys carried out by Dr Francis Rose.

Appendix 5 Ditch management and the occurrence of species

Variations between types of watercourse

The four main types of watercourse, with their distinctive forms of management, support different plant communities.

1 The shallow pasture ditch

The richest habitat is the shallow ditch to which stock have access. There is no coarse growth. The gentle slope of the banks means that a variety of soil moisture and water depths is present, allowing a wide range of species to coexist. Where the ditch is used as a 'wet fence', true aquatics are particularly favoured.

2 The main drain

Intensive forms of management, commonly associated with main drains, tend to favour those submerged species which reproduce well from vegetative fragments. Species which prefer shallow water or waterlogged soils are rare.

3 The minor arable ditch

Because there are no large herbivores to suppress their growth, these less intensively managed ditches in arable land are soon dominated by common reed or another tall emergent. The shallow and fluctuating depth of water prevents the submerged species from becoming established. The deep shade cast by the reed suppresses the light-demanding low herbs.

4 The dry ditch

Dry ditches have no true aquatic plants. If stock are present, there is a low turf. Where they are absent, the vegetation is dominated by coarse grass, bramble and nettle. Dry ditches are often associated with hedges, which may cast a dense shade over the nearby vegetation.

5 Some species are present in all forms of watercourse and have no preference for any particular type. These are referred to in the diagram as 'generalist'.

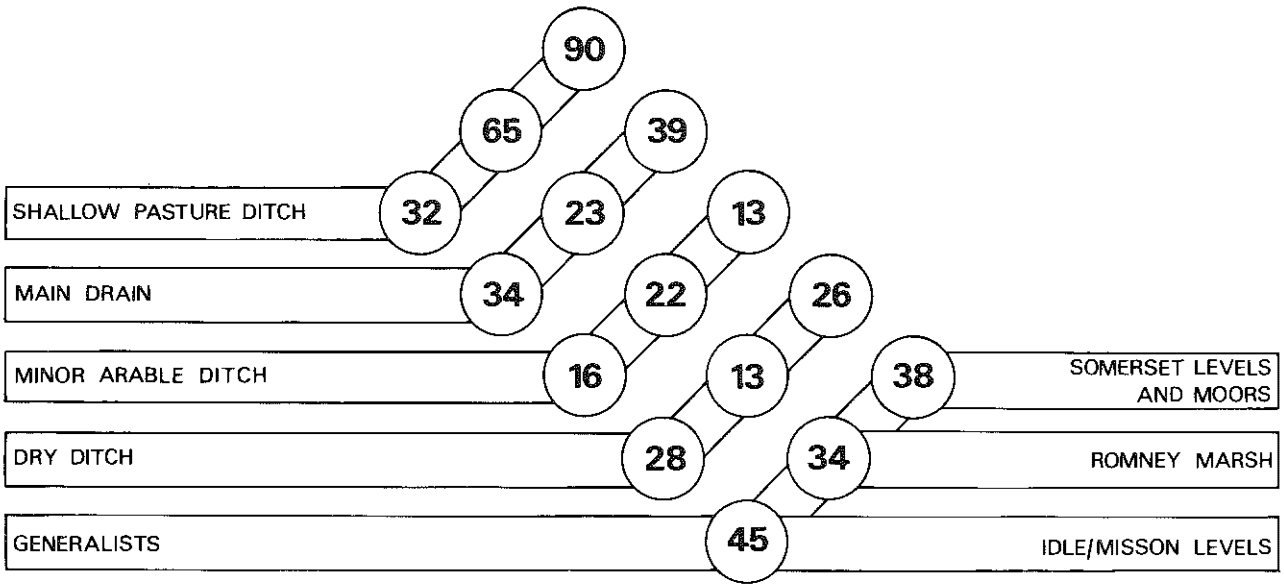
Variations between the study areas

In general, the richness of the flora is in inverse proportion to the intensity of agriculture. In the Somerset Levels and Moors, there is a wide variety of plants, with over 200 species associated with the drainage ditches. The reliance on grazing and more traditional forms of management has maintained an open-water habitat, with a range in water depth. Even the shallow pasture ditches are notably richer in Somerset than in the other study areas, where the sites of many species (which probably always had a very restricted distribution) have now been destroyed or much modified. This is particularly true of the Idle/Misson Levels.

The main drains are an especially important resource in the Idle/Misson Levels, where there are scarcely any small pasture ditches to be found. The very restricted tracts of shallow water encountered in the less-intensively managed parts of these main drains provide the only refuge for species which, in the other study areas, would be strongly associated with the pasture ditches.

The minor arable ditches are relatively poor in species in all areas. The higher number of species present in Romney Marsh probably reflects both the frequency of this type of ditch and its generally wetter nature compared with the Idle/Misson Levels.

Dry ditches are less common in Romney Marsh, but very widespread in the Idle/Misson Levels.

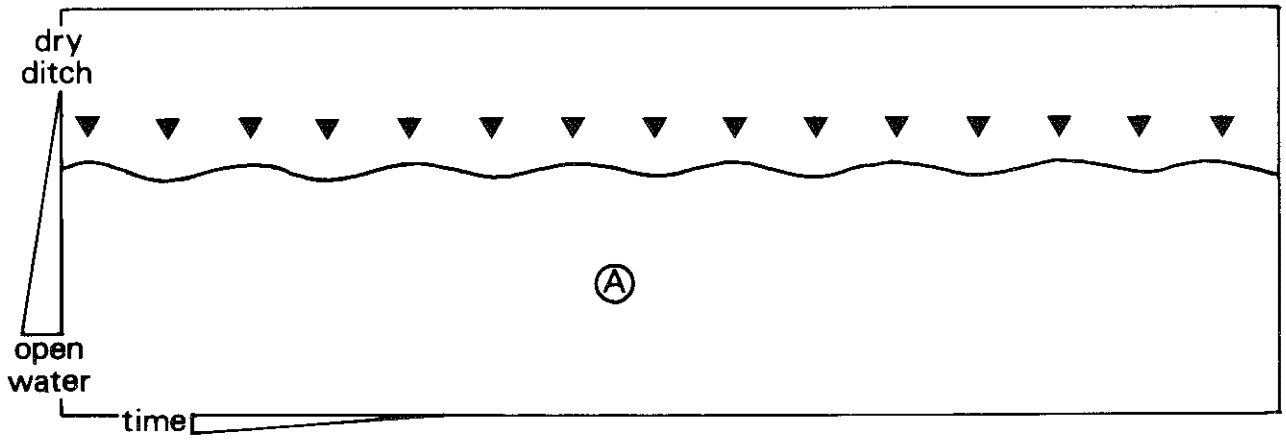


The diagram shows the number of plant species which seem to prefer different types of watercourse in the three main study areas. For example, 90 species are particularly associated with shallow pasture ditches within the Somerset Levels and Moors, compared with the 13 species more commonly associated with the minor arable ditches of the same area.

Appendix 6
Patterns of ditch management

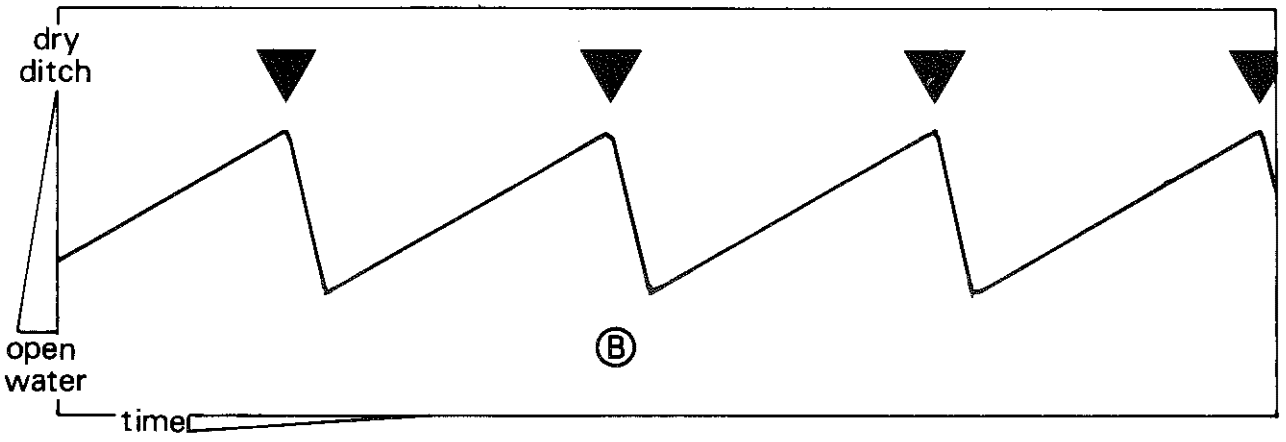
Four patterns of ditch management may be discerned, each of which is likely to have a distinctive range of plant species and communities present:

A The 'little-and-often' approach



Many watercourses are managed on the basis of this approach. The ditch and margins of many of the smaller pasture ditches are kept open by the grazing and trampling effect of livestock. The annual or more frequent scything of the vegetation or the use of a back-bucket can have a similar effect. The vegetation of the larger drains may also be maintained at about the same position in the succession, where very frequent use is made of a weed-cutting bucket, herbicides or a weed-cutting boat.

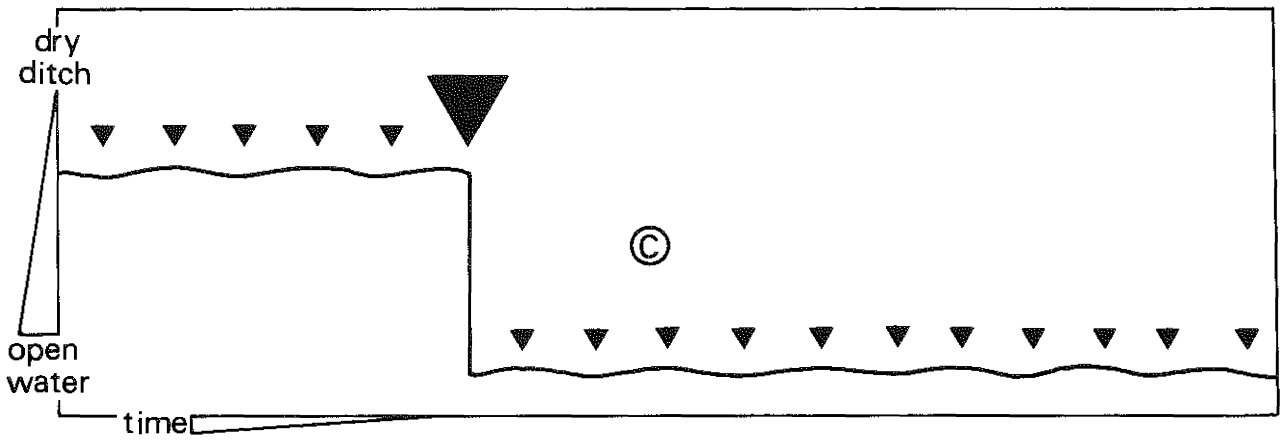
B The 'seldom, but more radical' form of management



Management effects of increasing magnitude

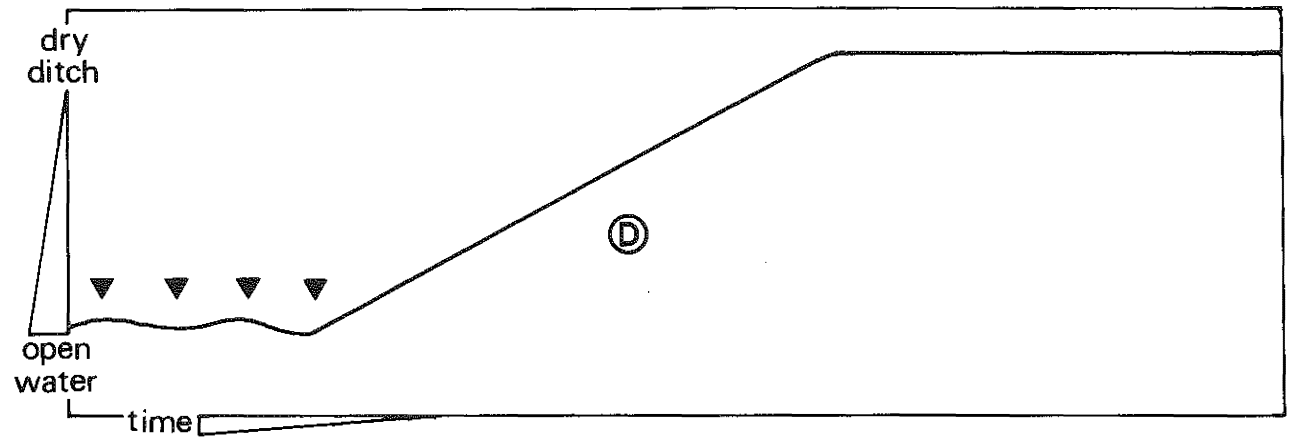
Other watercourses may also be managed regularly, but at much longer time intervals. The use of such radical forms of management as a drag-line is followed by a period of zero or minimal maintenance during which the vegetation recovers to its previous state. In some instances, where propagules and sediment have been almost entirely removed, there may be subtle differences in the vegetation.

C The 'catastrophic' change



Some watercourses are realigned, greatly deepened or given a completely different cross-section, particularly where the land use or drainage pattern has been altered. The conversion of the neighbouring land from pasture to arable can have a radical effect on the ditch vegetation. In all these cases, it may be impossible for the original vegetation to re-establish itself.

D The cessation of management



Where management ceases altogether (for example where improved pumping activity, under-drainage and/or the deepening of nearby watercourses render a ditch redundant), there may be a gradual succession to terrestrial vegetation. Unless arrested, this will lead to the extinction of aquatic and marshland vegetation.