THE RAISED BOGS OF IRELAND

their ecology, status and conservation

Report to the Minister of State at the Department of Finance

Front Cover

A large hummock of *Sphagnum* and ling heather (*Calluna vulgaris*) forming an island in the pool complex on Garriskil Bog, Co. Westmeath. The hummock is capped with the grey moss *Rhacomitrium lanuginosum* and bilberry (*Vaccinium myrtillus*)

THE RAISED BOGS OF IRELAND
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J.R. CROSS
with a contribution by H.J. Wilson
Wildlife Service, Office of Public Works

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PREAMBLE

'Since 1946 it (Bord na Móna) has . . . . created wealth out of what had been waste land.' (Bord na Móna: developing Ireland's peat resources).

'Irish bogs, which had been barren for centuries, are now productive under forest crops.' (O'Carroll, 1984).

'To the ordinary man mires are not only lonely and monotonous but even uninteresting, and when one wanders for mile after mile over the unvarying surface of a bog it may seem difficult to dispel such an impression. But it is nevertheless a mistaken one. One has only to persevere to reveal a whole series of fascinating details, to discover that these mires mirror variations in climate, topography and soil conditions, that in fact the interplay of these factors make its impress upon the history of the mire.' (Osvald, 1949).

'The need to safeguard as many midland (raised) bogs as possible before they are lost forever to peat extraction is the most urgent issue in Irish nature conservation.' (Union of Professional and Technical Civil Servants, 1987).

SUMMARY

In 1985 the Government instructed that '... the Department of Fisheries and Forestry* should carry out a research programme into Irish bogs with specific reference to bogs of conservation interest.' Details of all bogs which that Department proposes to acquire for conservation purposes were to be submitted for Government approval. This report provides details of the first part of that research programme *viz.* the survey of raised bogs.

The survey covered more than 25,000ha on over 200 raised bogs and was the most detailed survey of its kind undertaken in Ireland. It has provided a considerable amount of new information on the ecology of our raised bogs and provides a clear picture of the state of this extensive ecosystem which has played such an important role in the history, culture and economy of Irish society.

The report is divided into four parts which are summarised below. In Part 1 'The general ecology of raised bogs' provides the scientific background. Part 2 provides details of the systematic survey. Part 3 considers 'Conservation rationale, requirements and problems' and 'Conclusions and Recommendations' are presented in Part 4.

PART 1: THE GENERAL ECOLOGY OF RAISED BOGS

1. Raised bogs are domed shaped bodies of peat which developed in former lakes and shallow wet depressions. They are a distinctive and characteristic feature of the landscape of the midlands, in which they are concentrated.
2. They are classified into two types according to their morphology and flora which is dependent largely on rainfall: the 'True Midland' sub-type and the 'Western' sub-type. Both types are assigned to the Oceanic Raised Bogs which have a very restricted distribution in N.W. Europe. They are considered to reach their finest development in Ireland which is probably the global headquarters of this type of bog.
3. Peat is 94% water and the hydrology of a bog is therefore of over-riding importance. The structure of the bog, its surface features, vegetation and fauna are dictated by the water regime. Any activity affecting the hydrology will consequently have a profound impact on the bog.
4. In the course of their development bogs trap dust, pollen and artifacts falling onto their surfaces and so provide a unique and irreplaceable archive of the past including the climate, vegetation, land use and other human activities.
5. Raised bogs are typically tree-less and are characterized by a distinctive vegetation dominated by *Sphagnum* mosses, sedges and dwarf shrubs, all of which are adapted to waterlogged, acidic and exposed conditions. *Sphagna*, which have unique properties, are the principal component of peat, and are largely responsible for the typical surface features of hummocks, hollows and pools.

* This implied the Wildlife Service which is currently attached to the Office of Public Works, Department of Finance.

6. The wettest bogs, which have extensive pool systems have the greatest variety of plant and animal life, and some are of ornithological importance, principally as feeding sites for Greenland white-fronted geese. A few of these wet bogs have 'soak systems' where more nutrient-rich water reaches the bog surface. Preliminary research indicates that these areas are of particular importance for invertebrates.
7. The extremely nutrient poor environment is unfavourable to animal life and the fauna is characterised by relatively simple, but unique, communities and small numbers of species. Many animals spend at least part of their time in other habitats, although a few species of birds are closely tied to the bogland habitat. The aquatic invertebrate fauna is representative of extremely nutrient poor conditions.
8. Harvesting of peat is the principal use of the bogs. Combined with drainage and burning it has a major deleterious impact primarily through the disruption of the hydrology, leading to the dessication of the bog and loss of the characteristic fauna, flora and surface features.

PART 2: DETAILS OF THE SYSTEMATIC SURVEY

The principal findings of the survey are:

1. No completely intact raised bog remains.
2. 141 sites, covering 23,000ha have 'intact' surfaces of scientific interest. This represents 7.4% of the original area of raised bogs of 310,000ha, but only 53 sites covering 12,000ha (3.8%) have extensive wet areas of high scientific interest.
3. 'Intact' bogs are now concentrated in the centre of their original area of distribution i.e. Roscommon, east Galway, Offaly and North Tipperary. Several counties no longer possess unexploited bogs. In Northern Ireland only a few very small areas of intact bog remain.
4. All the very large sites, some of which covered several thousand hectares, have been exploited and most of the remaining 'intact' bogs are under 200ha in extent.
5. 93% of the loss is due to peat extraction and associated drainage: 67–70% as a result of hand cutting and 24% as a result of Bord na Móna's activities. Arterial drainage and afforestation have damaged some sites and fire has affected all to a greater or lesser extent.
6. There has been a 64% decline in the area of 'intact' bog in the period 1974–1987. At this rate of decline, of about 3,500ha per year, all unprotected bogs of the True Midland sub-type having a conservation interest will have been seriously damaged by 1993, and those of the Western sub-type by 1994 at the latest.

PART 3: CONSERVATION: RATIONALE, REQUIREMENTS AND PROBLEMS

1. The case for conserving Ireland's raised bogs is presented. They are:—
   a) the finest examples of their type in Europe, and probably in the world;
   b) of national and international importance as part of the biosphere, in which they are inextricably linked to other ecosystems;
   c) a unique repository of information of past climates, vegetation and human activity;
   d) a valuable genetic resource of potential use to humanity;
   e) valuable outdoor laboratories in which plants, animals and natural processes in an extremely inhospitable environment can be studied;
   f) a unique feature of the Irish landscape of considerable touristic value.
2. From an analysis of the land area conserved or planned for conservation in other countries it is concluded that a *minimum* area of 10,000ha of the highest quality raised bogs should be conserved in Ireland. This represents 3.2% of the original area of Irish raised bogs. In addition a certain amount of peripheral land is also required to ensure hydrological integrity.

3. At present only 763ha on three bogs are protected as nature reserves, but none are fully protected as the reserves do not include peripheral land. The conservation interest of all other sites must be considered as being under threat of destruction.
4. The method of site selection is discussed and a list of the 26 bogs of the highest scientific importance is recommended for conservation as nature reserves.
5. The principal difficulties regarding acquisition are
   a) Multiple land ownership often involving State and semi-state organisations and private individuals;
   b) Intense pressure from developers;
   c) Lack of funding for conservation organisations compared with development agencies;
   d) Lack of man-power to deal with acquisition on the ground and the necessary administrative and legal processes.

PART 4: CONCLUSIONS AND RECOMMENDATIONS

This section is located on pages 69–73.

INTRODUCTION

Peatlands, or mires, are an integral and characteristic part of the Irish landscape. More than 1.1m ha of the land surface of Ireland is under peat, a higher percentage (17%) than any other country in the world except Canada and Finland (Taylor 1983). To many people the vast, open expanses of the blanket bogs of Connemara and north-west Mayo are perhaps the most familiar aspect of our peatlands, if not from personal experience then from tourist brochures, paintings by artists such as Paul Henry, or films where the landscape is used as a backdrop to the action. The raised bogs of the midlands, which once covered nearly 5% of the land surface of Ireland, are less well known, although these too provide the setting for recent Irish films and literature (e.g. Laverty 1985). Where they are known it is probably as the remarkable landscape of Bord na Móna's open-cast mining which is so important to the economy of central Ireland.

These mires have played an important role in Irish history and society. While providing an important indigenous source of fuel they have been associated with hard work and poverty. They are difficult to traverse and have formed major barriers to communications. Although extensive areas of fen peats have provided productive agricultural soils bog peats are poor and unsuitable for agriculture. Many attempts were made in the past to exploit the resource commercially (van Eck *et al.* 1984) but all failed until the foundation of Bord na Móna in 1946. The success of this enterprise has revolutionized society in the midlands and tied it to the mechanical exploitation of the bogs on a vast scale. In recent years the private sector, which traditionally won peat by handcutting, has been aided by the State and in consequence many of the smaller and more fragmented deposits are now also being mechanically exploited for commercial purposes.

The scientific importance of Ireland's peatlands has been recognised for many years (e.g. Praeger 1934, Osvald 1949, Tansley 1953) but it is only within the last decade or so that a more general awareness of the intrinsic value of peatlands for their landscape, flora, fauna and wilderness qualities has developed (Viney 1987). This has resulted from an upsurge in tourism and general concern for environmental matters associated with an increasingly urbanized and sophisticated society. Even among scientists a general awareness of the conservation value of intact sites and their international significance is a relatively recent development (Barry 1976, Goodwillie 1980, Bellamy 1986).

The extent of exploitation is now such that, even where they have not been totally stripped of their vegetation, very few peatlands have escaped some modification through marginal cutting, burning, drainage and fragmentation. Unfortunately the idea of conservation rather than exploitation developed late in Ireland. The first steps were taken in response to European Conservation Year in 1970 following which a number of organisations set aside areas for conservation. These included Bord na Móna, An Taisce and the Forest and Wildlife Service and as a result several sites were subsequently designated as national nature reserves e.g. Raheenmore and Mongan Bogs, Co. Offaly, Pettigo Plateau, Co. Donegal. However, these sites are only a small fraction of the total area and were selected in something of a vacuum. It was only in the early part of this decade, with the increasing realization that our peatland resource was being rapidly depleted, that a systematic survey was begun and subsequently endorsed by an instruction from the Government.

The first survey of Irish peatlands was undertaken during the period 1810–1814 by the Bog Commissioners in order to assess their extent and value. This remained the standard reference for over 150 years. The first comprehensive survey which classified the peatlands into major ecological types (Figure 1) as well as indicating those areas which are man-modified, was undertaken in 1973/74 by An Foras Taluntais (Hammond 1979). That survey forms the principal basis for the present work, augmented with data from other sources e.g. Bord na Móna, Schouten (1984). The 1973/74 survey did not address the question of conservation, and the only attempt prior to the present survey to identify sites of conservation interest was that of An Foras Forbartha over the period 1968–74 (An Foras Forbartha 1980). Data from this survey were incomplete and are now largely outdated. However, it provided a valuable baseline for a subsequent review of both raised and blanket bogs, the purpose of which was to assess their current scientific and conservation status in Ireland (Ryan and Cross 1984). It was from this latter survey that the rapid rate of destruction of Irish bogs was first detected.

This report presents the results of the first part of the peatland survey being undertaken by the Wildlife Service. It looks at the extent, variety and quality of raised bogs in order to provide a firm foundation for the selection of potential nature reserves. It is divided into 4 parts: The first part looks at the ecology of raised bogs; the second examines in detail the results of the systematic county by county survey and the third part considers the conservation requirements. The fourth part provides recommendations for action to be taken to conserve raised bogs. Part 1 is of necessity technical in places but parts 2 to 4 are mostly non-technical and hopefully intelligible to the layman.

The survey was begun in 1983, and completed in 1987. It was undertaken principally by three contract employees, one of whom worked for four years, one for three years and one for two years. A high degree of continuity was obtained, therefore, which minimised observer-based variation, although inevitably some difficulties with site assessment were encountered during the first two years. Two extremely dry summers — 1983 and 1984 — followed by two exceptionally wet summers also presented problems in comparison of sites, but problems of 'standardization' were overcome to some extent by repeat visits to certain sites.

Nomenclature

Nomenclature used in the text is as follows:

Bryophytes: Corley and Hill (1984)
Lichens: Hawksworth *et al.* (1980)
Pteridophytes and Spermatophytes: Tutin *et al.* (1964–80)
Birds: Voous (1973, 1977)

PART 1

AN OUTLINE OF THE ECOLOGY OF RAISED BOGS

CHAPTER 1

DISTRIBUTION

Irish peatlands are largely of the ombrotrophic (rain-fed) type i.e. bogs. Minerotrophic (ground water-fed) peat, i.e. fens, today cover only c.100,000ha or 9% of the total area of peatland (Hammond 1979), although in the past they were probably much more extensive. Ombrotrophic mires are classified into two major groups — raised bogs and blanket bogs. The former are concentrated in the central lowlands with a few outliers to the north and south-west, while the latter occur on the lowlands adjacent to the west coast and on mountains throughout the country (Figure 1).

Raised bogs are distinguished from blanket bogs by the presence of *Andromeda polifolia** and *Vaccinium oxycoccus* and the absence of *Schoenus nigricans* and *Molinia caerulea* on the bog dome. Unlike blanket bogs the vegetation is dominated by *Sphagna* and the peat is poorly humified. They are sub-divided into two sub-types: the Western raised bogs and the True Midland raised bogs (Schouten 1984), the boundary between the two being taken as the 1000mm isohyet. The Western sub-type is typified by the presence of the moss *Campylopus atrovirens* and the liverwort *Pleurozia purpurea*, both character species of lowland blanket bog, and the abundance of *Carex panicea*. Western raised bogs also show a greater tendency to extend beyond their original basins, although this difference is rather subjective. Schouten (*op. cit.*) also recognises an Intermediate bog, with characteristics of both blanket and raised bog on the boundary between these two types. These divisions are, of course, somewhat artificial and in reality there is a continuum across the country from lowland blanket bog in the hyper-oceanic west to True Midland raised bog in the drier centre and east (Bellamy and Bellamy 1966, Schouten 1984).

Bellamy (1967, 1986) found the mean pH of raised bogs to be c.4.0 and an overwhelming dominance of chlorides, and to a lesser extent sulphates, in the ionic balance of the water. In contrast lowland blanket bogs were found to have a pH of c.4.5, a concentration of minerals almost double that of raised bogs (57ppm cf 29ppm) and sodium replacing sulphates as the second most important ion present in the water. Free bicarbonates are also present. These differences are a reflection of both increased oceanicity and rainfall, and the Western sub-type, which was largely overlooked by Bellamy, almost certainly shows intermediate characteristics, in terms of water chemistry, between lowland blanket bog and the True Midland sub-type of raised bogs.

The term 'western' as employed here is synonymous with the term 'transitional' used by Hammond (1979) and is preferred in order to avoid confusion with communities transitional between bog and fen.

GEOGRAPHICAL RANGE IN IRELAND

The distribution of raised bogs within Ireland is largely a function of topography and climate and is shown in detail in Figure 2 (back pocket). They occur principally on land below 130m and although they can develop in favourable locations at higher altitudes in such situations they usually form part of mountain blanket bog complexes. As such this type is outside the scope of this report. The main concentration is in the central plain where they extend from c.30km west of Dublin almost to Galway city. They are most extensive and abundant where the limestone

* For nomenclature see page xiv.

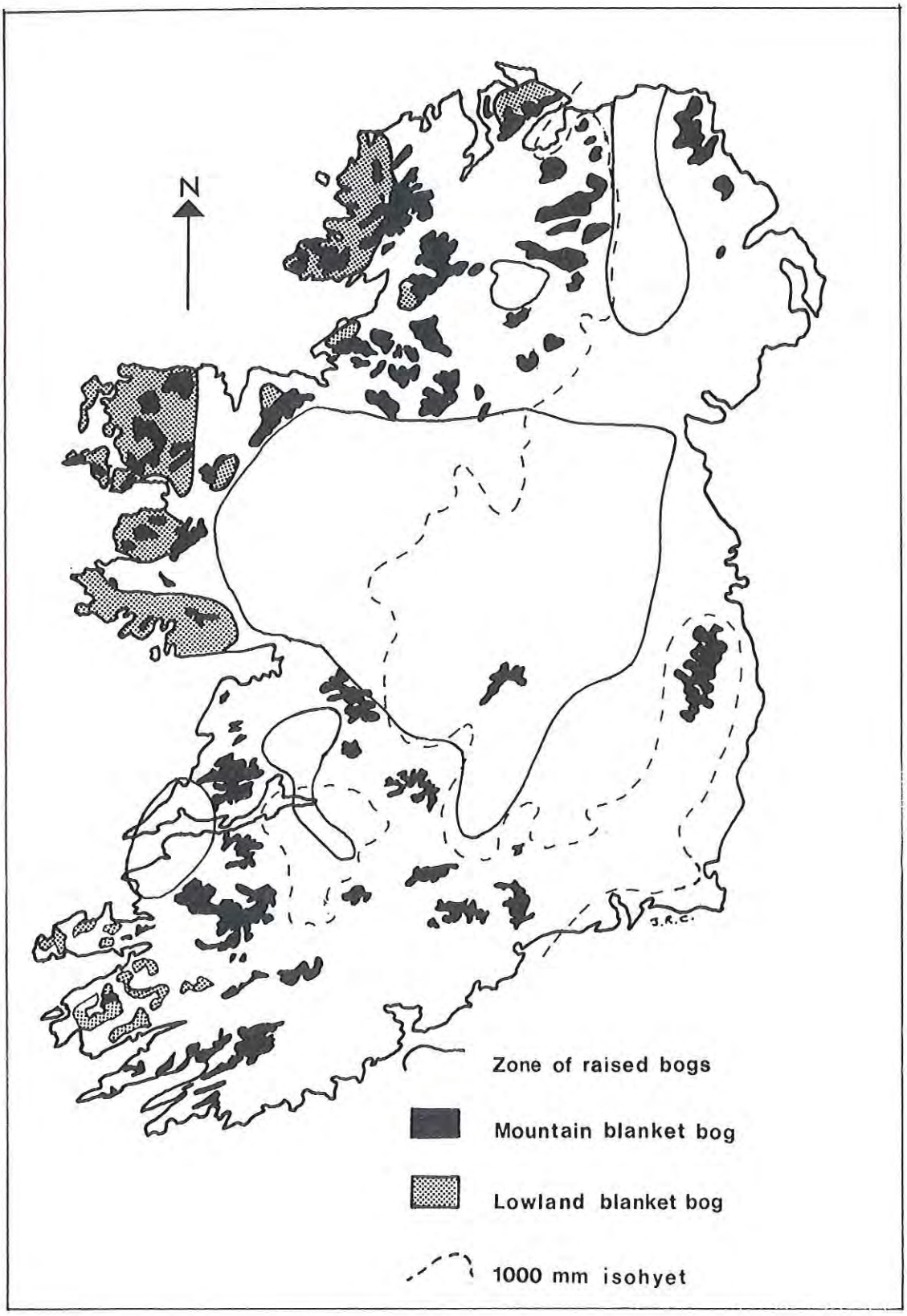

FIGURE 1: The distribution of the principal types of oligotrophic mires in Ireland. The 1000mm isohyet represents the boundary between the True Midland and Western sub-types of raised bogs.

plain is covered by a variable thickness of undulating glacial drift which originally provided suitable basins for the development of lakes which, in turn, acted as precursors to the bogs. The eastern boundary was probably originally less clearly defined than it appears on the map today, as many of the smaller bogs have since been cut away entirely. Nevertheless the deep and relatively even boulder clay deposits of counties Dublin, Louth and Meath were in general always less suitable terrain for bog initiation. Goodwillie (1980) and Bellamy (1986) suggest that some of these extreme eastern bogs may be remnants of concentric domed mires. However, all these eastern bogs have now gone and all remaining bogs are considered to be of the oceanic or ridge-raised type (Bellamy 1986, Moore and Bellamy 1974). In the west, except for one site on the east shore of L. Corrib, the boundary of the raised bogs is associated with the band of much thinner drift in south Galway and Mayo, where the limestone is close to the surface. This also explains the gap running north-south in eastern Roscommon.

The northern boundary is demarcated by higher ground. In Cavan and Leitrim the bogs become attenuated in the drumlin swarms and it is only in Sligo and eastern Mayo that they approach the Atlantic coast and the blanket peats. Unfortunately extensive cutting in the past has largely destroyed the transition zone between raised and blanket bogs. High ground also forms the southern boundary but a corridor of bogs extends south between the hills from Roscrea/Portlaoise to near Killenaule, Co. Tipperary. Again bogs may have extended further south and east but have now all been completely cut away.

Outliers occur in east Clare and North Limerick, on either side of the mouth of the Shannon and in the vicinity of Omagh, Co. Tyrone, while an extensive group of bogs occur in the Lough Neagh/Bann valley region of Northern Ireland.

Geology

The solid rock underlying the bogs is mostly carboniferous limestone, except in parts of Clare and Kerry where there are carboniferous shales and sandstones, and in the Bann Valley where it is basalt. The solid geology is overlain in most places by glacial drift comprising tills, clays, sands and gravels, also mostly calcareous. The nature of the underlying material is important where there may be an upwelling of water through the peat, and also where arterial drainage has penetrated into the underlying mineral material, but otherwise it has little direct influence on the present character of the bogs. From a landscape point of view the stark contrast between the nutrient-poor, acidic environment of the bogs and the surrounding nutrient-rich mineral soils, which provide lush pasture, is striking.

Climate

The climate of Ireland is extremely oceanic with cool summers, mild winters and frequent but not heavy falls of rain. Table 1 gives data for 3 stations in the midlands, Birr, Claremorris and Mullingar, which characterize the climate of the raised bog zone. Climatic diagrams for Birr and Claremorris are given in Figure 3.

Rainfall is spread relatively evenly over the year but evapotranspiration shows a definite yearly cycle with a maximum in summer. Consequently in average or dry years a soil moisture deficit develops for a short period in summer, this being more common in the drier eastern part of the midlands than the western part (Table 1b, Figure 3).

Hammond (1984) has classified organic soils (i.e. peats) into three climatic zones based on the annual difference between rainfall and evapotranspiration as follows:

Pluvic: Rainfall > Evapotranspiration by 700mm/yr
Humid: Rainfall > Evapotranspiration by 700–250mm/yr
Sub-humid: Rainfall > Evapotranspiration by 250mm/yr or less

These zones are shown in Figure 4 from which it can be seen that the raised bogs fit neatly into the humid zone, with the exception of those outliers in West Clare and North Kerry which lie in the pluvic zone. It is of interest to note the absence of bogs from the sub-humid zone but it is within this zone that the concentric domed mires would have occurred (Bellamy 1986).

The True Midland sub-type occurs where rainfall is less than 1000mm and falls of 0.2mm occur on less than 225 days a year (Figure 5). The Western sub-type occurs

TABLE 1a: Climatological data for Birr, Claremorris and Mullingar. RD—rain days (precipitation 0.2mm or more); R—rainfall (mm); ET—Estimated potential evapotranspiration (mm); RS—rainfall surplus (mm) over evapotransporation; T—temperature (°C). Data from Rohan (1986) and Meteorological Office (pers. comm.) for the period 1951–80, except for ET which is for the period 1958–82.

	RD	R	ET	RS	Temperature				
					Max.	Min.	Mean	Mean Max. Warmest	Mean Min. Coldest
Birr (70m O.D.)	207	816	454	362	13.0	5.6	9.3	18.8	1.3
Claremorris (69m O.D.)	234	1113	415	698	12.6	5.3	9.0	18.1	1.0
Mullingar (101m O.D.)	218	922	455	467	12.3	5.2	8.8	18.3	0.6

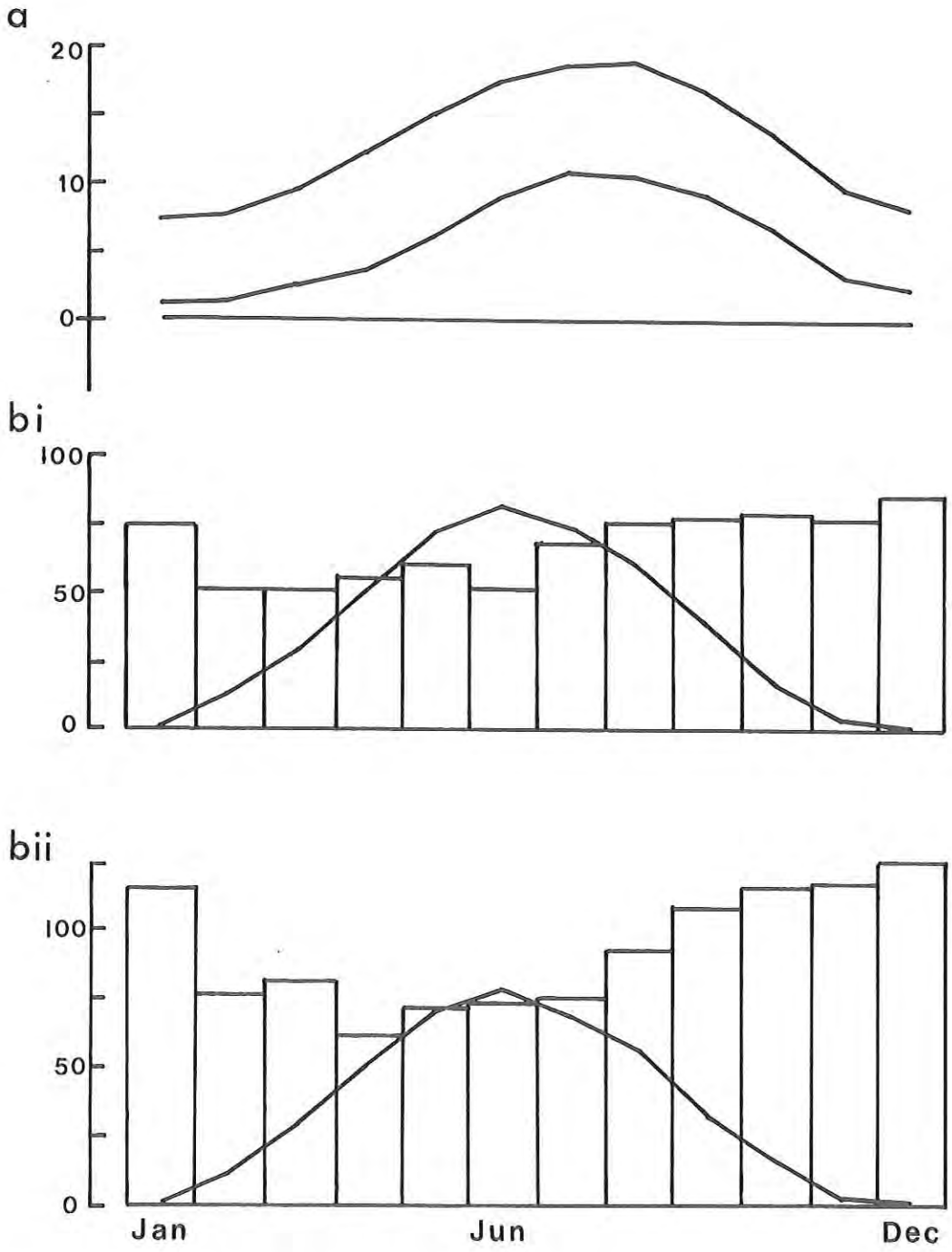

FIGURE 3: Climatic diagrams for the raised bog zone
(a) Mean maximum and minimum temperature (°C) curves for Birr, Co. Offaly.
(b) Rainfall (mm) and potential evapotranspiration (mm) for (i) Birr, Co. Offaly, (ii) Claremorris, Co. Mayo.

TABLE 1b: Monthly means of rainfall (mm) and estimated potential evapotranspiration (mm) for the above stations. Months when evapotranspiration exceeds rainfall underlined. Data from Rohan (1986).

	J	F	M	A	M	J	J	A	S	O	N	D
Birr												
R	76	52	53	55	62	52	68	76	79	80	77	86
ET	2	14	30	52	74	83	75	62	40	17	4	1
Claremorris												
R	116	77	81	62	72	74	75	93	107	115	117	124
ET	2	13	29	50	70	77	67	56	33	15	2	1
Mullingar												
R	91	60	62	59	67	63	72	79	90	90	91	98
ET	1	13	31	54	74	84	77	63	39	16	2	1

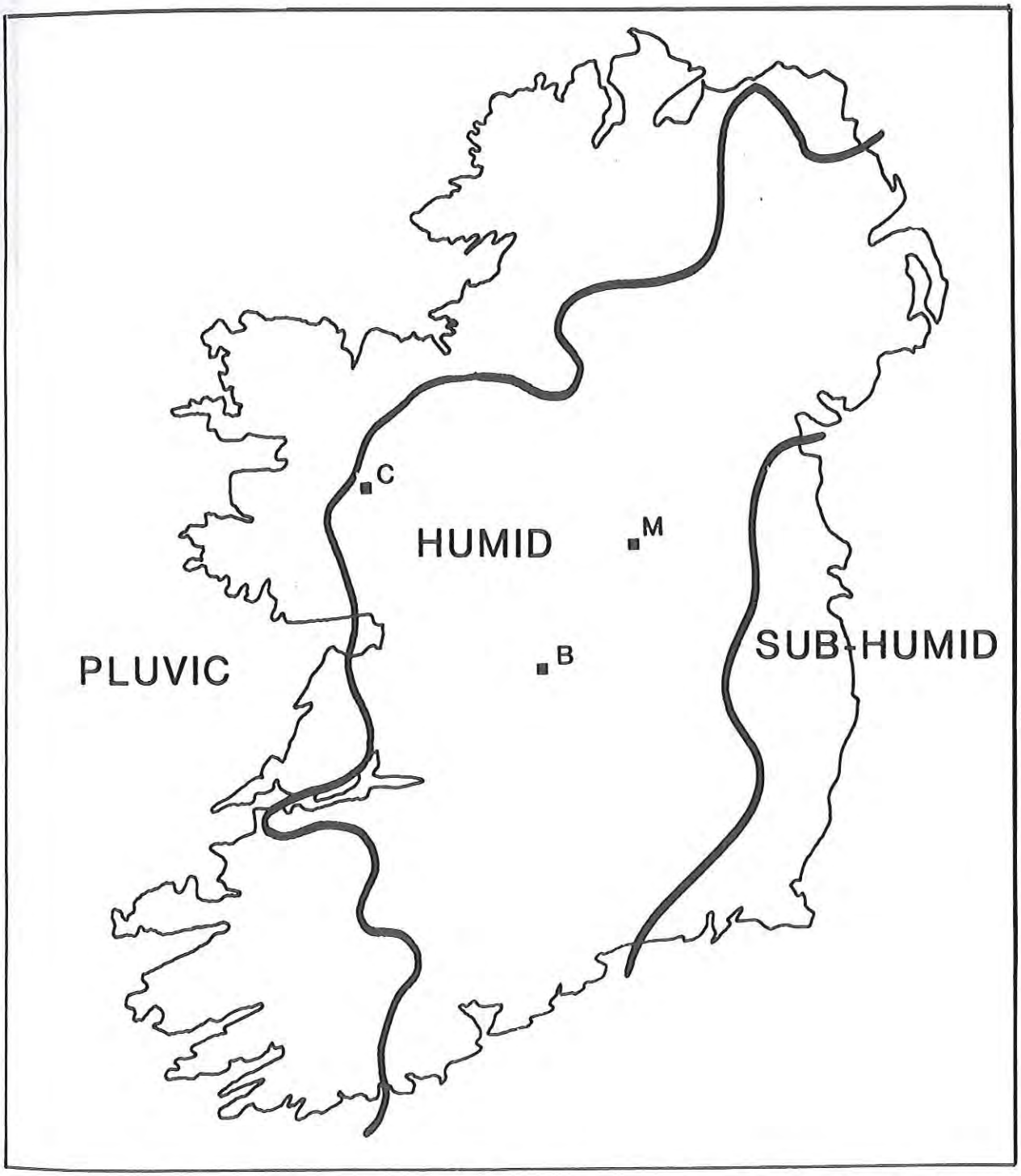

FIGURE 4: The distribution of organic soil classes based on the annual differences between rainfall and evapotranspiration. (Based on a map by Hammond 1984).
B = Birr C = Claremorris M = Mullingar

where rainfall is between 1000mm and 1200mm and occurs on 225–250 days a year. Lindsay *et al.* (1988) argue that the number of raindays is a better index of ecological wetness than total rainfall but the 1000mm isohyet and the 225 day isopleth follow very similar paths through the midlands. The western boundary of raised bogs more closely follows the 1200mm isohyet than the 250 day isopleth, although there has been so much disturbance in this area that it is difficult to know exactly where the transition to blanket bog occurs. In Galway and Mayo the boundary also follows closely the boundary between the pluvic/humid zone of Hammond (1984) but in west Clare and Kerry the Western type lies well within the pluvic zone.

INTERNATIONAL DISTRIBUTION

Raised bogs occur across much of the land masses of the northern hemisphere in a band of about 15° centred on the latitude of Ireland (53°N) (Moore and Bellamy 1974). They are subdivided into several types but their classification and nomenclature is very complex and is still the subject of considerable debate. Irish raised bogs are assigned to the ridge-raised mires or oceanic-raised mires (Moore & Bellamy 1974, Goodwillie 1980). The latter author shows them as being restricted to Ireland, central and eastern Scotland, Wales and western England, a small area of the Netherlands, Western Germany and Denmark bordering the North Sea and also the coastal fringe of Norway (Figure 6).

In Britain raised bogs were never as extensive as in Ireland and were localized in coastal lowlands and broad river valleys, mostly at low altitudes (Ratcliffe 1977). Lindsay (pers. comm.) believes that the oceanic type is much more restricted than is shown by Goodwillie (1980) being confined mostly to the lowlands of southern, central and north-eastern Scotland and parts of Cumbria. Very few raised bogs survive in Britain, most having been drained, afforested, exploited for peat or converted to agricultural land. Several of the better remaining examples are now nature reserves, but all of these are damaged to some extent.

All the raised bogs bordering the continental shores of the North Sea have been severely damaged and very few remain intact in this region. For example, in the Netherlands bogs formerly covered about 260,000ha but only 4% of this remains, most of it in a highly fragmented and disturbed state (Anon 1987). Enormously expensive steps are now being taken to restore some of these sites: restoration of the Bargerveen Reserve, for example, is estimated to cost IR£11m.

Norwegian mires show a great variety of forms (Moen 1985). The type with the closest affinity to Irish raised bogs is the Atlantic type (*sensu* Moen) which is more or less confined to the coastal lowlands in the south (Moen, pers. comm.). However, as might be expected for a continental site, the flora is considerably richer than on the Irish bogs and includes numerous boreal species absent from Ireland. The west coast of Norway also has a higher rainfall and cooler winter than is associated with Ireland's raised bog zone.

Whatever the precise classification of Ireland's raised bogs they represent an extreme oceanic variant of the ecosystem. Goodwillie (1980) stated that 'raised bogs of the oceanic type reach their finest development in Ireland . . . .' Certainly they are now very rare outside Ireland, and, even allowing for the extensive exploitation that has occurred, it might reasonably be argued that they represent some of the finest, if not the finest, examples of their type in the world. In this respect they parallel the importance of the blanket bogs for which Britain and Ireland are considered as the global 'type' regions (Lindsay *et al.* 1988).

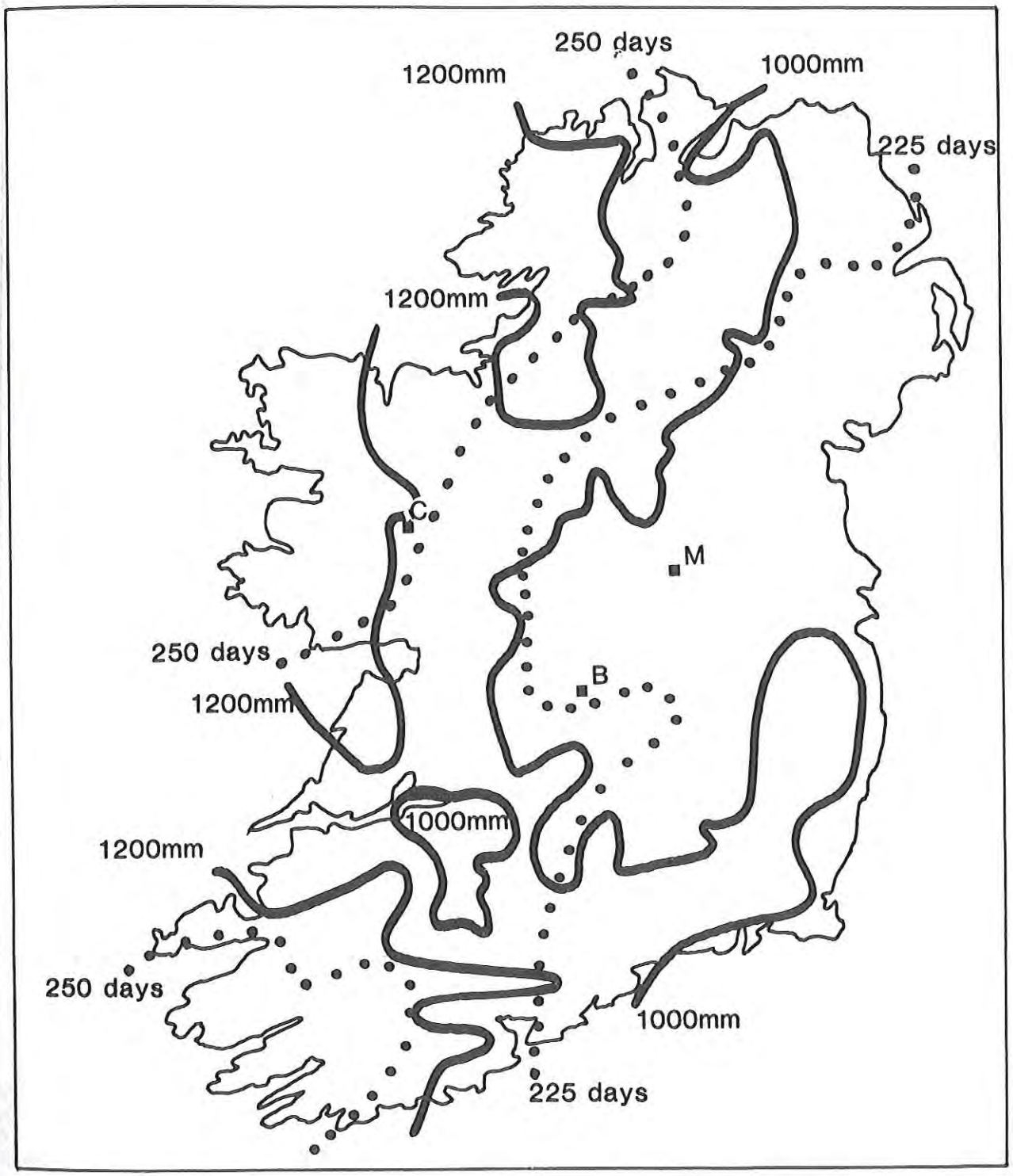

FIGURE 5: Isopleths for annual average number of rain days (dotted lines) and isohyets for annual average rainfall (continuous lines) relevant to the development of raised bogs. A rain-day is a period of 24 hours during which 0.2mm or more of precipitation is recorded.
B = Birr C = Claremorris M = Mullingar

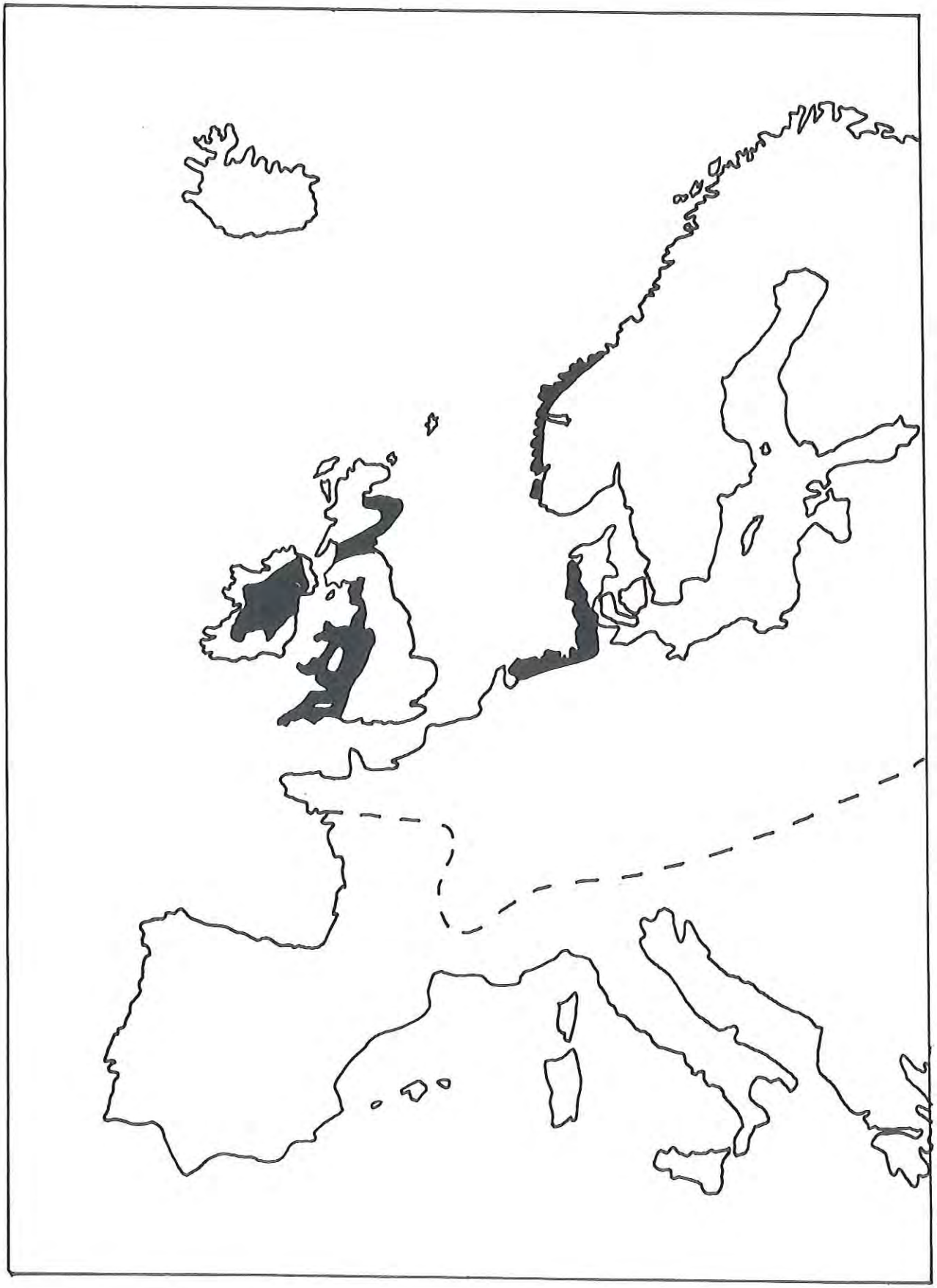

FIGURE 6: The distribution of ridge-raised bogs in Western Europe. The broken line indicates the approximate southern limit of non-minerotrophic mires. (Based on an original map of Goodwillie, 1980).

CHAPTER 2

THE CHARACTER AND DEVELOPMENT OF RAISED BOGS

Raised bogs are domed shaped masses of peat occupying former lakes or shallow depressions in the land surface. Compared with blanket bogs they are relatively discrete entities in the landscape, being circumscribed by low ridges and hills or river valleys. However, as Bellamy (1967) notes they "...are not all separate entities, dotted over the midland plain but often they form great complexes separated only by adventitious eskers and stream courses ...". They are characterized by low-growing, open vegetation dominated by mosses (principally *Sphagna*), sedges and dwarf shrubs mostly of the Ericaceae (heather) family. These plants which are predominantly red-brown in colour for much of the year contrast strikingly with the surrounding agricultural land and have given rise to the name of 'red bogs'. Trees are rarely present on their surfaces so that even a relatively small bog can provide a sense of space and wilderness normally associated with blanket bogs.

The general process of raised bog formation is well documented (e.g. van Eck *et al.* 1984, Bellamy 1986, Mitchell 1986) although the details are still a matter of debate. They began to develop in Ireland c.8000 years ago in depressions occupied by shallow lakes in which anaerobic conditions occurred. Dead vegetation fails to decay completely in such situations and accumulates as peat. Eventually the lakes become completely filled with peat and the open water is replaced by species-rich plant communities washed by ground water rich in minerals. This is known as a fen.

At this stage if conditions are suitable the surface of the fen may be colonized by certain species of *Sphagna* which are less nutrient demanding and are able to survive solely on rain water i.e. they are ombrotrophic. If the climate is wet enough these species will expand across the fen surface and peat will continue to accumulate above the influence of the ground water. Accumulation is greatest in the centre and least around the margins where decay is somewhat faster, leading to a dome-shaped mass of peat or raised bog. As the peat accumulates the water table rises with it, thus maintaining very wet conditions. These processes of development are illustrated in Figure 7. The height of the water table is dependent on rainfall rather than capillary action drawing water up from lower levels. The rate of water loss from the peat is so slow that in an undrained bog additional rain always recharges the water table before it falls more than a few cm.

The extent to which raised bogs continue to expand is dictated by a combination of climate and local topography. Over much of Ireland the climatic regime is such that the bogs are able to grow beyond the confines of their original basins to coalesce into complexes which bury the intervening low ridges of mineral soil. These are known as ridge-raised bogs (Moore and Bellamy 1974, Bellamy 1986) and are the principal type occurring in Ireland.

Raised bogs may be as much as 15m deep and have well defined strata of different peat types overlying the mineral soils which consist of sands, loams, clays and marl (Carey and Hammond 1970). The peat becomes more humified, darker and denser with depth, while the surface peats of an actively growing bog are light in colour, fibrous and permeable. Remains of trees are found at the interface between fen peat and bog peat, representing a relatively brief period of fen woodland, and an additional layer of tree remains is often encountered within the bog peat itself representing periods when the bog surface dried out (McNally & Doyle 1984). Details of peat soils and bog structure are given in Hammond (1979).

The principal features of an idealized bog are shown in Figure 8. The bog is surrounded by a narrow channel or lagg which receives run-off from the bog as well

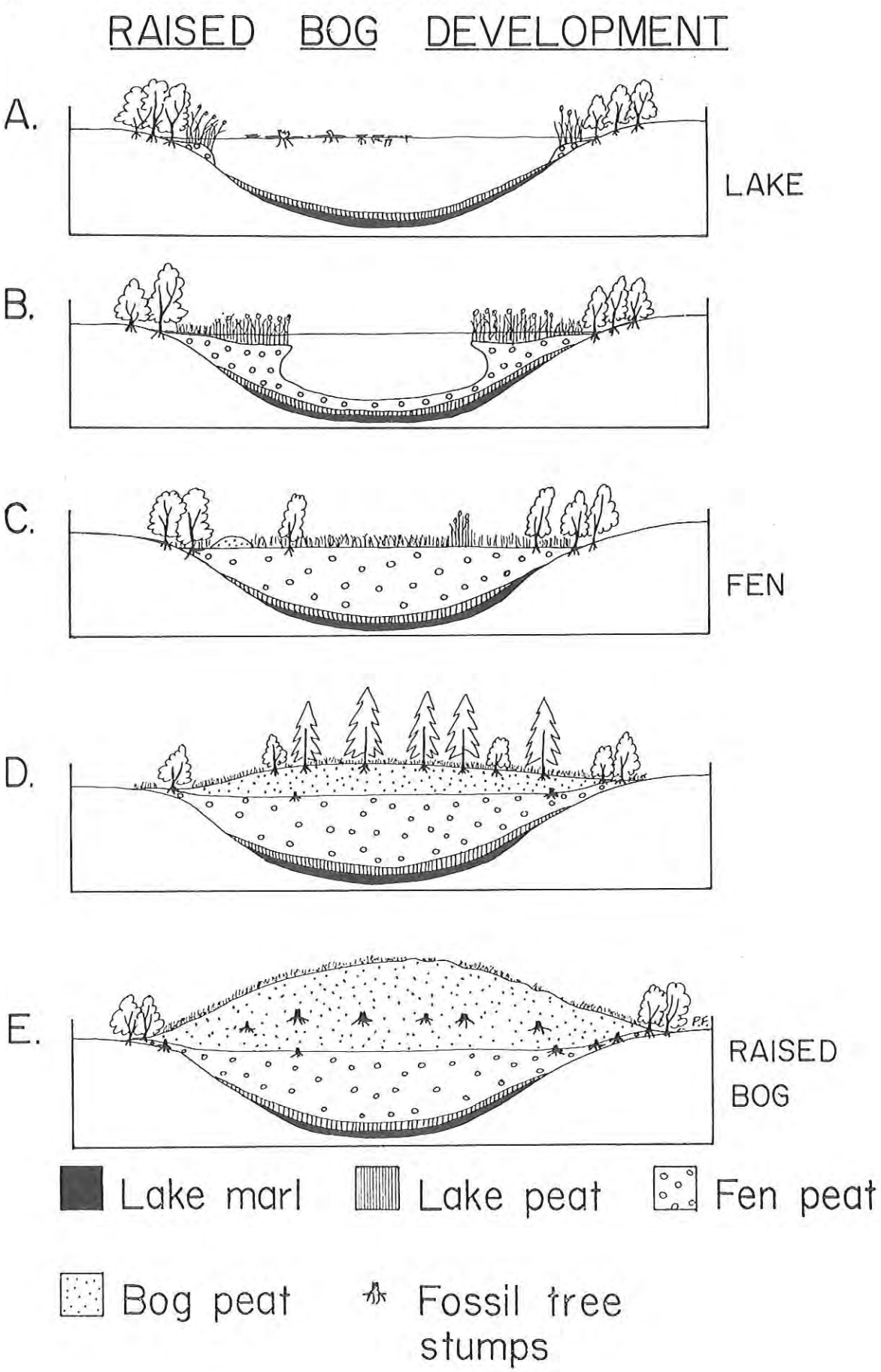

FIGURE 7: The developmental stages from a lake to a raised bog. 'A' represents a lake with an open body of water and marginal reedbeds. The lake has thin layers of marl and lake peat. 'B' represents a lake which is being infilled with reed or fen peat. 'C' is the fen stage. 'D' is the raised bog woodland phase and 'E' is a profile through a present raised bog showing a pine stump layer buried in acid peat. (Reproduced by permission of P. Foss).

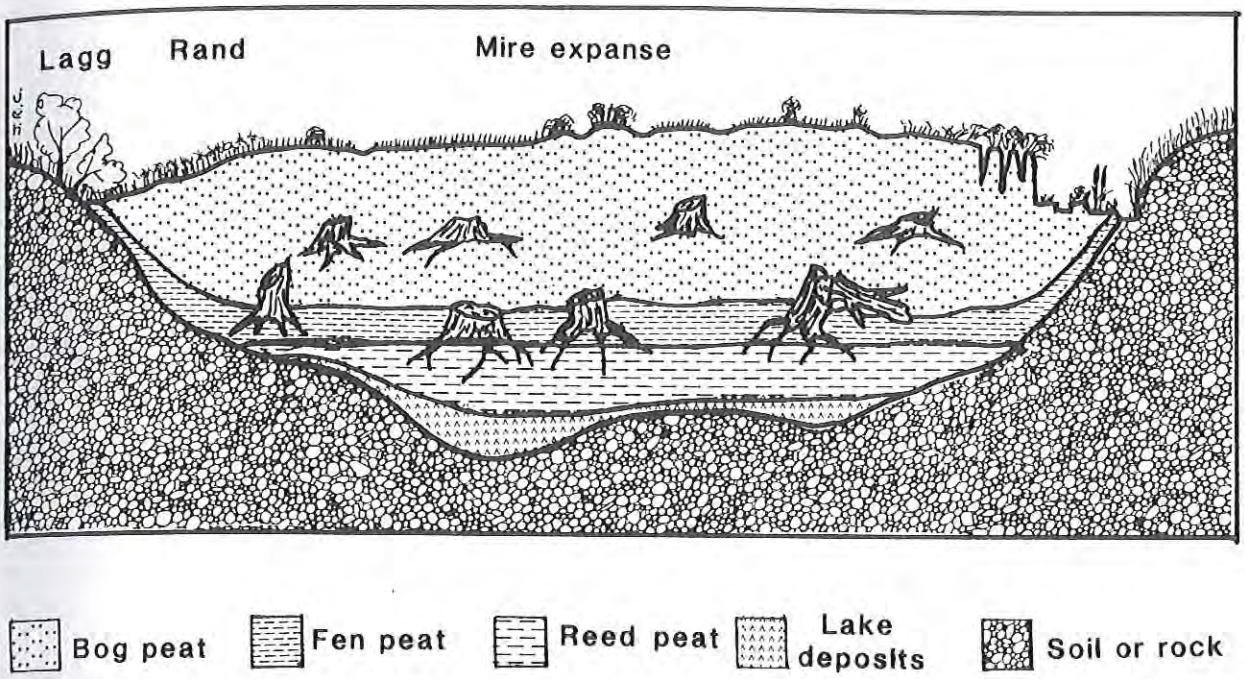

FIGURE 8: Cross section through a raised bog showing principal features. Cutting has destroyed the lagg and damaged the rand on the right hand side which has dried out leading to the formation of deep cracks.

as the surrounding mineral soil and is marked by a narrow band of fen. The marginal slope, or rand, is relatively steep and dry, but the mire expanse, or area contained within the rand, has only a very gentle gradient and the water table is close to, or at, the surface. (For terminology see Gore 1983).

The surface features of a raised bog are not as uniform as they may appear to be at first sight and in fact show considerable, if often rather subtle, variations. Typically the surface is a mosaic of hummocks and hollows formed by the differential growth of *Sphagna*. On the wetter parts some of the hollows form small pools of shallow water which may consist entirely of open water or may be wholly or partly colonized by aquatic plants. These and other surface features are discussed in more detail in Chapter 4.

The nature of peat

Peat has many remarkable properties which distinguish it from mineral soils. Its most important attribute is that it is an organic soil and its character and properties are products of biological processes. *Sphagna* are the principal components of raised bog peat and their ability to absorb water, more than 10 times their own dry weight, is one of over-riding importance in determining the characteristics of peat and in turn the bog itself. Peat is approximately 94% water, i.e. it contains fewer solids than milk, but much of this water is either intracellular or tightly bound intra-particular water and relatively small amounts are mobile, interstitial water (Lindsay *et al.* 1988). The physical stability and strength of peat is imparted by its fibrous nature and the very high cation exchange ability (Hobbs 1986, cited in Lindsay *et al., op. cit.*). These properties of peat have an important role to play in the hydrology of bogs.

As well as their water absorbtive properties *Sphagna* create an extremely acidic environment (Clymo and Hayward 1982). The combination of acidity and waterlogging ensures minimal decomposition thus promoting the development of the bog. These qualities also ensure that any matter falling onto, or placed within, a bog will be preserved. This applies not only to artifacts (e.g. gold ornaments) and animal remains (e.g. giant elk) but also to atmospheric borne particles such as dust and pollen. This material, trapped and preserved in the bog, acts as a record of past environments. Unlike fossils however, which are mineralized 'copies' of the original item, the actual material itself is preserved within the peat. It is from this archive that the history of the vegetation, climate and man's activities in Ireland over the past 8000 years has been unravelled (see for example Mitchell 1986).

CHAPTER 3

HYDROLOGY

The hydrology of mires in general and bogs in particular is extremely complex and it is not the intention to discuss the subject in detail here. However, it is so fundamental to their ecology and to an understanding of the impact of developments and management of sites that a brief examination of the salient features of their hydrology is required (Ingram & Bragg 1984). The subject is examined in detail by Ivanov (1981) and Ingram (1983), although it should be emphasized that mire hydrology is still far from being fully understood.

The process of raised bog formation described in Chapter 2, in which a dome-shaped body rises above the influence of ground water, and which then becomes dependent solely on atmospheric precipitation, is known as terrestrialisation. Once formed, the bog is to some extent self-perpetuating because as it continues to expand horizontally and vertically it causes a deterioration of the drainage in the surrounding land. Through this process, known as paludification, raised bogs can continue to expand to form ridge-raised bogs, provided the climate is suitable. The extreme manifestation of this process of 'overflowing' the original basins is the blanket mires of the west, although here conditions are so wet that bog can form on the underlying base-poor soils without the preliminary fen phase.

An idealized raised bog will form a dome from which water drains radially into the marginal lagg. Such symmetry is rarely encountered (Raheenmore Bog, Co. Offaly closely approaches it) because the original basins were either irregular in outline, or because subsequent development or coalescence dictated by the topography has distorted and obscured the original shape.

HYDROLOGICAL STRUCTURE

As the peat accumulates the lower layers become completely anaerobic and waterlogged and only the very thin surface layers receive oxygen. The bog can therefore be considered as consisting of two layers, the 'core' or catotelm and the surface layer or acrotelm (Ivanov 1981, Ingram 1983). The catotelm is the body of colloidal, compressed peat which remains permanently waterlogged and gives the bog its overall shape. The acrotelm, which overlies this, is shallow, not more than c.50cm thick, includes the surface of live vegetation in which most of the biological activity occurs, and protects the catotelm. The characteristics of these two layers, summarized by Lindsay *et al.* (1988), are given below:—

Catotelm

— a constant or little changing water content;
— a very slow exchange of water with the subjacent mineral strata and the area surrounding it;
— very low hydraulic conductivity in comparison with the acrotelm (a difference of 3–5 orders of magnitude);
— no aerobic micro-organisms and a reduced quantity of other kinds in comparison with the acrotelm.

Acrotelm

— an intensive exchange of moisture with the atmosphere and the surrounding area;
— frequent fluctuations in the level of the water table and a changing content of moisture;

— high hydraulic conductivity and water yield and a rapid decline of these with depth;
— periodic access of air to interstitial spaces during periods of lowered water table;
— a relatively large quantity of aerobic bacteria and micro-organisms facilitating the rapid decomposition and transformation into peat of each year's dying vegetation;
— the presence of a living plant cover, which constitutes the top layer of the acrotelm, and which binds the whole surface together into a 'skin', preventing the water-saturated catotelm from starting to flow, even under heavy rains.

The depth of the water table in the acrotelm varies not only over time but spatially within the bog. It is deepest on the rand, which is consequently drier and better drained, and shallowest on the mire expanse, which is therefore wetter. It is here that the typical hummock and hollow complexes occur.

The acrotelm serves the very important function of protecting the catotelm which, if exposed and allowed to dry out, can be subsequently destroyed by oxidation. This protective role is partly a function of the remarkable properties of *Sphagna* which are the dominant plants on an intact bog surface. Among these properties are:

1. The structure of *Sphagnum*. This is such that they can absorb very large quantities of water — more than ten times their dry weight. However, as they lack a proper vascular system they cannot maintain continuity of a water supply between the surface and the water table at times of high evapotranspiration. Consequently, as the surface layer dries out it insulates the underlying peat against further desiccation.

2. As *Sphagna* dry out their surface colour becomes lighter. This increases the albedo of the mire surface, there is a greater reflection of short wave radiation and hence less energy is available for evapotranspiration.

Dwarf shrubs and herbs occurring on bogs are also adapted to minimize water loss.

The acrotelm also inhibits sheet flow by the nature of its structure. The permeability of the peat increases towards the surface so that during heavy rain water flows away increasingly rapidly through the peat as the water table rises. Consequently surface flow, which could erode the rootless *Sphagna*, fails to occur on an intact bog (Ingram and Bragg, 1984).

The pattern of pools which occurs within the acrotelm was at one time considered to be a product of instability, with the pools forming in response to stresses and tensions in the peat. It is now generally considered that the pools are in fact a product of stability of the water table and peat surface and that the vegetation pattern reflects this stability which is largely controlled by climate (Lindsay *et al.* 1985). Splitting or tearing of the bog surface may occur as a result of disturbance but in this case a different pattern of pools develops (Schouten 1984).

The catotelm always lies below the water table. It forms a ground water mound (Ingram and Bragg 1984) and thus maintains the overall shape of the bog. Permeability within the catotelm is several orders of magnitude lower than within the acrotelm. The peat is in colloidal form and consequently if exposed to the air alters irreversibly, principally due to the fact that once dried out it cannot re-absorb water.

The importance of the acrotelm and catotelm are discussed further in Chapter 6.

OTHER HYDROLOGICAL FEATURES

The Lagg

The lagg is the marginal drainage channel which circumscribes the bog and receives water draining off the bog. It also receives water from the adjacent mineral soil and hence is richer in nutrients thus enabling fen vegetation to persist. Where bogs coalesce the lagg becomes incorporated into an internal drainage system but often continues to be identifiable by the presence of poor fen communities. Vestiges of such features may be seen for example on Redwood Bog, Co. Tipperary.

Soaks and flushes

In bogs exceeding c.260ha (Moore 1955) internal drainage systems may develop, perhaps as a response to differential growth of the bog resulting in the formation of depressions or valleys. Surface water becomes concentrated here, initially as diffuse flushes or pools which then develop down the slope into definite streams. The increased flow probably elevates both oxygen and nutrient flux leading to the formation of linear, poor-fen communities. They may also be a response to artesian water upwelling through the peat bringing nutrients from the underlying mineral substrate. There appears to be a correlation between these flushed areas and adjacent ridges of high ground, usually eskers, but the precise relationship is as yet unclear.

Such features appear to have been common on the larger Irish bogs. Osvald (1949) called them soaks and described examples from near Edenderry, Portlaoise and Athlone on bogs which have all since been destroyed. Moore (1955) also described such a system on Pollagh Bog, Co. Offaly, just prior to its destruction. Remnants of these systems can still be found. Clara Bog, Co. Offaly, which possesses several, is the most famous, but they also occur on other sites e.g. Shanville, Co. Roscommon, Addergoole, Co. Galway.

Preliminary studies of these soaks and flushes indicate that the pH of the water is in general the same as, or only slightly higher, than that of the mire expanse, which averages 3.9 (Bellamy 1986). A small number of readings, taken in September from the soaks on Clara Bog (West) and All Saint's Bog, Co. Offaly, show a pH of between 3.9 and 4.3, although Reynolds (1985) recorded a pH of 5.8 to 6.0 in the eastern soak on Clara Bog during the winter. A flush on Lough Lurgeen Bog, Co. Galway, a Western sub-type, showed variations in pH in September from 4.1 to 5.6 with a pH of 4.3 in pools on the mire expanse.

Conductivity measurements show a similar pattern, with no major difference detectable at some sites, to slight, but significant differences at others. For example, on the mire expanse of All Saint's Bog, the mean conductivity recorded on a day in September was 121us, while in the flushed birch woodland it was 140us. (M. Proctor, pers. comm.).

These figures suggest that the vegetation differences are a reflection of either an increased nutrient budget, arising from an upwelling of ground water, or an increased waterflow through the peat increasing the availability of nutrients per unit time. Both processes may well be at work, for in the flush on Lough Lurgeen Bog the highest pH recorded at the head of the flush and the decrease down the slope indicates 'mopping up' of nutrients by the peat and vegetation.

Underground Streams

On some raised bogs underground streams occur. There may be little surface indication of their existence although not uncommonly their course can be traced by the presence of *Molinia caerulea*. Such streams are a result of 'pipe flow' (subterranean channels) along the peat/mineral soil interface. Eventually the overlying peat collapses forming swallow holes which gradually amalgamate so as to form a surface channel. These features are more common on blanket bogs than raised bogs.

Lakes

Some bogs are associated with small lakes. Usually these form part of the bog margin, and are separated from the bog by a narrow band of fen. A now unique situation exists on L. Lurgeen bog, Co. Galway, where the lake occurs centrally and wave action is eroding the bog on its eastern shore. The exact relationship between the lake and bog is not known, but there appear to be springs within the lake which may be too powerful to allow the lake to in-fill with vegetation. Lakes incorporated into bog complexes occurred elsewhere prior to large-scale peat mining e.g. Boora Lough, Co. Offaly.

CHAPTER 4

THE VEGETATION AND SURFACE FEATURES

It is somewhat surprising that until recently the only detailed description of the vegetation of Irish raised bogs was that of Osvald (1949) who elaborated on the more general account of Tansley (1953). A more recent, and highly detailed, study has been undertaken by Schouten (pers. comm.) but only part of the results are published (Schouten 1984). Van der Molen (1986) gives an extremely detailed account of the surface features and vegetation of four bogs. Moore (1968) in his classification of the bogs and wet heaths of Northern Europe classified Irish raised bogs into the extreme Atlantic race of the *Erico-Sphagenetum magellanici* association. White & Doyle (1982) refined this by assigning that association to the flats and low hummocks, and the vegetation of the water-logged hollows to the *Sphagno tenelli-Rhynchosporetum albae* association.

The vegetation of a typical raised bog which is still hydrologically intact is characterized by the dominance of several species of *Sphagna* and dwarf, ericoid shrubs. The most abundant species are *Sphagnum capillifolium,** *S. imbricatum* and *S. papillosum* which form hummocks or low ridges. *S. fuscum* and *Leucobryum glaucum* also form hummocks, although they are much less abundant than the other *Sphagna*. *Calluna vulgaris, Erica tetralix* and the sedge *Scirpus cespitosus* are the most abundant angiosperms and are most vigorous in the *Erico-Sphagnetum magellanici* association in which *Andromeda polifolia* and *Drosera rotundifolia* also occur with a high constancy but low cover value. If the bog has been unburnt for any length of time the lichens *Cladonia ciliata* and *C. portentosa* may be co-dominant with the *Sphagna*.

On the flats *Sphagnum magellanicum, S. subnitens* and *Narthecium ossifragum* are abundant, sometimes with *Vaccinium oxycoccus* and *Aulacomnium palustre*, although these last two species appear to prefer areas where there is slight flushing. The permanently water-logged hollows (the *Sphagnotenelli-Rhynchosporetum albae* association) are dominated by *S. cuspidatum* and *Rhynchospora alba*, with *Drosera anglica, Eriophorum angustifolium* and *Menyanthes trifoliata* commonly present.

This characterization of the bog surface into broad vegetation categories is something of an oversimplification, as is also the concept of simple hummocks and hollows, for they obscure the considerable variations which occur on the surface of a raised bog. The hummocks, for example, may vary in height from a few centimetres to a metre or more above the water table, while the hollows vary from moist depressions barely reaching the water table, to deep pools of open water. In between the two extremes occur more or less flat areas which may be just above or just below the water table.

The National Vegetation Classification of Britain (Rodwell 1987) has gone some way towards recognising this problem. Three communities and several sub-communities characterize raised bog vegetation. A major part of the vegetation is attributed to the *Erica tetralix — Sphagnum papillosum* community. Two sub-communities are recognised:

a) the *Sphagnum magellanicum — Andromeda polifolia* sub-community on the middle level of the bog i.e. between the hummocks and pools. This is dominated by *S. papillosum, S. magellanicum* and *S. capillifolium* with some *S. tenellum*

*For nomenclature see page xiv.

b) the *Empetrum nigrum* ssp. *nigrum* — *Cladonia* spp. sub-community of the larger hummocks and ridges which are dryer than a).

The pools are assigned principally to the *Sphagnum cuspidatum/S. recurvum* communities dominated by those two species with *Eriophorum angustifolium, Erica tetralix, Drosera rotundifolia* and *Rhynchospora alba*. Two sub-communities are recognised:

a) *R. alba* sub-community in which *S. cuspidatum* is dominant with *R. Alba, Andromeda polifolia, Eriophorum angustifolium* and *Erica tetralix.*

b) *Sphagnum recurvum* sub-community in which this species is dominant, *R. alba* is absent and *Vaccinium oxycoccus* is a preferential species.

Some pools in more oceanic sites fall into the *Sphagnum auriculatum* community in which *S. auriculatum* is dominant and *S. cuspidatum* is much less abundant. *Menyanthes trifoliata* and *Eriophorum angustifolium* are common components.

All these communities are recognisable on Irish raised bogs although there are differences in terms of the abundance of certain species.

Lindsay *et al.* (1985) have refined this classification still further and from an analyses of British mires, have distinguished 6 vegetation zones related to the main structural elements of the microtopography, using the water table as a base line. Their table is reproduced in Table 2 and the distribution of zones is shown in Figure 9. It is apparent from this that, allowing for the slight floristic differences and the fact that their sites are largely within blanket bog, similar zones can be recognized within Irish raised bogs.

Leach and Corbett (1987) have used the system of Lindsay *et al.* (*op. cit.*) to classify relevés from bogs in N. Ireland into 14 communities. In the absence of relevés such detail cannot be attempted for the survey described here, but almost all the 14 communities do occur on the raised bogs in the Republic. The information obtained in this survey, augmented with more detailed descriptions given elsewhere e.g. Tubridy (1984), van der Molen (1986), is used in an attempt to describe raised bog vegetation in terms of these zones. The corresponding communities described by Leach and Corbett (*op. cit.*) are indicated in the description of each zone given below.

A complete species list of plants recorded on the bogs is given in Table 3 with the species arranged in constancy classes. These cannot be compared with constancy classes based on relevés, as they incorporate all the bog communities, but nonetheless they serve as a useful indication of the general nature of the bog flora.

PRINCIPAL VEGETATION ZONES ON RAISED BOGS

Terrestrial Zones: (Table 2 and Figure 9)

Zone T3. Hummocks at least 20cm above the water table. Dominated by *Sphagnum imbricatum,* and occasionally *S. fuscum* and *Leucobryum glaucum. Calluna vulgaris, Eriophorum vaginatum, Empetrum nigrum* and sometimes *Vaccinium myrtillus* occur on the hummocks and *Hypnum jutlandicum* has a high degree of constancy as an 'understorey' beneath the shrubs. Taller hummocks may be capped with *Rhacomitrium lanuginosum* and they may be moribund and eroding. Small lichens e.g. *Cladonia coccifera* and the moss *Campylopus introflexus* often colonize the bare peat thus exposed. This zone includes several communities described by Leach and Corbett (*op. cit.*): *Empetrum nigrum* hummock/ridge, *Cladonia impexa* (*portentosa*) hummock/ridge and *Sphagnum fuscum/S. imbricatum* hummock.

This zone is best developed in association with zones A2 and A3 on the wetter bogs which are infrequently burnt, but scattered large hummocks may occur on drier bogs which have not been subject to repeated burning.

Zone T2. 10–20cm above the water table. Lower hummocks or 'plateaux' of the same *Sphagnum* species as in Zone T3 or more commonly *S. capillifolium* and *S.*

TABLE 2 Percentage abundance of species within 22 noda derived from 5 sites in Scotland and N. England. Both noda and species are ordered with respect to mean height above or below the average water table. Based on Lindsay *et al.* (1985).

(a) *Terrestrial noda.* (b)*Aquatic noda.*

Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Rhacomitrium lanuginosum	[87]			38		1	9		3													
Cladonia pyxidata	1			8																		
Dicranum scoparium		1																				
Rhytidiadelphus loreus		1																				
Plagiothecium undulatum		2																				
Hylocomnium splendens		1																				
Rhytidiadelphus squarrosus		3																				
Empetrum nigrum	4	19		[69]	7	13																
Aulacomnium palustre		4							1													
Dry bare peat	2	[41]	13	19	23	[65]	6		16		26											
Cladonia fimbriata				11																		
Hypnum cupressiforme		[26]		[32]	2	[28]	15					1										
Sphagnum inbricatum					[52]							1										
Cladonia arbuscula						[41]																
Molinia caerulea	19						[47]		6		7											
Arctostaphylos uva-ursi		[10]				5			1	3												
Cladonia portentosa	9	3			3	15	[63]		7													
Cladonia uncialis	3			3			6		2													
Calluna vulgaris	19	[88]	1		[31]	[65]	4		28	3	[34]	9										
Pleurozium schreberi		4							3													
Eriophorum vaginatum	13	14	[86]	19	15	1	27		18	24		8	9	13								
Sphagnum capillifolium	1	28		3	[38]	2	2		29	27		11	1	12								
Drosera rotundifolia		1			14	1		16	6	3		3	2									
Odontoschisma sphagni		1			5		1		4		[39]	1										
Erica tetralix	1	8	[33]		15	[26]	20		[33]	5	21	23		2								
Scirpus cespitosus	4				5	2	2	23	13			3										
Myrica gale									[2]													
Pleurozia purpurea					2				3			3										
Campylopus atrovirens									[1]													
Sphagnum fuscum									[1]													
Narthecium ossifragum		12		11	6	5			[31]	5	6	18	6	6		3	1					
Kurzia pauciflora							1		1		12											
Rhynchospora alba							1		[8]			1	3		8	1	1					
Betula nana									[1]			[1]										
Sphagnum subnitens								[78]	1			1										
Drosera anglica					3				4	1		4	3	4		1	1	1				
Sphagnum tenellum		2		1	6			4	14	1	[28]	16	4	19		4	3	1				
Sphagnum papillosum		3	[62]		3				18	[99]	6	28		[50]		3	9	6				
Andromeda polifolia			1					[26]				9					1					
Vaccinium oxycoccus											5					1						
Eriophorum angustifolium	7	8	9	19	19	[60]	3	16	22	23	[97]	27	8	11		17	19	24	9	16		
Sphagnum magellanicum			12					[38]	4		12	[58]	1	8		25	1					
Sphagnum pulchrum													[82]									
Sphagnum cuspidatum												15	3	[52]	20	[45]	[92]	[63]		34		
Sphagnum auriculatum														6	[33]	3	10	[29]	7	4		
Drosera intermedia													1									
Rhynchospora fusca									1						[16]							
Menyanthes trifoliata									2	3		1	2	6			2	12	1			
Wet bare peat (mud-bottom)												2	2		47	39	2	28	[98]	[68]	[99]	[99]
Utricularia vulgaris												1				1			3	1	6	
Open water														15	[70]	[60]	[40]	[99]	[99]	[84]	[99]	[99]
Carex limosa																			[60]			
Utricularia minor																			9			
Eleocharis multicaulis																1	2				[81]	

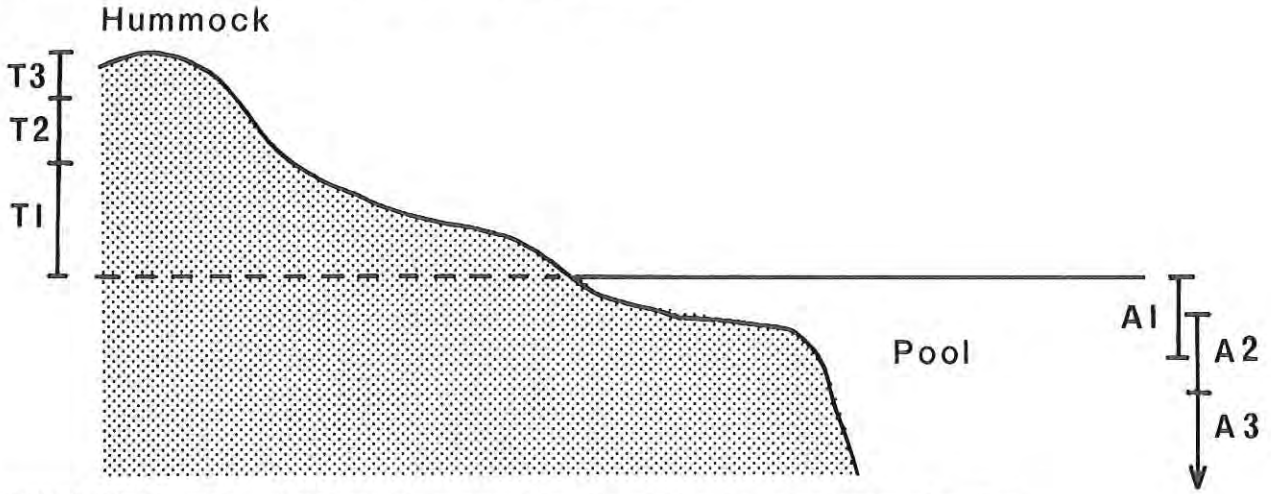

FIGURE 9: Zonation of vegetation communities in relation to microtopography. For explanation see text. (Based on a diagram by Lindsay *et al.* 1988).

papillosum with *Calluna* and *Erica tetralix. Andromeda polifolia, Scirpus cespitosus,* and *Vaccinium oxycoccus* are more abundant than in the British mires. *Cladonia ciliatus* and *C. portentosa* may be co-dominant with the *Sphagna* if the area has been unburnt for several years. This zone most closely resembles the *Erico-Sphagnetum magellanici* association described by Moore (1968). The *S. capillifolium/S. subnitens* and *S. papillosum* low hummock communities of Leach and Corbett (*op. cit.*) corresponds to this zone. It is the most typical and extensive community on most bogs and on drier sites is the principal vegetation type.

Zone T1. Lawns (Sjörs 1948) 0–10cm above the water table. Dominated by *S. papillosum, S. magellanicum* and sometimes *S. subnitens. S. tenellum* may be abundant especially after fire. *Drosera anglica, Eriophorum angustifolium, Narthecium ossifragum, Rhynchospora alba* and *Vaccinium oxycoccus* are common in this zone but *Calluna vulgaris* is less robust. On some bogs extensive tracts of *Narthecium*-dominated vegetation occur, accompanied by *E. angustifolium, Scirpus cespitosus* and *Carex panicea* but with little *Sphagna*, perhaps as a result of fire or slight flushing. *R. alba* may form almost mono-dominant swards. The *S. magellanicum* and *S. papillosum* communities of Leach and Corbett (*op. cit.*) would fall into this zone.

On wetter bogs extensive areas fall into this zone, but on drier bogs it is restricted to small and usually isolated patches.

Terrestrial/Aquatic boundary. A distinctive community, characterized by the abundance of *S. pulchrum* is described for the more westerly (British) mires by Lindsay *et al.* (1985). This is also a feature of a few Irish raised bogs, particularly west of the River Shannon, but the distribution of this species is very localized (Douglas 1987) and it is often absent from apparently suitable situations. Leach and Corbett (*op. cit.*) describe a similar community on a few sites in N. Ireland.

Aquatic Zones

Zone A1. 'Carpets' (Sjörs 1948). Lindsay *et al.* (1985) distinguish between 'lawns' which will bear the weight of an observer, and a 'carpet' which will not. This zone extends to 10cm below the water table. It is dominated by *S. cuspidatum. S. auriculatum* cited in Table 2 is relatively rare on Irish raised bogs. *Menyanthes trifoliata* is usually most abundant in this zone and *Rhyncospora alba* may be abundant also. *Utricularia minor* and *Cladopodiella fluitans* are also characteristic species. *S. recurvum* is common where there is slight flushing. The *S. cuspidatum* community of Leach and Corbett (*op. cit.*) would be accommodated in this zone.

The *Sphagno tenelli-Rhynchosporetum albae association* (White & Doyle 1982) would appear to accommodate both zones T1 and A1.

The distribution of Zone A1 is similar to that of Zone T1 but is absent from drier sites. On wet bogs it may form extensive zones around pools and in the vicinity of soaks.

TABLE 3: List of all plant species recorded on the bogs surveyed, arranged into constancy classes. V = 81–100%, IV = 61–80%, III = 41–60%, II = 21–40%, I = 1–19%

CONSTANCY V

Angiosperms, Gymnosperms & Pteridophytes	Musci	Hepatics	Lichens
Andromeda polifolia	*Aulacomnium palustre*	*Odontoschisma sphagni*	*Cladonia portentosa*
Calluna vulgaris	*Campylopus introflexus*		*C. uncialis ssp. biuncialis*
Carex panicea	*Dicranum scoparium*		
Drosera anglica	*Hypnum jutlandicum*		
D. rotundifolia	*Leucobryum glaucum*		
Erica tetralix	*Sphagnum capillifolium*		
Eriophorum angustifolium	*S. cuspidatum*		
	S. fuscum		
E. vaginatum	*S. imbricatum*		
Narthecium ossifragum	*S. magellanicum*		
Rhynchospora alba	*S. papillosum*		
Scirpus cespitosus	*S. subnitens*		
Vaccinium oxycoccus	*S. tenellum*		

CONSTANCY IV

Betula pubescens	*Pleurozium schreberi*	*Mylia anomala*	*Cladonia crispata* var. *cetrariiformis*
Menyanthes trifoliata	*Polytrichum alpestre*		*C. ciliata* var. *tenuis*
Molinia caerulea			*C. floerkeana*
Myrica gale			

CONSTANCY III

Juncus effusus		*Cephalozia connivens*	
Potentilla erecta		*Kurzia pauciflora*	
		Pleurozia purpurea	

CONSTANCY II

Anthoxanthum odoratum	*Campylopus atrovirens*	*Calypogeia fissa*	*Cladonia fimbriata*
Dryopteris dilatata	*C. paradoxus*	*C. muellerana*	
Empetrum nigrum	*Polytrichum commune*	*Cephalozia lunulifolia*	
Huperzia selago	*Rhytidiadelphus squarrosus*	*Cladopodiella fluitans*	
Phragmites australis	*Sphagnum auriculatum* var. *auriculatum*	*Lophozia ventricosa*	
Rhynchospora fusca	*S. palustre*		
Rubus fruticosus	*S. recurvum* var. *mucronatum*		
Succisa pratensis			
Vaccinium myrtillus			

CONSTANCY I

Agrostis canina	*Brachythecium rivulare*	*Aneura pinguis*	*Baeomyces rufus*
A. stolonifera	*Calliergon cuspidatum*	*Calypogeia sphagnicola*	*Cladonia arbuscula*
Angelica sylvestris	*C. stramineum*	*Cephalozia bicuspidata*	*C. cf. bellidiflora*
Athyrium filix-femina	*Campylopus pyriformis*	*C. loitlesbergeri*	*C. cervicornis ssp verticillata*
Betula pendula	*C. brevipilus*	*Cephaloziella elachista*	
Blechnum spicant	*Campylium stellatum*	*C. hampeana*	*C. chlorophaea*
Caltha palustris	*Ceratodon purpurea*	*C. rubella*	*C. coccifera*
Cardamine pratensis	*Eurhynchium praelongum*	*Diplophyllum albicans*	*C. digitata*
Carex binervis	*Funaria hygrometrica*	*Gymnocolea inflata*	*C. furcata*
C. demissa	*Hylocomium splendens*	*Lophocolea cuspidata*	*C. glauca*
C. echinata	*Isothecium myurum*	*Pellia epiphylla*	*C. gracilis*
C. lepidocarpa	*Leptobryum undulatum*	*Riccardia chamedryfolia*	*C. polydactyla*
C. limosa	*Pohlia nutans*	*R. latifrons*	*C. pyxidata*
C. nigra	*Polytrichum formosum*	*R. palmata*	*C. rangiferina*
C. paniculata	*P. juniperinum*	*Scapania gracilis*	*C. scabriuscula*
C. pulicaris	*Pseudoscleropodium purum*		*C. squamosa*
C. rostrata	*Rhacomitrium lanuginosum*		*C. sulphurina*
Cerastium fontanum	*Rhytidiadelphus loreus*		*Coelocaulon aculeatum*
Cirsium dissectum	*R. squarrosus*		*Cornicularia normoerica*
C. palustre	*Scorpidium scorpidiodes*		*Peltigera membranacea*
Cladium mariscus	*Sphagnum fimbriatum*		
Dactylorhiza incarnata	*S. pulchrum*		
Lychnis flos-cuculi	*S. recurvum* var. *tenue*		
Dryopteris carthusiana	*S. squarrosum*		
Equisetum fluviatile	*S. teres*		
Filipendula ulmaria	*Tetraplodon mniodes*		
Galium palustre	*Thuidium tamariscinum*		
Hedera helix			
Holcus lanatus			
Hydrocotyle vulgaris			
Hypericum pulchrum			
Ilex aquifolium			
Juncus articulatus			

CONSTANCY I—*continued*

J. bulbosus
J. squarrosus
Linum catharticum
Lonicera periclymenum
Luzula sp.
Lychnis flos-cuculi
Melampyrum pratense
Mentha aquatica
Nuphar lutea
Osmunda regalis
Pedicularis sylvatica
Pinguicula vulgaris
Pinus sylvestris
Plantago lanceolata
Platanthera bifolia
Polygala serpyllifolia
Potamogeton polygonifolius
Potentilla palustris
Prunella vulgaris
Pteridium aquilinum
Quercus petraea
Ranunculus acris
R. flammula
R. repens
Rhododendron ponticum
Rumex acetosa
R. acetosella
Salix atrocinerea
S. aurita
Sarracenia purpurea
Schoenus nigricans
Scirpus lacustris
Sorbus aucuparia
Triglochin palustris
Typha sp.
Ulex europaeus
Urtica dioica
Utricularia minor
Valeriana officinalis
Viola palustris

SINGLE OCCURRENCES

Agrostis capillaris
Bellis perennis
Carex binervis
C. curta
C. diandra
C. flacca
C. lasiocarpa
C. serotina
Centaurea nigra
Crepis paludosa
Deschampsia cespitosa
Digitalis purpurea
Eleocharis multicaulis
Epilobium angustifolium
E. palustre
Fraxinus excelsior
Geum rivale
Heracleum sphondylium
Hypochoeris radicata
Iris pseudacorus
Juncus bufonius
Lathyrus pratensis
Leontodon autumnalis
Luzula sylvatica
Lycopodium clavatum
Myosotis laxa
Pedicularis palustris
Pinguicula lusitanica
Poa trivialis
Potentilla anserina
Quercus robur
Rhinanthus minor
Senecio sp.
Trifolium pratense
Vaccinium vitis-idaea

Brachythecium rutabulum
Bryum pseudotriquetrum
Calliergon cordifolia
Campylopus schwarzii
Ctenidium molluscum
Dicranum bonjeanii
D. fuscescens
Hookeria lucens
Isopterigium elegans
Pogonatum urnigerum
Rhizomnium pseudopunctatum
R. punctatum
Sphagnum contortum

Cephalozia macrostachya
Cephaloziella subdentata
Chiloscyphus pallescens
Lophocolea bidentata
L. cuspidata
Lophozia incisa
Marchantia polymorpha
Metzgeria furcata
Riccardia multifida

Cladonia coniocraea
C. subulata
Icmadophila ericetorum

EPIPHYTIC SPECIES

Mostly recorded from Birch trees around soaks, but occasionally on *Calluna*.

Musci	Hepatics	Lichens
Homolothecium sericeum	*Frullania dilatata*	*Cladonia parasitica*
Hypnum mammillatum	*F. tamarisci*	*Evernia prunastri*
Ulota cripsa	*Lophocolea cuspidata*	*Hypogymnia physodes*
	Lophozia cf. ventricosa	*H. tubulosa*
	Lejeunia ulicina	*Lecanora chlarotera*
		Lecidella elaeochroma
		Lepraria incana
		Parmelia caperata
		P. glabratula
		P. perlata
		P. sulcata
		Peltigera horizontalis
		Pertusaria amara
		Physcia tenella
		Ramalina calicaris
		R. farinacea
		R. fastigiata
		R. fraxinea
		Usnea articulata
		U. fragilescens
		U. fulvoreagens
		U. hirta
		U. inflata
		U. subfloridana

Zone A2. Mud-bottom hollows (Sjörs 1948) 5–25cm below the water table. This is an impoverished extension of Zone A1 with much less *Sphagna* but in which *Carex limosa, Rhynchospora fusca* and *Utricularia minor* most commonly occur. The *Utricularia minor* and *Carex limosa* pools of Leach and Corbett (*op. cit.*) would occur in this zone.

This zone has a very restricted distribution, being confined to the wettest sites and occasionally where there has been a bog burst as a result of marginal cutting. It is most abundant on the Western sub-type.

Zone A3. Deep pools exceeding 25cm in depth, usually devoid of vegetation except for scattered stands of *Menyanthes trifoliata*. This zone is associated with Zone A2 but is even less common.

The relative proportion of these zones characterizes the surface of individual bogs. On many raised bogs the terrestrial zones predominate with the aquatic zones being relatively minor components. Arterial drainage, cutting and burning all interfere with the natural hydrological character of a bog so that regional variations in surface features tend to be obscured. Nonetheless aquatic zones, especially the A1 zone, tend to become more abundant and better developed as one moves westward and deep pools (A3) are rare in the True Midland raised bogs except as a result of apparent tearing. Carpets and pool systems are often associated with areas of quaking bog. Hummock formation is often more pronounced in association with pools, with the result that 'wet' bogs have a greater amplitude in surface features than the 'drier' examples. This is particularly well illustrated, for example, in Garriskil Bog, Co. Westmeath and L. Lurgeen Bog, Co. Galway. The better development of hummocks in the pool areas is probably due to a combination of increased aeration and a reduced incidence of burning. Even on wet bogs, however, fire can reduce the surface amplitude as is probably the case on Ardgraigue bog, Co. Galway, which is devoid of pools (A2 and A3 zones), but whose surface is dominated by *Sphagnum pulchrum*.

POOL SYSTEMS

Pools vary considerably in area and extent. They range from small hollows, which are only periodically submerged, to extensive, irregular, island-studded water bodies. Many are elongated and some show a tendency to be orientated along the contours.

Schouten (1984) has drawn attention to the presence of tear pools in raised bogs. Typically they occur in the wettest part of the bog with poorly humified peat, often forming a network at right angles to the slope. They are common on some bogs and are considered to be the result of marginal cutting or other disturbance causing 'splitting' of the surface peat, rather than a purely natural phenomenon. Lindsay *et al.* (1988) discuss this feature on a Scottish bog which had been subject to drainage and afforestation. Many of these pools gradually in-fill with carpets of *Sphagna*, but where they occur in drier peat they are more persistent, have steep sides and little vegetation apart from mats of algae and a little *Eriophorum angustifolium* and perhaps *Rhynchospora fusca* (O'Connell & Mooney 1983).

In extreme cases cutting can cause peat flows or bog bursts, the evidence for which can last for centuries. On Woodfield Bog, Co. Offaly, the result of a bog burst in 1821 can still be seen in the form of a shallow, very wet depression with linear pools in the centre of the bog (van der Molen 1986). On Curraghlehanagh Bog, Co. Galway, several small flows have occurred following marginal cutting resulting in the formation of localized patterns of arcuate pools.

Shallow pools which dry out periodically are usually characterized by the presence of algal mats and are devoid of other vegetation except for impoverished *Sphagnum cuspidatum*, and occasionally *Eriophorum angustifolium* and *Rhynchospora alba*. These pools occur most commonly around the perimeter of bogs, especially where the water table has been lowered (Tubridy 1984), but they also occur elsewhere on the bog surface, even mixed with permanent pools, suggesting that some mechanism other than a general lowering of the water table is involved.

In general pools and hollows show no obvious patterning although weak concentric arrangements can be detected in a few bogs. One of the best examples is Garriskil Bog, Co. Westmeath, but this may be due to arterial drainage of the adjacent River Inny. There is, however, a tendency for pools to be larger on the Western raised bogs, where they take on a character resembling blanket bog pools, with steep sides, mud bottoms and islands formed of large hummocks. In this respect the bogs conform fairly closely to the correlation between pool-pattern, wet days (1mm or more of rain per day) and temperature as illustrated by Lindsay *et al.* (1988) in which pool size and patterning increase north-westwards in Britain with increasing rainfall and decreasing temperature.

OTHER FEATURES OF RAISED BOGS

Flushed areas

Areas of nutrient enrichment occur on nearly all bogs, usually as a result of more concentrated horizontal water movement. They are particularly common near the bog margin and at the base of low mineral ridges and are characterized by the presence of *Molinia caerulea, Myrica gale* and often *Sphagnum recurvum*. Normally such areas are small and the peat is relatively firm.

Very localised nutrient enrichment occurs around large hummocks, which are used by hares, foxes or raptors, or isolated trees which are used as perching or feeding sites by raptors. Masing (1984) refers to these as 'hawk-trees'. They are usually marked by tufts of *Juncus effusus, Molinia caerulea* and sometimes small plants of *Rubus fruticosus*. The bryophyte flora also responds to the increased nutrients and drier conditions, with a decrease in *Sphagna* and the occurrence of species such as *Dicranum scoparium*. Very wet areas which are frequented by large numbers of waders will also be enriched by their faeces and this may account for the signs of slight flushing which are often associated with these wet areas.

Soaks are more extensive flushed areas usually characterized by small lakes, scragh (floating mats or schwingmoore), poor fen communities and scattered birch and pine. Lindsay (pers. comm.) suggests that they appear to be unique to Irish bogs. Osvald (1949) describes in detail a soak on a bog south-east of Edenderry, Co. Offaly and Moore (1955) gives a detailed description of the soak on Pollagh Bog, the only known site for *Scheuchzeria palustris*, in Ireland, and the only known site in the Republic for *Orthilia secunda*. (Both species are now extinct at that site, which has been destroyed by Bord na Móna.)

Soaks are characterized by a species-rich, well developed bryophyte community dominated by *Sphagna*, principally *S. palustre, S. recurvum* var. *mucronatum* and

occasionally *S. fimbriatum* and *S. squarrosum. Juncus bulbosus, J. effusus* and *Eriophorum angustifolium* are often present also. On the slightly drier margins *Aulacomnium palustre, Eriophorum vaginatum, Polytrichum commune, Pleurozium schreberi* and *Vaccinium oxycoccus* occur and sometimes *Empetrum nigrum* and *V. myrtillus*. Pools of open water or small lakes may also occur but it is more typical to find these infilled with a scragh of *Sphagna*, sedges and herbs such as *Hydrocotyle vulgaris, Lychnis flos-cuculi, Menyanthes trifoliata* and *Potentilla palustris*. Many soaks are marked by the presence of birch (*Betula pubescens*) and Scot's pine (*Pinus sylvestris*), usually as scattered individuals, but occasionally these tree species form small patches of woodland. The following description of wooded flushes or soaks is taken from Douglas and Grogan (1985):

'The canopy is dominated by *Betula pubescens* with an understory of *Salix* species and occasionally *Pinus sylvestris* and *Ilex aquifolium*. Beneath this the shrub layer typically includes *Myrica gale, Calluna vulgaris* and *Rubus fructicosus* agg. Often included in the herb layer are the ferns *Dryopteris dilitata* and *D. carthusiana* and sometimes *Osmunda regalis* and *Blechnum spicant*. A number of grass, sedge and rush species also occur e.g. *Agrostis canina, Holcus lanatus, Molinia caerulea, Eriophorum vaginatum* and *Luzula multiflora*. The bryophyte layer is generally in the form of a rich, deep, hummocky carpet and usually includes *Sphagnum palustre, S. recurvum* var. *mucronatum, S. squarrosum* and occasionally *S. fimbriatum*. The hummocks are often crowned by some of the following species: *Pleurozium schreberi, Polytrichum commune, P. alpestre, Hylocomium splendens, Dicranum scoparium* and *Thuidium tamariscinum. Vaccinium oxycoccus* and *Empetrum nigrum* may also be abundant. Occasionally *Peltigera* species also colonize the hummocks and in the wet hollows leafy liverworts such as *Lophozia* and *Riccardia* species often occur.

The rich epiphytic lichen flora festooning the trees is very characteristic and is dominated by species in the genus *Ramalina* and in the pollution-sensitive *Usnea* group though other species also occur'. A list of epiphytic lichens is given in Table 3.

The finest example of a wooded soak is to be found on All Saint's Bog, Co. Offaly which extends over an area of c.20 ha (Cross 1987a). Most of the poor fen species listed in constancy classes I and II (Table 3) occur in flushes or soaks, as do some of the woodland elements e.g. *Pteridium aquilinum*.

Streams and swallow holes

Where the horizontal flow of water becomes more concentrated definite stream channels occur. These are characterized by a narrow band of *Molinia caerulea*, with *Myrica gale*, ferns such as *Dryopteris dilatata, Osmunda regalis* and herbs such as *Angelica sylvestris, Succisa pratensis* and sometimes woody plants such as *Betula pubescens* and *Rubus fruticosus* . These streams may go underground and at such points, known as swallow holes, the vegetation described above is better developed, probably because it is rarely burnt. The underground course of the stream may be clearly marked by a band of *Molinia*, presumably as a result of increased aeration, and a series of 'swallow holes' caused by the collapse of the overlying peat.

Phragmites ridges

Low ridges of relatively dry peat occur on several bogs. They appear to mark underlying ridges in the mineral soil and are typically covered in dense *Calluna vulgaris* with *Phragmites australis* and sometimes *Myrica gale*. The occurrence of these last two species is probably due to the increased availability of nutrients from the mineral soil, even though the peat may be several metres deep.

Lakes

A number of bogs are adjacent to, or contain, lakes. Most are small and although there may be interesting transitional communities they have not yet been surveyed in detail.

The Rand

The rand is usually modified as a result of cutting and burning. Being naturally drier and closer to marginal cutting this part of the bog is probably subject to more frequent burning than elsewhere. The peat is dry and hard and deep cracks are common, resulting from the bog slumping towards an unsupported peat face, and

also from desiccation. Typically the rand is characterized by the dominance of *Calluna vulgaris*, which may be 1m or more tall if unburnt. Tussocks of *Scirpus cespitosus* and patches of *Epilobium angustifolium* and *Pteridium aquilinum* may also be present. *Betula pubescens, Pinus sylvestris* and *Ulex europaeus* may invade if fire is sufficiently infrequent. Bare peat is common and is usually colonized by *Campylopus introflexus*.

The lagg

No bog possesses a completely intact lagg nowadays, although some have areas of marginal fen which have developed on abandoned cut-away. A few bogs grade into callows bordering rivers e.g. Fisherstown Bog, Co. Longford. The most intact lagg known is that occurring around Sheheree Bog, a 9ha site occupying a kettle-hole near Killarney, Co. Kerry. This site is at the fen-raised bog transition and has not been included in this survey but it gives some indication of the nature of an untouched lagg. MhicDaeid (1976) gives the following description. 'The lagg is overgrown with stands of *Carex rostrata, Eriophorum angustifolium, Potentilla palustris* and *Agrostis stolonifera*, with a lower layer of small angiosperms and mosses including *Sphagnum subsecundum, Calliergon cuspidatum, Eurhynchium praelongum, Hydrocotyle vulgaris* and *Juncus bulbosus*. At the northern end *Typha latifolia* and *Iris pseudacorus* are frequent.' There are, in addition stands of *Salix* spp. and *Alnus glutinosa* with open water. Fragments of similar vegetation can be found on the modified margins of other bogs where there has been no recent activity.

Cut-away

All raised bogs have been cut away to a greater or lesser extent. Cutting is usually concentrated around the margins i.e. it proceeds from the lagg towards the centre. Where access roads have been created into the mire expanse cutting may then proceed from the centre out, a process which is much more damaging to the integrity of the remaining portion of the bog. Where cutting has been abandoned regeneration of the vegetation occurs forming a complex mosaic of communities. These include pools of open water, pockets of fen and incipient raised bog communities dominated by *Sphagna*. *Eriophorum angustifolium* may dominate extensive areas of more or less uniform surface, its white heads forming a distinctive landscape feature in mid-summer. Scrub of birch, willow and bracken develops in the drier parts.

Cut-away is often very rich floristically because it receives water charged with minerals released by the oxygenation of the cut peat, or because it cuts into the underlying fen peat, or because it is flushed by mineral-rich ground water. Its bird and invertebrate fauna is also correspondingly richer and these communities deserve study in their own right. However, it is an increasing resource and is not a substitute for the diminishing resource of intact raised bogs which are characterized by largely ombrotrophic conditions.

THE FLORA

A number of new stations were recorded for several species, particularly bryophytes, during the course of the survey. These include new vice-county records for relatively common species such as *Sphagnum fuscum* in Cos. Cavan and Leitrim, several records for the rare *S. recurvum* var. *tenue*, and the first record for Ireland of *S. subsecundum* on Carrowbehy Bog, Co. Roscommon (Douglas and Grogan 1985). *S. pulchrum*, a relatively rare species, which occupies a critical position at the boundary between the 'terrestrial' and 'aquatic' communities was recorded at eleven new stations in eastern Galway, Roscommon and Westmeath representing a considerable extension to its known range (Douglas 1987). This species has also been found recently at several new stations in Northern Ireland (Leach and Corbett 1987).

Of the higher plants no rarities were found but a new station for *Vaccinium vitis-idaea* was recorded on Cloonchambers Bog, Co. Roscommon. This species is more commonly associated with upland heaths in Ireland and Britain and on Scandinavian bogs, but has also been found recently around the margins of bogs in Northern Ireland. *Rhynchospora fusca* was found to be somewhat more widespread

than was formerly believed, although never very abundant. It is interesting to note that *Andromeda polifolia*, which is an abundant and characteristic plant on most bogs, was not recorded from the Kerry sites, and is only recorded from one bog in Northern Ireland (Leach and Corbett 1987).

The survey has provided considerable new information on the distribution of the lichen flora of raised bogs, with 51 species being recorded (Table 3). Most of these are relatively common but a few, e.g. *Cladonia rangiferina* and *Usnea articulata*, are rather rare and local (Seaward and Hitch 1982). Nearly half the species recorded are epiphytes, mostly on birch.

A list of new vice-county records for species found during the course of the survey is given in Table 4.

TABLE 4: New vice-county records of species found during the course of the survey

Cavan (H30)
- *Sphagnum fuscum*

Galway (H17)
- *Calliergon stramineum*
- *Leptobryum pyriforme*
- *Sphagnum pulchrum*
- *Tetraploden mniodes*

Leitrim (H29)
- *Sphagnum fuscum*

Longford (H24)
- *Brachythecium rivulare*
- *Campylopus pyriformis*
- *Riccardia palmata*
- *Sphagnum recurvum* var. *tenue*

Mayo East (H26)
- *Kurzia pauciflora*
- *Mylia anomala*
- *Pleurozia purpurea*
- *Sphagnum recurvum* var. *tenue*

Roscommon (H25)
- *Sphagnum subsecundum*
- *Sphagnum recurvum* var. *tenue*
- *Sphagnum contortum*
- *Sphagnum teres*
- *Vaccinium vitis-idaea*

Westmeath (H23)
- *Cephaloziella elachista*
- *Cephaloziella subdentata*
- *Sphagnum fimbriatum*
- *Sphagnum pulchrum*
- *Sphagnum recurvum* var. *tenue*

CHAPTER 5

THE FAUNA

Raised bogs are extremely nutrient poor ecosystems. Combined with the acidic, cold, wet and exposed conditions and the problems of fluctuating water levels they are an unattractive habitat for animal life. As a consequence they are relatively poor both in terms of species diversity and population densities. Many species are opportunists, vagrant or temporary rather than specialists, but nonetheless may have an important impact on the ecosystem through nutrient imports and exports or other interactions (Reynolds, in press). Pollinating insects and wintering birds are good examples.

An account of the broad principles relating to animal life in peatlands is given by Speight and Blackith (1983) and their references to oligotrophic bogs are of general relevance to raised bogs. The lack of nutrients, especially calcium, is a major limiting factor, especially for herbivorous vertebrates and shelled molluscs. Consequently the resident vertebrate fauna is very limited in terms of species diversity and it is possibly only the frog (*Rana temporaria* L.) which is a permanent inhabitant, as the birds, and even the Irish hare (*Lepus timidus hibernicus* Bell.), are able to feed elsewhere.

In general, however, the fauna of raised bogs has received far less attention than the flora and vegetation communities. Recent studies on the invertebrates highlight this with many 'first records' for the Irish midlands and several new records for Ireland, e.g. the spider *Gongylidiellum latebricola* O.P.-Cambridge (Higgins 1984). Indeed further studies on the invertebrates seem likely to prove particularly useful for most of the available information is based on detailed studies of only one or two bogs and no raised bog of the Western sub-type has been examined.

MAMMALS, REPTILES AND AMPHIBIANS

Raised bogs are unsuitable habitats for most herbivorous vertebrates, apart from a few birds. The Irish hare is the only mammal commonly occurring and its tracks or 'hare runs' are a characteristic feature of the bogs, as are the forms excavated in the larger hummocks. The tracks are often dominated by *Rhynchospora alba* which van Eck *et al.* (1984) attributed to trampling but may equally be due to increased waterlogging.

Domestic livestock such as sheep and cattle which feed principally on grasses and herbs rarely graze raised bogs except perhaps on the rand where they may be attracted by *Molinia*. Red deer (*Cervus elaphus* L.) which are intermediate feeders biased towards roughage feeding, would be attracted to the coarse ericaceous vegetation of bogs. Although no longer native in raised bog areas Harrington (pers. comm.) believes that raised bogs may have been important feeding areas for the species when it was more widespread.

The pygmy shrew (*Sorex minutus* L.) and fox (*Vulpes vulpes* (L.)) are occasional visitors to raised bogs, but there is little evidence of otters (*Lutra lutra* (L.)) compared with blanket bogs where their tracks are a characteristic feature.

The frog is the commonest vertebrate predator. Blackith and Speight (1974) found from studies on blanket bogs that they feed on a variety of organisms, principally predatory invertebrates, with Coleoptera being major constituents of their diet. There is no reason to believe that their behaviour would differ fundamentally on raised bogs. Blackith and Speight (*op. cit.*) have also emphasised how well adapted it is to the bogland habitat being well equipped to cope with more or less permanently waterlogged conditions and being small enough to escape exposure by sheltering in

the low vegetation. It might also be emphasised that its colouration provides it with excellent camouflage on a bog surface.

The newt (*Triturus vulgaris* L.), which is basically a fenland animal, is probably confined to flushes and soaks, while the common lizard (*Lacerta vivipara* Jacquin) may occur on the drier and warmer parts of the bog such as the rand.

BIRDS OF RAISED BOGS

Text by H.J. Wilson

INTRODUCTION

Systematic, quantitative surveys of the birds of raised bogs have only taken place in recent years, post-dating the exploitation of all the largest expanses of this ecosystem. Consequently the opportunity has already been lost to fully document and understand the bird communities of raised bogs. Thus recent surveys and any future investigations are limited by being confined to the remaining remnants, very few of which exceed 500 ha. The bird community has been further influenced by activities such as cutting, drainage and burning which alter the composition and abundance of the invertebrate fauna and plant communities, and the vegetation structure.

All recent studies have been part of wider ecological investigations. Madden (1987) reported on, and Rochford (1988) further reviewed, the records of all bird observations at Mongan bog, Co. Offaly, during the period 29 January 1985 and 9 January 1986 as part of the Clonmacnoise Heritage Zone Study (Tubridy 1984, Tubridy 1987, Tubridy and Jeffrey 1987). An environmental impact assessment (EIA) of the arterial drainage proposals for the Dunkellin/Lavally river catchments, Co. Galway, included detailed quantitative surveys of the breeding and wintering birds of the "damaged land" categories which included raised bogs (Buckley and McCarthy 1987). A similar study is currently in progress on the Owenmore catchment, Co. Sligo, which contains raised bogs also (P. Buckley pers. comm.). The Northern Ireland breeding waders survey covered 95 raised bog sites (4% of all sites) mostly in Co. Tyrone (Partridge 1988). The same study also surveyed the closely related blanket bog habitat type which has also been the subject of bird surveys in Ireland by Watson and O'Hare (1979 (a) and (b)) and Howarth (1987) (western blanket bog), MacLochlainn (1984) (mountain blanket bog) and notably in Scotland by Stroud *et al.* (1987) on the Caithness and Sutherland flows.

This short report, in so far as is possible, attempts to provide an account of the breeding and wintering (end of September to mid-February) birds of raised bogs, together with some speculative insight into species and their abundance in former times.

TYPICAL BREEDING BIRDS

The breeding species recorded by the various studies mentioned above are summarised in Table 5 together with density estimates where available. Although this shows 18 species breeding on raised bog, non exclusively so, Fuller (1982) considers Mallard (*Anas platyrhynchos*), Snipe (*Gallinago gallinago*), Curlew (*Numenius arquata*), Meadow Pipit (*Anthus pratensis*), Skylark (*Alauda arvensis*) and Cuckoo (*Cuculus canorus*) as typical breeders in this habitat. It must be added that the first three species, together with more loosely associated species such as Lapwing (*Vanellus vanellus*), largely utilise the bog as nesting habitat only. They are dependent on other neighbouring habitats such as open water bodies, callows and wet grasslands particularly for feeding; the high acidity and low nutrient status of raised bogs does not provide favourable conditions for their invertebrate prey, lumbricids for example being almost entirely absent. The last three typical species may complete their full breeding cycle on the bog.

In this context Red Grouse (*Lagopus lagopus*) must be a typical species also as it is a most characteristic all year round resident of moors and bogs generally. It survives on blanket bogs, and presumably also on raised bogs, by maintaining larger territories than on moorland, hence occurring there naturally at low densities (Lance and Mahon 1975 and Lance 1978). This reflects the substantially lower availability and utilisable productivity of heather (*Calluna vulgaris*), the grouse's principle food, on acid peatlands (Speight and Blackith 1983). Teal (*Anas crecca*) may also fit into this category though not recorded as present on the bogs surveyed. Like Mallard its presence would be dependent upon the occurrence of standing water, presumably on or adjacent to the bog, for feeding and brood rearing (Fox 1986).

The recorded absence of the Cuckoo is difficult to explain given that one of its principle hosts, the Meadow Pipit, is the most abundant species on raised bog. However, this may simply reflect host availability as density estimates are lower at 0.430 individuals/ha by comparison with neighbouring habitats such as cut-away bog (0.531), rough grassland (the "non-developed poor" category of Buckley and McCarthy 1987) (0.941) and wet grassland (1.067) in which the Cuckoo was more frequently observed or known to breed (Buckley and McCarthy 1987, Madden 1987).

Additional Habitat Features

Raised bogs often contain certain additional natural features such as scrub woodland, small lakes and pool complexes. Over the centuries man has also modified these bogs by attempting drainage, creating boundary ditches, cutting at the perimeters and managing the area for hunting, e.g. the provision of shooting butts and an extensive network of shallow surface drains in the interests of Red Grouse. These activities encourage the spread and growth of heather in the vicinity of ditches, perimeters and on the drier heaps of spoil as well as providing conditions suitable for the regeneration of birch (*Betula* spp.) and Scots pine (*Pinus sylvestris*). Likewise the ditch bottoms may be invaded by *Juncus* spp. Their combined effect adds considerably to the vertical structural component of the vegetation which in turn provides opportunities for scrub and woodland birds to breed. Although this aspect has not been specifically investigated it is likely that many of the scrub and woodland species recorded as breeding (see Table 5) have arisen from the presence of these habitat features. By way of confirmation the birch wood on All Saint's Bog, Co. Offaly, contained the following species: Hooded Crow (*Corvus corone cornix*), Wren (*Troglodytes troglodytes*), Robin (*Erithacus rubecula*), Willow Warbler (*Phylloscopus trochilus*), Chaffinch (*Fringella coelebs*) and Redpoll (*Carduelis flammea*) (M. Feehan pers. comm.). These and others such as Bullfinch (*Pyrrhula pyrrhula*) and Linnet (*Carduelis cannabina*) may also be found as isolated breeding pairs where conditions are suitable. Edge species like Stonechat (*Saxicola torquata*) and Reed Bunting (*Emberiza schoeniclus*) in particular will breed along ditches and on the bog perimeter.

Small lakes and pool complexes occur on certain bogs either as isolated oligotrophic waterbodies (e.g. Lough Lurgeen, Co. Galway) or situated at their edges (e.g. Finn Lough, Co. Offaly). The breeding bird community of Finn Lough, sandwiched between an esker ridge and a cutover bog, was investigated by Rochford (1988) as part of the Clonmacnoise Heritage Zone Study.

The 46.5 hectare study area contained 6.8 ha of open water, 7.7 ha of reedswamp, 2.5 ha of scrub carr, while the remaining 29.5 ha consisted mainly of tall sedge, *Schoenus* fen and fen-bog transition. The site's many fen-like characteristics, which give it a greater richness and range of habitats, is reflected in the breeding bird community recorded there (Table 6). Such diversity and numbers, highlighting the value of complex perimeter habitats, are most unlikely on the isolated oligotrophic lakes. Only the following species, excluding the obvious, are likely to be common to both with notable differences in density probable; Mallard, Teal, Wren, Sedge Warbler (*Acrocephalus schoenobaenus*) and Reed Bunting. Islands, where they occur, may hold colonies of gulls, most probably Black-headed Gulls (*Larus ridibundus*). Praeger (1934) refers to "a great colony of Black-headed Gulls on a bog near Tullamore, Co. Offaly", which had a profound influence on the vegetation and they still breed on the soaks on Clara Bog, Co. Offaly.

TABLE 5: Records of presence and densities of birds on raised bogs during the breeding season and in winter (* = breeding species, BR and W = breeding and winter seasons).

SPECIES	Mongan Bog[1]	Co. Tyrone[2]	Dunkellin Lavally[3]		Owenmore[3]
		BR	BR	W	W
Mallard *Anas platyrhynchos**	×*			×	
Kestrel *Falco tinnunculus*	×				
Peregrine *Falco peregrinus*	×				×
Red Grouse *Lagopus lagopus**			×	×	×
Golden Plover *Pluvialis apricaria**		×		×	
Lapwing *Vanellus vanellus**		0.01	0.007		×
Snipe *Gallinago gallinago**	×*	0.08	0.022	5.4	0.140
Curlew *Numenius arquata**	×*	0.03	0.007		×
Redshank *Tringa totanus**	×		0.022		
Skylark *Alauda arvensis**	×*		0.136	0.03	0.030
Meadow Pipit *Anthus pratensis**	×*		0.430	0.13	0.140
Wren *Troglodytes troglodytes**			0.036		0.080
Robin *Erithacus rubecula**			0.014		0.020
Stonechat *Saxicola torquata**			0.050		×
Blackbird *Turdus merula**			0.028		
Song Thrush *Turdus philomelos**			0.007		
Sedge Warbler *Acrocephalus schoenobaenus**			0.043		
Goldcrest *Regulus regulus*					0.040
Willow Warbler *Phylloscopus trochilus**			0.036		
Blue Tit *Parus caeruleus*					0.004
Great Tit *Parus major**			0.007		
Rook *Corvus frugilegus*	×				×
Hooded Crow *Corvus corone cornix*	×				0.020
Raven *Corvus corax*	×			×	
Redpoll *Carduelis flammea**			0.028		0.010
Bullfinch *Pyrrhula pyrrhula*					0.020
Reed Bunting *Emberiza schoeniclus**			0.050		0.020
Linnet *Carduelis cannabina*	×				
Total Densities			1.019		0.524

[1]Recorded during 10 equally spaced visits between 29.1.85 and 9.1.86 (Madden 1987).

[2]Northern Ireland Breeding Wader Survey, pairs/ha (Partridge 1987).

[3]Number of individuals/ha (density) calculated from the two inner 25m bands of 200m wide transects, Dunkellin/Lavally 1985/86 (Buckley and McCarthy 1987), Owenmore 1988/89, (P. Buckley pers. comm.).

Other Local Breeding Birds

The presence of a further group of birds from Table 5, which mostly breed in adjacent habitats, may be accounted for on the basis that they utilise the bog as a source of food. As scavengers the Hooded Crow and Raven (*Corvus corax*) are frequently seen quartering the bog seeking carrion or unattended nests. The Peregrine (*Falco peregrinus*) and Merlin (*Falco columbarius*) hunt other birds there, while the conspicuous Kestrel (*Falco tinnunculus*) may be observed hovering in search of certain invertebrate prey, e.g. beetles, and small mammals. The bog fringes provide ideal opportunities for the Sparrowhawk (*Accipiter nisus*) and the less common Hen Harrier (*Circus cyaneus*) to surprise their small bird prey. The common frog which inhabits the lakes and pools is preyed upon by the Heron (*Ardea cinerea*).

Finally, other species such as Lapwing and Redshank (*Tringa totanus*) are not strictly bogland species but may be present occasionally due to the close proximity of their preferred habitats, which in their cases are callows and wet grassland.

Former Breeding Species

According to Ussher and Warren (1900) the "great bogs of the central plain" were the chief resort of the Marsh Harrier (*Circus aeruginosus*), now absent in Ireland as

TABLE 6: Abundance and density of breeding birds at Finn Lough, Co. Offaly, in 1987. After Rochford (1988)[1].

SPECIES	TERRITORIES	DENSITY (pairs/km)
Little Grebe *Tachybaptus ruficollis*	2	—
Mute Swan *Cygnus olor*	2	—
Mallard *Anas platyrhynchos**	c10	—
Shoveler *Anas clypeata*	?*	—
Tufted Duck *Aythya fuligula*	?*	—
Moorhen *Gallinula chloropus*	3	—
Coot *Fulica atra*	5–10	—
Water Rail *Rallus aquaticus*	1*	—
Lapwing *Vanellus vanellus*	2–3	—
Ringed Plover *Charadrius hiaticula*	1	—
Snipe *Gallinago gallinago*	c8	—
Black-tailed Godwit *Limosa limosa*	?**	—
Black-headed Gull *Larus ridibundus*	500–600	—
Cuckoo *Cuculus canorus*	?*	—
Skylark *Alauda arvensis*	12	31
Meadow Pipit *Anthus pratensis*	10	26
Pied Wagtail *Motacilla alba yarrellii*	1	3
Wren *Troglodytes troglodytes*	4	10
Sedge Warbler *Acrocephalus schoenobaenus*	24	62
Hooded Crow *Corvus corone cornix*	1	3
Chaffinch *Fringilla coelebs*	1	3
Reed Bunting *Emberiza schoeniclus*	28	72

[1]Method used was a modification of the BTO Common Bird Census Technique (Marchant 1983) for short-term intensive surveys; 6 visits between 16.5.87 and 11.7.87.

*Breeding not confirmed but strongly suspected.
**Not breeding.

a breeding species due largely to persecution in the last century. This association is understandable but probably erroneous as the species may have occasionally nested on the edge of raised bogs close to reeds (*Phragmites*) but would still have almost exclusively hunted the nearby reedbeds of lakes and rivers; they are adapated to hunting tall structured vegetation, not bog or even heather areas. It is probable, although no records exist, that the Hen Harrier also bred on these once extensive bogs. It was likely to have been only an occasional breeder due to its preference for montane heather moorland areas.

Ussher and Warren (1900) also record the Merlin as breeding "on the flat bogs which cover so much of Laois, Offaly, Westmeath and Eastern Galway". Breeding sites nowadays may only be located in the woodland areas of the cut-away, the species continuing to use the raised bog for hunting its principal prey, the Meadow Pipit and dragonflies. *Sphagnum* hummocks and occasional trees are used as perches and plucking posts (D. Norriss pers. comm.). The last known record of ground nesting that I am familiar with was some 6–8 years ago when a pair bred successfully in two successive years on a heather covered islet in a complex of pools in Co. Westmeath (J. Moore pers. comm.).

Another possibility is the Golden Plover (*Pluvialis apricaria*) though Ussher and Warren (1900) report that "it does not appear to breed on the flat bogs of the midland counties". However, it currently breeds almost down to sea level on western blanket bogs while a pair bred recently on a raised bog located at altitude within blanket bog in Co. Tyrone (Partridge 1987). The species requires a combination of large wet areas with short vegetation, usually as a result of fire, linked to "anthropogenic habitats" for both feeding and breeding (Stroud *et al.* 1987). It is difficult to envisage the necessary conditions being provided to sustain a regularly breeding population in the absence of the extensive burning which takes place on blanket bogs for spring grazing purposes. Conditions for occasional breeding or attempted breeding almost certainly existed in the past.

Breeding Birds of Cut-away Bog

Cut-away bog is a variable complex of pools, peat banks, rough grassland, scrub, deciduous woodland and coniferous plantations. Each raised bog is fringed to a

TABLE 7: Species recorded on cut-away bog (Madden 1987, Buckley and McCarthy 1987, and Partridge 1987).

Grey Heron *Ardea cinerea* =	Mistle Thrush *Turdus viscivorus**
Mallard Anas platyrhnychos =	Song Thrush *Turdus philomelos**
Hen Harrier *Circus cyaneus*	Redwing *Turdus iliacus*
Kestrel *Falco tinnunculus*	Whitethroat *Sylvia communis**
Merlin *Falco columbarius**	Chiffchaff *Phylloscopus collybita**
Peregrine *Falco peregrinus*	Willow Warbler *Phylloscopus trochilus*
Red Grouse *Lagopus lagopus**	Goldcrest *Regulus regulus**
Corncrake *Crex crex* =	Grasshopper Warbler *Locustella naevia**
Pheasant *Phasianus colchicus**	Blue Tit *Parus caeruleus**
Lapwing *Vanellus vanellus**	Coal Tit *Parus ater**
Snipe *Gallinago gallinago**	Great Tit *Parus major**
Curlew *Numenius arquata**	Pied Wagtail *Motacilla alba yarellii* =
Stock Dove *Columba oenas**	Magpie *Pica pica**
Cuckoo *Cuculus canorus**	Rook *Corvus frugilegus* =
Short-eared Owl *Asio flammeus*	Hooded Crow *Corvus corone cornix**
Skylark *Alauda arvensis**	Starling *Sturnus vulgaris**
Meadow Pipit *Anthus pratensis**	Chaffinch *Fringilla coelebs**
Wren *Troglodytes troglodytes**	Greenfinch *Carduelis chloris**
Dunnock *Prunella modularis**	Linnet *Carduelis cannabina**
Robin *Erithacus rubecula**	Redpoll *Carduelis flammea**
Blackbird *Turdus merula**	Bullfinch *Pyrrhula pyrrhula*
Fieldfare *Turdus pilaris*	Reed Bunting *Emberiza schoeniclus**
OTHER PROBABLE SPECIES	
Sparrowhawk *Acipiter nisus* =	Long-tailed Tit *Aegithalos caudatus* =
Woodcock *Scolopax rusticola*	Whinchat *Saxicola rubetra* =
Woodpigeon *Columbia palumbus* =	Goldfinch *Carduelis carduelis* =
Long-eared Owl *Asio otus* =	Siskin *Carduelis spinus*
Sedge Warbler *Acrocephalus schoenobaenus* =	Yellowhammer *Emberiza citrinella* =

* Breeding species

= Potential breeder

greater or lesser extent with this most diverse habitat type justifying a brief mention of its bird fauna. Not surprisingly therefore is the large number of breeding species (32), with a further 12 species recorded as present, of which 5 are potential breeders in certain situations (Table 7). The surveys listed in the Introduction have also missed other likely breeding species such as Long-tailed Tit (*Aegithalos caudatus*), Yellowhammer (*Emberiza citrinella*) and Goldfinch (*Carduelis carduelis*) for instance. The remaining four species in Table 7, exclusive of Kestrel and Peregrine are essentially wintering species; Hen Harrier, Short-eared Owl (*Asio flammeus*), Fieldfare (*Turdus pilaris*) and Redwing (*Turdus iliacus*).

On cut-away bog Buckley and McCarthy (1987) recorded 19 species with an overall density of 2.352 individuals/ha while on the closely related habitat type, termed "non-developed poor" 19 species were present at an overall density of 3.430 individuals/ha. Only 10 species were common to both habitat types. These densities are approximately two to three times higher than those found on uncut raised bog.

WINTERING BIRDS

Numbers of species and density (Table 5) are low during winter which spans the period late September to mid-February. Densities also vary over this long period. In the case of Meadow Pipit and Skylark they are usually scarce and absent respectively during late November to early February but are numerous in late September and October as they congregate in separate migratory flocks and again in February as they establish breeding territories. Similar patterns of use are probable amongst other species e.g. Reed Bunting while certain residential breeders like Wren and Robin will remain on the bogs throughout the winter. The Merlin will also be present as it regularly, perhaps even usually, remains within its breeding territory on raised bogs (D. Norriss pers. comm.). Small parties (< 30) of roosting Golden Plover have occasionally been flushed from these bogs. As they require short vegetation they are most probably utilising areas which have been burnt recently. However, three species, the Greenland White-fronted Goose (*Anser albifrons*

TABLE 8: Minimum and maximum numbers of Greenland White-fronted geese and signs of use recorded on raised bogs from 1982/83–1987/88. (V = visited but no geese or field signs observed, NV = not visited, * = field signs observed, ( ) indicate probable use by nearby flock). Unpublished records of the Wildlife Service.

RAISED BOG AND LOCATION	MAIN FLOCK	NUMBERS, FIELD SIGNS ETC.					
		1982/ 1983	1983/ 1984	1984/ 1985	1985/ 1986	1986/ 1987	1987/ 1988
Redwood and Ballyea Bogs, Co. Tipperary[1, 2]	Little Brosna	3–130+	6–150	*	*	*	NV
All Saint's Bog, Co. Offaly[1]	Little Brosna	3–100+	8–100	58–217	15–25	39–173	20–46
Mongan Bog, Co. Offaly[2]	Middle Shannon (excluding Little Brosna)	*	*	5–26	*	V	13+
Cloonown Bog, Co. Galway[1]	Middle Shannon (excluding Little Brosna)	52–97	4–65	4–30	NV	NV	NV
Cloonbonny and Kilgarvan Bogs, Co. Westmeath[1]	Middle Shannon (excluding Little Brosna)	NV	NV	50	V	NV	NV
Ballykenny/ Fisherstown Bogs, Co. Longford[1, 3]	Castleforbes	45–95	28–87	17	V	V	V
Lough Lurgeen Bog, Co. Galway	Glenamaddy	54–56	48	(49)	(78)	(47)	(106)
Garriskil Bog, Co. Westmeath[1]	Midlands	NV	NV	NV	V	43–60	V

[1]Raised bogs being developed in whole or in part by Bord na Móna and/or private interests.

[2]Raised bogs with statutory protection in whole or in part.

[3]Nearby Cashel and Curracrump raised bogs used regularily by 20–55 geese in 1984/85 only, although checked in subsequent years.

flavirostris), Red Grouse and Snipe (the former two species now confined to certain raised bogs) occur to relieve the impression of an area almost devoid of birds at this time of year.

The traditional association of the White-front with raised and blanket bogs was documented by Ruttledge and Hall-Watt (1957). In this publication they drew attention to the impending impact on the species of the development, for mechanised turf cutting, of the midland raised bogs. These predicted losses were confirmed by Ruttledge and Ogilvie (1979) and have continued to the present day (Wildlife Service, unpublished data). In summary therefore it has taken as little as 25 years to deprive the White-front of all but a handful of raised bogs, one of the species' traditional habitats, and those remaining are all currently under threat from exploitation (see Table 8).

The White-front is commonly referred to as the "bog goose" which is not without foundation. It has evolved a specialised method of feeding in which it probes for food which consists of the underground storage organs of certain wetland plants. The efficiency of this method is related to the softness, which in these habitats is equated with wetness, of the plants' substrate. In raised bogs, as well as blanket bogs, the goose confines feeding to the wettest quaking areas which are usually characterised by "pool and hummock" systems. Here it can easily extract the "bulbs" of the common cotton grass (*Eriophorum angustifolium*), an important food item also on its breeding (Greenland) and staging (Iceland) areas, and white-beaked sedge (*Rhyncospora alba*), perhaps the richest and most abundant food sources within these low productivity systems. Likewise on the callows another traditional habitat often existing in close association with the bogs, the "bulbs" of the buttercup (*Ranunculus bulbosus*) and the grass (*Agrostis stolonifera*) are probed for in the wetter parts.

In the past therefore raised bogs were capable of providing the goose with its daily nutritional requirements as evidenced by the exclusive use of blanket bog today by a few flocks (e.g. Connemara). Furthermore bogs with lakes provide safe night roosts (e.g. Lough Lurgeen, Co. Galway) while the bogs also act as refuges during periods of disturbance on their alternate feeding grounds. It is incorrect to regard bogs as principally roosting or refuge sites; they were once capable of providing all the goose's seasonal food requirements as well. It is unlikely however that raised bogs were exclusively utilised by White-front flocks given their juxtaposition with their other traditional habitat — the callows.

The almost complete loss of these bogs has had a threefold affect. As well as virtually eliminating opportunities for bogland feeding, their loss also deprives the goose of safe refuges and has forced it to congregate on the only remaining suitable habitat — the callows. However, callows, due to their linear distribution along river courses are prone to disturbance from a variety of sources such as drainage and subsequent agricultural intensification, hunting, fishing and boating (Norriss and Wilson 1988). The consistently low numbers of White-fronts utilising the extensive callows of the central Shannon from Portumna to Athlone (excluding the flocks associated with the callows of the Little Brosna and Suck tributaries) are an example of the combined effect of bogland exploitation and increasing utilisation of the rivers for recreation (Stroud *et al.* in press).

While the White-front has largely accommodated itself on farmland in recent decades and is not threatened by bogland loss in an overall population context (although a number of blanket bog flocks face serious threats) it is regrettable that the plans for the exploitation of raised bogs were not able to accommodate the objective of retaining the species on its traditional habitat, given the early expression of concern by Ruttledge and Hall Watt (1957) in the mid-fifties. The loss of raised bogs has proved to be a contributory factor in the species' midlands population decline during the 60s and 70s (Ruttledge and Ogilvie 1979). Happily this decline has been arrested and the population is increasing once again due to the introduction of protective measures (Wilson and Norriss 1986, Stroud *et al.* in press). However, the continued use of this traditional habitat, unfortunately, remains precarious due to the continued exploitation of the last remaining raised bogs (Ryan and Cross 1984).

The Red Grouse was formerly a popular quarry species on raised bogs, some of which were managed in the traditional manner for driven grouse, i.e. lines of butts, and surface drained with perhaps rotational burning also to improve heather cover and growth. As heather is never abundant on the wet boglands of Ireland densities must nearly always have been low. However, raised bogs as discrete manageable units together with the presence of Snipe, White-front geese and the occasional Woodcock (*Scolopax rusticola*), probably compensated for this as far as the hunters were concerned. Nowadays the small size of the remaining bogs and the frequency of fires militates against the future survival of Red Grouse on this ecosystem, though currently it is present on more raised bogs than is generally accepted.

The Snipe, as a night-time feeder, utilises raised bogs as a daytime roost. Large numbers, up to several hundred, may be flushed from an undisturbed bog, especially in mid-winter. This diurnal roosting habit has given rise to "walked up" snipe shooting popular amongst certain hunters. Disturbance levels, which generally equate with the frequency and scale of hunting, and the quality of nearby feeding grounds, will largely determine snipe numbers and the extent to which they utilise the bog. Bog loss and the absence of suitable alternative day-time roosts will effectively reduce the abundance of wintering Snipe in large areas where once raised bogs predominated.

In the past raised bogs provided a wonderful array of hunting opportunities whether for flighting geese, for driven grouse and snipe, for hunting over dogs or simply "walked up" and always with a chance of woodcock in the scrub infested or wooded cutaways.

DISCUSSION

To animal or plant the raised bog environment represents a complex of extremes characterised by high acidity, low nutrient status and severe hydrological conditions. These physical and nutritional constraints largely limit both the

occurrence and productivity of species unless specific adaptations come into play. Whereas adaptations are apparent amongst the plants (e.g. carnivorous feeding), none appear obvious amongst the birds recorded by the various surveys, except the specialised feeding (probing) of Greenland White-fronted geese and the year round dependence of Red Grouse on heather. Without exception all bird species recorded on raised bogs may be found in greater abundance on other habitats. Their presence therefore appears largely opportunistic irrespective of time of year.

The raised bog avifauna is thus species-poor, with perhaps 5 or 6 typical species, all of which occur at very low densities. It is also likely that the various surveys have exaggerated the diversity and abundance of the breeding birds due to the small size of the remaining raised bogs, various man-related physical changes to the bog's surface and fringes, and their proximity to extensive cut-away with its diverse and numerous breeding bird communities.

In contrast, the potential of this tundra-like ecosystem to support breeding birds is given by Stroud *et al.* (1986) in their study of the Caithness and Sutherland flows or blanket bogs in Scotland. There species occur representing several taxonomic groups which include the waders (15), particularly, but also other waterfowl (18), predatory and scavenging birds (9), passerines (13) and a miscellany of other types (8). The relatively southerly development of this northern tundra-like ecosystem, due to a highly Atlantic climate, accounts for this diverse avifauna containing many species usually associated with more northerly zones such as the Boreal-subarctic forest zone and the true tundra. This diversity in breeding birds and their significance in European terms is thus related to the conjunction of climate and topography together with the total extent, continuity and diversity of mire forms and vegetation complexes making up these blanket bogs. While for climatic reasons alone many of these species will probably never breed on the raised and blanket bogs of Ireland, we shall never know exactly which species bred on raised bogs nor their abundance. We have lost that essential characteristic of "total extent" and hence the inherent diversity of forms which accompany it.

On an ornithological basis, therefore, the information available is fragmentary both in an historical perspective and in terms of the raised bog ecosystem from which much of the information is derived. As such birds alone provide weak grounds for proposing raised bog conservation. Nevertheless, the current use made of raised bogs by Greenland White-fronted geese and Merlin, both of which are listed in Annex I of the EC Directive on the Conservation of Wild Birds provide grounds to utilise the provisions of Article 4 and, furthermore, for the successful procurement of funds under the ACE regulation to aid the purchase of raised bogs. Article 4 obliges Ireland to take special conservation measures concerning the habitat "of these species to ensure their survival and reproduction in their area of distribution". In this connection account shall be taken of species vulnerable to specific changes in habitat, species considered rare because of small populations or restricted local distribution or species requiring particular attention for reasons of the specific nature of their habitat, all of which are relevant to Greenland White-front and Merlin. Particular emphasis is also placed on regularly occurring migratory species not listed in Annex 1 e.g. Snipe (also the object of the Bonn Convention, ratified by Ireland in 1983), and the protection of internationally important wetlands, which includes raised bogs, according to the criteria of the Ramsar Convention. This international wildlife convention, ratified by Ireland in 1984, is based on the concensus that wetlands, which include all bog types, "constitute a resource of great economic, cultural, scientific and recreational value, the loss of which would be irreparable" and the desire "to stem the progressive encroachment upon and/or loss of wetlands now and in the future". The convention primarily promotes the wise use of wetlands, hence the wise use of our raised bogs. Grounds exist therefore for an active conservation programme to safeguard representative examples of these internationally important and renowned raised bogs in their own rights as ecosystems and as habitats for birds.

INVERTEBRATES

Invertebrates are by far the most abundant animals on raised bogs with certain groups, such as the Collembola (detritivores), Lepidoptera (herbivores) and spiders (predators) being well represented. Higgins (1984) however has noted the striking

absence of many species which are abundant in other habitats. As with the vertebrates few species are unique to raised bogs, although many species, or species assemblages, may be typical of certain bogland habitats because of specific pH or relative humidity requirements (Reynolds, in press). Certain species, as with the plants, are basically arctic in their distribution e.g. the chironomid *Lasiodiamesa sphagnicola* Kieffer (Ashe 1987).

Reynolds (in press) has grouped bogland habitats into three major categories: aquatic, the neuston (surface of standing water) and terrestrial. On some bogs small patches of woodland provide additional habitat, while the marginal cut-away provides a mosaic of all major habitat types.

From present available evidence the aquatic communities are simple and represent the extreme oligotrophic end of the spectrum. The principal aquatic habitats are the bog pools which are mostly *Sphagnum*-floored (Zone A1), or occasionally peat-floored (Zones A2 and A3). Algae, pollen and debris provide the principal food source for herbivores and detritivores and in peat-floored pools particles of peat may be important. Chironomids and chydorid cladocerans are the principal inhabitants of pools providing food for predators such as the cladoceran *Polyphemus pediculus* L. and dragonfly nymphs (Reynolds, in press). In general the energy flow appears likely to be from terrestrial to aquatic habitats although temporarily flooded pools, which often contain thick algal mats, may be important in recycling nutrients when they dry up.

Soaks provide an important, although localized contrast to the oligotrophic pools, with their more base-rich waters attracting species such as *Asellus aquaticus* L. and *Hesperocorixa sahlbergi* Fieb. These were found to co-exist with species more characteristic of acid moorland habitats e.g. *H. castanea* Thoms indicating 'the delicate interplay of minerotrophic and oligotrophic influences in the soak lake' (Reynolds 1985).

Reynolds (in press) considers the neuston to be an important and neglected habitat which acts as a one-way valve for nutrients which includes wind-blown terrestrial pollen, leaf debris and insects trapped on the surface film. It is dominated by predatory heteropterans (e.g. *Gerris* species, *Velia* species).

In the terrestrial habitats acidity and chemical deficiencies exclude lumbricids, which are absent below pH 4.0, and their place is taken by mites (Aranea) and springtails (Collembola). Waterlogging prevents access by these groups to lower layers of peat. The paucity of chewing plant feeders means that large quantities of senescent plant material, rather than comminuted young material, is the only food source for detritivores, while the absence of micro-fungi and bacteria is also a limiting factor (Speight and Blackith 1983). The hummock and hollow topography of raised bogs provides a range of habitats for invertebrates, but Blackith (1974) found that in blanket bogs each plant species had its own characteristic Collembolan community. A similar situation was found to exist in raised bogs (Speight and Blackith 1983).

Detailed studies on Mongan Bog, Co. Offaly, found that invertebrate herbivores feed principally on the Ericaceae (leaf mining being an important feeding method) and the monocotyledons (leaf rolling being particularly prevalent). Aphids, ground-hoppers and Lepidopteran larvae are particularly important with over 130 species of moth being recorded. Tipulid flies are important root feeders. The only mollusc recorded is the slug, *Arion ater* L. The principal carnivores are ground-beetles, parasitic ichneumonoids, ants and spiders, with over 43 species of the last being recorded by Higgins (1984). Ants (*Myrmica ruginodis* Nylander and *M. scabrinodis* Nylander) are abundant in *Sphagnum* hummocks and Reynolds (in press) draws attention to American studies which found that they play an important role in hummock destruction.

The terrestrial facies of the soaks provide a focus for woodland elements of the fauna. The green hairstreak butterfly (*Callophrys rubi* L.) for example, is a particularly conspicuous and abundant species in late spring. These woodlands show little human interference so that there is often significant quantities of decaying wood which is important for saproxylic species. O'Connor and Speight (1987) record the Tipulid *Dictenidia bimaculata* L. from the woodlands on Clara and All Saint's Bogs, Co. Offaly. This is a representative of the ancient forest fauna of Europe and is a threatened European species.

CHAPTER 6

THE EFFECTS OF LAND USE PRACTICES ON RAISED BOG ECOSYSTEMS

Utilisation of a bog for domestic, industrial or agricultural purposes, and burning of the vegetation, modifies the mire structure. Such land use practices have a deleterious effect on the hydrology, and consequently on the plant and animal communities of the bog. The impact of these activities is discussed below.

FIRE

While fire is used deliberately on blanket bogs in order to improve the quality of the grazing lands, on raised bogs extensive burning, although common, is more often accidental. Typically a raised bog is set on fire by the careless burning of the vegetation to facilitate marginal cutting. The impacts of fire have been examined in detail by Lindsay *et al.* (1988) and are given below:

a) Loss of carbon, nitrogen, sulphur, potassium, magnesium and calcium through volatilisation and nitrogen and phosphorus through long-term leaching.

b) Accumulation of nutrient-rich ash on the peat surface. The nutrients may be retained if the *Sphagnum* carpet is largely undamaged, but may be lost otherwise. Ash raises the pH of the peat encouraging bacterial decay.

c) Deposition of waxes and bitumens forming a water-repellant film leading to increased run-off.

d) Lowered albedo causing a rise in temperature of upper peat layers and hence increased decomposition.

e) Damage or destruction of the acrotelm. An occasional, fast fire will have relatively small effects but a slow fire, which penetrates well into the peat, or frequent fires, will eventually destroy the acrotelm leading to a firm, hard surface of bare peat or algal slime. Permeability is greatly reduced, run-off correspondingly increased and in time this may lead to erosion of the catotelm and ultimate destruction of the bog (Ingram and Bragg 1984).

f) Vegetational changes. The changes in vegetation vary considerably depending on the type and frequency of fires. In general, with increasing frequency and severity of fires, there is a trend towards reduced *Sphagnum* cover and increased cover of herbs, especially *Eriophorum vaginatum* and *Scirpus cespitosus*, and dwarf shrubs, principally *Calluna vulgaris*. In the wetter areas *Narthecium ossifragum* becomes more abundant (Tubridy 1984). Lichens, particularly those epiphytic on *Calluna vulgaris* stems, are destroyed by fire and the history of burning on an individual bog may be obtained from examining the abundance and variety of lichens. Van Eck *et al.* (1984) states that it takes about 30 years for epiphytic communities to re-establish themselves.

Fires on raised bogs are the rule rather than the exception, even though they are usually accidental, and few if any bogs have not been burnt at least on part of the dome in the last 10 years. It is unusual however, for the entire bog to be burnt and as a result a macro-mosaic of vegetation develops from repeated limited, but often overlapping, fires. The most extensive fires occur on bogs

already dry from repeated burning or drainage. On a wet bog the *Sphagnum* lawns and pools often act as a barrier and consequently unburnt patches, particularly hummocks, of considerable age may occur.

Repeated frequent burning probably explains why some bogs are dry and firm even though the area is undrained. Intense, repeated burning, however, does not appear to be very common for while all bogs show evidence of burning, most show signs of good recovery with the re-establishment of *Sphagnum* cover even where the surface is firm. An abundance of *S. tenellum*, which is a primary colonizer, is often an indicator of past burning.

g) Fauna: No specific information is available but the impact of fire will depend on the severity of the burn and the wetness of the bog. In dry areas fire is likely to have a devastating effect on all but the most mobile species and perhaps certain detritivores which may escape if the burn is superficial. Exposure will be further increased reducing cover for invertebrates and nesting birds, but this may be beneficial for certain species, e.g. Greenland white-fronted geese, golden plover, which prefer more open habitats. The fauna of large hummocks and pool complexes probably escape damage unless the burn is particularly severe and comes after a prolonged dry spell. Wind-blown ash, however, may cause temporary enrichment of pools and *Sphagnum* dominated communities. The increased nutrient status of the bog will also stimulate new growth which will be beneficial to herbivores e.g. grouse (*Lagopus lagopus*) although specialist feeders may not regain their former population levels for many years.

DRAINAGE AND CUTTING

Removal of peat from a bog as practiced by Bord na Móna, and to an increasing extent by private operators, clearly has a devastating effect on the bog ecosystem. Once the surface vegetation has been removed the bog can be considered to have been destroyed and to be no more than a deposit of peat which is exploited by open-cast mining. Not only are the plant and animal communities lost but so also is the irreplaceable sub-fossil pollen record.

The principal effect of cutting and associated drainage is to reduce the height of the water table. This leads to the desiccation of the peat in the acrotelm, an increase in temperature and oxygen levels within the peat and hence an increase in biological activity causing decomposition. With the destruction of the acrotelm the catotelm is exposed to the atmosphere and the bog ecosystem is degraded to dry heathland.

This is the extreme event, but even small areas of cutting on isolated drains can have pronounced effects on a raised bog (Tubridy 1984, Lindsay *et al.* 1988). A drain will speed up the loss of water from the bog causing a localized lowering of the water table. Even a shallow drain, such as occurs along townland boundaries, can have a pronounced effect over a period of time leading to wastage of peat on either side and producing a shallow valley in the bog. Such a drain can also lead to pool systems drying out, either by directly draining the pools or by a general lowering of the water table. The drop in water table need not be great to have a profound effect as *Sphagna* have very narrow ranges of tolerance to water stress. For example *Sphagnum papillosum* is incapable of survival after 16 days of drought and a drain may in effect extend a drought period on the bog surface (Clymo and Hayward, 1982). The impact of drainage is likely to be greater on the True Midland sub-type, which has less humified and more permeable peat, than on the Western sub-type.

However, the acrotelm does have a certain degree of buffering capacity and can adapt to hydrological changes, either climatic or man-induced (Ivanov cited in Lindsay *et al.*, 1988). During 'wet climate phases' the hollow and pool communities expand while in dry phases the hummock and ridge communities expand. This may explain the state of Raheenmore Bog for example, which in the 1950s had well developed pool systems, but now, following peripheral drainage, has only thick *Sphagnum* carpets.

Deep peripheral drains, such as are excavated when a bog is being prepared for mechanical peat harvesting, and marginal cutting by hand have a major impact on the bog. Not only is the lagg destroyed but the activity cuts deep into the catotelm which therefore dries out and oxidizes. The net effect is to reduce the height of the

water table in the adjacent intact bog which consequently sinks. Hydrological studies on Mongan Bog (Tubridy 1984) have shown that the 'effective acrotelm' has expanded vertically and that the water table fluctuates more. Close to the cut-away edge the acrotelm varies between 20cm and 50cm in depth while in the centre of the bog it is always less than 30cm deep and for seven months of the year the water table is less than 5cm below the surface. Water flows more rapidly through the peat where the acrotelm is deeper and the areal extent of the pools is reduced. The wider the cut-away the further from the edge of the bog are the pools.

Another response of the bog to drying out as a result of cutting is the development of vertical cracks parallel to the cut margin. If the cut face is high and straight the bog may slump outward in an 'attempt' to re-adjust to its original shape by forming a new rand. The net effect is that the bog shrinks from the edge inwards. It is uncertain whether this wastage of peat is progressive or whether it can come to a halt. There is evidence from some bogs that the damage can heal with time with the catotelm somehow sealing itself, much as a scab prevents blood loss from a flesh wound. On other bogs wastage appears to be continuous, eventually resulting in the total disruption of the system (O. Bragg pers. comm.).

Arterial drainage, while directed at improving agricultural land, can also have an impact on peatlands. In some instances, e.g. Raheenmore, the marginal drains which represent the original lagg have been deepened, thus directly affecting the water table of the bog. In other cases there is no direct effect but the water table of the entire region may be lowered. The catotelm may therefore lose water, but as the peat is colloidal it does not necessarily dry out but may just shrink to a new, lower level. If, however, the bog lies on a perched water table it would be unaffected. It is significant that several of the remaining wetter raised bogs lie on watersheds where the impact of arterial drainage is least e.g. L. Lurgeen Bog, Co. Galway.

Cutting on the bog margin can also result in the bog surface tearing or splitting, resulting in the development of elongated, sinuous pools. Unlike the characteristic hummock and hollow complexes these may occur in areas of otherwise dry surface peat. In extreme cases the cutting can trigger-off a bog burst resulting in the mass movement of peat as a flow, leaving behind a depression, often with pools.

Impact on vegetation

The main impact of drainage is to cause a gradual loss of hygrophilous species. Initially the changes may be very subtle and be detectable only by detailed monitoring. The bryophytes, especially the *Sphagna*, are the first species to respond with a decline in the pool and carpet species such as *S. cuspidatum* and *S. pulchrum*, and an increase in those species tolerant of dryer conditions e.g. *S. capillifolium*. Simultaneously, but more slowly, higher plants such as *Rhynchospora alba* and *Menyanthes trifoliata* will also decline while *Scirpus caespitosus, Calluna vulgaris* and *Erica cinerea* gradually increase in abundance and trees such as *Betula pubescens* and *Pinus sylvestris* may invade the bog surface. Such changes may occur when the average water table is lowered by only 4–5cm (Ivanov 1981). To a developer these changes are clearly insignificant, but to the bog communities this lowering is sufficient to produce profound changes.

Drying out of the bog surface will obviously have a major impact on soaks and flushes. Open pools infill with vegetation to form a scragh, but as desiccation proceeds this is replaced progressively by dryer types of communities with *Molinia caerulea* and *Myrica gale* often becoming dominant. With increased aeration of the surface peat birch and Scot's pine may invade the bog, further speeding up the drying process. The net effect is a reduction in the variety of habitats, communities and species and the loss of the subtle nutrient and hydrological gradients which exist around the pools, streams and soaks.

Drying out as a result of cutting and drainage is invariably accompanied by fire so that it is impossible to distinguish completely between the effects of drainage and burning, but burning undoubtedly accelerates the changes.

Impact on the fauna

The impact of cutting and draining on the fauna is largely indirect through the changes exerted on the vegetation. The principal effects will be a decline in the communities associated with aquatic habitats and *Sphagnum* lawns and carpets. Work on Mongan bog (Tubridy 1988) indicates that the flowing water of drains cut into raw peat has little to offer aquatic invertebrates with only pond skaters (*Gerris*

sp.) able to exploit the habitat. The gradual drying out of the bog will increase the depth to which detritivores can penetrate, so speeding up the process of peat wastage. Lumbricids may also move in as soil conditions ameliorate. The unique faunal assemblages of soak systems will be lost as they slowly dry out.

Cut-away

The areas of hand cut-away revegetate relatively quickly but the original plant and animal communities and the unique and irreplaceable pollen record are all lost. Ironically cut-away is much richer in terms of species diversity, especially the fauna, but this is a reflection of the habitat diversity. The scrub provides a woodland habitat, the pools simulate fen and the areas are more sheltered and warmer. Tubridy (1984) has suggested that cut-away is analagous to the lagg of an intact bog, providing a habitat for adventive organisms which can range over the bog surface and provide food for, or act as predators upon, the true bog fauna. Cut-away therefore acts as a valuable buffer zone around the intact bog and its retention is important, not only to retain habitat and species diversity, but also to improve the chances of controlling the mire hydrology.

If cut-away is left undisturbed for a long enough period, and provided the conditions are sufficiently wet, raised bog communities will almost certainly regenerate. However, this must be considered as a very long term process i.e. many hundreds of years, and bogs cannot be considered as renewable resources and cut-away should not be thought of as a substitute for an intact bog.

AFFORESTATION

Afforestation is not a major land use activity on raised bogs in Ireland. Some of the impacts are similar to that of drainage which of course is an essential pre-requisite to planting. Increased evapotranspiration probably speeds up drying of the bog while application of fertilisers produces pronounced floristic changes with dwarf shrubs and grasses dominating the characteristic bog ecosystem species. The effect is essentially that of surface disruption i.e. destruction of the acrotelm, at least initially, rather than fundamental modifications of the catotelm, such as is caused by cutting.

The initial policy of afforestation of raised bogs was subsequently reversed (O'Carroll 1984) so that relatively few complete bogs have been damaged. On several sites, however, there are small plantations and the impact varies from one site to another. On some the planted area is obviously drying out: on others the impact of drainage has been slight and the ground remains wet. For example, on Shanville Bog, Co. Roscommon, *Sphagnum pulchrum* is still abundant under trees 3m tall. Unless the forest block is large the micro-climatic effects are likely to be slight but even small blocks might have deleterious effects on the attractiveness of the site for critical species, such as the Greenland white-fronted goose, while the trees provide habitat for predatory birds.

GRAZING

This is a rare land use practice on raised bogs because the substrate is unsuitable i.e. too wet or dried out and cracked: either state poses dangers to animals. It is only encountered occasionally and then invariably on bogs that have dried out as a result of fire and/or drainage e.g. parts of Redwood Bog, Co. Tipperary. The effect of grazing animals is to damage the bog surface further by 'poaching', and to cause nutrient enrichment.

OTHER LAND USE PRACTICES

a) Dumping of rubbish is a common practice around the margins of bogs, principally in old cut-away. It is usually done by individuals but in a few instances county council dumps adjoin bogs e.g. Rossagad Bog, Co. Laois. The impact on bog ecosystems is mostly indirect through fires which develop in the rubbish, particularly in official dumps. Dumping also leads to eutrophication of marginal drains and paper and plastic may be blown onto the bog.

b) One bog in Co. Tipperary, Arraghmore, is used to pipe slurry from an adjacent pig farm, a practice which has had profound effects on the ecology of the bog!

c) Shooting. As far as is known organized shooting no longer occurs on raised bogs, although in the past it was common, especially in the vicinity of large estates. Its decline will have reduced the incidence of regular and controlled burning which probably explains the decrease in numbers of grouse which is frequently reported by elderly local people. A relatively low level of shooting occurs on most bogs, the major impact of which is probably slight on most bird populations, but may be critical on certain species which are very sensitive to disturbance.

In conclusion, the impact of man on raised bogs results in the degradation and destruction of the ecosystem. At best occasional fires will alter the pattern and structure of vegetation and animal communities and lead to the local and temporary loss of certain species. At worst the combination of fire, drainage and cutting leads to the total disruption of the hydrology, the loss of the plant and animal communities and the eventual destruction of the peat body.

At present the loss of the communities, which attain their finest development in Ireland, is much more serious than the loss of individual species, for it is doubtful whether any one species occurring on the bog is currently under threat. However, given the rapid rate of destruction the distribution of many species is likely to decline rapidly. This applies particularly to species of pools and soaks which are most sensitive to desiccation. The cases of *Scheuchzeria palustris* and *Orthilia secunda* are, fortuitiously, well documented, but other previously unrecorded species, particularly invertebrates, may well have become extinct. It is interesting to note that *Sphagnum pulchrum*, often considered to be a 'western' species, was recorded by Osvald (1949) from a soak near Edenderry near the eastern limit of raised bogs. The new records reported by Douglas (1987), especially those from Westmeath, which appear to extend its range eastwards, may in fact just be filling in a gap in our knowledge of its real distribution, which has been disrupted by exploitation of the bogs.

PART 2

DETAILS OF THE SYSTEMATIC SURVEY

CHAPTER 7

METHODS AND RESULTS

In this section the methods and results of the survey are presented along with a detailed analyses of the data to give a 'State of the Nation' account of Ireland's raised bogs.

METHODS

Maps used in the An Foras Taluntais survey (Hammond 1979), aerial photographs and, to a limited extent, satellite imagery (Hogan 1984), were employed in a preliminary survey to locate bogs with an intact surface. These were identified in 14 of the 21 counties which originally contained raised bogs. A total of 223 sites were examined in the field but as the documentary evidence was about 10 years old many sites were found to have been destroyed or badly damaged. The following information was recorded for each site: flora; type and extent of principal vegetation communities; hydrological condition; type and extent of microtopographical features (e.g. pool systems, hummock and hollow complexes); area of intact surface; extent and type of damage and apparent threat to the site. The information was obtained from a general, relatively superficial survey involving walking over most of the bog surface. A more thorough examination was made of features such as soaks and pool complexes which are richer floristically, but resources did not permit a detailed assessment using transects or relevés. Nonetheless the general character of each site is documented accurately enough to enable an assessment of its conservation value to be undertaken. Details of the results of the survey are to be found in O'Connell and Mooney (1983), Douglas and Mooney (1984) and Douglas and Grogan (1985, 1986, 1987).

Following the field surveys each site was assessed initially using four criteria: size; hydrological condition; diversity of species and habitat; integrity. The bogs were classified into six site-quality categories, details of which are given in Table 9 below.

Those sites in Classes A and Bi are of high conservation interest. Class Bii represents more damaged sites from which it will be necessary to select nature reserves should no category A and Bi sites exist within a region — as for example in Co. Kildare. Class Biii sites are those which should be managed for conservation only after careful consideration, and which could be restored only with the input of significant resources. The scientific interest of classes C and D lies more in their potential for regeneration to a secondary bog or fen community. Given sufficient resources even these have significant wildlife potential and, in fact, in many cases it is sufficient to let natural vegetation succession follow its own course for such sites to re-develop an actively-growing wetland habitat. For the purposes of this report, however, these two classes are not considered further.

Data obtained from the survey are given in Tables 10 to 13 and Figures 10 to 12. The distribution of the various classes of bog are shown in Figure 2.

TABLE 9: Site quality categories for the classification of raised bogs.

Category	*Generalized site description*
A	Very good quality, or unique, sites. Hydrology relatively intact. Extensive wet, soft and often quaking areas. *Sphagnum* cover extensive. Wide diversity of vegetation communities and plant species, particularly those associated with wet habitats. Mainly intact or damage localized. If damage more extensive then site of exceptional interest.
Bi	Good quality sites. Hydrology damaged but not seriously. Wet, soft and quaking areas and *Sphagnum* cover less well developed than A. Damage similar to, or slightly more extensive than, A but sometimes badly burnt.
Bii	Moderate quality sites. Hydrology seriously damaged but restoration possible. Extensive dry areas but wet and soft areas still present. *Sphagnum* cover less extensive than A or Bi. Disturbance and damage more extensive particularly from marginal peat cutting or from drainage or repeated burning.
Biii	Poor quality sites. Hydrology very seriously damaged and restoration extremely difficult. Extensive dry areas, peat hard with little *Sphagnum* except for localized 'soft' spots. Extensive damage from cutting, drainage and burning.
C	Sites seriously damaged, largely from hand cutting. Very little intact bog surface left.
D	Sites drained and/or mechanically cut away or afforested over most of the area. All Bord na Móna developed sites fall into this class.

TABLE 10: Area (ha) and number of raised bogs according to site quality categories for each county.

	QUALITY CATEGORIES							
COUNTY	A		Bi		Bii		Biii	
TRUE MIDLAND	NO.	AREA	NO.	AREA	NO.	AREA	NO.	AREA
Cavan	—	—	—	—	1	80	—	—
Galway	3	746	2	204	6	566	5	419
Kildare	—	—	—	—	3	770	1	90
Laois	—	—	1	120	1	130	—	—
Leitrim	—	—	—	—	1	275	2	175
Longford	1	60	4	757	3	307	3	320
Offaly	3	1101	9	1930	6	773	4	299
Roscommon	—	—	1	154	3	553	3	760
N. Tipperary	3	547	4	885	3	371	—	—
Westmeath	1	165	1	105	7	973	5	372
Sub-total	11	2619	22	4155	34	4798	23	2435
WESTERN								
Clare	—	—	—	—	1	35	2	53
Galway	3	1615	7	921	13	2472	4	539
Kerry	—	—	—	—	2	172	1	80
Mayo	—	—	3	270	2	204	1	115
Roscommon	3	1499	4	601	2	242	2	257
Sligo	—	—	—	—	—	—	1	112
Sub-total	6	3114	14	1792	20	3125	11	1156
TOTALS	17	5733	36	5947	54	7923	34	3600
Mean area of bogs	337		165		146		105	

TOTAL AREA ALL CATEGORIES 23203

TOTAL NUMBER ALL CATEGORIES 141

MEAN AREA ALL CATEGORIES 164

TABLE 11: Area (ha) of raised bogs of conservation value in categories A + Bi in relation to the original area for each county. Addition of category Bii in brackets.

COUNTY	ORIGINAL AREA OF RAISED BOG (After Hammond 1979)	AREA OF INTACT BOG			
		ha		%	
Clare	6766	—	(35)	—	(0.5)
Cavan	7689	—	(80)	—	(1.0)
Galway	52894	3486	(6524)	6.6	(12.3)
Kerry	11000	—	(172)	—	(1.5)
Kildare	18473	—	(770)	—	(4.2)
Laois	10478	120	(250)	1.1	(2.4)
Leitrim	5876	—	(275)	—	(4.7)
Limerick	1853	—		—	
Longford	20527	817	(1124)	4.0	(5.5)
Louth	1012	—		—	
Mayo	28906	270	(474)	0.9	(1.6)
Meath	6638	—		—	
Monaghan	1073	—		—	
Offaly	47712	3031	(3804)	6.3	(8.0)
Roscommon	39796	2254	(3049)	5.7	(7.8)
Sligo	6662	—		—	
Tipperary	14964	1432	(1803)	9.6	(12.0)
Westmeath	26702	270	(1243)	1.0	(4.6)

TABLE 12 Area (ha) of different land uses on raised bogs.

LAND USE	AREA	
	Ha.	%
Developed by Bord na Móna	73,600	24
Developed privately	210,220 to 218,420	67 to 70
Afforested	6,300	2
'Intact' (A + Bi + Bii)	11,680 to 19,880	4 to 6

RESULTS

The results given below are an updating of the data given in Cross & Douglas (in press) and Cross (in press).

1. The most significant point to emerge from the survey is that no completely intact raised bog remains. All sites have been damaged to some degree by hand cutting, which at best has destroyed only the margins so that no intact lagg remains, and at worst has resulted in the total removal of the original surface. Further, all sites have been damaged to some degree by burning, usually in association with hand cutting.

2. There is a complete spectrum from very wet bogs, with well developed pool systems, soaks, etc. (e.g. Clara, Co. Offaly, Garriskil, Co. Westmeath) to dried out sites more closely resembling *Calluna* heath (e.g. Cloncumber, Co. Kildare). There is also considerable variation in the diversity of habitats, with some bogs having a more or less homogeneous surface and others showing considerable heterogeneity with, for example, pools, flushes, streams, dry ridges, etc. The least damaged sites are of national or international scientific interest.

3. Of the original area of c.310,000ha only c.23,000ha (7.4%) in 141 sites remain with an intact surface. However, only 12,000ha (3.8%) in 53 sites fall into the top two categories (A, Bi) and there are 7,900ha in 53 sites of category Bii bogs. This gives a total reservoir of 105 sites covering 19,900ha from which potential reserves, based on relatively undisturbed sites, could be selected (Tables 10 and 11). This represents 6.2% of the original area or 0.3% of the total land area of the country — a figure similar to the area remaining under ancient woodland which is generally acknowledged to have been decimated (Mitchell 1986, Cross 1987b).

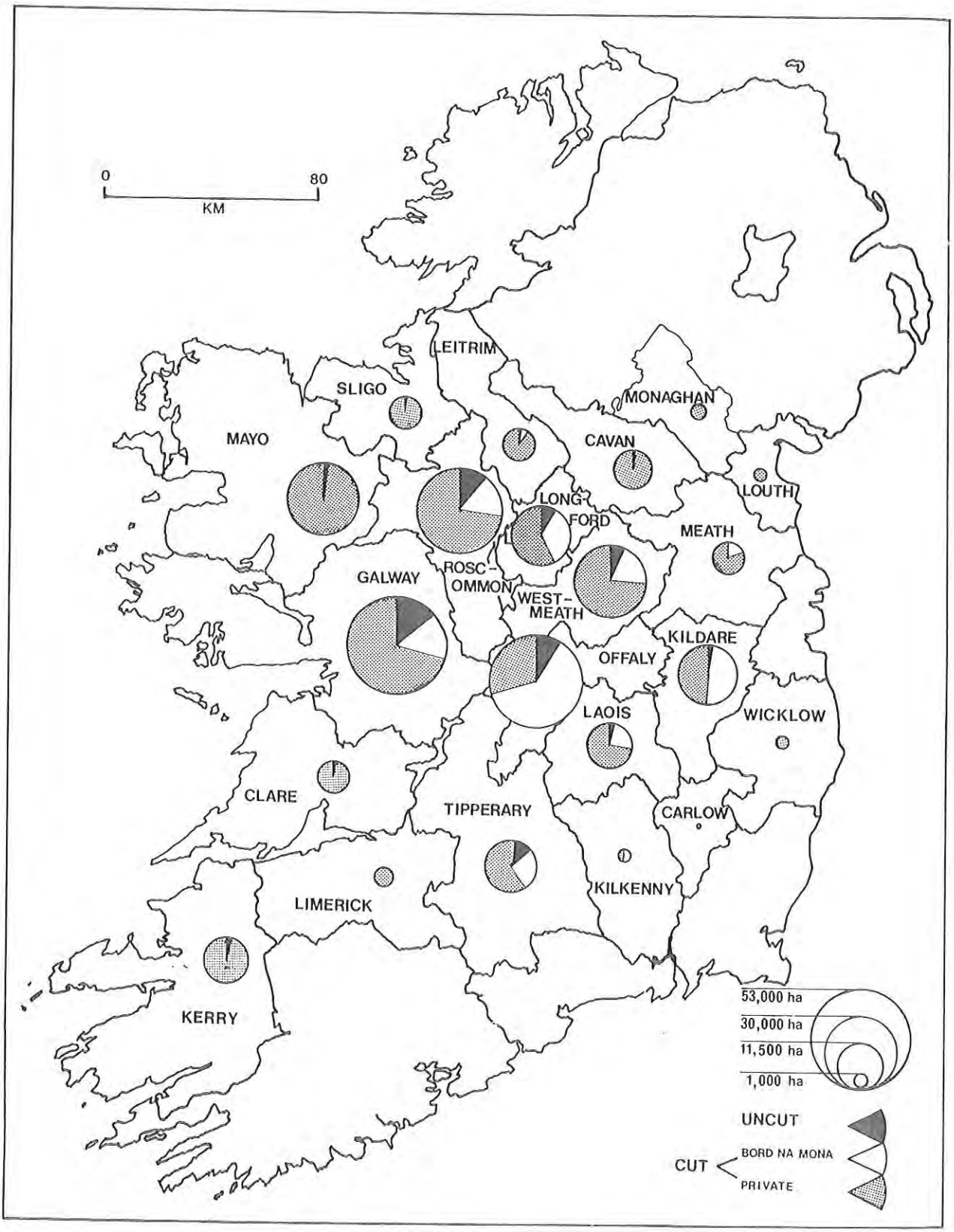

FIGURE 10: The distribution of raised bogs on a county basis, showing the original area (circles) and current land use (segments).

TABLE 13: Change in area (ha) of raised bogs 1974 to 1987
'Unmodified bog' 1987 represents categories A + Bi.
Addition of category Bii in brackets.

COUNTY	AREA OF 'UNMODIFIED BOG' (ha)			DECLINE IN AREA 1974 to 1987			
	1974		1987	ha		%	
TRUE MIDLAND							
Cavan	81	—	(80)	—		—	
Galway	3395	950	(1516)	2445	(1829)	72	(55)
Kildare	2529	—	(770)	2529	(1759)	100	(69)
Laois	2226	120	(250)	2103	(1976)	94	(87)
Leitrim	5018	—	(275)	5018	(4743)	100	(94)
Limerick	651	—	—	651	—	100	—
Longford	4537	817	(1124)	3720	(3413)	82	(75)
Louth	526	—	—	526	—	100	—
Meath	1319	—	—	1319	—	100	—
Monaghan	1073	—	—	1073	—	100	—
Offaly	7875	3031	(3804)	4844	(4071)	61	(51)
Roscommon	4682	154	(707)	4528	(3975)	96	(84)
Tipperary	2310	1432	(1803)	876	(507)	38	(21)
Westmeath	4793	270	(1243)	4523	(3550)	94	(74)
Sub-total	41015	6774	(11572)	34241	(29443)	83	(71)
WESTERN							
Cavan*	1922	—	—	1922	—	100	—
Clare	2412	—	(35)	2412	(2377)	100	(98)
Galway	7511	2536	(5008)	4975	(2503)	66	(33)
Kerry	2165	—	(172)	2165	(1993)	100	(92)
Leitrim	858	—	—	858	—	100	—
Mayo	2027	270	(474)	1753	(1553)	86	(76)
Roscommon	6600	2100	(2342)	4500	(4258)	68	(64)
Sligo	1445	—	—	1445	—	—	100
Sub-total	24940	4906	(8031)	20034	(16909)	80	(67)
TOTAL	65955	11680	(19603)	54275	(46352)	82	(70)

* The figures given by Hammond (1979) would appear to be erroneous as his accompanying map shows areas of bog which have not existed.

4. In terms of distribution there has been a contraction of intact bogs towards the centre of their range, i.e. the greatest concentration is now found in counties Roscommon, east Galway, west Offaly and the extreme north of Tipperary (Figure 10). Several counties on the edge of the range of raised bogs now possess no intact sites e.g. counties Limerick and Meath, and the Western sub-type in particular has suffered severely from cutting. The decline in the eastern counties is explained by their originally limited area (Louth had only 1,000ha). The decline in the west is more likely to be a result of formerly higher population densities, particularly during the nineteenth century, when the bogs were heavily exploited both for fuel and in attempts to expand the area of agricultural land. County Mayo, for example, originally had 29,000ha of raised bog of which, as a result of hand cutting, barely 1% remains intact.

   There is a tendency for the remaining bogs, particularly the least damaged sites, to cluster. This is most noticeable on the Galway/Roscommon border, around the northern end of Lough Derg and across central Offaly (see Figures 2 and 11).

5. Most intact bogs are under 200ha in extent and very few exceed 500ha (Figure 12). Most bogs over 200ha fall into the categories A and Bi. All the very large areas, some of which covered several thousand hectares, and which probably existed more or less intact until the formation of Bord na Móna, have now been cut away and many of the surviving sites are relatively isolated bogs in small basins which until recently had not been attractive for mechanical exploitation (See Figure 2).

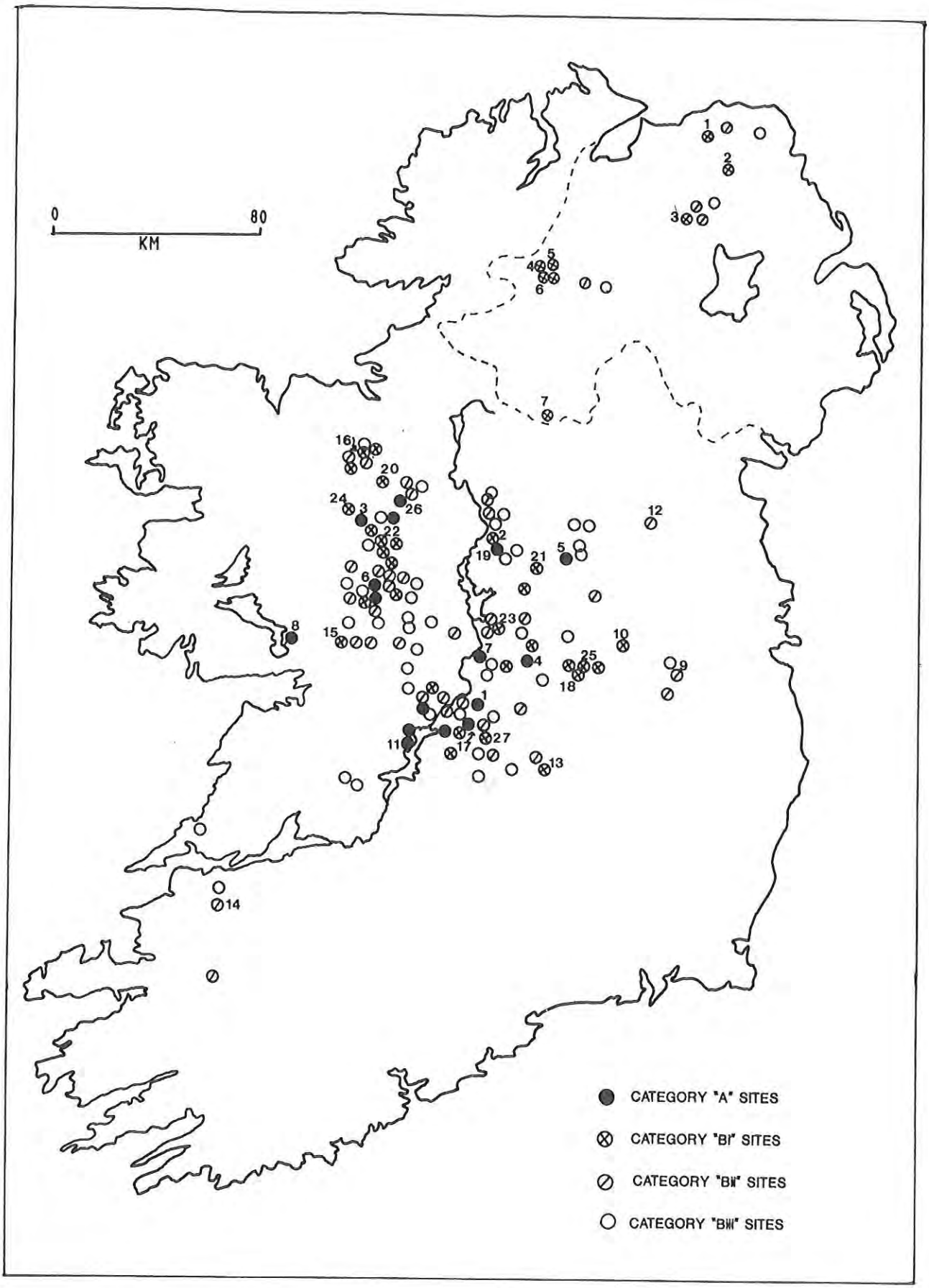

FIGURE 11: The distribution of remaining raised bogs with an intact surface based on site quality categories described in Table 9. Numbers refer to existing and proposed nature reserves listed in Table 15. Site quality classification for Northern Ireland is not exactly comparable with those for the Republic.

6a) *c.* 93% of the decline in the area of raised bogs is due to peat extraction and associated drainage, with 67% to 70% being attributable to hand cutting over a period of many centuries (Table 12). In the 40 years of its existence Bord na Móna has exploited 24% of the total area and has concentrated on the very large bogs, although in recent years it has moved onto smaller bogs. Private machine cutting is now replacing traditional hand cutting to an increasing extent and, in places, co-operatives are cutting turf on a commercial basis. This poses a threat to small isolated bogs which are unattractive to Bord na Móna. Private mechanized development has been assisted by grant aid under the 1981 Turf Development Act. During the period 1982 to 1986 25,556ha were approved for assistance with grants totalling IR6.1m (Bord na Móna, annual reports). (This financial assistance has recently stopped).

b) Drainage and cutting go hand in hand on most sites but arterial drainage, directed at improving agricultural land, has unintentionally affected a few sites where peat cutting is relatively insignificant e.g. Raheenmore Bog, Co. Offaly in the Blackwater catchment, Shrubbywood Bog, Co. Westmeath in the Inny catchment.

c) Fire has affected all sites resulting in the typical macro-mosaic of vegetation structure. In parts of some bogs, however, fire has not occurred for many years so that the vegetation structure is well developed and there is a rich lichen flora e.g. Mongan Bog, Co. Offaly (Tubridy 1984), Garriskil Bog, Co. Westmeath. At the opposite end of the scale otherwise intact bogs have been burnt so frequently that the acrotelm has been largely destroyed e.g. Cadamstown Bog, Co. Offaly.

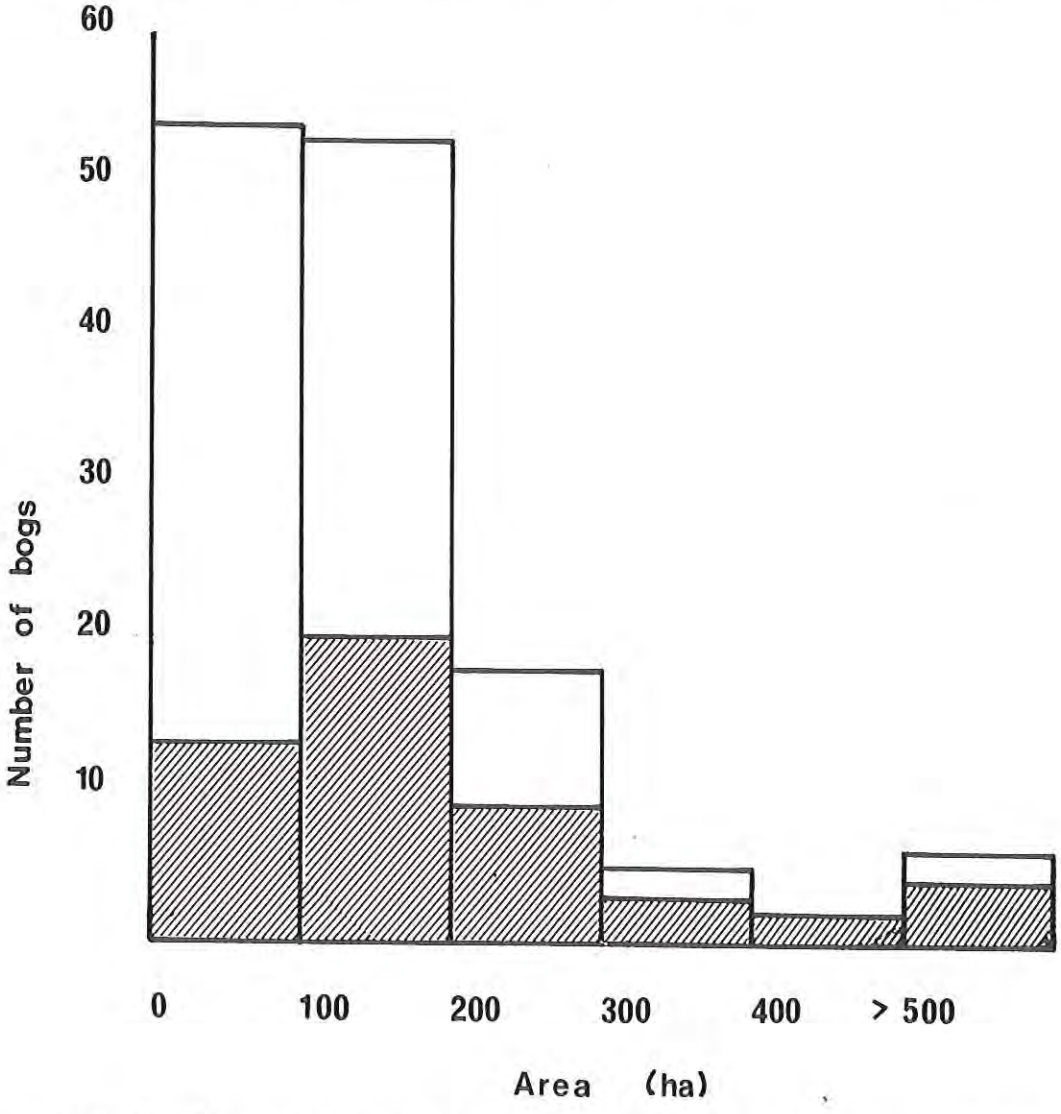

FIGURE 12: The number of raised bogs in relation to area(ha) of intact surface. Shaded areas represent category A and Bi sites.

d) Afforestation has affected only a small percentage of the total area of bog (Table 12). Several sites have small plantations e.g. Arraghmore Bog, Co. Tipperary, Shanville Bog, Co. Roscommon but their impact appears to be slight and restricted, probably because the bogs are very wet and the drainage inadequate. On other, drier sites, afforestation has compounded damage caused by cutting and drainage e.g. Ballynafagh, Co. Kildare.

e) Other land use practices have had only minor impacts on the bog.

7. By comparing the figures given by Hammond (1979) with those obtained from this survey it is possible to estimate the decline in area of intact bog over the period 1974–87, and to estimate future trends (Cross 1985).

Here the differences in the two surveys need to be examined in order to understand the limitations in comparing the data. In his classification of peatlands Hammond (1979) recognised two major physiographic groups: man-modified and non man-modified. Non man-modified bogs were defined as those with more than 66% of their surface intact, even if dried-out. Man-modified bogs were defined as those of which 33% or more of the topographic unit had been cut away even though the remainder might still include an ecologically significant bog unit. In contrast the data presented here are based on an ecological classification (Table 9). However, it is still possible to compare the data if it is assumed that those areas which were dried out in 1974, but classified as non man-modified are balanced by those areas which were wet but classified as man-modified. For the purposes of this paper therefore Hammond's total 'non man-modified' area is taken as being more or less synonymous with the total 'intact' area cited here. This may give rise to some distortions, especially in predicting trends, but the overall picture is unlikely to be grossly misleading.

Assuming that all of the non man-modified bogs fall into the A and B categories there has been a 64.4% decline in the area of non man-modified bog during the 13 year period 1974 to 1987. However, as category Biii represents grossly modified sites, this figure tends to under-estimate the extent of destruction and a more accurate picture from a conservation viewpoint is obtained if categories A + Bi and A + Bi + Bii only are considered (Table 13). On this basis the area of raised bog which has suffered relatively little disturbance can be taken as being between 11,680ha and 19,880ha, representing between 17.7% and 30.0% of the non man-modified area in 1974. Of these areas 6,800ha–11,600ha are of the True Midland sub-type and 4,900ha–8,000ha are of the Western sub-type. The greatest decrease in percentage terms occurred in those counties with the smallest areas in 1974 i.e. those on the periphery of the range of raised bogs, but the greatest actual decrease occurred in those counties affected by the third development programme of Bord na Móna i.e. counties Galway, Offaly and Roscommon.

The decline in counties Clare, Kerry, Leitrim and Mayo is particularly large and it is possible that the figures are distorted by the comparative problems between the two surveys discussed above. However, there is appreciable private cutting in these counties so that the figures may well reflect accurately the extent of cutting.

Tipperary is rather anomalous in that the decline is much less than for any other county. There is no obvious reason for this but the bogs in the North Riding are somewhat removed from the main centre of Bord na Móna operations, yet nonetheless there is easy access to a supply of fuel peat. This may have discouraged local private development. Bogs in the South Riding were developed before 1974.

8. At the above rates of decline of c.3,500ha per year, and allowing for the difficulties in comparing the two sets of data as already discussed, it is projected that all relatively undisturbed bogs of the True Midland sub-type will have been seriously damaged by between 1990 and 1993, and those of the Western sub-type between 1991 and 1994 (apart from the few sites currently receiving some degree of protection).

These figures are in close agreement with predictions made by Ryan and Cross (1984) and Cross and Douglas (in press) with the exception of 'extinction dates'

for the Western sub-type, which have been brought forward by between 1 and 3 years. This difference is attributable to the collection of more precise data for several western counties during the intervening period.

The rapid rate of loss is further illustrated by an examination of lists of proposed nature reserves compiled by Ryan and Cross (1984), Bellamy (1986) and Foss *et al.* (1987). All authors list eleven sites, and in the case of the last two authors most sites are also listed in Table 15, but in the case of those listed by Ryan and Cross (*op. cit.*) several sites have been severely damaged in the interim period.

A list of the 141 remaining raised bogs with an intact surface giving their location, quality and area is to be found in Appendix 2. These sites are also shown in Figure 11 which should be examined in conjunction with Figure 2.

A brief resumé of the situation in each county is given in Appendix 1.

Northern Ireland

Recent surveys in Northern Ireland have shown an even worse picture of the destruction of raised bogs. The Northern Ireland Peatland Survey (Cruickshank and Tomlinson, 1987) estimated that only 2,270ha of lowland peatland remained intact from an original total of 25,196ha. This was based on the most recent aerial photographs available, but these were of varying age and further losses are known to have occurred in the interim period. It is likely that less than 2,000ha of intact raised bog now remain. A ground survey of raised bogs was initiated by the Countryside and Wildlife Branch, Department of the Environment (N.I.) in 1985 (Leach and Corbett 1987; Weyl, Leach and Corbett, in press). A total of 57 sites were investigated; of those which had not been completely cut-over the mean area was 30ha with only 7 bogs having an intact surface of 50ha or more. Subsequently, more comprehensive surveys have confirmed these results.

With such small remnants it is not surprising that most bogs lack well developed hummock, hollow and pool systems, although a few retain partially intact laggs (principally in the Main Valley in Co. Antrim). As in the Republic, much of the destruction is a result of cutting and drainage, although there have been few equivalents to the extensive mechanised cutting undertaken by Bord na Móna.

A provisional list of eight sites, since reduced to seven following more recent survey work, were identified as being of national or international importance. One of these — Ballynahone Bog, Co. Derry is to be commercially exploited for horticultural peat following a public enquiry in 1987. Two sites (Garry and Dunloy bogs in Co. Antrim) have been declared Areas of Special Scientific Interest under the Nature Conservation and Amenity Lands Order (N.I.) 1985. The remaining sites at Moninea, Co. Fermanagh and in the Fairy Water Valley Complex, Co. Tyrone, are as yet unprotected but it is anticipated that they will be designated in the near future.

Another two raised bogs have also been identified as being of national or international importance but these fall into the category of upland raised bogs within blanket bog complexes and are outside the scope of this report.

PART 3

CONSERVATION: RATIONALE, REQUIREMENTS AND PROBLEMS

CHAPTER 8

WHY CONSERVE RAISED BOGS?

Peatlands are usually thought of as wastelands (they are often referred to as such by Bord na Móna) to be 'improved' for agriculture or forestry, or as a fuel resource. This attitute has led to the current state of affairs where only *c.* 7% of the original area of raised bogs remains with an intact surface, and only about half of this is wet bog closely resembling the original undamaged ecosystem. Why not exploit this remaining fraction? Why conserve valuable fuel supplies which are otherwise apparently useless? The arguments for conservation have been stated by numerous authorities e.g. Moen (1973), Barry (1976), Goodwillie (1980), Doyle (1983), Maltby (1986) and are summarized below:

1. Ireland's oceanic raised bogs are the most important remaining in Europe and are probably the most extensive of their type in the world. They occupy an important position in the continuum of peatlands across Europe (and in fact the Northern Hemisphere). This re-inforces our national and international obligation to conserve examples as part of the natural heritage of Ireland and in the wider context of Europe.

2. As part of the biosphere they are inextricably linked to other ecosystems. This linkage may be local or regional, as for example in the water flowing from bogs to supply mires and lakes downstream, or international, for example migratory birds using the bogs as roosting/feeding/breeding sites. In this context Ireland has an international obligation to protect certain species of bird under the EC Bird Directive and the Berne and Ramsar Conventions, both of which have been ratified by Ireland.

   Peatlands are an important 'sink' for carbon and play an important role in buffering atmospheric carbon dioxide levels. This carbon is released into the atmosphere when the peat is burnt or oxidized by drying out and methane is also released. While it would be overstating the case to argue that conservation of our remaining raised bogs would have a major impact on the levels of these gases in the atmosphere, the current concern over the 'greenhouse effect' on world climates suggests that their importance should not be ignored. The balance of natural systems, near the limit of their tolerance, can be tilted very easily the wrong way by a minor change in any one factor.

3. Peatlands are unique in that they accumulate information, in the form of dust, pollen and macro-fossils, on the contemporary environment, and as such provide an irreplaceable record of the past. It is from this that a detailed chronology of the Quaternary period, including climatic and vegetational changes and the activities of man, has been established. They have also recorded major geological and 'cultural' events such as volcanic eruptions and the beginning of the industrial revolution. As such they are valuable baselines against which to measure environmental changes e.g. air quality, and their total destruction would mean the loss of a priceless 'living archive', one which, once lost, can never be replaced even though the bog may eventually re-grow.

4. Plants and animals inhabiting bogs are adapted to extremely inhospitable conditions of wetness, acidity and exposure. They are therefore an important genetic resource of possible value to humanity, for example as a source of pharmaceuticals or for modifying the genetic properties of other existing or potential crop species. Complete destruction of our raised bogs will greatly

reduce the genetic diversity of this resource, if not actually result in the extinction of certain species within Ireland. One plant species (*Scheuchzeria palustris*) has already become extinct and another species (*Orthilia secunda*) is now confined to Northern Ireland (Curtis and McGough 1988).

5. They can be used as outdoor laboratories for studying plants and animals in their natural environment, and for detailed research into the biological and physical processes operating within them. This is true of course of any ecosystem, but peatlands have characteristics related to their poor nutrient supply which make them of particular interest and importance. The loss of bogs elsewhere in western Europe means that Irish bogs are attracting increasing numbers of European scientists who recognise their value.

6. Last, but by no means least, the aesthetic and 'wilderness' value of raised bog landscapes must not be ignored. They are a unique feature of the Irish landscape found nowhere else on the same scale in Western Europe, and providing the last remnants of 'wilderness' in an otherwise profoundly man-modified landscape. In this respect they are a valuable tourist attraction.

CHAPTER 9

CONSERVATION REQUIREMENTS

The purpose of this survey was to assess the extent and quality of raised bogs with the objective of identifying those areas which should be conserved. The survey results reveal a far greater extent and rate of development, and consequently destruction in conservation terms, than had been anticipated. All the extensive sites, many of which existed until 40 years ago or less and which contained a great range of variation, have been destroyed. Those remaining are merely remnants of these huge systems, lacking their variety and extent and often severely damaged. Moreover the rate of destruction is such that a number of sites examined during the course of this survey have already been further damaged or destroyed.

On the other hand the survey has shown that even in their truncated form very important raised bogs still remain. They are the most extensive semi-natural ecosystems in the midlands after the River Shannon, containing a great wealth of genetic material, archives of past environments and human activity and providing natural laboratories for research and education. As a result of the destruction of this bog type in other countries their global significance has increased so that there is both a national and international obligation on Ireland to ensure the conservation of representative examples of the remaining bogs.

The total area of peatland which should be conserved in Ireland should take into account the extent of the ecosystem, their national and international importance as well as practical considerations relating to conflicts of land use. As Goodall (1983) has pointed out they are in many respects one of the most difficult of ecosystems to conserve because of the need to maintain hydrological integrity. This is particularly acute with raised bogs as it can only be achieved by conserving the complete basin, including the adjacent mineral soil. This will be difficult even for relatively small sites such as Raheenmore Bog, Co. Offaly but it will be even more difficult for large sites such as Clara Bog, Co. Offaly or Cloonmoylan Bog, Co. Galway,which are surrounded by cut-away and a plethora of land owners. Indeed it may be necessary to settle for less than the entire basin initially in the hope that a smaller but still hydrologically viable unit can be conserved in the interim.

Some indication of the area to which we should aspire to conserve can be obtained by a consideration of the area of protected land in other countries. This is not easy because of the difficulties of comparing the variety of protection categories. Nonetheless, it does provide some guidelines, however imperfect.

Data from most member states of the Council of Europe (1984) shows that the area protected in each of 18 countries ranges from 0.8% to 10.2% of the total area of the country with a mean of 3.2% (Ireland has by far the smallest protected area). Van Eck *et al.* (1984) give figures for the protected area of virgin peatlands in nine European countries showing a range of 0.1% to 3.1% with a mean of 1.3%. Finland, which has 3% of its land area protected, has 70,000ha of peatland conserved (0.7% of its total peatland area and 0.2% of the country), and the objective is to conserve ten times that amount (Salminen in press). In Norway c.200 mire reserves have been established and it is hoped to increase this number to c.300 (Moen pers. comm.) covering between 2% and 4% of the total mire area (Moen 1979). Estonia has 122,200ha of its peatlands protected representing 13% of its total peatlands and 2.7% of the country (Masing 1984). In the Netherlands, where most of the peatlands have been destroyed, c.7,700ha are conserved (Anon 1987). This represents 2.7% of the original area or 0.2% of the total land area.

It should be remembered that the figures given by the Council of Europe are for existing protected areas and the objective in most countries is considerably higher. However, a realistic minimum figure for all ecosystems would be the Council of

Europe mean of 3.2% of the land area. This accords closely with the figures of '. . . . nearly 4% of the Earth's land area . . . . managed explicitly to conserve species and ecosystems . . . .' given by the World Commission on Environment and Development (1987). These figures are higher than the 2.3% given by Neff (1984) but this figure was arrived at on the basis of incomplete surveys and should undoubtedly be revised upwards.

What area of our peatlands therefore should be conserved? Given that they are extensive ecosystems their area in relation to the total protected area should be proportionally high, as Finland is quite clear in recognising. Doyle (1983) suggests 0.85% of the original raised bog area, but this is considered to be too small to incorporate the variation which exists. If the Finnish objective of 7% of the original peatland area were adopted the area of raised bogs to be conserved would be c.22,000ha. This is roughly equal to the total area of more or less intact bog remaining. However desirable it might be to conserve this area it is an unrealistic target as a large proportion would be extremely difficult, and require considerable resources, to conserve. Taking the Council of Europe mean of 3.2% would give a figure of c.10,000ha, close to the total A+Bi category bogs of 11,680ha. This represents c.50% of the remaining intact bog area and is a reasonable, though ambitious, minimum objective. Given that the area must include marginal cutaway and a certain amount of mineral land in order to conserve the entire basin, then appreciably more than 10,000ha is required.

THE SELECTION OF SITES

The process of evaluating and selecting sites for conservation purposes has been the subject of many studies e.g. Ratcliffe (1977), Wright (1977), Lockhart (1987) and there is no general agreement as to the most reliable method. In many ways site quality classification is an art, rather than a science, and is based on a series of value judgements, the success of which may be gauged by the strong level of agreement by independent observers. In practice there is usually little difficulty in recognizing the best and worst sites, but it is more difficult to draw up a priority list for the large number of sites of intermediate quality.

The selection process outlined here is based almost entirely upon botanical and physiographic criteria and it is recognised that the fauna, particularly the invertebrates, has been almost totally ignored because there is inadequate information available. However, the method is relatively simple and quick and it must be viewed against the background of a shortage of man-power and other resources and the need for quick decisions in the face of the rapid rate of destruction. If too much time is spent debating the relative merits of sites the chances are that there will be none left to conserve by the time a decision is made!

The principal objective of a conservation strategy for peatlands is to establish a network of nature reserves which would include examples of all the mire types in all climatic 'regions' of the country. The raised bogs selected should incorporate the natural variation occurring within them, take cognisance of the east-west gradient in climate, include both exceptional and typical sites and sites of particular floristic and faunistic value.

Ideally sites for potential nature reserves should be selected by using quantitative methods to analyse the data in order to give a truly objective basis to the survey results. However, limitations of man-power and time for the necessary field work made such methods totally impractical, while the nature of the exercise, which needs to combine both scientific and pragmatic criteria, renders a purely quantitative approach of dubious value. The selection process used has been one of a series of steps with the placing of badly damaged sites to the bottom of the priority list, followed by comparative analyses and judicious selection of the remaining areas. While this is essentially a subjective process an attempt has been made to ensure that it is not totally haphazard.

The first step was the initial classification into six groups described in Table 9. The next step was to select those sites which, by virtue of one or more attributes, were considered unique, or of such importance that their conservation is considered essential. These are the 'red flag' sites of Larsen (1976) which are often selected intuitively by a number of independent observers. Seven such sites have been

selected including such well known bogs as Clara, Co. Offaly, with its series of soaks, and previously 'unknown' sites such as All Saint's Bog, Co. Offaly with its unique birch woodland and Garriskil Bog, Co. Westmeath with its remarkable pool system.

In the third step all bogs falling into the A and Bi initial assessment categories were ranked on the basis of a numerical evaluation. The method used was a modification of that of Wright (1977) and seven criteria were used: hydrology, integrity, habitat diversity, relationship with other sites, rare and protected species, size and recorded history. The scoring system for each criteria is explained in Table 14. Hydrology is considered critical to the survival of a bog and the total score for each site has therefore been weighted by multiplying the sum of the other six criteria by the score for hydrology.

The total possible score is 124 but the chances of any one site possessing all the rare species and the complete range of habitat diversity is remote. The top two sites, Carrowbehy Bog, Co. Roscommon and Lough Lurgeen Bog, Co. Galway, scored 84 and 78 respectively. Both are 'red flag' sites and it is of interest to note that five of the seven such bogs fell into the top 10 sites.

Ranking sites in this manner should be used only as a guide to site selection rather than as a means of producing a hard and fast list, for other factors must be taken into account. One of the most important is the representativeness of the sites along the east-west rainfall gradient across the country, and the fourth step in site selection was to select sites along this gradient. As already noted, the bogs tend to cluster in certain parts of the country, but the 'red flag' sites are fairly evenly spread across the country. There are, however, numerous gaps especially on the periphery of the zone of raised bogs. Four sites were selected in this step: Addergoole and Monivea in central Galway, as representatives of the more westerly bogs, Blackcastle in east Offaly as one of the most easterly bogs and Cloonmoylan, Co. Galway, as the best example of the more southerly bogs.

TABLE 14: Scoring system for criteria used in the evaluation of raised bogs.

1. HYDROLOGY
   - Apparently undamaged 4
   - Slightly damaged 3
   - Moderately damaged 2
   - Seriously damaged 1

2. INTEGRITY
   - More or less intact 4
   - Slightly damaged 3
   - Moderately damaged 2
   - Seriously damaged 1

3. HABITAT DIVERSITY
   One point scored for each of the following:
   Undifferentiated bog; quaking bog; pool systems; lakes; flush; flush with stand of trees; soak; flowing water; swallow hole; dry ridge; marginal fen.
   Maximum possible score = 11.

4. PROTECTED AND RARE SPECIES
   Presence of Greenland White-fronted Goose 2
   (Protected under the EC Bird Directive)
   One point scored for each of the following species:
   Vaccinium vitis-idaea
   Sphagnum pulchrum
   S. recurvum var. *tenue*
   Cephaloziella elachista
   Cladonia rangiferina
   Maximum possible score = 7.

5. RELATIONSHIP WITH OTHER SPECIES
   - Parts of a complex of inter-related sites 3
   - Associated with one other site 2
   - Isolated site 1

6. SIZE OF INTACT DOME
   - 250 ha 3
   - 100–250 ha 2
   - 100 ha 1

7. RECORDED HISTORY
   - Well documented 3
   - Limited information available 2
   - Information unavailable but unexplored 1

The total score for each site is obtained by multiplying the sum of criteria 2 to 7 by criterium 1.
Maximum possible score = 124.

This still leaves gaps in the distribution especially on the eastern and south-western margins. In order to select sites in these areas it was necessary to consider Bii quality sites i.e. bogs requiring considerable rehabilitation, as no A or Bi quality sites occur in these regions. The number of potential sites is so small that a numerical evaluation was not considered necessary, site selection being relatively straight-forward and based on a combination of scientific and pragmatic criteria. Three sites, one each in Kerry, Kildare and on the Cavan/Meath border were selected.

The final step was to select another 10 or so sites to bring the total potential protected area close to the objective of 10,000ha. In selecting these sites pragmatic criteria, such as location relative to towns, proximity to other sites and the need for duplication in case of serious damage to a site, were also considered. An attempt was made to spread the sites across the gradients but not to the extent of ignoring the natural tendency to cluster.

The list of priority sites selected is given in Table 15 and their distribution is shown in Figure 11. The areas given are approximate and represent the intact dome only, so that the total falls well short of 10,000ha. However, in all cases peripheral cut-away is required in order to maintain hydrological integrity and inclusion of this will bring the total close to 10,000ha. This list should be considered the

TABLE 15: List of raised bogs selected for inclusion in a nature reserve network.

a) REPUBLIC

'Red Flag' Sites	*County*	*Grid reference*	*Area (ha)* (excluding marginal land)
1. All Saint's**	Offaly	N 010 110	305
2. Ballykenny/Fisherstown	Longford	N 080 780	520
3. Carrowbehy**	Roscommon	M 570 935	276
4. Clara*	Offaly	N 260 300	465
5. Garriskil**	Westmeath	N 360 670	165
6. Lough Lurgeen**	Galway	M 660 590	1100
7. Mongan*	Offaly	N 030 306	136
Representative Sites			
8. Addergoole	Galway	M 310 340	310
9. Ballinafagh	Kildare	N 810 280	127
10. Blackcastle	Offaly	N 580 350	170
11. Cloonmoylan	Galway	M 780 000	530
12. Kilconny	Cavan	N 680 832	80
13. Knockacolla**	Laois	S 310 910	120
14. Moanveanlagh	Kerry	R 045 350	136
15. Monivea	Galway	M 543 350	156
16. Tawnabeg	Mayo	G 585 040	82
Other sites			
17. Ballyduff/Clonfinane	Tipperary (N)	N 000 030	307
18. Brown	Longford	N 095 760	60
19. Callow	Roscommon	M 680 960	258
20. Clontymullen**	Westmeath	N 265 660	390
21. Corliska	Galway	M 670 740	300
22. Crosswood**	Westmeath	N 085 405	105
23. Derrinea	Roscommon	M 545 885	51
24. Raheenmore*	Offaly	N 440 320	190
25. Shanville	Roscommon	M 750 910	123
26. Sharavogue	Offaly	S 040 980	180
		TOTAL	6642

* Existing nature reserves
** Substantial areas owned by Bord na Móna

b) NORTHERN IRELAND

1. Garry	Antrim	C 938 298	55
2. Dunloy	Antrim	H 035 196	60
3. Ballinahone	Derry	H 860 980	105
4. Bomackatal	Tyrone	H 338 773	54
5. Claragh	Tyrone	H 353 764	40
6. Kilmore Robinson	Tyrone	H 312 790	30
7. Moninea	Fermanagh	H 300 210	25
			369

TABLE 16: Areas of raised bog owned by conservation organisations.

SITE	AREA (ha)	ORGANISATION
Clara, Co. Offaly	465	Wildlife Service
Mongan, Co. Offaly	136	An Taisce
Raheenmore, Co. Offaly	162	Wildlife Service
Redwood, Co. Tipperary	165	Wildlife Service
	928	

minimum requirement. A brief description of each site is given in Appendix 3. Alternative sites and additional sites for longer term consideration can be selected from those listed in Appendix 2 as well as those sites which have been largely cut-away but which could be allowed to redevelop.

The Irish Peatland Conservation Council (Foss *et al.* 1987) has compiled a list of 11 raised bogs which it believes should be conserved. All but one are included in the list in Table 15a, the exception, Ardgraigue bog, having been seriously damaged in the interim.

To complete a network of reserves throughout the island account should also be taken of the remaining raised bogs in Northern Ireland. The principal sites of interest surveyed by the Countryside and Wildlife Branch of the Department of the Environment for Northern Ireland are also indicated in Figure 15, and a list of sites is given in Table 15b.

CURRENT PROTECTION STATUS

The remaining intact raised bogs are mostly privately owned, usually by a large number of individuals but occasionally by small companies or co-operatives. Some areas are owned by the Land Commission and turbary plots leased to individuals. Bord na Móna own part of some of the larger remaining intact bogs, their normal pattern of acquisition being to leave a margin of peat for private cutting. It is their intention to develop these bogs at some future date. Coillte Teoranta (the Irish Forestry Board) owns small areas on several bogs.

The number of sites owned by conservation organisations is small and totals only 928ha. The fee simple is held on 73ha of one site. The sites are listed in Table 16. Three of these, Clara Bog and Raheenmore Bog, owned by the Wildlife Service, and Mongan Bog, owned by An Taisce, are nature reserves. Except for Raheenmore Bog parts of all the bog surfaces are privately owned. In all cases the boundaries fail to incorporate all the marginal land (cut-away and mineral soil) which is required to ensure a) hydrological integrity and b) that the threat from drainage and/or turf cutting is removed. All the sites require remedial work to restore areas damaged by cutting and drainage.

The area of Redwood Bog, Co. Tipperary owned by the Wildlife Service is only part of an extensive bog, large parts of which have been cut away. However, the intact portion remains wet and its proximity to the Little Brosna callows and its use as a roosting/feeding site for Greenland white-fronted geese, justifies its designation as a nature reserve. However, its long term survival is particularly uncertain and it should not be considered as an alternative to any of the sites listed in Table 15.

All 141 sites listed in Appendix 2 are designated as Areas of Scientific Interest and maps, together with an accompanying index, have been circulated to all relevant authorities such as County Councils, Bord na Móna, Department of Agriculture and Food. However, designation of a site as an Area of Scientific Interest carries no legal status and they are not protected, as is borne out by the number of sites which were listed by An Foras Forbartha (1980) and whose original bog surfaces have subsequently been destroyed (Table 17). Provision of grant aid for development under the 1981 Turf Development Act greatly speeded up destruction of sites and in fact several sites are known to have been damaged since this survey began (Table 18). While this financial incentive has now been removed in many cases it has provided 'seed' money for acquisition of equipment for draining and cutting so that further development will continue.

All remaining unprotected bogs must be considered therefore as being under imminent threat of destruction.

TABLE 17: Raised bogs listed by An Foras Forbartha (1980) as areas of scientific interest, subsequently destroyed or seriously damaged.

Co. Cavan	
Cloghbally (Kilconny)	N 68 83
Co. Galway	
Ahascragh	M 84 40
Island Causk	M 80 49
Pollboy	M 86 29
Killaclogher	M 55 40
Tiaquin	M 57 35
Co. Kildare	
Carbury	N 68 63
Prosperous	N 83 29
Co. Laois	
Ballaghmore	S 18 89
Bush	S 39 94
Cloonadadoran	S 47 92
Monettia	N 35 15
Rossagad	N 44 04
Co. Longford	
Cloondara	N 08 74
Cloonshinnagh	N 30 75
Co. Meath	
Bogtown	N 60 43
Doolystown	N 75 51
Girley	N 70 70
Mt. Hevey	N 63 48
Co. Offaly	
Ballycumber	N 16 39
The Derries	N 10 06
Co. Roscommon	
Bogs beside R. Suck	M 84 43
Co. Tipperary North	
Monaincha	S 18 88
Co. Westmeath	
Carranstown	N 64 54

TABLE 18: Sites on which significant development is known to have occurred since being surveyed by the Wildlife Service.

Co. Galway	*Co. Offaly*
Ardgraigue	Barnaboy
Barroughter	Clara
Moorfield	Monasset
Co. Kildare	*Co. Tipperary*
Ballina	Clonfinane
	Redwood
Co. Longford	Scohaboy
Fisherstown/Ballykenny	
	Co. Westmeath
	Garriskil

CHAPTER 10

PROBLEMS OF SITE ACQUISITION

The field surveys to identify raised bogs of conservation value represent the first phase in the process of establishing potential nature reserves. The second and consequential phase — acquisiton and protection — will undoubtedly prove harder to implement than the first because of two major constraints: availability of sites and availability of financial and manpower resources.

AVAILABILITY OF SITES

Land ownership patterns

The difficulties of acquisition and/or protection of sites, most of which are in multiple ownership, are daunting. Few, if any bogs are in the hands of one owner and most are owned by numerous individuals or organisations. These include

a) Bord na Móna, who may own the greater part of a bog e.g. Carrowbehy, Co. Roscommon, or only a few hectares.

b) The Land Commission, who own the turbary rights or fee simple on numerous bogs in parcels ranging in size from a fraction of a hectare to over 100ha.

c) Private companies who are actively exploiting a few sites.

d) Coillte Teoranta (The Irish Forestry Board), who own small blocks on a few bogs.

e) Large numbers of individuals who represent the principal landowners. In places they have formed co-operatives to exploit the peat more effectively.

In addition the Wildlife Service owns the greater part of three bogs, and a small part of one other, and An Taisce own most of Mongan Bog, Co. Offaly.

The main problem associated with e) above stems from the fragmentation of holdings dating back to the eighteenth and nineteenth centuries. Even a small bog may have several owners (e.g. Scragh Bog, Co. Westmeath, 16ha, 8 owners) and on a large bog such as Clara, there may be over 100 people who own, or have turbary rights on, the bog (H. Huggard, Bord na Móna, pers. comm.). Frequently there are also disputes between owners over boundaries and rights which further compound the problems, and in some cases land ownership is uncertain.

Bord na Móna have been able to surmount these difficulties by the use of compulsory purchase powers. While such powers exist under the Wildlife Act there is a reluctance to enforce them on the grounds that conservation can only succeed with the support of local communities: compulsory purchase orders may be counterproductive by generating ill-will and tend to be used only as a last resort.

Under the Wildlife Act protection can be effected only by acquisition or on the basis of management agreements. Given the problems of land tenure either process is likely to be slow and difficult and management agreements can probably be considered as impractical in all but exceptional cases and even then only as a 'holding' arrangement until acquisition can be effected. Acquisition is likely to be on a piece-meal basis and although the choice is limited the list of sites in Table 15 should not be considered immutable as it may be prudent to conserve an alternative, comparable site. Availability should therefore be another criterion to consider in selecting sites. In the case of 'red flag' sites however, there are no alternatives and every possible effort should be made to secure them for conservation.

The multiplicity of landowners is indicative of the competing interests for the bogs. Twenty years or so ago the interest in exploiting the bogs was far less than today. Hand cutting, while destructive, proceeded at a much slower pace and there is little doubt that sites could have been obtained relatively easily and inexpensively. The energy crisis of the early 1970s changed that and today the pressure to exploit the resource is intense. The third development programme of Bord na Móna has led to the exploitation of increasingly smaller bogs and they currently own substantial parts of several sites of high conservation interest which they plan to develop (Table 15a). The increasing interest in horticultural moss peat is a particular threat to the wetter remaining bogs.

Mechanisation of private cutting

The development of small-scale machinery has greatly increased the extent and speed of private cutting. Bogs which had been abandoned for decades have, as a consequence, been re-opened for development, assisted by grants for equipment and roading. Private cutting by individuals is increasingly being replaced by contract labour, while small co-operatives are harvesting peat on a commercial basis. A machine can cut drains the full length of a bog in a few days whereas formerly hand cutting merely nibbled away at the edges.

Mechanised, private development would be acceptable up to a point if it was undertaken in a rational or planned manner. Turf cutting, however, is exempt from planning control and is totally disorganized and haphazard in national planning terms. As a consequence there is hardly a bog in the country on which development is not taking place at present and as the predictions in Chapter 7 indicate those few currently more or less untouched are unlikely to remain so for long.

Once development activity has begun then the cost of acquisition increases, for the developer will look for compensation for development costs, the loss of peat and/or the cost of relocation. The longer the delay in conserving sites the greater will be the pressure on a diminishing resource and the more difficult and expensive will be both acquisition and eventual management.

AVAILABILITY OF RESOURCES

Lack of funding for land acquisition in the past has been the major obstacle to the conservation of raised bogs. To date approximately IR£1m has been spent on the purchase of raised bogs by the State. This figure should be compared with the money available for development. Bord na Móna, which is the largest single body concerned with developing peatlands, had an average annual turnover for the 6 years up to 1988 of IR£110.0m, ranging from IR£91.67m in 1982/83 to IR£116.1m in 1987/88. There was a surplus of IR£16.0m in 1982/83 and a deficit of IR£16m in 1986/87 following two exceptionally wet summers. This was reduced to IR£3.3m in 1987/88.

Under the 1981 Turf Development Act grant aid was provided to private turf cutters by the Department of Energy. Over the 5 year period 1982/83 to 1986/87 IR£6.15m was paid out for the development of 25,600ha. This included funds provided by the EC. This amount is equivalent to IR£240 per hectare, approximately a quarter the current land price for raised bogs. It should be noted that the area developed by this means is over twice the area that it is hoped to conserve and greater than the total area of remaining 'intact' bog. Although private development has concentrated on old cut-away, major works on 'intact' bogs have been undertaken also

In order to obtain the necessary funding for conservation the following sources need to be considered:

1. Central Government. Provision of an acquisition budget for the purchase of peatlands is essential. The amount needs to take account of the urgency of the situation. For sites of ornithological interest funding from the EC is obtainable (see below) but for most sites little or no alternative finance is available.

2. Local Government. Relevant county councils may be interested in contributing to the conservation of sites, thus improving the tourist/heritage interest of the

county. However, at present most county councils would probably not have adequate resources for this type of development which they may view as being in conflict with job creation.

3. European Community. Funds are currently available for bird sites under the Council Regulation on Action by the Community relating to the environment (2242/87 EC) and money has been provided for a few sites. However, this only applies to those raised bogs that are of ornithological importance (principally for the Greenland White-fronted goose). Funding may be available in future following implementation of the 'Draft directive on the protection of natural and semi-natural habitats and wild fauna and flora'. EC funding is normally granted on the basis of matching finance from the State or non-government organisations.

4. Bord na Móna and other development agencies. These organisations could be asked for donations of money or land as a form of 'compensation' for their development of the bogs. Given the current financial situation in Bord na Móna however, it is unlikely that this will prove a lucrative source of funds.

5. Sponsorship from companies. These could be approached for outright donations, or donations tied to, say, advertising rights. However, private industry and businesses are in receipt of large numbers of such requests and it is doubtful whether appreciable funds would be obtained.

6. Non-Governmental organisations. Unlike many other countries non-governmental conservation organisations in Ireland are small and poorly funded. The principal organisation concerned with peatland, the Irish Peatland Conservation Council, is increasing awareness of our bogs through its educational and publicity campaigns and is also raising funds for land acquisition. In this latter exercise it is supported by the Dutch Foundation for the Conservation of Irish Bogs, who have raised about IR£100,000. This represents a considerable achievement for a voluntary body, but it would only buy one moderately sized raised bog.

Finally, an acquisition programme of the magnitude required for the adequate protection of this resource will necessitate a considerable input of manpower. This will be needed not only for discussions with land owners on the ground, but also for the associated administrative and legal procedures involved in the sale and purchase of land.

PART 4

CONCLUSIONS AND RECOMMENDATIONS

A. IMPORTANCE OF IRELAND'S RAISED BOGS

1. Ireland's raised bogs are on the verge of extinction. Unless urgent steps are taken to conserve the few remaining intact examples we will witness, over the next 5 years or so, the final destruction of an irreplaceable resource which has taken over 8,000 years to develop.

2. Ireland's raised bogs are part of our national and European heritage. They are of international scientific importance for their distinctive plant and animal communities, which are a genetic resource, as an archive of past environments and as the finest examples of their type in Europe and probably the world.

3. Only 23,000ha, or 7.4% of the original area of raised bog remains with an intact surface and only 3.8% is of the highest scientific interest. Approximately 3,500ha are developed each year and at this rate of decline all remaining unprotected sites of scientific interest will be seriously damaged by 1994.

4. The three existing nature reserves are inadequate to represent the range of variation which occurs in the country.

Recommendations

The national and international importance of our raised bogs should be acknowledged and immediate steps taken to protect additional sites if this vital resource of biological, archaeological, cultural and touristic value is not to be lost. To this end a *minimum* of 10,000ha, representing 3.2% of the original area, should be conserved. A list of sites recommended for conservation is given in Table 15, page 62. Particular attention must be focussed on sites 1 to 7 in this Table.

B. RESOURCES

1. The principal obstacle to conserving the necessary area of raised bogs is the lack of resources, both financial and man-power, for acquisition and management in comparison with the resources available for development.

2. Several important sites are in imminent danger of being seriously damaged from existing or pending developments.

3. Delay in protection will increase the eventual cost of acquisition of sites which, in the meantime, will have been damaged. This, in turn, will result in increased management costs.

Recommendations

Adequate funding is essential for the conservation of raised bogs within the next five years in order to meet the target of conserving 10,000ha. Immediate protection is required for certain sites to prevent further deterioration and greater future costs. Additional resources of man-power are also required for an acquisition programme and for future management. As they form part of our European heritage Ireland should ensure that relevant EC aid is obtained for their protection and that other EC aid is not used to damage this resource.

C. ACQUISITIONS

1. Land ownership patterns on raised bogs are very complex with most being owned by a combination of a multitude of private landowners, Bord na Móna

and the Irish Land Commission. This makes acquisition extremely complicated, slow and labour intensive so that sites are likely to be destroyed or seriously damaged before they can be conserved.

2. The recent emphasis on developing the moss peat sector in Bord na Móna, and the increasing private mechanized exploitation pose a major threat to remaining bogs, particularly the wetter sites which are of greatest conservation interest.

Recommendations

A moratorium should be imposed on all further developments by state or semi-state organisations affecting bogs of scientific interest until a conservation strategy has been agreed. In addition there should be no further use of EC funds for exploitation of such bogs. Turbary rights held by the Irish Land Commission should be transferred to the Wildlife Service who could retain areas of scientific interest and use the remainder to relocate turf cutters from more sensitive sites.

In certain circumstances the use of compulsory purchase powers, which exist under the Wildlife Act, should be implemented.

D. PROTECTION OF EXISTING RESERVES

The three existing reserves are not adequately protected at present as the marginal land is not conserved. Consequently they do not represent an intact hydrological entity and development around the periphery could threaten their survival.

Recommendations

The necessary additional land around the periphery of the existing nature reserves must be conserved in order to have control over the hydrology of the bogs.

E. RESEARCH

1. Raised bogs can only be conserved on the basis of a thorough understanding of their hydrology so that proper management techniques can be implemented. Failure to undertake the correct management may result in the gradual destruction, through desiccation, of existing and future reserves.

2. Our knowledge of other aspects of the management of raised bogs is also inadequate, and information on their importance for fauna, especially invertebrates, is lacking.

Recommendations

Detailed research into the hydrology of raised bogs must be undertaken in order to understand how they function and how they should be managed for conservation. Research into other aspects of raised bog management should also be undertaken. Additional information is required on the fauna, especially invertebrates.

F. SITE REHABILITATION

1. 10,000–20,000ha of Bord na Móna cutaway will have significant wildlife potential if flooded to form lakes, or allowed to regenerate to fen or secondary bog communities once the peat resource is exhausted.

2. Bogs cut away largely by hand or by piece-meal mechanical means develop a mosaic of secondary vegetation types. These are of considerable wildlife interest but they should not be regarded as substitutes for intact bogs.

Recommendation

An immediate decision should be taken to allocate suitable areas of Bord na Móna cut-away for conservation purposes, before all such land is allotted to afforestation, agriculture or other commercial purposes. Areas cut away largely by hand should also be acquired for conservation purposes as resources and suitable sites become available.

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APPENDIX I

CONSPECTUS OF BOGS ON A COUNTY BASIS

Cavan
The original area of raised bogs was small and mostly in inter-drumlin hollows. Only one site, straddling the Louth border, remains. This is the most north-easterly bog left in the country, but is is being actively cut.

Clare
Raised bogs occurred in two areas: small bogs in the undulating lowlands east of Tulla and an extensive tract near Kilrush at the mouth of the Shannon (Monmore Bog). All bogs have been largely cut away leaving a few very small remnants.

Galway
Galway originally had the most extensive area of raised bog of any county. Bord na Móna have developed areas around Ahascragh and Attymon and very extensive areas have been cut away by hand. An eighth of the bogs remains with intact surfaces including representatives of the True Midland and Western sub-types. There are 15 A and Bi category bogs including several exceptional sites e.g. Lough Lurgeen, Addergoole and Cloonmoylan.

Kerry
The bogs are scattered occurring principally in the Listowel and Castleisland areas. They have been largely cut away by hand but Moanveanlagh is important as the most south-westerly example of a raised bog.

Kildare
Extensive raised bogs occurred in the west of the county around Allenwood and Athy. These were some of the first bogs to be exploited by Bord na Móna and all but a few small areas have been developed. Those which have not been cut by Bord na Móna have been severely damaged by hand cutting leaving only three sites which it might be possible to conserve as representative of the most easterly raised bog remaining.

Kilkenny
Only small areas of bog occurred in the county and these have all been cut away.

Laois
Extensive bogs occurred in the north-east of the county especially in the Portlaoise/Mountmellick area. Bord na Móna have exploited most of these leaving only two with an intact surface, one of which, Knockacolla, is the most southerly example of the True Midland sub-type remaining.

Leitrim
A relatively small area of Leitrim contains raised bogs, mostly intercalated between drumlins, except close to the Shannon. Only three bogs remain with intact surfaces and these are of poor quality.

Louth
The very small area of bog which once occurred has been entirely cut away.

Longford
Extensive areas of peat occur in the west and south of the county, the larger deposits having been exploited by Bord na Móna. Several intact areas of high quality remain although some of the larger ones, e.g. Clontymullen, are scheduled for development. Several sites west of Longford town, e.g. Brown Bog, are of exceptional interest.

Mayo
Very extensive areas of raised bog occurred in eastern Mayo but except for a few very small areas they have all been cut away by hand. Much of this destruction is old but mechanised harvesting is threatening some of the remaining intact sites which are of considerable value as examples near the western limit of raised bog development.

Meath
The relatively small area of raised bog which originally occurred in this county has been almost entirely cut away by hand.

Offaly
The county with the second most extensive area of raised bog with some very extensive complexes. All the large areas have been developed by Bord na Móna to feed four power stations and two briquette factories. The largest remaining example of the True Midland sub-type, Clara Bog, occurs in the county, as do several other very important sites. The three raised bog nature reserves in the country all occur in Offaly.

Roscommon
Third in importance after Galway and Offaly. The bogs are concentrated in the south and north-west with a gap in the centre where a l ow limestone plateau occurs. All the southern (True Midland sub-type) bogs have been badly affected by Bord na Móna activities but several very good examples of the Western sub-type occur in the north-west e.g. Carrowbehy, Shanville.

Sligo
The original area in Sligo was small and only one site remains with an intact surface and this is badly damaged.

Tipperary
Two zones of raised bog occur in Tipperary: an extension of the Offaly bogs in the extreme north and the corridor of bogs running south from Roscrea to Killenaule. This latter has been exploited by Bord na Móna and private companies and no intact bogs remain. The bogs in the north are more isolated and several very good examples remain more or less intact e.g. Ballyduff/Clonfinane.

Westmeath
Extensive raised bogs occur in this county and Bord na Móna have exploited most of the larger sites in the east and south. Hand cutting has damaged most of the remainder but there are a few good quality sites, including Garriskil bog.

APPENDIX 2

LOCATION, QUALITY AND AREA OF REMAINING RAISED BOGS

Site	Grid Ref.	Area (ha)	Site No. (& ½" O.S. Map No.)	Survey Year	Source+
CAVAN					
Category Bii					
Kilconny	N 68 83	80	(13) 652	1986	D & G
CLARE					
Category Bii					
Monmore	Q 95 62	35	(17) 75	1987	D & G
Category Biii					
Ayle Lower	R 54 83	28	(17) 76	1987	D & G
Loughanilloon	R 56 82	25	(17) 77	,,	,,
GALWAY: True Midland Raised Bogs					
Category A					
Ardgraigue	M 83 14	80	(15) 436	1984	D & M
Barroughter	M 79 03	136	(15) 35	1983	O'C & M
Cloonmoylan	M 78 00	530	(15) 37	,,	,,
Category Bi					
**Kilnaboris	M 97 17	117	(15) 432	1984	D & M
Moorfield	M 86 16	87	(15) 434	,,	,,
Category Bii					
Ballygar	M 78 53	122	(12) 424	,,	,,
*Castlefrench E.	M 77 46	80	(12) 417	,,	,,
Cloonoolish	M 83 15	64	(15) 438	,,	,,
Crit Island W.	M 75 35	102	(15) 427	,,	,,
*Keave	M 76 45	72	(12) 416	,,	,,
Meneen	M 90 12	126	(15) 428	,,	,,
Category Biii					
Killure Castle	M 82 33	100	(15) 453	,,	,,
Capira/Dereew	M 85 10	52	(15) 435	,,	,,
Coxtown	M 78 22	90	(15) 430	,,	,,
Eskerboy	M 79 17	135	(15) 429	,,	,,
Castlegar	M 70 47	42	(12) 425	,,	,,
GALWAY: Western Raised Bogs					
Category A					
Addergoole	M 31 34	310	(14) 521	1985	D & G
**L. Lurgeen	M 66 59	1100	(12) 51	,,	,,
Corliska	M 67 74	300	(12) 53	,,	,,
**Curraghlehanagh	M 68 54	205	(12) 422	1984	D & M
Category Bi					
**Shankill W.	M 63 52	80	(12) 420	1984	D & M
*Kilmore	M 74 55	90	(12) 53	,,	,,
Monivea	M 54 35	156	(14) 522	,,	,,
L. Namucka	M 61 73	180	(11) 516	,,	,,
Cloonfellev	M 65 74	55	(12) 510	,,	,,
Bracklagh	M 65 70	60	(12) 512	,,	,,
Category Bii					
*Carrownagappal	M 67 50	355	(12) 423	1984	D & M
L. Tee	M 59 36	329	(14) 49	,,	,,
Raford River	M 62 29	194	(15) 411b	,,	,,
Derrynagran	M 57 52	43	(11) 519	1985	D & G
*Camderry	M 70 57	185	(12) 515	,,	,,
*Kilsallagh	M 67 67	230	(12) 55	,,	,,

Site	Grid Ref.	Area (ha)	Site No. (& ½" O.S. Map No.)	Survey Year	Source+
Cloonmore	M 56 63	270	(11) 58	,,	,,
*Clooncullaun	M 70 59	133	(12) 513	,,	,,
*Funshin	M 71 60	130	(12) 514	,,	,,
*Lisnageeragh	M 63 65	285	(12) 54	,,	,,
*Leaha	M 71 58	65	(12) 52	,,	,,
Moorfield	M 64 74	69	(12) 511	,,	,,
*Kelloges	M 68 62	184	(12) 57	,,	,,
Category Biii					
*Aughrim	M 78 56	170	(12) 523	,,	,,
Cloonarkin	M 55 56	90	(11) 525	,,	,,
Killaclogher	M 55 41	210	(14) 524	,,	,,
Derrinlough	M 64 74	69	(11) 518	,,	,,
KERRY					
Category Bii					
Moanveanlagh	R 04 35	136	(17) 71	1987	D & G
Anna More	R 00 05	36	(20) 74	,,	,,
Category Biii					
Gabbets	R 03 40	80	(17) 73	,,	,,
KILDARE					
Category A	None				
Category Bi	None				
Category Bii					
Mouds	N 78 12	550	(16) 21	1982	FWS
Ballynafagh (Blackwood)	N 81 28	127	(16) 314	1983	O'C & M
Ballina	N 70 42	140	(16) 32	1983	O'C & M
Category Biii					
Hodgestown	N 80 30	90	(16 322	1983	O'C & M
LAOIS					
Category A	None				
Category Bi					
**Knockacolla	S 31 91	120	(15) 344	1983	FWS
Category Bii					
Coolrain	S 26 91	130	(15) 319	1983	O'C & M
LEITRIM					
Category A	None				
Category Bi	None				
Category Bii					
Aghnamona	N 06 87	275	(12) 63	1986	D & G
Category Biii					
Rinnagown/Corracrump	N 07 90	120	(12) 653	,,	,,
Cashel	N 08 90	55	(12) 654	,,	,,
LONGFORD					
Category A					
Brown Bog	N 09 76	60	(12) 616	,,	,,
Category Bi					
Ballykenny Bog	N 02 79	130	(12) 614	,,	FWS, D&G
Fisherstown	N 07 77	114	(12) 615	,,	D & G
**Clontymullen	N 26 66	390	(12) 620	1984	,,
Williamstown	N 22 56	223	(12) 622	1986	,,

Site	Grid Ref.	Area (ha)	Site No. (& ½" O.S. Map No.)	Survey Year	Source+
Category Bii					
Derrymore	N 15 72	107	(12) 212	1982&86	FWS, D&G
Mt. Jessop	N 12 70	90	(12) 213	,,	,,
Clooneen	N 07 84	110	(12) 64	1986	D & G
Category Biii					
Cloonageeher	N 10 85	157	(12) 612	,,	,,
Forthill	N 06 59	78	(12) 69	,,	,,
Annaghcooleen	N 09 83	85	(12) 613	,,	,,
MAYO					
Category Bi					
Tawnabeg	G 58 04	82	(7) 644	,,	,,
Flughany	G 60 06	91	(7) 645	,,	,,
Derrynabrock	G 56 03	97	(7) 649	,,	,,
Category Bii					
Gowlaun	G 56 04	154	(7) 646	,,	,,
Kilgarrif	G 57 03	50	(7) 647	,,	,,
Category Biii					
Derrykinlough	G 59 05	115	(7) 643	,,	,,
OFFALY					
Category A					
Clara	N 26 30	660	(15) 345	1983	FWS
Mongan	N 03 30	136	(15) 346	,,	AT, FWS
**All Saint's	N 01 11	345	(15) 52	1985	FWS
Category Bi					
Raheenmore	N 44 32	190	(15) 25	1982	FWS
Woodfield	N 26 35	150	(15) 26	,,	,,
**Barnaboy	N 43 29	400	(15) 34	1983	O'C & M
Sharavogue	S 04 98	180	(15) 310	,,	,,
**Ferbane	N 11 25	160	(15) 321	,,	,,
Kilduff	N 46 32	140	(15) 324	,,	,,
**Monasset	N 40 31	440	(150 327	,,	,,
Black Castle	N 58 35	170	(16) 53	1985	FWS
Cloghan Demesne	N 96 12	100	(15) 78	1987	,,
Category Bii					
**Cadamstown E.	N 21 09	157	(15) 315	1983	O'C & M
**Cadamstown W.	N 20 09	256	(15) 316	,,	,,
**Clonlyon	N 09 28	100	(15) 318	,,	,,
Clonydonnin	N 12 33	100	(15) 629	1986	D & G
Kilballyskea	S 07 92	70	(15) 323	1983	O'C & M
**Moyclare	N 08 24	90	(15) 328	,,	,,
Category Biii					
Screggan	N 28 19	54	(15) 347	1983	FWS
Cangort	S 03 93	84	(15) 317	,,	O'C & M
**Derries	N 12 07	120	(15) 320	,,	,,
Barna	S 04 88	41	(15) 313	,,	,,
ROSCOMMON: True Midland Raised Bog					
Category A	None				
Category Bi					
**Corbo	M 94 69	154	(12) 461	1984	D & M
Category Bii					
Ballynamona	M 94 43	81	(12) 472	,,	,,
*Cloncraff/Cloonlarge	M 95 63	220	(12) 471b,c	,,	,,
Derrycanan	M 90 72	253	(12) 462	,,	,,
Category Biii					
Ballyforan	M 83 46	80	(12) 448	,,	,,
Ballynahowna	M 75 90	77	(12) 441	,,	,,
Carrickynaghtan	N 03 37	603	(15) 41	,,	,,

Site	Grid Ref.	Area (ha)	Site No. (& ½" O.S. Map No.)	Survey Year	Source+
ROSCOMMON: Western Raised Bog					
Category A					
**Bellanagare	M 72 87	1100	(12) 455	,,	,,
*Shanville	M 75 91	123	(12) 440	,,	,,
**Carrowbehy	M 57 83	276	(11) 520	1985	D & G
Category Bi					
*Callow	M 68 96	158	(12) 444	1984	D & M
*Cloonchambers	M 63 80	207	(11/12) 445	,,	,,
Trien	M 65 76	185	(12) 517	1985	D & G
Derrinea	M 54 88	51	(11) 651	1986	,,
Category Bii					
Bella Bridge	M 75 95	166	(12) 454	1984	D & M
Cornaveagh	M 75 95	76	(12) 439	,,	,,
Category Biii					
Tullaghan	M 78 96	50	(12) 442	,,	,,
Drumalough	M 62 83	207	(11/12) 457	,,	,,
SLIGO					
Category Biii					
Cloongoonagh	G 44 07	112	(7) 650	1986	D & M
TIPPERARY (N. Riding)					
Category A					
Ballyduff	N 01 03	120	(15) 33	1983	O'C & M
Clonfinane	M 99 03	187	(15) 36	,,	,,
Firville	M 95 01	240	(15) 38	,,	,,
Category Bi					
Arraghmore	M 98 02	280	(15) 31	,,	,,
Kilcarren	M 93 02	200	(15) 39	,,	,,
Scohaboy	R 96 92	240	(15) 28	1982	FWS
Redwood	M 94 11	165	(15) 349	1983	,,
Category Bii					
Monaincha	S 17 89	150	(15) 348	,,	,,
Ballymacegan	M 92 11	80	(15) 312	,,	O'C & M
Killeen	N 02 03	141	(15) 325	,,	,,
WESTMEATH					
Category A					
**Garriskil	N 36 63	310	(12) 636	1986	D & G
Category Bi					
*Crosswood	N 08 40	105	(15) 627	,,	,,
Category Bii					
Carn Park	N 11 42	208	(15/12) 630	,,	,,
**Cloonbonny (Bunnahinly)	N 06 39	190	(15) 215	1982/86	FWS/D&G
Wooddown	N 48 54	140	(12) 624	1986	D & G
Ballynagrenia	N 21 42	128	(12) 632	,,	,,
Tullycross	N 07 42	74	(12) 631	,,	,,
Shrubbywood	N 39 71	109	(12) 640	,,	,,
*Cloncrow (New Forest)	N 40 38	124	(15) 329	1983/86	FWS/D&G
Category Biii					
Clareisland	N 42 81	76	(12) 638	1986	D & G
Mayne	N 39 72	75	(12) 642	,,	,,
Moneybeg	N 45 81	86	(12) 639	,,	,,
Nure	N 36 44	68	(12) 634	,,	,,
Ballinderry	N 20 41	67	(12) 638	,,	,,

+ *Sources:* O'C & M O'Connell and Mooney; D & M Douglas and Mooney; D & G Douglas and Grogan } [See list of references]
FWS Surveys conducted by FWS staff
AT An Taisce

* Sites partly acquired by Bord na Móna, some listed for development.
** Sites planned for development, extensive areas acquired by Bord na Móna.

APPENDIX 3

DESCRIPTION OF RAISED BOGS SELECTED FOR INCLUSION IN A NATURE RESERVE NETWORK (SEE TABLE 15)

1. *All Saint's, Co. Offaly.* The only known example of a raised bog in Ireland possessing an extensive, wet birch wood across the centre of the dome. It is a wet bog with well developed hummocks, shallow pools and *Rhynchospora alba* flats and it is an important feeding and roosting site for Greenland White-fronted geese which frequent the adjacent callows (floodplain) of the Little Brosna River. Bord na Móna plan to develop the bog.

2. *Ballykenny/Fisherstown, Co. Longford.* The best remaining examples of flood-plain bogs, this complex grades into callows along the Camlin and Shannon Rivers and is utilised by Greenland White-fronted geese. Parts of the surface are very wet, although damage has been caused by burning.

3. *Carrowbehy, Co. Roscommon.* A very wet, Western sub-type inter-drumlin bog with several small soaks, lakelets and well developed pools and hummocks. It grades into fen alongside the River Suck and into incipient blanket-bog vegetation on the marginal drumlin. It is very rich in plant species.

4. *Clara Nature Reserve, Co. Offaly.* The largest remaining example of the True Midland sub-type. It contains the finest examples of soak systems remaining in Ireland and well-developed hummock and hollow complexes. The eastern part has been damaged by attempts to drain it, but restoration is now in progress.

5. *Garriskil, Co. Westmeath.* An exceptionally wet bog, used by Greenland White-fronted geese, with well developed pools, large hummocks and a small soak system. It is surrounded by old cut-away which is regenerating to fen and secondary bog communities. It is under threat from private development and Bord na Móna.

6. *Lough Lurgeen, Co. Galway.* A large and complex example of the Western sub-type. It possesses a range of features including pool complexes with large hummocks, a spring-fed lake draining into a stream, several flushes, and oligotrophic fen. At its north-west end it grades into a turlough. It is a feeding and roosting site for Greenland White-fronted geese.

7. *Mongan Nature Reserve, Co. Offaly.* This bog lies between two parallel esker ridges. It is very wet with very well developed pool systems. Parts of it have not been burnt for many years and it possesses a rich lichen flora. It is the most intensively studied raised bog and is owned largely by An Taisce.

8. *Addergoole, Co. Galway.* The most westerly raised bog. Although extensively cut around the margins the intact area is still large and it possesses a well developed soak system. Its value is enhanced by its proximity to L. Corrib and the marginal fen.

9. *Ballynafagh, Co. Kildare.* One of the most easterly raised bogs. It contains a wet central section but there is extensive marginal cutting and a forestry plantation on one side which should be removed. It is relatively close to Dublin and has good educational possibilities.

10. *Blackcastle, Co. Offaly.* The most easterly raised bog after Ballynafagh still reasonably intact. It is wet, has good *Sphagnum* cover and small *S. cuspidatum* pools, although rather uniform. It is much less damaged than Ballynafagh, although there is extensive cut-away on the northern and eastern sides.

11. *Cloonmoylan, Co. Galway.* A large, rather flat bog with several flushes containing patches of birch scrub and an underground stream with swallow holes. The northern part of the bog is relatively dry with localized wet, quaking areas but the central and southern parts are extremely wet with extensive *Sphagnum/Rhynchospora alba* flats. Much of the surface is quaking with pools and abundant *S. pulchrum.*

12. *Kilconny, Co. Cavan.* The only remaining bog in the north-east and one of the most easterly sites in the country. There is a typical flora despite damage from burning. There is extensive cutting around the margin which has almost bissected the bog. Considerable remedial action will be required to rehabilitate the site

13. *Knockacolla, Co. Laois.* The most southerly of the True Midland sub-type and the only one south of the Slieve Blooms still intact. The central part is wet with pools and good *Sphagnum* growth. The southern and eastern margins have not been seriously damaged but the northern and western margins are extensively cut-away. Proper management would almost certainly improve the site. Bord na Móna plan to develop the bog.

14. *Moanveanlagh, Co. Kerry.* The most south-westerly raised bog in the country still reasonably intact, an important link with lowland blanket bog and one of the very few remaining in the vicinity of the Shannon estuary. It will require considerable restoration work to the margins which are being cut away.

15. *Monivea, Co. Galway.* The second most westerly raised bog still possessing intact surfaces after Addergoole. Although affected by cutting on the eastern side it contains very wet areas with pools, *Sphagnum* carpets, a small lake and a soak system.

16. *Tawnabeg, Co. Mayo.* The most north-westerly raised bog still in reasonable condition. It has extensive wet areas with pools and a central *Molinia* flush grading into old fenny meadows.

17. *Ballyduff/Clonfinane, Co. Tipperary.* A complex of bogs containing well developed pool systems and flushes with small stands of trees. In places the margins are relatively intact.

18. *Brown, Co. Longford.* A small bog confined within a small basin. The margins are reasonably intact and the bog is very wet with well developed pool systems, hummocks and hollows and a small flush in which there appears to have been a peat flow.

19. *Callow complex, Co. Roscommon.* Two bogs bordering Lough Gara and separated by the Lung River. The larger has been badly damaged by fire but has good pool systems on the top of the dome and a series of diffuse flushes draining towards the lake. Marginal cutting is mostly old. The smaller bog is rather uniform but remarkably intact with the lake and river margins undamaged. It has several pool systems and grades into fenny fields on the western side.

20. *Clontymullen, Co. Longford.* An extensive bog with several domes, one of which is badly damaged. The intact area is wet and varied with good hummock and hollow complexes, pools, flushes and possibly a bog burst. Rationalization of cutting will be required to conserve the site which is planned for development by Bord na Móna.

21. *Corliska, Co. Galway.* A large, wet bog with good pool systems and a complex flush system at the north-west end including a small birch stand. It has

similarities to Shanville but is generally less quaking. Most of the margins are damaged and in particular require restoration in the vicinity of the flush.

22. *Crosswood, Co. Westmeath.* A relatively isolated bog and the most northerly of the central midland group. Although relatively small and cut away extensively on the south side much of the intact part is very wet and quaking and the north and west sides are not seriously damaged.

23. *Derrinea, Co. Roscommon.* A small but very wet bog close to Cloonagh Lough. It is surrounded on two sides by the River Anaderryboy and the margins here are intact. There are well developed pool systems, a small lakelet and dry ridge. Marginal cutting is not too serious so far but a new drain has been excavated on the western side.

24. *Raheenmore nature reserve, Co. Offaly.* A rather uniform bog with a good *Sphagnum* cover. It occupies a relatively isolated but very deep basin and is well documented. Marginal drains threaten to cause it to dry out further and these need to be blocked at an early date.

25. *Shanville, Co. Roscommon.* A very wet bog with well developed *Sphagnum* carpets and soak/flush system. *S. pulchrum* is abundant. The flush expands into a fen on the eastern side. There are three small blocks of forest (one badly burnt) but these have not had a major impact on the bog.

26. *Sharavogue, Co. Offaly.* A flood plain bog in the valley of the Little Brosna River. It is largely intact and grades into woodland and callows alongside the river. However, it has suffered severe damage from burning which must be controlled in order to ensure regeneration of the surface.