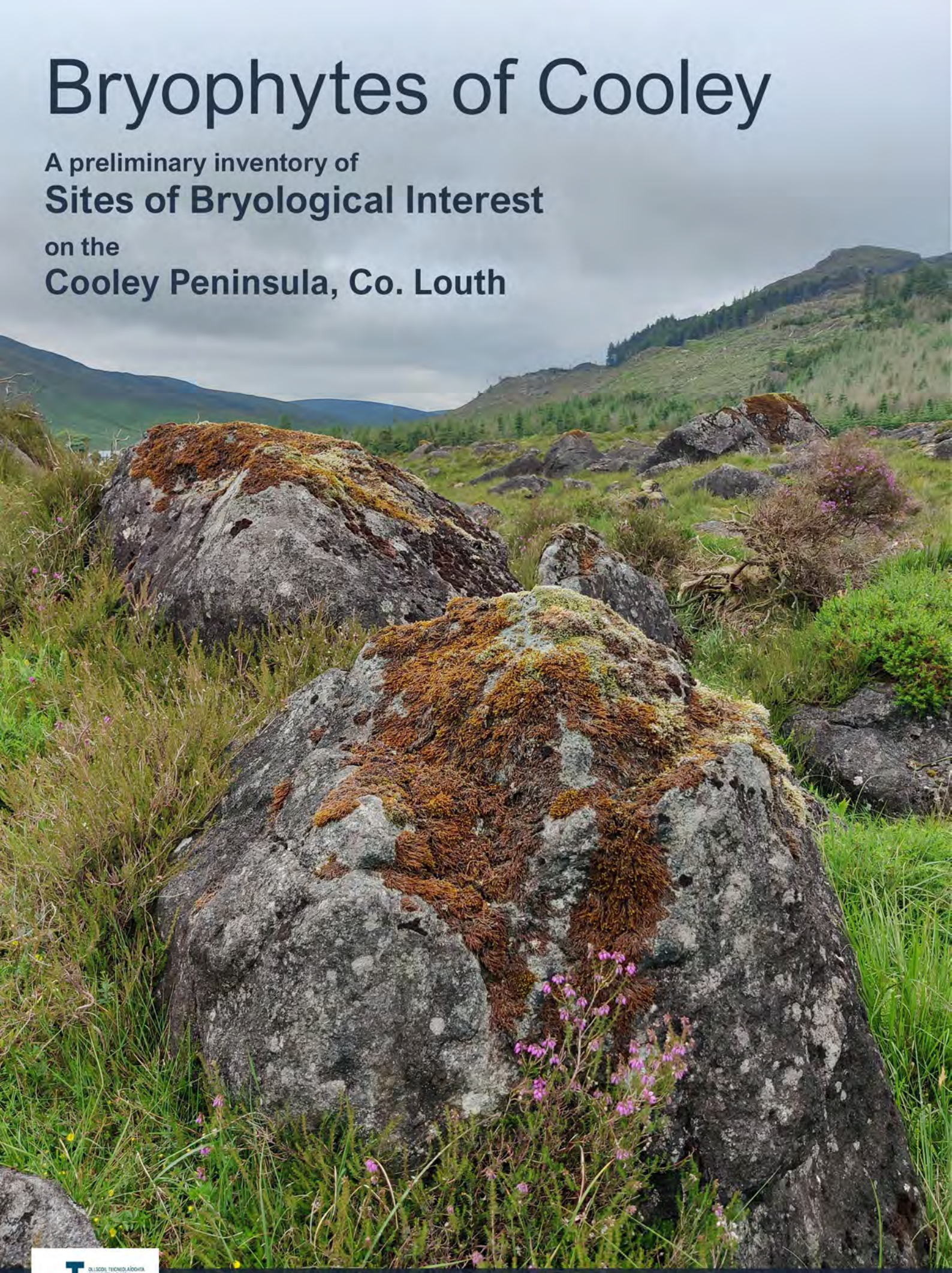
Bryophytes of Cooley

A preliminary inventory of
Sites of Bryological Interest
on the
Cooley Peninsula, Co. Louth



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Front Cover: Boulder with the legally protected species, *Braunia imberbis* (FPO 2022), along with *Racomitrium lanuginosum* and *Andreaea* species, south of The Windy Gap (Site 4).

Back Cover: Boulder at The Windy Gap (Site 4) with a range of rare bryophyte species of ecological significance.

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Contents

Executive Summary

A field survey of bryophytes on the Cooley peninsula was carried out between December 2021 and July 2023, to investigate bryophyte communities with respect to ecological factors and to document the distribution of rare, biogeographically significant species. Our findings highlight the importance of Cooley for habitats of high nature conservation value, and they illustrate the significance of bryophytes as indicators of habitat quality.

Bryophyte communities were examined at eleven sites — consisting of hillside flushes, bedrock outcrops, boulders, shaded ravines, stream edges, springheads and old walls, in upland, lowland and coastal habitats — and all sites were found to contain ecologically significant and scientifically important communities. They contain a striking number of rare species, especially those oceanic species that are more typically associated with habitats in the west of Ireland. We set out the ecological context of these important semi-natural habitat types in Part 1 of this report and then proceed to describe our findings at individual sites in Part 2.

Highlights of our findings:

- A new site for the legally protected Flora (Protection) Order 2022 (FPO) species *Braunia imberbis* on **The Round Mountain**; it was previously known from Carlingford Mountain and Slievenagloch.
- At Carlingford Mountain, *Braunia imberbis* grows in a boulder field below The Ravens Rock (south-east of **The Windy Gap**) — a small extension of the previously known range for this FPO species.
- The Red List 'Near Threatened' species, *Grimmia ramondii* was recorded on both **The Round Mountain** and in the boulder field below The Ravens Rock (south-east of **The Windy Gap**). There were only two previous records for *G. ramondii* in Co. Louth (both near The Windy Gap).
- The Red List 'Near Threatened' species, *Grimmia donniana* was recorded on **Slieve Foye**. There were only two previous records for this species in Co. Louth (Tullaghomeath and Clermont Cairn).
- The Red List 'Near Threatened' species, *Grimmia decipiens* was recorded on **The Round Mountain.** It was previously known to occur in a number of places on the peninsula, but not at this location.
- *Bryum sauteri* was found with sporophytes at **Mullaghattin**. This is the first time this species has been seen with sporophytes in Britain or Ireland.
- *Jubula hutchinsiae*, a leafy liverwort, was discovered in a ravine at **Marble Bridge, Ravensdale Park.** This species had not previously been recorded in Co. Louth.
- *Bryum pallescens* was discovered on **Black Mountain** beside the mast at Clermont Cairn. This species had not previously been recorded in Co. Louth.
- *Oligotrichum hercynicum* was recorded on **Black Mountain**, and *Thuidium delicatulum* at **Moneycrockroe** — neither species had been recorded in Co. Louth for more than fifty years.
- *Plagiothecium denticulatum,* found in **Fathom Forest**, Co. Armagh, had not been seen in that county for over 50 years.

Of the bryophyte species recorded in our study, we deemed 42 species to be of high ecological significance on the basis of their limited biogeographical distribution in Ireland and their strong habitat affinities. Each of the eleven sites visited contained at least one of these species, along with a range of other more common and widespread bryophyte species. These ecologically significant species, and the broader bryophyte communities to which they belong, are excellent indicators of habitat quality.

Recognising and actively protecting these habitats is crucial if we are to halt and reverse present trends of biodiversity loss. If damaged or destroyed, these specialised habitats simply cannot be recreated. Already, signs of damage from inappropriate works are evident in the landscape of Carlingford (due, for example, to afforestation and infrastructural works). Our hope is that by bringing these sites, habitats and bryophyte communities to attention, further loss or damage can be avoided. We believe our findings, survey approach and rationale to be of relevance in bringing to attention habitat types and their characteristic bryophyte species not just in Carlingford, but further afield where fragments of the natural landscape have survived in a relatively intact and ecologically specialised form.

Over the course of the study, habitats at one of the sites we visited, Carlingford Marina, were damaged by inappropriate and seemingly unnecessary works, probably carried out without any recognition of the value of the habitat. In the context of addressing biodiversity loss, it is crucial that this needless destruction of habitats of high nature conservation value ceases — in Cooley and elsewhere — and that proper inventories of sites of importance are held and put to good use by the local authorities.

To this end, we direct our comments to the officials of statutory bodies who are responsible for the protection of the significant biodiverse resources of the Cooley peninsula. We urge them to deploy the resources (legal, financial, good will, etc.) available to them in a respectful, thoughtful and well-informed manner.

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Part 1

The Ecology and Habitat Types of Cooley

and implications for land-use planning and management

Introduction

This study identifies areas of high nature and ecological conservation value on the Cooley Peninsula, by reference to their included bryophyte species (mosses and liverworts). It has been prepared as a contribution to assist those who are concerned directly or indirectly with the long-term protection and conservation of these important sites. It is therefore directed primarily towards heritage officers, biodiversity officers, conservation rangers, and officials of the various statutory bodies with responsibility for habitat protection. Additionally, it is intended to inform other agencies whose actions may exert undesirable pressures on the natural environment, but who are not aware of the local and national significance of these areas. It is also intended to inform the body of mainly voluntary members of the non-governmental conservation movement who have become acutely aware of the rate at which important sites such as these throughout Ireland are losing their value as the result of habitat change, abandonment, alterations in land use and agricultural intensification.

In the identification and recognition of these areas, we hope to bring the importance of these sites to the attention of the relevant participants in the planning process. This is intended to include local authority planning officials, but also those with responsibility for the greater landscape protection in ensuring that these matters receive informed due consideration by applicants (private and state developers and their agents), the Local Planning Authorities, defendants, An Bord Pleanála and if necessary, the higher judicial authorities. By placing this contemporary information on record, we hope that the direct and indirect consequences of any proposed alteration in land use on the existing sites, habitats and their included species will be examined carefully and at a level of detail well above the traditionally acceptable thresholds of scrutiny.

In some instances, the sites which we have recognised fall beyond the present boundaries of legally designated areas such as Special Areas of Conservation (SACs) but which were not included in the various inventories, despite their inherent interest and considerable biogeographical significance. It is our opinion that due consideration should be given to the official recognition of some of these areas with a view to their incorporation into an expansion of the present boundaries of the designated SACs. In this document we set out our rationale for site selection. This includes an explanation of the natural habitat conservation issues operating on each of the identified sites, their biogeographical significance in the broader context of the east of Ireland, all set within the legislative provisions of the Wildlife Act in the Republic of Ireland. Fundamental

to this is an enumeration of the species of bryophyte present on each site and a commentary on the geographical and ecological significance of the occurrence of certain key species on each site.

In recent years the character of the pre-existing flora and vegetation has deteriorated throughout most of lowland Ireland, as a result of land use changes, intensification of agriculture (particularly the chemical applications needed to promote grass sward growth for silage and pasture), the accumulating impact of price support mechanisms and drainage. The Cooley Peninsula has been far less impacted by these changes than many other parts of Ireland, due in no short measure to its unusual and complex geology, topography, land use and related historical agricultural practices. It is for these reasons that we felt it worthwhile to prepare this document. We hope that its relevance will be apparent not just within the Cooley peninsula, but that it will have ramifications for other areas within Ireland. Many of the ecological processes, issues and understandings raised here have analogous counterparts elsewhere in Ireland. In presenting the material in this way, we hope that the pertinent issues of contextual significance will be accorded due consideration by the statutory authorities whenever relevant planning issues are raised.

An on-going problem regarding matters of nature conservation is the difficulty encountered by concerned parties (statutory and otherwise) in accessing relevant, reliable data and information and setting that knowledge, significance and understanding within a broader geographical context. To this end we have embarked on the development of this preliminary inventory and description of sites of high nature conservation value within the peninsula, presenting authentic recently generated occurrence records for bryophytes, and interpreting these primary-source data in relation to the differing underlying habitat characteristics of the immediate area and set within the broader all-Ireland context.

Bryophytes, (comprising mosses, liverworts and hornworts) are particularly well-represented in Ireland. Almost half of the species known from Europe occur on the island (Porley *et al*. 2008). Most of these species have physiological requirements that necessitate a continuance of humid conditions throughout the year. Therefore, many are commoner in the west of Ireland where they benefit from the moist Atlantic weather fronts, even at low altitudes. The precipitation characteristics of the east of Ireland are, however, very different, with far less rainfall, and with many more completely dry days leading to lower humidity levels, especially at lower altitudes. This west-east contrast is contradicted in areas of higher ground in the east of Ireland, where precipitation is greater, mean temperatures are lower and the effects of rainfall in terms of water supply, leaching and landscape transformation are more evident. The effect of these processes is compounded and evidenced by the prolonged duration of cloud cover on higher ground which retards evapotranspiration, especially on north-facing slopes. This feature is particularly apparent in the Wicklow mountains, the mountains of Mourne and, lying between them, the uplands of the Cooley peninsula.

The outcome of these processes in Cooley, is that many wetland species of both vascular plants and bryophytes with restricted habitat requirements can maintain a presence on higher ground where the impacts of agriculture are less severe, the productivity of soil is reduced, and the overall impact of anthropogenic influences is lessened. The main exception to these factors is the manner in which land of inferred previous high nature conservation value has been assigned to commercial forestry. In these instances, the pre-existing functioning ecosystems and their associated distinctive sites have been obliterated from the landscape. Their former steams and rivulets have been drained or diverted, their seepage zones and shallow pools are unreplenished, and the former cohesiveness of concatenated ecosystems destroyed. These changes have led to a direct loss of floristic and structural diversity as well as

to the depletion of the range of invertebrate species dependent on light, a varied selection of food plants and clean water. Dense shading and non-decaying leaf litter accumulations caused by closely-planted conifer stands have greatly reduced the number of light-requiring species capable of surviving in this environment, to the point where by now only a few remnants of the original vegetation can survive and then only on the outer margins of these forests.

Conifer plantation on The Foxes Rock, south of The Long Woman's Grave now partly clear-felled and revealing the complex boulder field formerly hidden (Nov. 2022). In its pre-afforestation state, this boulder field would have provided a typical habitat for rupestral species such as the legally protected *Braunia imberbis* and rare and threatened *Grimmia* species. These species, however, are unlikely to have survived the profound ecological changes brought about by afforestation.

The value of bryophytes as indicators of habitat

Many bryophyte species are particularly useful indicators of and are strongly associated with various specialised habitats. Their short rhizoidal anchoring system means that the species are very closely tied to the underlying substate — rock, soil, peat, trees, etc. Within a site or small area, a range of species with distinct environmental requirements can occur, the presence of many being directly related to the characteristic habitat components present. This within-site structural diversity at a local or broader level provides niches where species with differing ecological requirements can maintain a presence within small parcels of land. Many bryophytes, particularly mosses, have evolved to grow on rocks and boulders. A boulder field (an area where retreating ice has dropped large rocks from its melting surface) set within existing moorland will have a number of species associated with both habitat types — rock and wet ground — all occurring within a small area. The bryophyte flora of windy exposed slopes of mountain tops will include species which are pre-adapted physiologically to endure the abrasive and desiccating effects of high

winds, and the alternating and contrasting effects of intense solar radiation and dense cloud. Some species are typically associated with spring heads at the point where water emerges from upland peaty ground. Others follow these waters as they trickle down through more base-rich mineral soils. These and other physical, chemical and climatic characteristics coalesce to determine and constrain the species-assemblages of given sites. These species-combinations, in turn, are further conditioned by the characteristics of the available species-mix within much broader spatial and environmental contexts and the capacity of these species to spread to and within the subject areas. These contexts can extend and apply far beyond the limits of the Cooley peninsula, County Louth, or the east of Ireland. As a consequence, colonisation / recolonisation processes within the Cooley Peninsula are presently restricted by habitat fragmentation brought about by land use changes elsewhere, leading to the lack of suitable matching habitat types on ground in intermediate areas.

Rare species are often rare because they are strongly associated with habitat types which are themselves rare. A given species may be very common within or be strongly associated with a particular habitat type. Where the habitat type is itself of rare occurrence, it follows that the species in question is geographically rare. Many of these habitat types occupy very little space in the broader landscape, but their occurrence often indicates a continuity of distinctive life-support systems for their included surviving species. Hence species with broad ecological amplitude (those capable of occupying a variety of common habitat types) are or can be relatively widespread. Conversely, rare species are indicative of rare habitat types. Species with narrow ecological amplitude are confined to unusual sites with supporting rare environmental conditions.

It is often the case throughout Ireland that many of these small sites have been lost or degraded by avoidable actions. This is particularly so in the case of wetland areas. Here, larger landscape alterations (e.g. forestry) exert huge pressures on some of these habitats, both directly by dense planting but also by altering the drainage profile of adjacent and remote lands, by shading and by modifying local microclimates. Many of these larger upland forestry developments now fall within the planning process and thus their impact on the social and ecological landscape is subject to a slight measure of scrutiny and evaluation within the environmental assessment process. Smaller developments, set below certain spatial thresholds, usually escape scrutiny entirely. The distinctive species-mixes characteristic of open mountain blanket bog, wet heathland, and the associated biodiverse base-rich and base-poor flushes are unable to survive in these inimical conditions.

Habitat, habitat type, site, vegetation, vegetation type.

These terms sometimes become interchanged and conceptually often overlap.

The term **habitat** refers to the physical setting with which a species is associated. Thus, the main habitats of Cowslip *Primula veris* are lime-rich grassland and sand dunes.

Habitat type. Habitat type relates to the physical and chemical nature of the habitat in question. Heathland is a habitat type, within which there are subdivisions — dry heath and wet heath, for example. Similarly, flushes may be base-rich, neutral or base-poor. These and similar subcategories blend into each other on their interface. An overall conspectus of Irish habitats has been prepared by The Heritage Council which describes the physical characteristics of the many different habitat types and indicates a selection of the various plant species typically found within them (Fossitt 2000). The soils, bedrock, and strewn boulders can

be poor in bases and their associated species are conveniently classified as being **calcifuge** (lime-hating, intolerant of alkaline soils) and the vegetation types as calcifugous. Base-rich soils support **calcicole** (lime-loving) species and their associated vegetation community types are referred to as calcilolous. Various intermediate states of habitat type and vegetation type occur on the base-poor to base-rich spectrum.

Vegetation. Where we use the term vegetation, we simply refer to the covering of living plants on a given site.

Vegetation type. Here we intend the different types of vegetation under consideration. The vegetation types are classified initially in terms of their major formations e.g. woodland, sand dunes, lakes, mountain blanket bog. Each of these is divided and subdivided into smaller units, which repeatedly share the same combinations of species and differing from others which share distinct and separate species-compositions. These plant community groupings, termed associations, are the fundamental units for vegetation typification and can be amalgamated to form the sub-community, community, and major formation levels. At a broad level these associations of differing rank are related to the habitat type (and sub type) within which they occur and of which their included species are the natural expression of the environmental characteristics of the site. The vegetation types present in Britain are described and detailed in a series of major studies as part of the British Plant Communities project, the National Vegetation Classification (NVC; Rodwell 1991–2000). The communities are defined and classified according to their characteristic species-combinations and are named accordingly (e.g. the *Hypericum elodes – Potamogeton polygonifolius* soakway community is named thus along with listings of the additional species which are strongly associated with that particular community). At a finer level of resolution, differing sub-communities (also defined solely on their species composition) will varyingly correspond with more subtle physical and chemical differences within their habitat and vegetation types. Many species can and do occur in more than one vegetation type.

Site. The term site refers to parcels of land which, because of their physical, topographical and vegetational characteristics, can be distinguished from other adjoining sites. Each topographically delineated site may include several habitat types and consequently several vegetation types.

Climate

At a global level, climate determines major vegetation types such as rain forest, temperate forest or tundra. Within these major biomes a variety of associated species have evolved and have developed growth and survival strategies appropriate to the areas. A subsection of these species spread to Ireland after the last Ice Age and are formed into identifiable and discernible vegetation types, whose composition varies according to past and present environmental conditions. At the Irish level our main vegetation types include temperate forest, blanket bog / moorland, heaths and grassland, some fragments of which survive in Cooley. The present state of these vegetation types represents the outcome of the long-term impacts of climate, and they have taken form and character by their interaction with the physical and geochemical environment within which they operate are as we encounter them in the present. The structural characteristics of the Cooley peninsula, with its admixtures of geological bedrocks of various types interacting with glacial erosion and deglaciation deposition patterns has created a landscape which enables some measure of semi-natural interaction between these ancient and present-day processes. It is that complex mixture of very ancient geological and much more recent environmental processes which has led to the character of the present flora and much besides, and which is the focus and driver of this investigation.

The climate of Cooley is varied and is influenced primarily by its position and topography. Located on the east coast of Ireland, it experiences far less rainfall than equivalent areas in the west or southwest of Ireland. The peninsula has a roughly north-west to south-east orientation and the slopes of its more southerly side receive more sunshine than those of the north-facing side; insolation is at a maximum on slopes inclined perpendicular to the incoming angle of the sun. These variations in climate exert a profound influence on the characteristics not only of the prevailing flora and fauna and the condition of their supporting habitats, but more fundamentally on the nature of the underlying soils and substrates of the area.

The combined effects of elevation, leaching, weathering and erosion, driven by rainfall and wind have initiated and dictated the processes of peat and soil formation and the manner in which these have been subsequently influenced by other factors. Although the prevailing winds of Ireland come from a south-westerly direction, the Cooley Peninsula in north-east Ireland receives at least some of its rain from elsewhere, and this in turn influences the way in which rainwater, moving above or below ground is retained, or released. Precipitation falling on steeply sloping ground moves rapidly to lower levels. Gentler slopes enable water to meander and pause, its rate of transit conditioned by the topography and vegetation which has formed thereon.

Having fallen, rainwater makes its way downward to lower ground. Where there is little soil cover it moves rapidly before encountering deeper soil where it slows and soaks through, forming wet patches where the underlying bedrock is flat or concave. There is an on-going process of translocation of finer materials as clay and silt, some of which accumulates in these depressions. Initially these are open-water features, but act as sumps in the landscape, retaining water-borne sand and grit, which usually, over time, fill in and become covered with wetland vegetation. During episodes of high rainfall these subsoil depressions retain their inflowing rainwater for some time after the surrounding ground has dried out.

In some situations where large volumes of water fall and where there are sudden dips in the underlying bedrock, these percolating waters form trickles which in turn join to form small streams. Following periods of heavy and continuous rainfall, some of these streams can have significant force episodically, and the shearing impact of the fast-moving waters gouge out narrow but deep gorges in the landscape, eroding soil or moving and re-depositing large boulders in their torrents. This water accumulates minerals and nutrients, especially as it reaches lower ground and its associated glacial drift (till) deposits. At this juncture its momentum slows, and its profile broadens.

The nature of habitat, site, vegetation and species and their protection

The geological (bedrock, glacial deposition, evolved soil type), physical characteristics (exposure, drainage, soil chemistry) and land use attributes (past and present) of a site determine the nature of the habitat which forms. This in turn leads to the range of species (flora, fauna) that come to occupy the site. This is an on-going process, subject originally to climatic effects and more recently to anthropogenic influences (farming, forestry, habitation). The suite of species living on a site thus provides evidence of the prevailing environmental conditions as well as providing longitudinal perspectives of former landscape and land use changes. The present-day species mix has been conditioned historically by the composition of the available species occurring within a greater catchment area. However, at local level, the availability of suitable habitats and their condition determines the conservation value of most sites. On this basis, conventional habitat names (moorland, bogland, woodland) are often replaced by more concise ecological terms relating

to the description of the vegetation types (associations) which have developed on these landforms or habitat types.

The vegetation type relates to the formation of the species present on a site. It is a convenient term which we here define as the major dominant species present. Within Cooley we recognise a variety of vegetation types whose character and subsequent classification are underpinned by the supporting habitat type and governed by land use. The effective sustainable functioning of these life-support systems is essential in order to ensure the continuance of the relevant species on-site. In striving for the maintenance of particular species or groups of species, it becomes essential to understand the operating factors which have enabled the habitat mixture (physical, chemical, climatic) to have developed its distinctive character. Moreover, it becomes essential also to appreciate the ecological requirements of each component species when envisaging the impact of any future land-use changes. In this way it becomes possible for ecologists to advance both diagnosis (recording which species are currently present on-site) and prognosis (what will happen to them, in the event of any particular contemplated land use alteration, whether immediate or remote).

The botanical significance of the Cooley Peninsula has been well appreciated, particularly in relation to the flowering plants and ferns. Much of the interest has centred on Carlingford Mountain itself where a number of national rarities have been recorded. On the higher exposed ground, nationally-rare rock-dwelling species such as *Aquilegia vulgaris*, *Rhodiola roseum*, *Salix herbacea* and *Cryptogramma crispa* are known to occur and are now very rare in the east of Ireland. In more sheltered ground ferns such as *Hymenophyllum wilsonii*, *Phegopteris connectilis*, *Dryopteris aemula* and *Osmunda regalis* occur, and on wetter ground *Crepis paludosa* and *Pinguicula lusitanica* are still present. At an all-island level, these species are strongly associated with more humid habitats in the west and south-west of Ireland and in Cooley occur (or occurred) as atypical east of Ireland geographical outliers testifying to the unusual habitat conditions which prevail here and which contrast strongly with those of the intensively farmed lowlands.

This biogeographical pattern is reflected further in the composition of bryophyte assemblages in certain sites within the peninsula, where favourable low-impact traditional land use practices have allowed the continued survival and expression of these species and hence indicate the quality and significance of their underlying environment as support systems for these rare species. Additionally, many less rare species recorded in the past have since become nationally-endangered as a result of habitat degradation and destruction elsewhere in Ireland. Therefore, the Cooley Peninsula now stands as an important refugium with considerable positional significance relative to the present flora of Ireland brought about by its substantial proportion of relatively undamaged habitat and vegetation types. This in turn is reflected in the number of vascular plants from Cooley which are known to be or to have become rare at a national level in recent times.

The protection of individual species is not necessarily the sole aim of conservation. Rather it is the maintenance of their associated habitat support systems which underpins any contemplated protection measures. In identifying sites of high nature conservation value, we are deeply conscious of the need for a greater understanding and appreciation of the many factors which have enabled the relevant species and vegetation types to maintain a presence on individual sites. These factors are many and they interact in complex manners. Drainage, abandonment, intensification of agriculture and afforestation have taken their toll, often in an information and knowledge vacuum. The measurable and verifiable loss of a known species from an area signifies that not only has the species in question has disappeared, but that the favourable

ecological characteristics of its former site have also disappeared, along with its other associated species. Thus, the term Current Conservation Status has emerged to describe the present condition of a site and can be applied to a species or to its site of occurrence.

Habitats and vegetation types on the Cooley Peninsula

Rivers

Within the peninsula a number of small streams enter the sea on the north side of Dundalk Bay or directly into Carlingford Lough. By this stage their movement has slowed and their waters often leave the land through shingle ridges and pebble beaches. On higher ground, these rivers have a much more turbulent presence, their flow characteristics being the result of complex interactions between the fall of the land, the bank, the glacial deposits set on the underlying bedrock and the extent to which the river when in torrent has dislodged boulders. Small waterfalls, pools and gorges have formed, their character also depending on the nature of the underlying bedrock. Small stones, sands and peaty silts, eroded from the adjoining hinterland by the force of the moving water, accumulate in the lee of these boulders whose upper protruding parts are washed by the river when in spate. The tops of smaller boulders may only be exposed in summer when water levels are lower and flow rates reduced. Where shearing by force of water and abrasion by sand and gravel are most severe, few plant species can survive. However, a number of moss species can cope with this apparently inhospitable environment, growing usually on the lower sheltered side (lee) of the larger boulders and receiving their nutrients from in-washed soil particles. Though often inundated, they remain clinging to the substrate, their survival enabled by their unusual growth form of very strong wiry stems which can resist with the force of water. Along the course of the Ryland River (Site 3) leafy liverworts thrive in the splash zone in the lee of these boulders, by forming low-growing mats which are closely appressed to, and conform to the curvature of, the boulders.

The banks of these steeply-cut streams and rivers also support a range of bryophytes as well as higher plants. Here the eroding impact of the river is evidenced by the presence of steep bare earthen banks where it has cut through post-glacial deposits resting on bedrock. The exposed mineral soils and their occasional included boulders, stones and tree roots are lapped by the rivers in summer but scoured in winter. The eroded material is conveyed downriver or deposited on the opposite side of the stream in more sheltered situations. Here a variety of other mosses and liverworts can also grow. Thallose liverworts are especially well suited to these conditions. Lacking any differentiation into leaves and stems which would be shredded by the force of the water, they form low consolidated patches which adhere closely to the bank.

The exposed banks and their associated soils are usually of an acid character, a feature which is reflected in the range of calcifuge species of higher plant. Thus, *Digitalis purpurea*, *Umbilicus rupestris*, *Blechnum spicant* and *Dryopteris affinis* grow vigorously, especially where erosion by these small rivers has created gullies sheltered from the wind. In these deep cuttings the impact of grazing is greatly reduced and elements of the natural vegetation of the area are evident in small higher stretches of their banks. This includes trees whose trunks and branches in these steep valleys have their distinct bryophyte communities, conditioned by relatively high humidity levels which prevail throughout the year, which in turn are brought about by shelter from the wind, spray from the rivers and evaporation from exposed damp sand and gravel on the banks in summer.

Where rivers have cut down deeply, exposing bedrock as at Marble Bridge, Ravensdale Park (Site 8), the deep valleys and its torrents are not suitable for most vascular plants, as they cannot cope with the force of water. Additionally, the tree canopy on both of its banks has converged to cut off light to the ground. However, the elevated levels of humidity are particularly suitable for bryophytes, due in part to the spray of mist from the turbulent waters and also because of the shelter from the wind brought about by the dense tree cover. This ground is very suitable for shade-demanding species of moss and liverwort and includes a number of species of very restricted distribution in the east of Ireland.

Mountain blanket bog

Mountain blanket bog, or moorland (PB2 Upland Blanket Bog, Fossitt 2000), forms in areas where the amount of rainfall is relatively high and exceeds evaporation, usually where the underlying base-poor, non-porous bedrock is level or slopes gently. Where the bedrock shelves steeply, wetland vegetation cannot cling to the underlying surfaces and therefore slides off, accumulating sometimes in dips and hollows below. The vegetation and species of mountain blanket bog are slow-growing because of the low nutrient characteristics of the underlying ground. Peat forms in these low-nutrient conditions, driven mainly at the initial stages by a succession of *Sphagnum* mosses. The peaty and spongy ground that forms here retains moisture from precipitation and has a low pH. It is not suitable for tillage but is often lightly grazed by sheep or cattle. These upland areas can be very extensive, and function as large catchments to capture rainfall which is retained or eventually released into runnels and streamlets, depending on local weather conditions and set within the prevailing climate and topography. In these areas decomposition is very slow, and nutrients previously assimilated by vegetation are released very slowly.

In Cooley, the main species of mountain blanket bog are *Molinia caerulea*, *Calluna vulgaris*, *Eriophorum angustifolium* and *E. vaginatum*, with *Erica tetralix* with many *Sphagnum* species present. Where streams have cut forcefully into the vegetation matrix, exposing bedrock or boulders, ferns such as *Dryopteris dilatata* and *D. affinis* occur and flowering plants such as *Filipendula ulmaria* and *Vaccinium myrtillus*. Trees such as *Salix aurita*, *Sorbus aucuparia* and *Betula pubescens* grow in the deeper cuttings.

However, depending on the configuration of the bedrock, rainwater gradually seeps through the peaty ground, following the fall of the land, picking up small amounts of weathered sand and humic material, in the course of its passage cross-country. Though the quantities of nutrient are small they gradually move through the peat and accumulate in dips in the underlying terrain. The ongoing throughput of water and nutrients can be tracked, as its associated vegetation and species-mix is often different in colour from that of the surrounding terrain, a feature that is related to the different chemical composition of these irrigated areas and the slightly different species mix following the percolation route.

These slow-moving subsoil features are known as flushes and can be either base-poor or base-rich and they also differ from the immediately adjoining peaty ground in their physical characteristics, where sand and silt, derived from the parent substrate, have been transported slowly by the movement of water. Where there is a sufficient head of accumulated water or an abrupt dip in the landscape, the trickling water issues as springs which are evident as small pools of open water, even in summer. The water levels on the margins of these pools fluctuate through the year, but where there is a sufficient supply of water and minerals, their margins become colonised by a group of bryophyte species, known informally as the “brown mosses”. These springs can overflow, and their overspilling waters may subsequently disappear underground in a series of submergences and emergences as they traverse the down-slope terrain. Ultimately these slow-moving

waters will join with others to form small runnels, coalescing streams and eventually rivers where their speed and physical character then changes abruptly.

In certain instances, especially where moving ground water has passed through or over other base-rich rock types such as gabbro, the superficial or underground waters are infused with minerals originating in the ancient past from deep within the earth. This on-going process exerts a profound effect on the soil chemistry in these flushed areas, particularly where their downward flow is slightly impeded by out jutting boulders or the levelling of the subsoil bedrock. These factors result in a reduction in the throughput of subsoil water and its contained minerals. In these small pockets a group of base-demanding species occurs, most obviously *Schoenus nigricans*, with which are associated a very distinct suite of bryophytes. Most of these species occur in fen or marsh communities on the wet, lime-rich soils in the Central Plain, but are here present because of the elevated levels of base-rich minerals which are concentrated within the flushes.

The distinctive suite of species associated with these base-rich flushes includes *Schoenus nigricans*, whose presence usually signals the presence of these flushes from a distance, *Carex flacca*, *C. hostiana*, *C. panicea*, *C. pulicaris*, *Euphrasia* species, *Juncus articulatus*, *Linum catharticum*, *Lysimachia tenella* (syn. *Anagallis tenella*), *Pinguicula vulgaris*, *P. lusitanica*, *Selaginella selaginoides* and *Succisa pratensis*.

These base-rich flushes may only be a few metres wide, and their vegetation and species often intermingle with those of other much commoner adjoining habitat/vegetation types, such as mountain blanket bog and damp heathland. This is particularly evident in the system of slopes and shallow pools at Moneycrockroe (Site 5). The presence of even a small number of these species can often indicate the presence of incipient weakly-defined flushes, at an early stage of their distinct and separate formation. Their species-composition, positioning and disposition in the landscape corresponds strongly with NVC *Schoenus nigricans* flush communities, particularly the *Briza media-Pinguicula vulgaris* sub-community, M13b (Rodwell 1991a), but in Ireland the equivalence is complicated by climatic factors which enable certain species to occupy slightly different ecological niches in the landscape than might be the case in Britain. Examples of the manner in which these base-rich flushes fit into the landscape can be examined on land above the upper car park on Slieve Foye (Site 1a). In some instances, as on the forestry track leading back to Carlingford (Site 1b), the flushes cut across the trail and in undisturbed stretches, some of the characteristic flush species such as *Schoenus nigricans*, *Selaginella selaginoides* and *Pinguicula vulgaris* grow. This contrasts with the vegetation and species in the roadside drains leading down from the carpark, which have a much more calcifuge facies (Site 1c).

In other circumstances where the slow-moving waters pass over base-poor soils on bedrock, or lodge in areas where displaced granite gravel, pebbles and coarse sand accumulate, a very distinct vegetation type develops. This association is characterised by the presence of *Hypericum elodes* and *Potamogeton polygonifolius*, both species of base-poor, shallow, silty pools with fluctuating water levels which are usually nutrient-poor. Here they constitute a striking example of the vegetation type known as the *Hypericum elodes-Potamogeton polygonifolius* Soakway (M29) of the NVC (Rodwell 1991a), whose distinct Irish character and significance was recognised by pioneering vegetation analysts Braun-Blanquet and Tüxen (1952). A cluster of adjoining fields occurs at Cornamucklagh (Site 10), where water spreads over base-poor soils and gravels A very large number of species recorded from this NVC vegetation type are present here but also occur in varying degrees at separate less-well defined sites within the peninsula. At some spots an extremely very high correspondence exists between the species there present and those considered to be

typical of the association. These include *Carex demissa*, *C. panicea*, *C. hostiana*, *Drosera rotundifolia*, *Eleocharis multicaulis*, *Eriophorum angustifolium*, *Hydrocotyle vulgaris*, *Juncus bulbosus*, *Lotus pedunculatus*, *Lysimachia tenella*, *Narthecium ossifragum*, *Potentilla erecta*, *Ranunculus flammula*, *Succisa pratensis* and *Veronica scutellata*.

Marshes

The lower slopes of the hills and the adjoining flatter land on the Cooley Peninsula are coated with a covering of glacial drift — material deposited in the course of advance and retreat of glaciers during the last ice age. These soils are often sandy in character and, depending on the slope on which they are deposited, are usually well drained and suitable for farmland. Their chemical composition and nutrient status vary, depending on the characteristics of the bedrock from which the glacial drift was derived. Some of the more substantial deposits have been quarried for sand and gravel.

However, in some instances, ground water from higher areas, instead of entering streams and leaving the study area rapidly, has accumulated on more level ground and subsequently spread over wider areas. Where these waters irrigate the glacial till areas, they form wetlands or marshes, with a very different range of species ensuing. The mineral soils are more base-rich and nutrient-rich and where these have not been drained, they include a selection of species rare on the peninsula and elsewhere in the east of Ireland.

The pattern of glacial deposits on the Carlingford peninsula is very complex and represents the outcome of various advances and retreats of the last great ice sheet. At least some of the deposited material may have been of Irish Sea origin, additional to that abraded by glacial action impacting directly on the existing exposed bedrock. On higher ground the glacial till is much thinner and eventually tapers off. Above this, the prevailing soil cover consists of a mixture of deposited material intermingled with material weathered in situ from the underlying bedrock — usually granite or gabbro — supplemented by decayed plant remains which are gradually humified. This material provides a substrate for plant species typical of base-poor conditions which can grow on these immature soils or peats. The vegetation that grows in the driest areas develops as dry heathland, with wetter areas forming blanket bog, intermingled with wet heathland and grassy moorland.

Dry heathland

Dry heathland (Dry Siliceous Heath HH1, Fossitt 2000) occurs over acid rocks such as granite, in situations where the slope of the land is too steep for mountain blanket bog to develop. Where soils are shallow, rainwater runs off rapidly. Large boulders and dry-stone walls also form the basis for small pockets of dry heathland, and for similar reasons. In situations where boulder fields have formed, the flora of these large rocks may contrast sharply with that of the ground within which they are embedded (e.g. at The Windy Gap, Site 4d). These topographically-complex areas, because of their uneven character, have greater surface areas. Although livestock can graze the ground-based flora, they have far less impact on the species that are adapted to live on the surface of these boulders. This is particularly apparent at The Round Mountain and its associated small valley (Site 6d).

In its pure state, dry heathland is characterised by the presence of drought-tolerant species such as *Calluna vulgaris*, *Danthonia decumbens*, *Deschampsia flexuosa*, *Erica cinerea*, *Festuca ovina*, *Galium saxatile*, *Hypericum pulchrum*, *Nardus stricta*, *Potentilla erecta*, *Ulex gallii* and, in less exposed situations, such as shaded bare rock faces, *Umbilicus rupestris*. Steep rock exposures as at The Windy Gap (Site 4a Corrakit; Site

4b opposite the carpark; and Site 4c at The Foxes Rock) provide suitable habitat for many bryophyte species in areas where the rapidly-draining rock surfaces include species from the immediately adjoining heathy ground. In many areas where dry heathland abuts onto mountain blanket bog, great stands of Bracken (*Pteridium aquilinum*) dominate the landscape. In many places its dense fonds function to provide shade, under which some species normally encountered in woodland grow successfully. *Ulex europaeus* occasionally forms loose scrub, which is taller than *Ulex gallii* and usually grows on deeper soils. However, this vegetation type is often surrounded and infiltrated by species of wet heathland and mountain blanket bog, depending on the manner in which rainwater is distributed or retained in the immediate locality. Micro-topographical differences of as little as 10 centimetres vertically can result in the juxta-positional occurrence of very different vegetation types within areas as small as 2x2 metres.

Exposed bedrock and boulders on The Foxes Rock which provide specialised niches — geologically and climatically — for rare and ecologically significant bryophyte species, including the legally protected species, *Braunia imberbis* (April 2023).

Wet heathland

Wet heath (HH3; Fossitt 2000) forms within larger areas of mountain blanket bog and in situations where depressions in the bedrock allow for the gradual accumulation of weathered material (sand and gravel) transported by water and which over time become vegetated by plants typical of base-poor conditions. The shallower pools are often covered or fringed by *Sphagnum* mosses, with *Erica tetralix* and *Calluna vulgaris* on the margins. Some of these pools can be relatively deep and their water levels fluctuate through the seasons. The surrounding upland landscape serves as a broad catchment area for rainfall which is retained in these low pockets even during periods of drought when much of the surface of the surrounding mountain blanket bog has dried out. Vascular plants characteristic of wet heath are *Carex binervis*, *Juncus squarrosus*, *Molinia cerulea* and *Narthecium ossifragum*.

Free-draining glacial deposits

Where sand/gravel mixtures have been deposited by glacial action, a distinct flora is maintained, due in part to their innate porosity but also to the nature of the parent material that formed these deposits. Their free-

draining and hence lighter character creates suitable ground for some species usually associated with lime-rich (or base-rich) grassland soils on lower ground, such as *Galium verum, Thymus drucei, Trifolium repens, Carex flacca, Lotus corniculatus, Scorzoneroides autumnalis, Hieracium pilosella*, various *Euphrasia* species and here, as elsewhere in north-east Ireland, *Campanula rotundifolia*.

Forestry on mountain blanket bog

The land set aside for planted conifer woodlands (forestry) is dewatered with many deep trenches conveying water off a site and into drain systems, which eventually connect into existing watercourses. On lower ground where these areas are now afforested, trackside drains and small open pools support a mixture of aquatic and wetland-margin species, conditioned to some extent and enriched by the throughput of minerals conveyed by the movement of water. The bottoms of some of these forestry drains may thus have admixtures of peat which has been washed out of the adjoining lands (especially after clear-felling), particles of displaced granite freestone and partly humified mineral soils. Depressions in the landscape alter the flow of these small drains and act as sumps where particulate matter lodges. Over time these drain features become clogged with silt and are occasionally cleared out, thereby initiating a re-colonisation sequence. In summer some of these vegetated features dry out on the surface, though they remain sufficiently wet to maintain wetland species with deeper rooting systems. Here various robust species of Rush (*Juncus effusus*, *J. conglomeratus*, *J. articulatus*) may form substantial stands, sometimes consolidating the peat/subsoil matrix on slopes by virtue of their deep rooting systems, and all are able to penetrate downwards as water tables fall. Some of these drains have sufficient minerals to support and maintain the amphibious existence of *Ranunculus flammula* and *Potamogeton polygonifolius* — both species able to tolerate periodic inundation and exposure on the bare mud. In places, deep pools have been excavated to serve as attenuation tanks in the event of flash flooding, and here base-poor rainwater issuing from the former blanket bog supports *Potamogeton natans* and *Glyceria* species. The water levels in the drains are not sufficiently consistent to permit the formation of *Hypericum elodes* communities. These features can be regarded as (relatively) unobstructed fast-flowing flushes, maintained in a semi-permanent open state by drain-clearing, to the point where permanent vegetation never evolves or stable vegetation communities mature. In these conditions, and especially where the drains pass through peat or mineral soils, species of acid conditions (*Juncus bulbosus*, *Carex demissa*, *Lotus uliginosus*) will grow in close proximity to species of more alkaline conditions (*Carex lepidocarpa*, *Juncus articulatus*, *Leontodon autumnalis*, *Linum catharticum*). A number of these trackside drains follow the forestry trails, intercepting waters moving transversely across the slopes. The drains at the cleared forest at Mullaghattin (Sites 7a, 7b, 7c) are of particular interest because of the presence there of admixtures of calcifuge and calcicole species, and of a rare bryophyte (*Bryum sauteri*), but elements of this species-mixture may be encountered in many afforested parts of the peninsula. They will gain and lose species, depending on the frequency and manner of drain management. In addition, the higher and less waterlogged banks of these drains support colonies of various vascular plant species which indicate the acidic and free-draining nature of the substrate — e.g. *Hypericum pulchrum*. After clear-felling, *Chamaenerion angustifolium* invades the drying-out open ground along with many species of Bramble.

Upland vegetation

In the last glaciation Carlingford Mountain was not overridden, and a lobe of ice pushed down Carlingford Lough between Carlingford Mountain and the Mourne Mountains. The ice flowed round the Mourne Mountains and out into the basin of the Irish Sea (Holland 1981). The top of the highest peaks on Slieve

Foye are windswept and their very shallow soils have developed in-situ. The vegetation is wind-planed, and few tall species can cope with the severe conditions. There is little nutrient, and this leads to the formation of a slow-growing stunted heathland vegetation, with small pockets of soil accumulating in declivities in the terrain or in the lee of out-jutting boulders. The few flowering plants that can exist here are tough low-growing species, but many rock-dwelling bryophyte species are present here also and these do not occur on lower ground. This is partly conditioned by virtue of the amount of available exposed rock and by the lack of viable competition from other vegetation. However, many species also have physiological modifications that enable them to cope here. Some have low mounded growth forms and others have protruding hair-points to their leaves. Both these features serve to conserve water, by deflecting drying winds away from the core of the plants. The complex of bare earth and rocky features near the mast at Clermont Cairn on Black Mountain (Site 9a) demonstrates these features clearly. When set against the moss-dominated bryophyte communities of the more sheltered edges of the access road, at almost the same elevation, these provide clear evidence of the effects of exposure.

Coastal seepage areas

Much of the Carlingford peninsula is fringed by deposits of sand and gravel, deposited in a series of events associated with the last glaciation. The physical and chemical composition of these deposits is related to the nature of their parent materials, the manner of their deposition (glacial outwash features, deposits of marine origin) and their subsequent alteration as the result of weathering (leaching). In some areas these deposits form steep unstable cliffs with their alternating layered sand and gravel profiles indicating the diverse manner and conditions under which they formed. Those areas nearest the present-day coast are additionally influenced by wind-blown sand from the shore. This results in the formation of a band of vegetation which includes species more usually associated with sand dune systems. One conspicuous species, *Galium verum*, is often indicative of the presence of these lighter soils and can be seen on many low-level roadside verges and reoccurring on dry base-rich soils on slightly higher ground.

Usually, these deposits slope gently to the coast and their covering of grasses is grazed by sheep and cattle. However, in some cases, steep cuttings and low cliffs are formed, partly by erosion by marine action. Where ground water percolates through the sandy and usually base-rich soil, a very different vegetation type forms which incorporates species more usually encountered in calcareous spring-fed nutrient-poor landscapes. These seepage zones are irrigated by exuding ground water moving off the adjoining farmland. These features in their surviving condition are distributed parallel to the shore and just above the upper tideline. On occasions, following periods of very heavy rainfall, a buildup of hydraulic pressure causes the water/soil/root matrix to rupture episodically, resulting in conspicuous slumpages of soil onto the foreshore. The resultant deposits are often subsequently eroded by wave action, but where they stand above and clear of the upper tidal limits, an interesting and significant local calcicole flora, typical of base-rich conditions, forms. In some instances, the presence of petrifying springs characterises this process, particularly where wet sand/soil is positioned securely on protruding bedrock. Here, subterranean waters pass between the covering of soil and the underlying bedrock and emerge, their presence indicated by the occasional dripping or trickling of water over otherwise dry rocks. Tufa deposits are often evident, indicating the extent of washing out and deposition of base-rich minerals. The exposed faces of these features have low levels of vegetation cover, brought about where the species and vegetation succession is maintained and reactivated by marine erosion, and characterised by the presence of species of more open muddy ground. The semi-permanent robust species such as *Schoenus nigricans*, *Succisa pratensis* and *Juncus articulatus* consolidate

the matrix and provide a secure footing for less sturdy or less strongly-rooted species such as *Isolepis cernua*, *Lysimachia tenella*, *Carex lepidocarpa*, *Pinguicula vulgaris* and *Samolus valerandi* which are usually associated with more unstable open base-rich muddy ground both inland and on the coast. The exception is *Isolepis cernua*, a small member of the Cyperceae (sedges), which is almost exclusively associated with wet soils just above the tidal limits, occasionally lapped by waves driven by on-shore winds. These species and others often occur on the lime-rich but nutrient-poor wetlands of the midlands, particularly where fluctuating water tables contribute to the maintenance of muddy patches and inhibit the growth and expansion of heavier vegetation. Reduced examples of this formation occur in small, isolated pockets in many spots on the shore of the peninsula, depending on the characteristics of the ground water supply. In some areas, coastal erosion has swept away the shore features to leave steep cliffs where water runs off rapidly. In other areas, as on the shore north-west of Carlingford Marina on the Greenway, typical examples of this significant and vulnerable habitat still survive (Site 2c).

Some of the waters that flow down near Carlingford Marina over rock exposures, often with considerable force, have been walled-in and release their waters via culverts into the sea. In other instances, water passes through post-glacial deposits and trickles down the exposed bedrock cliffs. Until recently, shallow pools occurred here with a number of wetland species, including those associated with petrifying springs, which are dependent on the continual supply of water from above. This habitat conformed to the Habitats Directive priority habitat 'Petrifying springs with tufa formation (*Cratoneurion*) 7220'. A number of significant species of bryophytes occurred in association with these semi-permanent pools, but some also grew on the adjoining low moist cliffs (Site 2a, 2b). Here the nature of the supply of percolating water was and still is crucial for the survival of the petrifying springs. However, recent work in this area has resulted in the infilling of the system of pools at the base of the rock exposures and has truncated the seepage area, thus resulting in the loss of a significant portion the Habitats Directive priority habitat.

Part 2

Field survey of bryophytes on the Cooley Peninsula

and accounts of individual sites

Aims of the present study

The present study was carried out by Dr Melinda Lyons and Dr Declan Doogue FLS with the following objectives:

- To describe habitats of high nature value on the Cooley Peninsula, especially on Carlingford Mountain, with special reference to their bryophyte species.
- To show how bryophytes act as indicators of environmental conditions.
- To promote high quality botanical studies in areas of high nature value.
- To draw together experts and put on record knowledge and field-based expertise at the level of detail which is required to address the biodiversity crisis.
- To underpin and inform future planning and land-use decisions to ensure sustained protection of the most worthwhile habitats on the Cooley peninsula.

ML received funding from a private sponsor, through TU Dublin, to facilitate the work.

Bryum species, including capsule-bearing *Bryum sauteri* (confirmed by microscopic examination of tubers on rhizoids, inset), growing on the track at Mullaghattin (Site 7, October 2023). A specimen collected earlier at the same location was confirmed by BBS referee Dr David Holyoak to be the first record of *B. sauteri* bearing capsules in either Britain or Ireland.

Bryophyte recording on the Cooley peninsula

Much work has been done on recording the presence of bryophyte species on the Cooley peninsula in the past. The British Bryological Society (BBS) holds records for Co. Louth (Vice-county H31) including both historic records, those made during BBS field outings in recent decades and work done by various other experts. These include records for the Cooley peninsula by:

- H.W. Lett, 1882–1915
- C.H. Waddell, 1882–1919
- A.L.K. King, 1953
- D.M. Synnott, 1963–1968
- J.W. Fitzgerald and R.D. Fitzgerald, 1964
- T.L. Blockeel, 1999
- D.T. Holyoak 2007 and 2008
- Various BBS excursions, led by S.D.S. Bosanquet and J. Denyer, and lists made by individual BBS members, in 2010 and 2012
- M. Eakin, 2010–2014

The legally protected species *Braunia imberbis* (syn. *Hedwigia integrifolia*) was surveyed and mapped by R.L. Hodd in 2015. *B. imberbis* is protected under The Flora (Protection) Order, 2022 (FPO), made under Section 21 of the Wildlife Act 1976 to afford legal protection to rare and threatened plant species wherever they occur, whether within sites legally designated for nature conservation or not.

British Bryological Society records

BBS records are stored in spreadsheet format, stating the species name, date, location, recorder and, in some cases, a note on the habitat. They provide an authoritative and wide-ranging account (temporally and geographically) of the bryophyte species present on the Cooley peninsula, confirmed by experts and verified by voucher specimens where appropriate. They do not, however, attempt to provide individual site accounts or detailed information on habitats, ecological settings or species communities — hence the relevance of the present study.

Red List for bryophytes

Substantial survey work on the bryophytes of Ireland was carried out by specialist bryologists in the early 2000s and published in 'Rare and threatened bryophytes of Ireland' by Lockhart, Hodgetts and Holyoak in 2012. This work includes an assessment of all species of mosses, liverworts and hornworts occurring in Ireland according to International Union for Conservation of Nature (IUCN) criteria, to identify taxa under threat and to compile a 'Red List' of threatened bryophytes. Thus, species most at risk of regional extinction were assigned to one of the following categories: 'Critically Endangered' (facing an extremely high risk of regional extinction in the immediate future), 'Endangered', 'Vulnerable' or 'Near Threatened'. Most bryophyte taxa do not fall into these categories and are regarded as 'Least Concern' — i.e. they have a reasonably widespread distribution in Ireland (occurring in >20 hectads (10 x 10 km squares); or in 13–19 hectads and not showing signs of decline). Where used in this report, threat categories correspond to the assessment by Lockhart et al. (2012).

Methods

A preliminary site visit was made in December 2021, prior to the commencement of the project, followed by monthly site visits from September 2022 to July 2023 (by ML and DD). Sites were selected both by using prior knowledge of the region and on an ad hoc basis by visiting interesting topographical or ecological features in the landscape which came to our attention in the course of our site visits. In one case, Site 3 at 'Omeath Glen', historic bryophyte records caused us to seek out a location which was not previously known to us or named on maps, using aerial photographs.

At each location, bryophytes were examined, and small samples of unknown species were collected for identification. Habitat types and key vascular plant species were noted, in so far as was possible at the time of the visit (but as most visits were over the winter months, many vascular plants were not visible or identifiable). Grid references and altitudes were recorded with a Garmin GPS unit and verified against Ordnance Survey Discovery Series maps. Water samples were collected at sites with wetland habitats, wherever sufficient water was available. Water pH value was measured with a Eutech PCSTestr 35, calibrated prior to use.

Background information on legal site designations for nature conservation was obtained from the National Parks and Wildlife Service map viewer ('NPWS Designated Areas' layer on NPWS Protected Sites Map Viewer). Bedrock geology data were taken from the Geological Survey Ireland (GSI) map viewer 'Bedrock Geology 100k' and 'Quaternary Sediments' layers.

Nomenclature of bryophytes is according to the Census Catalogue of British and Irish bryophytes (Blockeel *et al*. 2021) and vascular plants according to Stace (4th edition, 2019). *Carex flava* group sedges (including *Carex lepidocarpa* and *C. demissa*) are extremely variable and difficult to assign to the currently accepted taxonomic categories. Hence, we have reported some specimens as '*Carex* cf *lepidocarpa'* ('cf', 'confer' or 'compare', indicates that this is the closest taxonomic group without being an exact fit).

* Rare and ecologically significant species

Bryophyte species of highest ecological significance, which are relatively rare in Ireland, are marked with an asterisk in the text (e.g. *Jubula hutchinsiae**) and labelled '*** Sig.**' in site tables. Many other species have strong ecological affinities and are therefore confined to particular habitat types but are generally more widely distributed in Ireland. These are considered to be 'moderately' significant and are marked 'Mod.' in tables of species.

The distributions of these ecologically significant species (*) in Ireland are shown in an Appendix (and some are also included within the site accounts). Maps are from the BBS Atlas of British and Irish Bryophytes (Blockeel *et al*., 2014). Black dots are records from 1990–2013; grey dots 1950–1989; white / open dots pre-1950 records.

Abbreviations

* *or* *Sig.	Bryophyte species of highest ecological significance
Mod.	Bryophyte species of moderate ecological significance
Agg.	Aggregate; group of closely related species
Alt. m	Altitude in metres
BBS	British Bryological Society (www.britishbryologicalsociety.org.uk)
cf	Confer or compare (indicates closest taxonomic grouping without being an exact fit)
FPO	Flora (Protection) Order
IBrA	Important Bryophyte Area (Lockhart *et al*. 2012)
IUCN	International Union for Conservation of Nature
NVC	National Vegetation Classification (Rodwell 1991–2000)
pNHA	Proposed Natural Heritage Area
SAC	Special Area of Conservation
SPA	Special Protection Area
subsp.	Subspecies
s.s.	*Sensu stricto* — in the strict sense
s.l.	*Sensu latto* — in the broad sense
NT	Near Threatened, an IUCN category (see Lockhart et al. 2002)

A dry boulder at The Foxes Rock, set in dry heathland, with the mosses *Hedwigia stellata** (centre of photo on right above, leaves with white tips), *Braunia imberbis**, a legally protected FPO species (to the left of *H. stellata*, golden-green) and *Racomitrium heterostichum* agg.* (fine green leaves, to the right of *H. stellata*). July 2023.

Site accounts

The sites we visited are listed in the table below and their locations are shown on the accompanying map. Each site is described in turn in the section that follows. Together, these sites encompass a range of different characteristics and habitat types, as described in Part 1.

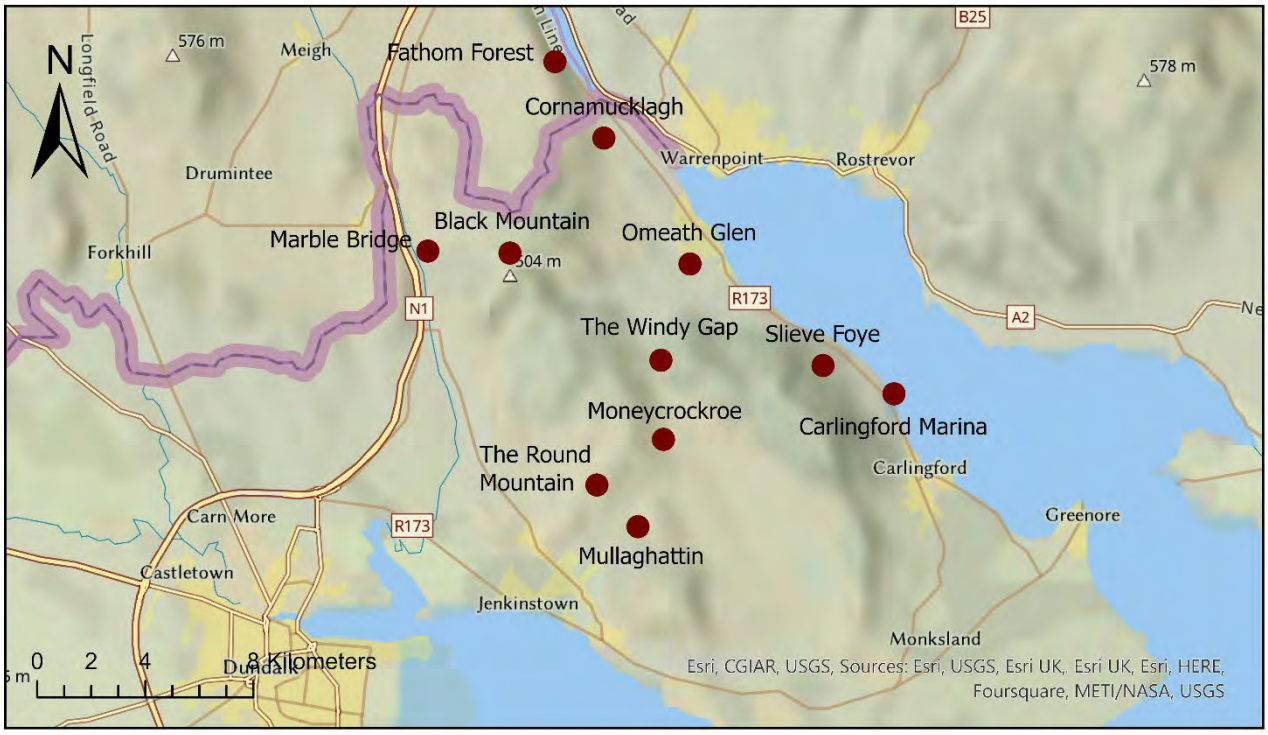
The complex geology of the Cooley peninsula is integral to the diversity of its habitats. The higher ground in the central part consists largely of igneous rocks — granite, gabbro and basalt — of Tertiary origin (i.e. formed *c*. 61 million years ago). Granite contains a high proportion of silica and is therefore acidic while gabbro and basalt, in contrast, are base-rich rocks. Low ground at the southern end of the peninsula is underlain by base-rich Carboniferous limestone. The Inniskeen formation underlies land along the shore of Carlingford Lough and also running in a narrow band across the peninsula, from Omeath to Ravensdale. This formation consists of Silurian metasediments (turbiditic greywacke sandstones) of the Longford-Down Inlier. The bedrock formations underlying each site are listed in the site accounts. For full details, see GSI bedrock maps.

Much of the uplands of Cooley lie within the Special Area of Conservation (SAC) and proposed Natural Heritage Area (pNHA) Carlingford Mountain (Site 000453). The north-eastern coastline falls in places within Carlingford Shore SAC (Site 002306), Carlingford Lough pNHA (Site 000452) and Carlingford Lough Special Protection Area (SPA; Site 004078). The south-western shore lies within various designated areas (Dundalk Bay SAC, SPA and pHNA — these do not overlap with any of our sites). There is a small pNHA in the north-west of the peninsula, Ravensdale Plantation (Site 001805). The legal designations pertaining to each site are listed in the site accounts. See the NPWS Designations Viewer for full details.

The significance of species-rich bryophyte assemblages within the Carlingford Mountain SAC (Site 000543) is further recognised by its concomitant designation as an Important Bryophyte Area (IBrA; Lockhart *et al*. 2012), a designation designed to fulfil Target 5 of the Convention on Biological Diversity's Global Strategy for Plant Conservation (Campbell & Lockhart 2017).

View from Slieve Foye across Carlingford Lough to the Mourne Mountains in Co. Down (Dec. 2021).

Sites visited



Sites examined on the Cooley peninsula 2021–2023

No.	Site Name	Main Habitat Types
1	Slieve Foye (Carlingford Mt)	Hillside flushes, flushed boulders / bedrock outcrops
2	Carlingford Marina	Coastal flushes and seepages
3	Ryland River, 'Omeath Glen'	Stream in wooded glen; large boulders in stream
4	The Windy Gap	Springs, flushes, small streams, flushed rocks, dry boulders
5	Moneycrockroe	Hillside flush and dry boulders
6	The Round Mountain	Dry boulders, flushes and small streams
7	Mullaghattin	Track with drainage channel; blanket bog
8	Marble Bridge	Stream in shaded ravine
9	Black Mountain	Upland exposed bedrock, heath, drainage channels
10	Cornamucklagh	Flushed fields
11	Fathom Forest, Co. Armagh	Shaded roadside banks, exposed bedrock outcrops and walls

Key species and sites

	Species	Main habitat type	Site Number									
	of highest ecological significance (*)	on Cooley Peninsula	1	2	3	4	5	6	7	8	9	10	11
	Mosses												
	Amphidium mougeotii	Flushed rocks, stream edges and waterfalls	✓		✓	✓							
	Andreaea rothii	Dry boulders	✓			✓		✓					
	Andreaea rupestris	Dry boulders	✓				✓	✓					
	Blindia acuta	Flushes and wet rocks	✓			✓	✓	✓				✓	
FPO	*Braunia imberbis*	Dry boulders				✓		✓					
	Breutelia chrysocoma	Flushes and damp hillsides	✓			✓	✓						
	Bryum alpinum	Flushed rocks and damp ground	✓			✓	✓	✓	✓		✓		
NVCR	*Bryum pallescens*	Beneath metal railings on mountain top									✓		
Cap.	*Bryum sauteri*	Forest track							✓				
	Campylopus atrovirens	Flushes and wet rocks	✓			✓		✓					
	Dichodontium palustre	Edge of drainage channels							✓		✓	✓	
	Dicranum majus	Sheltered hillsides	✓					✓					
	Fissidens osmundoides	Flushed rocks	✓			✓							
NT	*Grimmia decipiens*	Dry boulders						✓					
NT	*Grimmia donniana*	Dry boulders	✓										
NT	*Grimmia ramondii*	Dry boulders				✓		✓					
	Hedwigia stellata	Dry boulders	✓			✓							
	Homalia trichomanoides	Shaded stream side			✓								
	Hyocomium armoricum	Flushed rocks; rocks in streams	✓							✓			
	Neckera crispa	Boulders and rocky ground on hillside	✓										
VCd	*Oligotrichum hercynicum*	Drainage channel at edge of track									✓		
	Palustriella commutata	Base-rich seepages, especially on coast	✓	✓									
	Palustriella falcata	Base-rich flushes	✓										
	Philonotis calcarea	Calcareous coastal seepages		✓									
	Plagiomnium elatum	Damp, shaded places; coastal flush	✓	✓									
VCd	*Plagiothecium denticulatum*	Shaded retaining wall at roadside											✓
	Racomitrium affine	Dry boulders				✓							
	Racomitrium aquaticum	Flushed boulders	✓			✓		✓					
	Racomitrium heterostichum s.s.	Dry boulders				✓							
	Scorpidium cossonii	Hillside flushes	✓	✓		✓	✓	✓					
	Scorpidium revolvens	Hillside flushes	✓				✓	✓				✓	
	Scorpidium scorpioides	Hillside flushes	✓			✓	✓						
	Sphagnum inundatum	Flushes										✓	
VCd	*Thuidium delicatulum*	Flush and stream edge	✓				✓						
	Liverworts												
	Cephaloziella divaricata	Damp rock	✓										
NVCR	*Jubula hutchinsiae*	Deeply shaded humid gorge								✓			
	Lejeunea lamacerina	Stream edges	✓		✓					✓			
	Marsupella emarginata	Hillside boulders	✓										
	Mesoptychia bantriensis	Flush below springhead, water pH 6.8				✓							
	Saccogyna viticulosa	Flushed rock	✓										
	Scapania gracilis	Boulders on hillside	✓			✓		✓					
	Tritomaria quinquedentata	Damp boulders and banks	✓					✓					

FPO = Flora Protection Order 2015 / 2022; NVCR = New Vice-county Record; VCd = Vice-county debracket (not seen in the last 50 years); NT = Red List 'Near Threatened'; Caps = capsules not seen previously in Britain or Ireland.

1. Slieve Foye (Carlingford Mountain)

Location

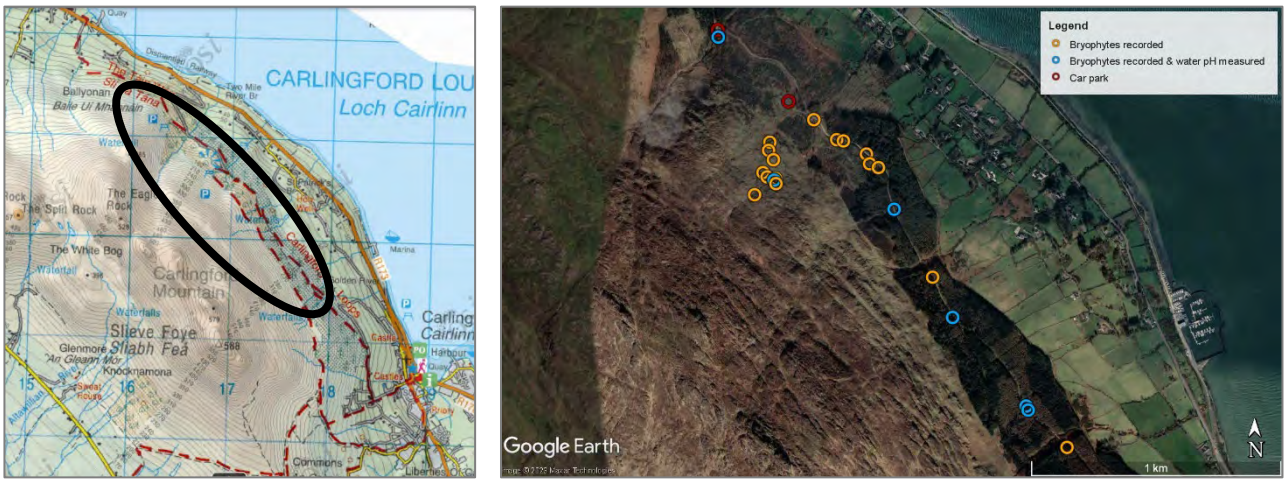


Fig. 1.01: Location of study sites on Slieve Foye. Source: OSI Discovery Series (left); Google Earth (right).

Study site

The areas examined were accessed from the carparks on the north-eastern side of Slieve Foye, located just off the R173, midway between Carlingford and Omeath (Fig. 1.01):

a) From the upper, south-eastern car park (J 168 137, alt. 175 m), uphill in a southerly direction for a distance of approximately 550 m (to J 168 131, alt. 340 m).
b) Forest track running south-east of upper car park towards Carlingford town, for a distance of 2 km to J 181 123, alt. c. 150 m. This area was clear-felled in the past few years.
c) Areas surrounding upper and lower car parks: J 168 137, alt. 175 m and J 165 139, alt. 90 m respectively.

Legal designations

The hillside above car park (i.e. south-west of the car park), but not including the forest track, lies within:

- Carlingford Mountain SAC (Site 000453) and Cooley Mountains IBrA (Site 19)
- Carlingford Mountain pHNA (Site 000453)

Bedrock geology

- Greywacke — Inniskeen Formation; Silurian turbidite
- Several Tertiary dolerite dykes occur on the hillside.

Habitats and species

Flushes on Slieve Foye (Site 1a)

Flushes and seepages on Slieve Foye were very variable in their physical and chemical structure and in their species composition (Figs 1.02–1.05). In base-rich flushes flowing over gritty soil, *Blindia acuta**, *Fissidens osmundoides**, *Palustriella falcata**, *Scorpidium cossonii**, *S. revolvens* s.s.*, *S. scorpioides**, *Bryum pseudotriquetrum, Campylium stellatum, Ctenidium molluscum, Tortella tortuosa* and the thallose liverwort *Aneura pinguis* grew (Figs 1.06–1.08). Elsewhere, the vegetation was indicative of neutral to acidic

conditions with *Breutelia chrysocoma*, Sphagnum subnitens* and — on adjoining acid heathland and blanket bog — *Hylocomium splendens, Hypnum jutlandicum, Pleurozium schreberi, Polytrichum formosum* and *Sphagnum papillosum* were present. Vascular plants were indicative of similar patterns with calcicoles such as *Carex dioica, C. flacca, C. panicea, Eleocharis quinqueflora, Juncus articulatus, Linum catharticum, Lysimachia tenella* (syn. *Anagallis tenella*), *Pinguicula vulgaris, Schoenus nigricans*[1] and *Selaginella selaginoides* growing in base-rich flushes, while calcifuge species such as *Blechnum spicant, Erica cinerea*, *Nardus stricta* and *Narthecium ossifragum* occurred on nearby ground that was apparently more acid.

Rock outcrops (Site 1a)

Bedrock outcrops and scattered boulders were prominent features of the hillside (Figs 1.09–1.13). Some were constantly irrigated by spring water issuing from above. Others were arid habitats, irrigated only by rainfall.

The species most frequently encountered on rocks irrigated with spring water were the mosses *Amphidium mougeotii*, Blindia acuta*, Campylopus atrovirens*, Racomitrium aciculare* and *R. aquaticum*,* and the leafy liverworts *Diplophyllum albicans* and *Scapania undulata.* Also present within this habitat type, but less frequently, were the mosses *Bryum alpinum*, Hyocomium armoricum** and *Campylium stellatum* s.s. and the leafy liverworts *Cephaloziella divaricata**, *Marsupella emarginata*, Saccogyna viticulosa** and *Tritomaria quinquedentata**.

The complexity of pH was apparent in both the water samples tested (see table below) and the juxtaposition of species with different requirements occurring in nearby locations. On wet rocks *Campylopus atrovirens** (in water with pH 5.8 to 6.0)*, Cephaloziella divaricata*, Marsupella emarginata** and *Diplophyllum albicans* were indicative of calcifuge communities. Conversely, calcicole communities were indicated by the species *Campylium stellatum* and *Aneura pinguis* (both in water with pH 7.1), and *Tritomaria quinquedentata*.*

Dry boulders (Site 1a)

Dry boulders were colonised by a very different bryophyte flora. The 'Near Threatened' species, *Grimmia donniana**, was growing here, along with other upland, calcifuge species *Andreaea rothii**, *A. rupestris*, Hedwigia stellata**, *Racomitrium heterostichum* agg.**, R. lanuginosum* and the leafy liverwort *Scapania gracilis**. The calcicole species *Neckera crispa**, *Fissidens dubius* and *Tortella tortuosa* were also present. Several common species including *Bryum capillare, Hypnum andoi, Isothecium myosuroides* and the liverwort *Frullania tamarisci*, which are widespread throughout Ireland, grew here also.

Forest track (Site 1b)

The forest track running through the now partly deforested area south-east from the upper car park is intersected by small, fast-flowing streams in narrow, shaded channels, as well as steep, flushed rock faces on the uphill side of the track (Figs 1.14–1.15). The water pH here was slightly higher (pH 6.9 – 7.2) than in the habitats occurring on the hillside (described above).

Several of the species found on Slieve Foye above the car park were also present in the streams and flushes along the forest track, but with a reduced presence of calcifuge species. *Amphidium mougeotii**, *Blindia acuta*, Fissidens osmundoides*, Tritomaria quinquedentata*, Bryum pseudotriquetrum, Campylium*

[1] *Schoenus nigricans* occurs in calcareous habitats in the east of Ireland. On the west coast, however, it has a much broader ecological range.

stellatum and *Ctenidium molluscum* — species of circumneutral to moderately base-rich habitats — were frequent. In addition, more strongly calcicole species were also present: *Palustriella commutata*, Pellia endiviifolia* and *Fissidens adianthoides*, growing on flushed rocks and soil. The damp, shaded banks along the track also provided suitable ground for species such as *Dicranum majus**, *Plagiomnium elatum*, Thuidium delicatulum**, *Hookeria lucens, Lejeunea lamacerina*, Rhizomnium punctatum, Riccardia chamedryfolia* and *R. multifida*.

Other habitats

Where there was some disturbance of soil, or where rudimentary soil or peaty material had formed over boulders, pioneer species such as *Campylopus pyriformis, C. introflexus, Pogonatum aloides, P. urnigerum* and *Polytrichum piliferum* grew.

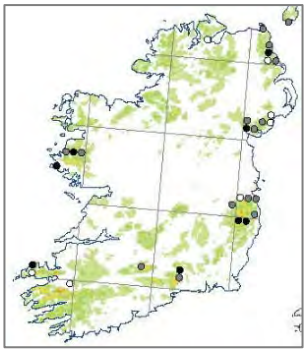
Woodland species occurred in shaded places in the vicinity of the carparks, including *Atrichum undulatum, Eurhynchium striatum, Pseudotaxiphyllum elegans* and *Thuidium tamariscinum.*

On track edges, in grassy places and on banks near the car park other common species were encountered, including *Campylopus flexuosus, Dicranella heteromalla, Dicranum scoparium, Didymodon insulanus, Kindbergia praelonga, Pseudoscleropodium purum, Rhytidiadelphus squarrosus* and *Tortula truncata*.

Significance

Habitats on Slieve Foye consist of a mosaic of wet flushes and small streams, as well as dry boulders, heath, blanket bog and grasslands. These support a wide range of ecologically significant bryophytes (*), many of which are rare in the east of Ireland. The flushes, boulders and rock outcrops are of particular interest, their ecological conditions influenced by both bedrock geology and overlying deposits at each point on the hillside, as well as by minerals carried from further afield by the moving water. The complexity of the site allowed species with very different ecological requirements to grow in close proximity. Those of wet and dry habitats, as well as those with different pH preferences often intermingled. The different conditions were created and maintained by the intricate network of water channels, above and below ground, irrigating some parts of the hillside, while allowing others to remain relatively dry. In addition, the contrasting bedrock types, the overlying deposits and the particular substrates through which the water has travelled result in varying combinations of conditions with distinct chemical signatures.

Thus, the habitats on Slieve Foye, including those along the forest track, are highly significant for the range of habitats and rare species they support. Many of these species, such as *Andreaea rupestris*, Bryum alpinum*, Grimmia donniana**, *Hedwigia stellata*, Thuidium delicatulum** and *Tritomaria quinquedentata**, have very limited geographical distributions in Ireland (see maps, Appendix). Others, such as *Scorpidium cossonii*, S. revolvens* s.s.* and *S. scorpioides**, though somewhat more widespread, are nevertheless confined to narrowly defined ecological settings and are in decline due to the ongoing loss of and damage to their specialised habitat types. All of these species had been recorded from Co. Louth previously but *Thuidium delicatulum** had not been seen since 1965.



*Grimmia donniana** was assessed as 'Near Threatened' on the Red List for Ireland (Lockhart *et al*. 2012). It occurs in very few places (left) and the Carlingford peninsula is therefore an important location for this species. There are only two former records for H31 Co. Louth — 1968 at Tullaghomeath (anon.) and 2007 Clermont Cairn (D.T. Holyoak).

Source of map: BBS Atlas, Blockeel *et al*. 2014. Black circles are records from 1990–2013; grey circles are from 1950–1989; white / open circles are pre-1950 records.

Bryophyte species on Slieve Foye (Carlingford Mountain; Site 1)

	Mosses		
***Sig.**	***Amphidium mougeotii***	-	*Hypnum jutlandicum*
***Sig.**	***Andreaea rothii***	-	*Isothecium myosuroides*
***Sig.**	***Andreaea rupestris***	-	*Kindbergia praelonga*
-	*Atrichum undulatum*	***Sig.**	***Neckera crispa***
-	*Aulacomnium palustre*	***Sig.**	***Palustriella commutata***
***Sig.**	***Blindia acuta***	***Sig.**	***Palustriella falcata***
-	*Brachythecium rivulare*	***Sig.**	***Plagiomnium elatum***
-	*Brachythecium rutabulum*	-	*Plagiomnium undulatum*
***Sig.**	***Breutelia chrysocoma***	-	*Pleurozium schreberi*
***Sig.**	***Bryum alpinum***	Mod.	*Pogonatum aloides*
-	*Bryum capillare*	Mod.	*Pogonatum urnigerum*
Mod.	*Bryum pseudotriquetrum*	-	*Pohlia nutans*
-	*Calliergonella cuspidata*	-	*Polytrichum formosum*
Mod.	*Campylium stellatum* s.s.	Mod.	*Polytrichum piliferum*
***Sig.**	***Campylopus atrovirens***	-	*Pseudoscleropodium purum*
-	*Campylopus flexuosus*	-	*Pseudotaxiphyllum elegans*
-	*Campylopus introflexus*	Mod.	*Racomitrium aciculare*
-	*Campylopus pyriformis*	***Sig.**	***Racomitrium aquaticum***
-	*Ctenidium molluscum*	***Sig.**	***Racomitrium heterostichum* agg.**
-	*Dicranella heteromalla*	Mod.	*Racomitrium lanuginosum*
***Sig.**	***Dicranum majus***	-	*Rhizomnium punctatum*
-	*Dicranum scoparium*	-	*Rhynchostegium confertum*
-	*Didymodon insulanus*	-	*Rhytidiadelphus squarrosus*
-	*Eurhynchium striatum*	Mod.	*Sciuro-hypnum plumosum*
Mod.	*Fissidens adianthoides*	***Sig.**	***Scorpidium cossonii***
Mod.	*Fissidens dubius*	***Sig.**	***Scorpidium revolvens* s.s.**
***Sig.**	***Fissidens osmundoides***	***Sig.**	***Scorpidium scorpioides***
-	*Fissidens taxifolius*	Mod.	*Sphagnum papillosum*
***Sig. (NT)**	***Grimmia donniana***	Mod.	*Sphagnum subnitens*
***Sig.**	***Hedwigia stellata***	Mod.	*Sphagnum squarrosum*
Mod.	*Hookeria lucens*	***Sig.**	***Thuidium delicatulum***
-	*Hylocomium splendens*	-	*Thuidium tamariscinum*
***Sig.**	***Hyocomium armoricum***	-	*Tortella tortuosa*
-	*Hypnum andoi*	-	*Tortula truncata*

	Liverworts		
Mod.	*Aneura pinguis*	***Sig.**	***Marsupella emarginata***
-	*Calypogeia fissa*	-	*Pellia endiviifolia*
***Sig.**	***Cephaloziella divaricata***	-	*Pellia epiphylla*
-	*Conocephalum conicum* s.s.	-	*Riccardia chamedryfolia*
-	*Conocephalum salebrosum*	-	*Riccardia multifida*
-	*Diplophyllum albicans*	***Sig.**	***Saccogyna viticulosa***
-	*Frullania tamarisci*	***Sig.**	***Scapania gracilis***
***Sig.**	***Lejeunea lamacerina***	Mod.	*Scapania undulata*
-	*Lophocolea bidentata*	***Sig.**	***Tritomaria quinquedentata***

NT = Near Threatened, Red List (Lockhart *et al*. 2012)

Water chemistry

Sample location and details	**pH**	**Description**
Site 1a, Slieve Foye, above car park (WS14, n=2, 21/01/2023)	7.1	Vertical flushed rock with *Schoenus nigricans, Campylium stellatum* and *Aneura pinguis*
Site 1a, Slieve Foye, above car park (WS15, n=2, 21/01/2023)	5.8 – 6.0	Vertical flushed rock with *Campylopus atrovirens** and *Erica cinerea*
Site 1a, Slieve Foye, above car park (WS42, n=1, 27/06/2023)	6.0	Flush with *Drosera rotundifolia* and *Scorpidium revolvens* s.s.* See photo below.
Site 1b, Track SE of car park, towards Carlingford, through clear-felled forest (WS10–WS13, n=5, 31/12/2022)	6.9 – 7.2	Four separate locations, where small streams and seepages flowed off the hillside
Site 1c, Two Mile River, at bridge in small car park (WS16, n=2, 21/01/2023)	7.2	Stream immediately above bridge

Site Photographs

Fig. 1.02: North-east facing slopes of Slieve Foye (Carlingford Mountain) overlooking Carlingford Lough. Rocky outcrops, boulders scattered on the hillside and areas flushed with emerging groundwater provide a variety of habitats for bryophytes. Dec. 2021.

Fig. 1.03: Hillside flushes are harsh, exposed environments for species to survive in. Frozen water, at the time of this visit in January 2023, highlights the extent to which parts of the hillside are irrigated by shallow, moving water which would normally be inconspicuous and concealed by the vegetation.

Fig. 1.04: Flush vegetation with the very dark-coloured 'brown mosses' (*Scorpidium** species). Dec. 2021.

Fig. 1.05: Stony flush with *Scorpidium revolvens* s.s.* (in the wettest parts) and *Drosera rotundifolia* (red leaves, bottom left). Water pH 6.0. June 2023.

Fig. 1.06: The acrocarpous moss *Blindia acuta** in a stoney flush. July 2023.

Fig. 1.07: *Palustriella falcata** (golden moss, foreground) and the clubmoss *Selaginella selaginoides* (centre) in a hillside flush. July 2023.

Fig. 1.08: An unusually large patch of the thallose liverwort, *Aneura pinguis*, also known as Greasewort, due to the texture of the surface of the thallus. July 2023.

Fig. 1.09: The reddish leafy liverwort *Marsupella emarginata** growing on a periodically flushed rock (with a pale-coloured shoot of P*seudoscleropodium purum*, bottom right). July 2023.

Fig. 1.10: The small acrocarpous moss, *Andreaea rupestris** on a dry boulder. To withstand desiccation, the leaves are tightly appressed to stems when in the dry state, and it often looks jet black. July 2023.

Fig. 1.11: *Andreaea rupestris** (centre) in the wet state, looking a much brighter golden colour (compare Fig. 1.10), and *Racomitrium heterostichum* agg.* (bright green). July 2023.

Fig. 1.12a: Boulder irrigated with thin film of water, on which a variety of species characteristic of wet rocks grew, including (1) *Fissidens osmundoides** (Fig. 1.12b below), (2) *Bryum alpinum** (Fig. 1.02c below) and (3) *Breutelia chrysocoma**. June 2023.

Fig. 1.12b: *Fissidens osmundoides** (on rock above, Fig. 1.12a)

Fig. 1.12c: *Bryum alpinum** (on rock above, Fig. 1.12a)

Fig. 1.13: Dry boulder with (1) *Racomitrium lanuginosum*, (2) R*. heterostichum* agg.*, (3) *Andreaea rupestris** and (4) *Pohlia nutans* (with capsules on orange setae). June 2023

Fig. 1.14a: Flushed rock exposure on forest track (Site 1b), with (1) *Sphagnum subnitens* and (2) *S. squarrosum* on top and with dripping water irrigating (3) the mosses *Bryum pseudotriquetrum*, *Campylium stellatum*, *Fissidens adianthoides*, *F. osmundoides* and the liverworts *Pellia endiviifolia* and *Riccardia chamedryfolia*. *Palustriella commutata** grew within the *Molinia* tussock (4) at the base of the rock. Water dripping onto rock pH 6.9, July 2023.

Fig. 1.14b: Position of species listed above.

Fig. 1.14c: (2) *Sphagnum squarrosum* detail.

Fig. 1.15: Drainage channel alongside forest track (above left) flowed into culvert (arrow, and above right). On the damp shaded banks at the bend into the culvert, the moss *Thuidium delicatulum** grew, along with *Fissidens adianthoides*, *Pellia epiphylla, Pseudotaxiphyllum elegans*, *Rhizomnium punctatum* and *Scapania undulata*. Water pH 7.1 (calcifuge species were just out of reach of the flow). July 2023.

2. Carlingford Marina and Greenway

Location

Fig. 2.01: Location of study sites at Carlingford Marina. Source: OSI Discovery Series (left); Google Earth (right).

Study Site

The area examined extended from the access point from the R173 (J 185 126) to the greenway track north of the marina (J 177 138; Fig. 2.01), with particular focus on:

a) Flushed hillside along access road between R173 and marina buildings: J 185 126, alt. <5 m
b) Small waterfalls and seepages over rocks near marina building: J 184 128 to J 183 130, alt. ≤10m
c) Flush beside greenway, north of marina: J 177 138, alt. <5 m

Legal designations

The areas of interest lie close to the boundary of, but mostly outside:

- Carlingford Shore SAC (Site 002306)
- Carlingford Lough pNHA (Site 000452)

Thus, Sites 2a and 2b were not within the designated areas; Site 2c lay on the boundary (possibly just outside).

Bedrock geology and Quaternary sediments

- Greywacke — Inniskeen Formation; Silurian turbidite
- Till derived from granites occurs locally in this area.

Habitats and species

Site overview

Wetland features of interest occurred along the west side of the access road leading to the marina and, further north, along the greenway (Figs 2.02–2.11). Water trickling off Carlingford Mountain emerged from below ground, giving rise to a series of seepage zones, small rivulets and rocky waterfalls. In places, calcareous material was deposited from the spring water in the form of paludal tufa (Fig. 2.07). Continuity of seepage, an important ecological feature of these habitat types, was indicated by the presence of species such as *Molinia caerulea* and *Palustriella commutata**.

Site 2a: springs and seepages at access road

Seepage zones on the hillside adjacent to the access road leading to the marina contained an ecologically specialised group of bryophytes, indicative of clean, base-rich water: *Palustriella commutata*, Bryum pseudotriquetrum, Calliergonella cuspidata, Didymodon tophaceus*, *Fissidens adianthoides* and the thallose liverworts *Aneura pinguis* and *Pellia endiviifolia* (Figs 2.02–2.06). The pH of water in the seepage zone, pH 7.2, was within the range that is typical for these species (Lyons 2015). The vascular plant *Isolepis cernua* grew in a small channel at the base of the hillside into which the water flowed from the hill (water pH 7.9). These bryophyte and vascular plant species were recorded during site visits in November 2022 and February 2023.

On a later trip, in April 2023, however, these habitats were found to have been severely damaged and some components had been destroyed entirely. The area between the access road and the base of the hillside had been filled in with hard core (Fig. 2.04). Thus, the lower portion of the seepage zones and the drainage channel with *Isolepis cernua* were destroyed. The rivulets on the hillside show signs of having been cleared and deepened with a consequent loss or reduction in coverage of the bryophyte species previously growing there.

Site 2b: waterfalls and seepages near marina

Close to the marina buildings and car park, water emerged from the hillside in small streams and waterfalls. *Rhynchostegium riparioides* was plentiful in small waterfalls with fast-flowing water (Fig. 2.08). It can withstand the shear force of the water in such settings better than most other bryophytes. In the spray zone near the waterfalls and in other damp, seepage areas, the mosses *Brachythecium rivulare, Bryum pseudotriquetrum, Cratoneuron filicinum, Didymodon insulanus* and *D. tophaceus* and the liverworts *Aneura pinguis, Chiloscyphus polyanthos* agg., *Conocephalum conicum* s.s., *Lunularia cruciata, Pellia endiviifolia* and *Riccardia chamedryfolia* were growing. *Palustriella commutata** and *Fissidens adianthoides* were also present but in smaller amounts than at Site 2a. Higher plants associated with these habitats included *Carex lepidocarpa*, *Eupatorium cannabinum*, *Helosciadium nodiflorum* (syn. *Apium nodiflorum), Linum catharticum* and *Prunella vulgaris*. The non-native, invasive species *Centranthus ruber, Leycesteria formosa* and *Clematis vitalba* were also present on the hillside in the vicinity of wetland habitats.

Site 2c: flush at greenway

North of the buildings and yards, a more gently sloping seepage zone occurred adjacent to the greenway (Figs 2.09–11). This area contained an important and ecologically distinctive community of calcicole plants with the mosses *Palustriella commutata*, Philonotis calcarea*, Plagiomnium elatum**, *Scorpidium cossonii*, Calliergonella cuspidata, Campylium stellatum* s.s., *Ctenidium molluscum* and *Fissidens adianthoides*, and the liverworts *Aneura pinguis* and *Riccardia chamedryfolia*. The vascular plants recorded here — *Carex lepidocarpa, C. flacca, Dactylorhiza fuchsia, Hypericum tetrapterum, Isolepis cernua, Juncus articulatus, Pinguicula vulgaris, Schoenus nigricans*, *Selaginella selaginoides* and *Succisa pratensis* — are also characteristic members of this plant community, as is a stonewort (*Chara* sp.) in the channel at the base of the slope.

Significance

Within the site complex, where *Palustriella commutata** was present and there were traces of tufa precipitation, the habitats had a high degree of correspondence with the Annex 1 Priority habitat type 'Petrifying springs with tufa formation (*Cratoneurion*) 7220'. High pH values at this site were influenced both by the calcareous nature of the underlying bedrock and by proximity to the sea. These values, and the constant movement and aeration of the water, provided suitable habitats for communities that are confined to a narrow range of ecological conditions and are therefore limited in distribution. Thus, this site is of high conservation value and the recent damage amounts to a serious loss of ecologically important habitat and species. The rationale as to why these works were deemed necessary is not clear; were the proposed developments subjected to relevant ecological scrutiny in view of the sensitive status of the habitats?

The calcareous flush adjacent to the greenway (Site 2c) is an excellent example of what is an increasingly rare, ecologically significant habitat type. This was the only location in Carlingford at which *Philonotis calcarea* was found during the study. The closely related *P. fontana* is widespread in springs on the Cooley peninsula. *P. calcarea*, however, is considerably more ecologically restricted than *P. fontana*, and it is confined to these high pH springs (Atherton *et al*. 2010; Blockeel *et al*. 2014; Lyons 2015).

The abundance of *Rhynchostegium riparioides* in the small waterfalls near the marina suggests some elevation of nutrients in these channels (Lyons 2015). By comparison, the species present in the flush on the greenway are indicative of low nutrient levels, a factor which contributes to the significance of the habitat. Nutrient levels are important in determining species composition and low nutrient levels are necessary to ensure the continued survival of the existing plant communities at Site 2c on the greenway.

Bryophyte species at Carlingford Marina and Greenway (Site 2)

	Mosses		
-	*Barbula unguiculata*	Mod.	*Didymodon tophaceus*
-	*Brachythecium rivulare*	Mod.	*Fissidens adianthoides*
-	*Bryum capillare*	-	*Fissidens taxifolius*
Mod.	*Bryum pseudotriquetrum*	***Sig.**	***Palustriella commutata***
-	*Calliergonella cuspidata*	***Sig.**	***Philonotis calcarea***
Mod.	*Campylium stellatum* s.s.	***Sig.**	***Plagiomnium elatum***
-	*Cratoneuron filicinum*	-	*Pseudoscleropodium purum*
-	*Ctenidium molluscum*	-	*Rhynchostegium riparioides*
-	*Didymodon fallax*	***Sig.**	***Scorpidium cossonii***
-	*Didymodon insulanus*	Mod.	*Weissia controversa* var. *controversa*

	Liverworts		
Mod.	*Aneura pinguis*	-	*Lunularia cruciata*
-	*Chiloscyphus polyanthos* agg.	-	*Pellia endiviifolia*
-	*Conocephalum conicum* s.s.	-	*Riccardia chamedryfolia*
-	*Lophocolea bidentata*		

Water Chemistry

Sample location	pH	Description
Site 2a, south of marina, along access road (WS05, 06, 39, 40, n=4, 22/11/2022, 13/04/2023)	7.2 – 8.0	Seepage over rock + channel at base of rock + waterfall
Site 2b, at marina / boatyard (WS07, 38, n=3, 22/11/2022, 13/04/2023)	7.5 – 7.9	Waterfall / water trickling over rock
Site 2c, Carlingford Greenway, north of marina (WS18, 38, n=5, 07/02/2023, 13/04/2023)	7.3 – 7.8	Drainage channel at base of slope, parallel to track

Site Photographs

Fig. 2.02: Seepage zones and the drainage channel along this part of the hillside contained ecologically significant wetland plant communities (Site 2a, November 2022).

Fig. 2.03: The same location as in Fig. 2.02 (Site 2a) in April 2023 having been severely damaged. The seepage zone has been truncated and the small stream in the drainage channel has been entirely lost.

Fig. 2.04: *Palustriella commutata** formed large wefts where water issued from the slope. The drainage channel at the base of the slope was an important component of the habitat (Site 2a, November 2022).

Fig. 2.05: The pleurocarpous moss *Palustriella commutata**, an indicator of base-rich springs and seepages where the water flow is continuous (Site 2a, November 2022).

Fig 2.06: *Fissidens adianthoides* in crevice in rock within seepage zone (Site 2a, November 2022). Bryophyte communities were severely damaged by works at this location in or around spring 2023.

Fig. 2.07: Seepage at Site 2b with *Palustriella commutata** (golden-green moss) and paludal tufa (pale coloured deposit, right of moss). July 2023.

Fig. 2.08: Waterfall near marina (Site 2b). *Rhynchostegium riparioides* can withstand the force of the water with its tough wiry stems. Other bryophytes, especially thallose liverworts such as *Pellia endiviifolia*, prefer the damp, shaded edges of the waterfall (April 2023).

Fig. 2.09: The acrocarpous moss, *Philonotis calcarea**, in the flush along the greenway (Site 2c). This moss is confined to clean, base-rich springs and seepages. July 2023.

Fig. 2.10: Flush adjacent to greenway (Site 2c). The gently sloping ground and the drainage channel at the base both contain ecologically significant bryophyte species and are of high nature conservation value (April 2023).

Fig. 2.11: *Schoenus nigricans* (green tussock; white arrow) and *Palustriella commutata** (golden moss, black arrow) indicate the continued throughput of base-rich waters. Site 2c adjacent to greenway (April 2023).

3. Ryland River, Omeath Glen

Location

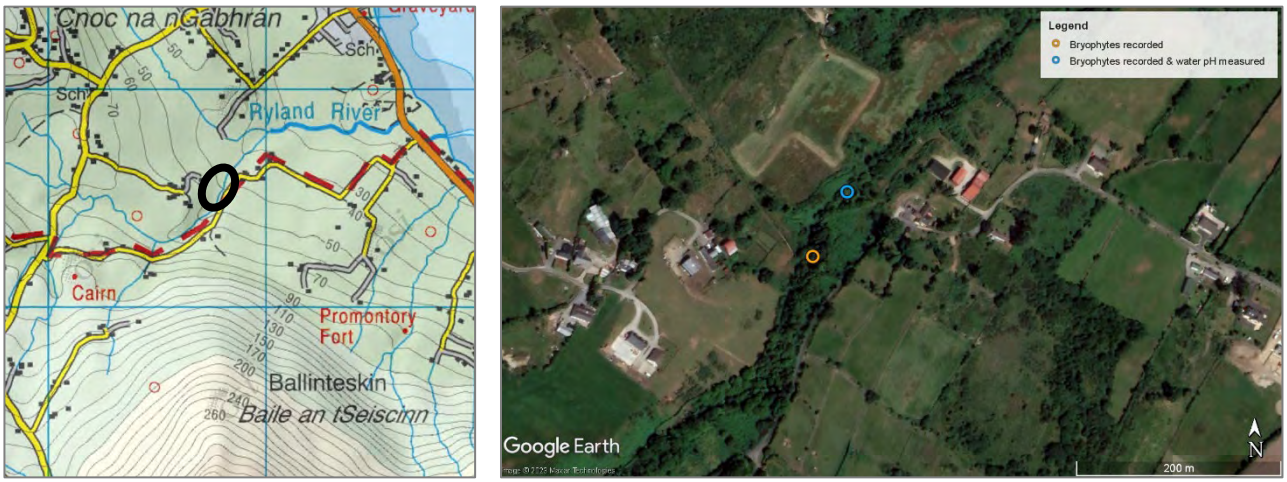


Fig. 3.1: Location of study site on Ryland River at 'Omeath Glen'. Source: OSI Discovery Series (left); Google Earth (right).

Study site

The Ryland River was accessed at J 138 156 at an old ford (OSI historic maps), alt. 30 m. Bryophytes on boulders in the river and on the banks were examined upstream of the ford, to a distance of 75 m (Figs 3.1–3.4).

There are records for several rare bryophyte species at 'Omeath Glen' by Canon H.W. Lett (Lett 1889; McArdle 1904), but no place with this name could be found on OSI maps, historic or recent. The section of the Ryland River we examined, in a small, wooded valley approx. 1 km south of Omeath, seemed the most likely match for the site visited by Canon Lett.

Legal designations

None

Bedrock geology and Quaternary sediments

- Greywacke — Inniskeen Formation; Silurian turbidite
- Till derived from granites occurs on the hillsides on either side of the site

Habitats and species

The Ryland River provided suitable habitats for a range of species typically associated with rocky streams and damp, shaded ravines, such as the mosses *Amphidium mougeotii**, *Brachythecium rivulare, Ctenidium molluscum, Dichodontium pellucidum* agg., *Fissidens bryoides* s.s., *Hookeria lucens, Racomitrium aciculare, Rhynchostegium riparioides* and *Sciuro-hypnum plumosum*, and the liverworts *Lejeunea lamacerina**, *Chiloscyphus polyanthos* agg. and *Plagiochila porelloides* var. *porelloides* (Fig. 3.2). The aquatic species, *Fontinalis antipyretica* grew beneath the water surface. Growing on the wooded banks were the mosses *Homalia trichomanoides*, Atrichum undulatum, Fissidens dubius, Mnium hornum, Plagiomnium undulatum, Rhizomnium punctatum, Rhynchostegium confertum* and *Thamnobryum alopecurum* and the liverworts *Conocephalum conicum* s.s., *Lunularia cruciata, Pellia endiviifolia and P. epiphylla*. Key vascular plants on the banks were *Blechnum spicant* and *Chrysosplenium oppositifolium*.

Significance

The humid, shaded conditions in this small, wooded valley provided optimal conditions for a wide range of bryophytes. Some of those recorded on boulders in the stream, or in the flood or spray zone, were indicative of at least mildly basic conditions — for example, *Amphidium mougeotii**, *Ctenidium molluscum* and *Pellia endiviifolia* — and these are in keeping with the measured pH of the water (pH 7.1–7.5). Other species growing on the banks — *Homalia trichomanoides*, Hookeria lucens, Mnium hornum* and *Pellia epiphylla*, for example — are indicative of somewhat more acidic conditions, apparently arising from the presence of local granite till on the hillsides above the stream.

Of the species recorded in Omeath Glen by Canon Lett, we refound only *Plagiochila porelloides* var. *porelloides*. However, there is undoubtedly much more to be explored along this stretch of the river and further upstream, and this site merits further study.

Bryophyte species at Omeath Glen (Site 3)

	Mosses		
-	*Amblystegium serpens*	***Sig.**	***Homalia trichomanoides***
***Sig.**	***Amphidium mougeotii***	Mod.	*Hookeria lucens*
-	*Atrichum undulatum*	-	*Mnium hornum*
-	*Brachythecium rivulare*	-	*Oxyrrhynchium hians*
-	*Brachythecium rutabulum*	-	*Plagiomnium undulatum*
-	*Ctenidium molluscum*	Mod.	*Racomitrium aciculare*
Mod.	*Dichodontium pellucidum* agg.	-	*Rhizomnium punctatum*
Mod.	*Fissidens bryoides* agg.	-	*Rhynchostegium confertum*
Mod.	*Fissidens dubius*	-	*Rhynchostegium riparioides*
-	*Fissidens taxifolius*	Mod.	*Sciuro-hypnum plumosum*
-	*Fontinalis antipyretica*	-	*Thamnobryum alopecurum*

	Liverworts		
-	*Calypogeia fissa*	-	*Lophocolea bidentata*
-	*Chiloscyphus polyanthos* agg.	-	*Lunularia cruciata*
-	*Conocephalum conicum* s.s.	-	*Pellia endiviifolia*
-	*Frullania dilatata*	-	*Pellia epiphylla*
***Sig.**	***Lejeunea lamacerina***	Mod.	*Plagiochila porelloides* var. *porelloides*

Water chemistry

Sample location	**pH**	**Description**
Site 3 Ryland River, Omeath Glen (WS17, n=4, 07/02/2023, 13/04/2023)	7.1 – 7.5	Ryland River, at ford

Site Photographs

Fig. 3.2: Bryophytes are abundant on boulders in the Ryland River and on its damp, shaded banks, February 2023.

Fig. 3.3: Access point at ford, Feb. 2023.

Fig. 3.4: Downstream from ford, Feb. 2023.

4. The Windy Gap

Location

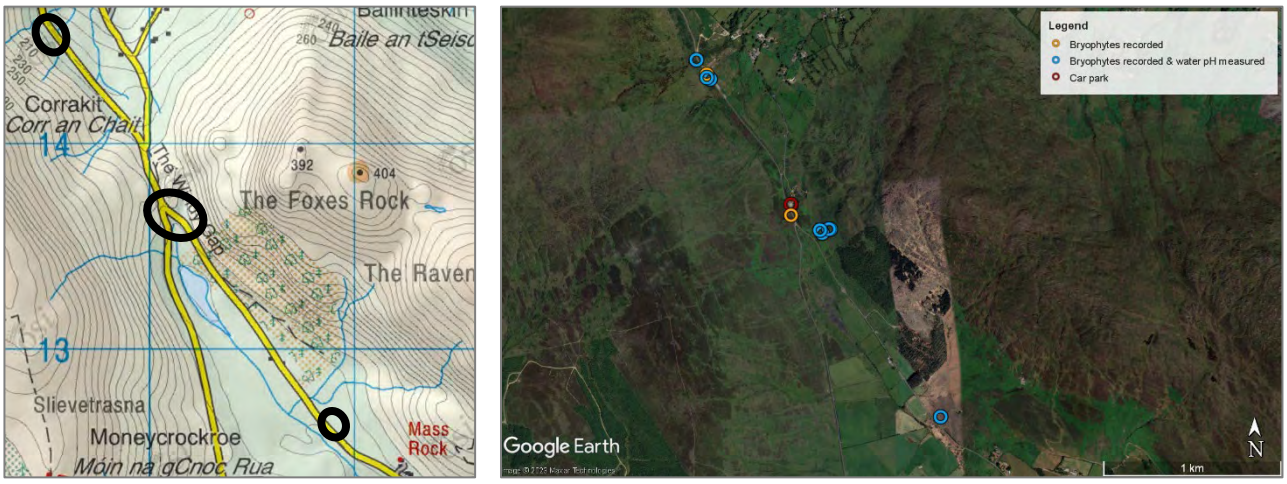


Fig. 4.01: Location of study sites near The Windy Gap. Source: OSI Discovery Series (left); Google Earth (right).

Study site

Four separate locations close to The Windy Gap were examined (Fig. 4.01):

a) Corrakit, north-west of The Windy Gap: J 125 145, alt. 180 m.
b) Wet rock face, opposite The Windy Gap car park: J 130 137, alt. 200 m.
c) Springhead and flush, 250 m south-east of The Windy Gap car park: J 132 136, alt. 220 m.
d) Boulder field below The Ravens Rock, 1.4 km south-east of The Windy Gap: J 139 126, alt. 190 m.

Legal designations

All locations examined were located within:

- Carlingford Mountain SAC (Site 000453) and Cooley Mountains IBrA (Site 19)
- Carlingford Mountain pHNA (Site 000453)

Bedrock geology and Quaternary sediments

- Layered gabbros — Carlingford Complex; Tertiary (to the north and east of the area; Sites 4a, 4b, 4c)
- Geological faults between and within bedrock types (Sites 4a, 4b, 4c)
- Microgranite — Slieve Gullion Complex granophyre; Tertiary (to the south and west; Site 4d)
- Till derived from granites; locally, in low-lying parts of site (Site 4d)

Habitats and species

Site 4a: stream, flush and drainage channel north-west of The Windy Gap

The site at Corrakit was on the south-west side of the road where a small stream flowed over a rock outcrop, through a flushed area and then into a channel running parallel to the road (Figs 4.02, 4.03). On the rock outcrop, in the spray of the stream, were the mosses *Amphidium mougeotii**, *Breutelia chrysocoma**, *Fissidens osmundoides**, *Bryum pseudotriquetrum, Campylium stellatum* s.s., *Cratoneuron filicinum, Ctenidium molluscum* and the liverworts *Aneura pinguis, Pellia endiviifolia, P. epiphylla* and *Riccardia multifida*. The flushed area below the rock outcrop was dominated by the grass *Molinia caerulea*, along with

Calluna vulgaris, *Erica tetralix* and *Schoenus nigricans*. The presence of this combination of species with different ecological requirements reflects the complexity of soil and water chemistry of the site and the structural diversity within a small area.

The water flowed away from the flush in a narrow stoney channel, parallel to the road. Here, the mosses present were *Blindia acuta** (on stones in the stream bed, Fig. 4.03), *Breutelia chrysocoma** and *Campylium stellatum* s.s., along with the liverwort *Aneura pinguis* and the vascular plants *Carex lepidocarpa*, *Eleocharis multicaulis* and *Selaginella selaginoides*. The pH value of the water flowing over the bedrock outcrop was pH 6.9–7.1 (sampled on two different occasions), and that of the water in the channel below the flush was pH 7.1.

At a bridge approximately 100m further north-west, a larger stream descended. The pH value of the water was 7.0. Fewer bryophytes were present in the fast-flowing water, but *Amphidium mougeotii**, *Fissidens osmundoides**, *Racomitrium aciculare* and *Pellia endiviifolia* were present on the bank of the stream close to the road.

Site 4b: wet rock outcrop opposite The Windy Gap car park

On the opposite side of the road to The Windy Gap car park, a wet vertical rock outcrop formed an east-facing cliff and was irrigated from above by water seeping off the hillside. It was colonised by *Bryum alpinum**, *Racomitrium heterostichum* agg.*, *Fissidens adianthoides, Ptychomitrium polyphyllum* and *Sciuro-hypnum plumosum* (Figs 4.04, 4.05). There was insufficient water available to measure the pH.

Site 4c: springhead and flush south-east of The Windy Gap car park

Water issued from the hillside of The Foxes Rock in a small spring (pH 6.4–6.6) south-east of the car park. The springhead was dominated by a large stand of the bright green acrocarpous moss *Philonotis fontana* (Fig. 4.06). Below this, spring water descended in a small rivulet (pH 6.8) in which the mosses *Bryum pseudotriquetrum, Calliergonella cuspidata, Pleurozium schreberi, Pseudoscleropodium purum, Sphagnum papillosum, S. subnitens* and *S. tenellum* and the liverwort *Mesoptychia bantriensis** grew. Further downhill, the rivulet gave way to a broader flush (pH 6.8–6.9; Fig. 4.07). Here, the mosses *Blindia acuta**, *Breutelia chrysocoma**, *Campylopus atrovirens**, *Scorpidium scorpioides** and *Campylium stellatum* s.s. were present, along with the liverwort *Aneura pinguis*. Key vascular plants in the area irrigated by the spring and flush were *Schoenus nigricans, Pinguicula vulgaris, P. lusitanica, Lysimachia tenella, Carex flacca, C. lepidocarpa* and *Selaginella selaginoides*.

On dry or slightly damp boulders close to the springhead (but not in the main flow of the water), the mosses *Braunia imberbis** (syn. *Hedwigia integrifolia*; FPO species), *Andreaea rothii**, *Campylopus atrovirens**, *Hypnum andoi, Isothecium myosuroides* and the liverwort *Scapania gracilis** were found.

Site 4d: boulder field south-east of The Windy Gap

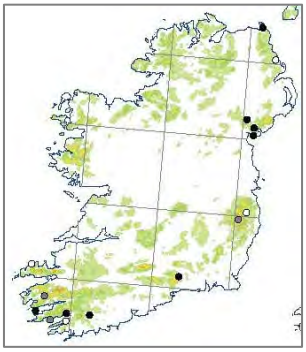
In a field south-east of The Windy Gap, large, dry boulders were colonised by *Braunia imberbis**, *Andreaea rothii**, *Grimmia ramondii**, *Racomitrium affine* s.s.*, *Racomitrium aquaticum**, *R. heterostichum* s.s.*, *Hypnum cupressiforme, Polytrichum piliferum* and *R. lanuginosum* (Figs 4.08–4.10). Separation of *Racomitrium affine* s.s. from *R. heterostichum* s.s., as per current taxonomic understanding, is difficult (Frisvoll 1988; Blockeel *et al*. 2014). It requires microscopic examination of sectioned nerves and, even then, specimens often cannot be assigned with certainty. Specimens collected at this location and assigned to

these two taxa *sensu stricto* were confirmed by the BBS referee. (At other sites, for the purposes of this study, plants belonging to this pair were grouped under *R. heterostichum* agg.)

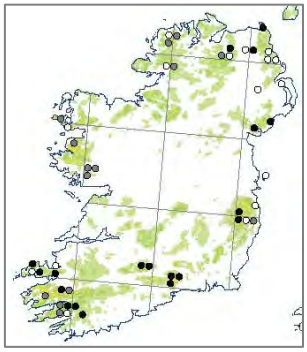
The ground between the boulders was very wet in places, and the species present indicated complex and varied ecological conditions. *Sphagnum papillosum* (strongly calcifuge) dominated the wetter parts, while elsewhere the calcicole mosses *Scorpidium cossonii** and *S. scorpioides** were present in small amounts. Vascular plants included *Calluna vulgaris*, *Carex echinata*, *C. panicea*, *C. pulicaris*, *Danthonia decumbens*, *Drosera rotundifolia*, *Erica tetralix*, *Eriophorum angustifolium*, *Lysimachia tenella*, *Molinia caerulea*, *Myrica gale*, *Narthecium ossifragum*, *Pinguicula vulgaris* and *Selaginella selaginoides.* These species are mostly indicative of acidic conditions, but the presence of *L. tenella*, *P. vulgaris* and *S. selaginoides* is indicative of at least some base enrichment. The water pH measured 5.0 in areas with *S. papillosum* and was thus markedly more acid than at the other sites described above. (There was no surface water available to test at the location where *Scorpidium* species grew.)

Significance

Site 4d, the boulder field south-east of The Windy Gap, is highly significant for the range of nationally rare, ecologically significant species it contains, including the FPO species, *Braunia imberbis** and the Red List 'Near Threatened' *Grimmia ramondii**. This location represents a slight extension, in a south-easterly direction, of the known range of *B. imberbis** as mapped by Hodd (2015). There are only two records for *G. ramondii** on the Cooley peninsula, both from the one-kilometre square immediately north of Site 4d. In addition, the site is an excellent example of a boulder field habitat — a habitat type which is by now uncommon, but in Carlingford has survived in an otherwise waterlogged field which is subjected to low grazing pressure. The species-rich bryophyte community supported by this habitat highlights the importance of the Carlingford peninsula in relation to bryophyte biogeography.



Braunia imberbis (syn. *Hedwigia integrifolia*) FPO



Grimmia ramondii (Red List: Near Threatened)

Source of map: BBS Atlas, Blockeel *et al*. 2014. Black circles 1990–2013; grey circles 1950–1989; white circles pre-1950 records.

The other areas examined within Site 4 were small but distinctive features in the landscape with specialised niches for particular bryophyte species. The diversity of features in the landscape — the complex underlying bedrock types; the various conditions created by the waters of slightly different chemical composition, depth and flow rates; the range of substrates for colonisation in irrigated areas — contributed to subtle differences in the composition of plant communities in different places. This mosaic also enabled the juxtaposition of what are normally regarded to be calcicole and calcifuge species, as well as the rich diversity in rare and ecologically significant species.

At the spring at Site 4c, for example, a change was detectable in the pH value of the water descending the short distance (c. 50 m) from the springhead to the flush and this was mirrored by a change in species composition: *Philonotis fontana* occupied the area irrigated by base-poor water (pH 6.4–6.6) while the brown mosses *Scorpidium cossonii* and *S. scorpioides**, along with the Long-stalked Yellow-sedge *Carex lepidocarpa* — species typical of more base-rich flushes — grew in water with pH 6.8–6.9 in the flush below. At a larger scale, the differences in pH values of the water reflect the diversity of underlying bedrock: gabbro (base-rich) underlies Corrakit, where the water pH was 6.9–7.1, while the boulder field (Site 4d) is underlain by acidic granite and there the water pH was 5.0. Yet, within this large-scale pattern, local variations create complex mixtures of both calcifuge and calcicole species, amongst both bryophyte and vascular plant communities.

Bryophyte species at The Windy Gap (Site 4)

	Mosses		
***Sig.**	***Amphidium mougeotii***	-	*Isothecium myosuroides*
***Sig.**	***Andreaea rothii***	Mod.	*Philonotis fontana*
***Sig.**	***Blindia acuta***	-	*Pleurozium schreberi*
***Sig. / FPO**	***Braunia imberbis* (syn. *Hedwigia integrifolia*)**	Mod.	*Polytrichum piliferum*
***Sig.**	***Breutelia chrysocoma***	-	*Pseudoscleropodium purum*
***Sig.**	***Bryum alpinum***		*Ptychomitrium polyphyllum*
Mod.	*Bryum pseudotriquetrum*		*Racomitrium aciculare*
-	*Calliergonella cuspidata*	***Sig.**	***Racomitrium affine* s.s.**
Mod.	*Campylium stellatum* s.s.	***Sig.**	***Racomitrium aquaticum***
***Sig.**	***Campylopus atrovirens***	***Sig. / ++**	***Racomitrium heterostichum* s.s.**
-	*Campylopus introflexus*	Mod.	*Racomitrium lanuginosum*
-	*Cratoneuron filicinum*	-	*Schistidium crassipilum*
Mod.	*Ctenidium molluscum*	Mod.	*Sciuro-hypnum plumosum*
Mod.	*Fissidens adianthoides*	***Sig.**	***Scorpidium cossonii***
***Sig.**	***Fissidens osmundoides***	***Sig.**	***Scorpidium scorpioides***
-	*Fissidens taxifolius*	Mod.	*Sphagnum papillosum*
***Sig. / NT**	***Grimmia ramondii***	Mod.	*Sphagnum subnitens*
***Sig.**	***Hedwigia stellata***	Mod.	*Sphagnum tenellum*
-	*Hypnum andoi*	-	*Thuidium tamariscinum*
-	*Hypnum cupressiforme*	-	*Tortula muralis*

	Liverworts		
Mod.	*Aneura pinguis*	-	*Riccardia multifida*
***Sig.**	***Mesoptychia bantriensis* (syn. *Leiocolea bantriensis*)**	***Sig.**	***Scapania gracilis***
-	*Pellia endiviifolia*		

NT = Near Threatened; + New location for FPO species; ++ New VC record for this species on the basis of a taxonomic revision.

Water chemistry

Sample location and details	pH	Description
Site 4a, Corrakit, south-west side of road (WS09, n=2, 22/11/2022, 13/04/2023)	6.9 – 7.1	Fast flowing water, coming from hill above, flowing over rock outcrop
Site 4a, Corrakit, south-west side of road (WS34, n=1, 13/04/2023)	7.1	Drainage channel receiving water from hillside above road
Site 4a, Corrakit, south-west side of road (WS35, n=1, 13/04/2023)	7.0	Stream below waterfall, at bridge
Site 4c, spring SE of The Windy Gap car park (WS08, n=2, 22/11/2022, 13/04/2023)	6.4 – 6.6	At spring head with *Philonotis fontana*.
Site 4c, spring SE of The Windy Gap car park (WS37, n=1, 13/04/2023)	6.8	Small rivulet below springhead
Site 4c, spring SE of The Windy Gap car park (WS36, n=2, 13/04/2023)	6.8 – 6.9	Flush below springhead, near fence
Site 4d, boulder field (WS04, n=1, 04/11/2022)	5.0	Water in field of boulders (not in contact with bryophytes on boulders)

Site Photographs

Fig. 4.02: Site 4a at Corrakit where a small stream flows over a bedrock outcrop to form a flush. Nov. 2022.

Fig. 4.03: Drainage channel below the flush with *Blindia acuta** (arrow). Site 4a, Corrakit, April 2023.

Fig 4.04: Flushed rock outcrop with *Bryum alpinum**, opposite The Windy Gap car park. Site 4b, April 2023.

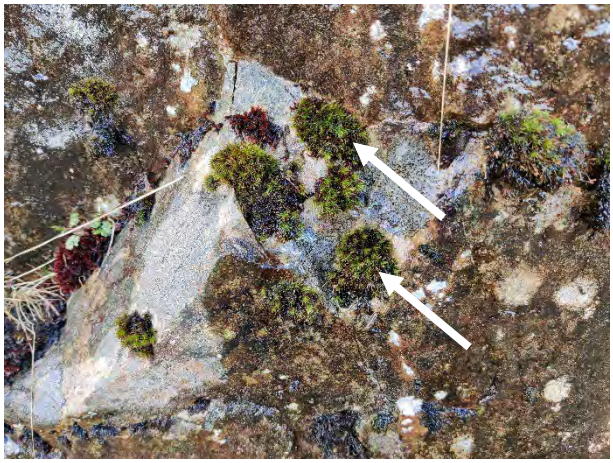


Fig 4.05: *Ptychomitrium polyphyllum* (and *B. alpinum**) on flushed rock at Site 4b, April 2023.

Fig 4.06: Springhead at Site 4c with bright green colony of *Philonotis fontana* (centre) at the point where base-poor (pH6.4–6.6) water emerges from below ground, April 2023.

Fig 4.07: Flush at Site 4c below the springhead, with brown mosses (*Scorpidium** species) and Long-stalked Yellow-sedge *Carex lepidocarpa*, in base-enriched water (pH 6.8–6.9), April 2023.

Fig. 4.08: This boulder field (Site 4d) was exceptionally rich in bryophyte species which grew on dry boulders set within very wet ground. The flora on the ground surface amongst the boulders was also species-rich and contained a mosaic of both calcicole and calcifuge bryophytes and vascular plants. July 2023 (left) and November 2022 (right).

Fig 4.09: This large boulder was colonised by the golden-green FPO species *Braunia imberbis** (arrow) and a range of other bryophytes of considerable biogeographical interest. Site 4d, November 2022.

Fig. 4.10: *Braunia imberbis** (golden-coloured) growing with *Racomitrium lanuginosum* (pale-coloured) — both in the dry state. July 2023.

5. Moneycrockroe

Location

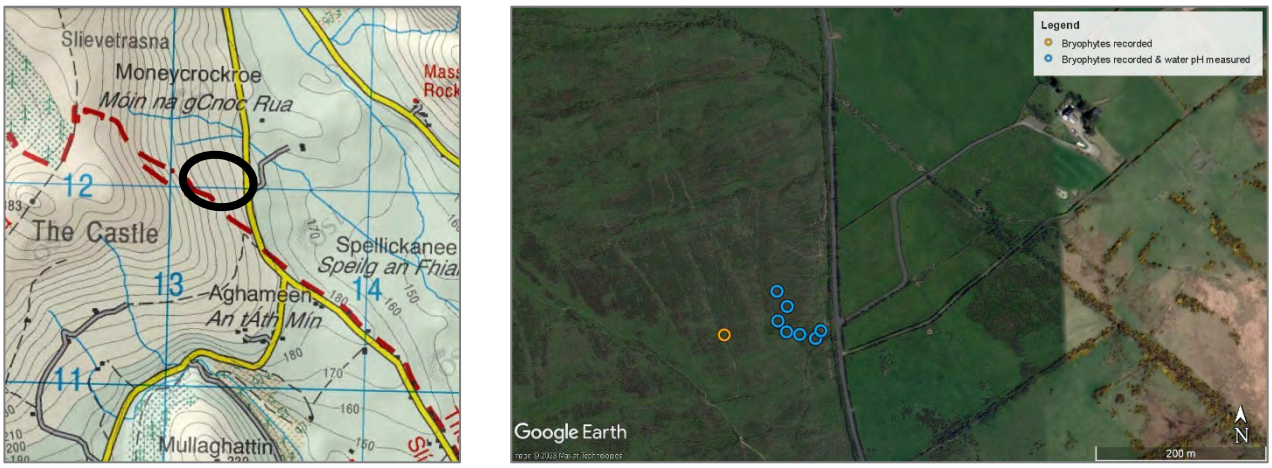


Fig. 5.1: Location of study site Moneycrockroe. Source: OSI Discovery Series (left); Google Earth (right).

Study site

Flush in field on west side of road: J 133 119, alt. 215 m. (Figs 5.1, 5.2)

Legal designations

- Carlingford Mountain SAC (Site 000453) and Cooley Mountains IBrA (Site 19)
- Carlingford Mountain pHNA (Site 000453)

Bedrock geology

- Microgranite — Slieve Gullion Complex granophyre; Tertiary

Habitats and species

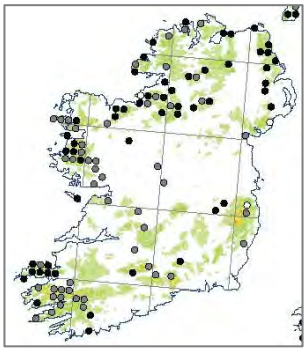
Water issued from the hillside in a diffuse seepage zone and formed a large flush with shallow rivulets of water over stoney soil (Fig. 5.2, 5.3). The moss *Thuidium delicatulum* was found here. There was only one former record for this species in Co. Louth, made by Donal Synnott in 1965 (at 'Omeath Road north of Dundalk'). The Moneycrockroe specimen was confirmed by the BBS referee and a voucher will be lodged in the National Botanic Gardens, Dublin. Also present in the flush were *Blindia acuta**, *Breutelia chrysocoma** (Fig. 5.4), *Bryum alpinum**, *Scorpidium cossonii**, *S. revolvens* s.s.*, *S. scorpioides**, *Bryum pseudotriquetrum, Campylium stellatum* s.s., *Hypnum jutlandicum, Philonotis fontana, Racomitrium aciculare* and *Sphagnum capillifolium* subsp. *capillifolium*, and the liverwort *Aneura pinguis*. Key vascular plants in this habitat were *Carex lepidocarpa, Eleocharis quinqueflora, Erica tetralix, Eriophorum angustifolium, Lysimachia tenella, Pinguicula vulgaris, P. lusitanica, Schoenus nigricans* and *Selaginella selaginoides*.

A short distance uphill, on dry boulders not irrigated by the flush, the mosses *Andreaea rupestris**, *Racomitrium heterostichum* agg.*, *R. lanuginosum* and *Dicranum scoparium* were present.

Significance

Most of the species occurring here are strongly indicative of calcareous flush communities — including the vascular plants *Carex lepidocarpa, Eleocharis quinqueflora, Lysimachia tenella, Pinguicula vulgaris, Selaginella selaginoides* — and this is an excellent example of such a vegetation type. The number of ecologically significant bryophyte species (*) indicates the quality and importance of the habitat.

On the margins of the flush, are species more normally associated with blanket bog, e.g. *Erica tetralix* and *Sphagnum capillifolium*. The value of the site is enhanced by the presence of a small boulder field feature which has the effect of providing habitat for a number rupestral species, including *Andreaea rupestris** and *Racomitrium heterostichum* agg*.



*Thuidium delicatulum** is uncommon in Ireland (left) and mostly occurs in western coastal counties. There are few known populations of this moss in the east of Ireland. Thus, its presence on the Cooley peninsula (at Moneycrockroe and on Slieve Foye) is significant.

Source of map: BBS Atlas, Blockeel *et al*. 2014. Black circles 1990–2013; grey circles 1950–1989; white circles pre-1950 records.

Bryophyte species at Moneycrockroe (Site 5)

	Mosses		
***Sig.**	***Andreaea rupestris***	Mod.	*Racomitrium aciculare*
***Sig.**	***Blindia acuta***	***Sig.**	***Racomitrium heterostichum* agg.**
***Sig.**	***Breutelia chrysocoma***	Mod.	*Racomitrium lanuginosum*
***Sig.**	***Bryum alpinum***	-	*Rhytidiadelphus squarrosus*
Mod.	*Bryum pseudotriquetrum*	***Sig.**	***Scorpidium cossonii***
-	*Calliergonella cuspidata*	***Sig.**	***Scorpidium revolvens* s.s.**
Mod.	*Campylium stellatum* s.s.	***Sig.**	***Scorpidium scorpioides***
-	*Campylopus introflexus*	Mod.	*Sphagnum capillifolium* subsp. *capillifolium*
-	*Dicranum scoparium*	Mod.	*Sphagnum papillosum*
-	*Hypnum jutlandicum*	***Sig. (VCd)**	***Thuidium delicatulum***
Mod.	*Philonotis fontana*		

	Liverworts
Mod.	*Aneura pinguis*

VCd = Vice-county 'debracket' (i.e. this is the first confirmed record in 50 years or more).

Water chemistry

Sample location and details	pH	Description
Site 5, Moneycrockroe (WS03, WS25–30, n=7, 04/11/2022, 11/04/2023)	6.5–7.2	Flushes with shallow, slow-flowing water

Site Photographs

Fig. 5.2: Shallow water trickling downhill from a seepage zone at Moneycrockroe, April 2023. Different bryophyte communities occupy the wet, flushed ground contrasting with those of dry boulders on the hill above the flush.

Fig. 5.3: Brown mosses (*Scorpidium* species) and *Carex lepidocarpa* on flushed ground, April 2023.

Fig. 5.4: *Breutelia chrysocoma* on a slightly drier part of the flushed area, April 2023.

6. The Round Mountain

Location

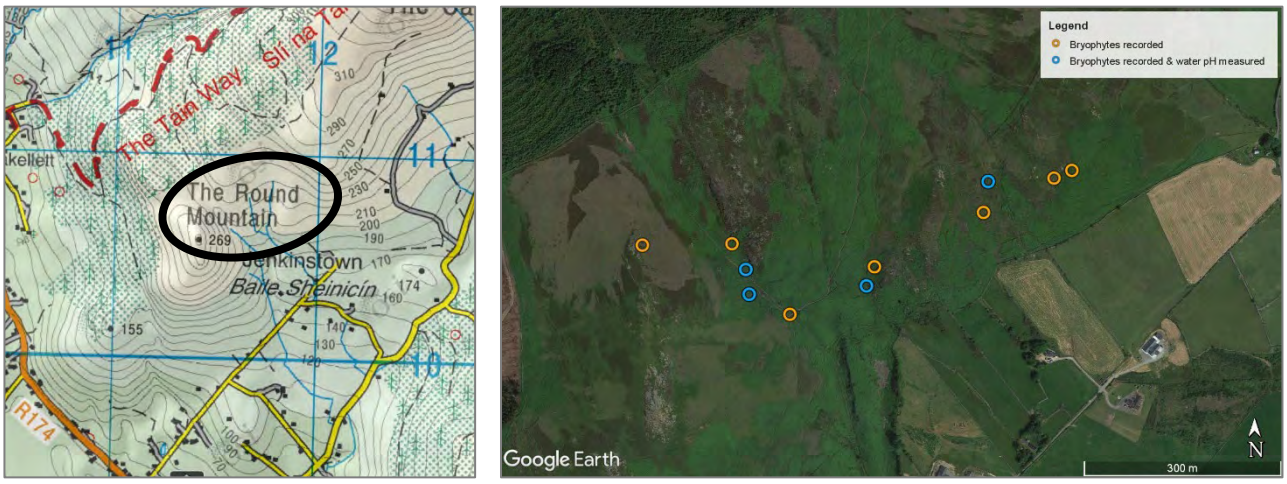


Fig. 6.1: Location of study sites at The Round Mountain. Source: OSI Discovery Series (left); Google Earth (right).

Study sites

A number of locations were examined on the east side of The Round Mountain (Fig. 6.1, 6.2):

a) Boulder field: J 120 108 alt. 240 m; scattered boulders to J 119 107 alt. 220 m.
b) Small streams and flushes in valleys: J 119 107 alt. 220 m and J 117 106 alt. 190 m.
c) Cliff consisting of dry boulders: J 117 106 alt. 200 m.
d) The Round Mountain peak (J 114 106, alt. 260 m) and adjacent valley (J 115 106 alt. 210 m).
    - Springheads and flushes at J 115 106 alt. 201 m.

Legal designations

The locations examined all lie within:

- Carlingford Mountain SAC (Site 000453) and Cooley Mountains IBrA (Site 19)
- Carlingford Mountain pHNA (Site 000453)

Bedrock geology and Quaternary sediments

- Layered gabbros — Carlingford Complex; Tertiary; fault lines run through parts of the study site.
- Till derived from granites present over parts of the site

Habitats and species

Boulder field (Site 6a)

The Flora Protection Order (FPO) moss species, *Braunia imberbis** (syn. *Hedwigia integrifolia*), grew on a large, dry boulder (J 12028 10799; Fig. 6.3). This site is additional to those already known at The Windy Gap (4 km north-east) and on Slievenagloch (3 km south-east). *Grimmia decipiens**, assessed on the Red List (Lockhart *et al*. 2012) as 'Near Threatened' was growing with *Braunia imberbis** on the same boulder (specimen confirmed by BBS referee). Another 'Near Threatened' Red List species, *G. ramondii**, occurred on a separate nearby boulder.

Elsewhere, on dry boulders scattered throughout this part of the hillside, the mosses *Andreaea rothii**, *A. rupestris**, *Bryum alpinum**, *Racomitrium heterostichum* agg.*, C*ampylopus flexuosus, Grimmia trichophylla, Hylocomium splendens, Hypnum cupressiforme* var. *lacunosum, H. jutlandicum, Isothecium myosuroides, Polytrichum juniperinum* and *P. piliferum* occurred. Key vascular plants growing on dry ground among the boulders were indicative of heathy conditions: *Calluna vulgaris, Erica cinerea, Nardus stricta, Pteridium aquilinum, Ulex gallii* and *Veronica chamaedrys*.

Valley flushes (Site 6b)

Water flowing off the hillside through valleys formed small rivulets moving through broader flushed areas (Fig. 6.5). In these irrigated zones, the mosses *Scorpidium cossonii**, *S. revolvens* s.s.*, *Campylium stellatum* s.s., *Leucobryum glaucum*, *Racomitrium aciculare*, *Sphagnum auriculatum*, *S. capillifolium* subsp. *rubellum*, *S. palustre* and *S. subnitens* grew. *Dicranum majus** was in a sheltered spot at the base of a hill on the edge of the flush. Water in rivulets through these flushes had pH values of 6.8–6.9.

Boulder dump cliff (Site 6c)

A large collection of massive boulders lying on a steep slope (Fig. 6.4) had many of the species noted above in the boulder field (Site 6a), including the FPO species *Braunia imberbis**, as well as *Andreaea rupestris** and *Bryum alpinum**. In addition, *Racomitrium lanuginosum* and *Sciuro-hypnum populeum* were noted here, along with the liverworts *Scapania gracilis**, *Tritomaria quinquedentata** and *Diplophyllum albicans*. Key vascular plants amongst the boulders — *Digitalis purpurea* and *Umbilicus rupestris* — indicated the acidic character of the substrate.

The Round Mountain peak and adjoining valley (Site 6d)

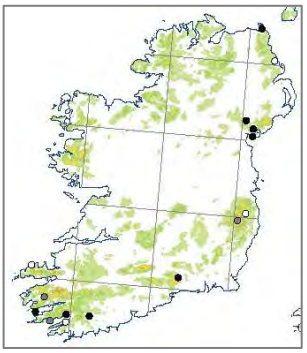
A similar suite of bryophyte species was encountered on the rocky summit of The Round Mountain (Fig. 6.6) as had been recorded on boulders on the lower slopes (Sites 6a and 6c) but with the addition of *Campylopus atrovirens** and *Racomitrium aquaticum**.

In a valley on the east side of round mountain (Fig. 6.7), two distinct springs were noted. In both cases, the springhead was dominated by a large stand of *Philonotis fontana* (Fig. 6.8). In the flushes below (water pH 6.8–6.9), the mosses *Blindia acuta**, *Bryum pseudotriquetrum, Calliergonella cuspidata, Campylium stellatum* s.s., *Ctenidium molluscum, Fissidens adianthoides* and *Racomitrium aciculare* grew, along with the liverworts *Aneura pinguis*, *Chiloscyphus polyanthos* agg., *Riccardia chamedryfolia* and *Scapania undulata*. Key vascular plants in these flushes were *Bellis perennis, Cardamine pratensis, Carex* cf. *lepidocarpa, C. flacca, Chrysosplenium oppositifolium, Juncus articulatus, Lysimachia tenella, Polygala serpyllifolia, Potentilla erecta, Ranunculus flammula* and *Selaginella selaginoides*.

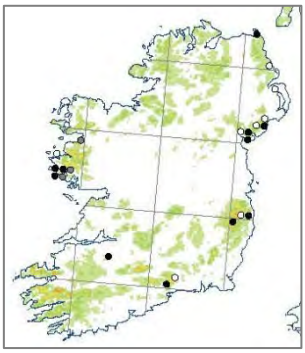
An old dry-stone wall was a striking feature of the valley, supporting several of the dry boulder bryophyte species, including conspicuous wefts of *Racomitrium lanuginosum* (Fig. 6.9).

Significance

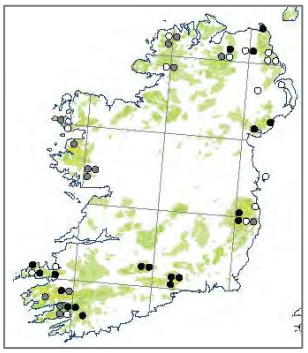
The two new localities for the legally protected species *Braunia imberbis** are of particular importance. Other very significant records are those for *Grimmia decipiens** and *G. ramondii**, both of which are assessed to be 'Near Threatened' in Ireland. There are two earlier records for *G. ramondii** in Co. Louth, both from Carlingford Mountain (2010, 2012). There are six records for *G. decipiens** from the Carlingford peninsula, but none is from The Round Mountain. These species have very limited distributions in Ireland (see maps below).



Braunia imberbis (syn. *Hedwigia integrifolia*) FPO



Grimmia decipiens (Red List: Near Threatened)



Grimmia ramondii (Red List: Near Threatened)

Source of map: BBS Atlas, Blockeel et al. 2014. Black circles 1990–2013; grey circles 1950–1989; white circles pre-1950 records.

This site supports a very diverse suite of bryophyte species. This is directly attributable to the presence of the large boulder field and the exposed bedrock on the summit of the mountain (at a lower altitude than some of the other upland sites visited) as well as the presence of a number of springs, flushes and streamlets passing through the site.

Some of the boulders are particularly large and inaccessible to grazers. Their free-draining, skeletal soils which have formed in situ provided niches for a few significant species, but most grew directly on the bare rock surfaces. The dry-stone wall provided a striking example of a habitat for *Racomitrium lanuginosum*, although it occurs elsewhere in the area, its dominance on this wall indicates the particular value and distinctive character of this feature in the landscape.

Wetland bryophytes occurred in springs, on small boulders in the streamlets or on the margins on flushed ground. The springheads are characterised by pure stands of *Philonotis fontana*. The brown mosses *Scorpidium cossonii** and *S. revolvens* s.s.* are associated with flushed substrates on more gently sloping ground.

Bryophyte species at The Round Mountain (Site 6)

	Mosses		
***Sig.**	***Andreaea rothii***	-	*Hypnum cupressiforme* var. *lacunosum*
***Sig.**	***Andreaea rupestris***	-	*Hypnum jutlandicum*
-	*Aulacomnium palustre*	-	*Isothecium myosuroides*
***Sig.**	***Blindia acuta***	Mod.	*Leucobryum glaucum* (sensu Smith, 2004)
-	*Brachythecium rutabulum*	Mod.	*Philonotis fontana*
***Sig. / FPO+**	***Braunia imberbis* (syn. *Hedwigia integrifolia*)**	-	*Polytrichum formosum*
***Sig.**	***Bryum alpinum***	Mod.	*Polytrichum juniperinum*
-	*Bryum capillare*	Mod.	*Polytrichum piliferum*
Mod.	*Bryum pseudotriquetrum*	-	*Pseudoscleropodium purum*
-	*Calliergonella cuspidata*	Mod.	*Racomitrium aciculare*
Mod.	*Campylium stellatum* s.s.	***Sig.**	***Racomitrium aquaticum***
***Sig.**	***Campylopus atrovirens***	***Sig.**	***Racomitrium heterostichum* agg.**
-	*Campylopus flexuosus*	Mod.	*Racomitrium lanuginosum*
-	*Campylopus introflexus*	-	*Rhytidiadelphus squarrosus*
-	*Ctenidium molluscum*	Mod.	*Sciuro-hypnum populeum*
Mod.	*Dicranoweisia cirrata*	***Sig.**	***Scorpidium cossonii***
***Sig.**	***Dicranum majus***	***Sig.**	***Scorpidium revolvens* s.s.**
-	*Dicranum scoparium*	Mod.	*Sphagnum capillifolium* subsp. *rubellum*
Mod.	*Fissidens adianthoides*	Mod.	*Sphagnum auriculatum*
***Sig. (NT)**	***Grimmia decipiens***	Mod.	*Sphagnum palustre*
***Sig. (NT)**	***Grimmia ramondii***	Mod.	*Sphagnum subnitens*
Mod.	*Grimmia trichophylla*	-	*Thuidium tamariscinum*
-	*Hylocomium splendens*	-	*Tortella tortuosa*
-	*Hypnum cupressiforme*		

	Liverworts		
Mod.	*Aneura pinguis*	-	*Lophozia ventricosa*
-	*Chiloscyphus polyanthos* agg. ++	-	*Riccardia chamedryfolia*
-	*Diplophyllum albicans*	***Sig.**	***Scapania gracilis***
-	*Frullania tamarisci*	Mod.	*Scapania undulata*
-	*Lophocolea bidentata*	***Sig.**	***Tritomaria quinquedentata***

NT = Near Threatened (Lockhart *et al*. 2012); + = new location for FPO species; ++ = unusual form of this species with very large, almost undivided underleaves.

Water Chemistry

Sample location and details	pH	Description
The Round Mountain, small valley #1 (WS19, n=2, 07/03/2023)	6.9	Small rivulet through *Molinia caerulea*
The Round Mountain, small valley #2 (WS20, n=2, 07/03/2023)	6.8 – 6.9	Small rivulet through *Molinia caerulea*
The Round Mountain, south of old wall (WS21, n=2, 07/03/2023)	6.7	Springhead
The Round Mountain, north of old wall (WS22, n=1, 07/03/2023)	6.8	Springhead

Site Photographs

Fig. 6.2: The Round Mountain: dry boulders and small valleys with streams and flushes provide a range of habitat types for bryophytes. February 2023.

Fig. 6.3: FPO species *Braunia imberbis** and *Grimmia decipiens** on a large dry boulder on The Round Mountain (Site 6a, Feb. 2023).

Fig. 6.4: Steep slope strewn with boulders (Site 6c) with the mosses *Braunia imberbis**, *Andreaea rupestris** and *Bryum alpinum**, and the liverworts *Scapania gracilis** and *Tritomaria quinquedentata**. Feb. 2023.

Fig. 6.5: Small streams coming off the hillside (left) are flanked with flushes (right) as the valley broadens. Feb. 2023.

Fig. 6.6: Exposed bedrock at the summit of The Round Mountain with low-growing bryophytes adapted to harsh, dry conditions. Feb. 2023.

Fig. 6.7: Valley on the east side of The Round Mountain with small springheads and flushes, and a dry-stone wall. Feb. 2023.

Fig. 6.8: Springhead with *Philonotis fontana* (bright green, centre of photo) and emerging flush below. Feb. 2023.

Fig. 6.9: Old dry-stone wall with *Racomitrium lanuginosum.* Feb. 2023.

7. Mullaghattin

Location

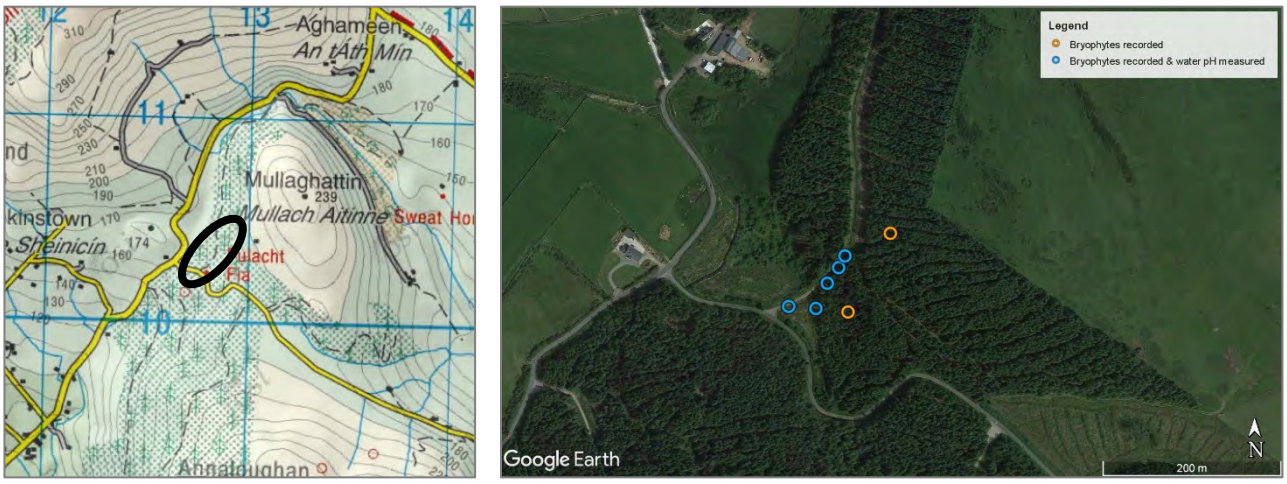


Fig. 7.1: Location of study site at Mullaghattin. Source: OSI Discovery Series (left); Google Earth (right).

Study site

Track, drainage channel and adjacent land in former conifer plantation which has since been clear-felled (Figs 7.1–7.3), located at J 127 102, alt. 170 m.

Legal designations

None

Bedrock geology and Quaternary sediments

- Microgranite — Slieve Gullion Complex granophyre; Tertiary
- Till derived from granites

Habitats and species

*Bryum sauteri** was found at the edge of the track (Fig. 7.4; specimen confirmed by the BBS referee). It was identifiable (under the microscope) by the distinctive tubers produced on rhizoids below ground. The tiny plants bore capsules — this is the first time for this species to have been recorded bearing capsules in either Britain or Ireland[2]. The record was formally published in Field Bryology No. 130 (Amy, 2023). Other species

[2] From BBS referee, Dr David Holyoak, on the Mullaghattin specimen (March 2023): 'It was immediately obvious that there were plenty of the characteristic tubers of *B. sauteri*. The specimen also has three immature capsules arising from gametophytes that look right for those of *B. sauteri*, and there was no evidence of any other *Bryum* or *Pohlia* species in the sample. Eventually two of the fertile plants were each found to have two of the characteristic tubers on rhizoids conjoined to them, in one case just below the inflorescence, in the other arising from a distant branch. Both inflorescences appeared to be all-female (unused archegonia present, but not antheridia), but I did not completely strip the bracts from either of them. Smaller plants closely associated with the fertile stems had apical male inflorescences, and these might have represented branches from autoicous material where the original branch bases had decayed away. Thus you have the first record from Ireland of *B. sauteri* with sporophytes and these remain unknown in British plants, although they are known from Norway, central Europe and Africa.'

found along the edge of the track were *Bryum alpinum**, *Campylopus pyriformis, Dicranella schreberiana, Didymodon insulanus, Pogonatum aloides, Pohlia wahlenbergii* var. *wahlenbergii, Polytrichum formosum* and *Trichostomum crispulum*.

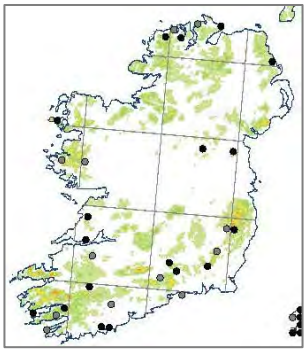
On damper soil on the banks of the drain, *Dichodontium palustre** was conspicuous, forming large colonies. Other mosses found here were *Bryum pseudotriquetrum, Calliergonella cuspidata, Dicranella varia, Fissidens adianthoides* and *Thuidium tamariscinum*, along with the liverworts *Diplophyllum albicans, Pellia endiviifolia* and *Riccardia chamedryfolia*. *Sphagnum auriculatum* and *S. palustre* were present in flushes entering the drainage channel from the peat above (Figs 7.5 and 7.6) and, in wetter pools, there was *S. cuspidatum*.

Significance

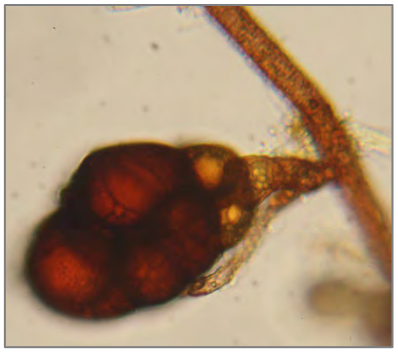
Drains alongside the track were cut through the peat deposits, exposing underlying substrates. Following clear-felling, large volumes of water — which would otherwise have been lost into the atmosphere via evapotranspiration — were released to flow out of the woodland site through these channels. As with other sites, there was a complex pattern of interactions between the peat and the various underlying substrates through which water travelled prior to reaching the drains. The pH at the north-eastern part of the drain was 5.8–5.9, while further west (close to the road) the water was markedly less acid (pH 6.7). The most acidic water was that entering the drain directly from the peat above (pH 5.5–5.9).

This chemical variation was evident in the contrasting plant communities, with calcifuge species on or near the peatland edges (e.g. *Sphagnum auriculatum*, *S. palustre* and *Diplophyllum albicans*), while calcicole species were present on other parts of the damp banks of the drains (e.g. *Bryum pseudotriquetrum, Dicranella varia* and *Fissidens adianthoides*).

The discovery of *Bryum sauteri* bearing capsules was of interest as these had not been seen previously on British or Irish specimens. It demonstrated the importance of open habitats for these small species which cannot compete where the covering of vegetation closes in and shades them out.



Bryum sauteri
Source: Blockeel *et al*. 2014



Tubers (approx. 100 x 50 µm) as seen through compound microscope.

Capsule (2 mm long) borne on Mullaghattin specimen, not previously seen in Britain or Ireland.

Bryophyte species at Mullaghattin (Site 7)

	Mosses		
***Sig.**	***Bryum alpinum***	-	*Grimmia pulvinata*
Mod.	*Bryum pseudotriquetrum*	-	*Hypnum cupressiforme* var. *lacunosum*
***Sig. +**	***Bryum sauteri***	-	*Hypnum jutlandicum*
-	*Calliergonella cuspidata*	Mod.	*Pogonatum aloides*
-	*Campylopus introflexus*	-	*Pohlia wahlenbergii* var. *wahlenbergii*
-	*Campylopus pyriformis*	-	*Polytrichum formosum*
-	*Ceratodon purpureus*	-	*Pseudoscleropodium purum*
***Sig.**	***Dichodontium palustre***	-	*Rhytidiadelphus squarrosus*
-	*Dicranella schreberiana*	Mod.	*Sphagnum auriculatum*
-	*Dicranella varia*	Mod.	*Sphagnum capillifolium* subsp. *rubellum*
-	*Didymodon fallax*	Mod.	*Sphagnum cuspidatum*
-	*Didymodon insulanus*	Mod.	*Sphagnum palustre*
Mod.	*Fissidens adianthoides*	-	*Thuidium tamariscinum*
-	*Funaria hygrometrica*	-	*Trichostomum crispulum*

	Liverworts		
-	*Diplophyllum albicans*	-	*Riccardia chamedryfolia*
-	*Pellia endiviifolia*		

+ = First record for sporophytes on this species in Britain or Ireland.

Water Chemistry

Sample location and details	**pH**	**Description**
Mullaghattin (WS01, n=2, 04/11/2022; 11/04/2023)	5.8 – 5.9	Drain running along edge of track, north-east of fenced pond
Mullaghattin (WS23–24, n=2, 11/04/2023)	5.5 – 5.9	Flushes from peat entering pond
Mullaghattin (WS02, n=1, 04/11/2022)	6.7	Drain running along edge of track, west of fenced pond (between pond and road)

Site Photographs

Fig. 7.2: Forest track with drainage channel running alongside, water pH 5.8–5.9. April 2023.

Fig. 7.3: Clear-felled former conifer woodland on peat. April 2023.

Fig. 7.4: Knife indicates habitat of *Bryum sauteri** along the edge of the track. April 2023.

Fig. 7.5: *Sphagnum auriculatum* in flush entering drainage channel (Fig. 7.6 below). April 2023.

Fig. 7.6: Flush from peat entering the drainage channel, water pH 5.5. *Sphagnum auriculatum* (above) grew in the flush at this point. April 2023.

8. Marble Bridge, Ravensdale Park

Location

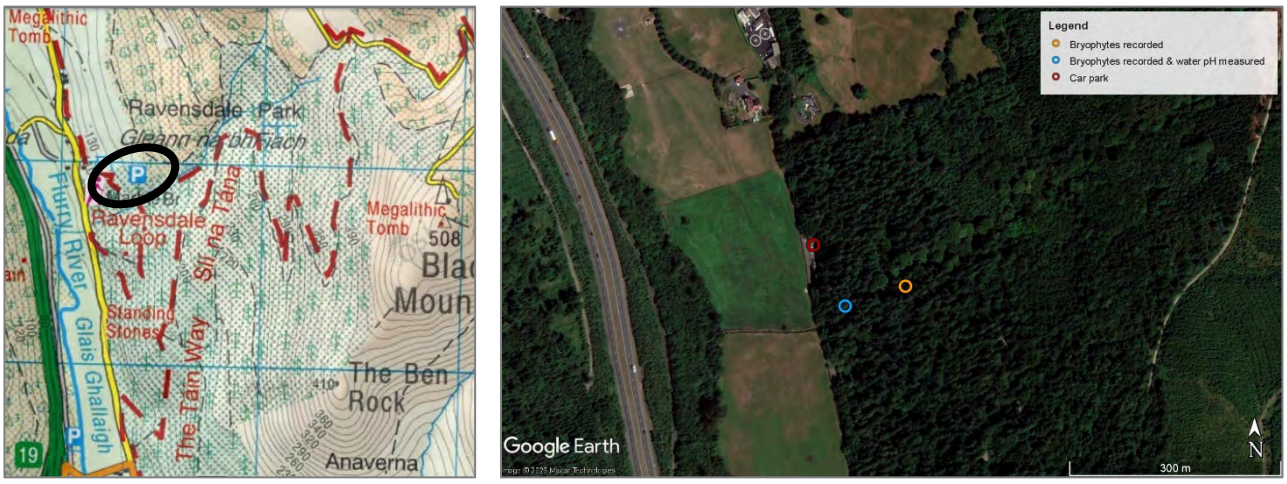


Fig. 8.1: Location of study site at Marble Bridge. Source: OSI Discovery Series (left); Google Earth (right).

Study site

Stream south-east of Marble Bridge car park: J 082 157, alt. 120 m (Fig. 8.1–8.4).

Legal designations

- pNHA Ravensdale Plantation (Site 001805)

Bedrock geology

- Microgranite (Slieve Gullion Complex granophyre; Tertiary)

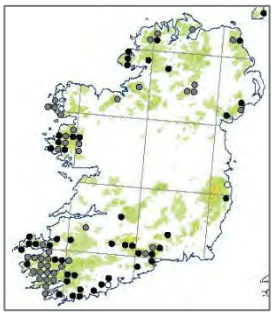
Habitats and species

The study site consisted of a fast-flowing stream in a humid gorge, deeply shaded due to the presence of Cherry Laurel *Prunus laurocerasus* overhead. Bryophytes growing on the steep banks of gorge, in the spray zone of the stream and on boulders and logs within the stream were examined. The leafy liverwort *Jubula hutchinsiae** grew on boulders within the stream and on the steep sides of the gorge (Fig. 8.5). This species had not previously been recorded in Co. Louth. We also found the mosses *Hyocomium armoricum**, *Fissidens bryoides* agg., *F. dubius, Hookeria lucens, Pseudotaxiphyllum elegans, Rhizomnium punctatum* and the liverworts *Lejeunea lamacerina*, Calypogeia arguta, Chiloscyphus polyanthos* agg., *Pellia epiphylla, Riccardia chamedryfolia* and *Scapania undulata*. Apart from *Prunus laurocerasus* and some overhanging conifers, vascular plants were absent from the most deeply shaded parts of the gorge.

The adjacent coniferous woodland, however, especially near the margins, were slightly better illuminated. Characteristic woodland mosses found growing there were *Eurhynchium striatum, Mnium hornum, Polytrichum formosum, Thamnobryum alopecurum* and *Thuidium tamariscinum*. Key vascular plants at the edge of the plantation near the stream were *Asplenium scolopendrium, Athyrium filix-femina, Blechnum spicant, Carex sylvatica, Dryopteris filix-mas, Luzula sylvatica, Oxalis acetosella, Polystichum setiferum* and *Viola riviniana*.

Significance

The gorge, with its low light levels and moist atmosphere, is a very specialised habitat and one to which bryophytes are much better adapted than vascular plants. The sheltered gorge retains spray from the stream created by turbulence of the fast-flowing water tumbling over boulders and bedrock.



Source: Blockeel *et al*. 2014

The discovery of *Jubula hutchinsiae** is of particular significance. This liverwort has a very limited distribution in Ireland (left), mostly along the western seaboard and especially in counties Cork and Kerry. However, the habitat at Marble Bridge conforms closely to its known optimal ecological requirements — a deeply shaded, wooded ravine in the spray zone of the fast-flowing, cascading stream (Blockeel *et al*. 2014). *Riccardia chamedryfolia*, which was also present, is a recognised associate.

Several other associated species, such as *Hyocomium armoricum**, *Hookeria lucens* and *Lejeunea lamacerina** are also indicative of these specialised ecological conditions.

Bryophyte species at Marble Bridge (Site 8)

	Mosses		
-	*Eurhynchium striatum*		
Mod.	*Fissidens bryoides* agg.	-	*Polytrichum formosum*
Mod.	*Fissidens dubius*	-	*Pseudotaxiphyllum elegans*
Mod.	*Hookeria lucens*	-	*Rhizomnium punctatum*
***Sig.**	***Hyocomium armoricum***	-	*Thamnobryum alopecurum*
-	*Kindbergia praelonga*	-	*Thuidium tamariscinum*
-	*Mnium hornum*		

	Liverworts		
-	*Calypogeia arguta*	-	*Pellia epiphylla*
-	*Chiloscyphus polyanthos* agg.	-	*Riccardia chamedryfolia*
***Sig. (NVCR)**	***Jubula hutchinsiae***	Mod.	*Scapania undulata*
***Sig.**	***Lejeunea lamacerina***		

NVCR = New Vice-county Record

Water chemistry

Sample location and details	**pH**	**Description**
Stream below shaded gorge, at wooden bridge (WS31, n=1, 13/04/2023)	6.6	Fast-flowing stream

Site Photographs

Fig. 8.2: Stream flowing below shaded gorge, close to car park, at edge of conifer plantation. April 2023.

Fig. 8.3 Boulders, bedrock and fallen trees in the stream provide a number of different niches for bryophytes. April 2023.

Fig. 8.4: Humid, shaded banks of the steep gorge either side of the stream are colonised by bryophytes, including *Jubula hutchinsiae**. Low light levels the shearing effect of fast-flowing water preclude vascular plants. Sept. 2022.

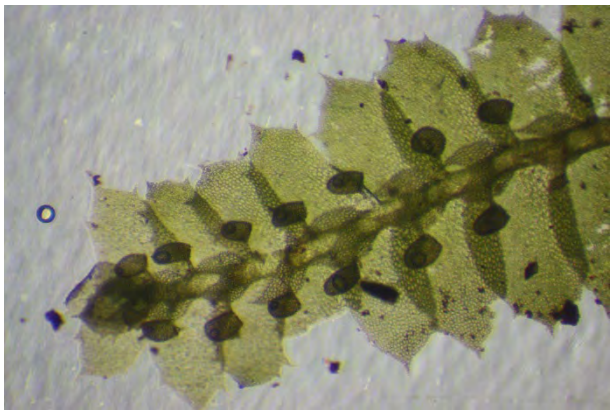


Fig. 8.5: The leafy liverwort *Jubula hutchinsiae** in petri dish and under the dissecting microscope (top). Leaves are arranged on either side of the stem in flattened shoots, 1–3 mm wide. The leaves are toothed, and each has a small, helmet-shaped lobule lying beneath.

9. Black Mountain and Clermont Cairn

Location

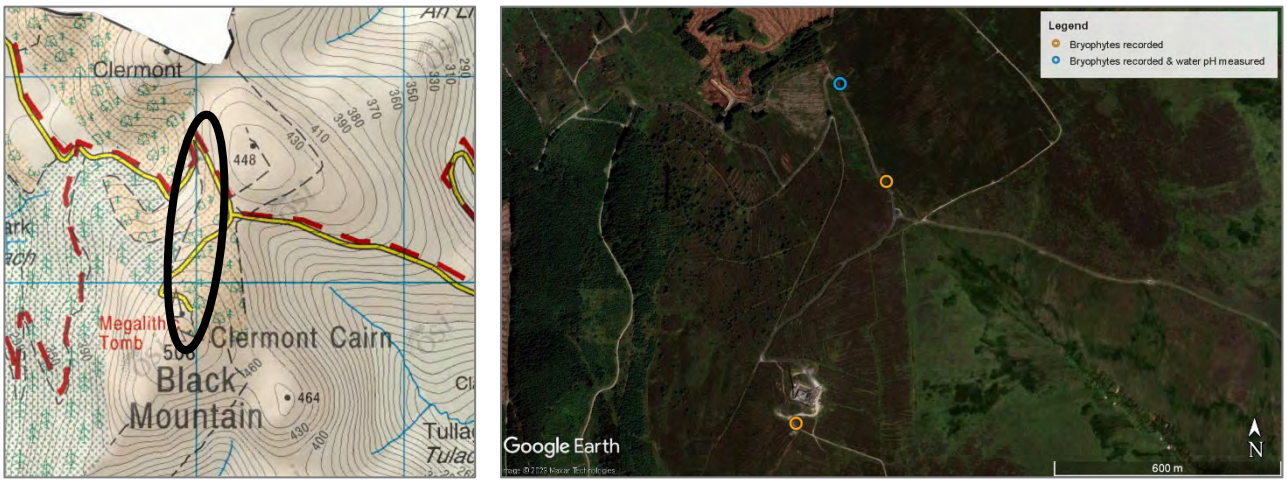


Fig. 9.1: Location of study sites at Black Mountain. Source: OSI Discovery Series (left); Google Earth (right).

Study site

The areas investigated were around Clermont Cairn and telecommunications mast, and along the access road (Figs 9.1–9.3):

a) Clermont Cairn and masts on summit of Black Mountain: J 099 157, alt. 510 m.

b) Access road to telecommunication masts: J 101 164, alt. 430 m; J 100 166, alt. 410 m.

Legal designations

The areas examined straddle the boundaries but mostly lie outside of:

- Carlingford Mountain SAC (Site 000453) and Cooley Mountains IBrA (Site 19)
- Carlingford Mountain pHNA (Site 000453)

Bedrock geology

- Microgranite — Slieve Gullion Complex granophyre; Tertiary

Habitats and species

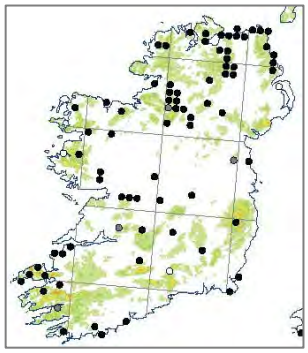
*Bryum pallescens** grew in dense cushions in a distinct line beneath metal railings surrounding an anchorage point for the mast on the summit of Black Mountain (Fig. 9.2). This species had not previously been recorded in Co. Louth. Elsewhere, near the mast compound and Clermont Cairn, the mosses *Hypnum jutlandicum, Polytrichum juniperinum, P. piliferum* were growing on peat, and *Racomitrium heterostichum* agg.* and *Grimmia trichophylla* on bare rock. Key vascular plants were *Empetrum nigrum, Erica tetralix* and *Juncus squarrosus*. Disturbed ground and tracks had *Streblotrichum convolutum, Campylopus flexuosus* and *Cratoneuron filicinum*.

*Oligotrichum hercynicum** was found in a drainage channel alongside the access road to the mast (Fig. 9.3). This species had not been recorded in Co. Louth since 1890, when it was reported by C.H. Waddell on Carlingford Mountain. Also growing in open drainage channels along the track were the mosses *Bryum alpinum**, *Dichodontium palustre**, *Dicranella varia, Fissidens adianthoides, Philonotis fontana, Polytrichum*

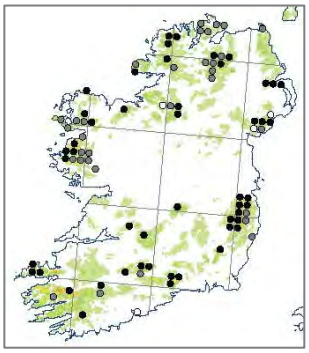
commune, Sphagnum fallax, S. papillosum and the liverworts *Aneura pinguis, Nardia scalaris, Pellia endiviifolia* and *Riccardia multifida*. The clubmoss *Huperzia selago* grew close to the channel.

Significance

*Bryum pallescens** and *Oligotrichum hercynicum** are both rare species in Ireland (maps below, Blockeel *et al*. 2014). *B. pallescens** is often found in places where there is some contamination by metals, for example in the drip zone below metal railings, as was the case at this site (Blockeel *et al*. 2014). *O. hercynicum** is a pioneering calcifuge species of moist, bare, mineral soils and track edges, often where there is intermittent flooding and thus it is ecologically well adapted to growing on the edge of the drain on Black Mountain. *Nardia scalaris*, another pioneering calcifuge species present at the same location, is a known associate of *O. hercynicum** (Blockeel *et al*. 2014).



*Bryum pallescens**



*Oligotrichum hercynicum**

*O. hercynicum** specimen collected on Black Mt.

As at all of the sites visited, there are many more species present than those reported here. For example, rare or uncommon species recorded at Clermont Cairn in 2007 by David Holyoak include *Bryoerythrophyllum ferruginascens, Bryum archangelicum, Grimmia donniana, Polytrichum strictum, Sphagnum fimbriatum* — they are indicative of the distinctive character of the site.

Bryophyte species on Black Mountain (Site 9)

	Mosses		
***Sig.**	***Bryum alpinum***	-	*Hypnum jutlandicum*
***Sig. (NVCR)**	***Bryum pallescens***	***Sig. (VCd)**	***Oligotrichum hercynicum***
-	*Calliergonella cuspidata*	Mod.	*Philonotis fontana*
-	*Campylopus flexuosus*	-	*Polytrichum commune*
-	*Ceratodon purpureus*	Mod.	*Polytrichum juniperinum*
-	*Cratoneuron filicinum*	Mod.	*Polytrichum piliferum*
***Sig.**	***Dichodontium palustre***	***Sig.**	***Racomitrium heterostichum* agg.**
-	*Dicranella varia*	-	*Rhytidiadelphus squarrosus*
Mod.	*Fissidens adianthoides*	Mod.	*Sphagnum fallax*
Mod.	*Grimmia trichophylla*	Mod.	*Sphagnum papillosum*
-	*Hypnum cupressiforme* var. *lacunosum*	-	*Streblotrichum convolutum*

	Liverworts		
Mod.	*Aneura pinguis*	-	*Pellia endiviifolia*
Mod.	*Nardia scalaris*	-	*Riccardia multifida*

NVCR = New Vice-county Record; VCd = Vice-county debracket (only one previous record: Waddell, 1890, Carlingford Mountain)

Water chemistry

Sample location and details	pH	Description
Black Mountain (WS32, WS33, n=2, 13/04/2023)	5.4 – 5.9	Drainage channels alongside access road

Site Photographs

Fig. 9.2: Black Mountain summit with compound for anchoring telecommunications mast. Dark brown cushions of *Bryum pallescens** grew in a line beneath metal railings surrounding mast equipment. April 2023.

Fig. 9.3: Open drainage channels along edge of access road with exposures of stony substrate. It was in this habitat that *Oligotrichum hercynicum** grew. April 2023.

Fig. 9.4: Construction and maintenance of the mast infrastructure has altered habitats and caused localised damage on the summit of Black Mountain and close to Clermont Cairn which is a protected structure under the National Monuments Acts. April 2023.

10. Cornamucklagh

Location

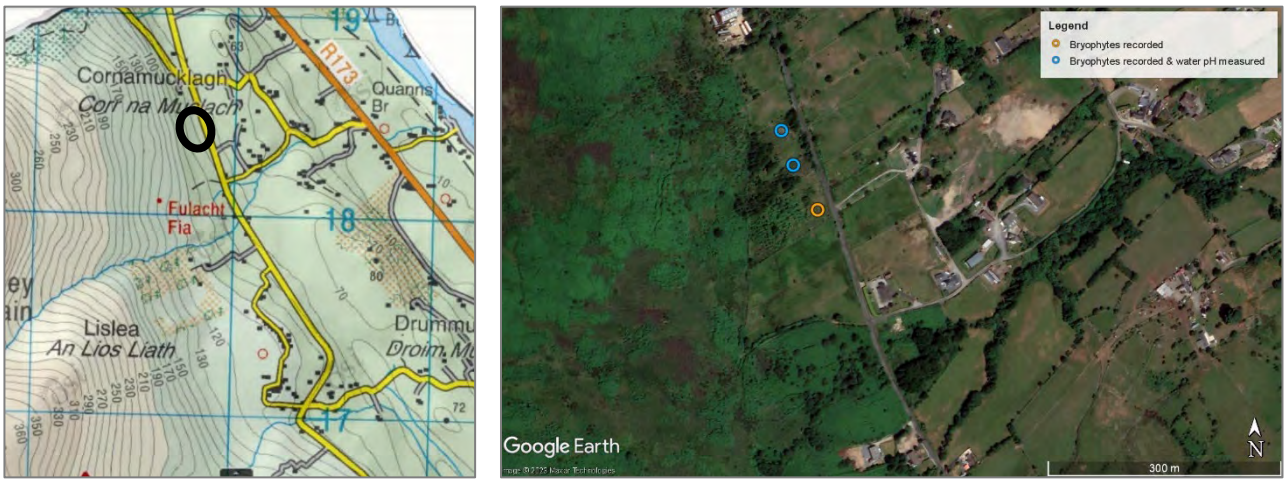


Fig. 10.1: Location of study site at Cornamucklagh. Source: OSI Discovery Series (left); Google Earth (right).

Study site

This site consists of three small, interconnected fields containing wetland habitats (Fig. 10.1–10.2)

a) Southern-most field: J 118 183, alt. 70 m.
b) Middle field: J 118 183, alt. 70 m.
c) Northern-most field: J 118 184, alt. 70 m.

Legal designations

None. These fields lie immediately outside the boundary of Carlingford Mountain SAC / pNHA (Site 000453).

Bedrock geology and Quaternary sediments

- Porphyritic Granophyre — Slieve Gullion Complex; Tertiary; fine-grained granite, forming part of the ring-dyke of the Slieve Gullion complex (Baxter 2008)
- Till derived from granites

Habitats and species

These fields were flushed with water issuing from the hillside above to the west. The pH of water samples, where available in small rivulets, was 5.9 and it reflected the acid nature of the underlying bedrock of both the fields themselves and the adjoining hillside. Scrub was present in the western parts of the fields and along some boundaries, but the focus of this study was the unshaded parts of the fields which were grazed by horses. The southern-most field was especially species-rich, with wet, slightly poached land but without any surface water at the time of our visits. The two other fields retained small amounts of surface water in depressions and rivulets.

Sphagnum species were the most conspicuous bryophytes throughout: *Sphagnum inundatum*, S. auriculatum, S. capillifolium, S. palustre, S. papillosum, S. subnitens* (Fig. 10.3) and *S. tenellum* were present. These were accompanied by the mosses *Blindia acuta*, Dichodontium palustre*, Aulacomnium palustre, Bryum pseudotriquetrum, Calliergonella cuspidata, Campylium stellatum* s.s., *Philonotis fontana* (Fig. 10.4), *Racomitrium aciculare, Rhizomnium punctatum* and the liverworts *Aneura pinguis, Calypogeia fissa, C.*

muelleriana, Cephalozia bicuspidata, Pellia neesiana, *Riccardia multifida* and *Scapania irrigua*. Vascular plants of note in this habitat were *Calluna vulgaris, Carex echinata, C. flacca, C. hostiana, C. panicea, C. pulicaris, Dactylorhiza fuchsia, D. maculata, Eleocharis multicaulis, Erica tetralix, Hydrocotyle vulgaris, Hypericum elodes, Juncus acutiflorus, J. articulatus, J. bulbosus, J. conglomeratus, J. effusus, J. squarrosus, Lotus corniculatus, L. uliginosa, Luzula congesta, Lysimachia nemorum, L. tenella, Lythrum salicaria, Mentha aquatica, Narthecium ossifragum, Pinguicula lusitanica, P. vulgaris, Platanthera chlorantha, Potentilla erecta, Prunella vulgaris, Pteridium aquilinum, Ranunculus flammula* and *Succisa pratensis*.

In the middle and northern-most fields, additional species of note were the moss *Scorpidium revolvens* s.s.* and the vascular plants *Carex binervis, C. demissa* (Fig. 10.5)*, C. nigra, Drosera rotundifolia, Eriophorum angustifolium, Myosotis laxa, M. secunda, Osmunda regalis, Pedicularis sylvatica*, *Potamogeton polygonifolius* (in shallow pool, Fig. 10.6) and *Veronica scutellata*.

Significance

This community corresponds very closely to the NVC M29 *Hypericum elodes-Potamogeton polygonifolius* soakway in which (in addition to *H. elodes* and *P. polygonifolius*) *Ranunculus flammula, Sphagnum auriculatum* and *Juncus bulbosus* are constants (Rodwell 1991a). Typical accompanying species in that vegetation type include *Hydrocotyle vulgaris, Eleocharis multicaulis, Eriophorum angustifolium, Lysimachia tenella, Carex demissa, C. echinata, C. panicea, C. nigra, Drosera rotundifolia* and *Lotus uliginosa*, all of which were present at this site. Other bryophytes are typically sparse in the M29 community, but may include *Aulacomnium palustre, Calliergonella cuspidata* and *Scorpidium revolvens* s.s.*, each of which was present at Cornamucklagh.

The structural diversity of the site underpins its species richness. Light grazing serves to inhibit encroachment by scrub, thus preserving its open character. As a result of this, various types of substrate are exposed and soil accumulation is slight. To some extent, the open character is maintained by seasonally fluctuating water levels — flooding impedes the development of a closed sward. The underlying nature of the bedrock is disclosed by the presence of an abundance of granite pebbles on the surface and the water pH (5.9) confirms its acid nature. A number of small pools are present on the site, which support the aquatic species *Potamogeton polygonifolius* and *Hypericum elodes* (NVC M29 species).

Bryophyte species at Cornamucklagh (Site 10)

	Mosses		
-	*Aulacomnium palustre*	-	*Rhytidiadelphus squarrosus*
***Sig.**	***Blindia acuta***	***Sig.**	***Scorpidium revolvens* s.s.**
Mod.	*Bryum pseudotriquetrum*	Mod.	*Sphagnum auriculatum*
-	*Calliergonella cuspidata*	Mod.	*Sphagnum capillifolium*
Mod.	*Campylium stellatum* s.s.	***Sig.**	***Sphagnum inundatum***
***Sig.**	***Dichodontium palustre***	Mod.	*Sphagnum palustre*
Mod.	*Philonotis fontana*	Mod.	*Sphagnum papillosum*
-	*Polytrichum formosum*	Mod.	*Sphagnum subnitens*
-	*Pseudoscleropodium purum*	Mod.	*Sphagnum tenellum*
Mod.	*Racomitrium aciculare*	-	*Thuidium tamariscinum*
-	*Rhizomnium punctatum*		

	Liverworts		
Mod.	*Aneura pinguis*	-	*Pellia neesiana*
-	*Calypogeia fissa*	-	*Riccardia multifida*
-	*Calypogeia muelleriana*	Mod.	*Scapania irrigua*
-	*Cephalozia bicuspidata*		

Water chemistry

Sample location and details	**pH**	**Description**
Cornamucklagh (WS41, n=2, 27/06/2023)	5.9	Flush: depression with *Potamogeton polygonifolius* and small drainage channel with *Scorpidium revolvens**.

Site Photographs


Fig. 10.2: The southern-most field contains a mixture of small-scale but structurally diverse habitat types with granite boulders surrounded by flushed, poached, lightly grazed open ground. Nov. 2022 (above right) and June 2023 (above left).

Fig. 10.3: *Sphagnum subnitens* with abundant capsules. June 2023

Fig. 10.4: *Philonotis fontana* with capsules in the flush. June 2023

Fig. 10.5: *Carex demissa*, a member of the *Carex flava* group, which is smaller than *C. lepidocarpa*, with a preference for lower base status substrates. June 2023.

Fig. 10.6: Slight variations in the topography lead to the retention of water in small pools with *Potamogeton polygonifolius.* Water pH 5.9. June 2023

11. Fathom Forest

Location

Fig. 11.1: Location of study site at Fathom Forest, Co. Armagh.

Study site

Roadside habitats at Fathom Forest, Co. Armagh (H37) at J107 199, J106 202 and J102 210; alt. 160–180 m (Figs 11.1–11.2).

Legal designations

Ring of Gullion Area of Outstanding Natural Beauty

Bedrock geology

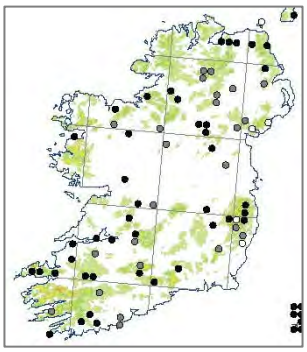
- Porphyritic Granophyre (Slieve Gullion Complex; Tertiary)
- Dolerite dyke in Porphyritic Granophyre

Habitats and species

Bryophytes on shaded roadside banks and prominent rocky outcrops were examined (Fig. 11.2). On a mossy retaining wall by the roadside, *Plagiothecium denticulatum** was found (J 107 199; specimen confirmed by BBS referee). This species had not been recorded in Co. Armagh (H37) since 1964 when it was found by J.W. and R.D. Fitzgerald.

Elsewhere, on banks and rock outcrops, the mosses *Campylopus flexuosus, Dicranum scoparium, Hypnum andoi, H. jutlandicum, Polytrichum commune, P. juniperinum, Pseudotaxiphyllum elegans, Ptychomitrium polyphyllum* and *Thuidium tamariscinum* were found, along with the liverworts *Diplophyllum albicans* and *Lophozia ventricosa*.

Significance



Despite being widespread in Britain, there are few records for *Plagiothecium denticulatum* in Ireland. It occurs in moist shady places on peat, tree bases, boulders and old walls (Blockeel *et al*. 2014). Its presence at Fathom Forest suggests that there is an unusual set of environmental conditions prevailing, which requires further investigation.

Source of map: BBS Atlas, Blockeel *et al*. 2014. Black circles 1990–2013; grey circles 1950–1989; white circles pre-1950 records.

Bryophyte species at Fathom Forest (Site 11)

	Mosses		
-	*Brachythecium rutabulum*	***Sig. (VCd H37)**	***Plagiothecium denticulatum***
-	*Campylopus flexuosus*	-	*Polytrichum commune*
-	*Campylopus introflexus*	Mod.	*Polytrichum juniperinum*
-	*Ceratodon purpureus*	-	*Pseudoscleropodium purum*
-	*Dicranum scoparium*	-	*Pseudotaxiphyllum elegans*
-	*Hypnum andoi*	Mod.	*Ptychomitrium polyphyllum*
-	*Hypnum cupressiforme*	-	*Thuidium tamariscinum*
-	*Hypnum jutlandicum*	-	*Tortula muralis*
-	*Kindbergia praelonga*		
	Liverworts		
-	*Diplophyllum albicans*	-	*Lophozia ventricosa*
-	*Lophocolea bidentata*		

VCd = Vice-county 'debracket' for Co. Armagh, H37. Only former record by Fitzgerald & Fitzgerald, 1964, Slieve Gullion / Camlough.

Water chemistry

There were no wetland features at the locations examined.

Site Photographs

Fig. 11.2: Shaded banks and bedrock outcrops on the roadside at Fathom Forest, Sept. 2022.

Discussion and conclusions

The Cooley peninsula contains a wide range of habitats of high nature conservation value. These are important for the individual rare species they contain and also for the excellent examples of specialised habitat types and plant communities present.

Of particular of importance are the FPO species *Braunia imberbis** and the 'Near Threatened' species *Grimmia decipiens**, *G. donniana** and *G. ramondii**, all of which have a very limited geographical distribution in Ireland. Cooley also holds significant populations of an additional 38 species of mosses and liverworts which have very restricted distributions in Ireland. Many of these are oceanic species found mainly along the western seaboard; thus, Cooley is especially important in the context of eastern Ireland.

Classical combinations of species correctly tied to known habitat and/or vegetation types were found at many sites. This is particularly the case on the larger sites where a greater degree of habitat type variability prevailed. However, many sites contained apparent contradictions in the juxtaposition of calcicole and calcifuge species, demonstrating the ecological complexity of the habitats and plant communities. These insights challenge the orthodoxy and are potentially related to the complex sources of base-rich and base-poor waters. These perspectives may also imply a greater ecological tolerance under certain circumstances on the part of individual species to cope with these apparently conflicting conditions.

Key bryophyte habitats

Bryophyte habitats and communities of greatest ecological significance identified during this survey, which must be afforded the highest level of protection are as follows.

Boulders and bedrock exposures

Dry (or slightly damp) boulders and rock outcrops support a bryophyte community of exceptionally high nature conservation value, with many rare species: FPO *Braunia imberbis**, NT *G. decipiens**, NT *G. donniana**, NT *Grimmia ramondii**, *Andreaea rothii**, *A. rupestris**, *Hedwigia stellata**, *Neckera crispa**, *Racomitrium affine* s.s.*, *R. aquaticum** and *R. heterostichum* s.s.*. These occur along with the more common species *Bryum capillare*, *Dicranoweisia cirrata*, *Dicranum scoparium*, *Grimmia trichophylla*, *Hypnum andoi* and *Isothecium myosuroides*. This group of species, characteristic of the dry boulder habitat type, is often found growing together elsewhere, in south-west Ireland and in the Scottish Highlands, for example (Porley & Hodgetts 2005; Blockeel *et al*. 2014).

On wet boulders, irrigated at least periodically by flushes or streams, the mosses *Amphidium mougeotii**, *Blindia acuta**, *Breutelia chrysocoma**, *Bryum alpinum**, *Campylopus atrovirens**, *Fissidens osmundoides**, *Hyocomium armoricum** and the liverworts *Cephaloziella divaricata**, *Jubula hutchinsiae**, *Lejeuna lamacerina**, *Marsupella emarginata**, *Saccogyna viticulosa**, *Scapania gracilis** and *Tritomaria quinquedentata** were typical, the exact species groupings at any location being strongly influenced by the mineral composition of both the rock substrate and the water. They were accompanied by common species such as *Campylopus flexuosus* and *Scapania undulata* (in acidic settings) or *Didymodon tophaceus* and *Fissidens adianthoides* (in base-rich conditions).

Springs, seepages and flushes

In base-rich springs, seepages and flushes, the mosses *Palustriella commutata*, *P. falcata*, *Philonotis calcarea* and *Scorpidium cossonii* were characteristic. The habitat type in which they are found, permanently irrigated by clean, base-rich water, has become increasingly rare due to pollution and loss of wetland habitats. Where there is some precipitation of tufa, as at Carlingford Marina, the habitat corresponds with the Habitats Directive Annex I habitat type 'Petrifying springs with tufa formation (*Cratoneurion*) 7220'. Where the base

concentration was somewhat less extreme, *Blindia acuta**, *Mesoptychia bantriensis**, *Plagiomnium elatum**, *Scorpidium revolvens* s.s.*, *S. scorpioides** and *Thuidium delicatulum** became more frequent. In more acidic springs, seepages and flushes, *Sphagnum* species dominated, including *S. inundatum**.

Other important habitat types

Various other habitat types contained rare, ecologically significant species in smaller amounts. These included drainage channels which were long enough established for species to have colonised but were kept open by the flushing effect of shallow flowing water. It was in this habitat type that *Dichodontium palustre** and *Oligotrichum hercynicum** were growing. *Bryum sauteri** grew on the track edge associated with this type of habitat.

Damp, shaded banks — often in woodland or on stream edges — were also significant for species such *Homalia trichomanoides** and *Plagiothecium denticulatum**.

Site designations and site protection

Some of sites examined occurred within areas legally designated for nature conservation (SACs, pNHAs). Others lay outside the designated areas. In some cases, the areas examined were contiguous with designated areas, but lay outside the boundary. To ensure their continued survival, consideration should be given to amending the boundaries of the legally protected areas to include the sites described here.

Whether within legally designated areas or otherwise, sites of the quality and value of those at Carlingford Marina which were recently damaged must serve as a warning before further damage takes place. It is only by recognising the value of such habitats in advance that measures can be put in place to prevent such losses in future. We hope this study will make a contribution in this regard.

Further work

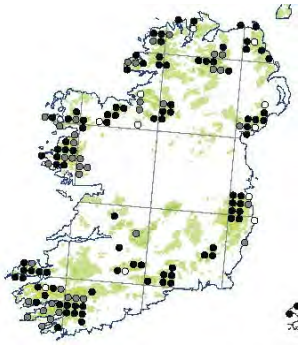
This preliminary study sets out an initial evaluation of a number of locations on the Cooley peninsula. Further investigation of these locations would no doubt reveal the presence of many more species of interest. There are, for example, additional species recorded in the BBS database that were not seen during this survey. Sites of ecological significance extend far beyond the boundaries of the locations documented in this report. There is scope, therefore, for a much broader study of the peninsula, to expand both the geographical extent of these close-focus studies and to add to the level of detail through repeated visits to sites.

From a scientific perspective, the complexity of the sites indicated by bedrock formations, water pH values and the intercalation of calcicole and calcifuge species merits further study. This would be revealing, not just in the context of the peninsula in its own right, but in terms of understanding the ecological processes and requirements of habitats and plant communities, both for their intrinsic value, and by way of contributing to our capacity to interpret and address biodiversity loss and impending climate-related changes.

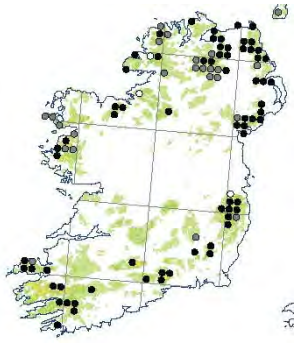
Appendix: Species distribution maps

Species of highest ecological significance (marked * in text): distribution in Ireland. Source: Blockeel *et al*. 2014.

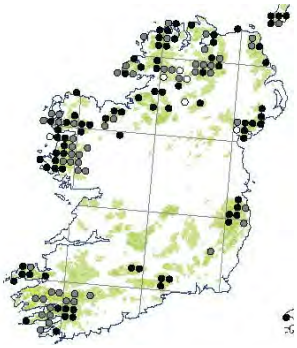
Amphidium mougeotii



Andreaea rothii

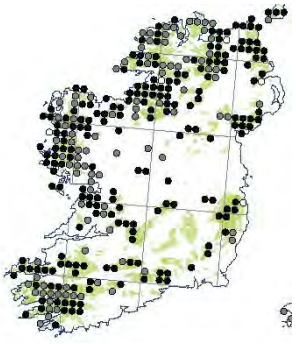


Andreaea rupestris

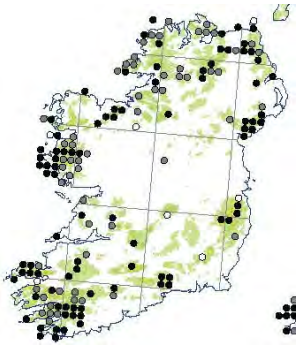


Blindia acuta

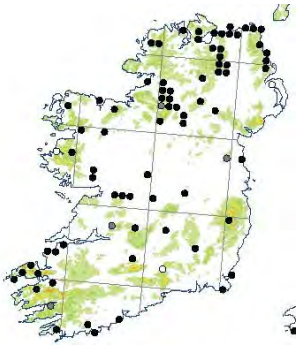
Braunia imberbis (syn. *Hedwigia integrifolia*) FPO



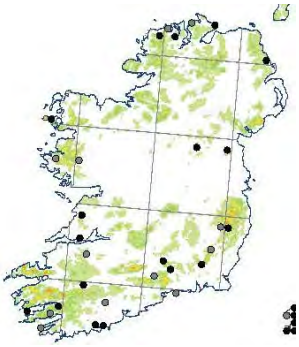
Breutelia chrysocoma



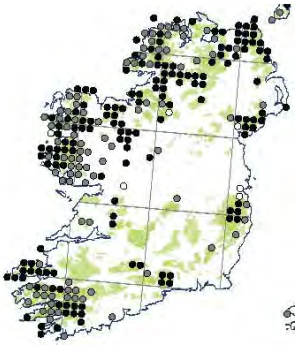
Bryum alpinum



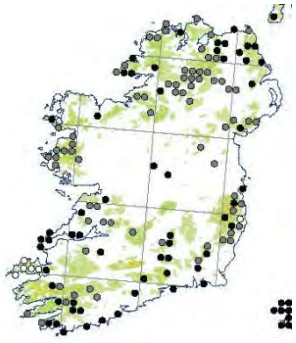
Bryum pallescens



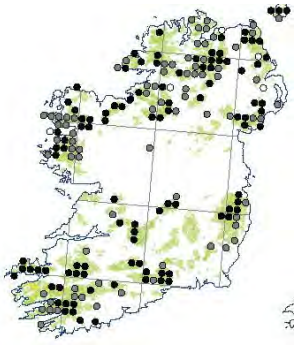
Bryum sauteri



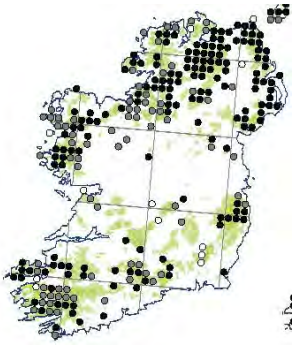
Campylopus atrovirens



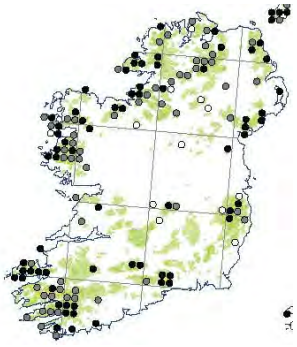
Cephaloziella divaricata



Dichodontium palustre



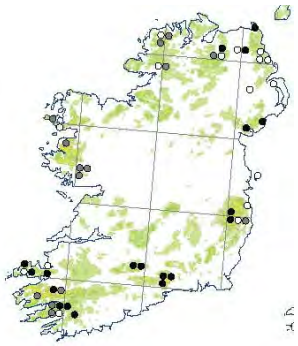
Dicranum majus



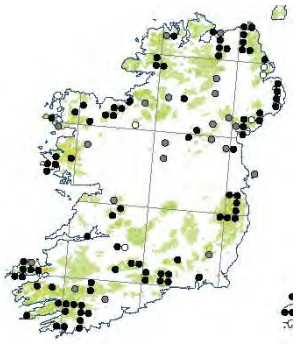
Fissidens osmundoides

Grimmia decipiens (Red List: Near Threatened)

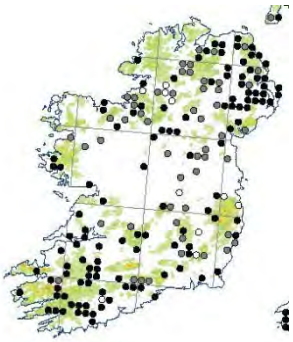
Grimmia donniana (Red List: Near Threatened)



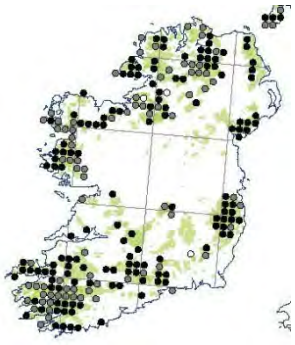
Grimmia ramondii (Red List: Near Threatened)



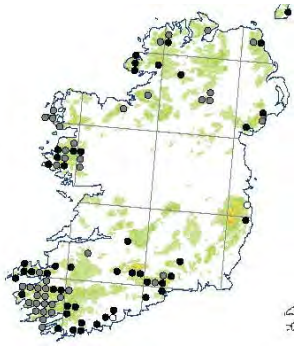
Hedwigia stellata



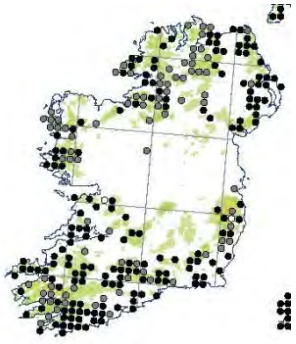
Homalia trichomanoides



Hyocomium armoricum



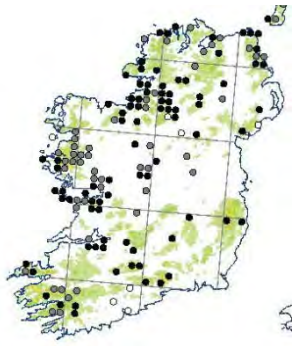
Jubula hutchinsiae



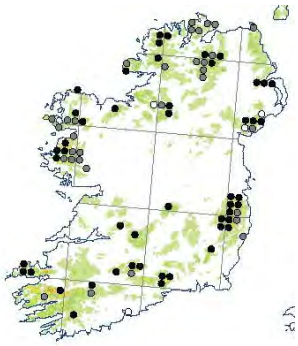
Lejeunea lamacerina

Marsupella emarginata var. *emarginata*

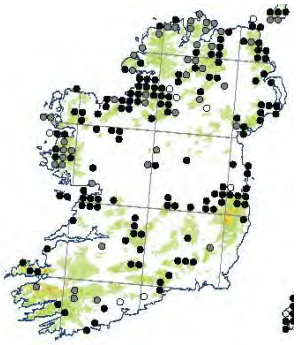
Mesoptychia bantriensis



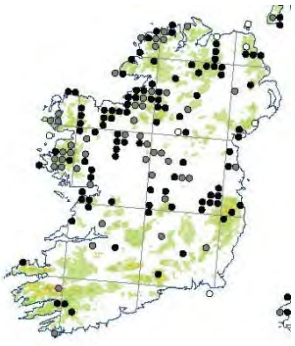
Neckera crispa



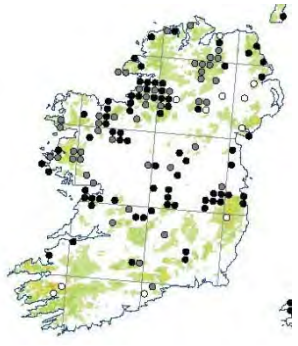
Oligotrichum hercynicum



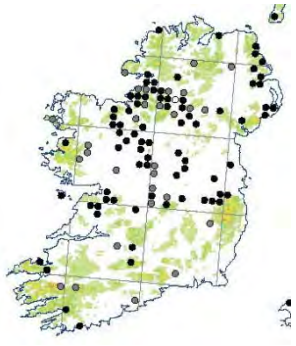
Palustriella commutata



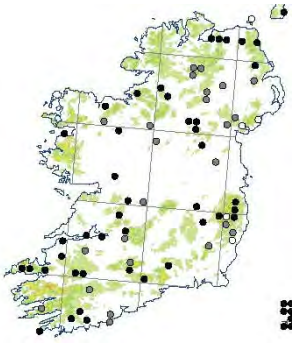
Palustriella falcata



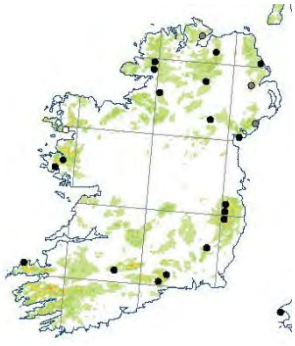
Philonotis calcarea



Plagiomnium elatum



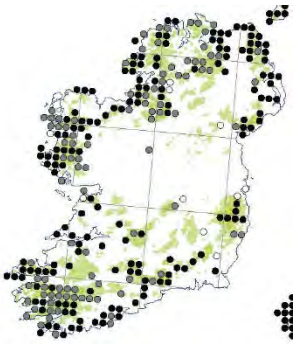
Plagiothecium denticulatum



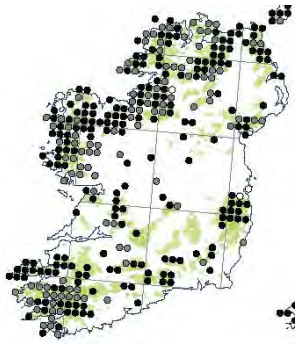
Racomitrium affine s.s.

Racomitrium aquaticum

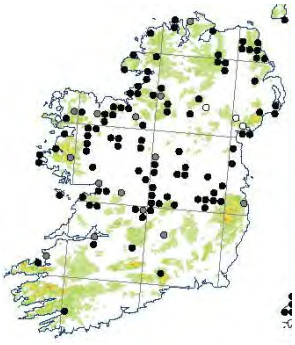
Racomitrium heterostichum (including *R. obtusum*)



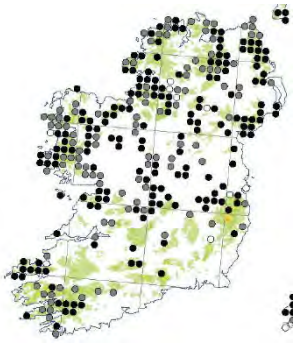
Saccogyna viticulosa



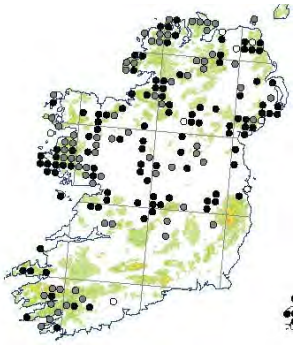
Scapania gracilis



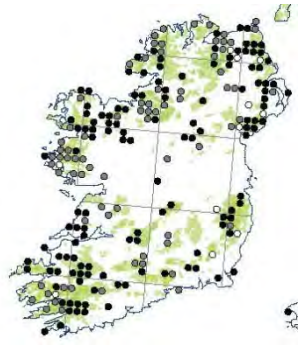
Scorpidium cossonii



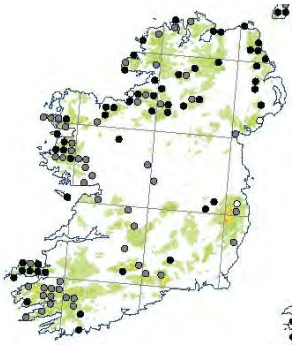
Scorpidium revolvens s.l.



Scorpidium scorpioides



Sphagnum inundatum



Thuidium delicatulum

Tritomaria quinquedentata

Black circles are records from 1990–2013; grey circles are from 1950–1989; white / open circles are pre-1950 records.

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