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THE HABITATS OF CUTOVER RAISED BOG

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An Roinn Tithíochta,
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Front cover, small photographs from top row:

Limestone pavement, Bricklieve Mountains, Co. Sligo, Andy Bleasdale; **Meadow Saffron** *Colchicum autumnale*, Lorcan Scott; **Garden Tiger** *Arctia caja*, Brian Nelson; **Fulmar** *Fulmarus glacialis*, David Tierney; **Common Newt** *Lissotriton vulgaris*, Brian Nelson; **Scots Pine** *Pinus sylvestris*, Jenni Roche; **Raised bog pool**, Derrinea Bog, Co. Roscommon, Fernando Fernandez Valverde; **Coastal heath**, Howth Head, Co. Dublin, Maurice Eakin; **A deep water fly trap anemone** *Phelliactis* sp., Yvonne Leahy; **Violet Crystalwort** *Riccia huebeneriana*, Robert Thompson

Main photograph:

Round-leaved Sundew *Drosera rotundifolia*, Tina Claffey

The habitats of cutover raised bog

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Executive Summary

This report presents details of cutover raised bog surveys undertaken as part of The Living Bog project (LIFE14 NAT/IE/000032), an EU LIFE funded project named *Restoring Active Raised Bog in Ireland's SAC Network 2016-20*. The cutover habitats of the twelve project sites were mapped, a classification scheme developed, and habitats of high conservation value identified.

Of the 770.7 ha of cutover that was surveyed, 419.8 ha (54.5%) was classed as peatland habitat, 243.2 ha (31.6%) classed as scrub or woodland and 93.3 ha (12.1%) classed as grassland. 414.6 ha of the peatland area was classed as cutover bog and it is to this habitat that the newly developed classification relates. Apart from cutover bog, the next most extensive habitat recorded was bog woodland (200.5 ha).

The classification was developed using data from 249 relevés undertaken during the surveys in open cutover habitat (excludes woodland and scrub). The classification scheme is divided into four habitat groups defined using the percentage cover of *Sphagnum* – Low *Sphagnum* (LS), Moderate *Sphagnum* (MS), High *Sphagnum* (HS) and bare peat (BP). These encompass 16 habitat types which are defined using species composition. Affinities with the Irish Vegetation Classification communities and Habitats Directive Annex I habitats were explored and a dichotomous key to aid in assigning habitats is included.

Using the newly developed classification scheme, the most common cutover bog habitat group was Low *Sphagnum*, which covered 271.9 ha (65.6% of the cutover bog habitat), followed by Moderate *Sphagnum* (86.5 ha; 20.9% of cutover bog), bare peat (30.9 ha; 7.4%) and High *Sphagnum* (25.3 ha; 6.1%). LS1, a Low *Sphagnum* type characterised by a high cover of *Calluna vulgaris* was the most extensive habitat type (133.3 ha) followed by LS3 (98.9 ha), a Low *Sphagnum* type characterised by a high cover of *Molinia caerulea*.

Cutover bogs are disturbed and degraded ecosystems whose most common habitats, LS1 and LS3 are generally of low conservation value. However, habitats of high conservation value can occur such as High *Sphagnum* habitats (25.3 ha), which may contain areas of the priority Annex I habitat types active raised bog (7110) and bog woodland (91D0). Other Annex I habitats are also present on cutover bog, including alkaline fen (7230) and transition mire (7140). A methodology for assessing whether an area of High *Sphagnum* habitat corresponds with active raised bog was developed based on numbers of positive indicator species, *Sphagnum* cover and absence or low levels of negative indicator species. This is the first time that active raised bog has been recognised as occurring on cutover in the Irish context.

The report concludes with a recommendation to refine the cutover bog classification scheme as well as testing and reviewing the criteria to be used in assessing areas of High *Sphagnum* as potential areas of active raised bog Annex I habitat.

Acknowledgements

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1 Introduction

When mapping habitats in Ireland, the Heritage Council's *A Guide to Habitats in Ireland* (Fossitt, 2000) is the standard used in ecological surveys, be it in relation to landuse planning or conservation programmes (Smith *et al*., 2011). Fossitt (2000) can be useful in identifying potential areas of high conservation value, such as those listed in Annex I of the Habitats Directive (92/43/EEC). However, such a broad habitat classification has limitations, because some habitats such as cutover bog are highly variable, as reflected in the description in Fossitt (2000):

> *Cutover bog is a variable habitat, or complex of habitats, that can include mosaics of bare peat and revegetated areas with woodland, scrub, heath, fen and flush or grassland communities. The nature of the recolonising vegetation depends on numerous factors including the frequency and extent of disturbance, hydrology, the depth of peat remaining, and the nature of the peat and the underlying substratum.*

Due to the potential diversity of the recolonising vegetation, the presence of habitats of high conservation value are subsequently not readily identifiable when using Fossitt (2000), except where "the regenerating habitats cover a sizeable area and can easily by fitted elsewhere in the classification". Thus, there is a need for a more comprehensive, specialist classification scheme of cutover bog not only for landuse planning and conservation purposes, but also in relation to carbon cycle and greenhouse gas studies, as there are significant differences in carbon balances (from carbon sink to source) between different types of cutover bog vegetation from bare peat to regenerating bog (Renou-Wilson *et al*., 2019; Swenson *et al*., 2019; Wilson *et al*., 2012). These differences need to be accounted for in calculating national greenhouse gas budgets and in emissions reporting.

An Irish Vegetation Classification (IVC) is currently under development that provides a more detailed classification of most Irish semi-natural vegetation communities, including bogs (NPWS *et al*., 2019). This is an objective classification system based on quantitative analysis of plant cover data from thousands of quadrats recorded across the country. It does not take into account habitat characteristics, such as the history of peat cutting or the overall *Sphagnum* cover. The utility of the IVC for conservation and research on cutover raised bog has not been assessed to date.

Cutover bog is a term used to describe areas of both blanket and raised bog that have had part of their peat mass removed. This study concerns only cutover raised bog. There is also a distinction between cutover bog and cutaway bog, with the latter generally referring to areas that were industrially cut in the past, often leaving little (up to 50 cm) or no peat layer remaining. Cutover bog refers to areas that have been domestically cut for peat, and which generally have greater and often more variable depths of peat remaining (O'Connell & Foss, 1999).

In Ireland, turf has been exploited as a domestic fuel as far back as the 7th century, and had probably become the principal fuel source for most people in the country by the 17th century (Feehan *et al*., 2008). Turbary rights have a long tradition in the Irish midlands in particular with each home owner usually having had a plot of bog to cut turf from (O'Connell & Foss, 1999). Up until the 1970s turf was usually cut by hand with a unique type of spade called a sleán. This method caused much less impact on the bog and its vegetation than the mechanised form of cutting that has been used to cut turf throughout the last 40 years. The most common form of domestic cutting on midland raised bogs in that time has been the hopper technique where large, deep chunks of peat are directly cut from the high bog margin (facebank) using the bucket of a digger operating from the cutover. This extracted peat is then deposited into the feeder container of the 'hopper' machine that works alongside the digger and the loose chunks of peat are churned up and exuded out on to the adjacent cutover in continuous and regular rows. This method of peat cutting also involves the insertion and maintenance of drains in the cutover, generally perpendicular to the facebank, to drain the bog and dry out the spread grounds on which the turf is saved as well as to define the turbary right boundaries (Fernandez *et al*., 2006). Frequently, high bog drains are also inserted close to the facebank. Turf plot width generally varies from 20 to 40 m. Using

the hopper technique, the entire cutover plot is constantly being driven over by machinery, compacting the peat and giving vegetation little opportunity to recolonise while cutting continues. Furthermore drainage is usually more intensive and the rates of extraction quicker than for hand-cut turf. Other forms of cutting include Difco and lateral cutting, and these are described by Fernandez *et al*. (2006). They were more common on western raised bogs and generally considered more damaging as machines usually worked on the high bog. Regardless of extraction method, the methods of 'saving' the turf has remained practically unchanged with good weather and 'footing' some of the essential ingredients.

Of the original figure of 310,000 ha of raised bog estimated by Hammond (1979) to have existed in Ireland, less than 50,000 ha (16%) of near intact (uncut) high bog remains, as well as an estimated 157,500 ha of secondary degraded raised bog habitat, which includes intensively drained high bog devoid of vegetation, cutaway bog, cutover bog and occasionally reclaimed agricultural land with peaty soils (Fernandez *et al*., 2014). Approximately 17,995 ha (36%) of high bog is within designated sites (Special Areas of Conservation or Natural Heritage Areas) and within these areas, only 1,639 ha corresponds with active raised bog (ARB; habitat code 7110), a priority Annex I habitat under the EU Habitats Directive (NPWS, 2018). A further 9,100 ha of cutover bog is estimated to occur within the designated raised bog network, which added to the area of high bog in the network, means that 27,095 ha (or 9%) of the original area of raised bog resource is within the conservation network. This area of cutover bog has an important role to play in Ireland meeting its conservation targets for ARB as set out in the National Raised Bog Special Areas of Conservation Management Plan 2017–2022 (NPWS, 2018). To date, however, regenerating bog on the cutover has not been classified as ARB, unlike in other jurisdictions such as Northern Ireland (Anon., 2019). The presence of wet, peat-forming vegetation on several cutover bogs suggests that a clear definition and set of criteria is needed to identify ARB on cutover.

National Parks and Wildlife Service has set national restoration targets for raised bog habitats (NPWS, 2018) that will require the restoration of the national network of raised bog Special Areas of Conservation (SACs) and Natural Heritage Areas (NHAs). These targets are set by a scientific process on a national and site-specific level, making use of eco-hydrological models (Mackin *et al*., 2017a) and best practice methods (Mackin *et al*., 2017b) to ensure targets are achievable. The target for the area of ARB in the national raised bog network is set at 3,600 ha, which is derived by summing the area of ARB and Annex I degraded raised bog (DRB; habitat code 7120) habitat within the current SAC and NHA network when the Habitats Directive came into force in 1994. This target is not achievable on the high bog alone, and thus to meet the ARB national conservation objective, it will be necessary to create peat-forming conditions on up to 448 ha of cutover areas (NPWS, 2018).

In this study, undertaken as part of The Living Bog project (LIFE14 NAT/IE/000032), an EU LIFE funded project named *Restoring Active Raised Bog in Ireland's SAC Network 2016–20*, cutover habitats within 12 raised bog SACs were mapped and assessed, a classification scheme was developed, and habitats of high conservation value were identified. It is important to understand that this classification was developed for cutover raised bog and though it may be applicable to areas of cutaway, it should be noted that a different classification for cutaway bog has been developed by Bord na Móna (2016). Furthermore, it may be necessary to add to this cutover classification scheme in the future as more sites are surveyed with potentially different environmental conditions that may be reflected by different vegetation types. It is also intended to follow up this assessment by combining these results with hydrological studies and Greenhouse Gas Emissions studies, which have also been undertaken as part of The Living Bog project.

2 Materials and methods

The 12 project sites that encompassed the Living Bog LIFE project and form the basis of this study are shown in Figure 1 and listed in Table 1.

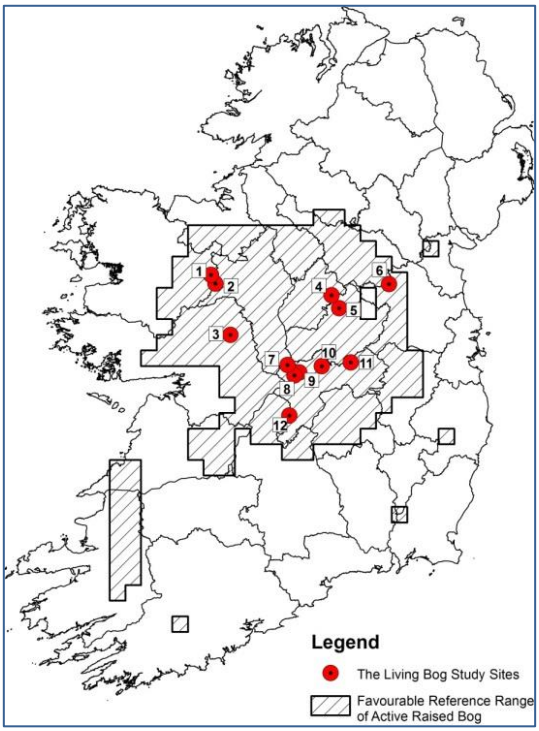

Figure 1 Locations of the 12 sites and the Favourable Reference Range of Active Raised Bog in Ireland as defined by NPWS (2019).

Table 1 Project sites and the areas of cutover surveyed. Note that additional areas mapped as heath or woodland on mineral outcrops etc. are not included in these figures. For analysis sites 1–3 were considered western, sites 4–6 northern and sites 7–12 as Co. Offaly sites.

Site Number	SAC Site Code	Site Name	SAC Area (ha)	Area of cutover surveyed (ha)
1	IE0000604	Derrinea Bog	89.2	10.7
2	IE0000597	Carrowbehy/Caher Bog	345.7	68.9
3	IE0001242	Carrownagappul Bog	485.7	123.3
4	IE0002341	Ardagullion Bog	116.5	51.5
5	IE0000679	Garriskil Bog	351.3	143.0
6	IE0000006	Killyconny Bog	185.0	80.4
7	IE0000580	Mongan Bog	206.5	21.7
8	IE0000581	Moyclare Bog	130.0	31.0
9	IE0000575	Ferbane Bog	151.9	27.8
10	IE0000572	Clara Bog	836.2	129.4
11	IE0000582	Raheenmore Bog	209.9	33.0
12	IE0000585	Sharavogue Bog	223.4	50.2

2.1 Habitat surveys

The cutover habitats of each of the 12 project sites were surveyed largely between August 2016 and November 2017, although a limited number of surveys were also carried out in 2018. The main objective of the cutover surveys was to act as a baseline for the Living Bog LIFE project. Habitats present within the zones of influence of restoration works on the cutover were mapped and permanent monitoring relevés were established (Section 2.2) prior to restoration activities in order that the impact of restoration can be assessed in the future.

The baseline survey of the cutover habitats of each site followed the following methodology:

1. A preliminary habitat map of the cutover was created through desktop analysis of aerial photographs (2012) using ArcMap 10.3. This involved delineating habitat/vegetation boundaries without determining what habitat/vegetation types they were.
2. A field survey was undertaken to check and amend (move, amalgamate and/or create extra) habitat boundaries on the ground using (when available) a GeoExplorer handheld GPS minicomputer (Trimble Geo7x) with sub-metre accuracy (when not available a GPS enabled tablet was used). A minimum mappable habitat area of 400 m^2 with a minimum habitat width of 4 m was used as recommended for general habitat surveys by Smith *et al*. (2011).
3. Each polygon was assigned to a habitat category using Fossitt (2000). In the case of open cutover bog (PB4) that could not clearly be assigned to another habitat type, such as dense bracken (HD1) or scrub (WS1), a "working" cutover habitat subtype was also assigned. (Note that heath-type vegetation on cutover bog was treated this way; HH1 and HH3 were not used). Where appropriate, habitat polygons were also assigned to the applicable Annex I habitat type, such as alkaline fen (7230) or transition mire (7140). In particular, Annex I bog woodland (91D0) habitats were mapped separately from non-Annex bog woodland (WN7) using the criteria defined by Cross & Lynn (2013). Some areas were mapped as mosaics of different habitats.
4. A species list with DAFOR cover values, an estimate of the percentage *Sphagnum* cover, and an estimate of the percentage bare peat cover were recorded for each polygon.
5. Post survey, and after an analysis of the relevés recorded (Section 2.2), the "working" habitat types were refined and each mapped polygon was retrospectively assigned to the final cutover habitat types.

2.2 Relevé analysis

2.2.1 Field surveys

A total of 249 relevés were recorded on cutover bog across the 12 study sites and were candidates for the classification analysis. Of these, 231 relevés were established primarily as a baseline to monitor the effects of restoration works on the cutover bog. Areas predicted by hydrological modelling to have good peat-forming potential following restoration were prioritised for field survey. These were identified as areas having gentle surface slopes (≤0.3%) and within enclosed depressions that have a contributing catchment area of at least 5000 m^2 (NPWS, 2018). Additional relevés were recorded to obtain a sample of the different habitat types present and to obtain a representative geographic spread across each site. The number of relevés sampled in different habitat types was not proportional to cutover habitat area. Relatively more relevés were collected in wetter cutover bog habitats and those with better potential for restoration to peat-forming conditions than in drier cutover bog. As the primary objective of the cutover habitat classification is to aid in conservation assessment and planning, this was considered to be a practical requirement of the sampling procedure.

Relevé size was 4x4 m, except in woodlands, where a 10x10 m relevé size was used. In the baseline relevés, the following data were collected:

- Relative abundance of all vascular plant, bryophyte and *Cladonia* species according to the Domin scale
- Percent cover of *Sphagnum*
- Percent cover of bare peat
- Average acrotelm depth in cm in 5 classes (0, 0–5, 5–10, 10–20, >20 cm)
- Substrate firmness (firm, soft, very soft, quaking)
- Moisture levels (wet, intermediate, dry)
- Soil type (bog peat, fen peat, mineral)
- Peat-forming status of the habitat: yes, no, potentially following restoration (see below)
- Depth of pools/standing water
- Fossitt (2000) vegetation type and, where applicable, working cutover bog habitat subtype
- Annex I habitat type, where applicable

The average acrotelm depth was taken to be the average depth of the living *Sphagnum* layer. This was estimated by assessing the depth to humified peat in a several locations within each plot. Current peat-forming status was assessed using expert judgement based on the cover of typical peat-forming *Sphagnum* mosses and presence of at least a patchy *acrotelm* (the living, actively growing upper layer of a raised bog, composed mainly of living bog mosses). Peat forming potential was subjectively assessed in the field based on local topographical position, presence of blockable drains in the vicinity, water depth in drains, and the current vegetation composition.

The remaining 18 relevés in the analysis were part of a transect in Killyconny Bog surveyed in 2018. This transect was originally surveyed in 2005 prior to restoration work, and the 2018 resurvey was primarily an assessment of the success of the measures undertaken. These relevés were 5 mx5 m in size, and the same data were collected as in the baseline relevés.

2.2.2 Irish Vegetation Classification evaluation

Prior to developing a new habitat or vegetation classification for cutover bogs, the IVC (NPWS *et al*., 2019) was assessed to determine if that system could adequately describe cutover raised bog vegetation. The data from the 249 surveyed cutover bog relevés were inputted into the ERICA tool (version 4.4; Perrin 2020), which assigned them to 30 different communities (Table 2). One relevé in a conifer plantation could not be assigned, indicated by Noise in the table.

Table 2 Cutover bog relevé assignments to the Irish Vegetation Classification (IVC) types.

IVC Division	IVC Community Code	IVC Community Name	No. Relevés
Bog	BG1A	*Sphagnum cuspidatum–Sphagnum subsecundum* agg. bog	1
	BG1B	*Rhynchospora alba–Narthecium ossifragum* bog	1
	BG1D	*Eriophorum angustifolium–Campylopus introflexus* bog	5
	BG2A	*Eriophorum vaginatum–Vaccinium oxycoccos* bog	7
	BG2B	*Erica tetralix–Andromeda polifolia* bog	34
	BG2C	*Erica tetralix–Molinia caerulea–Cladonia portentosa* bog/heath	54
	BG2D	*Erica tetralix–Schoenus nigricans* bog	1
	BG2E	*Calluna vulgaris–Eriophorum* spp. bog	35
Fen	FE1A	*Schoenus nigricans–Campylium stellatum* fen	2
	FE1B	*Schoenus nigricans–Succisa pratensis* fen	1
	FE2D	*Carex rostrata–Menyanthes trifoliata* mire	1
	FE2E	*Menyanthes trifoliata–Sphagnum recurvum* agg. mire	1
	FE2F	*Menyanthes trifoliata–Calliergonella cuspidata* mire	2
Grassland	GL1A	*Juncus acutiflorus–Holcus lanatus* grassland	1
	GL2B	*Juncus effusus–Holcus lanatus grass*land	1
	GL2D	*Juncus effusus–Rumex acetosa grass*land	2
	GL3E	*Festuca rubra–Rhinanthus minor grass*land	1
	GL4D	*Agrostis canina/vinealis–Rhytidiadelphus squarrosus* grassland	2
Heath	HE2B	*Calluna vulgaris–Hypnum jutlandicum* heath	13
	HE2C	*Calluna vulgaris–Agrostis capillaris* heath	1
	HE2D	*Calluna vulgaris–Molinia caerulea–Erica cinerea* heath	9
	HE4C	*Molinia caerulea–Schoenus nigricans* bog/heath	1
	HE4D	*Molinia caerulea–Potentilla erecta–Erica tetralix* heath	9
	HE4E	*Molinia caerulea–Calluna vulgaris–Erica tetralix* heath	30
Woodland	WL3E	*Salix cinerea–Galium palustre* woodland	4
	WL4A	*Betula pubescens–Vaccinium myrtillus* woodland	4
	WL4C	*Betula pubescens–Sphagnum palustre* woodland	10
	WL4D	*Betula pubescens–Rubus fruticosus* woodland	7
	WL4E	*Betula pubescens–Salix cinerea* woodland	7
	WL4F	*Betula pubescens–Pteridium aquilinum* woodland	2
Noise	N		1
	Total		249

The median maximum correspondence with communities was 62.5%, and 28.1% of relevés were considered transitional (correspondence with any IVC type was <50%). The vast majority of relevés were assigned to communities BG2B, BG2C, BG2E or HE4E:

- BG2B (*Erica tetralix–Andromeda polifolia* bog) is the principal raised bog community in the IVC and encompasses ARB, DRB and non-Annex raised bog, as well as some blanket bog vegetation.

- BG2C (*Erica tetralix–Molinia caerulea–Cladonia portentosa* bog/heath) is a blanket bog or wet heath community of lower hillsides.
- BG2E (*Calluna vulgaris–Eriophorum* spp. bog) is a heathy, upland blanket bog community of deep, wet peat.
- HE4E (*Molinia caerulea–Calluna vulgaris–Erica tetralix* heath) is a wet heath community of lower to middle montane slopes.

The correspondence between IVC communities and working cutover bog habitat subtypes assigned in the field was quite poor. For example, the working subtype "PB4/regenerating", which was assigned to areas that were wet with a high cover of peat-forming *Sphagnum* species, was divided amongst six different IVC communities, mostly in group BG2. Furthermore, many IVC communities included relevés assigned to working cutover bog subtypes representing a wide range of ecological conditions, from *Sphagnum*-rich to dry and *Calluna*-dominated and from ombrotrophic to flushed.

The affinity between the cutover bog relevés and the IVC was then considered at the group rather than the community level to evaluate if this typology would provide useful results. At this level, the vast majority of non-woodland relevés were assigned to the BG2 heathery bog group (130), with HE4 *Molinia* heath (26) and HE2 *Calluna* heath (17) being the next most frequent. A total of 19 relevés were transitional across groups. Classification by IVC groups rather than communities still suffered from the drawback of an inability to distinguish wetter *Sphagnum*-rich cutover from dry *Sphagnum*-poor cutover. For example, most of the "PB4/regenerating" working cutover subtype was assigned to group BG2 along with most of the "PB4/marginal" subtype, which supported vegetation similar to the dry Marginal ecotope of high bog edges.

The main reasons the IVC was found to be unsuitable as a classification system at present for the conservation management of cutover bog include:

1. the lack of cutover raised bog data in the IVC,
2. the fact that it is a vegetation classification rather than a habitat classification,
3. the IVC is still in development.

Firstly, there appear to be few if any relevés from cutover raised bogs used in the development of the IVC classification of bogs and heaths. The technical report for this phase of the classification makes no mention of cutover raised bog relevés (Perrin, 2017), and the number of general raised bog relevés in the analysis was small compared with the number of relevés from blanket bog (P. Perrin, pers. comm.). Secondly, as a vegetation classification, the IVC does not make use of environmental characteristics that are useful for conservation management, such as moisture status and cover of bare peat. Lastly, the IVC is still in development and some communities, such as *Juncus–Sphagnum* flushes, have not yet been included in the classification (P. Perrin, pers. comm.). As a result, affinities between such vegetation and IVC communities are expected to be low. For these reasons, it was considered that a specific cutover raised bog habitat classification would be useful for conservation planning and management.

2.2.3 Woodland relevés

Prior to the development of the cutover classification, relevés assigned to woodland habitat types, including all WN and WD types and WS2 immature woodland under Fossitt (2000) were removed from the dataset. A total of 26 relevés were thus omitted. This was done in part because the plot size of these relevés (100 m^2) was larger than that of open cutover relevés (16 m^2), which would make direct comparison problematic. In addition, the IVC woodland classification is mainly based on the National Semi-natural Woodland Survey, which included many woodland relevés on cutover raised bog (Perrin *et al.*, 2008a & b). Therefore, the IVC woodland classification was used to describe woodland on cutover bog in the study sites. In addition, woodland relevés were also classified as Annex I bog woodland (91D0), where appropriate, using the criteria developed by Cross & Lynn (2013).

2.2.4 Non-woodland relevés

2.2.4.1 Preliminary data preparation

Prior to classification, where Domin cover-abundance values were used in the monitoring plot data, these were replaced with percentage cover scores according to the methods used for the IVC (Table 2a in Perrin, 2015).

Four groups of taxa were combined to generic level due to difficulties or inconsistencies in recording to species in the field.

Cephaloziella spp: All records of *Cephaloziella* species (including species determined as *C. hampeana* and *C. divaricata*) were amalgamated due to the frequent occurrence of non-fertile plants that were not able to be determined to species and also taxonomic difficulties in the genus.

Cladonia sp: Records of *Cladonia* sp. and *Cladonia crispata* were combined as *Cladonia* sp. as the latter species was not consistently recorded. Other *Cladonia* species (e.g. *C. portentosa* and *C. floerkeana*) were retained.

Kurzia pauciflora: *Kurzia* species were sometimes recorded only to genus level, but these were combined with records of *K. pauciflora* as the habitat preferences of other species in the genus make this a safe assumption.

Riccardia sp: A small number of *Riccardia* sp. records were deleted from the dataset, as most records of the genus were confidently assigned to *R. chamedryfolia*, *R. multifida* and *R. latifrons*.

2.2.4.2 Habitat Groups

A classification of vegetation based strictly on relative abundances of species was initially trialled; however, the results were unsatisfactory. As with the IVC, the resulting vegetation types generally did not clearly separate out wetter, more *Sphagnum*-rich habitats, but grouped these together with drier habitats of less conservation interest. The decision was then made to pursue a classification where the dataset was initially partitioned according to habitat characteristics after which vegetation classification methods would be used within each habitat group.

Two of the key pieces of information not used in the vegetation classification were total S*phagnum* cover and bare peat cover. The former variable provides information on the wetness of the cutover, successional stage of the cutover, and similarity to intact raised bog, including ARB. Cover of bare peat is useful in identifying the younger and more disturbed cutover, and also the drier cutover that is very slow to colonise and thus remains "immature" for a long time. To identify thresholds for partitioning the dataset, *Sphagnum* cover and cover of bare peat were plotted (Figure 2) and the literature on *Sphagnum* cover in ARB on the high bog was reviewed.

Previous raised bog research in Ireland indicates that ARB, at least in the midlands, generally supports cover of *Sphagnum* greater than 40% (Fernandez Valverde *et al.*, 2005, 2012). In the dataset, cover of bare peat of 10% or more is associated with generally low *Sphagnum* cover on disturbed and young cutover or older, dry cutover with poor vegetation development (Figure 2). *Sphagnum* cover of 10% or less is associated with degraded ecotopes (Marginal and Facebank) on the high bog (Fernandez Valverde *et al.*, 2005, 2012) and was found during field surveys to be associated with heath, fen, grassland or other non-raised bog vegetation. Using these thresholds, four habitat groups were defined:

- **High *Sphagnum***: *Sphagnum* cover >40% (regardless of bare peat cover)
- **Bare peat**: *Sphagnum* cover ≤40% and bare peat cover ≥10%
- **Moderate *Sphagnum***: *Sphagnum* cover 11–40% and bare peat cover <10%
- **Low *Sphagnum***: *Sphagnum* cover ≤10% and bare peat cover <10%

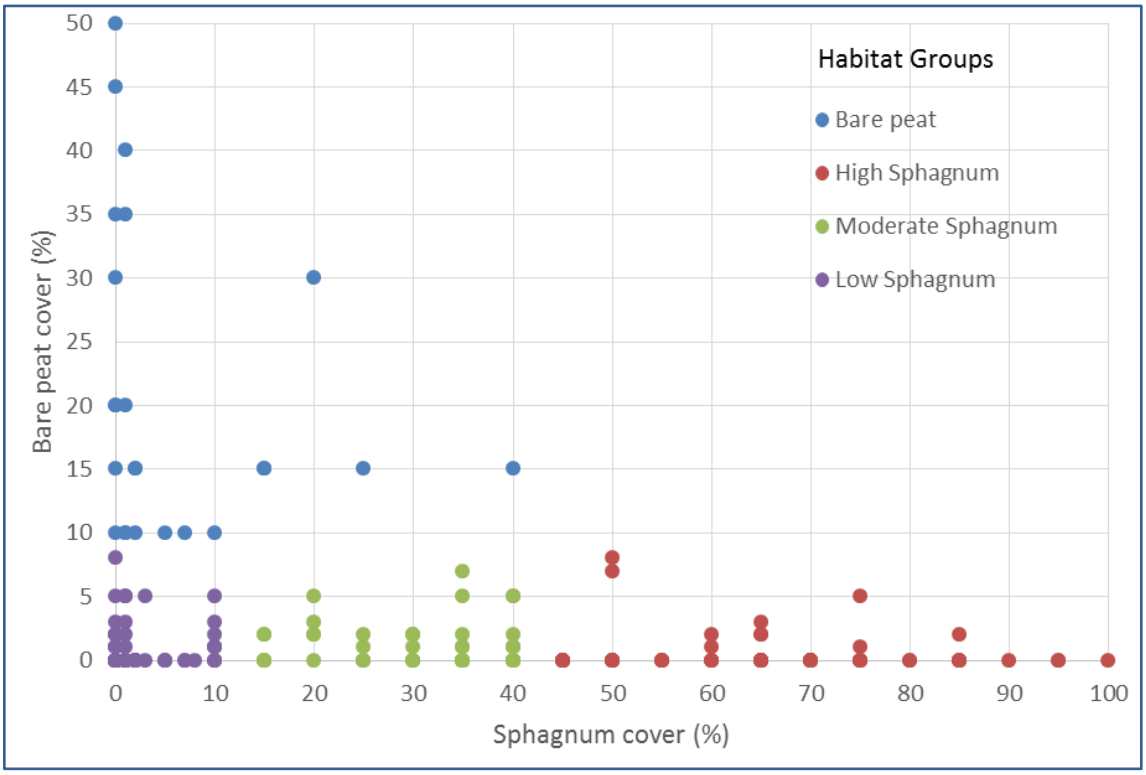

Figure 2 Distribution of *Sphagnum* cover and cover of bare peat in the relevés used in the cutover bog habitat classification.

2.2.4.3 Cluster analysis

Cluster analyses were performed using the vegetation data for each of the above habitat groups. Bray-Curtis distance was the dissimilarity measure chosen to compare vegetation composition among relevés (Legendre & Legendre, 1998). The cluster method chosen was a version of fuzzy clustering called noise clustering in which each relevé is assigned a degree of membership to each of the clusters formed by the analysis (De Cáceres *et al*., 2010). Membership is also assigned to a 'noise' class, which represents outliers not adequately described by the classification. This method was chosen as it is a well-established method particularly suited to vegetation classification where transitional types and anomalous plant communities are frequent. This is also the methodology used in developing the IVC (Perrin, 2015), which may promote interoperability between the two classification schemes.

There are two parameters for the noise clustering model that must be set. The fuzziness coefficient m controls how fuzzy the resulting classification is. Smaller values of m yield solutions that are closer to hard partitions, i.e. complete membership of one and only one cluster. Values between m = 1.1 and m = 1.25 are common in ecology (De Cáceres *et al*., 2010). The noise parameter δ controls how far an outlier relevé must be from cluster centroids to be considered a member of the noise class, and thus excluded from membership of the "good" clusters. Smaller values of δ result in greater numbers of relevés assigned to the noise class. Different values of m and δ were tested for each habitat group clustering. In the end, m = 1.2 and δ = 0.65 were used for all cluster analyses as these values appeared to accurately identify relevés with truly transitional vegetation and outlier relevés.

Within each habitat group, solutions with different final cluster numbers were evaluated. Silhouette analysis was used to assist in determining the best number of final clusters. This method numerically evaluates the dissimilarity in vegetation composition among all members of a cluster compared with their dissimilarity with members of other clusters. The mean silhouette width of all relevés in a cluster analysis indicates the quality of the classification, and these were compared among classifications with different numbers of final clusters. In addition, the numbers of relevés considered transitional (i.e. membership of any cluster <50%) and those assigned to the noise class were compared.

For the High *Sphagnum* group (n=57), a 3–cluster solution was considered best, as it had a higher mean silhouette width than other solutions considered (2–5 clusters). All clusters were easy to interpret ecologically, and adding a fourth cluster provided no additional understanding of the vegetation.

In the Bare Peat group (n=23), the 2–cluster solution was adopted, as it had a higher mean silhouette width than other solutions considered (3 and 4 clusters). The 4–cluster solution included one cluster with only one relevé member. The 3–cluster solution included an *Eriophorum angustifolium* dominated habitat type and two types characterised by *Calluna*. These were not well-distinguished into slightly more or less flushed variants.

For the Moderate *Sphagnum* group (n=62), a 5–cluster solution was considered best. It had the highest mean silhouette width of the other solutions considered (3–7 clusters), with the exception of the 7–cluster solution. The latter was considered sub-optimal, as it included two very small clusters with n=3 and n=4 and a larger number of noise and transitional relevés. A 6–cluster solution split a *Juncus* dominated cluster to create two flush vegetation types, one of which was difficult to interpret and characterise.

In the Low *Sphagnum* group (n=71) a 5–cluster solution was considered best. It had the highest mean silhouette width of the other solutions considered (3–6 clusters), with the exception of the 6–cluster solution. The latter was not chosen as it divided a cluster characterised by abundant *Molinia* into poorly defined oligotrophic and more eutrophic types.

When vegetation classifications were obtained for each of the habitat groups, Indicator Species Analysis (Dufrêne & Legendre, 1997) was used to identify the best indicator species for use in describing and identifying cutover bog habitat types. All statistical analyses were performed in the R statistical environment. The Bray–Curtis distance matrix was produced using function `vegdist` in package `vegan`. Noise clustering was performed using function `vegclustdist` in package `vegclust`. Silhouette analysis was performed using function `silhouette` in package `cluster`. Indicator Species Analysis was done using function `indval` in package `labsdv`.

2.3 Assessment of Active Raised Bog (ARB) on cutover

As noted in Section 1 above, there is currently no recognition or definition of Annex I ARB (7110) on cutover raised bog. It is stated in NPWS (2019) that:

> *Although ARB is currently described as confined to the high bog, surveys in recent years have indicated the occurrence of peat-forming vegetation on cutover areas at some sites. These areas occasionally correspond to regenerating ombrotrophic vegetation characterised by* Sphagnum *cover greater than 40–50%, but they generally lack the diversity and abundance of Sphagnum species, micro-topographical features and good quality indicators associated with ARB. These cutover areas have the capacity to develop into embryonic ARB but longer time periods (50-100 years) are likely to be required for high quality ARB to develop.*

The High *Sphagnum* group in the cutover classification describes cutover bog habitats with >40% *Sphagnum* cover (Section 2.2.4), but many of these areas lack other characteristics of ARB on the high bog and so should not be considered as ARB. However, some of these areas do possess such features, which suggest that a set of criteria defining ARB on cutover bog should be developed.

To identify suitable indicator species of ARB on cutover bog, intact raised bog was analysed with reference to the species listed (Table 3) as characteristic of ARB by NPWS (2019). Intact raised bog is composed of a number of community complexes (Kelly & Schouten, 2002), and the minimal area (Mueller-Dombois & Ellenberg, 1974) of these community complexes combined has been calculated as being 100 m^2 by Schouten (1990). In order to establish how many of the species listed by NPWS (2019) typically occur within ARB, thirty-four 10x10 m quadrats were recorded in ARB on three sites (Carrownagappul, Garriskil and Clara) in May 2020, recording the presence/absence of the ARB

characteristic species in each plot. In addition, 15 high bog relevés (4x4 m), which were taken on three of the project sites (Mongan, Raheenmore and Ardagullion) as part of the high bog monitoring programme were also analysed.

Table 3 Species listed as being characteristic of Active Raised Bog (ARB) for Ireland by NPWS (2019) with the addition of *Cladonia uncialis*.

Vascular Plants	Mosses, Liverworts and Lichens
Andromeda polifolia	*Aulacomnium palustre*
Drosera anglica & *D. intermedia*	*Campylopus atrovirens, Pleurozia purpurea* & *Racomitrium lanuginosum* (Western indicators)
D. rotundifolia	*Cladonia ciliata* & *C. portentosa*
Menyanthes trifoliata	*C. uncialis*
Narthecium ossifragum	*Leucobryum glaucum*
Rhynchospora alba	*Sphagnum austinii,*
Utricularia minor	*S. beothuk*/*S. fuscum*
Vaccinium oxycoccos	*S. capillifolium*
Eriophorum vaginatum	*S. cuspidatum*
Eriophorum angustifolium	*S. denticulatum*
	S. magellanicum agg.
	S. papillosum
	S. pulchrum
	S. subnitens

To avoid a bias in favour of western raised bogs, a number of the western indicator species (Cross, 1990) were grouped together and their presence was counted as one. Similarly in order to reduce error and effort in the identification process the species pairs, *Cladonia portentosa* and *C. ciliata*, and *Drosera anglica* and *D. intermedia,* were each counted as one taxon. During the course of this project, *Sphagnum magellanicum* was split into three species, two of which occur in Ireland: *S. medium* and *S. divinum* (Hassel *et al.*, 2018); both are counted as one. *Sphagnum fuscum*, as previously understood, has recently been split into two similar species, *S. fuscum sensu stricto* and *S. beothuk* (Kyrkjeeide *et al.*, 2015). The latter species appears to be more typical of lowland raised bogs, while *S. fuscum sensu stricto* is thought to occur mainly in uplands and in flushed or lagg zone conditions. The two species can be difficult to separate without microscopic examination, however, and so the two are usually referred to together as *S. fuscum sensu lato*.

The presence of microtopographical features typical of some high bog ARB was not included as an explicit criterion for cutover bog ARB. The presence of a diversity of positive indicator species implies the initiation of at least some microtopographical differentiation. Furthermore, some high bog ARB consists primarily of *Sphagnum* lawns with pools, hummocks and hollows relatively rare.

The 57 cutover bog relevés assigned to the High *Sphagnum* group were then assessed to determine how many ARB characteristic species occurred within them and whether they fulfilled the criteria to be considered as ARB. However, this exercise was purely indicative, as these relevés were smaller (16 m^2) than the minimal area of ARB (100 m^2).

3 Cutover bog classification

The cutover bog habitat classification includes open habitats on cutover bog. Woodland and scrub are excluded from the classification, as discussed above. The cutover bog classification is divided into four habitat groups that encompass 16 habitat types.

Unlike the IVC, which is a vegetation classification that relies entirely on botanical data, this is a habitat classification that makes use of habitat structural characteristics (i.e. overall percentage *Sphagnum* cover and bare peat cover) in addition to botanical information. Other physical features such as substrate type, depth to water table or wetness, and slope, although not used in the classification are referred to in the habitat descriptions and often assist in identifying typical characteristics of a habitat type. Use of structural information is required because, firstly, there is only a small pool of species that are common on cutover raised bogs, which makes an ecologically meaningful purely vegetation classification extremely difficult. In addition, much cutover bog vegetation is in a state of flux, recovering from relatively recent disturbance and has not yet reached stable "climax" communities (*sensu* Clements, 1916).

The four habitat groups are:

- **High *Sphagnum* (HS) group**: habitats with greater than 40% total cover of *Sphagnum* (regardless of bare peat cover)
- **Bare Peat (BP) group**: habitats with 10% or more cover of bare peat
- **Moderate *Sphagnum* (MS) group**: habitats with less than 10% cover of bare peat and *Sphagnum* cover ranging from 11–40%
- **Low *Sphagnum* (LS) group**: habitats with less than 10% cover of bare peat and *Sphagnum* cover 10% or less

After the initial division based on habitat characteristics, each group is divided into 3–5 habitat types based on their vegetation, including the fidelity of species to particular types and the abundances of species within types. The classification is outlined in Table 4 and a key to assist in assigning habitats to types is presented as Appendix 1.

Table 4 Cutover Bog Habitat Classification

Group	Habitat Code	Habitat Type
High *Sphagnum* (>40% cover)	HS1	*Sphagnum subnitens–Erica tetralix*
	HS2	*Sphagnum cuspidatum–Eriophorum vaginatum*
	HS3	*Sphagnum palustre–Molinia caerulea*
Bare Peat (>10% cover)	BP1	*Calluna vulgaris*–bare peat
	BP2	*Eriophorum angustifolium*–bare peat
	BP3	Bare peat
Moderate *Sphagnum* (11–40% cover)	MS1	*Calluna vulgaris–Sphagnum subnitens*
	MS2	*Eriophorum vaginatum–Sphagnum papillosum*
	MS3	*Molinia caerulea–Polygala serpyllifolia*
	MS4	*Cladonia portentosa–Trichophorum germanicum*
	MS5	*Juncus effusus–Sphagnum palustre*
Low *Sphagnum* (≤10% cover)	LS1	*Calluna vulgaris*
	LS2	*Eriophorum angustifolium*
	LS3	*Molinia caerulea*
	LS4	*Filipendula ulmaria*
	LS5	*Schoenus nigricans*

Synoptic tables summarising the 16 cutover bog habitat types are presented in Appendices 2–5. In each table, the percentage of samples in which a species is found in a given habitat type is summarised using frequency classes as outlined in Table 5.

Table 5 Synoptic table frequency classes.

Frequency Class	Percentage of samples
I	0–20%
II	21–40%
III	41–60%
IV	61–80%
V	81–100%

Species with a frequency of no more than I for any habitat type are not included in the tables, but are listed underneath them.

Below the frequency class, the abundance range of each species in a given habitat type is shown in the format (minimum)–median–(maximum). Abundances are given according to the Domin scale ranks used in the field.

Significant indicator species, as determined using Indicator Species Analysis (Dufrêne & Legendre, 1997), are grouped together for each habitat type and marked with a bold outline. Other species that appear to have some value as indicators are marked with a dashed outline.

Also included in the habitat type descriptions are environmental proxy scores for moisture, reaction (acidity) and nitrogen (fertility), generated using ERICA (Perrin, 2020). These are the means of the combined Ellenberg values (Hill *et al.*, 2004; Hill *et al.*, 2007) for the relevés in a habitat type. The

combined Ellenberg value for a relevé is the mean value of each species weighted by its abundance in the plot. Ellenberg values range from 1–9:

- High scores for moisture indicate wetter conditions.
- High scores for reaction indicate more basic conditions.
- High scores for nitrogen indicate more fertile conditions.

3.1 High *Sphagnum* Group

The High *Sphagnum* Group is defined by a cover of *Sphagnum* mosses that is clearly greater than 40%. It accounted for 25.3 ha of all cutover bog habitats surveyed, which equates to 3.2% of all habitat surveyed and 6.1% of habitat that would be classed as PB4 under Fossitt (2000). *Sphagnum capillifolium* ssp. *rubellum* is virtually constant across habitat types in this group, and in many habitats, it is the most abundant *Sphagnum* species. *Sphagnum magellanicum* agg. and *Drosera rotundifolia* are also usually present.

Species typical of intact raised bog such as *Calluna vulgaris*, *Erica tetralix*, and *Eriophorum* species, frequently occur across the group, although some may be more abundant in particular habitat types. In addition, *Molinia caerulea* is generally present at a higher frequency than on intact high bog.

The habitats in this group are typical of older areas of cutover bog that receive significant surface water flows from the high bog or surrounding cutover or areas where there have been significant restoration works on the cutover. These habitats generally form on level topography or local depressions, conditions which have facilitated good regeneration of *Sphagnum*. HS group habitats are slightly more common on western sites, with 46.5% of HS habitats recorded from the three western sites (Table 6). This figure would be higher (57.8%) if the HS2 habitat that has formed on Killyconny Bog as a result of the extensive restoration works carried out there in the late 2000s was excluded. Higher effective rainfall levels in the west may be a reason why HS habitat types are more common on western sites. Mean acrotelm depth for the group was 5.1 cm. Ground conditions are usually soft or very soft.

Affinities of relevés in the HS habitat types to IVC communities were produced using ERICA (Perrin, 2020). Mean affinities of each habitat type are summarised in Table 7, and the means of the combined Ellenberg values (Hill *et al*., 2004; Hill *et al*., 2007) for the relevés in a habitat type in the HS group are presented in Table 8.

Table 6 Proportion (%) of High *Sphagnum* (HS) habitat types in each geographical region as well as the overall proportion of cutover surveyed per geographical region.

	Western (%)	**Northern (%)**	**Co. Offaly (%)**
HS1	47.6	16.4	36.0
HS2	27.4	64.6	8.0
HS3	74.4	18.0	7.6
Total HS	**46.5**	**35.6**	**17.9**
Total cutover surveyed	**37.3**	**33.2**	**29.5**

Table 7 Mean percentage affinities of cutover bog in High *Sphagnum* (HS) and Moderate *Sphagnum* (MS) group habitat types with Irish Vegetation Classification (IVC) communities. Affinities over 50% are indicated in bold. An IVC type with an affinity of 1–5% is given as <5, of 0.1–1% as <1 and of <0.1% as –. Affinities of Active Raised Bog (ARB) recorded on high bog from 15 relevés taken on the project sites are given for comparison.

Code	ARB	HS1	HS2	HS3	MS1	MS2	MS3	MS4	MS5
n	15	27	14	16	11	14	15	16	6
BG2A	6.0	<5	15.4	19.1	<1	<5	<1	<1	<1
BG2B	**91.0**	46.8	<5	<1	18.2	14.9	<1	**68.2**	–
BG2C	<1	22.6	5.8	30.6	13.4	<5	36.3	14.5	<5
BG2E	<1	22.0	**63.0**	<5	**51.4**	**72.8**	2.6	16.6	<1
HE4D	–	–	<1	<5	–	–	7.2	–	31.2
HE4E	–	<1	<5	34.3	7.0	<5	45.4	<1	7.6
WL4B	–	–	–	–	–	–	<1	–	14.5
Other BG	<5	5.7	5.3	<5	<1	<1	<5	<1	8.1
Other HE	<1	<1	<5	<5	9.3	<5	<5	–	11.9
Other WL	–	–	<1	5	–	–	–	–	<1
Total BG	**99.9**	**98.5**	**93.5**	**57.5**	**83.7**	**94.7**	43.7	**99.9**	13.3
Total FE	–	–	–	<1	–	–	<1	–	<5
Total GL	–	–	–	<1	–	–	<1	–	17.6
Total HE	<1	<5	6.2	39.4	16.3	5.2	**55.3**	<1	**50.7**
Total WL	–	–	<1	<5	–	–	<1	–	15.2
Total Other	–	–	<1	<1	–	<1	–	–	<5
TOTAL	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Table 8 Means and standard errors of the combined Ellenberg values for the relevés in each High *Sphagnum* (HS) habitat type.

	HS1	HS2	HS3
Moisture	7.6 ± 0.1	7.8 ± 0.1	7.7 ± 0.1
Reaction	2.2 ± 0.1	2.0 ± 0.1	2.6 ± 0.1
Nitrogen	1.4 ± 0.0	1.4 ± 0.0	1.8 ± 0.1

3.1.1 *Sphagnum subnitens–Erica tetralix* cutover bog (HS1)

This habitat type is usually characterised by a mixture of *Calluna vulgaris*, *Erica tetralix*, *Eriophorum angustifolium*, *E. vaginatum* and *Sphagnum* spp. Among the latter, *Sphagnum capillifolium* ssp. *rubellum* and *S. papillosum* are typically the most abundant, but are generally accompanied by *S. subnitens* and *S. tenellum*. Other typical raised bog species are usually present, including *Narthecium ossifragum*, *Cladonia portentosa* and *Odontoschisma sphagni*.

A total of 8.7 ha of this habitat type was mapped across eleven of the twelve project sites, mainly on older cutovers. Peat cutting had ceased on 74% of the relevés prior to the 1970s. Mean acrotelm depth in this habitat type is 3.4 cm.

Apart from *Sphagnum* cover, HS1 is distinguished from the similar habitat MS4 by greater frequency of *Drosera rotundifolia* and *Molinia caerulea*, lower frequency of *Trichophorum germanicum* and lower cover of *Cladonia portentosa*.

This habitat type is the most similar cutover bog habitat to the peat-forming Sub-central ecotope on the high bog (Fernandez *et al.*, 2014, Kelly & Schouten, 2002). A notable difference from peat-forming habitats on the high bog is the frequent presence of *Molinia*. The vegetation of these relevés had only a moderate affinity on average with the standard IVC raised bog community '*Erica tetralix–Andromeda polifolia* bog (BG2B)' (Table 7).

Figure 3 *Sphagnum subnitens–Erica tetralix* cutover bog (HS1) on Raheenmore Bog.

Figure 4 *Sphagnum subnitens–Erica tetralix* cutover bog (HS1) on Carrowbehy Bog.

Although it is not "pristine" bog, as it lacks well-developed hummock–hollow–pool systems, it is a high-quality habitat type of high conservation value, some examples of which can correspond to the Habitats Directive priority habitat Active raised bog (7110). Swenson *et al.* (2019) have found that similar cutover bog vegetation at Abbeyleix is a net carbon sink.

3.1.2 *Sphagnum cuspidatum–Eriophorum vaginatum* cutover bog (HS2)

This distinctly wet habitat type is characterised by an abundance of *Eriophorum vaginatum* and lawns of *Sphagnum papillosum*. The aquatic *Sphagnum cuspidatum* is almost always present, and is sometimes abundant. Otherwise, the habitat typically comprises *Calluna*, *Erica tetralix*, *Eriophorum angustifolium*, *Molinia*, *Sphagnum palustre* and *S. capillifolium* ssp *rubellum*.

A total of 9.5 ha of this habitat type was mapped across six of the study sites. It is characteristic of cutover bog that has undergone secondary rewetting relatively recently. Indeed 49.9% (4.7 ha) of the area of HS2 was associated with the extensive restoration works that were carried out on Killyconny Bog in the period 2005–2010. In contrast, only 15% of HS1 relevés and 25% of HS3 relevés were located in restored cutover. Peat cutting ceased in or after the 1970s in 64% of HS2 relevés, which is a greater proportion than in HS1 or HS3. Rewetting can be due to drain-blocking, other restoration works, localised subsidence, or as highlighted by Mackin *et al.* (2017b), the existence of enclosed depressions which receive significant run-off from the high bog. HS2 tends to be slightly wetter than HS1. Mean acrotelm depth is 6.9 cm.

Apart from *Sphagnum* cover, HS2 is distinguished from the similar habitat MS2 by generally higher cover of *Eriophorum vaginatum* and lower cover of *Molinia* and *Aulacomnium palustre*.

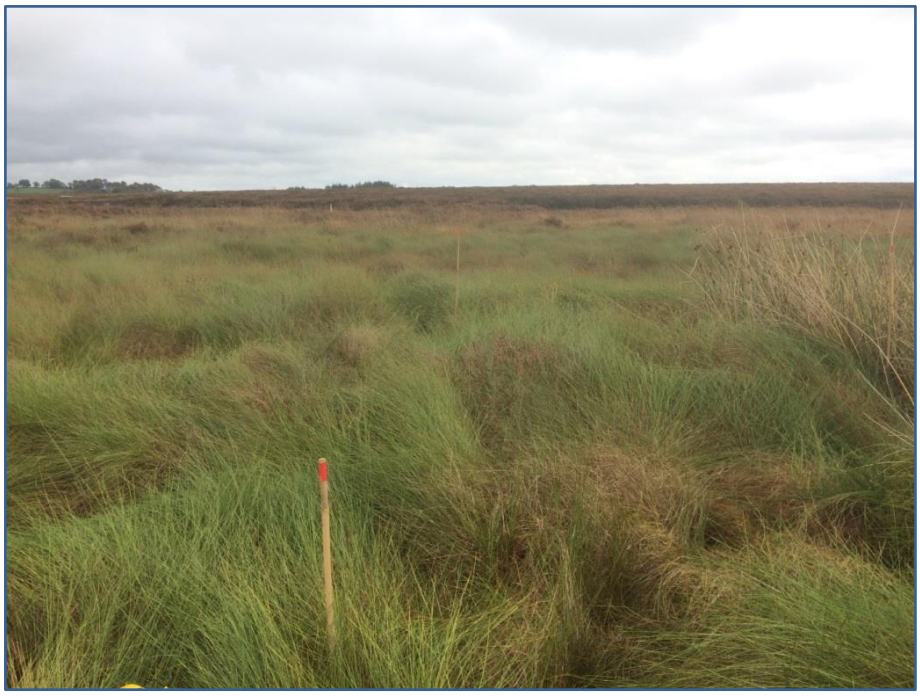

Figure 5 *Sphagnum cuspidatum–Eriophorum vaginatum* cutover bog (HS2) on restored cutover at Killyconny Bog.

This habitat type is similar to the Sub-central ecotope community complex 9/10 (Fernandez *et al.*, 2014). The importance of *Eriophorum vaginatum* in the vegetation means that the vegetation of HS2 relevés had a relatively strong mean affinity with '*Calluna vulgaris–Eriophorum* spp bog (BG2E)' community when analysed using ERICA, while mean affinity with the standard IVC raised bog community '*Erica tetralix–Andromeda polifolia* bog (BG2B)' was only 3.9% (Table 7).

Although it is not "pristine" bog, as it lacks well-developed hummock–hollow–pool systems, it is a high-quality habitat type that is likely to be a net carbon sink, or is at least developing along that trajectory. As such, it is of high conservation value, and a small number of examples may be analagous to the Habitats Directive priority habitat Active raised bog (7110).

Figure 6 *Sphagnum cuspidatum–Eriophorum vaginatum* cutover bog (HS2) on abandoned cutover at Ardagullion Bog.

3.1.3 *Sphagnum palustre–Molinia caerulea* cutover bog (HS3)

This type comprises flushed *Sphagnum*-rich habitats where *Molinia* is abundant or dominant. *Sphagnum palustre*, *S. capillifolium* ssp *rubellum* and *S. magellanicum* agg. are the most frequent and usually the most abundant *Sphagnum* species present. Other distinctive species are indicators of flushed conditions, such as *Potentilla erecta* and *Aulacomnium palustre*. *Betula* saplings and *Juncus effusus* are more frequent in this type than in HS1 and HS2. Otherwise, typical species present include *Calluna*, *Erica tetralix*, *Eriophorum vaginatum* and *E. angustifolium*.

A total of 6.2 ha of this habitat was mapped across seven of the 12 study sites with 74% of the habitat recorded from western sites (Table 6). The conditions in this habitat type are more base-rich and nutrient-rich than in HS1 and HS2 (Table 8). Mean acrotelm depth in this habitat type is 4.6 cm.

The main distinction between HS3 and the very similar habitat MS3 is *Sphagnum* cover. *S. palustre* is less frequent in MS3, where the principal *Sphagnum* is usually *S. capillifolium* ssp *rubellum*, but the latter species can also be the dominant in HS3.

This habitat type is similar to *Molinia*-dominated active flushes on the high bog. It does not match any IVC communities very well, as HS3 relevés have a 58% mean affinity with the IVC communities in the bog division (BG) and a 39% mean affinity with heath division communities (HE) (Table 7). It is a high-quality habitat type that may be a net carbon sink or developing along that trajectory. As a wet, *Sphagnum*-rich habitat, it is of high conservation value. Where birch regeneration is significant, this habitat may develop towards the Habitats Directive priority habitat *bog woodland (91D0).

Figure 7 *Sphagnum palustre–Molinia caerulea* cutover bog (HS3) on Raheenmore Bog.

Figure 8 *Sphagnum palustre–Molinia caerulea* cutover bog (HS3) on Carrownagappul Bog.

3.2 Moderate *Sphagnum* Group

The Moderate *Sphagnum* Group is defined by a cover of *Sphagnum* 11–40% and bare peat cover <10%. It accounted for 86.5 ha of all habitats surveyed, which equates to 11.2% of all habitat surveyed and 20.8% of habitat that would be classed as PB4 under Fossitt (2000). This is a diverse group with few constant species across all habitat types, with the exception of the ubiquitous *Calluna* and *Eriophorum angustifolium*.

The habitats in this group have generally had sufficient time to develop relatively stable vegetation, and conditions are wet enough for moderate levels of *Sphagnum* regeneration. Peat cutting ceased in 90% of the relevés in this group prior to 2005. Ground conditions are usually soft, but can range from firm to very soft or even quaking in a very few cases. MS group habitats are slightly less common on Co. Offaly sites, with only 17.6% of MS habitats recorded from Co. Offaly sites (Table 9).

Affinities of relevés in the MS habitat types to IVC communities were produced using ERICA (Perrin, 2020). Mean affinities of each habitat type are summarised in Table 7, and the means of the combined Ellenberg values (Hill *et al*., 2004; Hill *et al*., 2007) for the relevés in a habitat type in the MS group are presented in Table 10.

Table 9 Proportion (%) of Moderate *Sphagnum* (MS) habitat types in each geographical region as well as the overall proportion of cutover surveyed per geographical region.

	Western	Northern	Co. Offaly
MS1	15.3	58.0	26.7
MS2	55.9	30.8	13.3
MS3	59.0	26.0	15.1
MS4	6.9	71.0	22.1
MS5	72.4	16.6	11.0
Total MS	41.9	40.5	17.6
Total cutover surveyed	37.3	33.2	29.5

Table 10 Means and standard errors of the combined Ellenberg values for the relevés in each Moderate *Sphagnum* habitat type.

	MS1	MS2	MS3	MS4	MS5
Moisture	6.8 ± 0.1	7.5 ± 0.1	7.6 ± 0.1	7.5 ± 0.1	7.3 ± 0.1
Reaction	2.2 ± 0.1	2.1 ± 0.1	2.7 ± 0.1	2.3 ± 0.1	3.6 ± 0.1
Nitrogen	1.7 ± 0.0	1.4 ± 0.1	1.7 ± 0.0	1.3 ± 0.0	3.1 ± 0.2

3.2.1 *Calluna vulgaris–Sphagnum subnitens* cutover bog (MS1)

The '*Calluna vulgaris–Sphagnum subnitens* cutover bog (MS1)' habitat type is characterised by the dominance of *Calluna*. Other prominent components of the vegetation include *Molinia*, *Erica tetralix* and *Eriophorum* species. The most frequent *Sphagnum* species include *Sphagnum subnitens*, *S. capillifolium* ssp *rubellum* and *S. papillosum*. *S. palustre* may also be present. *Cladonia floerkeana* also appeared in 18% of relevés and was restricted to this habitat type within the group. This appears to be a rather variable habitat type in terms of species composition and conservation value.

This habitat type covered 18.5 ha across ten of the 12 study sites. It is perhaps found in drier sites than most of the habitats in this group (*cf.* Ellenberg moisture values), although the substrate of 67% of relevés was still considered soft rather than firm. It is less common in western sites where only 15% of the habitat was mapped.

Apart from higher *Sphagnum* cover, this habitat type can be distinguished from the *Calluna*-dominated LS1 habitat type by greater frequency and abundance of *Eriophorum vaginatum*, lower cover of *Hypnum jutlandicum*, and the absence of *Ulex europaeus* and *Pseudoscleropodium purum*.

This habitat type would be most similar to the lower quality Sub-marginal and better quality Marginal ecotopes on the high bog. MS1 relevés had the strongest affinity on average with the '*Calluna vulgaris–Eriophorum* spp bog (BG2E)' community (Table 7). Although the plots showed 83.7% mean affinity with bog vegetation in general, they also showed 16.3% mean affinity with heathland communities.

This is a habitat type of generally moderate but variable conservation interest. A total of 33% of relevés were subjectively assessed in the field as being partially peat-forming, as judged by cover of typical peat-forming *Sphagnum* species and presence of at least a patchy acrotelm.

Figure 9 *Calluna vulgaris–Sphagnum subnitens* cutover bog (MS1) on Clara Bog.

3.2.2 *Eriophorum vaginatum–Sphagnum papillosum* cutover bog (MS2)

The '*Eriophorum vaginatum–Sphagnum papillosum* cutover bog (MS2)' habitat type is characterised by the abundance of *Eriophorum vaginatum*, which is typically greater than 33%. *Sphagnum papillosum* and *S. cuspidatum* are more frequent and abundant in this habitat type than others in the group. Otherwise, the main constituents of the vegetation are similar, including *Calluna*, *Erica tetralix*, *Molinia*, *Eriophorum angustifolium* and *Sphagnum capillifolium* ssp *rubellum*.

A total of 11.0 ha of this habitat was mapped across seven of the 12 study sites; it was absent from four of the six Co. Offaly sites (Table 9). Eight of the 14 relevés defining this habitat type and 19.6% (2.2 ha) of the area mapped were on Killyconny Bog in an area where there were extensive restoration works in the late 2000's, while 55.9% (6.2 ha) of MS2 habitat was mapped on western sites. Thus, this habitat type appears to be typical of western sites and areas that have undergone rewetting either naturally or as a result of drain blocking or other restoration works. The habitat type was mainly found on cutover bog that had been abandoned between the 1970s and 2005. The vegetation reflects less fertile conditions than in other habitat types in this group, apart from MS4.

This habitat type is quite similar to HS2 but with less than 40% *Sphagnum* cover. MS2 also has generally lower cover of *Eriophorum vaginatum* and higher cover of *Molinia* and *Aulacomnium palustre*.

This habitat would be similar to the Sub-marginal ecotope community complex 9/7, but with *Molinia* quite frequent and *Narthecium ossifragum* quite rare. The importance of *Eriophorum vaginatum* in the vegetation means that the vegetation displayed a 73% mean affinity with the '*Calluna vulgaris–Eriophorum* spp bog (BG2E)' community (Table 7).

This habitat type is of generally moderate conservation importance, but in some cases appears to be developing towards *Active raised bog (7110). In this case, typical conservation value would be higher. This is supported by the observation that 63% of relevés were subjectively assessed in the field as being at least partially peat-forming.

Figure 10 *Eriophorum vaginatum–Sphagnum papillosum* cutover bog (MS2) on Ardagullion Bog.

3.2.3 *Molinia caerulea–Polygala serpyllifolia* cutover bog (MS3)

The '*Molinia caerulea–Polygala serpyllifolia* cutover bog (MS3)' habitat type is characterised by an abundance of *Molinia*, which usually covers 33% or more of the habitat. Other common raised bog species are usually present but subordinate to *Molinia*, including *Calluna*, *Erica tetralix*, *Eriophorum vaginatum*, *Sphagnum capillifolium* ssp *rubellum* and *S. papillosum*. The only other significant indicator species is *Polygala serpyllifolia*, which was only present in 40% of relevés, but is quite rare in other habitat types in this group. Other species that are characteristic of this habitat type and are usually present include *Potentilla erecta*, *Eriophorum angustifolium*, *Aulacomnium palustre* and *Sphagnum subnitens*.

A total of 22.9 ha of this habitat was mapped across ten of the 12 study sites. This habitat type is typical of moist, somewhat flushed cutovers with slightly more base enrichment and fertility than most other types in the group, except for MS5 (Table 10). It can be found on cutovers of any age, except perhaps the very youngest. There was a western bias among the relevés and habitat area, with 60% and 59%, respectively, recorded west of the Shannon.

The main distinction between MS3 and the very similar habitat HS3 is *Sphagnum* cover. *S. palustre* is less frequent in MS3, where the principal *Sphagnum* is usually *S. capillifolium* ssp *rubellum*, but the latter species can also be the dominant in HS3. LS3 is also similar, but has lower *Sphagnum* cover and is usually more strongly dominated (>60%) by *Molinia*. *Eriophorum* species and *Erica tetralix* are more frequent and usually more abundant in MS3.

This habitat type is similar to *Molinia*-dominated inactive flushes on the high bog. Better quality examples with higher cover of peat-forming *Sphagnum* may be similar to high bog active flushes. MS3 relevés had 45% mean affinity with the '*Molinia caerulea–Calluna vulgaris–Erica tetralix* heath (HE4E)' community, and 36% mean affinity with the '*Erica tetralix–Molinia caerulea–Cladonia portentosa* bog/heath

(BG2C)' community (Table 7). It had greater overall affinity with heath vegetation (55%) than bog vegetation (44%).

This habitat type is generally of moderate conservation interest. However, where *Succisa pratensis* is present in significant abundance, it may be an important habitat for Marsh Fritillary *Euphydryas aurinia*, the only Irish insect listed on Annex II of the Habitats Directive. In these cases, the habitat would be considered of high conservation interest. MS3 tends to have greater species richness than the other habitat types in the group. Overall, 33% of MS3 relevés were subjectively assessed in the field as already being at least partially peat-forming.

Figure 11 *Molinia caerulea–Polygala serpyllifolia* cutover bog (MS3) on Killyconny Bog.

3.2.4 *Cladonia portentosa–Trichophorum germanicum* cutover bog (MS4)

The '*Cladonia portentosa–Trichophorum germanicum* cutover bog (MS4)' habitat type is distinctive in the abundance of *Cladonia portentosa*, which usually comprises more than 25% of the habitat. This indicates that the vegetation has not been burned for a significant length of time (Cross, 1990). Otherwise, the vegetation typically consists of common raised bog species, including *Calluna*, *Erica tetralix*, *Eriophorum angustifolium*, *E. vaginatum* and *Carex panicea*. The abundance of the latter, particularly in western sites, is a feature of this habitat relative to others in the group. *Narthecium ossifragum* and *Rhynchospora alba* are more frequent in this habitat than in others. The main and often only species of *Sphagnum* here is *S. capillifolium* ssp *rubellum*, which is almost always accompanied by *Odontoschisma sphagni*.

This habitat type covered 23.9 ha across eight of the 12 study sites, being particularly uncommon in the western sites where only 6.9% of the habitat was recorded (Table 9). This habitat type is characteristic of older, well-established cutover bog; peat cutting ceased in 81% of relevés before the 1970s. The vegetation reflects less fertile conditions than in other habitat types in this group, apart from MS2.

Cover of *Cladonia* can be high in habitat types LS1 and LS2, which are mainly distinguished by lower *Sphagnum* cover. MS4 is also different than LS2 in its generally lower cover of *Eriophorum angustifolium*, greater frequency and abundance of *E. vaginatum*, absence of *Juncus effusus* and lower frequency of *Molinia*. MS4 differs from LS1 in its lower abundance of *Callluna*, greater frequency and abundance of *E. vaginatum*, and lower frequency of *Molinia*. *Cladonia* cover can be high in some examples of HS1, which is distinguished from MS4 mainly by high cover and diversity of *Sphagnum* species.

This habitat type would be analogous to Sub-marginal ecotope on the high bog (Kelly & Schouten, 2002; Fernandez *et al.*, 2014). MS4 relevés had 68% mean affinity with the standard IVC raised bog community '*Erica tetralix–Andromeda polifolia* bog (BG2B)' (Table 7). This is likely to reflect the ombrotrophic nature of the habitat, absence of disturbance and the length of time available for colonisation by typical raised bog species, such as *Narthecium* and *Rhynchospora alba*. The scarcity of *Molinia* in this habitat type also distinguishes the habitat type from many other cutover bog habitats and increases similarities with high bog.

This habitat type is of moderate conservation interest. No MS4 relevés were subjectively assessed in the field as being peat-forming, but 64% were considered as having good restoration potential.

Figure 12 *Cladonia portentosa–Trichophorum germanicum* cutover bog (MS4) on Carrowbehy Bog.

3.2.5 *Juncus effusus–Sphagnum palustre* cutover bog–flush (MS5)

The '*Juncus effusus–Sphagnum palustre* cutover bog–flush (MS5)' habitat type is a distinctive habitat with abundant or dominant *Juncus effusus* and usually abundant *Sphagnum palustre* on flushed cutover bog. The other main habitat component is *Molinia*, and *Calluna* and *Eriophorum angustifolium* are usually present. *Kindbergia praelonga* typically takes advantage of the shade cast by the tall rushes. The grasses *Anthoxanthum odoratum* and *Agrostis canina* are often present as are a number of other flush species outlined in the synoptic table.

This habitat type is significantly less oligotrophic than the others in the group (Table 10). It covered 9.8 ha across seven of the 12 study sites, being particularly common in the western sites where 72.4% of the habitat was recorded (Table 9).

This habitat type could possibly be confused with examples of HS3 with abundant *Juncus effusus*, but grasses other than *Molinia* are rare or absent in HS3, and *Aulacomnium palustre* is normally less abundant in MS5. Examples of LS2 and LS3 with frequent to abundant *Juncus effusus* lack *Sphagnum palustre*.

This habitat type has no similar communities on the high bog. Affinities to IVC communities were weak, with the highest being '*Molinia caerulea–Potentilla erecta–Erica tetralix* heath (HE4D)' at 31% mean affinity (Table 7). This is to be expected, as *Juncus–Sphagnum* flushes have not yet been included in the IVC.

This is a habitat type of moderate conservation importance. Where birch regeneration is significant, this habitat may develop towards *bog woodland (91D0). In this case, typical conservation value would be higher.

Figure 13 *Juncus effusus–Sphagnum palustre* cutover bog–flush (MS5) on Ardagullion Bog.

3.3 Low *Sphagnum* Group

The Low *Sphagnum* Group is defined by 10% or less cover of *Sphagnum* and cover of bare peat less than 10%. It accounted for 271.9 ha, which equates to 35.3% of all habitat surveyed and 65.6% of habitat that would be classed as PB4 by Fossitt (2000). The habitat types in this group are highly divergent, and the low cover of *Sphagnum* is the result of different historical and environmental factors. This group includes two types that can no longer be considered bog habitats. There are no constant species across all habitat types. Perhaps the only vegetation characteristic in common is that birch regeneration can be frequent.

Environmental conditions in this group are quite variable. Ground conditions in most habitat types in the group are firm, but LS5 is a notable exception. The LS Group in general was equally distributed across the three geographic regions (Table 11).

Affinities of relevés in the LS habitat types to IVC communities were produced using ERICA (Perrin, 2020). Mean affinities of each habitat type are summarised in Table 12, and the means of the combined Ellenberg values (Hill *et al*., 2004; Hill *et al*., 2007) for the relevés in a habitat type in the LS group is presented in Table 13.

Table 11 Proportion (%) of Low *Sphagnum* (LS) habitat types in each geographical region as well as the overall proportion of cutover surveyed per geographical region.

	Western	Northern	Co. Offaly
LS1	28.5	38.1	33.4
LS2	20.2	5.2	74.5
LS3	51.6	28.4	20.1
LS4	42.7	5.4	51.9
LS5	0.9	0.0	99.1
Total LS	37.3	31.6	31.0
Total cutover surveyed	37.3	33.2	29.5

Table 12 Mean percentage affinities of cutover bog in Low *Sphagnum* (LS) and bare peat (BP) group habitat types with Irish Vegetation Classification (IVC) communities. Affinities over 50% are indicated in bold. An IVC type with an affinity of 1–5% is given as <5, of 0.1–1% as <1 and of <0.1% as –. Affinities of Active Raised Bog (ARB) recorded on high bog from 15 relevés taken on the project sites are given for comparison.

Code	ARB	LS1	LS2	LS3	LS4	LS5	BP1	BP2
N	15	21	9	33	4	4	10	13
BG1D	–	<1	7.5	–	–	–	**54.5**	<5
BG2B	**91.0**	5.6	27.3	–	–	<1	7.3	33.3
BG2C	<1	5.5	12.5	<5	–	<5	<5	6.7
BG2E	<1	11.0	10.5	<1	–	<1	21.9	15.6
FE1A	–	–	<1	–	–	**53.8**	–	–
FE1B	–	–	<1	<1	<1	28.4	–	–
FE2F	–	–	<1	–	23.7	<1	–	–
GL1B	–	–	<1	–	13.8	–	–	–
GL1D	–	–	<1	<5	10.8	<5	–	–
HE2B	–	**53.6**	<5	<1	–	–	<1	11.4
HE2D	–	17.8	<5	<5	–	<1	<1	16.0
HE4D	–	–	<5	33.7	<1	<1	–	<1
HE4E	–	<5	12.4	**53.5**	–	<5	<5	7.3
Other BG	7.8	<1	6.4	<1	–	<5	9.8	<5
Other FE	–	–	6.3	<1	5.5	<5	–	–
Other GL	–	–	<1	<1	37.6	<1	–	–
Other HE	<1	<5	5.2	<5	<1	7.3	<5	6.0
Total BG	**99.9**	22.6	**64.2**	<5	–	<5	**96.3**	**59.1**
Total FE	-	-	6.6	<1	29.4	84.0	<1	-
Total GL	-	-	<5	<5	**62.1**	<5	-	-
Total HE	<1	**77.3**	24.1	**90.9**	<1	9.9	<5	40.8
Total WL	-	-	<1	<5	<5	<1	<1	-
Other	-	-	<5	<1	6.5	<1	<1	-
TOTAL	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Table 13 Means and standard errors of the combined Ellenberg values for the relevés in each Low *Sphagnum* (LS) habitat type.

	LS1	LS2	LS3	LS4	LS5
Moisture	6.2 ± 0.1	7.7 ± 0.2	7.3 ± 0.1	7.1 ± 0.5	7.9 ± 0.2
Reaction	2.4 ± 0.1	3.2 ± 0.2	3.1 ± 0.1	5.7 ± 0.2	5.0 ± 0.2
Nitrogen	2.0 ± 0.1	1.8 ± 0.1	2.2 ± 0.1	4.1 ± 0.3	2.2 ± 0.2

3.3.1 *Calluna vulgaris* cutover bog (LS1)

The '*Calluna vulgaris* cutover bog (LS1)' habitat type is dominated by bushy *Calluna* with abundant *Hypnum jutlandicum*. Other common, but less abundant, components of the vegetation include *Molinia*, *Eriophorum angustifolium* and *Erica tetralix*. *Cladonia portentosa* and *Pseudoscleropodium purum* are frequent and can be abundant.

This was the most common habitat type in the study with 133.3 ha mapped across all 12 of the study sites. It accounted for 32.2% of all habitat that would otherwise be classed as PB4 using Fossitt (2000) habitat types. This is the driest of all cutover bog habitat types (Table 13). Ground conditions are always firm. This type can be found on cutover bogs of all ages, except the very youngest.

This habitat type is most similar to *Calluna vulgaris–Sphagnum subnitens* cutover bog MS1. The latter supports higher *Sphagnum* cover, greater frequency and abundance of *Eriophorum vaginatum*, lower cover of *Hypnum jutlandicum*, and *Ulex europaeus* and *Pseudoscleropodium purum* are absent. Examples of LS1 habitats can support high cover of *Cladonia portentosa*, similar to MS4, but that habitat type has more *Sphagnum*, lower abundance of *Calluna*, greater frequency and abundance of *E. vaginatum*, and lower frequency of *Molinia*.

Figure 14 *Calluna vulgaris* cutover bog (LS1) on Moyclare Bog.

This habitat type is similar to Facebank ecotope on the high bog. Relevés had greater mean affinity with heath division IVC communities (77%), particularly '*Calluna vulgaris–Hypnum jutlandicum* heath (HE2B)', than bog vegetation (23%) (Table 12). Swenson *et al*. (2019) have found that similar cutover bog vegetation at Abbeyleix is a substantial net carbon source, emitting significantly higher levels of carbon than the other four vegetation types studied there. This is a degraded habitat type of low conservation importance. As it is frequently situated high above the water table, most examples are likely to be more difficult to restore to peat forming conditions than many other habitat types.

3.3.2 *Eriophorum angustifolium* cutover bog (LS2)

The '*Eriophorum angustifolium* cutover bog (LS2)' habitat type supports abundant *Eriophorum angustifolium* and occasional *Trichophorum germanicum*. Otherwise, vegetation composition is mixed, with no clear dominant species. *Calluna*, *Molinia* and *Hypnum jutlandicum* are usually present in moderate amounts, and *Erica tetralix* tends to be more abundant in this type than in other types in the LS group. *Cladonia portentosa* and *Juncus effusus* frequently are found, and can be abundant. *Sphagnum subnitens* and *S. papillosum* are often found in small quantities. Also included in this type are some flushed examples supporting such species as *Juncus effusus*, *Carex rostrata*, *C. echinata* and *Aulacomnium palustre*.

A total of 5.0 ha of this habitat was mapped across five of the study sites, with a bias towards the Co. Offaly sites where 74.5% of the habitat was recorded. This habitat type is notably wetter in character than LS1 and LS3, the other oligotrophic cutover bog types in the group. Despite this, ground conditions are usually firm. Examples of this habitat type were relatively more frequent on sites where peat cutting had ceased after 2005, but were also found on very old (pre 1970s) cutovers.

Apart from bare peat cover, this habitat type is distinguished from the similar habitat BP2 by the greater relative abundance of species other than *E. angustifolium* and the greater diversity of species. Examples of LS2 with high covers of *Cladonia portentosa* can be similar to the more *Sphagnum*-rich type MS4. The latter habitat differs in its generally lower cover of *Eriophorum angustifolium*, greater frequency and abundance of *E. vaginatum*, absence of *Juncus effusus* and lower frequency of *Molinia*.

Some examples of this habitat type are similar to Marginal ecotope on the high bog. Mean affinities with individual IVC communities were low. Although there was a 64% affinity with the IVC bog division in general, this was spread across a number of different IVC bog communities (Table 12). Swenson *et al*. (2019) have found that similar cutover bog vegetation at Abbeyleix is a net carbon source.

This is a habitat type of generally low conservation importance, although more species-rich examples may be of greater value. One relevé in this habitat type was recorded from a quaking bog along the margins of a dystrophic pond and is referable to the Annex I habitat type transition mires and quaking bogs (7140). Where this is the case, typical conservation value would be high.

Figure 15 *Eriophorum angustifolium* cutover bog (LS2) on Clara Bog.

3.3.3 *Molinia caerulea* cutover bog (LS3)

The '*Molinia caerulea* cutover bog (LS3)' habitat type is dominated by *Molinia*, and small amounts of *Potentilla erecta* can almost always be found. Other frequent species with low to moderate cover include

Calluna, *Erica tetralix* and *Hypnum jutlandicum*. A diverse range of other species can be minor components of the vegetation. Birch regeneration can be frequent and cover of saplings and small trees can sometimes approach 50%.

This was the second most common habitat type, with 98.9 ha of this habitat mapped across all 12 of the study sites. It accounted for 23.9% of all habitat that would otherwise be classed as PB4 using Fossitt (2000) habitat types. There was a slight western bias with 51.6% of the habitat mapped from western sites. This habitat type can be found in cutover bog of any age. Ground conditions are almost always firm.

'*Molinia caerulea* cutover bog (LS3)' can only be confused with the similar MS3, which is readily distinguished by higher *Sphagnum* cover. LS3 is usually more strongly dominated (>60%) by *Molinia*. *Eriophorum* species and *Erica tetralix* are more frequent and usually more abundant in MS3.

This habitat type is analogous to *Molinia* dominated Inactive Flush on the high bog. It has much greater mean affinity with communities in the IVC heath division (90.9%) than with bog vegetation (2.4%) (Table 12). The habitat type had 54% mean affinity with the '*Molinia caerulea–Calluna vulgaris–Erica tetralix* heath (HE4E)' community, and 34% mean affinity with '*Molinia caerulea–Potentilla erecta–Erica tetralix* heath (HE4D)'.

This is a habitat type of low conservation importance and low species richness (mean = 16.3). However, this needs to be caveated with the acknowledgment that where *Succisa pratensis* is frequent, the habitat can be important for the Annex II species Marsh Fritillary. In these cases, it would be of high conservation importance.

Figure 16 *Molinia caerulea* cutover bog (LS3) on Clara Bog.

3.3.4 *Filipendula ulmaria* cutover bog (LS4)

The '*Filipendula ulmaria* cutover bog (LS4)' habitat type is characterised by wet grassland, marsh or, rarely, transition mire vegetation with *Filipendula ulmaria* and *Vicia cracca* as constant species, and *Mentha aquatica*, *Anthoxanthum odoratum*, *Holcus lanatus* and *Calliergonella cuspidata* present in 3 of the 4 relevés in this group. *Molinia* was moderately abundant in two of the relevés, but other typical cutover bog species, such as *Calluna*, *Erica tetralix* and *Eriophorum* species, were absent.

A total of 9.4 ha of this habitat was mapped across nine of the 12 study sites. It was absent from two of the three northern sites, with the third northern site accounting for only 5% of the overall area of the habitat. This is the most base-rich and most fertile of the cutover bog habitat types (Table 13). All relevés were on cutover bog last cut (if ever) before the 1970s. This type occurred on the former lagg zones of

the raised bog, and attempts may have been made in some of the areas where the relevés were recorded to reclaim these areas for agriculture. This habitat type cannot be mistaken for any other cutover bog types.

Relevés from this habitat type have close to zero mean affinity with IVC bog division vegetation. Mean affinities with individual IVC communities were low, with the vegetation showing greatest affinity with the grassland (62%) and fen (29%) vegetation divisions (Table 12).

This is a relatively species-rich cutover bog type (mean 21.3). All 4 relevés were considered to have poor potential for raised bog restoration, although lagg zone restoration may be a possibility. On balance, it is of moderate conservation interest. However, areas where there is a high frequency of *Succisa pratensis* can be an important habitat for the Annex II species Marsh Fritillary. In these cases, it would be of high conservation importance. Similarly, the rare examples where vegetation is or approaches transition mire (7140) would be of high conservation value.

Figure 17 *Filipendula ulmaria* cutover bog (LS4) on Mongan Bog.

3.3.5 *Schoenus nigricans* cutover bog–fen (LS5)

The '*Schoenus nigricans* cutover bog–fen (LS5)' habitat type is characterised by species typical of alkaline fen vegetation with *Schoenus nigricans*, *Campylium stellatum*, *Molinia caerulea*, *Succisa pratensis* and *Erica tetralix* always present. *Calliergonella cuspidata*, *Carex lepidocarpa*, and the raised bog species *Calluna* and *Hypnum jutlandicum* were present in 3 of the 4 relevés in this habitat.

A total of 4.1 ha of this habitat was mapped from three of the study sites (Sharavogue, Mongan and Carrowbehy). This habitat type is found on older cutovers on fen peat in the raised bog lagg zone. Peat cutting ceased in 3 of the 4 relevés in this habitat type prior to the 1970s. The mean Ellenberg value for reaction (Table 13) reflects irrigation by calcium-rich groundwater. Ground conditions are very wet to quaking.

This habitat cannot be confused with any other raised bog habitat type. Habitats with higher than 10% *Sphagnum* cover, particularly *Sphagnum subnitens* or the more calcicolous species, such as *S. contortum* or *S. teres*, should be included in this type.

Two of the 4 relevés in this group were assigned by ERICA to different communities in the FE1 *Schoenus nigricans–Campylium stellatum* fen group, and one was assigned to the '*Molinia caerulea–Schoenus*

nigricans bog/heath (HE4C)' community. The fourth was a transitional habitat with affinities to the FE3 *Agrostis stolonifera–Carex nigra* fen group. Overall, there is only 4.7% mean affinity with the IVC bog division, while there is 84% affinity with fen vegetation (Table 12).

Where well developed, this habitat type may be analagous to the Annex I habitat type alkaline fen (7230). These examples would be of high conservation value, although less developed areas may only be of moderate interest.

Figure 18 *Schoenus nigricans* cutover bog (LS5) on Sharavogue Bog.

3.4 Bare Peat Group

The Bare Peat Group is defined by a cover of *Sphagnum* of less than 40% and a cover of bare peat of 10% or greater. Species composition is usually heterogeneous and patchy, representing different stages in vegetation succession following peat extraction. Species that can colonise raw peat are constants in this habitat group. These include *Calluna*, *Erica tetralix* and *Eriophorum angustifolium*. Birch saplings are often present, and patches of *Campylopus introflexus* are usually colonising the bare peat. Species richness in the relevés of this group tends to be lower than in most other cutover bog habitat types.

The habitats in this group are characteristic of recently abandoned cutover bog that has not yet been restored. Peat cutting ceased only after 2005 in 78% of the relevés in this group. These habitats are most common near the high bog facebank. Ground conditions are usually firm.

In the synoptic table in Appendix 5, there are no values given for 'Bare peat-dominated cutover bog (BP3)', as there were no relevés in The Living Bog project with bare peat cover over 50% or greater. As some cutover bog, especially industrial cutaway or recent cutover, can support such high covers of bare peat and assigning these habitats to the other two types would be difficult, BP3 has been defined using only habitat (bare peat) characteristics.

Affinities of relevés in the BP habitat types to IVC communities were produced using ERICA (Perrin, 2020). Mean affinities of each habitat type are summarised in Table 12, and the means of the combined Ellenberg values (Hill *et al.*, 2004; Hill *et al.*, 2007) for the relevés in a habitat type in the BP group is presented in Table 14.

Table 14 Means and standard errors of the combined Ellenberg values for the relevés in each Bare Peat (BP) habitat type.

	BP1	BP2	BP3
Moisture	6.7 ± 0.2	8.1 ± 0.1	N/A
Reaction	2.5 ± 0.3	3.3 ± 0.1	N/A
Nitrogen	1.9 ± 0.2	1.4 ± 0.1	N/A

3.4.1 *Calluna vulgaris*–bare peat cutover bog (BP1)

The '*Calluna vulgaris*–bare peat cutover bog (BP1)' habitat type is characterised by moderate abundances of several raised bog species, none of which dominate the vegetation, with the occasional exception of *Calluna*. In addition to *Calluna*, these include *Erica tetralix*, *Eriophorum angustifolium* and *Hypnum jutlandicum*. They are often accompanied by *Molinia*, *E. vaginatum* and/or *Sphagnum capillifolium* ssp *rubellum*. A smattering of *Cladonia portentosa* is usually also present.

This habitat type is characteristic of young cutovers: peat extraction ceased on 77% of relevés after 2005. Environmental proxy data suggest that it is significantly drier and somewhat more fertile than the BP2 habitat type.

A total of 12.9 ha of this habitat type was mapped, including 0.9 ha of a variant of the habitat type with abundant *Narthecium ossifragum* and/or *Rhynchospora alba*. In these areas, conditions appeared slightly wetter with the ground softer underfoot.

Figure 19 *Calluna vulgaris*–bare peat (BP1) on Clara Bog.

The variable and early successional BP1 habitat type can be similar to a number of different habitat types in the LS and MS groups, depending on *Sphagnum* cover and species composition. Bare peat cover is the only reliable means of distinguishing them. Given time and depending on environmental conditions, most BP1 habitats would be expected to develop into one of the habitat types LS1–3 or MS1–4.

The variability of this habitat type is reflected by the fact that mean affinities with individual IVC communities are low and divided between bog (59%) and heath (41%) divisions. It has greatest affinity (33.3%) with the typical IVC raised bog community '*Erica tetralix*–*Andromeda polifolia* bog (BG2B)'. This cutover bog habitat type is a degraded and early successional habitat type of low conservation value.

3.4.2 *Eriophorum angustifolium*–bare peat cutover bog (BP2)

The '*Eriophorum angustifolium*–bare peat cutover bog (BP2)' habitat type is characterised by an abundance of *Eriophorum angustifolium*, which usually covers over 50% of the habitat. Other species typically present include *Calluna*, *Erica tetralix* and *Campylopus introflexus*, with *Betula* saplings also frequent. However, the relative abundance of these other species is always lower than *E. angustifolium*.

This habitat type is characteristic of young cutovers: peat extraction ceased on 80% of relevés after 2005. Environmental proxy data (Table 14) suggest that it is significantly wetter than the BP1 habitat type, most likely due in large part to the dominance of *E. angustifolium*. Many examples of this habitat may be flooded in winter and dry out in summer. A total of 16.0 ha of this habitat was mapped across seven of the study sites.

Apart from bare peat cover, the similar habitat LS2 is distinguished from BP2 by the greater relative abundance of species other than *E. angustifolium* and the greater diversity of species. Over time and given appropriate conditions, most BP2 habitats are likely to develop into the LS2 type.

In comparison with BP1, this habitat type was much more clearly dominated by bog vegetation with 96% mean affinity to the IVC bog division (Table 12). Greatest mean affinity (54.5%) was with '*Eriophorum angustifolium*–*Campylopus introflexus* bog (BG1D)'. It is a degraded and early successional habitat type of low conservation value; however, it may have good restoration potential, especially if there is a seasonally high water table.

Figure 20 *Eriophorum angustifolium*–bare peat (BP2) on Carrownagappul Bog.

3.4.3 Bare peat cutover bog (BP3)

As discussed above, no relevés from The Living Bog project were assigned to this habitat type. The BP3 type was created to cater for the extreme cases of cutover bog where vegetation cover is very poor and bare peat occupies more than 50% of the habitat. In these cases, assigning a habitat to BP1 or BP2 would be difficult. It is a degraded and early successional habitat type of low conservation value.

3.5 Using the classification

The cutover bog habitat classification should be used when carrying out habitat mapping of cutover and cutaway raised bog. To aid in assigning habitat types to particular areas of cutover bog, a dichotomous key to the classification is presented in Appendix 1. A habitat classification is only a descriptive tool, however, and there will be habitats that will not neatly fit into any of the classified habitat types (Smith *et al*., 2011). In the case of cutover bogs, especially those more recently abandoned, where the habitats have been highly disturbed and the vegetation is undergoing significant change on the path to a new more or less steady state, areas that are difficult to classify are likely to be especially frequent. In addition, where restoration works have taken place, environmental changes can result in a complete change in successional trajectory. Difficult–to–classify areas can include variant habitat types, transitional habitats, mosaics and anomalous habitats.

The cutover bog habitat classification should be viewed as an addition to other habitat and vegetation classification schemes, rather than a substitute for them. Advice on applying the two main habitat classification systems used in Ireland, Fossitt (2000) and Habitats Directive Annex I habitats (European Commission, 2013), is provided below.

3.5.1 Variant habitats

Where the habitat is different than one of the described habitat types in a small number of habitat or vegetation characteristics, it could be considered a variant type. For example, a *Schoenus* dominated cutover may support >10% *Sphagnum* cover, particularly *S. subnitens* or basophilic *Sphagnum* species, such as *S. contortum*. One such relevé with a 15% combined cover of *S. subnitens* and *S. capillifolium* ssp *rubellum* in the MS group was treated as noise in the noise clustering. Such a habitat should be included in the *Schoenus nigricans* cutover bog (LS5) habitat type, despite having a higher than "normal" *Sphagnum* cover.

In some cases, a habitat may have one or two abundant species that are not typical of a classified habitat type, but may be otherwise similar to the type. For example, a poor flush habitat on cutover bog may have abundant *Juncus acutiflorus* rather than *J. effusus*, but could be similar to the *Juncus effusus*–*Sphagnum palustre* cutover bog (MS5) habitat type in most other respects. Such habitats should be assigned to the appropriate type, but it may be useful to record the fact that is a variant type in the project's habitat database.

In this study, a recurring variant habitat was noted that supported abundant to dominant *Juncus effusus* as well as abundant *Molinia caerulea*. Scattered *Betula pubescens* was frequent while *Potentilla erecta* was the most frequent herb. Moss cover was low and *Sphagnum* cover was close to zero. The habitat was recorded across five of the project sites, including all three of the western sites and covered a total of 6.3 ha. Only one relevé (R00124209) on Carrownagappul Bog was recorded in this habitat, however, and it was treated as transitional in the noise clustering analysis. Given its similarities to *Juncus effusus*–*Sphagnum palustre* cutover bog (MS5), it should be mapped as a variant of that type, despite the lower *Sphagnum* cover. Future studies may better define this as a new LS habitat type.

As another example, *Narthecium ossifragum* and *Rhynchospora alba* were rather uncommon on the cutover bogs in this study, apart from HS group habitat types and *Cladonia portentosa*–*Trichophorum germanicum* cutover bog (MS4). Outside of these types, *Narthecium* and *Rhynchospora* were notably abundant in some areas associated with erosion channels or seepage zones. They were typically associated with relatively low cover of stunted *Calluna* and soft ground conditions. Depending on covers of bare peat and *Sphagnum*, 0.9 ha of this *Narthecium*/*Rhynchospora* habitat would fall under the BP group, 0.6 ha under the MS group, and 1.5 ha under the LS group. Examples of this habitat are best classed as being variants of BP1, MS4 and LS1, respectively.

3.5.2 Transitional habitats

Habitats that are transitional between two (or more) types are likely to be common and should be recognised as such. This can be done by separating the habitat types with a dash, e.g. "*Calluna vulgaris–Sphagnum subnitens–Molinia caerulea–Polygala serpyllifolia* cutover bog (MS1–MS3)". Alternatively, the second habitat type in a transitional type could be recorded in the project's habitat database in a secondary habitat type column. See Smith *et al*. (2011) for additional advice.

3.5.3 Mosaics

Intimate mosaics of habitat types should be treated similarly to transitional habitats, but should be separated by a slash "/" in print or a backslash " \ " in a project GIS or other database (Smith *et al*., 2011) (*cf.* Appendix 6).

3.5.4 Anomalous habitats

It was not possible to fit all cutover bog habitats surveyed as part of The Living Bog Project into a simple habitat classification scheme. This was mainly because there were few or no relevés recorded in a habitat, especially if it was rare. Where unusual habitats were represented by only one or two relevés, they were usually placed by the noise clustering analysis in the noise class or treated as transitional types. Other surveys are likely to find other rare or unusual cutover bog habitats that will not fit at all into the cutover classification scheme. Anomalous habitats should be assigned to a habitat or vegetation type under another classification scheme. The IVC should be used where possible. If not, then Fossitt (2000) should be used. Correspondence to any Habitats Directive types (European Commission, 2013) should always be noted.

In this study, a habitat that was not sampled was areas of open water with emergent *Eriophorum angustifolium*. This covered 1.5 ha and only occurred in two sites: Killyconny Bog, where it was more abundant and restricted to flooded areas along blocked drains, and Carrowbehy Bog, where there was only a small amount present. This was a very species poor habitat type that could possibly be included in the cutover bog habitat types BP2 or LS2. To ensure that the presence of open water was not overlooked, however, it was decided to not assign a (terrestrial) cutover habitat type and instead to use the Fossitt (2000) type dystrophic lakes (FL1). In this study, such open water pools were found on relatively deep residual peat. In situations where calcareous groundwater upwelling or inputs of eutrophic surface water occur, other lake habitat types may be appropriate.

A total of 2.6 ha of transition mire and quaking bog (PF3) was mapped in the study sites, with an additional 0.5 ha in mosaic with *Calluna vulgaris* cutover bog (LS1) at Carrownagappul Bog (Appendix 6). Three relevés were recorded in this habitat, and another was recorded in a habitat transitional between marsh and transition mire. Three were recorded in the LS group (LS2, LS4 and one transitional) and one in the MS group (transitional). In addition, there were significant vegetation differences among them, and so a transition mire cutover bog habitat type with meaningful vegetation frequency and cover parameters could not be defined.

Acidic flush habitat types were identified by the noise cluster analysis for vegetation dominated by *Molinia* (HS3, MS3, LS3) or *Juncus* (MS5). A total of 2.5 ha of flush habitats with abundant *Carex rostrata* was recorded, however, that was not well catered for in the classification. These areas were mapped as poor fen and flush (PF2), and two relevés considered transitional by the noise clustering analysis were recorded. A variety of *Carex* species were recorded in these poor flush habitats and relevés, such as *C. disticha*, *C. echinata*, and *C. paniculata*. Other species commonly recorded here included *Menyanthes trifoliata*, *Eriophorum angustifolium*, *Erica tetralix*, *Succisa pratensis*, *Equisetum* spp and *Comarum palustre*. The most common species of *Sphagnum* were *Sphagnum subnitens* and *S. palustre*.

3.5.5 Links with Fossitt (2000)

Following best practice (Smith *et al.*, 2011) habitats should also be classified using Fossitt (2000). For most cutover bog habitats, the appropriate type would be cutover bog (PB4). Where vegetation is well-developed, other Fossitt types can be confidently assigned to an area. There are clear links between two cutover bog habitat types and Fossitt types:

- *Schoenus nigricans* cutover bog–fen (LS5) can frequently be referred to rich fen and flush (PF1). All four LS5 relevés in this study were assigned to PF1 during the field survey.
- *Filipendula ulmaria* cutover bog (LS4) can often be classified as wet grassland (GS4). Some wet, herb-rich examples may be better considered as examples of marsh (GM1) or perhaps degraded rich fen and flush (PF1). In this study, three LS4 relevés were classified as GS4 and one was classified as GM1 during the field survey.

Well-developed examples of the *Molinia* or *Juncus*-dominated cutover bog habitats may in some cases be better assigned to poor fen and flush (PF2) than cutover bog (PB4). These could include, among others:

- *Sphagnum palustre–Molinia caerulea* cutover bog (HS3)
- *Molinia caerulea–Polygala serpyllifolia* cutover bog (MS3)
- *Juncus effusus–Sphagnum palustre* cutover bog–flush (MS5)

Transition mire and quaking bog (PF3) may also occur infrequently on cutover bog, as noted above. This habitat may be present where deep peat cutting has resulted in calcareous groundwater upwelling through acid peat. Well-developed floating mats of *Carex rostrata*, other sedges and *Sphagnum* species at the edges of pools may also fall into this category. Correspondences with cutover bog habitats could include *Eriophorum angustifolium* cutover bog (LS2), *Filipendula ulmaria* cutover bog (LS4) and perhaps others, such as variants of *Eriophorum vaginatum–Sphagnum papillosum* cutover bog (MS2) with high cover of *Eriophorum angustifolium* in place of *E. vaginatum* and a good representation of flush species.

Woodland on cutover bog mostly corresponds to bog woodland (WN7), but in some lagg zones can include wet willow–alder–ash woodland (WN6) (*cf.* Section 4).

In drier cutover bog areas, *Ulex europaeus* or *Salix aurita* may be abundant, and in these cases classification under Fossitt (2000) as scrub (WS1) may be appropriate. In this study, three *Molinia caerulea* cutover bog (LS3) relevés were also identified as WS1.

Where small trees (<4 m tall) are dominant, usually *Betula pubescens*, *Salix cinerea* or *Pinus* species, it can be difficult to distinguish between scrub (WS1) or immature woodland (WS2). In most cases, the latter would be the most appropriate as a canopy height of over 4 m–the threshold for classification as a wet woodland (Fossitt, 2000)–should eventually develop. On old cutover where trees are clearly stunted and unlikely to develop further, scrub (WS1) may be the better alternative.

Pteridium aquilinum frequently occurs on dry, degraded cutover bog, most often in association with LS group habitat types. Habitats referable to dense bracken (HD1) can be frequent, but only one relevé classified as such was recorded in this study. It was placed in the *Molinia caerulea* cutover bog (LS3) habitat type due to codominance by *Molinia*. Examples of *Calluna vulgaris* cutover bog (LS1) could also be assigned to HD1, if *Pteridium* were abundant.

Cutover bog habitats should only rarely be considered examples of dry siliceous heath (HH1) or wet heath (HH3). These habitats are defined by peat depths of less than 0.5 m (Fossitt, 2000), which seldom occur on cutover bog. Only where a habitat is underlain by shallow peat and good indicators of heath are present, such as *Carex binervis*, *Galium saxatile* and *Juncus squarrosus*, should heath habitats be considered for cutover bog.

3.5.6 Links with Annex I habitats

Annex I habitats were found only rarely on cutover bog in this study. Two of the most important in the context of raised bogs are *bog woodland (91D0) and *active raised bog (7110). These are discussed at greater length in Sections 4 and 4.1 below. Another Annex I habitat frequently found on raised bogs is Rhynchosporion depressions (7150). Similarly to ARB, to date this habitat has not been described from cutover areas in Ireland. NPWS (2019) state that "in raised bogs, *Rhynchospora* vegetation communities are only considered Annex I type when they occur in their most developed form in the wettest sections of Active raised bog (7110), which correspond with pools, *Sphagnum* lawns and hollows". Thus, any areas from the cutover that would qualify as ARB (Section 6) and support such *Rhynchospora* vegetation communities now also qualify as the Annex I habitat Rhynchosporion depressions (7150).

Well-developed examples of *Schoenus nigricans* cutover bog (LS5) may correspond to the Annex I habitat type alkaline fen (7230). Several examples of this habitat were recorded in this study in old cutover where peat cutting has lowered the uppermost peat layers to where the vegetation is influenced by calcareous groundwater. These areas were most frequently found in former lagg zones. Identification of this Annex I habitat type should be informed by the Interpretation Manual (European Commission, 2013) and indicator species and other habitat characteristics detailed in the most recent Article 17 report and backing document (Long *et al.*, 2018; NPWS, 2019).

As discussed above, although transition mire was recorded in cutover bog in this study, there were too few relevé data collected from a range of transition mire communities to define a cutover bog transition mire habitat type. Where well-developed, transition mire on cutover bog may correspond to the Annex I habitat type transition mires and quaking bogs (7140). As with alkaline fen, these habitats were found to occur in former lagg zones. They were also found within peat cuttings where the vegetation is influenced by calcareous water, but also support more acidophilic species, perhaps as a result of acidic surface water runoff from adjacent bog. Lastly, quaking bog vegetation was found to occur along the edges of dystrophic pools. Identification of this Annex I habitat type should be informed by the Interpretation Manual (European Commission, 2013) and indicator species and other habitat characteristics detailed in the most recent Article 17 report and backing document (Long *et al.*, 2018; NPWS, 2019).

A pilot national fen survey was in progress at the time of writing, and the outputs are expected to inform a better characterisation and indicator species to describe both alkaline fen (7230) and transition mires and quaking bogs (7140).

Other Annex I habitat types that could conceivably occur on cutover bog, but have not yet been recorded, include:

- *Molinia* meadows (6410): a candidate area for this was noted in part of the semi-intact lagg of Carrownagappul where frequent *Cirsium dissectum* was recorded as well as *Carex pulicaris*, *C. echinata*, *C. viridula*, *Juncus conglomeratus*, *Luzula multiflora*, *Potentilla erecta* and *Succisa pratensis*. A more focused survey of the area is underway to establish if this area qualifies as *Molinia* meadows.
- *Cladium fens (7210)
- *Alluvial woodland (91E0)

4 Woodland on cutover

4.1 Irish Vegetation Classification

Twenty-five 100 m² relevés were collected in woodland habitat on cutover bog, including bog woodland (WN7) (n=20), wet willow–alder–ash woodland (WN6) (n=2), woodland types transitional between the two (WN6–WN7) (n=2) and immature woodland (WS2) (n=1). ERICA (Perrin, 2020) was used to assign these relevés into six IVC communities (Table 15).

Table 15 Irish Vegetation Classification (IVC) communities to which woodland relevés were assigned and the mean affinities to those communities. n = number of relevés

IVC Type	n	WL3E	WL4A	WL4C	WL4D	WL4E	WL4F
WL3E	3	70	0	0	11	9	1
WL4A	4	0	50	7	21	5	13
WL4C	51	0	0	79	0	10	3
WL4D	6	0	5	0	74	11	9
WL4E	5	6	3	8	16	51	8
WL4F	2	0	10	0	17	1	72

WL3E *Salix cinerea–Galium palustre* woodland

The two wet willow–alder–ash woodland (WN6) woodland relevés and one transitional WN6–WN7 relevé were assigned to IVC community WL3E. These relevés were recorded in the lagg zones of Raheenmore and Mongan Bogs. This *Salix cinerea* and *Betula pubescens* dominated woodland type is described as transitional between base-rich wet woodlands and oligotrophic bog woodlands. The field layers of the relevés reflected this transitional status. *Crataegus monogyna* was present in the understorey of all the relevés. The IVC describes this woodland type as a species-rich community with a diverse bryophyte flora and states that where it occurs along rivers and lakes which are subject to periodic inundation it qualifies as the priority Annex I habitat * alluvial forests (91E0).

WL4A *Betula pubescens–Vaccinium myrtillus* woodland

Two of the four relevés assigned to this woodland type were considered transitional, *i.e.* highest affinity was for WL4A but affinity was less than 50%. Despite the community name, only one of the relevés supported *Vaccinium myrtillus*. *Sorbus aucuparia*, a characteristic canopy species of the type, was frequent in three. Otherwise this dry woodland community comprises a mixture of *Rubus fruticosus* agg, *Hedera hibernica* and abundant pleurocarpous mosses, especially *Pseudoscleropodium purum* and *Thuidium tamariscinum*. The IVC describes this woodland type as typically developing on the drier parts of degraded raised bog sites in the lowlands and identified no significant correspondence with Annex habitats.

WL4C *Betula pubescens–Sphagnum palustre* woodland

Sphagnum palustre was present in all the relevés assigned to this community, although abundances were low in two that were dominated by *Molinia*. This woodland type is characterised by vegetation reflecting oligotrophic and damp to wet conditions. The IVC describes this community as comprising open stands of birch woodland on soils with a fairly high water table or a high degree of flushing, typically occurring on basin peats or occasionally on peaty gleys including stands of intact and degraded raised bog systems in the lowlands, and identified a high affinity with the priority Annex I habitat *bog woodland (91D0).

WL4D *Betula pubescens–Rubus fruticosus* woodland

In the relevés assigned to this community, *Salix cinerea* was usually frequent in the canopy or sub-canopy. Other tree species, including *Quercus robur*, *Pinus sylvestris* and *Taxus baccata* were present in some of the relevés, making for a more diverse tree component than many other birch-dominated bog woodlands. The field layer of this otherwise anonymous woodland type was largely dominated by *Rubus fruticosus*. The IVC describes this community as occurring mostly on basin peats on flat or gently sloping ground in the lowlands commonly associated with degraded raised bogs. No significant correspondence with *bog woodland (91D0) is noted whilst a small proportion of stands may qualify as *alluvial forests (91E0).

WL4E *Betula pubescens–Salix cinerea* woodland

Salix cinerea and *S. x multinervis* were at least frequent and sometimes abundant in the *Betula pubescens* canopy of this woodland type. One relevé was classified as a transitional WN6–WN7 wet woodland using Fossitt (2000) classification. Conditions underfoot ranged from dry to soft and wet. Most relevés included at least some field layer species favouring mesotrophic conditions. Unlike the similar WL4D community, no one species dominated the field layer, which comprised *Rubus fruticosus*, *Dryopteris dilatata* and *Carex* species, among others. Two of the relevés assigned to this community were transitional between this type and WL4C, WL4D and WL3E. The IVC describes this community as occurring predominantly on stands of wet, acidic basin peats in the lowlands on flat ground, being commonly associated with degraded bogs, particularly smaller bogs or the lagg zone of large ones, where there is some groundwater intrusion. It is described as quite a species-rich woodland community with a fairly diverse bryophyte flora. Stands with a high cover of *Sphagnum* are recognised by the IVC as potentially qualifying as priority Annex I habitat *bog woodland (91D0) and a small proportion of stands are identified as *alluvial forests (91E0).

WL4F *Betula pubescens–Pteridium aquilinum* woodland

Betula pubescens dominated the canopy of the relevés in this type, accompanied by *Pinus sylvestris* in one. *Salix* species were absent. Despite the name of the community, *Pteridium* occurred sparsely in only one relevé and was absent in the other. The species-poor field layer of this dry birchwood community consisted mainly of bramble. The IVC describes this community type as occurring on highly organic, drained basin peats on predominantly flat ground in the lowlands, usually as part of a mosaic of habitats on degraded raised bogs and identified no significant correspondence with Annex habitats.

4.2 Annex I bog woodland

Four relevés were considered to correspond to the Habitats Directive Annex I type *bog woodland (91D0). Two were assigned (98% and 63% affinity) to the WL4C *Betula pubescens–Sphagnum palustre* woodland community. One was a more base-enriched example assigned (54% affinity) to the WL4D *Betula pubescens–Rubus fruticosus* woodland type. However, this relevé also had high affinity (40%) with WL4E. The last was a transitional community with greatest affinity (33%) to WL4E *Betula pubescens–Salix cinerea* woodland, but also with relatively strong affinities to WL4D (23%) and WL4C (21%).

Sphagnum cover in the 91D0 relevés ranged from 35–95%. The numbers of positive indicators in addition to *Betula pubescens* and *Sphagnum* spp., following Cross & Lynn (2013), in each relevé ranged from 4–8. The monitoring and conservation assessment targets for *Sphagnum* cover and positive indicators are >25% and ≥5, respectively (Cross & Lynn, 2013). The WL4D plot had the lowest *Sphagnum* cover and only 4 positive indicators; it was in the lagg zone of Ferbane Bog and supported species indicative of base-enriched conditions, such as *Carex remota* and *Viburnum opulus*. It is therefore a borderline example of 91D0.

Other monitoring assessment criteria (Cross & Lynn, 2013) were met, apart from tree size distribution, tree regeneration and dead wood, which were not recorded. The exception is the criterion for negative species cover ≤10%. Negative indicators include *Pteridium*, *Rubus fruticosus* agg, *Rhododendron*, and non-native tree species. Two of the relevés fail this criterion due mainly to high cover of *Rubus*. A moderate cover (4–10%) of *Pteridium* and *Picea sitchensis* was also present in one of these relevés, while a moderate cover (4–10%) of *Fagus sylvatica* was present in the other.

4.3 Woodland habitat mapping

Woodland habitat mapping was carried out using the methodology outlined in Section 2.2, with each area of woodland assigned a habitat category using Fossitt (2000) and where relevant an Annex I category. IVC categories were not used in mapping as vegetation composition changes within stands makes such mapping difficult.

4.4 Assessing woodland on cutover bog

The first step in the key to cutover bog habitats (Appendix 1) is the exclusion of woodland and (dense) scrub habitats. These were not included in the cutover bog habitat classification as the IVC classification of woodland communities included many samples of woodlands on cutover bog in its definition. Scrub habitats are only poorly catered for by the IVC, but as very few relevés were recorded in this study in what are quite low conservation value habitats, they were not included in the cutover bog habitat classification. The IVC communities SC1C *Pteridium aquilinum–Rubus fruticosus* agg. and SC1D *Ulex europaeus–Rubus fruticosus* agg. are likely to be the most common scrub communities on cutover bog.

Most woodland on cutover bog is birch-dominated, relatively dry and species-poor and are therefore of low conservation value. The principal focus of cutover bog woodland surveys should be identifying the exceptional, often small, stands of greater conservation interest. The main questions are:

- Is the stand an example of Annex I *bog woodland (91D0)?
- Is the stand an example of wet lagg zone woodland?
- Is the stand an example of a different, unusual woodland type that may be of conservation interest?

4.4.1 Assessing Annex I bog woodland

The current monitoring and conservation assessment criteria for 91D0 bog woodland should be used to identify these habitats of very high conservation interest. At present, Cross & Lynn (2013) set conservation targets for 91D0 bog woodland, including indicator species. The minimum threshold for *Sphagnum* cover is 25%, and 91D0 bog woodland on cutover bog should normally exceed this. The current list of positive indicator species (Cross & Lynn, 2013, updated in NPWS, 2019) is provided in Table 16.

NPWS (2019) also notes other species that are typical, but are not used in monitoring assessments: *Erica tetralix*, *Eriophorum vaginatum*, *Pinus sylvestris*, *Polytrichum strictum*, *Sphagnum capillifolium*, *S. squarrosum* and *S. teres*. Positive indicator species and typical species should be used to determine if a stand corresponds to 91D0 bog woodland.

Annex I *bog woodland (91D0) is considered to principally occur in birch woodland communities WL4C and WL4E. Cross & Lynn (2013) also point out, however, that it can occur "in association with weak ground-water influence, indicated by the presence of carr species, e.g. Ash (*Fraxinus excelsior*) and Marsh Horsetail (*Equisetum palustre*)".

Table 16 Positive Indicator species of Annex I *bog woodland (91D0).

Vascular Plants	Bryophytes
Betula pubescens (target species)	*Aulacomnium palustre*
Salix aurita	*Hylocomium splendens*
Salix cinerea	*Polytrichum commune*
Salix x multinervis	*Sphagnum fallax*
Calluna vulgaris	*Sphagnum fimbriatum*
Carex rostrata	*Sphagnum palustre*
Dryopteris dilatata	
Dryopteris carthusiana	
Empetrum nigrum	
Epilobium palustre	
Juncus effusus	
Molinia caerulea	
Potentilla erecta	
Vaccinium myrtillus	
Vaccinium oxycoccos	

4.4.2 Lagg zone woodland

Intact raised bog lagg zones are extremely rare in Ireland. Frequently, intact or modified lagg zones may support woodland of *Salix cinerea* and other species with a field layer showing base-enrichment. Such woodlands are of conservation interest, especially if they are wet and species-rich, due to their rarity. Where woodlands show a continuum from oligotrophic bog woodland to willow carr or other woodlands with base-enriched conditions, this can be of particular interest.

In this study, woodlands associated with cutover bog lagg zones were classified as WL3E *Salix cinerea–Galium palustre* woodland. Lagg zone woodlands may also support other vegetation communities, some of which may be difficult to relate to the IVC. For example, there are extensive lagg zone woodlands of *Salix cinerea*, *Betula pubescens* and *Alnus glutinosa* with a swampy *Carex paniculata*-dominated field layer at Abbeyleix Bog (Smith & Crowley, 2019).

Where lagg zone woodlands are adjacent to rivers or lakes, they may qualify as Annex I *alluvial woodland (91E0).

4.4.3 Other woodlands of conservation interest

Dry woodland types of conservation interest may occur where cutover peat depths are shallow or where mineral soil ridges emerge from the peat. For example, these could include oak–ash–hazel woodland (WN2) on exposed eskers. No such examples were found in this study, although some modified mixed broadleaf–conifer woodland (WD2) of lower conservation value was recorded on emergent rocky knolls.

5 Habitat surveys

Of the 770.7 ha of cutover that was surveyed (Appendix 6), 419.8 ha (54.5%) is classed as peatland habitat using Fossitt (2000) habitat types, with 243.2 ha (31.6%) classed as scrub or woodland and 93.4 ha (12.1%) classed as grassland. Of the 419.8 ha, 414.6 ha was mapped as cutover bog (PB4). Apart from cutover bog (PB4) as defined by Fossitt (2000), the next most extensive habitat was bog woodland (WN7) (200.5 ha including 5.4 ha of 91D0).

Of the 414.6 ha of cutover bog (PB4) mapped across the twelve sites, 25.3 ha (6.1%) was mapped as having a high *Sphagnum* cover and assigned to the HS group of cutover bog habitats. A small percentage of this, mostly from HS1, is likely to correspond with ARB, but further surveys must be carried out in these HS areas to confirm this.

The results of the cutover habitat surveys showing the extent of each habitat recorded is summarised in Appendix 6.

6 Assessment of Active Raised Bog (ARB) on cutover

6.1 *Sphagnum* cover

A key characteristic of ARB is that it is wet and "still supporting a significant area of vegetation that is normally peat forming" (European Commission, 2013). As a proxy for assessing peat formation in raised bog monitoring, a general threshold of *Sphagnum* cover of 40% is used as a criterion in determining whether an area of high bog is ARB (Fernandez Valverde *et al*., 2005, 2012). Accordingly, an area of cutover bog must have *Sphagnum* cover of more than 40%, in addition to the other criteria discussed below, to qualify as ARB. As this is the threshold used for the High *Sphagnum* habitat group, it follows that an area of cutover should fall into the HS1, HS2 or HS3 habitat types. Given the indicator species criterion discussed below, most or all ARB on cutover is expected to be classified as *Sphagnum subnitens–Erica tetralix* cutover bog (HS1).

6.2 ARB positive indicator species

To identify positive indicator species of ARB and to define thresholds, the presence and absence of characteristic ARB species were recorded in thirty-four 100 m² plots on ARB on the high bog, as discussed in Section 2.4. Comparison was also made with fifteen 16 m² vegetation quadrats recorded previously in high bog ARB. The results of the analysis of the high bog plots are given in Table 17 and Table 18 below.

Table 17 Number of Active Raised Bog (ARB) plots against the number of species characteristic of ARB recorded in 100 m² and 16 m² plots.

Relevé size	Number of relevés with the following number of species characterisitic of ARB											
	≤10	11	12	13	14	15	16	17	18	19	≥20	Total
100 m²	0	0	3	6	2	2	5	5	1	3	3	34
16 m²	0	1	1	2	4	3	1	1	2	0	0	15

The results of Table 17 suggest that a 100 m² area of ARB on the high bog has a minimum of 12 of the ARB characteristic species listed by NPWS (2019). Nine species were ever-present in the 100 m² plots (Table 18) and five (*Andromeda polifolia*, *Drosera rotundifolia*, *Sphagnum capillifolium*, *S. papillosum* and *Narthecium ossifragum*) of these were also present in all the 16 m² plots. The remaining four were absent in either one (*Eriophorum vaginatum*, *E. angustifolium* and *Rhynchospora alba*) or two of the 16 m² plots (*Sphagnum cuspidatum*). Allowing for the facts that *Andromeda polifolia* is more common in midland sites and no true western sites were sampled in the analysis, this species may not always be present in ARB. However, for a cutover area to be considered as ARB, all eight of the other constant species in Table 18 should be present in a 100 m² plot on cutover bog, and at least four of the other species listed should also be present (Table 19) to reach the minimum threshold of 12 indicated by the high bog data.

Table 18 Frequency of occurrence of each Active Raised Bog (ARB) characteristic species in 100 m² and 16 m² plots.

Species	100 m² quadrat	16 m² quadrat
Sphagnum capillifolium	34	15
Andromeda polifolia	34	15
Drosera rotundifolia	34	15
Narthecium ossifragum	34	15
Sphagnum papillosum	34	15
Eriophorum vaginatum	34	14
Eriophorum angustifolium	34	14
Rhynchospora alba	34	14
Sphagnum cuspidatum	34	13
Cladonia portentosa	33	13
Sphagnum magellanicum agg.	32	9
Drosera anglica	27	11
Sphagnum subnitens	23	11
Cladonia uncialis	22	11
Vaccinium oxycoccos	20	11
Sphagnum austinii	20	6
Menyanthes trifoliata	17	5
Sphagnum fuscum s.l.	14	6
Sphagnum denticulatum	11	1
Racomitrium lanuginosum	10	2
Aulacomnium palustre	5	2
Pleurozia purpurea	5	2
Cladonia ciliata	4	2
Leucobryum glaucum	2	0
Campylopus atrovirens	1	0
Drosera intermedia	0	0
Sphagnum pulchrum	0	0

Table 19 Indicator species of Active Raised Bog (ARB)

Constant All eight species required	Additional Any four species / groups of species required	
Sphagnum capillifolium	*Andromeda polifolia*	*Menyanthes trifoliata*
Drosera rotundifolia	*Cladonia portentosa* and/or *C. ciliata*	*Sphagnum fuscum s.l.*
Narthecium ossifragum	*Cladonia uncialis*	*Sphagnum denticulatum*
Sphagnum papillosum	*Aulacomnium palustre*	*Sphagnum subnitens*
Eriophorum vaginatum	*Drosera anglica* and/or *D. intermedia*	*Sphagnum pulchrum*
Eriophorum angustifolium	*Leucobryum glaucum*	*Sphagnum magellanicum* agg
Rhynchospora alba	*Vaccinium oxycoccos*	*Sphagnum austinii*
Sphagnum cuspidatum	*Racomitrium lanuginosum, Pleurozia purpurea* and/or *Campylopus atrovirens*	

6.3 Negative indicators

In rare situations, transition mire may support both ombrotrophic ARB species and species typical of calcareous fens. To exclude these habitats, any area classed as ARB should be devoid of calcicolous species indicative of rich fen conditions, such as the 'brown mosses' *Campylium stellatum*, *Scorpidium scorpioides* or *S. revolvens*). Some species, such as *Menyanthes trifoliata* and *Eriophorum angustifolium*, are typical of both raised bogs and rich fens and their presence is not grounds for disqualification.

In addition, to qualify as ARB, a cutover area should have a combined cover of <10% of species that are not typical of ombrotrophic raised bog. These include scrub and heath species, such as *Rubus fruticosus, Ulex europeaeus* or *Pteridium aquilinum*, and poor flush species, such as *Molinia caerulea, Carex rostrata* or *Juncus effusus*. ARB with ≥10% cover of trees, such as *Betula pubescens* or *Pinus* species, is acceptable, although perhaps indicative of sub-optimal conditions.

6.4 ARB on cutover in project sites

A total of 25.3 ha of HS group habitats were mapped on the 12 project sites, and a small subset of this is believed to correspond to ARB. To assess whether the areas are ARB or not, a 100 m² assessment plot will be evaluated during post-restoration surveys in each area and presence/absence data of the characteristic species listed in Section 6.2 taken. The results of this will be available at a later stage in the Living Bog project.

During the baseline surveys, no 100 m² assessment plots were recorded. In the interim, the 16 m² monitoring plots recorded pre-restoration were assessed to establish whether any of these areas fulfil the criteria. Table 20 below shows that three HS1 relevés supported 12 indicator species.

Table 20 Number of High *Sphagnum* (HS) group cutover relevés against the number of positive indicator species for Active Raised Bog (ARB)

Relevé size	Number of relevés with the following number of positive indicator species									
	≤5	6	7	8	9	10	11	12	>12	Total
HS1	1	3	2	6	1	8	1	3	0	25
HS2	2	3	3	0	4	0	0	0	0	12
HS3	6	1	3	1	2	0	1	0	0	14

However, the actual characteristic species occurring also needs to be assessed to ensure that all constant species are present (Table 19). It can be seen from this analysis that no cutover relevé would pass as ARB since some of the constant species were absent in every relevé (Table 21). Assessing species numbers from a 16 m² plot based on 100 m² plot criteria is unduly harsh, however, and once 100 m² assessment plots are undertaken, it is highly likely that these and additional areas will fulfil the criteria.

Table 21 Species recorded in the High *Sphagnum* (HS) group plots that had a minimum of 12 of the Active Raised Bog (ARB) characteristic species. Values refer to Domin scale abundances.

Relevé Number	R00057503	R00058511	R00124239
Habitat type	HS1	HS1	HS1
Sphagnum cover	85	85	65
Constant species			
Drosera rotundifolia	2		2
Eriophorum angustifolium	5	3	3
Eriophorum vaginatum	2		6
Narthecium ossifragum	4	4	3
Sphagnum capillifolium	6	4	7
Sphagnum cuspidatum	2	6	
Sphagnum papillosum	8	7	4
Rhynchospora alba		4	
Total	7	6	6
Additional species			
Andromeda polifolia		1	1
Aulacomnium palustre		2	4
Campylopus atrovirens			
Cladonia portentosa	3	3	1
Cladonia uncialis	1		
Drosera anglica	1	2	
Menyanthes trifoliata			
Sphagnum fuscum	3	3	
Sphagnum magellanicum agg.	3	1	5
Sphagnum subnitens			4
Vaccinium oxycoccos			2
Total	5	6	6
Other species			
Betula pubescens	2		
Juncus effusus			2
Molinia caerulea			4
Potentilla erecta			2
Calluna vulgaris	7	5	6
Erica tetralix	5	4	4
Dicranum scoparium	2		1

Relevé Number	R00057503	R00058511	R00124239
Hypnum jutlandicum	4	4	2
Kurzia pauciflora	1	2	
Odontoschisma sphagni	4	2	3
Sphagnum tenellum	2	2	1
Trichophorum germanicum	4	1	3
Sphagnum fallax	4		
Carex panicea			4
Campylopus introflexus			1
Equisetum palustre		2	
Cephalozia connivens			2
Calypogeia sphagnicola			1
Dactylorhiza maculata			1

Figure 21 Relevé R00124239 on Carrownagappul which supported 12 species characteristic of Active Raised Bog.

6.5 Definition of ARB on cutover

To qualify as Annex I *active raised bog (7110) (ARB), a relatively homogenous area of cutover bog must meet the following criteria:

- Total *Sphagnum* cover >40%
- Presence of all eight (8) constant species (Table 19) within a 100 m² plot
- Presence of an additional four (4) indicator species, or species groups, (Table 19) within a 100 m² plot
- Absence of calcareous fen species, such as brown mosses
- <10% cover of species not typical of ombrotrophic raised bog

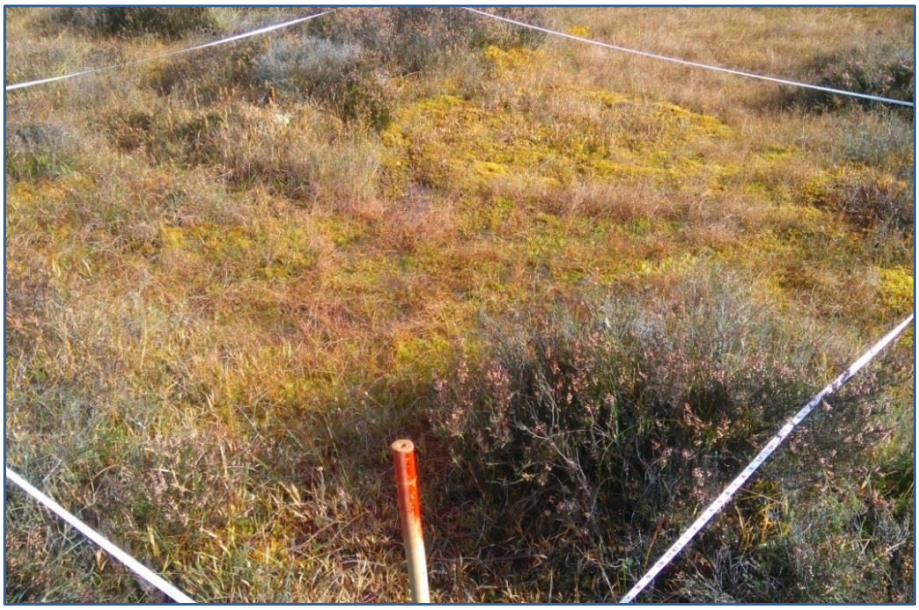

Figure 22 Relevé R00058511 on Sharavogue, which supported 12 species characteristic of Active Raised Bog.

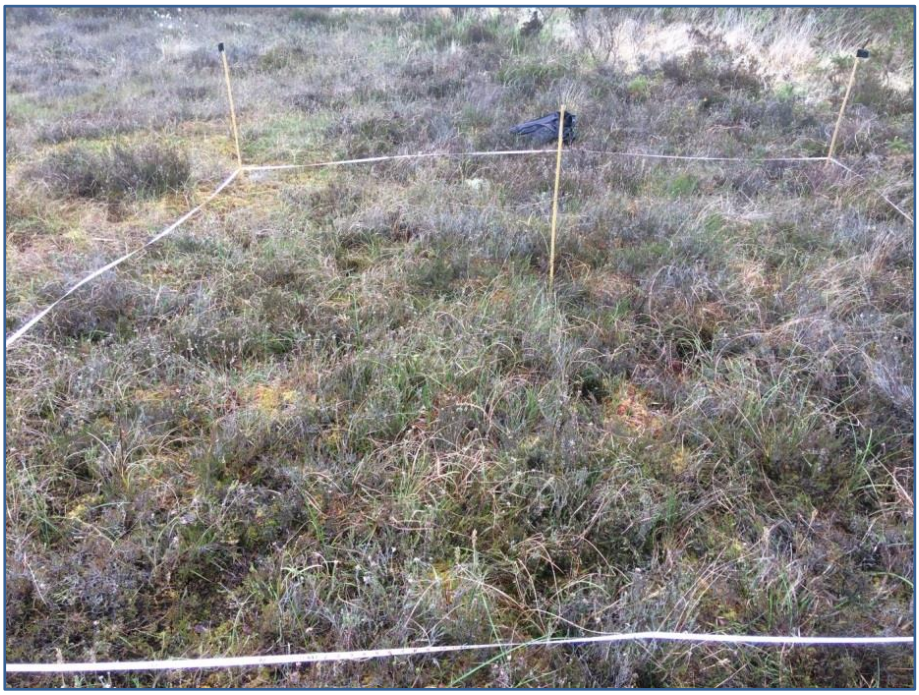

Figure 23 Relevé R00057503 on Ferbane which supported 12 species characteristic of Active Raised Bog.

7 Cutover bog habitats and conservation

Cutover bog habitats are by their nature disturbed, degraded and of lower conservation value than the former active raised bog that they have replaced. Ironically, some cutover bog may support greater species richness than intact raised bog, but this comes as the result of a loss of a habitat that is rare and declining in Ireland and worldwide. Furthermore, most cutover bog lacks several specialist active raised bog species, such as *Sphagnum beothuk* and *S. austinii* and liverworts including *Cladopodiella fluitans* and several *Cephalozia* and *Cephaloziella* species.

This study has found that large areas of cutover bog are occupied by dry, species-poor habitats. Using the newly developed classification scheme, the most common cutover bog habitat was *Calluna vulgaris* cutover bog (LS1), which covered (32.2% of the area mapped as PB4, followed by *Molinia caerulea* cutover bog (LS3), which covered 23.9% of PB4. LS1 corresponds with vegetation types previously described on cutover by O'Connell & Foss (1999) and O'Connell & Geraghty (2017) as Heather heathland. Both LS1 and LS3 habitats are generally dry with a low *Sphagnum* cover and of low conservation value. However, an exception to this can occur where LS3 supports frequent *Succisa pratensis*, as this habitat can then sometimes support populations of the Annex II listed Marsh Fritillary (*Euphydryas aurinia*). However, this is possibly an early successional stage habitat that without intervention will develop into scrub and woodland.

Among the habitats of highest conservation value are the HS1–3 habitats, which in this study covered 6.1% of PB4. They correspond with vegetation types previously described by O'Connell & Foss (1999) and O'Connell & Geraghty (2017) as Regenerating Raised Bog and Wet Raised Bog Vegetation. These habitats have a high conservation value due to their similarity to active raised bog or peat-forming flushes. Some examples support raised bog specialist species, and some may contain priority Annex I habitat ARB.

As discussed in Section 3.5.6, several other Annex I habitat types may occur on cutover bog, and these would also be of high conservation value. Next to ARB, the cutover bog habitat of highest value is priority Annex I *bog woodland (91D0). It may be more frequent on cutover bog than ARB. Individual areas of *bog woodland (91D0) on high bog are usually limited in extent, and *bog woodland (91D0) patches on cutover bog are also usually small.

In this project, a total of 4.1 ha of *Schoenus nigricans* cutover bog–fen (LS5) was mapped. This is analogous to the IVC community FE1A *Schoenus nigricans–Campylium stellatum* fen, and some may be classified as the Annex I habitat type alkaline fen (7230). Transition mire and quaking bog (7140) was also recorded during this study, and it is possible that other Annex I habitats may be found on cutover bog. These habitat types are of high conservation value as they are rare habitats of European conservation importance.

The typical conservation value of other cutover bog habitat types is indicated in Appendix 7. As a general rule, conservation value decreases as habitats become drier and become dominated by a handful of competitive species, such as *Calluna* or *Molinia*. Current conservation value of bare peat habitats is also low due to their highly disturbed condition; however, the importance of young bare peat habitats may increase over time if environmental conditions are favourable or interventions can be made to promote improved habitat status. When assessing the conservation value of a particular area of cutover bog, it is important to evaluate the indicative values suggested in Appendix 7 in the context of other factors, such as:

- Habitat diversity
- Species richness
- Presence of high quality indicator species for other habitats, such as ARB or fen
- Presence of rare or protected plant or animal species

- Presence of unusual hydrological or geological features, such as groundwater flushes or mineral outcrops
- Presence and transitions between lagg zone habitats
- Potential future conservation value following restoration or natural succession
- Landscape context

Regarding the last factor, conservation value should be considered in the context of surrounding habitats. For example, if a cutover bog is one of the few unmanaged areas in a landscape dominated by intensive agriculture, its value would be higher at the local scale than a similar cutover bog surrounded by higher quality habitats. Similarly, open cutover bog surrounded by extensive forest or woodland would add to the overall habitat diversity of an area and thus increase its conservation value.

8 Recommendations

- Insufficient numbers of relevés were taken in some cutover habitats noted in the field to adequately separate them out in the noise clustering analysis and characterise them. Habitat types where additional relevé data should be collected are discussed in Section 4.2 and are listed below. Once such a process is completed, further habitat types are likely to be added to the classification. Indeed, the classification as a whole should be considered as a working document that may need to be updated once additional areas of cutover are surveyed. Habitats that should be prioritised for additional recording are:
    - Low *Sphagnum* habitats with high cover of *Juncus*
    - Habitats with abundant *Narthecium* and/or *Rhynchospora alba* in Medium *Sphagnum*, Low *Sphagnum* and Bare Peat areas
    - Transition mire and quaking bog
    - Flushes with abundant *Carex rostrata*
- The criteria recommended here to assess the presence of ARB on cutover bog needs to be tested and may need to be revised.
- The habitats defined using this classification are evolving, and how they develop as a result of the restoration measures enacted by The Living Bog project may have significant bearing on how future restoration work on these or other sites is carried out. As such these sites need a carefully planned monitoring strategy to help make these assessments.
- Gas chamber studies need to be carried out in each of the most common habitat categories in order that the impact of restoration on greenhouse gas emissions can be estimated.
- Where significant populations of Marsh Fritillary are recorded in areas that are undergoing succession to scrub habitat, suitable management techniques such as grazing or cutting should be investigated and implemented.
- Since the IVC is a dynamic classification system, the data collected during this project should be incorporated into the IVC in the future. This may result in new communities or sub-communities being defined which are more specific to cutover raised bog vegetation.

9 Bibliography & Relevant Literature

Anon (2019) Supporting documentation for the conservation status assessment for the habitat: H7110 - Active raised bogs Northern Ireland. Fourth report by the UK under Article 17, JNCC. https://jncc.gov.uk/jncc-assets/Art17/H7110-NI-Habitats-Directive-Art17-2019.pdf, accessed November 2020.

Bord na Móna (2016) *Biodiversity Action Plan 2016–2021*. Bord na Móna. Dublin.

Clements, F.E. (1916) *Plant succession, An analysis of the development of vegetation*. Publication No. 242. Carnegie Institution, Washington, DC.

Cross, J. (1990) *The raised bogs of Ireland*. Report to the Minister of State at the Department of Finance. Stationery Office, Dublin.

Cross, J. & Lynn, D. (2013) Results of a monitoring survey of bog woodland. *Irish Wildlife Manuals*, No. 69. National Parks and Wildlife Service, Department of Arts, Heritage and the Gaeltacht, Dublin, Ireland.

De Cáceres, M., Font, X. & Oliva, F. (2010) The management of vegetation classifications with fuzzy clustering. *Journal of Vegetation Science,* **21**, 1138-1151.

Dufrêne, M. & Legendre, P. (1997) Species assemblages and indicator species: the need for a flexible assymetric approach. *Ecological Monographs*, **67**, 345-366.

European Commission (2013) *Interpretation Manual of European Union Habitats*. EUR 28. DG Environment.

Feehan, J., O'Donovan, G., Renou-Wilson, F. & Wilson, D. (2008) *The Bogs of Ireland: An Introduction to the Natural, Cultural and Industrial Heritage of Irish Peatlands*. School of Biology and Environmental Science, University College Dublin.

Fernandez, F., Connolly K., Crowley W., Denyer J., Duff K. & Smith G. (2014) Raised Bog Monitoring and Assessment Survey 2013. *Irish Wildlife Manuals,* No. 81. National Parks and Wildlife Service, Department of Arts, Heritage and the Gaeltacht, Dublin, Ireland.

Fernandez Valverde, F., Crowley, W. & Wilson, S. (2012) *Raised Bog Monitoring Project 2011 - Volume 1: Main Report.* Irish Wildlife Manuals No. 62. NPWS, Dublin.

Fernandez Valverde, F., Fanning, M., McCorry, M. & Crowley, W. (2005) Raised bog monitoring project 2004-2005. Report prepared for NPWS, Dublin.

Fernandez, F., MacGowan, F., Farrell, M., Crowley, W., Croal, Y., Fanning, M. & McKee A.-M. (2006) *Assessment of the Impacts of turf cutting on designated Raised Bogs 2003-06*. Unpublished report, National Parks and Wildlife Service, Department of Environment, Heritage and Local Government, Dublin.

Fossitt, J.A. (2000) *A Guide to Habitats in Ireland*. The Heritage Council, Kilkenny.

Hammond, R.F. (1979) *The Peatlands of Ireland*. An Foras Talúntais, Dublin.

Hassel, K., Kyrkjeeide, M.O., Yousefi, N., Prestø, T., Stenøien, H.K., Shaw, J.A. & Flatberg, K.I. (2018) *Sphagnum divinum* (sp. nov.) and *S. medium* Limpr. and their relationship to *S. magellanicum* Brid. *Journal of Bryology,* **40,** 197-222.

Hill, M.O., Preston, C.D., Bosanquet, S.D.S. & Roy, D.B. (2007) *BRYOATT: Attributes of British and Irish Mosses, Liverworts and Hornworts*. CEH, Monks Wood.

Hill, M.O., Preston, C.D. & Roy, D.B. (2004) *PLANTATT: Attributes of British and Irish Plants - Status, Size, Life History, Geography and Habitats*. CEH, Monks Wood.

Kelly, L. & Schouten, M.G.C. (2002) Vegetation. *Conservation and Restoration of Raised Bogs*: *Geological, hydrological and ecological studies* (ed M.G.C. Schouten), pp. 110-169. Dúchas – The Heritage Service of the Department of Environment and Local Government, Dublin, Ireland; Staatsbosbeheer, The Netherlands; Geological Survey of Ireland.

Kyrkjeeide, M.O., Hassel, K., Stenøien, H.K., Prestø, T., Boström, E., Shaw, A.J. & Flatberg, K.I. (2015). The dark morph of *Sphagnum fuscum* (Schimp.) H. Klinggr. in Europe is conspecific with the North American *S. beothuk*. *Journal of Bryology* **37,** 251-266.

Legendre, P. & Legendre, L. (1998) *Numerical Ecology*. Developments in Environmental Modelling, 20. 2nd English edition. Elsevier, Amsterdam.

Long, M.P., Crowe, O., Kimberley, S. & Denyer, J. (2018) Backing document – National Conservation Status Assessments (NCAs) for three fen habitat types: 7140 –Transition mires and quaking bogs, 7210– Calcareous fens with *Cladium mariscus* and species of Caricion davallianae, 7230–Alkaline fens. Report prepared for National Parks and Wildlife Service.

Mackin, F., Flynn, R., Barr, A. & Fernandez Valverde, F. (2017a) Use of geographical information system-based hydrological modelling for development of a raised bog conservation and restoration programme. *Ecological Engineering*, **106A**: 242–252.

Mackin, F., Barr, A., Rath, P., Eakin, M., Ryan, J., Jeffrey, R. & Fernandez Valverde, F. (2017b) Best practice in raised bog restoration in Ireland. *Irish Wildlife Manuals*, No. 99. National Parks and Wildlife Service, Department of Culture, Heritage and the Gaeltacht, Dublin, Ireland.

NPWS (2018) *National Raised Bog Special Areas of Conservation Management Plan 2017-2022*. National Parks & Wildlife Service, Department of Culture, Heritage and the Gaeltacht, Dublin, Ireland.

NPWS (2019) *The Status of Protected EU Habitats and Species in Ireland. Volume 2: Habitat Assessments* (D. Lynn & F. O'Neill eds.). Unpublished Report, National Parks & Wildlife Services. Department of Culture, Heritage and the Gaeltacht, Dublin, Ireland.

NPWS, BEC Consultants & National Biodiversity Data Centre (2019) *Irish Vegetation Classification*. National Biodiversity Data Centre, Waterford. http://www.biodiversityireland.ie/projects/national-vegetation-database/irish-vegetation-classification/

O'Connell, C. & Foss, P. (1999) *A survey of cutover & cutaway bog habitats of the Irish midlands*. Irish Peatland Conservation Council, Lullymore, Rathangan, Co. Kildare.

O'Connell, C. & Geraghty, K. (2017) *Girley Bog Peat-forming Cutover Bog Survey 2017*. Report to the Heritage Council. Irish Peatland Conservation Council, Lullymore, Rathangan, Co. Kildare.

Perrin, P. (2015) *Irish Vegetation Classification Technical Progress Report No. 1*. Report prepared for NPWS, National Biodiversity Data Centre and the Heritage Council.

Perrin, P. (2017) *Irish Vegetation Classification Technical Progress Report No. 3*. Report prepared for NPWS, National Biodiversity Data Centre and the Heritage Council.

Perrin, P. (2020) *ERICA: Engine for Relevés to Irish Communities Assignment.* Version 5.1. BEC Consultants. Accessed 14/04/20. https://biodiversityireland.shinyapps.io/vegetation-classification/.

Perrin, P., Martin, J., Barron, S., O'Neill, F., McNutt, K. & Delaney, A. (2008a) National Survey of Native Woodlands 2003-2008. Volume I: Main Report. National Parks and Wildlife Service, Dublin.

Perrin, P., Martin, J., Barron, S., O'Neill, F., McNutt, K. & Delaney, A. (2008b) National Survey of Native Woodlands 2003-2008. Volume II: Woodland Classification. National Parks and Wildlife Service, Dublin.

Renou-Wilson, F., Moser, G., Fallon, D., Farrell, C.A., Müller, C. & Wilson, D. (2019) Rewetting degraded peatlands for climate and biodiversity benefits: Results from two raised bogs. *Ecological Engineering*, **127**, 547–560.

Smith, G.F. & Crowley, W. (2019) *Abbeyleix Bog Ecological Surveys of Cutover*. Report prepared for the Abbeyleix Bog Project.

Smith, G.F., O'Donoghue, P., O'Hora, K. & Delaney, E. (2011) *Best Practice Guidance for Habitat Survey and Management.* Heritage Council, Kilkenny.

Swenson, M.M., Regan, S., Bremmers, D.T.H., Lawless, J, Saunders, M & Gill, L.W. (2019) Carbon balance of a restored and cutover raised bog: implications for restoration and comparison to global trends. *Biogeosciences*, **16**, 713–731.

Wilson, D., Renou-Wilson, F., Farrell, C., Bullock, C. & Müller, C. (2012) *Carbon Restore - the potential of Irish peatlands for carbon uptake and storage*. Climate change research programme. Report Series No.17 prepared for the Environmental Protection Agency, Johnstown Castle, Co. Wexford, Ireland by Uni-versity College Dublin.

Appendix 1 Cutover Habitat Key

No dichotomous key is perfect, particularly habitat or vegetation keys that rely on average abundances and frequencies of a large number of species. Where the key does not seem to work, the habitat type descriptions and synoptic tables in Appendix 2-5 should be reviewed to see if the habitat can actually fit into one of the types in the classification, despite inadequacies in the key. There will still be habitats, however, that will not neatly fit into any of the classified habitat types. These can include variant habitat types, transitional habitats, mosaics and anomalous habitats. See Section 3.5 for further discussion.

Note that this key was designed for the purpose of mapping *relatively* homogenous areas of >400 m^2. Cutover bog habitat types could also be applied to smaller habitat patches, and due to the often heterogeneous nature of cutovers, it may be possible to map a number of different habitat types within a small area. Depending on the study area and the survey objectives, such an approach may not be an efficient use of resources. See *Best Practice Guidance for Habitat Survey and Mapping* (Smith *et al*., 2011) for further discussion on minimum habitat sizes for mapping. DAFOR values are used in line with the guidance outlined by Smith *et al*. (2011). The key should also be used in conjunction with the synoptic tables (Appendices 2-5) where species frequencies and percentage covers can be gauged.

Key

1. Habitat is closed-canopy woodland or scrub (WN, WD or WS, according to Fossitt (2000).Use the **Irish Vegetation Classification** types[1]

   Habitat is open, although trees and tall shrubs may be frequent.....**2**

2. Total *Sphagnum* cover is clearly >40% .....**High *Sphagnum* (HS)** group

   Total *Sphagnum* cover is ≤40%.....**3**

3. Total cover of bare peat is ≥10% .....**Bare Peat (BP)** group

   Total cover of bare peat is <10% **4**

4. Total *Sphagnum* cover is 11-40% .....**Medium *Sphagnum* (MS)** group

   Total *Sphagnum* cover is ≤10%.....**Low *Sphagnum* (LS)** group

High *Sphagnum* (HS) Group Key

1. *Molinia* is abundant to dominant. *Potentilla erecta* and *Sphagnum palustre* are almost always present, and cover of the latter is usually >10%. Other bryophytes indicative of flushed conditions, such as *Aulacomnium palustre* and *Polytrichum commune* are often present and sometimes relatively abundant.....**HS3**

   Molinia is usually present, but never dominant. *Sphagnum palustre* may be present, but cover is usually <25%. *Potentilla erecta* and other bryophytes of flushed conditions are less frequent and cover never exceeds 10%.....**2**

2. *Eriophorum vaginatum* is abundant to dominant. *Calluna* cover is usually <25% and *Erica tetralix* cover is almost always <10%. *Sphagnum cuspidatum* and *S. papillosum* are almost always present and often abundant. *Narthecium*, *Rhynchospora alba* and *Odontoschisma sphagni* are infrequent**HS2**

[1] Most woodlands on cutover bog will fall within the WL4 *Betula pubescens–Molinia caerulea* group. Where influenced by base-rich groundwater, WL3 *Alnus glutinosa - Filipendula ulmaria* group woodlands can occur. *Sphagnum*-rich woodlands, mainly in IVC types WL4C or WL4E, can occur on cutover bog and can correspond to the Habitats Directive type '*bog woodland (91D0)'.

Eriophorum vaginatum is usually present, but never dominant. *Calluna* cover is usually >25% and *Erica tetralix* cover is usually >10%. *Sphagnum cuspidatum* and *S. papillosum* are often present, but usually less abundant. *Narthecium ossifragum* and *Odontoschisma sphagni* are usually present, and *Rhynchospora alba* is sometimes present. **HS1**

Bare Peat (BP) Group Key

1. Cover of bare peat is >50%. **BP3**

   Cover of bare peat is ≤50%. **2**
2. *Eriophorum angustifolium* is abundant to dominant. *Calluna* is usually present, but cover is seldom >10%. *Hypnum jutlandicum* and *Cladonia portentosa* are occasional to frequent and *Cladonia floerkeana* is absent. **BP2**

   Eriophorum angustifolium is frequent but seldom abundant. *Calluna* cover is >10%. *Hypnum jutlandicum* and *Cladonia portentosa* are almost always present, with cover of the former usually >10%. *Cladonia floerkeana* is frequent. **BP1**

Medium *Sphagnum* (MS) Group Key

1. Flushed habitats with *Molinia* cover usually >10%. *Potentilla erecta* and *Juncus effusus* often present, the latter sometimes abundant. *Calluna* cover usually <25%. **2**

   Ombrotrophic habitats with *Molinia* cover usually <10%. *Potentilla erecta* and *Juncus effusus* infrequent, the latter usually absent. *Calluna* cover usually >25% but sometimes less. **3**
2. *Molinia* cover is usually >35%. *Juncus effusus* is frequent, but cover is usually <10%. Main *Sphagnum* species are *S. capillifolium* and *S. papillosum*, sometimes *S. palustre*. *Agrostis canina* and *Anthoxanthum odoratum* are rare or absent. **MS3**

   Molinia cover is usually <25%. *Juncus effusus* is always present with cover >25% and usually more. Main *Sphagnum* species is *S. palustre*; *S. papillosum* is absent. *Agrostis canina* and *Anthoxanthum odoratum* are frequent. **MS5**
3. *Cladonia portentosa* cover is usually >25% and *Erica tetralix* cover is usually >10%. *Trichophorum germanicum*, *Sphagnum tenellum* and *Odontoschisma sphagni* are usually present, and *Rhynchospora alba* and *Narthecium ossifragum* are often frequent. **MS4**

   Cladonia portentosa cover is <25% and *Erica tetralix* cover is usually <10%. *Trichophorum germanicum* and *Sphagnum tenellum* are only occasional, and *Rhynchospora alba* and *Narthecium ossifragum* are rare. **4**
4. *Calluna* cover is <50% and *Eriophorum vaginatum* cover is usually >25%. *Sphagnum papillosum* cover is usually >5%. *Sphagnum subnitens* is only frequent and *Cladonia floerkeana* is absent..... **MS2**

   Calluna cover is usually >50% and *Eriophorum vaginatum* cover is usually <10%. *Sphagnum papillosum* cover is usually <5%. *Sphagnum subnitens* is usually present and *Cladonia floerkeana* is sometimes present. **MS1**

Low *Sphagnum* (LS) Group Key

1. *Calluna*, *Eriophorum* species, and other typical bog flora are frequent and often abundant. Indicators of base-rich or nutrient-enriched conditions are rare or absent. **2**

   Calluna, *Eriophorum* species, and other typical bog flora are rare or absent. Indicators of base-rich or nutrient-enriched conditions characterise the habitat. **4**

2. *Eriophorum angustifolium* is abundant or dominant, sometimes accompanied by *Trichophorum germanicum*. *Molinia* and *Calluna* are usually present, but do not dominate. **LS2**

   Eriophorum angustifolium is occasional to frequent, but not abundant. *Trichophorum germanicum* is rare. Vegetation is dominated by *Molinia* or *Calluna*. **3**

3. *Molinia* is dominant and *Potentilla erecta* is usually present. *Calluna* and *Hypnum jutlandicum* are frequent but not abundant. **LS3**

   Calluna is dominant, accompanied by frequent to abundant *Hypnum jutlandicum*. *Molinia* is usually present but not abundant. **LS1**

4. Vegetation comprises marsh species: *Filipendula ulmaria*, *Vicia cracca, Mentha aquatica, Anthoxanthum odoratum* and *Holcus lanatus* are frequent. *Schoenus nigricans* and *Campylium stellatum* are absent. **LS4**

   Schoenus nigricans, Campylium stellatum and other alkaline fen species are frequent to abundant. *Filipendula ulmaria*, *Vicia cracca, Mentha aquatica, Anthoxanthum odoratum* and *Holcus lanatus* are rare or absent. **LS5**

Appendix 2 High *Sphagnum* Group synoptic table

	HS1 ***Sphagnum subnitens - Erica tetralix***	**HS2** ***Sphagnum cuspidatum - Eriophorum vaginatum***	**HS3** ***Sphagnum palustre - Molinia caerulea***
N	27	14	16
Calluna vulgaris	V 3-(6)-8	V 3-(5)-6	V 3-(4)-6
Erica tetralix	V 2-(5)-6	IV 2-(4)-4	V 2-(4)-4
Odontoschisma sphagnii	V 1-(2)-4	II 1-(2)-3	III 1-(2)-3
Eriophorum angustifolium	V 1-(4)-8	V 1-(4)-5	IV 1-(4)-5
Sphagnum tenellum	IV 1-(3)-4	II 1-(2)-4	I 2-(2)-2
Sphagnum subnitens	IV 2-(4)-5	II 2-(2)-3	III 2-(2)-4
Cladonia portentosa	IV 1-(3)-8	II 1-(3)-4	II 3-(4)-7
Narthecium ossifragum	IV 1-(3)-5	II 1-(2)-3	II 2-(3)-4
Rhynchospora alba	II 2-(4)-5		
Eriophorum vaginatum	IV 2-(5)-7	V 4-(8)-9	V 1-(4)-6
Sphagnum papillosum	V 1-(5)-8	V 3-(6)-8	III 1-(4)-5
Sphagnum cuspidatum	III 2-(3)-7	V 1-(3)-7	I 1-(3)-3
Molinia caerulea	IV 1-(4)-6	V 2-(4)-6	V 5-(8)-9
Sphagnum palustre	I 1-(2)-3	IV 2-(5)-7	IV 2-(5)-9
Potentilla erecta	II 1-(2)-3	I 1-(1)-2	IV 1-(3)-4
Aulacomnium palustre	III 1-(2)-4	II 1-(1)-4	IV 1-(4)-5
Calypogeia fissa	II 1-(1)-2	II 1-(1)-2	IV 1-(2)-3
Polytrichum commune	I 1-(1)-2	I 1-(1)-1	III 1-(2)-3

	HS1 *Sphagnum subnitens - Erica tetralix*	HS2 *Sphagnum cuspidatum - Eriophorum vaginatum*	HS3 *Sphagnum palustre - Molinia caerulea*
Hypnum jutlandicum	V 2-(4)-6	IV 2-(3)-5	V 1-(4)-4
Trichophorum germanicum	III 1-(3)-5	II 2-(3)-3	I 2-(4)-5
Betula pubescens	II 1-(2)-2	II 2-(3)-4	III 1-(3)-5
Juncus effusus	I 2-(3)-4	II 1-(2)-3	III 1-(2)-6
Sphagnum capillifolium	V 3-(6)-8	V 2-(4)-8	V 2-(6)-7
Drosera rotundifolia	IV 1-(2)-2	III 1-(1)-2	II 1-(1)-2
Sphagnum magellanicum agg.	III 1-(3)-6	III 2-(4)-5	IV 1-(4)-6
Polytrichum strictum	II 1-(3)-5	II 1-(3)-4	II 1-(4)-5
Campylopus introflexus	II 1-(1)-2	II 1-(1)-2	I 1-(1)-1
Dicranum scoparium	II 1-(2)-3	II 1-(1)-2	I 2-(2)-2
Carex panicea	II 2-(3)-5	I 2-(4)-4	II 2-(2)-3
Kurzia pauciflora	II 1-(1)-3	I 1-(1)-1	
Cephalozia connivens	I 1-(1)-2	II 1-(1)-2	II 1-(1)-2
Riccardia chamedryfolia		II 1-(1)-2	I 2-(2)-2
Sphagnum denticulatum		II 2-(3)-4	I 4-(4)-4
Pleurozium schreberi	I 1-(1)-1	I 1-(1)-2	II 1-(3)-5
Polygala serpyllifolia	I 1-(1)-2	I 2-(2)-2	II 1-(2)-2
Succisa pratensis	I 1-(4)-4	I 3-(3)-3	II 1-(2)-3
Pseudoscleropodium purum	I 2-(3)-4		II 1-(3)-3
Vaccinium oxycoccos	I 2-(3)-3		II 2-(2)-2

Other species present at frequency of **I**:

HS1: *Andromeda polifolia, Calliergonella cuspidata, Calypogeia sphagnicola, Campylopus atrovirens, Carex rostrata, Cephaloziella* spp, *Cladonia uncialis, Dactylorhiza maculata* ssp *ericetorum, Drosera anglica, Dryopteris affinis, Epilobium palustre, Equisetum palustre, Fagus sylvatica, Holcus lanatus, Hylocomium splendens, Hypochaeris radicata, Lemna minor, Lophozia incisa, L. ventricosa, Luzula sylvatica, Mylia anomala, Myrica gale, Odontoschisma denudatum, Osmunda regalis, Phragmites australis, Pinus contorta, P. sylvestris, Polytrichastrum formosum, Q. robur, Salix aurita, S. cinerea, S. x multinervis, Sorbus aucuparia, Sphagnum austinii, S. fallax, S. fuscum* s.l., *S. inundatum, Splachnum ampullaceum, Thuidium tamariscinum, Ulex europaeus, Vaccinium myrtillus*.

HS2: *Agrostis canina, Calypogeia muelleriana, C. sphagnicola, Carex rostrata, Cephalozia bicuspidata, Cephaloziella* spp, *Equisetum palustre, Hylocomium splendens, Kindbergia praelonga, Lophozia incisa, L. ventricosa, Luzula multiflora, Mylia anomala, Odontoschisma denudatum, Pedicularis sylvatica, Phragmites australis, Picea sitchensis, Plagiothecium undulatum, Polytrichastrum formosum, Riccardia multifida, Salix cinerea, Sphagnum fallax, S. fimbriatum, S. inundatum*.

HS3: *Agrostis canina, Andromeda polifolia, Anthoxanthum odoratum, Blechnum spicant, Calypogeia sphagnicola, Carex rostrata, Cephalozia bicuspidata, Cephaloziella* spp, *Cirsium palustre, Cladonia uncialis, Comarum palustre, Diplophyllum albicans, Dryopteris carthusiana, D. dilatata, Equisetum fluviatile, E. palustre, Galium saxatile, Holcus lanatus, Hylocomium splendens, Juncus bulbosus, Kindbergia praelonga, Hypochaeris radicata, Leucobryum glaucum, Lophozia incisa, L. ventricosa, Luzula multiflora, Menyanthes trifoliata, Myrica gale, Phragmites australis, Pinus contorta, Plagiothecium undulatum, Polytrichastrum formosum, Rhytidiadelphus squarrosus, Riccardia multifida, Salix aurita, S. cinerea, S. x multinervis, Scapania gracilis, Sphagnum fallax, S. fimbriatum, S. inundatum, S. squarrosum, Vaccinium myrtillus*.

Appendix 3 Moderate *Sphagnum* Group synoptic table

	MS1 *Calluna vulgaris - Sphagnum subnitens*	**MS2** *Eriophorum vaginatum - Sphagnum papillosum*	**MS3** *Molinia caerulea - Polygala serpyllifolia*	**MS4** *Cladonia portentosa - Trichophorum germanicum*	**MS5** *Juncus effusus - Sphagnum palustre*
N	11	14	15	16	6
Calluna vulgaris	V (7)-8-(9)	V (1)-6-(7)	V (1)-5-(6)	V (4)-5-(8)	IV (1)-4-(4)
Cladonia floerkeana	I (2)-2-(2)				
Eriophorum vaginatum	V (3)-5-(6)	V (5)-7-(9)	IV (1)-3-(5)	V (3)-5-(6)	I (2)-2-(2)
Sphagnum papillosum	IV (2)-3-(5)	V (3)-4-(6)	IV (2)-3-(6)	III (1)-4-(5)	
Molinia caerulea	V (2)-4-(6)	IV (2)-4-(5)	V (5)-7-(9)	II (2)-4-(7)	V (4)-5-(6)
Polygala serpyllifolia			II (1)-1-(2)	I (2)-2-(2)	
Cladonia portentosa	II (2)-2-(3)	III (1)-4-(5)	III (1)-4-(8)	V (5)-6-(9)	
Trichophorum germanicum	I (1)-3-(3)	II (2)-3-(3)	I (1)-2-(2)	V (1)-3-(5)	
Odontoschisma sphagni	IV (1)-2-(3)	III (1)-1-(3)	II (1)-1-(2)	V (2)-2-(3)	
Erica tetralix	V (3)-4-(4)	V (3)-4-(5)	V (2)-4-(5)	V (4)-5-(6)	
Sphagnum tenellum	III (1)-3-(4)	III (1)-1-(5)	II (1)-2-(3)	V (1)-3-(5)	
Narthecium ossifragum	I (3)-3-(3)	I (1)-4-(4)	II (1)-2-(4)	III (1)-3-(5)	
Sphagnum capillifolium	V (3)-4-(6)	V (3)-5-(7)	V (1)-5-(7)	V (4)-5-(7)	II (1)-5-(6)
Rhynchospora alba		II (3)-3-(4)		III (1)-3-(5)	
Kurzia pauciflora	I (1)-1-(1)	I (1)-1-(1)	I (1)-1-(1)	III (1)-2-(2)	
Juncus effusus		I (1)-1-(1)	II (3)-4-(5)		V (6)-8-(9)
Kindbergia praelonga	I (2)-2-(2)	I (2)-2-(2)			IV (1)-3-(3)
					III

	MS1	**MS2**	**MS3**	**MS4**	**MS5**
	Calluna vulgaris - Sphagnum subnitens	***Eriophorum vaginatum - Sphagnum papillosum***	***Molinia caerulea - Polygala serpyllifolia***	***Cladonia portentosa - Trichophorum germanicum***	***Juncus effusus - Sphagnum palustre***
Anthoxanthum odoratum					(2)-3-(3)
Agrostis canina			I (2)-2-(2)		III (4)-4-(5)
Sphagnum palustre	III (3)-4-(5)	I (2)-4-(4)	II (4)-5-(7)	I (2)-2-(2)	V (1)-5-(7)
Dryopteris carthusiana		I (1)-1-(1)			III (1)-1-(1)
Sphagnum fallax			I (1)-1-(1)	I (2)-2-(2)	II (4)-4-(4)
Rhytidiadelphus squarrosus		I (5)-5-(5)	I (1)-1-(2)	I (1)-1-(1)	II (4)-5-(5)
Sphagnum subnitens	V (1)-3-(5)	III (1)-3-(4)	IV (1)-3-(5)	IV (1)-2-(4)	I (3)-3-(3)
Sphagnum cuspidatum	II (1)-2-(3)	IV (1)-3-(5)	II (1)-1-(3)	II (2)-2-(5)	II (3)-5-(5)
Aulacomnium palustre	II (1)-1-(2)	II (1)-2-(5)	IV (1)-1-(4)	I (2)-2-(2)	II (1)-1-(2)
Potentilla erecta	I (2)-2-(2)	I (2)-2-(2)	V (1)-2-(4)	II (1)-2-(3)	III (2)-4-(4)
Eriophorum angustifolium	V (2)-4-(5)	V (1)-4-(5)	V (1)-4-(8)	V (1)-5-(7)	IV (1)-4-(6)
Carex panicea	I (3)-5-(5)	II (1)-2-(5)	IV (2)-3-(5)	IV (2)-4-(6)	
Betula pubescens	II (1)-2-(3)	I (3)-3-(3)	II (1)-2-(2)	I (3)-3-(3)	II (1)-4-(5)
Hypnum jutlandicum	V (3)-4-(7)	IV (3)-4-(6)	V (1)-4-(7)	V (3)-3-(5)	I (3)-3-(3)
Calypogeia fissa	III (1)-2-(3)	III (1)-1-(2)	II (1)-1-(2)	I (1)-1-(2)	IV (1)-1-(2)
Drosera rotundifolia	II (2)-2-(3)	II (1)-1-(2)	III (1)-1-(2)	II (1)-1-(2)	
Dicranum scoparium	I (1)-1-(2)	I (1)-1-(1)	II (1)-3-(4)	II (1)-2-(4)	I (2)-2-(2)
Cephalozia connivens	II (1)-1-(2)		II (1)-1-(2)	I (1)-1-(1)	
Succisa pratensis	I (2)-2-(2)		II (1)-1-(4)		I (4)-4-(4)
Salix aurita			II (1)-1-(3)		I (1)-1-(1)

	MS1	**MS2**	**MS3**	**MS4**	**MS5**
	Calluna vulgaris - Sphagnum subnitens	***Eriophorum vaginatum - Sphagnum papillosum***	***Molinia caerulea - Polygala serpyllifolia***	***Cladonia portentosa - Trichophorum germanicum***	***Juncus effusus - Sphagnum palustre***
Campylopus introflexus	II (2)-2-(3)	II (1)-1-(2)	I (1)-1-(2)	II (1)-1-(2)	I (1)-1-(1)
Sphagnum magellanicum agg.	I (3)-3-(4)	II (3)-3-(5)	I (1)-2-(3)	II (3)-3-(5)	
Cephaloziella sp.	I (1)-1-(1)	II (1)-2-(2)	I (1)-1-(1)	I (1)-1-(1)	
Pleurozium schreberi		II (1)-2-(2)		I (1)-1-(1)	
Polytrichum strictum	I (2)-2-(2)	II (1)-1-(1)	I (1)-4-(5)	I (1)-1-(1)	
Vaccinium oxycoccos		II (2)-2-(3)	I (2)-2-(2)	I (1)-2-(3)	
Pseudoscleropodium purum		I (1)-1-(1)	I (1)-2-(4)		II (2)-4-(4)
Polytrichum commune			I (2)-2-(4)		II (1)-3-(3)

Other species present at frequency of **I**:

MS1: *Andromeda polifolia, Calliergonella cuspidata, Campylopus flexuosus, Cephalozia bicuspidata, Cladonia* sp.*, Lophocolea bidentata, Lophozia incisa, Lophozia ventricosa, Plagiothecium undulatum, Polytrichastrum formosum, Riccardia* sp.*, Salix cinerea, Sphagnum inundatum*

MS2: *Calypogeia muelleriana, Calypogeia sphagnicola, Campylium stellatum, Campylopus flexuosus, Carex paniculata, Cephalozia macrostachya* var. *macrostachya, Cladonia uncialis, Hylocomium splendens, Lophozia incisa, Lophozia ventricosa, Mylia anomala, Polytrichum longisetum, Riccardia* sp.*, Sphagnum denticulatum, Ulex europaeus*

MS3: *Andromeda polifolia, Blechnum spicant, Calypogeia sphagnicola, Campylopus flexuosus, Carex echinata, Carex pulicaris, Cephalozia bicuspidata, Cladonia uncialis, Dactylorhiza fuchsii, Diplophyllum albicans, Equisetum palustre, Galium saxatile, Hookeria lucens, Hydrocotyle vulgaris, Hylocomium splendens, Hypericum pulchrum, Juncus bulbosus, Leucobryum glaucum, Lophozia ventricosa, Luzula multiflora, Menyanthes trifoliata, Myrica gale, Osmunda regalis, Picea sitchensis, Polytrichastrum formosum, Pteridium aquilinum, Riccardia* sp.*, Salix x multinervis, Scapania gracilis, Sphagnum inundatum, Ulex europaeus, Vaccinium myrtillus*

MS4: *Andromeda polifolia, Campylopus flexuosus, Cephalozia bicuspidata, Cephalozia macrostachya var. macrostachya, Leucobryum glaucum, Mylia anomala, Odontoschisma denudatum, Polytrichastrum formosum, Racomitrium lanuginosum, Rumex acetosa, Scapania gracilis, Sphagnum austinii*

MS5: *Brachythecium rutabulum, Calliergonella cuspidata, Carex nigra, Carex rostrata, Chamerion angustifolium, Galium palustre, Galium saxatile, Hylocomium splendens, Juncus acutiflorus, Lophocolea*

Appendix 4 Low *Sphagnum* Group synoptic table

	LS1	**LS2**	**LS3**	**LS4**	**LS5**
	Calluna vulgaris	***Eriophorum angustifolium***	***Molinia caerulea***	***Filipendula ulmaria***	***Schoenus nigricans***
N	21	9	33	4	4
Calluna vulgaris	V (8)-8-(9)	V (4)-5-(7)	V (2)-5-(7)		IV (2)-3-(4)
Hypnum jutlandicum	V (4)-6-(8)	IV (2)-4-(5)	V (1)-4-(8)		IV (2)-4-(5)
Eriophorum angustifolium	IV (2)-3-(7)	V (4)-7-(8)	III (1)-3-(6)		II (2)-2-(2)
Trichophorum germanicum	I (1)-2-(3)	II (1)-2-(5)	I (1)-3-(3)		
Molinia caerulea	V (1)-4-(6)	IV (2)-4-(7)	V (7)-8-(10)	III (5)-6-(7)	V (4)-5-(8)
Vicia cracca				V (2)-3-(4)	
Filipendula ulmaria			I (1)-2-(3)	V (4)-4-(5)	II (1)-1-(1)
Mentha aquatica			I (1)-1-(1)	IV (2)-4-(7)	
Anthoxanthum odoratum	I (1)-1-(1)		I (1)-2-(4)	IV (4)-4-(5)	II (3)-3-(3)
Holcus lanatus		I (2)-2-(2)	I (1)-5-(7)	IV (4)-4-(4)	
Calliergonella cuspidata		II (2)-3-(3)	I (1)-1-(4)	IV (7)-7-(8)	IV (2)-4-(6)
Arrhenatherum elatius				III (1)-4-(5)	
Lathyrus pratensis				III (3)-4-(4)	
Rumex acetosa				III (1)-1-(2)	
Festuca rubra			I (3)-3-(3)	III (4)-7-(8)	
Plantago lanceolata			I (2)-2-(2)	III (2)-4-(4)	
Agrostis stolonifera	I (2)-2-(2)		I (3)-3-(3)	III (4)-5-(5)	
Angelica sylvestris			I (1)-1-(1)	III (3)-4-(4)	III (2)-2-(2)
Kindbergia praelonga	I	II	I	III	

	LS1	**LS2**	**LS3**	**LS4**	**LS5**
	Calluna vulgaris	***Eriophorum angustifolium***	***Molinia caerulea***	***Filipendula ulmaria***	***Schoenus nigricans***
	(4)-4-(4)	(1)-1-(2)	(1)-2-(3)	(4)-4-(4)	
Comarum palustre		I (3)-3-(3)	I (1)-1-(2)	III (3)-4-(4)	II (2)-2-(2)
Galium palustre		I (2)-2-(2)	I (1)-1-(1)	IV (1)-2-(2)	III (1)-1-(2)
Carex rostrata		I (6)-6-(6)	I (4)-4-(4)	III (5)-5-(6)	III (2)-2-(2)
Potentilla anserina			I (2)-2-(2)	II (4)-4-(4)	
Carex flacca			I (4)-4-(4)	II (5)-5-(5)	
Schoenus nigricans					V (5)-5-(8)
Campylium stellatum			I (1)-1-(4)		V (4)-7-(8)
Carex lepidocarpa		I (2)-2-(2)			IV (3)-4-(4)
Ctenidium molluscum					III (4)-4-(4)
Scorpidium revolvens					III (2)-3-(3)
Narthecium ossifragum	I (1)-3-(3)	II (2)-3-(3)	I (1)-1-(1)		III (3)-3-(3)
Hydrocotyle vulgaris			I (2)-2-(2)	II (1)-1-(1)	III (1)-1-(2)
Cardamine pratensis		I (1)-1-(1)		II (1)-1-(1)	III (1)-1-(2)
Erica tetralix	IV (1)-3-(5)	V (1)-4-(6)	IV (1)-3-(5)		V (2)-3-(3)
Cladonia portentosa	III (1)-3-(9)	III (3)-5-(8)	I (2)-5-(7)		II (2)-2-(2)
Juncus effusus	I (2)-3-(4)	III (1)-5-(5)	II (1)-2-(5)		
Sphagnum papillosum	I (1)-3-(4)	III (1)-1-(3)	I (2)-3-(3)		
Potentilla erecta	II (1)-3-(4)	III (2)-2-(5)	V (1)-2-(4)	III (2)-2-(2)	III (2)-2-(2)
Rhytidiadelphus squarrosus	II (1)-1-(2)	II (1)-1-(2)	II (1)-2-(4)	III (2)-4-(4)	
Menyanthes trifoliata		I (1)-1-(1)	I (1)-1-(1)	II (5)-5-(5)	III (3)-4-(4)

	LS1	LS2	LS3	LS4	LS5
	Calluna vulgaris	***Eriophorum angustifolium***	***Molinia caerulea***	***Filipendula ulmaria***	***Schoenus nigricans***
Myrica gale		I (4)-4-(4)	I (1)-7-(8)		III (5)-5-(6)
Succisa pratensis	I (3)-3-(3)	III (1)-3-(4)	II (1)-3-(5)	II (3)-3-(3)	V (1)-2-(2)
Sphagnum subnitens	II (1)-3-(4)	IV (1)-2-(3)	I (1)-3-(3)		III (3)-4-(4)
Betula pubescens	III (1)-3-(5)	III (1)-2-(3)	III (1)-3-(7)	II (1)-1-(1)	III (1)-3-(3)
Salix cinerea	I (1)-3-(5)	III (3)-3-(3)	II (1)-1-(3)	III (1)-4-(4)	III (3)-3-(3)
Pseudoscleropodium purum	III (1)-4-(8)	III (2)-4-(5)	III (1)-3-(8)	II (5)-5-(5)	
Calypogeia fissa	III (1)-2-(3)	III (1)-2-(4)	II (1)-2-(3)		II (1)-1-(1)
Sphagnum capillifolium	III (1)-2-(4)	II (3)-3-(4)	III (1)-3-(4)		II (4)-4-(4)
Carex panicea	I (1)-4-(5)	III (2)-3-(5)	II (1)-2-(5)		III (1)-4-(4)
Eriophorum vaginatum	II (2)-4-(5)	III (1)-2-(6)	II (1)-3-(7)		
Campylopus introflexus	II (2)-3-(8)	III (1)-2-(4)	I (1)-1-(3)		
Odontoschisma sphagni	II (1)-2-(2)	II (1)-3-(3)	I (1)-1-(3)		II (1)-1-(1)
Aulacomnium palustre	II (1)-1-(3)	II (1)-1-(2)	II (1)-2-(4)		
Polytrichastrum formosum	II (1)-1-(2)	II (1)-2-(2)	I (1)-2-(3)		
Ulex europaeus	II (1)-3-(4)		I (4)-6-(7)	II (1)-1-(1)	
Drosera rotundifolia	I (1)-1-(2)	II (1)-1-(2)	I (1)-1-(2)		II (1)-1-(1)
Thuidium tamariscinum	I (2)-4-(4)	II (1)-1-(2)	I (1)-3-(5)	II (1)-1-(1)	
Polygala serpyllifolia	I (2)-2-(2)	I (1)-1-(1)	II (1)-1-(2)		II (1)-1-(1)
Agrostis canina			I (2)-2-(3)	II (4)-4-(4)	II (4)-4-(4)
Phragmites australis			I (2)-2-(2)	II (6)-6-(6)	II (4)-4-(4)
Epilobium palustre		I (4)-4-(4)		II (2)-2-(2)	II (1)-1-(1)

	LS1	LS2	LS3	LS4	LS5
	Calluna vulgaris	***Eriophorum angustifolium***	***Molinia caerulea***	***Filipendula ulmaria***	***Schoenus nigricans***
Cladonia uncialis	I (3)-3-(3)	II (2)-2-(2)			
Hypericum pulchrum	I (1)-1-(2)	II (1)-1-(1)	I (1)-1-(2)		
Rhynchospora alba	I (4)-4-(4)	II (3)-5-(5)			
Pleurozia purpurea		II (1)-1-(2)			
Sphagnum tenellum	I (1)-2-(3)	II (1)-1-(2)	I (1)-1-(1)		
Hylocomium splendens	I (2)-2-(2)	I (3)-3-(3)	II (1)-2-(7)		
Lophocolea bidentata	I (1)-1-(2)		II (1)-1-(2)		
Rubus fruticosus agg.	I (4)-4-(4)	I (1)-1-(1)	II (1)-2-(4)		

LS1: *Agrostis capillaris, Agrostis vinealis, Calypogeia muelleriana, Calypogeia sphagnicola, Campylopus flexuosus, Carex binervis, Cephalozia connivens, Cephaloziella* sp., *Cladonia floerkeana, Colura calyptrifolia, Crataegus monogyna, Dicranum scoparium, Dryopteris carthusiana, Dryopteris dilatata, Eurhynchium striatum, Galium saxatile, Hedera hibernica, Hypochaeris radicata, Kurzia pauciflora, Odontoschisma denudatum, Osmunda regalis, Peltigera membranacea, Pinus contorta, Pinus sylvestris, Pleurozium schreberi, Polytrichum commune, Polytrichum strictum, Pteridium aquilinum, Rhytidiadelphus loreus, Riccardia chamedryfolia, Salix aurita, Salix x multinervis, Sphagnum cuspidatum, Sphagnum magellanicum* agg., *Sphagnum palustre*

LS2: *Brachythecium rutabulum, Calypogeia sphagnicola, Campylopus flexuosus, Carex echinata, Carex paniculata, Cephalozia bicuspidata, Cephalozia connivens, Cirsium palustre, Cladonia floerkeana, Dicranum scoparium, Dryopteris carthusiana, Dryopteris dilatata, Galium saxatile, Hypochaeris radicata, Juncus bulbosus, Leucobryum glaucum, Lophozia incisa, Mylia anomala, Osmunda regalis, Picea sitchensis, Pinus sylvestris, Polytrichum strictum, Riccardia chamedryfolia, Salix aurita, Salix x multinervis, Scapania gracilis, Sphagnum cuspidatum, Sphagnum squarrosum, Taraxacum* agg.

LS3: *Agrostis capillaris, Athyrium filix-femina, Blechnum spicant, Brachythecium rutabulum, Breutelia chrysocoma, Bryum pseudotriquetrum* s.l., *Calliergon cordifolium, Calypogeia muelleriana, Carex echinata, Carex nigra, Carex paniculata, Centaurea nigra, Cephalozia bicuspidata, Cephalozia connivens, Cephaloziella* sp., *Chamerion angustifolium, Cirsium palustre, Climacium dendroides, Crataegus monogyna, Cryphaea heteromalla, Dicranum scoparium, Dryopteris affinis, Dryopteris carthusiana, Dryopteris dilatata, Equisetum palustre, Eurhynchium striatum, Festuca ovina, Fissidens adianthoides, Frullania tamarisci, Galium saxatile, Geranium robertianum, Hookeria lucens, Hypochaeris radicata, Ilex aquifolium, Lophozia incisa, Lophozia ventricosa, Luzula multiflora, Luzula sylvatica, Osmunda regalis, Oxyrrhynchium speciosum, Pedicularis palustris, Peltigera membranacea, Pinus contorta, Pleurozium schreberi, Polytrichum commune, Potamogeton polygonifolius, Prunus spinosa, Pteridium aquilinum, Ranunculus flammula, Rhizomnium punctatum, Rhytidiadelphus loreus, Riccardia chamedryfolia, Rubus idaeus, Salix aurita, Salix x multinervis, Senecio aquaticus, Sorbus aucuparia, Sphagnum fallax, Sphagnum fimbriatum, Sphagnum inundatum, Sphagnum palustre, Splachnum ampullaceum, Taraxacum* agg., *Urtica dioica, Vaccinium myrtillus*

LS4: *Calliergon cordifolium, Calystegia silvatica, Carex disticha, Cerastium fontanum, Cirsium palustre, Cynosurus cristatus, Epilobium obscurum, Equisetum fluviatile, Equisetum palustre, Juncus acutiflorus, Juncus*

conglomeratus, Lythrum salicaria, Oxyrrhynchium hians, Poa trivialis, Ranunculus acris, Ranunculus flammula, Ranunculus repens, Schedonorus arundinaceus, Taraxacum agg.*, Valeriana officinalis, Vicia sepium*

LS5: *Aneura pinguis, Brachythecium rutabulum, Bryum pseudotriquetrum* s.l.*, Chara globularis, Osmunda regalis, Scorpidium scorpioides, Utricularia intermedia*

Appendix 5 Bare Peat Group synoptic table

	BP1 *Calluna vulgaris* - bare peat	BP2 *Eriophorum angustifolium* - bare peat
N	13	10
Eriophorum angustifolium	V (2)-4-(7)	V (7)-8-(9)
Hypnum jutlandicum	V (2)-5-(7)	III (1)-4-(5)
Calluna vulgaris	V (5)-6-(8)	V (3)-4-(6)
Cladonia portentosa	V (1)-2-(3)	II (1)-2-(3)
Cladonia floerkeana	III (1)-2-(3)	
Juncus effusus	II (1)-1-(4)	III (1)-3-(4)
Erica tetralix	V (2)-4-(5)	V (1)-2-(4)
Eriophorum vaginatum	IV (1)-5-(7)	III (1)-3-(5)
Molinia caerulea	IV (1)-5-(6)	III (2)-3-(4)
Campylopus introflexus	V (1)-3-(5)	V (2)-3-(4)
Betula pubescens	IV (1)-2-(4)	IV (1)-2-(4)
Sphagnum capillifolium	IV (1)-4-(7)	II (1)-4-(4)
Sphagnum papillosum	II (1)-3-(5)	III (1)-3-(5)
Drosera rotundifolia	III (1)-2-(2)	II (1)-2-(2)
Potentilla erecta	III (1)-2-(3)	II (1)-1-(3)
Calypogeia fissa	II (1)-1-(2)	II (1)-2-(2)
Carex panicea	II (3)-4-(4)	II (2)-3-(4)
Polytrichastrum formosum	II (1)-1-(3)	II (1)-2-(3)
Cephalozia connivens	II	II

	BP1	**BP2**
	***Calluna vulgaris* - bare peat**	***Eriophorum angustifolium* - bare peat**
	(1)-1-(2)	(1)-1-(1)
Rhynchospora alba	I	II
	(3)-5-(6)	(2)-3-(5)
Juncus bulbosus	I	II
	(1)-3-(3)	(1)-1-(4)
Salix cinerea	I	II
	(1)-1-(1)	(1)-1-(2)
Dicranum scoparium	II	I
	(1)-1-(2)	(1)-1-(1)
Narthecium ossifragum	II	I
	(1)-2-(2)	(1)-3-(3)
Sphagnum magellanicum agg.	II	I
	(2)-2-(3)	(2)-2-(2)
Sphagnum subnitens	II	I
	(1)-2-(4)	(2)-2-(2)
Sphagnum tenellum	II	I
	(3)-3-(4)	(2)-2-(2)
Odontoschisma sphagni	II	I
	(1)-4-(4)	(1)-1-(2)
Hypericum pulchrum	II	
	(1)-1-(2)	

Appendix 6 Habitat types by area recorded during the cutover surveys

Total area of habitat types as defined by Fossitt (2000) and the cutover bog habitat classification recorded during the cutover surveys.

Level 1	Level 2	Level 3	Habitat Group	Habitat Type	Area (ha)
Peatlands	Bog (PB)	Cutover Bog (PB4)	Bare Peat	BP1	12.9
				BP2	16.0
				BP2/WS1	0.50
				BP3	1.54
				BP3	1.54
				Total	**30.9**
			High *Sphagnum*	HS1	8.7
				HS1/LS1	0.2
				HS2	9.5
				HS3	6.2
				HS3/LS1	0.8
				Total	**25.3**
			Moderate *Sphagnum*	MS1	18.5
				MS1/WS1	0.4
				MS2	11.0
				MS3	22.9
				MS3/WS1	0.2
				MS4	23.9
				MS5	9.8
				Total	**86.5**
			Low *Sphagnum*	LS1	133.3
				LS1/HS2	0.5
				LS1/HS3	0.2
				LS1/PF3	0.5
				LS1/WS1	3.0
				LS2	5.0
				LS3	98.9
				LS3/WS1	7.6
				LS4	9.4
				LS4/WS1	0.2
				LS5	4.1
				Other	9.3
				Total	**271.9**
			Total		**414.6**
	Fen and Flush (PF)	PF1			1.2
		PF2			1.1
		PF2/HS3			0.3

		PF3			2.6
		Total			**5.2**
	Total				**419.8**
Woodland and scrub	Highly modified (WD)	WD2			1.4
		WD4			3.3
	Semi-natural (WN)	WN6			19.2
		WN7 (including 5.4 ha of 91D0)			160.5
	Scrub/transitional woodland (WS)	WS1			49.3
		WS2			7.6
		WS5			1.9
	Total				**243.2**
Grassland		GA1			18.1
		GS1			0.2
		GS1/WS1			1.0
		GS2			1.4
		GS3			4.8
		GS4			66.4
		GS4/WN7			1.5
	Total				**93.4**
Other		BL3			0.4
		BL3/GS1			1.0
		ED2			1.6
		FL1			1.6
		HD1			9.7
	Total				**14.3**
Total					**770.7**

Appendix 7 Indicative conservation rating of cutover bog habitat types

Cutover bog habitat types, their relationship with the Heritage Council (Fossitt, 2000) and Annex I schemes, and an indicative rating of the conservation importance of each habitat.

Cutover bog habitat code	**Main Heritage Council habitats**	**Potential links with EU Annex I habitats (* = priority type)**	**Indicative Conservation Value**
HS1	PB4	*Active raised bog (7110)	HIGH
HS2	PB4	*Active raised bog (7110)	HIGH
HS3	PB4 or PF2	Where birch regeneration is significant may develop towards the priority habitat *bog woodland (91D0)	HIGH
MS1	PB4		MODERATE
MS2	PB4	May develop towards the priority habitat *Active raised bog (7110)	MODERATE TO HIGH
MS3	PB4 or PF2	Where *Succisa pratensis* is present in significant numbers, it may be an important habitat for Marsh Fritillary (*Euphydryas aurinia*), listed on Annex II of the Habitats Directive.	MODERATE TO HIGH
MS4	PB4		MODERATE
MS5	PB4 or PF2	Where birch regeneration is significant may develop towards the priority habitat *bog woodland (91D0)	MODERATE TO HIGH
LS1	PB4		LOW
LS2	PB4	Transition mire (7140)	LOW TO HIGH
LS3	PB4 or PF2	Where *Succisa pratensis* is present in significant numbers, it may be an important habitat for Marsh Fritillary (*Euphydryas aurinia*), listed on Annex II of the Habitats Directive.	LOW TO HIGH
LS4	PB4 or GS4 or GM1 or PF3	Where *Succisa pratensis* is present in significant numbers, it may be an important habitat for Marsh Fritillary (*Euphydryas aurinia*), listed on Annex II of the Habitats Directive. Transition mire (7140)	MODERATE TO HIGH
LS5	PB4 or PF1	Alkaline fen (7230)	MODERATE TO HIGH
BP1	PB4		LOW
BP2	PB4		LOW
BP3	PB4		LOW