Plantecol Limited

Cloiche Wind Farm:

Habitat and vegetation survey and condition assessment of blanket bog and montane heath habitats

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CLOICHE WIND FARM: HABITAT AND VEGETATION SURVEY AND ASSESSMENT OF CONDITION OF THE BLANKET BOG AND MONTANE HEATH HABITATS

1. SUMMARY

1.1 Introduction

Plantecol Limited carried out a vegetation survey of the areas where an application for the 29 Turbine Proposed Development at Cloiche Wind Farm in the Monadhliath Mountains, Scotland. The survey was also designed to address the concerns and objections to the 36 Turbine Scheme made by NatureScot. This report is provided as Additional Information (AI) comprising a technical appendix to **Chapter 4 – Ecology (Volume 1)**.

1.2 Methods

The vegetation within a 50 m buffer zone around the proposed infrastructure was mapped by ecologists in early July 2021. A total of 166 sample plots (4m^2 quadrats) of the vegetation were taken at the locations for the proposed wind turbines and at 150m intervals along the route of the proposed tracks to characterise the vegetation. All species of plant, including mosses, easily identifiable liverworts and macrolichens were identified and the abundance of the four most abundant species assessed. These sample quadrats were grouped using a multivariate statistical program (TWINSPAN). The similarity of these groupings or clusters to the National Vegetation Classification was carried out using the Tablefit and MAVIS programs.

The condition of the blanket bog habitat was assessed using the Common Standards Monitoring (CSM) guidance for upland habitats (JNCC 2009). A method devised by Penny Anderson Associates (PAA) was also used to assess the likelihood that the blanket bog habitat was accumulating peat (see Appendix 2). In addition to these the presence or absence of an acrotelm in each quadrat was noted as well as whether the peat was more (deep peat) or less (shallow peat) than 50 cm thick.

The location of notable species of bog-moss, rusty bog-moss (*Sphagnum fuscum*) and Austin's bog-moss (*S. austinii*), and bushes of dwarf birch (*Betula nana*) was recorded whilst walking between sample plots and survey areas.

1.3 Results

The majority of the dry modified blanket bog in the survey area was of the heather – hare's-tail cotton-grass bog community (M19). As a good deal of this is on shallow peat, it should really be classed as wet heath rather than blanket bog habitat. There were also extensive areas of vegetation that occurred on both deep and shallow peat that could be classed as either the reindeer lichen (*Cladonia* spp.) sub-community of the deer-grass – hare's-tail cotton-grass (*Trichophorum germanicum* – *Eriophorum vagninatum*) blanket mire community or the

reindeer lichen sub-community of the deer-grass – cross-leaved heath (*Erica tetralix*) wet heath community. Much of this vegetation was classed as wet heath habitat.

The area of bog habitat within the 50 m buffer zone around all the proposed infrastructure was calculated to be 35%, whilst it composed about 61% of the area outside this but within the red line of the application. In contrast wet heath composed about 50% of the area within the 50 m buffer zone and 27% of the outside this but within the red line of the application.

All of the blanket bog habitat failed at least one of the CSM targets and consequently it should be regarded as in unfavourable nature conservation condition. The level of peat erosion was the main reason for its failures, but high levels of browsing on heather was also frequent. Whilst walking between sample plots along the route of the proposed wind farm track erosion features (gullies or haggs) were found to be present on average every 50 metres. As the drying out effect of these features can be expected to extend up to 15 metres either side, as estimated NatureScot (2019), over half of the blanket bog has been and continues to be dried out by the erosion. The cover of bog-moss is low, i.e. less than 25%, in 92% of the 166 quadrats.

The mean weighted cover of bare peat in the sample plots on deep peat was 17% whilst the same statistic for shallow peat was 13%.

Despite the level of erosion rusty bog-moss was found to be relatively frequent, and occurred on the edge of erosion features as well in areas of intact bog habitat. Austin's bog-moss was found at three locations (Figure 8). Bushes of dwarf birch were found at a total of seven locations, most of which were not on blanket bog habitat.

1.4 Conclusions

The blanket bog habitat within the red-line boundary of the proposed Cloiche Wind Farm is in poor nature conservation condition due mainly to the levels of erosion. The drying effect has resulted in a lower than expected cover of bog-mosses that are required to maintain a good quality bog habitat that is self-sustaining. The significant areas of bare peat also mean that much of the peatland is losing mass through microbial decomposition as well as losses of particulate and dissolved organic matter. Although areas that are being re-vegetated by cotton-grasses and other species of bog plant, it will take a long time for these areas to start accumulating peat if the water-table is not raised in these gullies and peat flats. In fact, many of the re-vegetated gullies have types of acid grassland vegetation that would not be considered to be capable of accumulating peat.

The drawing down of the water-table in the bog habitat immediately around the gullies and haggs for a distance of up to 15 metres, irrespective of whether the gullies have been re-vegetated, means that these areas will no longer be 'actively' accumulating peat. If anything they are likely to be losing mass as a consequence of the decomposition of the peat underlying the extant vegetation.

Whether the presence of rusty bog-moss, Austin's bog-moss and dwarf birch is sufficient to justify the blanket bog habitat as nationally important for its biodiversity is debateable. However, without appropriate restoration work to the bog habitat these notable species of bog-moss are unlikely to remain across this site in the long-term.

2. Introduction

2.1 Background

SSE Renewables (SSE) put in an application on behalf of SSE Generation Ltd. for a 36 turbine wind farm at Cloiche south east of Fort Augustus in May 2020. NatureScot's objected to this application on the basis of

a) "*significant adverse effects on the Wild Land Area 19" (Braeroy, Glenshirra and Creag Meagaidh*); and
b) "*significant adverse impacts on the nationally important carbon-rich soils, deep peat and priority peatland habitat which are present on the site*."

NatureScot "had not been able to identify any mitigation measures that would address the impacts leading to these objections."

In the Annex to the letter of the 24th September 2020 a number of issues were raised by NatureScot with respect to the application's Appraisal of Impacts on Habitats. These were divided amongst the following headings:

a) Carbon-rich Soils, Deep Peat and Priority Peatland Habitat
b) Proximity of the Monadhliath Special Area of Conservation (SAC) and Site of Special Scientific Interest (SSSI)
c) Appraisal of Impacts on Montane Heath
d) General Advice on Peatland

The objections and observations under a) were:

- "*the development site is dominated by nationally important carbon-rich soils, deep peat and priority peatland habitat, and most of it satisfies our criteria to be considered of National Interest. This is on account of the number of positive indicators and paucity of negative ones. There are also relatively frequent occurrences of Sphagnum fuscum and Betula nana, indicative of a relative absence of disturbance.*
- *although the area includes numerous erosion features, particularly gullies, these are largely revegetated and, on the basis of the evidence, are not having a significant effect on the species complement or habitat quality.*
- *the large majority of the habitat losses from the proposed development will be of nationally important, high quality priority peatland habitat.*
- *due to the prevalence of nationally important carbon-rich soils, deep peat and high quality priority peatland habitat on the site, micrositing, or removing a proportion of the turbines, is unlikely to change that outcome*
- *the compensatory restoration proposed is of an insufficient scale to offset the anticipated loss and damage to high quality priority peatland habitat. We consider that restoration on a sufficiently large scale is unlikely to be feasible at this site*."

Under b) the main objection was that "*A 50m buffer should be maintained between site infrastructure and the boundary of the SAC*."

Under c) the main objection was that "*Turbines and other infrastructure should be micro-sited to avoid the loss of any montane heath*." It was noted that turbine C25 is located in an area of montane heath.

In response to these objections to the 36 Turbine Scheme Plantecol Limited to conducted further survey and provided additional information on the habitats, vegetation and plant species present.

2.2 Aims

The aim of the survey was to provide information on the extent of the various habitats that would be potentially affected by the proposed wind farm. A secondary aim was to provide an objective assessment of the quality of the peatland and montane habitats that will be potentially affected by the proposed development. This secondary aim was to determine the frequency of target species identified by NatureScot as being indicative of blanket bog of potentially 'national interest'.

2.3 Objectives

To achieve these aims the following objectives are covered by this report:

a) an assessment of the extent of the habitats within the red line of the proposed development;
b) an assessment of the different plant communities present within the red line of the proposed development;
c) a detailed assessment of the extent and quality of the habitats and different vegetation types directly impacted and potentially impacted by the proposed development;
d) the frequency of *Sphagnum fuscum, S. austinii* and *Betula nana* within the area directly impacted by the proposed development;
e) the extent of erosion within areas of peatland habitats and its impact on the hydrology and consequent ability of the peatland to accumulate peat.

These objectives were addressed by carrying out a comprehensive habitat and vegetation survey of the areas of infrastructure and a buffer zone of 50 metres around these areas. This included sampling the vegetation at *a priori* locations and listing all species of plant present within them. These samples would inform the classification of the vegetation across the site in an objective way and in assessing the diversity and consequently quality of the blanket bog and montane heath habitats. The frequency of erosion features along a sample of the routes that are planned for the proposed wind farm tracks was also carried out. Notable species of plant or feature, e.g. flushes, were also recorded whilst walking between the sample plots along the route of the proposed wind farm tracks.

3. Methods

3.1 Pre-survey preparation

The areas which were to be surveyed were segmented prior to the habitat survey using publicly available digital imagery. Areas of apparently uniform colour and texture were separated from one another using the QGIS Geographical Imaging System (GIS) programme. These segments or polygons were then printed against maps with the Ordnance Survey (OS) 1:25,000 digital maps along with the areas of the 29 Turbine Proposed Development infrastructure that had a 50 metre buffer zone added around them.

To assess the extent and quality of the vegetation in the blanket bog, wet heath, montane heath and other habitats, the vegetation needed to be sampled in an unbiased way along the route of the proposed tracks and at the locations where wind turbines were likely to be built. In order to do this the composition of the vegetation was assessed in at least 150 sample quadrats measuring 2m x 2m ($4m^2$) at each of the turbine locations and at 150 metre intervals along the route of the proposed tracks between the turbines and other infrastructure. Because the pre-arrangement of sample quadrats using the QGIS program resulted in some quadrats being in close proximity to one another at junctions in the tracks a number of these were removed from the list of quadrats to be surveyed before the field survey. Figure 1 shows the location of the sample quadrats actually taken in the field.

3.2 Field Survey

Four ecologists (Dr Alistair Headley, Tom Edwards, Fraser Milne and Gus Routledge) carried out the survey at the optimum time for carrying out upland surveys, between the 5th and 9th July 2021. Visibility during the survey was good, with significant rain occurring on the afternoon of the 5th July.

The $4m^2$ sample quadrats were marked out using plastic rods or yellow webbing tapes strung around wooden posts. All species of vascular plant, moss, most easily identifiable liverworts (e.g. *Odontoschisma sphagnii, Mylia anomala* and *M. taylorii*) and fruticose lichens (e.g. *Cladonia*, *Cornicularia aculeata* and *Cetraria islandica*) were recorded. The four most abundant species of plant were given an estimated (by eye) cover value in one of the eight class intervals given in Table 1. Cover values given to any higher level of precision than this is unrealistic as it has been shown that there are very large variations between different surveyors in estimating the cover of dwarf-shrubs in the same plot (Hurford 2007).

The depth of peat in the quadrat was checked by pushing a threaded metal rod with a wooden t-bar fitted at the end. The length of the rod standing proud of the peat surface after being pushed down until it hit bedrock/mineral soil, was measured with a steel tape measure.

The acrotelm is characterised as an unhumified layer of plant litter and mosses that has a significantly lower bulk density than the underlying relatively humified peat that makes up the catotelm (see Figure 1 in Clymo 1984). The boundary between these two layers is characterised by an increased resistance needed to push in a wooden dowel or tape measure. A tape measure or ruler was used to measure the thickness of the dead leaf litter and moss layer if it was present.

The condition of the blanket bog or montane heath habitats were assessed at each of the quadrats that were within these habitats using the targets and attributes set out in the JNCC's

Common Standards Monitoring (CSM) guidance (JNCC 2009). This includes an assessment of the levels of browsing on heather and other ericaceous dwarf-shrubs as well as other indicators of the condition of the blanket bog habitat (see Appendix 1 for details). In addition, the likelihood that the blanket bog was either active, possibly active, potentially active or inactive, was determined using a method of assessment provided by Penny Anderson Associates (PAA). The scoring system devised by PAA is given in Appendix 2.

To assess the frequency of erosion gullies and haggs (peat cliffs) within the peatland, their location, extent and size was noted whilst walking between sample quadrats along the route of the proposed tracks. If any cushions of rusty bog-moss (*Sphagnum fuscum*) or Austin's bog-moss (*Sphagnum austinii*) or bushes of dwarf birch (*Betula nana*) were seen whilst walking between sample quadrats their location was noted.

Whilst walking along the route of the proposed tracks and in areas of larger infrastructure and borrow pits, the vegetation types within each of the pre-assigned polygons created from aerial imagery were noted by the surveyor. The plant communities were decided by reference to the species that are constants for a community, and the preferential species that are indicative of the sub-communities that may be present for a particular plant community. Not all areas of vegetation could be assigned to a sub-community. This was usually due to the low number of species present or the small area of the stand of vegetation. Assignment of stands of vegetation to a single community or sub-community is also not possible where there are ecotones, i.e. gradients in the species composition from one habitat type to another. Some of the polygon boundaries were altered, added or removed in the field by marking in pencil on paper copies of the maps printed at a scale of 1:10,000, or changing the polygon boundaries of the maps within the Qfield GIS program.

The survey of most of the wider area outside that directly or indirectly impacted by the proposed development was surveyed by Dr Headley by taking a structured walk through the areas and noting the various plant communities and habitats present within the pre-assigned polygons.

Habitats are defined by their abiotic and biotic characteristics. The habitat types were, therefore, assigned to each polygon on the basis of the hydrology, peat depth and structure of the vegetation as well as the type of the vegetation present. Peat depths of less than 0.5 m thickness are usually used to classify areas as wet heath habitat even if it has a type of blanket bog vegetation. This is because peat less than 0.5 m thick is sufficiently shallow for minerogenic ground-waters to affect the peat, and for the roots of certain species of wetland plant to reach to those depths. Similarly montane heath is defined by the presence of wind-clipped dwarf-shrubs, principally heather (*Calluna vulgaris*). Lichen-rich heaths can occur at sea-level, especially on acidic sand dunes. The sole use of vegetation types to define habitat types is an incorrect short-hand method. The Phase 1 Habitat Manual (JNCC 2010) states in the heading to the correspondence table (Appendix 8), between NVC communities and the different habitat types – 'This table is not definitive, but gives provisional guidance only. Few of the correspondences are exact and many NVC communities correspond to more than one Phase 1 category.'

Data was entered into the field on to tablets with Excel spreadsheets and Qfield for the polygon data.

3.3 Data Analysis

The polygons mapped and altered in the field were digitised using the QGIS programme. These were displayed using the ArcMap10 programme.

In order that sample quadrats were divided objectively into relatively uniform groups with respect to their species composition using the publicly available version of the TWINSPAN program[1]. This programme uses a complex numerical process that produces a hierarchical divisive classification of communities. It is based on progressive refinement of a single ordination axis obtained by correspondence analysis (CA) or detrended correspondence analysis (DCA), on a data matrix of the quadrats and species. The clusters were then compared to the published community and sub-communities in the National Vegetation Classification (NVC)[2] using both Tabletfit[3], which uses the cover and frequency of each species, as well as the MAVIS[4] programme using just the frequency of each species in each of the clusters. The frequency of species is traditionally grouped into 5 class intervals:

Constancy V = frequency of more than 80 to 100% of samples
Constancy IV = frequency of more than 60 to 80% of samples
Constancy III = frequency of more than 40 to 60% of samples
Constancy II = frequency of more than 20 to 40% of samples
Constancy I = frequency of up to 20% of samples

As the frequency, or more usually termed constancy, of species is in 5 intervals it is not advisable to compare the constancy of a cluster/grouping of quadrats on fewer than 5 sample quadrats. For this reason, several of the clusters that were immediately adjacent to one another in the hierarchical classification were grouped together where there was fewer than 5 quadrats in one of the clusters and where there was little difference in their species composition.

Similarities of 70% or more produced by either the Tablefit or MAVIS programs are considered to be very good, whilst similarities between 60 and 70% are considered to be good. Similarities of between 50 and 60% are considered to be poor. Any similarities of less than 50% were discarded.

[1] Available at: https://www.ceh.ac.uk/services/decorana-and-twinspan
[2] Rodwell, J.S. 1991 to 2000. *British plant communities. Volumes 1 to 5.* Cambridge University Press, Cambridge
[3] Available at: https://www.ceh.ac.uk/services/tablefit-and-tablcorn
[4] Available at: https://www.ceh.ac.uk/services/modular-analysis-vegetation-information-system-mavis

4. Results

4.1 Plant Community Classification

The analysis of the 166 quadrats taken across the site produced 27 clusters using the TWINSPAN program (Table 2). Some of these clusters/groupings were then merged to produce 14 clusters/groupings to provide a sufficient number of quadrats for subsequent analysis with the programs used for matching the clusters to the NVC communities. The programs that were used were Tablefit and the MAVIS programs (Table 3). The MAVIS program tended to produce higher similarities to the published NVC constancy tables than the Tablefit program (Table 3). In most cases they ranked the same community or sub-community as the best fit to the particular cluster/grouping that was analysed. The results of this analysis was then used to generate the constancy values for the quadrat data taken in this survey, which are presented in Tables 4 to 12. This work has produced 10 sub-communities from 7 communities in the area covered.

The assignment of clusters or groupings to particular NVC communities is not always clear-cut. The clusters 01001 and 0101 were initially assigned to the M17b community/sub-community (Table 3). However, surveyors assigned 35 of the 54 sample quadrats to the M15c community/sub-community. This was because the M17 vegetation type is not usually considered to be present at high altitudes and nor is it expected to be present on shallow peat (i.e. less than 50 cm thick). However, 35 of the 54 plots that were placed in the M17b community were on shallow peat. The M15 wet heath has cross-leaved heath (*Erica tetralix*) as one of its constant species, but this species is usually absent from wet heath at high altitudes, typically above 600 to 700 metres. The area surveyed is at an altitude between 640 to 790 metres above sea-level (asl). Consequently, the clusters 01001 and 0101 have been labelled as M17b/M15c (Table 8).

Using the MAVIS program cluster 1 is most similar to the U5 vegetation (Table 3). However, this is considered to be inappropriate as there are too many mire species present at high frequencies, such as the various species of *Sphagnum*; star sedge (*Carex echinata*); common sedge (*Carex nigra*) and marsh violet (*Viola palustris*), for it to be placed in an acid grassland community (Table 6). The M6bi community does have mat-grass (*Nardus stricta*) and sweet vernal grass (*Anthoxanthum odoratum*) present at constancy values of 4 and 3, respectively. This is why the quadrats in this cluster have been placed in the M6b community rather than in the mat-grass – heath bedstraw (U5) community.

The areas of montane heath is largely composed of the H13 heath community, which is characterised by wind-clipped heather and an abundance of reindeer lichens (Table 4). There are some patches of types of montane acid grassland within these areas which have U10 and U7 plant communities. These are mostly restricted to Meall Caca (Figure 2).

The range in estimated area for each plant community within the 50 metre buffer zone around the proposed Cloiche Wind Farm development is given in Table 14. Alongside this is the estimated area for each plant community outside the infrastructure 50m buffer zone, but within the red-line of the proposed development. The plant community assessed by the field surveyors to be most widespread across the area within the infra-structure and 50 m buffer zone and across the wider area was the M15 wet heath community. What has to be remembered is that this community type can be found on areas of deep peat, especially where the bog habitat has been degraded through drying out, heavy grazing and/or extensive

burning. The second and third most widespread communities are the M19 and M17 plant communities, which are typically found in bog habitats (Table 14). Again, these community types are not exclusive to bog habitats as they can occur on shallow peat, which would otherwise be classed as wet heath.

A number of plant communities were found within the infra-structure and buffer zone and wider survey area that were not covered by the quadrat samples. These far less widespread communities within the survey area are listed below:

- M2 (feathery bog-moss/flat-topped bog-moss) bog-pool community
- M4 (bottle sedge - flat-topped bog-moss) mire
- M10 (butterwort – dioecious sedge) mire
- M23 (soft rush – marsh bedstraw) rush-pasture
- M31 (alpine silverwort - cow-horn bog-moss) spring
- M32 (fountain apple-moss – starry saxifrage) spring
- H12 (heather – blaeberry) heath
- H14 (heather – woolly hair-moss) heath
- H20 (blaeberry – woolly hair-moss) heath
- U2 (wavy hair-grass) grassland
- U4 (sheep's fescue – common bent – heath bedstraw) grassland
- U5 (mat-grass – heath bedstraw) grassland
- U6 (heath rush – sheep's fescue) grassland
- U7 (mat-grass – stiff sedge) grass-heath
- U10 (stiff sedge – woolly hair-moss) moss-heath
- S9 (bottle sedge) swamp

4.2 Habitats

In the Phase 1 habitat manual, blanket bog habitat is distinguished from wet heath and other habitat types by the presence of at least 0.5 m of peat (JNCC 2010). On this basis 46% of the sample quadrats were in blanket bog habitat as these had peat more than 0.5 m deep. However, as the location of the sample quadrats were determined by the turbine and track layout, the interpolated peat depths generated by Penny Anderson Associates show that deep peat is widespread within the red line of the 29 Turbine Proposed Development (see Appendix 3). The planned location of the 29 Turbine Proposed Development is in areas which have generally shallower peat and for the most part avoids the areas of deeper peat.

The Phase 1 habitat manual considers modified bog to have much reduced cover or no cover of bog-mosses. However, it is not possible to assess in one visit to a site whether the cover of bog-moss has been reduced and there is no indication in the manual as to what would be considered to be a minimum cover of bog-moss for an area to be considered as unmodified bog. The extent of erosion, including gullies; haggs and bare peat flats, suggest that all of the blanket bog habitat within the 29 Turbine Proposed Development is modified, without any reference to the extent and diversity of the bog-moss cover. Certain plant communities or sub-communities are usually taken by many ecologists as being indicative of wetter or drier conditions on a bog. The M18 mire community and M2 bog pool community is usually taken as being indicative of a wet bog which is relatively unmodified. In the CSM guidance for lowland blanket bogs includes a target for feathery bog-moss (*Sphagnum cuspidatum*), which is the dominant bog-moss of the M2 bog-pool community, to be present in at least 10% of

quadrats for the blanket bog to be in favourable condition. Both the absence of the M18 vegetation and the very low frequency of the M2 bog-pool community at Cloiche suggest that the blanket bog habitat is modified and relatively dry. The presence of large areas of the M19 community are also indicative of a relatively dry blanket bog habitat.

The only significant difference between the Phase 1 habitat map produced for the EIA Report (April 2020) and the one mapped in this survey (see Figure 13) is in the interpretation of the level of modification of the blanket bog and the type of grassland in the stream valleys. Most of the blanket bog was mapped as unmodified bog, which in the context of the level of erosion and drying out seems a rather over-optimistic assessment.

The relatively high altitude of the site means that there is a greater frequency of rain-days (days with at least 1 mm rainfall) as well as a higher total rainfall than lower altitude sites with blanket bog habitat (Bosanquet 2015, Ratcliffe 1968). This means that there is the potential for the blanket bog at this site to support more species of bog-moss and a greater cover than equivalent blanket bog at lower altitudes with the same amount and severity of erosion.

Based on this survey, which was carried out in summer when the water-tables in bogs are at their lowest, it appears that about 46% of the area is dry modified blanket bog and only 9% is wet modified blanket bog (Table 15). Wet heath is the second most widespread habitat type covering about 32% of the whole area surveyed. The area of wet heath within the infrastructure of the proposed wind farm and 50 metre buffer zone is significantly higher at about 50%.

The grasslands along the stream valleys make a significant contribution to the area. These were mostly classed as marshy grasslands based on the high frequency and significant cover of sedges, cotton-grass and bog-mosses. In places these merge with acid grassland where the water-tables are presumably lower for longer.

The montane heath habitat only makes up 8.7 hectares (2.4%) of the area within the 50 m buffer zone around the proposed development, whilst it makes up about 63 hectares, or 3.8% of the total area within the red-line of the 29 Turbine Proposed Development (Table 15). Figure 5 shows the location of the H13 montane heath community and it shows that most of the montane heath is on Meall Caca and small mounds in the south of the survey area to the east of Lochan Iain.

4.3 Ground-water Dependent Terrestrial Ecosystems

Five flushes were found during the survey and these are shown in Figure 6 along with the areas of M6 vegetation types. The M32 and M10 flushes are highly dependent on ground-waters for their maintenance. The M10a flush was found in the western part of the survey area on the northern slopes of Carn nan Caorach. Two other flushes were apparently borderline between M31 and M10 and were in the same area. The M32 flushes were found in the eastern part of the site between Caochan Uchdach and Allt Mòr (Figure 6).

As mentioned above, the M6 type of mire was mostly found along the stream valleys intermixed with areas of U5 grassland and M20 vegetation. In these situations, the grasslands are in the flood-plain of the streams. For most of the time their water supply will be coming from surface waters draining off the surrounding peatlands on to the peaty-mineral substratum that these types of mire and grassland communities are growing in. During storm events they are likely to be inundated by the streams over-flowing their banks.

4.4 Frequency and variety of bog-mosses (*Sphagnum*)

The sample quadrat data provides an objective assessment of the frequency and number of species of bog-moss present within the footprint of the proposed development (Table 16). The analysis separated the quadrats on deep peat from those on shallow peat. Bog-mosses are generally more frequent in the areas of deep peat, with about two-thirds of the plots with one or more species present being on deep peat. About half the plots on shallow peat have at least one species of bog-moss. There is, however, very little difference in the overall cover of the bog-mosses between the plots on shallow peat and those on deep peat, with both categories having a bog-moss cover of less than 10% in three-quarters of the plots (Table 16). Only 9% (seven plots) had a bog-moss cover greater than 25% in the areas of deep peat (Table 16). Figure 7 shows the cover and number of bog-mosses in each quadrat taken across the survey area.

A total of 13 species of bog-moss were recorded in the 166 sample quadrats (Table 16). *Sphagnum capillifolium* is the most frequent species, which was nearly as frequent in the quadrats on shallow peat as the deep peat. *Sphagnum papillosum* was the next most frequent species of bog-moss and it was generally more frequent on the deep peat (Table 16). Quadrats typically had only one or two species of bog-moss where at least one species was present (Table 16). This is a low level of diversity for bog-mosses.

The rarer species of bog-moss, Austin's bog-moss (*Sphagnum austinii*) and rusty bog-moss (*Sphagnum fuscum*), occurred in one and two sample quadrats, respectively. Rusty bog-moss is relatively frequent throughout the area surveyed and one or more cushions of this moss were found at 79 different locations (Table 23 and Figure 8). Austin's bog-moss was found at three different locations, one of which was in one of the sample quadrats. The cushions of this moss were widely scattered throughout the survey area (Figure 8).

4.5 Notable vascular plant species

Figure 8 shows the locations where certain notable species of vascular plant were found. None of the species of vascular plant are considered to be nationally scarce as they occur in at least a hundred 10km x 10km OS grid squares or hectads.

Dwarf birch (*Betula nana*) was found at seven locations in this survey (Table 23). Four of the locations were to the west of Sidhean Dubh na Cloiche Bàine in the south-west corner of the survey area (Figure 8). A group of about 12 small dwarf birch plants were found at the foot of the ridge that runs down between the River Tarff and the Min Choire in the south-west corner of the survey area (Figure 8). One plant was found on the ridge to the south-east of Meall Caca and a group of three or four plants just to the north of Carn Fraoich in the far south-east corner of the survey area (Figure 8). Apart from the location at Carn Fraoich, nearly all the plants of dwarf birch are in areas of shallow peat (Mott MacDonald 2020).

Small cranberry (*Vaccinium microcarpum*) was found at two locations along the transects that were surveyed.

Alpine bearberry (*Arctostaphylos alpinus*) was found at the north end of Meall Caca well away from the area of the proposed infrastructure (Figure 8).

Dwarf cornel (*Cornus suecica*) was found in an area of bog at the eastern end of the survey area.

4.6 Extent and frequency of bare peat and erosion

Forty six percent of the 166 sample quadrats had peat depths greater than 50 cms (Table 17). There was a slightly higher frequency of bare peat in the quadrats taken on shallow peat than the deep peat (Table 17). However, the areas of deep peat had on average a higher cover of bare peat with proportionally more plots with a greater area of bare peat.

Gullies are relatively frequent throughout the areas of blanket bog habitat, with on average 0.9 gullies present per 100 metre of transect walked (Table 18). They were typically 3 metres wide and just over a metre deep (Table 18). Some gullies were over 5 metres wide. Peat haggs were also relatively frequent at 0.3 haggs per 100m of transect, excluding 22 hectares of complex hagging. This does not include areas of complex hagging recorded by the surveyors whilst walking the transects. When the area of these areas of complex hagging are taken away from the length of the transect walked the average distance between the erosion features is 51 metres.

4.7 Condition of blanket bog and alpine dwarf-shrub heath habitats

The results of the assessment of the condition of the blanket bog habitat using the CSM guidance (JNCC 2009) has shown that the blanket bog habitat is in poor condition as it failed at least one of the 13 targets at all 77 plots that were located on deep peat (Table 19). The majority of the plots failed two targets or more (Table 19). All plots failed on the extent of erosion exceeding re-deposition and/or re-vegetation of bare peat, whilst the browsing of heather was above the trigger threshold at nearly two-thirds of the plots (Table 19). Other targets where the blanket bog failed include a lack of a sufficient cover of positive indicator species and number of positive indicator species (Table 19).

Despite some of the plots being in poor condition, 44 (57%) of the 77 plots had some acrotelm present (Table 21). The acrotelm was not usually present across all of the $4m^2$ plot and was typically restricted to where there was some *Sphagnum*. There is no obvious spatial distribution in the plots with or without an acrotelm (Figure 11).

The likelihood that the bog was active, possibly active, potentially active, or inactive was assessed using the method of PAA (see Appendix 2). This showed that at 48 (62%) of the 77 blanket bog plots were inactive and at 27 (35%) of the remaining 29 blanket bog plots were only ‘potentially active’ (Table 20). Only at one of the 77 plots was the blanket bog habitat assessed to be active and one to be ‘possibly active’, as they scored 4 and 3, respectively on the scale devised by PAA. At one of the 89 quadrats on shallow peat, the wet heath habitat was assessed as ‘possibly active’ (Table 20).

Two of the five sample quadrats taken from the alpine dwarf-shrub heath habitat passed all nine of the targets, but three of the plots failed on the browsing of the heather being above the threshold of a third of the long shoots being browsed (Table 22).

5. Interpretation and Discussion

5.1 The extent of the habitats

The Phase 1 manual separates bog habitat from other mire communities on the presence of at least 0.5 m of peat and it being dependent wholly on rain for its supply of water and consequently nutrients. However, many ecological surveyors use the presence of bog type vegetation as a short-hand determination of the presence of blanket bog habitat. Calow (1998) notes that 'habitat and vegetation classifications may be concordant, but are not always so'. The over-simplistic use of vegetation types to classify areas in terms of habitats is illustrated within the survey area where three of the nine plots assigned to the M15b wet heath community were on peat that was over 0.5 m thick. Conversely 39% of the 62 sample plots with M19 bog community were found on shallow peat and only five of the 12 plots with the M17c bog community were on deep peat. Of the 53 plots placed in the M17b community only 34% were on deep peat. Therefore, the extent of the bog communities over-estimates the true extent of the blanket bog habitat, which is probably less than that suggested by the number of sample plots/quadrats placed in the types of bog community, or by the extent to which the bog community types were mapped by the field surveyors. Figure 13 shows the extent of the bog and wet heath communities across the area that was determined in this survey. Much of the area is a mosaic of these two habitats, as a consequence of erosion resulting in areas of wet heath habitat interspersed within the blanket bog habitat.

The interpolated peat map shown in Appendix 3 of **Technical Appendix 4.2** (prepared by PAA) shows that there are significant areas of shallow peat in the area to the south-east of the Glen Doe Reservoir where much of the wet heath habitat was mapped in this survey. Deep peat covers virtually all of the area to the north of the main track and north-east of the Glen Doe Reservoir (see peat depth map in Appendix 3 of **Technical Appendix 4.2**). The few differences in the mapping of the habitats by Ramboll (2019) and in this survey are partly due to the interpretation of the Phase 1 manual. Cherrill & McClean (1999) have shown that the consistency in ecological surveyors in mapping habitats at an upland farm in Northumberland was poor. They found that the highest between two surveyors 39%, whilst the average level of consistency between all surveyors was 26% (Cherrill & McClean 1999). Taking into account mapping errors improved consistency by only a few percent. Therefore, on average there is less than a one in three chance of two ecologists independently mapping the same area as the same habitat type.

The widespread occurrence and high density of erosion gullies and peat haggs across the survey area suggests that all of the blanket bog is modified. The Phase 1 uses the cover of bog-mosses as a method for separating modified from unmodified bog. The results of this survey suggests that the cover of bog-mosses is for the most part between 1% and 5% for the areas of deep peat that were sampled (Table 16). The Phase 1 habitat manual places the M17 community in the unmodified type of blanket bog in its correspondence table (Appendix 8). In fact much of the apparent M17 vegetation at the 29 Turbine Proposed Development is on thin peat and/or eroding blanket bog.

Placing all of the stands of M6 vegetation into acid flush category of habitat is not necessarily correct. The M6 vegetation in the stream valleys were not continually flushed with acidic ground-waters. Where the vegetation was located on the flood-plains of the streams they are in a topogenous type of mire rather than a soligenous setting. Therefore, in this situation they

should be classed as marshy grassland rather than as acid flush or acid grassland. However, where the M6 vegetation is being flushed by ground-water seepages within the blanket bog and wet heath habitats they are ground-water dependent.

5.2 Assigning plant communities

The assigning of plant communities to stands of vegetation is fraught with difficulties. The use of the NVC for the classification is dependent on the method used to devise this classification system. The NVC is based on sample quadrats taken by many researchers and academics across Britain who chose the placing of samples of vegetation largely on what they thought were homogenous stands of vegetation. This sampling is in part biased by the researchers pre-conceived ideas and expectations as to what groupings of vegetation were present in the study area or type of habitat. The construction of the classes of vegetation by Rodwell *et al.* at Lancaster University was carried out in an objective manner using the DECORANA and TWINSPAN programs. However, this method generated classes which are mainly based on their floristic composition rather than on which species of plant dominate the vegetation. Averis *et al.* (2004) have subsequently re-interpretated the NVC classification for upland habitats. This illustrated re-interpretation, however, largely uses the balance in the abundance of the component species of plant. Only a cursory examination of the constancy tables in the 5 volumes of the NVC soon reveals that the abundance of the constant species in the vast majority of the communities or sub-communities can vary from less than 1% cover to 100%.

It is no surprise that the consistency of field surveyors in mapping plant communities is low and this was found to be the case in a study by Hearn *et al.* (2011) where several ecologists were asked to map exactly the same area of upland vegetation in Snowdonia. In this study Hearn *et al.* (2011) found that on average there was only a consistency of 34% in mapping vegetation to the same plant community type. At the sub-community level the consistency between surveyors was on average only 19%. The highest level of agreement between two individual surveyors was 67% at the community level without adding a 5 m buffer to the mapped polygons. As with the mapping of habitats there is a low likelihood that two maps of plant community types will correspond closely.

The use of objective sampling of the vegetation, as carried out in this survey, shows that many plant community types are not clearly separated from one another. The problem with the separation of the M17b and M15c community types illustrates this. In addition, many quadrats that fell in some areas dominated by heath rush (*Juncus squarrosus*) were placed by the field surveyors in the heath rush – heath bedstraw (*Galium saxatile*) grassland (U6). All seven of these quadrats were, however, subsumed into 3 other plant communities (M19, M17 and M15) using the TWINSPAN, Tablefit and MAVIS programs.

5.3 The condition and quality of the habitats

The quality of the habitats is not only governed by the species of plant that are present, but whether the habitat is a self-sustaining ecosystem that has a long-term future in its current state and management. The blanket bog at the 29 Turbine Proposed Development in its current state does not have a long-term future without some significant restoration work. This is because the habitat is gradually being eroded and wasted away through microbial oxidation of the peat, even under an intact layer of vegetation. This occurs where the water-table is reduced below the surface of the peat. The IUCN Peatland Code puts numbers to the rate at which bogs emit greenhouse gases in different conditions. Actively eroding bogs were

estimated to emit 23.8 tonnes of carbon dioxide equivalents per hectare per year (tCO_2e/ha/yr), whilst drained bogs were considered to emit 4.5 tCO_2e/ha/yr (Peatland Code, 2017).

The CSM guidance was devised to inform the management requirements for protected sites across the UK. The condition assessments of the blanket bog at the locations with deep peat show that the habitat is in poor condition. This is mainly due to the presence of significant areas of erosion. The results of this survey suggests that bare peat accounts for somewhere in the region of 17% of the blanket bog habitat (Table 17). The analysis by PAA of aerial imagery taken before the construction of the Stronelairg Wind Farm (see Bare Peat Map in Appendix 3 of **Technical Appendix 4.2**) shows that bare peat is widespread and very significant. Not all areas of bare peat are necessarily eroding, but they will still be losing mass and therefore emitting carbon dioxide through microbial decomposition processes.

The erosion gullies also dry out the adjacent blanket bog habitat. Estimates of the drying zone around the gullies varies, but the Peatland Action guidance indicates that the blocking of gullies will result in re-wetting of the surrounding peatland for distances of up to 15 metres either side of the gully (NatureScot, 2019). Given that this study found that there is an average distance of about 50 metres between erosion features, this suggests that at least half of all of the peatland has potentially dried out at the surface in this way. If the peatland is left in its current state it will carry on losing mass, even under an intact bog vegetation, and consequently the depth of peat will be reduced gradually over time.

5.4 Notable and indicator species of condition

NatureScot have provided guidance for their staff on when wind farm and other energy developments are likely to have a significant impact on peatland habitats. In Annex C of this guidance there is a decision-tree and list of criteria for deciding when an area of peatland is likely to be of ‘national interest’.

Although there are no drains or peat cuttings, the peatland at the 29 Turbine Proposed Development is heavily drained through an extensive network of gullies and peat haggs.

The plant species indicative of peat formation capability would mostly be the various species of bog-moss and hare’s-tail cotton-grass. They are present, but in limited in quantity and extent. Using the PAA criteria the principal peat forming bog-mosses are only at sufficient abundance in 36, or 22% of the 165 quadrats assessed. Hare’s-tail cotton-grass is more widespread, but it is not particularly abundant, with it being present at a cover of 5% or more in only 62 (37%) of the same 165 quadrats.

There is no natural surface patterning of the bog due to the extensive erosion. There has clearly been significant disturbance in the past, almost certainly through high densities of sheep and deer, to result in the peat erosion.

An absence of invasion by woodland or scrub at such a high altitude site as the 29 Turbine Proposed Development is hardly an applicable criteria to use. In fact most bogs are very unlikely to have invasion by trees and shrubs due to the levels of grazing in the uplands of Scotland.

There is nothing in the selection criteria for biological Sites of Special Scientific Interest as to how much bog-moss cover is required or how many species need to be present for an area of

bog to be considered *Sphagnum*-rich (Nature Conservancy Council 1989). However, the CSM guidance for lowland raised bogs and lowland blanket bogs gives a target of at least two of the following species of bog-moss to be present at a frequency of at least 60% and to have a combined cover of at least 20%: *S. capillifolium, S. magellanicum, S. papillosum* and *S. tenellum.* An analysis of the data collected from the quadrats on deep peat gives a maximum possible average combined cover of these species of bog-moss of 8.4%. As mentioned above, *S. capillifolium* is the most common bog-moss at the 29 Turbine Proposed Development, but it only has a frequency of 42% in the areas of deep peat. Based on these criteria, the bog-moss cover is neither extensive, nor is it particularly species-rich.

Austin's bog-moss is possibly more exacting in its requirement for significantly wet bogs. However, the climate associated with the high altitude nature of the 29 Turbine Proposed Development site, which results in a greater frequency of rain-days (Bosanquet 2015, Ratcliffe 1968), means that this species may be able to persist on an eroded blanket bog habitat that would not normally be able to support this species at lower elevations where the climate is not so wet and cloudy.

Where micro siting of tracks and other wind farm infrastructure is feasible, it could be possible to avoid, or minimise impacts upon, specific locations with dwarf birch and Austin's bog-moss. Rusty bog-moss is sufficiently frequent across the site that the loss of a few hummocks of this species due to construction work, that their loss would not significantly affect the size of the population of this moss at the 29 Turbine Proposed Development. To put the impact of the proposed development into context, the single biggest threat to the bog-mosses at the 29 Turbine Proposed Development is the continued erosion of the blanket bog habitat.

5.5 Ground-water dependent terrestrial ecosystems

Where micro-siting of tracks and other wind farm infrastructure is feasible, it could be possible to avoid, or minimise impacts upon, the M32 and M10 flushes that were found in this survey and those identified in the survey by Ramboll (2019).

Although the M6 vegetation is considered to be indicative of a wetland ecosystem highly dependent on ground-waters, the hydro-ecological setting of the river valley situations suggests otherwise. In this situation the M6 vegetation is in a topogenous mire rather than a soligenous mire and is therefore not dependent on ground-waters, but on surface waters.

6. References

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7. Tables

Table 1. *The class intervals used for assessing the proportion of a polygon or quadrat occupied by the component plant communities or species of plant.*

Cover range	Domin	Braun-Blanquet	**Cover range**	**Scoring in this study**
91–100%	10	5	**95 – 100%**	**8**
76–90%	9		**75 – 95%**	**7**
51–75%	8	4	**50 – 75%**	**6**
34–50%	7	3	**25 – 50%**	**5**
26–33%	6		**10 – 25%**	**4**
11–25%	5	2	**5 – 10%**	**3**
4–10%	4		**1 – 5%**	**2**
<4% (many individuals)	3	1	**<1%**	**1**
<4% (several individuals)	2	+		
<4% (few individuals)	1	Rare		

Table 2. *List of quadrats that were grouped into the various clusters generated using the TWINSPAN program using the default settings.*

Cluster	0000	167																	
	00010	29	154																
	000110	15	32	35	56	63	64	65	67	69	84	86	124	132	133	134	140	141	
		143	148	150	152	153	157	162	163	166	168	173	174						
	000111	37	125	130	146	147	158												
	001000	26	43	51	52	73	93	95	102	105	108	149							
	001001	FM11	22	38	66	85	103	116	144	155	156								
	001010	24	34	77	88	117	135												
	001011	25	89																
	001100	7	TE17	54	137	169	178												
	001101	170																	
	001110	75	TE202	TE203	TE204														
	001111	138																	
	010000	33	55	87	120	164													
	010001	2	20	74	97	110	111	122											
	010010	GR16	GR17	41	42	57	96	106	107	151									
	010011	6	40	44	59	71	91	100	114	177									
	010100	1	9	FM10	TE10	TE11	FM12	TE12	13	14	27	28	30	31	45	47	48	50	61
		68	78	79	83	98	113	115	118	121	123	128	131	139	172	175			
	010101	21	142																
	01011	136																	
	011000	8	36																
	011001	5	TE16	46	60														
	01101	82	129	165															
	011100	3	90	99	126														
	011101	161																	
	01111	94	101																
	10	49	58	FM200	AH201														
	11	72																	

Table 3. *Results of use of Tablefit and MAVIS analysis of data within the clusters generated using the TWINSPAN program. Alphanumeric codes are those used in the National Vegetation Classification (NVC). Similarities between 50 and 60% similarity are considered as poor levels of similarity, whilst similarities between 60 and 70% are considered as good. n = number of quadrats. Cells highlighted in yellow are the communities/sub-communities assigned to the clusters.*

Cluster	n	Method	Highest		2nd Highest		3rd Highest	
			NVC	% similarity	NVC	% similarity	NVC	% similarity
00010	2	Tablefit	M19	56	M19c	50	M19a	47
		MAVIS	M19a	56	M17c			
000110	17	Tablefit	M19c	64	M19b	56	M19a	55
		MAVIS	M19	71	M19c	68	M19b	67
000111	6	Tablefit	H12b	58	H12	58	M17c	56
		MAVIS	M19a	65	M19	64	M19c	64
001000	11	Tablefit	M20b	61	M20	56	M19	54
		MAVIS	M17b	55	M19a	51	M19	50
001001	10	Tablefit	M19	72	M19c	69	M19a	62
		MAVIS	M19a	61	M19	60	M19c	56
00101	8	Tablefit	M19c	57	M19	53	M18b	47
		MAVIS	M19c	55	M17b	54	M19	54
00110	7	Tablefit	M19c	48	H10b	48	H112	45
		MAVIS	M19c	60	M19	57	U7	51
00111	5	Tablefit	H13a	77	H17	73	H10b	52
		MAVIS	H13	61	U10b	61	H13b	60
01000	12	Tablefit	M17c	54	M17	51	M17b	48
		MAVIS	M17	74	M17c	68	M17a	67
01001	18	Tablefit	M17b	49	H10b	39		
		MAVIS	M17b	58	M17	53	M17a	51
0101	35	Tablefit	M17b	59	M16d	51	H10b	51
		MAVIS	M17b	65	M17	62	M15c	59
0110	9	Tablefit	M7	27	M6	26	M17c	24
		MAVIS	M15	56	M15b	55	M17	54
0111	7	Tablefit	M3	63	M2	57	M2b	30
		MAVIS	M20	41	M20a	40	M3	39
1	5	Tablefit	M6b	50	M6	46	U5b	36
		MAVIS	U5	57	U5a	56	U5b	54

Table 4. *Constancy table for 5 sample quadrats assigned to the heather – reindeer lichen (*Calluna vulgaris – Cladonia arbuscula*) heath,* Cladonia arbuscula – Cladonia rangiferina *sub-community (H13a).*

	Frequency	Range in cover (%)
all species of *Sphagnum*	0	0
all ericoids	100%	10 - 75
all graminoids	100%	<1 - 5
bare peat	80%	0 - 5
Species	Constancy	
Calluna vulgaris	5	10 - 75
Carex bigelowii	5	<1
Cetraria islandica	5	<1
Cladonia arbuscula	5	1 - 25
Cladonia portentosa	5	<1 - 25
Cladonia uncialis	5	<1 - 25
Empetrum nigrum	5	1 - 25
Racomitrium lanuginosum	5	5 - 50
Deschampsia flexuosa	4	<1
Vaccinium myrtillus	4	<1
Vaccinium vitis-idaea	4	<1
Cladonia rangiferina	2	<1 - 5
Diphasiastrum alpinum	2	<1
Cladonia spp.	1	<1
Cornicularia aculeata	1	<1
Festuca ovina	1	<1
Huperzia selago	1	<1
Hypnum jutlandicum	1	<1
Juncus trifidus	1	<1
Nardus stricta	1	<1
Pleurozium schreberi	1	<1
Salix herbacea	1	<1
Trichophorum germanicum	1	<1

Table 5. *Constancy table for 7 sample quadrats assigned to the common cotton-grass (*Eriophorum angustifolium*) bog pool community (M3).*

	Frequency	Range in cover (%)
all species of *Sphagnum*	29%	0 - 1%
all ericoids	14%	0 - 1%
all graminoids	100%	<1 - 95%
bare peat	100%	5 - 100%
Species	Constancy	
Eriophorum angustifolium	5	<1 - 95
Eriophorum vaginatum	3	<1 - 10
Trichophorum germanicum	3	<1 - 5
Calluna vulgaris	1	<1
Campylopus flexuosus	1	<1
Cladonia uncialis	1	<1
Cladonia spp.	1	<1
Huperzia selago	1	<1
Juncus bulbosus	1	<1
Sphagnum capillifolium	1	<1
Sphagnum denticulatum	1	<1

Table 6. *Constancy table for 5 sample quadrats assigned to the star sedge – bog-moss (*Carex echinata - Sphagnum recurvum/auriculatum*) mire, flat-topped (*Sphagnum recurvum*) bog-moss variant of the common sedge – mat-grass sub-community (M6bi).*

	Frequency	Range in cover (%)
all species of *Sphagnum*	60%	<1 - 100
all ericoids	0%	
all graminoids	100%	25 - 100
bare peat	20%	0 - 1
Species	Constancy	
Galium saxatile	5	<1 - 10
Luzula multiflora	5	<1 - 5
Anthoxanthum odoratum	4	<1 - 25
Nardus stricta	4	<1 - 25
Rhytidiadelphus squarrosus	4	<1 - 95
Viola palustris	4	<1 - 25
Carex echinata	3	5 - 95
Carex nigra	3	<1 - 95
Deschampsia flexuosa	3	<1 - 25
Potentilla erecta	3	<1 - 10
Carex binervis	2	<1 - 5
Hylocomium splendens	2	<1 - 50
Pleurozium schreberi	2	1 - 10
Polytrichum commune	2	<1 - 5
Sphagnum capillifolium	2	1 - 10
Sphagnum fallax	2	5 - 10
Agrostis vinealis	1	<1
Atrichum undulatum	1	1 - 5
Deschampsia cespitosa	1	1 - 5
Eriophorum angustifolium	1	5 - 10
Eriophorum vaginatum	1	<1
Festuca ovina	1	<1
Festuca vivipara	1	<1
Juncus bulbosus	1	<1
Molinia caerulea	1	10 - 25
Ranunculus repens	1	<1
Sphagnum papillosum	1	25 - 50

Table 7. *Constancy table for the 9 sample quadrats assigned to the deer-grass – cross-leaved heath (*Trichophorum germanicum – Erica tetralix*) wet heath community, typical sub-community (M15b).*

	Frequency	Range in cover (%)
all species of *Sphagnum*	100%	0 - 95%
all ericoids	100%	0 - 25%
all graminoids	100%	1 - 95%
bare peat	89%	0 - 100%
Species	Constancy	
Eriophorum angustifolium	5	<1 - 25
Calluna vulgaris	4	<1 - 25
Carex echinata	4	<1 - 5
Eriophorum vaginatum	3	<1 - 10
Juncus bulbosus	3	<1 - 5
Juncus squarrosus	3	1 - 95
Nardus stricta	3	1 - 25
Sphagnum subnitens	3	<1 - 10
Campylopus flexuosus	2	<1
Deschampsia flexuosa	2	<1
Huperzia selago	2	<1
Narthecium ossifragum	2	<1
Sphagnum capillifolium	2	<1 - 10
Sphagnum papillosum	2	1 - 50
Trichophorum germanicum	2	<1
Viola palustris	2	<1
Aulocomnium palustre	1	<1
Carex demissa	1	<1
Carex panicea	1	<1
Carex viridula	1	<1
Empetrum nigrum nigrum	1	<1
Galium saxatile	1	<1
Hypnum jutlandicum	1	<1
Juncus articulatus	1	<1
Molinia caerulea	1	<1
Polytrichum commune	1	<1
Potentilla erecta	1	<1
Sphagnum denticulatum	1	<1
Sphagnum fallax	1	<1
Sphagnum magellanicum	1	<1
Sphagnum palustre	1	<1
Sphagnum rubellum	1	<1
Sphagnum tenellum	1	<1

Table 8. *Constancy table for the 53 sample quadrats that could be assigned to the reindeer lichen (*Cladonia*) sub-community (M17b) of the deer-grass – hare's-tail cotton-grass (*Trichophorum germanicum – Eriophorum vagninatum*) blanket mire community, or to the reindeer lichen sub-community of the deer-grass – cross-leaved heath wet heath community (M15c).*

	Frequency	Range in cover (%)
all species of *Sphagnum*	40%	0 - 25
all ericoids	92%	<1 - 50
all graminoids	92%	<1 - 95
bare peat	68%	0 - 95
Species	Constancy	
Calluna vulgaris	5	<1 - 50
Cladonia portentosa	5	<1 - 50
Cladonia uncialis	5	<1 - 25
Racomitrium lanuginosum	5	<1 - 25
Trichophorum germanicum	5	<1 - 95
Eriophorum angustifolium	4	<1 - 10
Cladonia arbuscula	3	<1 - 50
Huperzia selago	3	<1
Juncus squarrosus	3	<1 - 75
Molinia caerulea	3	<1 - 50
Narthecium ossifragum	3	<1 - 50
Cetraria islandica	2	<1 - 5
Eriophorum vaginatum	2	<1 - 50
Hypnum jutlandicum	2	<1
Potentilla erecta	2	<1 - 10
Sphagnum capillifolium	2	<1 - 50
Agrostis vinealis	1	5 - 10
Campylopus flexuosus	1	<1
Carex bigelowii	1	<1
Carex demissa	1	<1 - 5
Carex echinata	1	<1
Carex nigra	1	5 - 10
Carex panicea	1	<1 - 5
Cladonia rangiferina	1	<1
Cladonia spp.	1	<1 - 5
Cornicularia aculeata	1	<1
Ctenidium molluscum	1	<1
Deschampsia flexuosa	1	1 - 5
Dicranum scoparium	1	<1
Empetrum nigrum	1	<1
Erica tetralix	1	<1
Euphrasia sp.	1	<1
Hylocomium splendens	1	<1 - 10
Juncus bulbosus	1	<1

	Frequency	Range in cover (%)
Leontodon autumnalis	1	<1
Mylia anomala	1	<1
Mylia taylorii	1	<1
Nardus stricta	1	<1 - 10
Pinguicula vulgaris	1	<1
Pleurozia purpurea	1	<1
Pleurozium schreberi	1	<1
Polygala serpylifolia	1	<1
Polytrichum commune	1	5 - 10
Polytrichum juniperinum	1	<1
Polytrichum strictum	1	<1
Ptilidium ciliare	1	<1
Rhytidiadelphus loreus	1	<1
Scorpidium revolvens	1	<1
Selaginella selaginoides	1	<1
Sphagnum compactum	1	<1
Sphagnum denticulatum	1	<1
Sphagnum papillosum	1	<1 - 5
Sphagnum subnitens	1	<1
Sphagnum tenellum	1	<1
Vaccinium myrtillus	1	<1
Vaccinium uliginosum	1	<1
Warnstorfia sarmentosa	1	<1

Table 9. *Constancy table for the 12 sample quadrats assigned to the deer-grass – hare's-tail cotton-grass (*Trichophorum germanicum – Eriophorum vagninatum*) blanket mire community, heath rush - little shaggy-moss (*Juncus squarrosus - Rhytidiadelphus loreus*) sub-community (M17c).*

	Frequency	Range in cover (%)
all species of *Sphagnum*	92%	0 - 100
all ericoids	100%	1 - 25
all graminoids	100%	10 - 100
bare peat	50%	0 - 95
Species	Constancy	
Calluna vulgaris	5	<1 - 25
Eriophorum angustifolium	5	<1 - 25
Sphagnum papillosum	5	<1 - 50
Trichophorum germanicum	5	1 - 75
Molinia caerulea	4	<1- 10
Narthecium ossifragum	4	<1- 10
Eriophorum vaginatum	3	<1 - 75
Potentilla erecta	3	<1 - 5
Racomitrium lanuginosum	3	<1
Sphagnum rubellum	3	<1- 10
Carex echinata	2	<1
Carex nigra	2	<1
Cladonia portentosa	2	<1
Cladonia uncialis	2	<1
Hypnum jutlandicum	2	<1 - 5
Juncus squarrosus	2	<1
Rhytidiadelphus loreus	2	<1
Sphagnum capillifolium	2	<1 - 50
Sphagnum subnitens	2	<1 - 95
Aulocomnium palustre	1	<1
Carex panicea	1	<1
Cladonia spp.	1	<1
Drosera rotundifolia	1	<1
Empetrum nigrum nigrum	1	<1
Erica tetralix	1	<1
Euphrasia sp.	1	<1
Galium saxatile	1	<1
Huperzia selago	1	<1
Hylocomium splendens	1	10 - 25
Juncus bulbosus	1	1 - 5
Nardus stricta	1	<1
Odontoschisma sphagnii	1	<1
Pinguicula vulgaris	1	<1
Pleurozium schreberi	1	<1
Pleurozia purpurea	1	<1

	Frequency	Range in cover (%)
Polygala serpylifolia	1	<1
Polytrichum commune	1	<1
Ptilidium ciliare	1	<1
Sphagnum fallax	1	<1
Sphagnum fuscum	1	<1
Sphagnum tenellum	1	<1
Viola palustris	1	<1

Table 10. *Constancy table for the 6 sample quadrats assigned to the heather – hare's-tail cotton-grass (*Calluna vulgaris – Eriophorum vagninatum*) blanket mire community, crowberry (*Empetrum nigrum*) sub-community (M19b).*

	Frequency	Range in cover (%)
all species of *Sphagnum*	83%	1 - 50
all ericoids	100%	5 - 75
all graminoids	100%	10 - 95
bare peat	17%	0 - 50
Species	Constancy	
Calluna vulgaris	5	10 - 25
Cladonia portentosa	5	<1 - 25
Empetrum nigrum	5	<1 - 10
Hylocomium splendens	5	<1 - 10
Hypnum jutlandicum	5	<1 - 10
Juncus squarrosus	5	5 - 50
Pleurozium schreberi	5	<1 - 25
Rhytidiadelphus loreus	5	<1 - 5
Vaccinium myrtillus	5	<1 - 10
Racomitrium lanuginosum	4	<1 - 10
Trichophorum germanicum	4	10 - 25
Dicranum scoparium	3	<1
Eriophorum angustifolium	3	<1
Eriophorum vaginatum	3	<1 - 25
Sphagnum capillifolium	3	<1 - 10
Cladonia arbuscula	2	<1
Cladonia uncialis	2	<1
Deschampsia flexuosa	2	<1
Mylia taylorii	2	<1
Vaccinium vitis-idaea	2	<1 - 5
Cetraria islandica	1	<1
Cladonia rangiferina	1	<1
Galium saxatile	1	<1
Nardus stricta	1	<1
Narthecium ossifragum	1	5 - 10
Polytrichum commune	1	1 - 5
Pseudoscleropodium purum	1	<1
Ptilidium ciliare	1	<1
Sphagnum fallax	1	<1
Vaccinium uliginosum	1	<1

Table 11. *Constancy table for the 56 sample quadrats assigned to the heather – hare's-tail cotton-grass (*Calluna vulgaris – Eriophorum vagninatum*) blanket mire community, typical variant of the cowberry – glittering wood-moss (*Vaccinium vitis-idaea – Hylocomium splendens*) sub-community (M19cii).*

	Frequency	Range in cover (%)
all species of *Sphagnum*	91%	0 – 95
all ericoids	91%	0 – 95
all graminoids	89%	1 – 95
bare peat	29%	0 – 100
Species	Constancy	
Calluna vulgaris	5	1 - 95
Cladonia portentosa	5	<1 - 95
Empetrum nigrum	5	<1 - 50
Eriophorum vaginatum	5	<1 - 95
Pleurozium schreberi	4	<1 - 50
Racomitrium lanuginosum	4	<1 - 50
Sphagnum capillifolium	4	<1 - 50
Vaccinium myrtillus	4	<1 - 25
Cladonia arbuscula	3	<1 - 95
Cladonia uncialis	3	<1 - 10
Eriophorum angustifolium	3	<1 - 25
Hylocomium splendens	3	<1 - 50
Rhytidiadelphus loreus	3	<1 - 50
Trichophorum germanicum	3	<1 - 25
Hypnum jutlandicum	2	<1 - 10
Juncus squarrosus	2	<1 - 75
Ptilidium ciliare	2	<1
Rubus chamaemorus	2	<1 - 10
Sphagnum papillosum	2	<1 - 25
Vaccinium vitis-idaea	2	<1
Aulocomnium palustre	1	<1 - 10
Campylopus flexuosus	1	<1
Carex bigelowii	1	<1
Carex nigra	1	<1 - 10
Cetraria islandica	1	<1
Cladonia rangiferina	1	<1
Cladonia spp.	1	<1
Cornicularia aculeata	1	<1 - 5
Deschampsia cespitosa	1	<1
Deschampsia flexuosa	1	<1 - 25
Dicranum scoparium	1	<1
Drosera rotundifolia	1	<1
Galium saxatile	1	<1 - 5
Huperzia selago	1	<1
Juncus bulbosus	1	<1

	Frequency	Range in cover (%)
Luzula multiflora	1	<1
Molinia caerulea	1	<1 - 10
Mylia taylorii	1	<1
Nardus stricta	1	<1 – 10
Narthecium ossifragum	1	<1
Odontoschisma sphagnii	1	<1
Plagiothecium undulatum	1	<1
Polytrichum commune	1	<1 – 10
Polytrichum strictum	1	<1 – 5
Potentilla erecta	1	<1
Sphagnum austinii	1	<1
Sphagnum cuspidatum	1	<1 – 10
Sphagnum denticulatum	1	<1 – 5
Sphagnum fallax	1	<1 – 5
Sphagnum fuscum	1	<1
Sphagnum magellanicum	1	5 - 10
Sphagnum palustre	1	1 - 25
Sphagnum rubellum	1	<1 - 25
Sphagnum subnitens	1	<1 - 50
Sphagnum tenellum	1	<1 – 5
Vaccinium uliginosum	1	<1
Viola palustris	1	<1

Table 12. *Constancy table for the 11 sample quadrats assigned to the hare's-tail cotton-grass (*Calluna vulgaris – Eriophorum vagninatum*) blanket and raised mire community, heather - reindeer lichen (*Calluna vulgaris – Cladonia*) sub-community (M20b).*

	Frequency	Range in cover (%)
all species of *Sphagnum*	18%	0 - 5
all ericoids	100%	5 - 50
all graminoids	100%	<1 - 50
bare peat	64%	0 - 75
Species	Constancy	
Calluna vulgaris	5	1 - 50
Cladonia portentosa	5	<1 - 95
Eriophorum vaginatum	5	<1 - 25
Racomitrium lanuginosum	5	<1 - 10
Trichophorum germanicum	5	<1 - 50
Cladonia uncialis	4	<1 - 10
Eriophorum angustifolium	4	<1 - 25
Hypnum jutlandicum	4	<1 - 5
Cetraria islandica	3	<1 - 5
Cladonia arbuscula	3	<1
Cladonia spp.	3	<1
Empetrum nigrum nigrum	3	<1 - 10
Cornicularia aculeata	2	<1
Pleurozium schreberi	2	<1 - 5
Carex bigelowii	1	<1
Huperzia selago	1	<1
Juncus squarrosus	1	<1
Luzula multiflora	1	<1
Mylia anomala	1	<1
Mylia taylorii	1	<1
Rhytidiadelphus loreus	1	<1
Sphagnum capillifolium	1	<1 - 5
Splachnum sphaericum	1	<1
Vaccinium myrtillus	1	<1 - 5

Table 13. *Species data for sample quadrats not assigned to any plant community or sub-community.*

Cluster	0000	01011
Quadrat Number	167	136
Easting	256360	255427
Northing	802654	801910
Date	08/07/2021	08/07/2021
Surveyor	ADH	GR
NVC (field surveyor assessment)	re-instatement	ruderal grasses
>50cm peat depth		
acrotelm depth	0	0
Total *Sphagnum* cover (%)	0	0
Total Ericoid cover (%)	1	0
Total graminoid cover (%)	3	4
bare peat	6	6
Species		
Agrostis vinealis		3
Aulocomnium palustre	1	
Calluna vulgaris	1	
Deschampsia cespitosa	3	
Epilobium montanum	1	
Eriophorum vaginatum	1	
Festuca ovina	3	2
Philonotis fontana	2	
Racomitrium lanuginosum		1
Trichophorum germanicum	1	1

Table 14. *The estimated areas (ranges in hectares) for each community within the 50 metre buffer around the proposed infrastructure and for the areas outside this buffer zone as well as the total area summed from these two estimates.*

Plant Community code	Infrastructure + 50m buffer	non-infrastructure area	All areas within the red-line
M2	0.2 – 1.2	0.4 – 3.4	0.6 – 4.6
M3	3.2 – 10.1	16 – 53	19 – 63
M4	0.04 – 0.10	0.86 – 1.83	0.9 – 1.9
M6	3.0 – 5.7	25 – 50	28 – 56
M10	0.01 – 0.09	0.00	0.01 – 0.09
M15	129 – 179	496 – 720	624 – 898
M17	27 – 43	74 – 139	101 – 182
M19	41 – 65	179 – 328	220 – 393
M20	0.9 – 1.8	6.4 – 17.5	7.3 – 19.3
M23	0.00	0.13 – 0.65	0.13 – 0.65
M25	0.07 – 0.24	0.36 – 0.71	0.42 – 0.96
M31	0.03 – 0.31	0.00	0.03 – 0.31
M32	0.03 – 0.19	0.01 – 0.10	0.04 – 0.29
H12	0.05 – 0.36	0.67 – 2.00	0.72 – 2.36
H13	5.1 – 7.2	41 – 54	46 – 62
H14	0.00	0.27 – 0.67	0.27 – 0.67
H20	0.23 – 0.57	0.34 – 0.86	0.57 – 1.43
U2	0.01 – 0.03	0.00	0.01 – 0.03
U4	0.00	1.29 – 3.24	1.29 – 3.24
U5	0.49 – 1.18	5.6 – 13.9	6.1 – 15.1
U6	5.0 – 10.1	7.6 – 24.0	13 – 34
U7	0.7 – 1.5	1.9 – 4.0	2.6 – 5.5
S9	0.00	0.20 – 0.49	0.20 – 0.49
water	0.03 – 0.16	1.9 – 3.5	1.9 – 3.7
rock	13 – 25	13 – 26	26 – 51
bare ground	13 – 25	44 – 78	47 – 81
Track	0.12 – 0.46	0.00	0.12 – 0.46
Total area	**335.52**	**1,297.95**	**1,633.48**

Table 15. *The estimated areas (hectares) for each habitat within the 50 metre buffer around the proposed infrastructure and for the areas outside this buffer zone as well as the total area summed from these two estimates.*

	Infrastructure + 50m buffer	**non-infrastructure area**	**All areas within the red-line**	
Habitat	hectares	hectares	hectares	% of total
Dry modified Blanket Bog	76.9	668.1	745.0	45.7%
Wet modified Blanket Bog	44.3	109.2	153.5	9.4%
Wet heath	178.6	344.4	523.1	32.1%
Montane heath	8.7	54.0	62.7	3.8%
Acid dry heath	0.5	3.0	3.5	0.2%
Marshy grassland	16.1	67.1	83.1	5.1%
Acid grassland	1.2	2.6	3.9	0.2%
Open water (standing and flowing)	0.2	2.6	2.8	0.1%
Bare and disturbed ground (peat + rocks)	27.3	24.1	51.4	3.2%
Total	353.8	1,274.7	1,628.6	

***Table 16**. Summary statistics and data on the extent and frequency of bog-mosses (Sphagnum) across the area surveyed.*

Peat depth		<50 cm	>50 cm
Number of plots assessed		89	77
% plots with one or more bog-moss species present	including *Sphagnum fallax*	49%	69%
	excluding *Sphagnum fallax*	48%	70%
Median number of species of bog-moss present (range in parentheses) in quadrats with at least one species		1.0 (1 to 4)	1.5 (1 to 5)
Number of quadrats (% of all quadrats surveyed in parentheses) in which each species of bog-moss was present	*Sphagnum austinii*	0 (0%)	1 (1%)
	Sphagnum capillifolium	30 (34%)	32 (42%)
	Sphagnum compactum	1 (1%)	0 (0%)
	Sphagnum cuspidatum	2 (2%)	2 (3%)
	Sphagnum denticulatum	3 (3%)	4 (5%)
	Sphagnum fallax	4 (5%)	6 (8%)
	Sphagnum fuscum	1 (1%)	1 (1%)
	Sphagnum magellanicum	1 (1%)	1 (1%)
	Sphagnum palustre	1 (1%)	3 (4%)
	Sphagnum papillosum	14 (16%)	19 (25%)
	Sphagnum rubellum	3 (3%)	12 (16%)
	Sphagnum subnitens	9 (10%)	8 (10%)
	Sphagnum tenellum	8 (9%)	10 (13%)
Cover of bog-mosses in the sample quadrats	range	0 – 100%	0 – 100%
	25th percentile	0%	0%
	median	0%	1 to 5%
	75th percentile	5 to 10%	5 to 10%
Proportion of plots where the bog-moss cover is greater than 25%		8%	9%

***Table 17**. Summary statistics and data on the extent and frequency of bare peat in the sample quadrats. The number of peat erosion features were taken from a sample of 6.6 km of transect covered by the surveyors.*

Peat depth		<50 cm	>50 cm
Number of plots assessed		89	77
% plots with some bare peat		58%	47%
Cover of bare peat	range	0 – 100%	0 – 100%
	25th percentile	0%	0%
	median	<1%	0%
	75th percentile	5 to 10%	10 to 25%
	Mean weighted cover	13%	17%

***Table 18**. The number of peat erosion features recorded along transects totaling to 6.6 km.*

Peat erosion gullies along transects	Total number	60
	Average number per 100 metre	0.9
	Median width (m)	3.0
	Median depth (m)	1.1
Peat haggs along transects	number	23
	Median depth (m)	1.1
	Areas of complex hagging (ha)	22
Average distance (m) between erosion features		77

***Table 19**. The results of the assessment of the condition of the 77 quadrats taken within the blanket bog habitat at Cloiche.*

Common Standards Monitoring target	**Number of failures**
Number of positive indicator species	13 (17%)
At least half of cover coming from at least 3 species	10 (13%)
Cover of *Sphagnum* not coming only from *S. fallax*	1 (1%)
No single positive indicator species with a cover less than 75%	6 (8%)
Cover of non-native species less than 1%	0
Cover of trees and/or shrubs less than 10%	0
Cover of agricultural grasses, bracken and creeping buttercup less than 1%	0
Less than a third of long-shoots of heather and/or blaeberry browsed	47 (61%)
Pioneer stage re-growth of heather browsing less than two-thirds	Not applicable
No signs of burning	0
No signs of disturbance in sensitive areas	0
The area of erosion less than the area of re-vegetation and/or re-deposition of peat	77 (100%)
Less than 10% of *Sphagnum* crushed and/or broken	0
Number of failed targets	**Number of quadrats**
None	0
One	16 (21%)
Two	46 (60%)
Three	14 (18%)
Four	1 (1%)

***Table 20**. The number of quadrats that were placed in different categories of 'active peat assessment' devised by Penny Anderson & Associates Ltd.*

	Depth of peat	
Level of 'peat activity'	deep peat (i.e. more than 0.5m thick)	shallow peat (i.e. less than 0.5m thick)
Active	1	0
Possibly Active	1	1
Potentially Active	27	5
Inactive	48	83

***Table 21**. Data on the frequency and depth of the acrotelm recorded in the 166 sample quadrats.*

Presence/absence	Statistic	Deep peat	Shallow peat
Present	Number of plots	43	21
	Minimum thickness	0 to 1 cm	0 to 1 cm
	Median depth	0 to 5 cm	0 to 5 cm
	Maximum thickness	13 cm	c. 10 cm
Absent	Number of plots	34 (44%)	59 (74%)
Not applicable	Number of plots		9

***Table 22**. The results of the assessment of the condition of the 5 quadrats taken within the alpine dwarf-shrub heath habitat at the 29 Turbine Proposed Development.*

Common Standards Monitoring target	**Number of failures**
At least one species of dwarf-shrub present	0
At least one moss, liverwort or non-crustose lichen present	0
Collective cover of positive indicator species more than 66%	0
Cover of non-native species less than 1%	0
Less than 10% of vegetation cover should consist of, collectively, *Agrostis capillaris, A. vinealis, Anthoxanthum, Deschampsia flexuosa, Festuca ovina/vivipara, Galium saxatile, Poa* spp. and *Potentilla erecta*	0
Signs of grazing on live leaves of *Carex bigelowii, Deschampsia flexuosa, Festuca ovina/vivipara, Juncus trifidus* should be less than 10%	0
Less than a third of long-shoots of heather and/or blaeberry browsed	3
No signs of burning inside the feature	0
Less than 10% of of the ground cover should be disturbed bare ground	0

***Table 23**. Notable species and other target notes recorded during the survey.*

Notable/protected species/feature	Date	Surveyor	Easting	Northing	comments
Arctostaphylos alpinus	09/07/2021	TE	248879	802918	
Betula nana	06/07/2021	TE	248978	802110	
Betula nana	08/07/2021	GR	255539	801659	3 to 4 plants
Betula nana	09/07/2021	GR	247539	801754	c. 12 plants
Betula nana	06/07/2021	FM	249425	801122	Low, stunted
Betula nana	06/07/2021	FM	249797	800869	Low, stunted
Betula nana	06/07/2021	FM	249435	801040	Low, stunted
Betula nana	06/07/2021	FM	249397	801206	Low, stunted
Cornus suecica	08/07/2021	TE	257141	802716	
M32 spring	08/07/2021	TE	256772	803230	*Warnstorphia exannulata, Sphagnum squarrosum, Rhizomnium magnifolium, Marchantia polymorpha*
M32 spring	08/07/2021	TE	257095	802690	Species as above . Covers an area of c. 30m^2
Sphagnum austinii	06/07/2021	TE	248456	800840	
Sphagnum austinii	09/07/2021	GR	247142	801609	
Sphagnum austinii	05/07/2021	FM	248341	804782	
Sphagnum fuscum	06/07/2021	TE	248998	800796	
Sphagnum fuscum	06/07/2021	TE	248753	800938	
Sphagnum fuscum	07/07/2021	TE	246228	801364	hummock badly trampled
Sphagnum fuscum	07/07/2021	TE	246349	801545	
Sphagnum fuscum	07/07/2021	TE	246104	801871	
Sphagnum fuscum	08/07/2021	TE	256709	803394	
Sphagnum fuscum	08/07/2021	TE	256761	803283	
Sphagnum fuscum	09/07/2021	TE	248234	802081	
Sphagnum fuscum	09/07/2021	TE	247821	801896	
Sphagnum fuscum	09/07/2021	TE	247656	802019	
Sphagnum fuscum	08/07/2021	ADH	256648	802426	
Sphagnum fuscum	08/07/2021	ADH	256613	802263	
Sphagnum fuscum	08/07/2021	ADH	256593	802247	
Sphagnum fuscum	08/07/2021	ADH	256781	802441	
Sphagnum fuscum	08/07/2021	ADH	256796	802454	
Sphagnum fuscum	07/07/2021	ADH	247107	803167	
Sphagnum fuscum	07/07/2021	ADH	247356	802835	
Sphagnum fuscum	07/07/2021	ADH	247425	802781	
Sphagnum fuscum	07/07/2021	ADH	247359	802540	
Sphagnum fuscum	09/07/2021	ADH	249264	801549	
Sphagnum fuscum	09/07/2021	ADH	249191	801499	
Sphagnum fuscum	05/07/2021	GR	248203	845280	
Sphagnum fuscum	05/07/2021	GR	248200	845200	
Sphagnum fuscum	05/07/2021	GR	248053	844790	
Sphagnum fuscum	05/07/2021	GR	248057	844670	
Sphagnum fuscum	05/07/2021	GR	248063	844600	

Notable/protected species/feature	Date	Surveyor	Easting	Northing	comments
Sphagnum fuscum	05/07/2021	GR	248027	844270	
Sphagnum fuscum	05/07/2021	GR	247820	844200	
Sphagnum fuscum	06/07/2021	GR	248956	802045	
Sphagnum fuscum	06/07/2021	GR	248954	802110	
Sphagnum fuscum	06/07/2021	GR	248938	802115	
Sphagnum fuscum	06/07/2021	GR	248641	802067	
Sphagnum fuscum	06/07/2021	GR	248615	802046	
Sphagnum fuscum	06/07/2021	GR	248595	802042	
Sphagnum fuscum	06/07/2021	GR	248550	802039	
Sphagnum fuscum	06/07/2021	GR	248487	802014	
Sphagnum fuscum	06/07/2021	GR	248271	801981	
Sphagnum fuscum	06/07/2021	GR	248288	801887	
Sphagnum fuscum	06/07/2021	GR	248274	801857	
Sphagnum fuscum	06/07/2021	GR	248261	801808	
Sphagnum fuscum	06/07/2021	GR	248245	801737	
Sphagnum fuscum	06/07/2021	GR	248213	801701	
Sphagnum fuscum	06/07/2021	GR	248141	801591	
Sphagnum fuscum	06/07/2021	GR	248155	801546	
Sphagnum fuscum	06/07/2021	GR	248102	801452	
Sphagnum fuscum	06/07/2021	GR	248111	801403	
Sphagnum fuscum	07/07/2021	GR	246658	801233	
Sphagnum fuscum	07/07/2021	GR	246717	801506	
Sphagnum fuscum	07/07/2021	GR	246973	802036	
Sphagnum fuscum	07/07/2021	GR	247055	802161	
Sphagnum fuscum	07/07/2021	GR	247088	802253	
Sphagnum fuscum	07/07/2021	GR	247801	802934	
Sphagnum fuscum	08/07/2021	GR	255541	801754	
Sphagnum fuscum	08/07/2021	GR	255539	801659	
Sphagnum fuscum	08/07/2021	GR	255521	801543	
Sphagnum fuscum	08/07/2021	GR	255611	801504	
Sphagnum fuscum	08/07/2021	GR	255660	801597	
Sphagnum fuscum	08/07/2021	GR	255683	801588	
Sphagnum fuscum	08/07/2021	GR	255695	801586	
Sphagnum fuscum	08/07/2021	GR	255803	801901	
Sphagnum fuscum	08/07/2021	GR	255902	801907	
Sphagnum fuscum	08/07/2021	GR	255969	801897	
Sphagnum fuscum	09/07/2021	GR	247007	801666	
Sphagnum fuscum	09/07/2021	GR	247206	801668	
Sphagnum fuscum	05/07/2021	TE	246973	803986	
Sphagnum fuscum	05/07/2021	TE	247116	804017	
Sphagnum fuscum	05/07/2021	TE	247080	803965	
Sphagnum fuscum	05/07/2021	TE	247045	803925	
Sphagnum fuscum	05/07/2021	FM	248284	804491	
Sphagnum fuscum	05/07/2021	FM	248314	804866	
Sphagnum fuscum	05/07/2021	FM	248430	805012	
Sphagnum fuscum	05/07/2021	FM	248338	804797	
Sphagnum fuscum	07/07/2021	FM	246424	802489	
Sphagnum fuscum	07/07/2021	FM	246598	802429	P:133642
Sphagnum fuscum	08/07/2021	FM	256289	803998	P:120714
Sphagnum fuscum	08/07/2021	FM	256457	804128	

Notable/protected species/feature	Date	Surveyor	Easting	Northing	comments
Sphagnum fuscum	08/07/2021	FM	257227	803946	P:153556
Sphagnum fuscum	09/07/2021	FM	248128	802804	P:114026
Sphagnum fuscum	09/07/2021	FM	248139	802508	P:122601
Vaccinium microcarpum	09/07/2021	TE	247656	802019	
Vaccinium microcarpum	06/07/2021	GR	248615	802046	
water vole burrow	06/07/2021	TE	247949	801002	
water vole burrows	07/07/2021	TE	246170	801511	

8. Figures

Figure 1. *Location of sample quadrats covered in this survey and wind farm tracks used for mapping vegetation and habitats.*

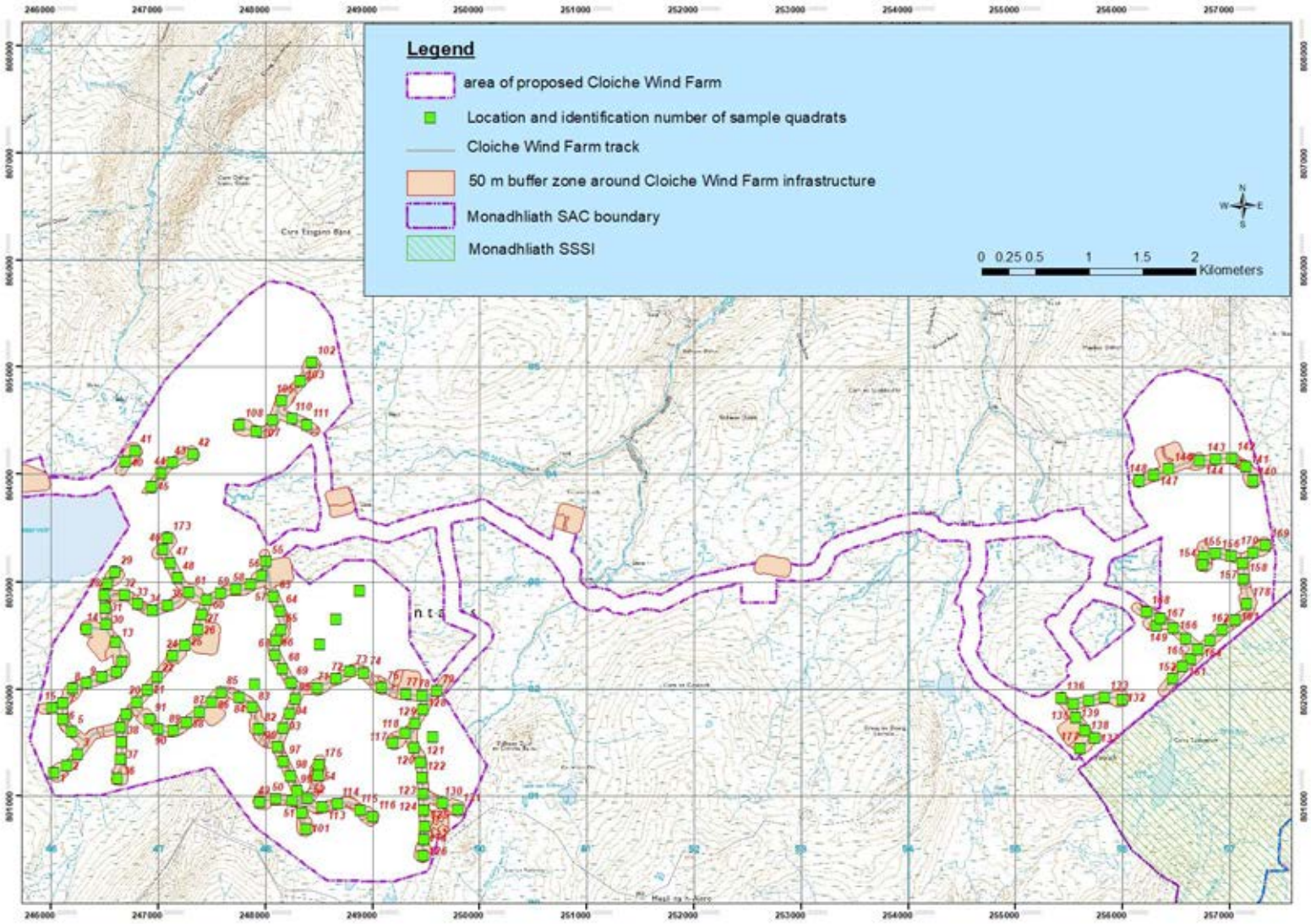


Figure 2. *The estimated cover of M15 (deer-grass – cross-leaved heath) wet heath plant community across Cloiche Wind Farm.*

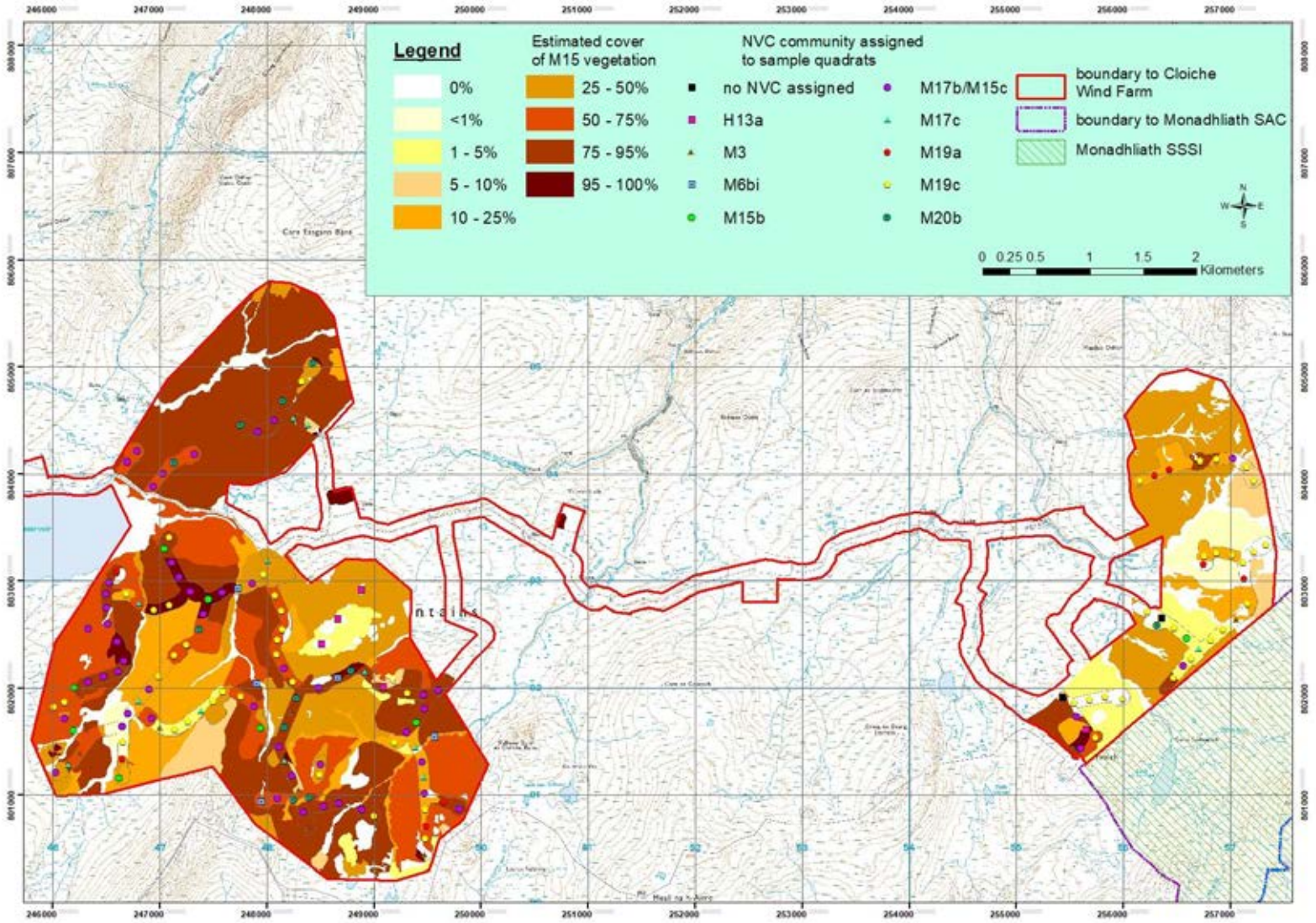


Figure 3. *The estimated cover of M17 (hare's-tail cotton-grass - deer-grass) bog plant community across Cloiche Wind Farm.*

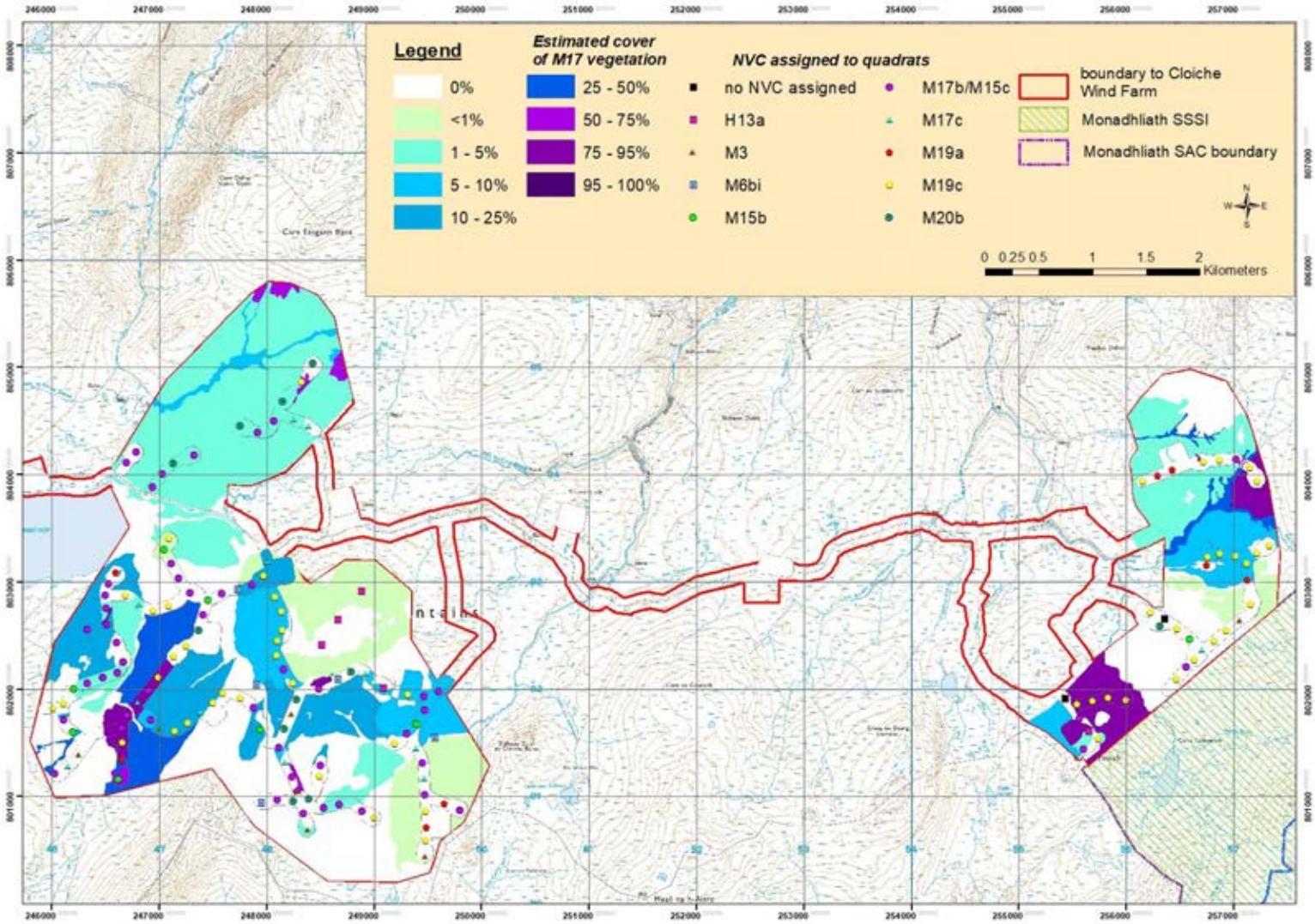


Figure 4. *The estimated cover of M19 (heather - hare's-tail cotton-grass) bog plant community across Cloiche Wind Farm.*

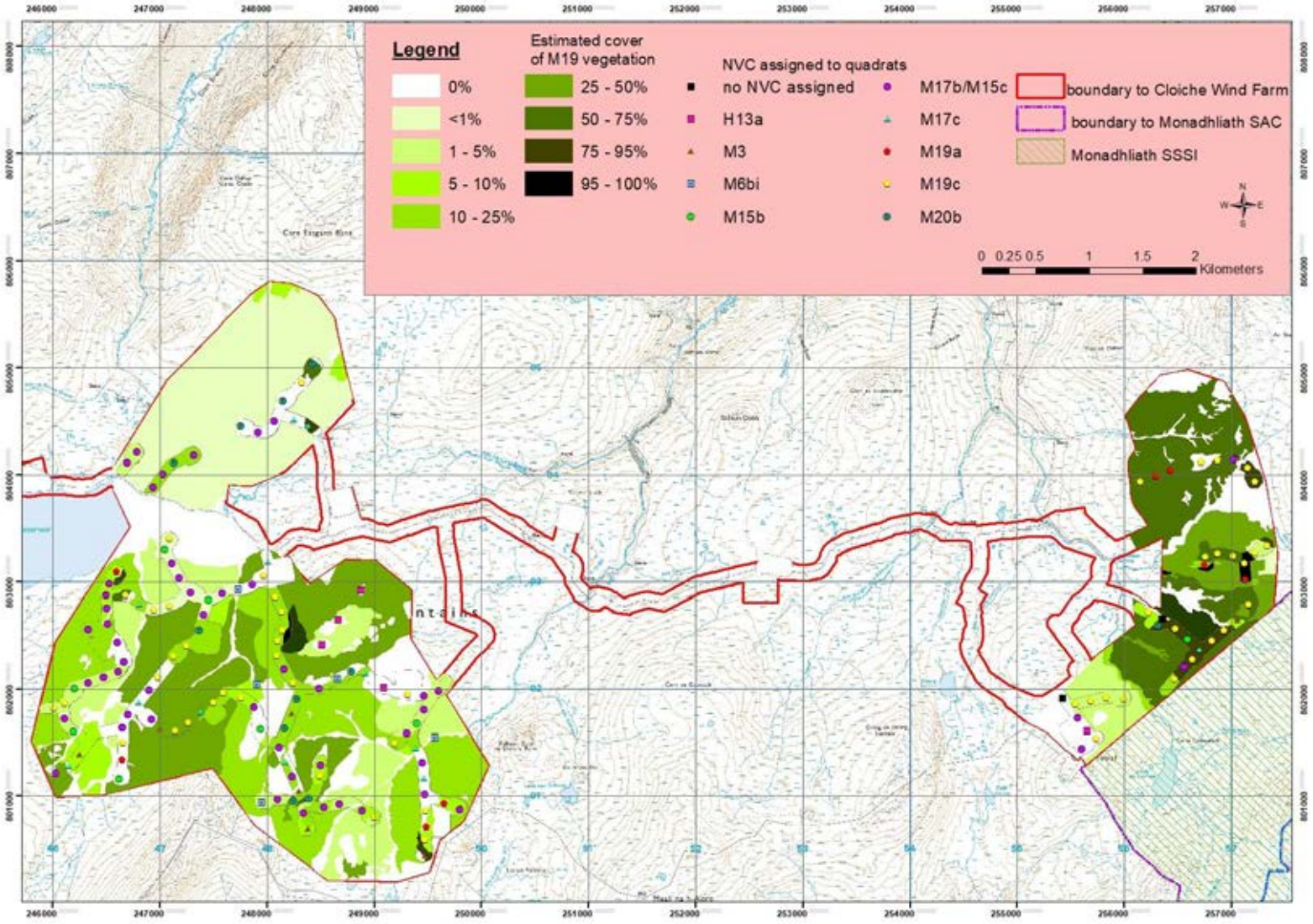


Figure 5. *The estimated cover of H13 (heather – reindeer lichen) montane heath community across Cloiche Wind Farm.*

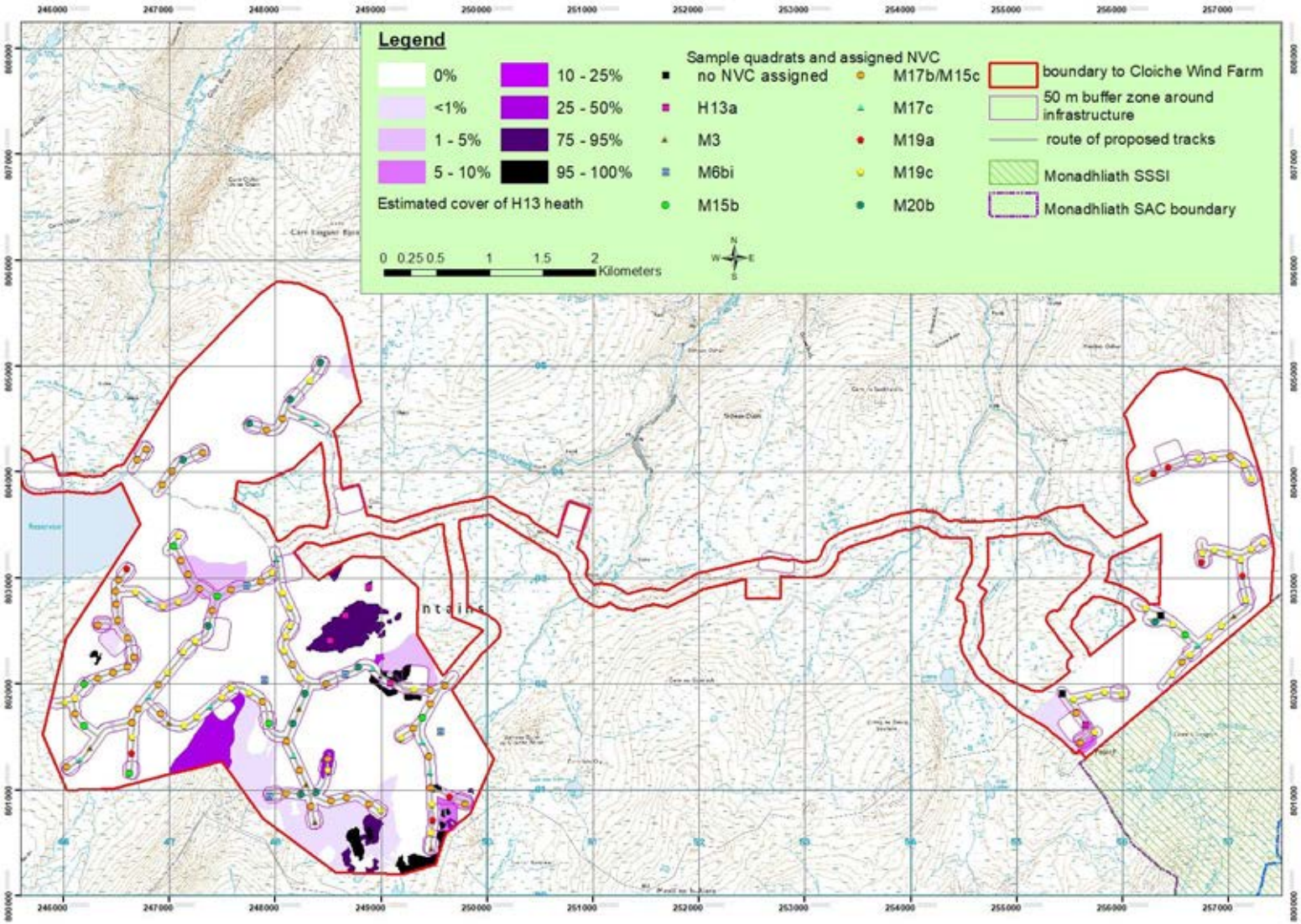


Figure 6. *The estimated cover of M6 (star sedge – bog-moss) mire community across Cloiche Wind Farm and the location of various flushes.*

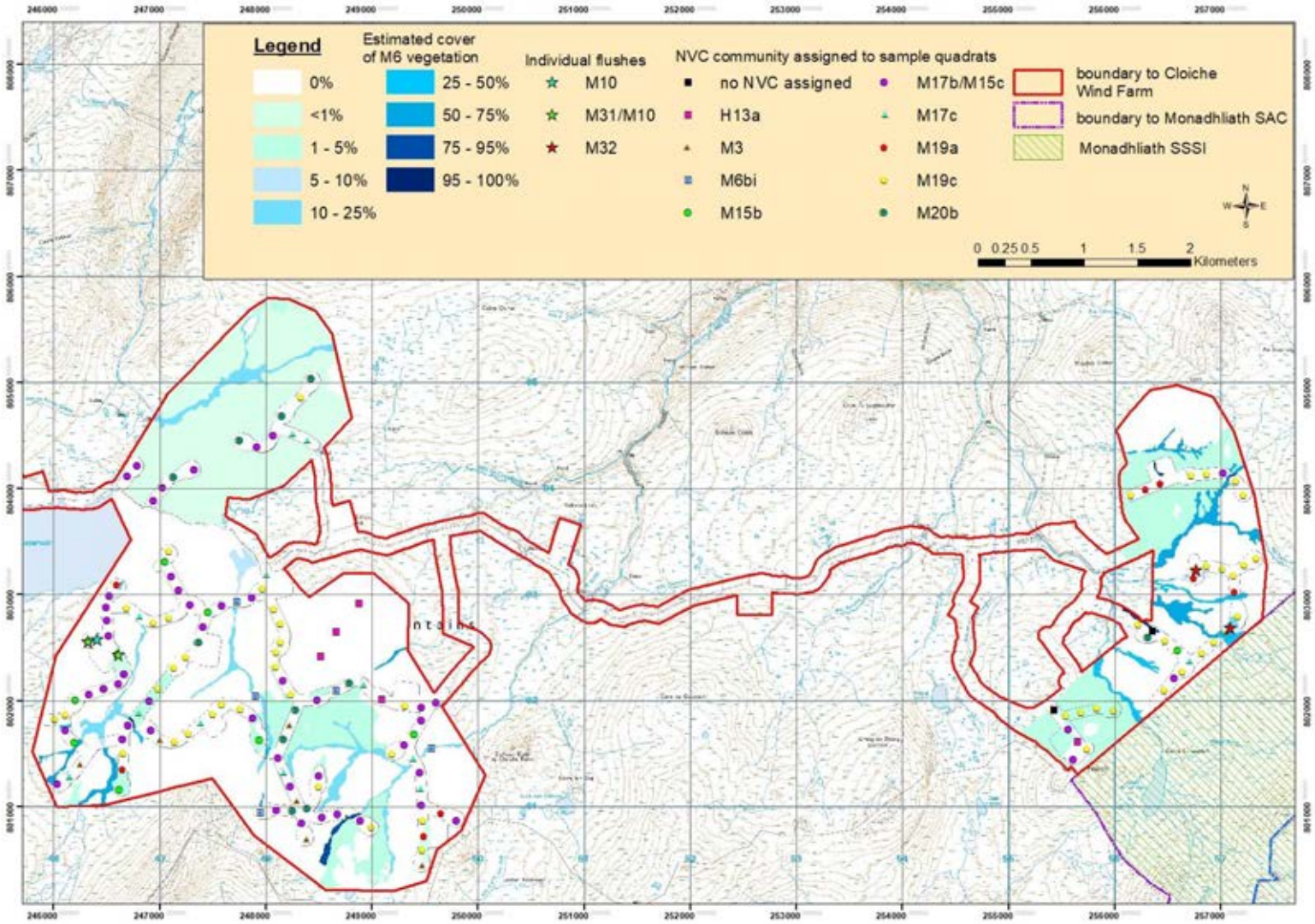


Figure 7. *The collective cover and number of species of bog-moss (*Sphagnum*) in each of the quadrats taken across the Cloiche Wind Farm.*

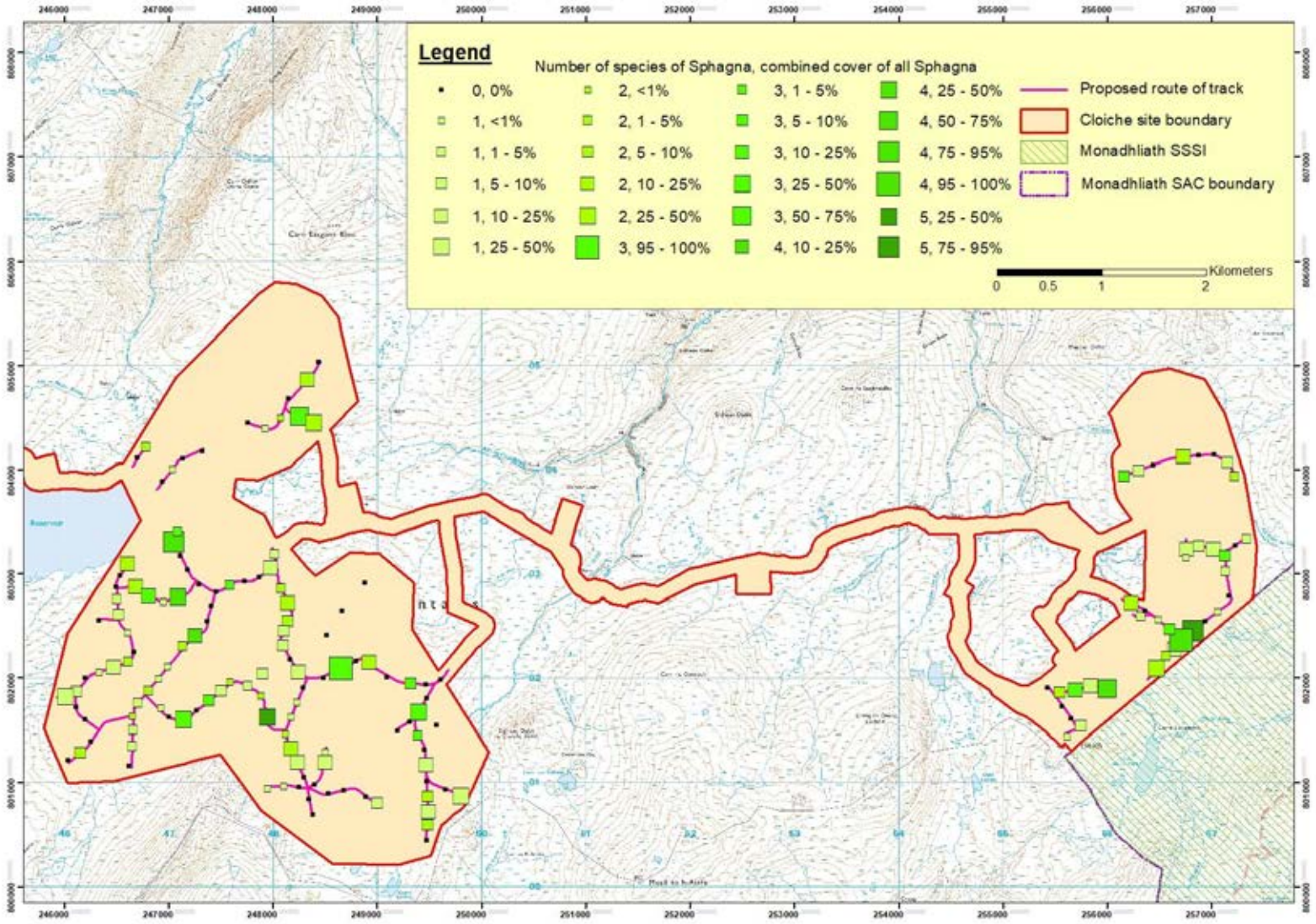


Figure 8. *The location of plants/cushions of notable species of bog-moss (Austin's and rusty) and vascular plant.*

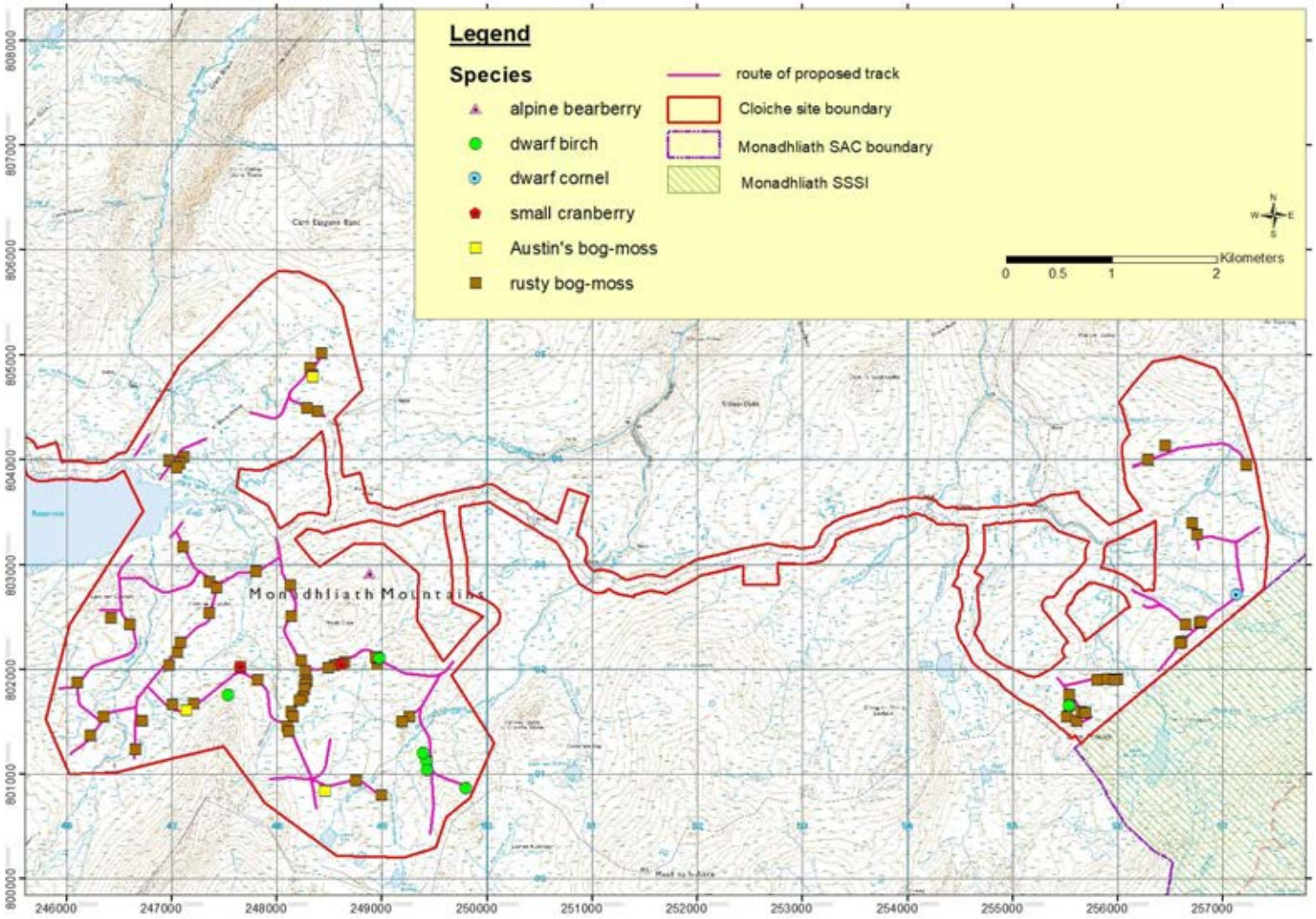


Figure 9. *The number of Common Standards Monitoring targets that the blanket bog habitat failed at the sample quadrats taken on deep peat (more than 50 cm thick).*

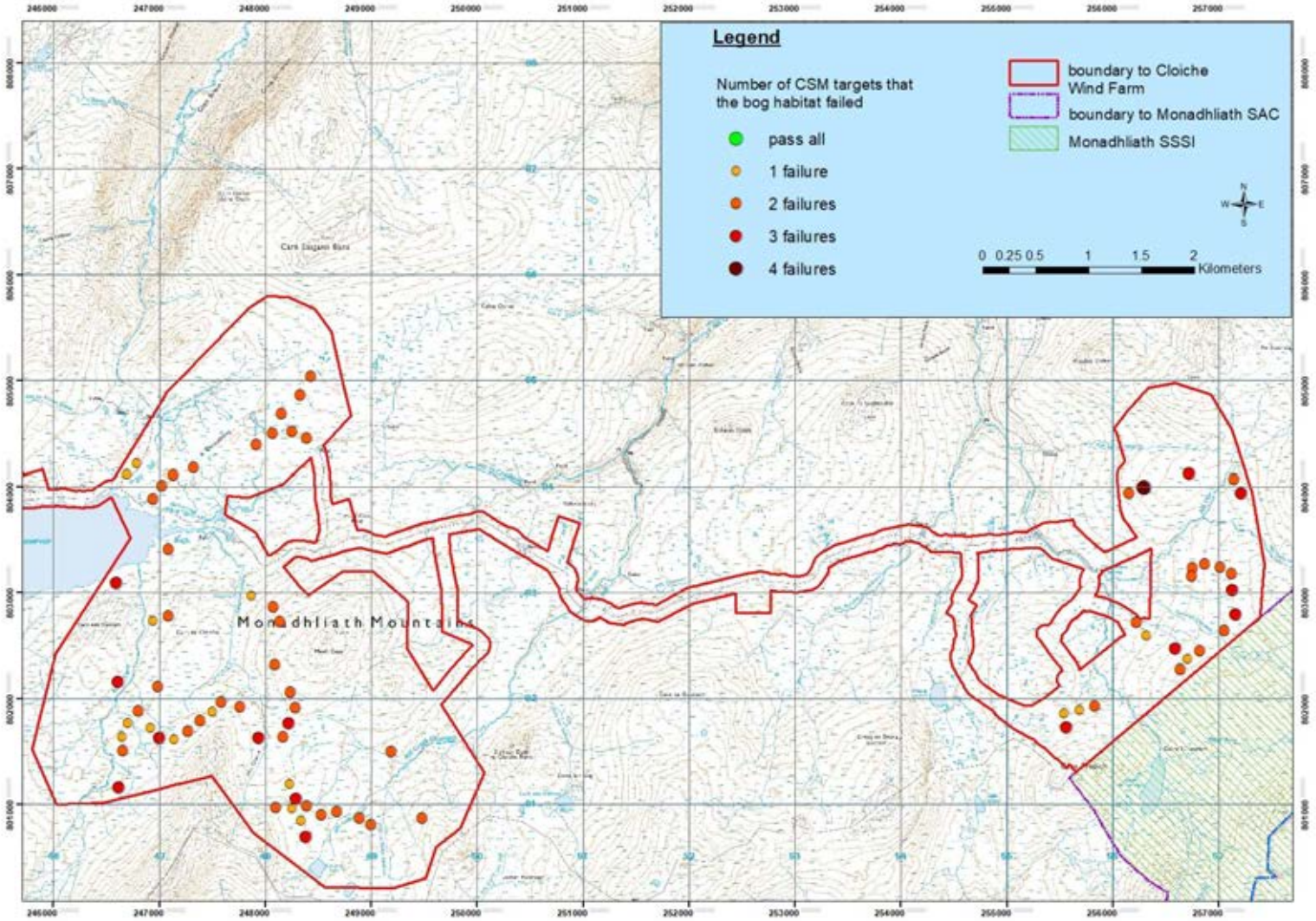


Figure 10. *The likelihood that the blanket bog is actively accumulating peat as assessed using the method devised by Penny Anderson & Associates Ltd.*

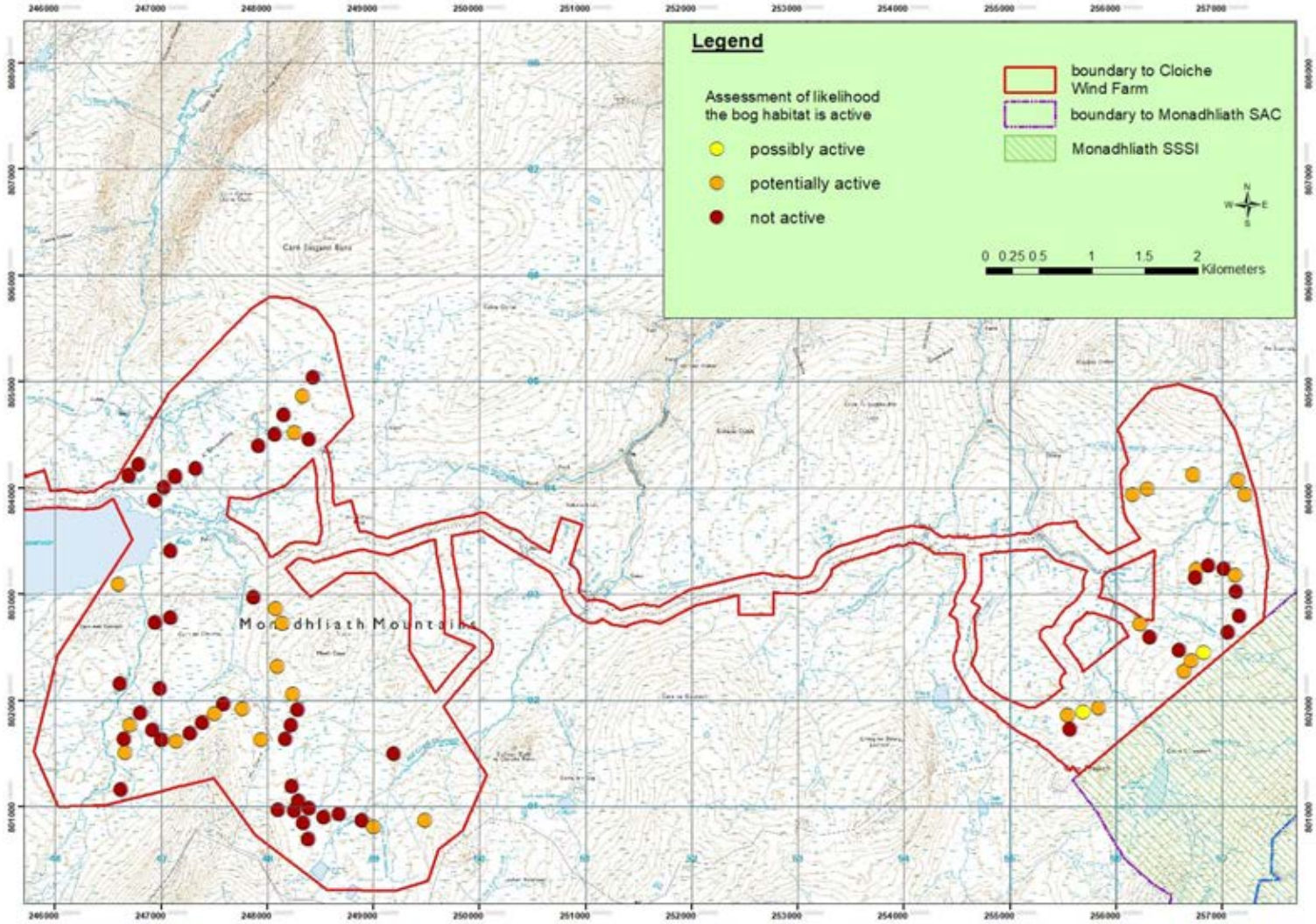


Figure 11. *The sample quadrats on deep peat where an acrotelm was present or absent.*

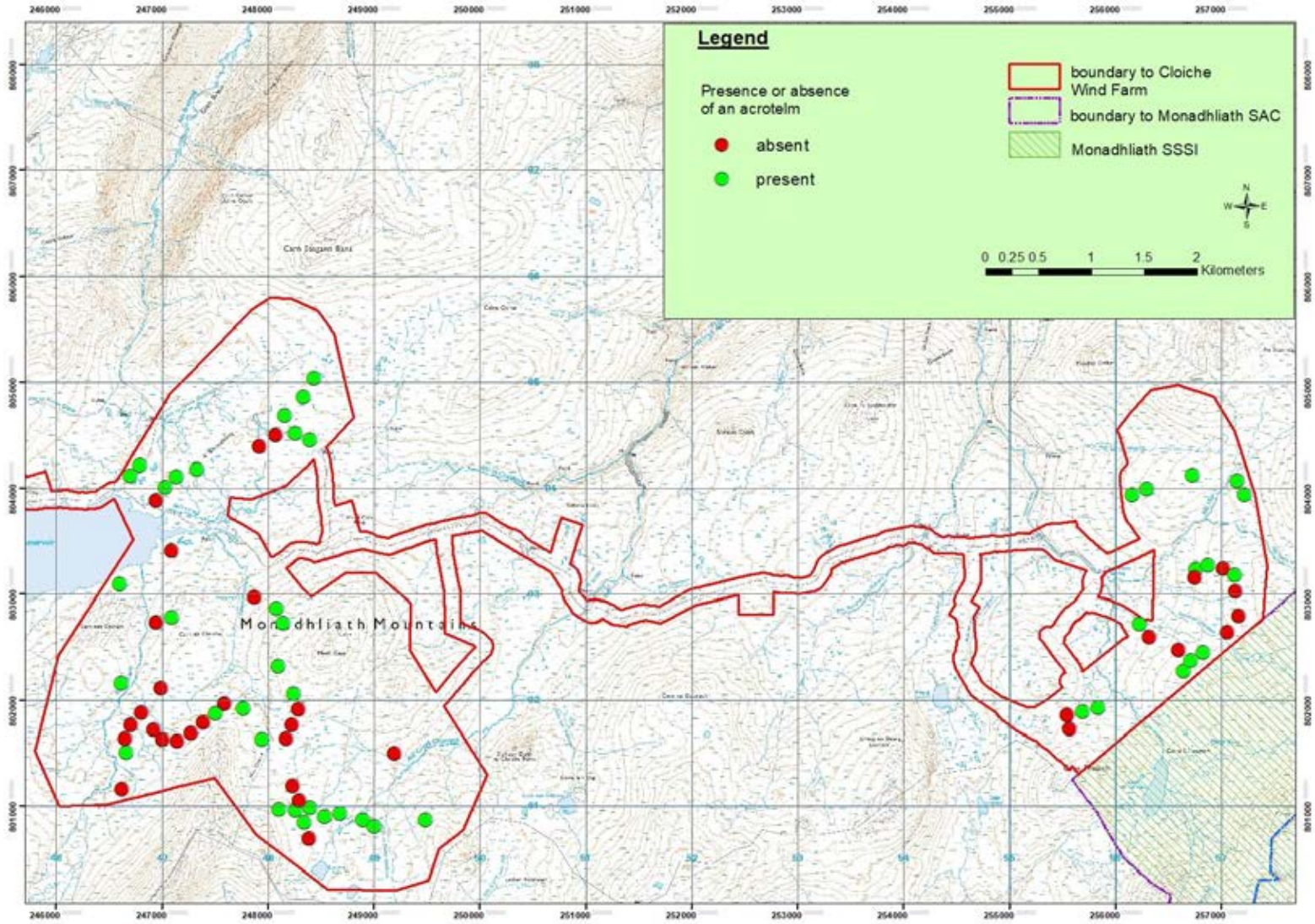
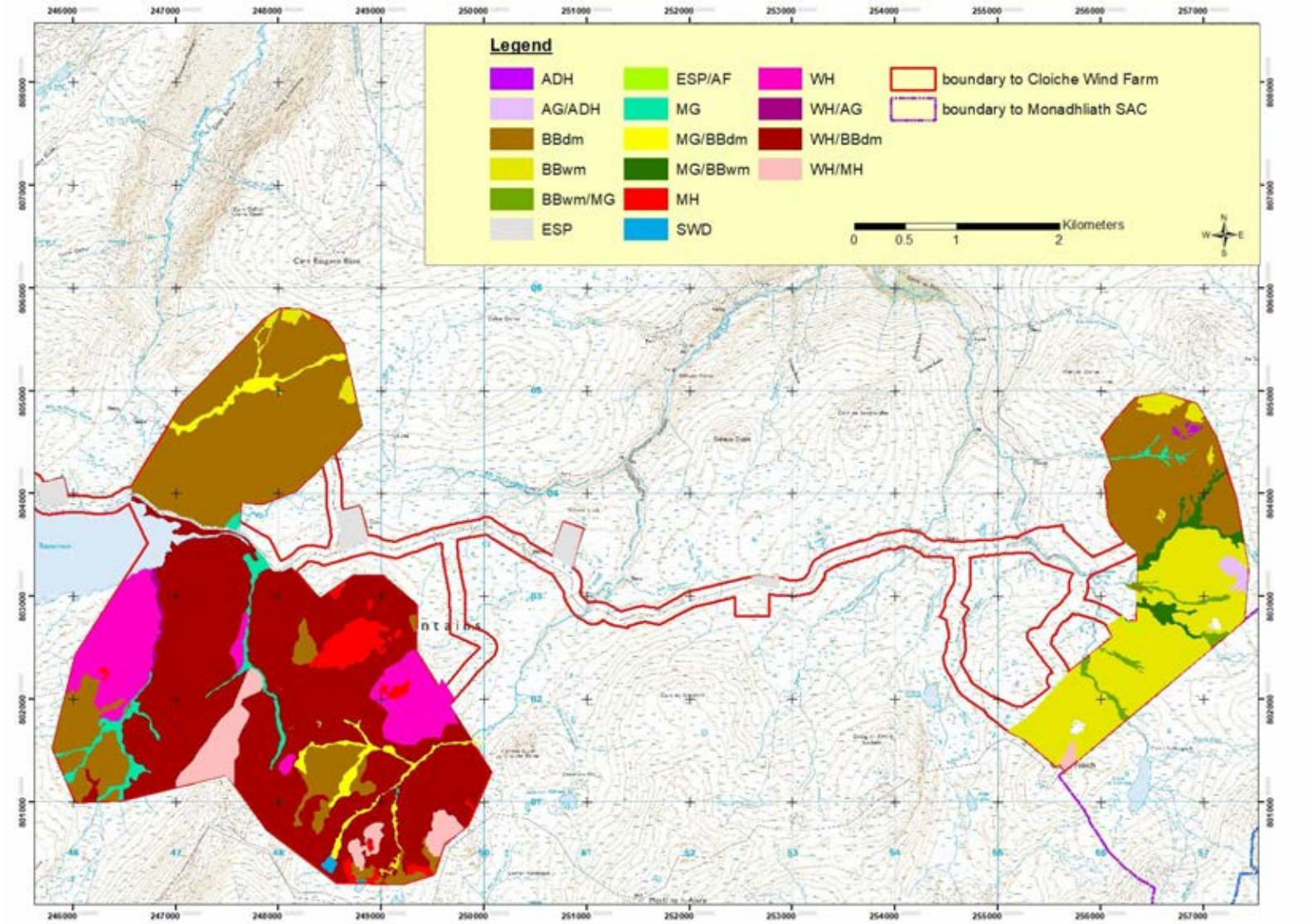


Figure 12. *Photographs of rusty bog-moss (*Sphagnum fuscum*) cushions growing on eroding peat banks.*

Figure 13. *Habitat map of the Cloiche Wind Farm area produced from this survey.*



APPENDIX 1.

Common Standards Monitoring guidance for blanket bog and montane habitats taken from JNCC 2009.

14.6 BLANKET BOG, VALLEY BOG AND RHYNCHOSPORION (Depressions on peat substrates of the Rhynchosporion)

Includes the following NVC types: M1 *Sphagnum auriculatum* bog pool community, M2 *Sphagnum cuspidatum/recurvum* bog pool community, M3 *Eriophorum angustifolium* bog pool community, M17 *Scirpus cespitosus-Eriophorum vaginatum* blanket mire, M18 *Erica tetralix-Sphagnum papillosum* raised and blanket mire, M19 *Calluna vulgaris- Eriophorum vaginatum* blanket mire, M20 *Eriophorum vaginatum* blanket and raised mire, M21 *Narthecium ossifragum- Sphagnum papillosum* valley mire.

The above communities can be heavily influenced by management, notably burning and grazing, leading to degradation and replacement by the following communities: H9 *Calluna vulgaris-Deschampsia flexuosa* heath, H12 *Calluna vulgaris-Vaccinium myrtillus* heath, M15 *Scirpus cespitosus- Erica tetralix* wet heath, M16 *Erica tetralix-Sphagnum compactum* wet heath, M25 *Molinia caerulea-Potentilla erecta* mire, U6 *Juncus squarrosus-Festuca ovina* grassland. See below on how to assess the condition of these communities.

General notes and qualifications:

- **Where blanket bog communities are being replaced by either degraded mire communities (M15, M16, M25), drier heath communities (H8, H12) or grassland types U6, and where restoration back to blanket bog is considered to be feasible, then the degraded communities should be assessed using the attributes and targets ascribed to blanket bog.**
- Rhynchosporion: giving the intimate relationship between blanket bog and the Rhynchosporion, with the latter typically occurring as a minor component of the former, no specific guidance has been developed for Rhynchosporion in a blanket bog setting. It should be assumed to reflect the condition of the surrounding blanket bog. Guidance for the assessment of Rhynchosporion in a lowland setting is given in the Lowland Wetland Guidance.
- When assessing frequency or cover within the vegetation, exclude all bare rock from the assessment.

Attributes	Targets	Method and Scale
Feature extent	There should be no measurable decline in the area of the feature	Field comparison with baseline map of features, or occurrence of feature at sample points on a systematic sample grid.
Vegetation composition –	In blanket bog, at least 6 indicator species should be present (Table 1).	Assessed against visual estimate at 4 m^2 scale. *Sphagnum fallax* (*sensu lato S. recurvum*) scores one

frequency of indicator species.		if other species of *Sphagnum* are present, but scores zero if it is the only species of *Sphagnum* present.
Vegetation composition – cover of indicator species.	At least 50% of the vegetation cover should consist of at least 3 indicator species (Table 1). *Sphagnum* cover should not consist only of *Sphagnum fallax*. Any one of *Eriophorum vaginatum*, Ericaceous species collectively, or *Trichophorum* should not individually exceed 75% of the vegetation cover.	Assessed against visual estimate at 4 m^2 scale.
Vegetation composition – cover of other species.	Less than 1% of vegetation cover should be made up of non-native species.	Assessed against visual estimate for as much of the feature as is visible while standing at a sample location.
	Less than 10% of the vegetation cover should be made up of a scattered canopy of trees and shrubs. Exclude *Betula nana* and *Myrica gale*. Refer to Woodland guidance for Bog Woodland.	
	Less than 1% of the vegetation cover should consist of, collectively, *Agrostis capillaris, Holcus lanatus, Phragmites australis, Pteridium aquilinum, Ranunculus repens.*	Assessed at two scales, and should be met at both scales: a) against visual estimate at 4 m^2; and b) against visual estimate for as much of the feature as is visible while standing at a sample location.
Vegetation structure – indicators of browsing.	Less than 33% of last complete season's shoots of dwarf-shrubs species collectively (excluding *Betula nana* and *Myrica gale*), should show signs of browsing.	Assessed against visual estimate at 4 m^2 scale.
	In pioneer stage regrowth, or where there is *Betula nana* or *Myrica gale* (at any stage of regrowth), less than 66% of the shoots of the dwarf-shrubs, collectively, should show signs of browsing.	
Vegetation structure – disturbance	There should be no observable signs of burning into the moss, liverwort or lichen layer or exposure of peat surface due to burning. Exclude 'cool' burns which remove the dwarf-shrub canopy yet leave behind a proportion of 'stick', which is likely to be consistent with no damage to the moss layer or peat. Burning of the dwarf shrub layer may result in bleaching of	Assessed against visual estimate for as much of the feature as is visible while standing at a sample location. For the second target if a feature is viewed at a distance, and there is uncertainty about whether or

	the bryophyte layer. This should not be confused with burning into the bryophyte layer and does not constitute failure.	not a burn has actually entered the feature, then use a rough guide of 25 m (i.e. if the burn is further than 25 m inside the feature, it is considered damaging).
	There should be no signs of burning or other disturbance (e.g. mowing) in the **sensitive areas** defined in Table 2.	
Physical structure – indicators of excessive drainage and drying-out.	Less than 10% of the total feature area should show signs of drainage, resulting from ditches or heavy trampling or tracking. If there is doubt about the cause of active drainage then assume that the target fails. Failure of the target should also be recorded if any evidence of this is found while walking between sample locations.	Assessed against visual estimate for as much of the feature as is visible while standing at a sample location. Typical effects would be exposed peat and/or modified vegetation with a linear pattern. There is no requirement to detect water movement. As a rule of thumb assume typical moorgrips affect a strip of vegetation totalling 10m wide.
Physical structure – peat erosion.	The area of eroding peat or mineral soil should be less than the area of re-deposition and re-vegetation within the feature.	Assessed against visual estimate for as much of the feature as is visible while standing at a sample location.
Physical structure – indicators of ground disturbance due to herbivore and human activity.	Less than 10% of the *Sphagnum* cover should be crushed, broken, and/or pulled-up.	Assessed against visual estimate at 4 m^2 scale.
	Less than 10% of the ground cover should be disturbed bare ground. This consists of hoof, foot or vehicle imprinted bare humus, bare peat, soil covered only by algal mats, bare mineral soil, or bare gravel.	Assessed at two scales, and should be met at both scales: a) against visual estimate at 4 m^2; and b) against visual estimate for as much of the feature as is visible while standing at a sample location.

Table 1. Indicator Species

Andromeda polifolia, Arctostaphylos spp., *Betula nana, Carex bigelowii, Calluna vulgaris, Cornus suecica, Drosera* spp., *Empetrum nigrum, Erica* spp., *Eriophorum angustifolium*, *Eriophorum vaginatum, Menyanthes trifoliata, Myrica gale, Narthecium ossifragum,* non-crustose lichens, pleurocarpous mosses, *Racomitrium lanuginosum, Rubus chamaemorus, Rhynchospora alba, Sphagnum* spp., *Trichophorum cespitosum, Vaccinium* spp.

Table 2. Areas very sensitive to disturbance

1. Slopes greater than 1 in 3 (18^{o}) and all the sides of gullies
2. Ground with abundant and/or an almost continuous carpet of *Sphagnum,* other mosses, liverworts and/or lichens
3. Areas with noticeably uneven structure, at a spatial scale of around 1 m^2 or less. The unevenness (e.g. more commonly found in very old heather stands) will relate to distinct, often large, spreading dwarf-shrub bushes. The dwarf-shrub canopy will not be completely continuous, and some of its upper surface may be twice as high as other parts.
4. Pools, wet hollows, haggs and erosion gullies and within 5 to 10 m of watercourses

14.3 ALPINE DWARF-SHRUB HEATH (Alpine and boreal heaths)

Includes the following NVC types: H13 *Calluna vulgaris-Cladonia arbuscula* heath, H14 *Calluna vulgaris-Racomitrium lanuginosum* heath, H15 *Calluna vulgaris-Juniperus communis* ssp. *nana* heath, H17 *Calluna vulgaris-Arctostaphylos alpinus* heath, H19 *Vaccinium myrtillus-Cladonia arbuscula* heath, H20 *Vaccinium myrtillus-Racomitrium lanuginosum* heath, H22 *Vaccinium myrtillus-Rubus chamaemorus* heath (in part).

General notes and qualifications: When assessing frequency or cover within the vegetation, exclude all bare rock from the assessment. Exclude any patches of obvious snowbed vegetation too small to appear on vegetation maps, and not caused by snow-fencing, from assessment. Exclude fellfield and other bare areas obviously due to exposure.

Attributes	Targets	Method and Scale
Feature extent	There should be no measurable decline in the area of the feature	Field comparison with baseline map of features, or occurrence of feature at sample points on a systematic sample grid.
Vegetation composition – frequency of dwarf-shrubs, bryophytes and lichens.	At least 1 species of dwarf-shrub should be present.	Assessed against visual estimate at 4 m^2 scale.
	At least 1 species of moss, liverwort or non-crustose lichen should be present.	
Vegetation composition – cover.	The collective cover of indicator species should make up at least 66% of the vegetation cover (Table 1).	Assessed against visual estimate at 4 m^2 scale.
	Less than 1% of vegetation cover should be made up of non-native species.	Assessed against visual estimate for as much of the feature as is visible while standing at a sample location.
Vegetation composition – indicators of current grazing.	Less than 10% of the vegetation cover should consist of, collectively, *Agrostis capillaris, A. vinealis, Anthoxanthum, Deschampsia flexuosa, Festuca ovina/vivipara, Galium saxatile*, *Poa* spp. (other than arctic-alpine spp.) and *Potentilla erecta.*	Assessed against visual estimate at 4 m^2 scale.

	Signs of grazing on less than 10% of live leaves of any of *Carex bigelowii, Deschampsia flexuosa, Festuca ovina/vivipara, Juncus trifidus*	
	Less than 33% of the last complete season's shoots of dwarf-shrubs should show signs of browsing.	
Vegetation structure – presence of burnt vegetation.	There should be no signs of burning inside the feature boundaries. Failure of this target should also be recorded if any evidence of this is found while walking between sample locations.	Assessed against visual estimate for as much of the feature as is visible while standing at a sample location. If a feature is viewed at a distance, and there is uncertainty about whether or not a burn has actually entered the feature, then use a rough guide of 25 m (i.e. if the burn is further than 25 m inside the feature, it is considered damaging).
Physical structure – indicators of ground disturbance due to herbivore and human activity.	Less than 10% of the ground cover should be disturbed bare ground. This consists of hoof, foot or vehicle imprinted bare humus, bare peat, soil covered only by algal mats, bare mineral soil, or bare gravel.	Assessed at two scales, and should be met at both scales: (a) against visual estimate at 1 m^2, for diffuse disturbed ground; and (b) against visual estimate for as much of the feature as is visible while standing at a sample location, for distinct and clearly defined paths and tracks.

Table 1. Indicator Species
Arctostaphylos alpinus, Arctostaphylos uva-ursi, Calluna vulgaris, Cetraria islandica, Cladonia arbuscula, Cladonia portentosa (= C.impexa), Cladonia rangiferina, Cladonia uncialis, Empetrum nigrum ssp. *hermaphroditum, Erica cinerea, Erica tetralix, Loiseleuria procumbens, Juniperus communis* ssp. *nana, Racomitrium lanuginosum, Sphagnum capillifolium* (in H22), *Vaccinium myrtillus, Vaccinium uliginosum, Vaccinium vitis-idaea*

APPENDIX 2.

SCORING SYSTEM FOR ACTIVE PEAT ASESSMENT

This method is based on the list of criteria produced by NIEA for identifying active peat in Northern Ireland.

Indicator 1 Key – Peat Forming *Sphagnum*

Sphagnum pulchrum, S. fuscum, S.imbricatum (now comprising *S. austinii* and *S. affine*), *S. balticum* and *S. magellanicum* as the main peat forming *Sphagna*) are key peat forming species of *Sphagnum*. For this assessment the definition has been expanded to include other *Sphagnum* species which are not specified in the category below (indicative of poorer quality habitat) although it is recognised that the speed of peat formation will vary dependant on the most abundant *Sphagnum* species. *S. papillosum* and *S. capillifolium* are frequently the most common species in this category.

- Dominant (cover more than 60%) scores 3;
- Abundant – frequent (cover 15 to 59%) scores 2;
- Occasional - Rare (cover 1 to 14%) scores 1;
- Absent scores 0.

Indicator 2 Other species of *Sphagnum*

Other Sphagna can, however, provide a first stage for the colonisation of key peat forming species by providing suitable substrate (versus bare peat) and are therefore considered to be indicative of bog that has the potential to become active if no key peat-forming *Sphagna* are currently present. The other *Sphagnum* species also contribute to the overall wetness of the bog and a small amount to overall peat formation. See list of key peat forming species above.

- Dominant-occasional, i.e. cover >5%, scores 1;
- Rare - absent (cover – 4% or less) scores 0.

3 Surface Wetness

The wetter the bog surface, the greater its capacity for forming active peat, however as a wet bog surface is a pre-requisite for active bog, rather than an indicator of it, it is considered a neutral feature rather than a positive one. Dry and drained bog with a water table below the surface provides sub-optimal conditions for the growth of Sphagna and may result in erosion of peat and is therefore considered a negative feature. A ‘squelch’ underfoot was counted as wet surface.

- Wet / spongy surface scores 0;
- Dry/drained surface scores -1

4 Peat Depth

Active peatlands are more likely to occur on deep peats, although they are not necessarily restricted to them and peat less than 0.5m deep is, therefore, considered to be a neutral feature rather than a negative one. Deeper peats are likely to occur in depressions or flat areas

and very shallow slopes that prevent or slow the flow of water and allow it to sit and stagnate within the peat.

- Peat depth 0.5m or more scores 1;
- Peat depth less than 0.5m scores 0.

5 Peat Hydrology

Peatlands with purpose-built drains or those affected by gullying or erosion retain less water than intact examples and are less able to create the stagnant hydrological conditions required for active peat formation. As intact hydrology is considered a pre-requisite of active bog rather than an indicator of it, it is considered a neutral, rather than a positive, feature. Drainage effects normally extends to 2-3m effect from drains, but grips can affect downslope areas as well. Drainage therefore is assessed across the vegetation unit. Make note on its density.

- Peat hydrology intact scores 0;
- Peat hydrology damaged by gullying or erosion scores -1.

6 Bare Peat

Large areas of bare peat or partially vegetated peat are likely to be completely devoid of Sphagna and are vulnerable to drying effects and to gully erosion, which further affects their hydrological integrity. An intact surface vegetation is therefore considered a pre-requisite for active peat formation, rather than indicator of active conditions and is considered a neutral, rather than a positive, feature. Assess within the vegetation unit, not just the quadrat.

- Rare or none present scores 0;
- Occasional - Dominant bare peat and/or algae mats on surface scores -1.

7 Hare's-tail cotton-grass (*Eriophorum vaginatum*)

Hare's-tail cotton-grass is highly typical of rain-fed ecosystems and presence of this species is indicative of the vegetation being isolated from the effects of irrigation by enriched surfaces or ground water. Hare's-tail cotton-grass is not, however, an indicator of active bog as the species is slow to form peat when present in monospecific stands, such as in some examples of M20a. Nevertheless, the species is a good indicator of ombrogenous conditions and is always present in the main NVC communities that form active bog (i.e. M17, M18 and M19) according to Rodwell (1991).

- Occasional – Dominant cover at least 5% scores 0;
- Absent to rare with cover of 4% or less scores -1.

8 Typical Blanket Bog Species

An abundance of typical blanket bog species as defined in EU 7310, is indicative that the vegetation is stable, whereas invasion by particular species, for example mat grass (Nardus stricta), soft rush (Juncus effusus) or heath rush (Juncus squarrosus), to form intermediate stands, can indicate a negative shift in plant composition due to management or other factors. As the typical range of blanket vegetation can include some very impoverished vegetation, a typical range of species is considered to be a neutral feature rather than a positive one. There is no threshold for the number of typical species which should be recorded in quadrats.

- Typical range of blanket bog species present score 0;
- Cover mostly of non-typical bog species score -1.

9 Hummock and Pool Formation

Hummock and pool formations are characteristic of the large expanses of blanket bog vegetation in the Flow Country, although they can occur elsewhere on a smaller scale. They are indicative of optimal peatforming conditions on blanket bogs. Assess within quadrat and surrounding 5-10m circle.

- Hummocks and pools present score 1;
- Hummocks and pools absent score 0.

10 Vegetation Mosaics

Mosaics of blanket bog vegetation with other types are less likely to be actively peat forming due to edge effects and invasion of species from the other community. Mosaics with acid grassland or species-poor heathland probably indicate drying of the peat due to management or environmental factors, or to where the peat is thin and at the edge of the peat mass. A homogenous stand referable to blanket bog is considered to be a neutral feature, rather than a positive one. Assess within scale of vegetation unit.

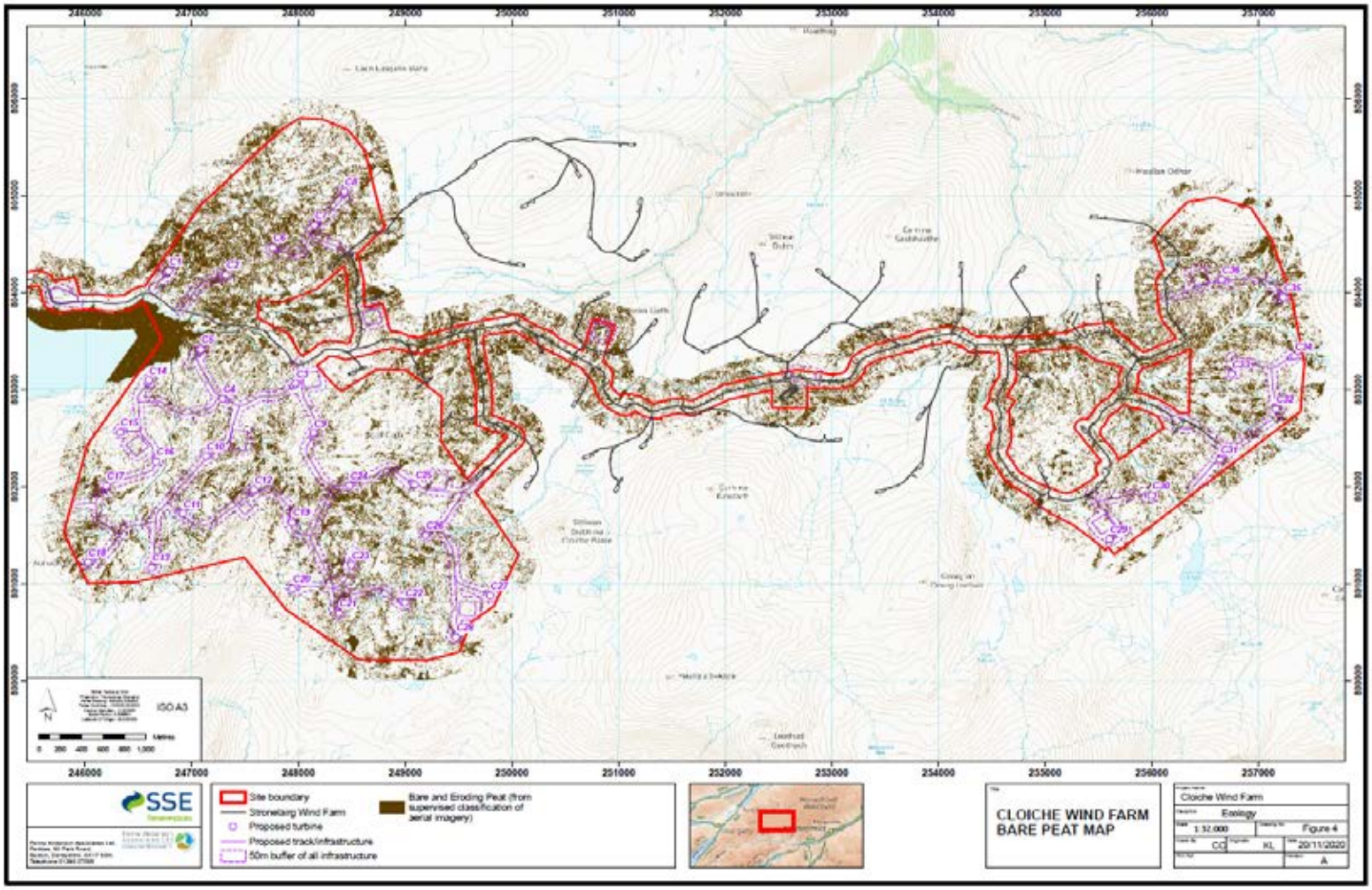
- Homogeneous stand referable to blanket bog score 0;
- Mosaic with acid grassland or dwarf shrub heath score -1.

Scoring

- Sum of scores of 4 to 7 are considered as **'active'**
- Sum of scores of 3 are considered as '**possibly active'**
- Sum of scores of 1 to 2 are considered as '**potentially active'**
- Sum of scores of 0 or less are considered as '**inactive'**

APPENDIX 3.

Bare Peat Map



Peat Depth Model