National Parks & Wildlife Service

Moneybeg and Clareisland Bogs SAC (site code 002340)

Conservation objectives supporting document - raised bog habitats

Version 1

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Contents

1 Introduction

This document presents a summary of the background information that has informed the process of setting the Site-Specific Conservation Objective in relation to the priority Annex I habitat 'active raised bog' (habitat code 7110) (hereafter referred to as Active Raised Bog (ARB)), for which Moneybeg and Clareisland Bogs Special Area of Conservation (SAC) has been designated.

Moneybeg and Clareisland Bogs SAC is also designated for two other related Annex I habitats, namely; 'degraded raised bogs still capable of natural regeneration' (habitat code 7120) (hereafter referred to as Degraded Raised Bog (DRB)) and 'depressions on peat substrates of the Rhynchosporion' (habitat code 7150). Based on the close ecological relationship between these three habitats types, it is not necessary to set specific Conservation Objectives for all three habitats individually. It is considered that should favourable conservation condition for ARB be achieved on the site, then, as a consequence, favourable conservation condition for the other two habitats would also be achieved.

1.1 Raised Bogs

Raised bogs are accumulations of deep peat (typically 3-12m) that originated in shallow lake basins or topographic depressions. The name is derived from the elevated surface, or dome, that develops as raised bogs grow upwards through the accumulation of peat; the domed effect is often exaggerated when the margins of a bog are damaged by turf cutting or drainage, and are drying out. Raised bogs are most abundant in the lowlands of central and mid-west Ireland.

Irish raised bogs are classified into two sub-types (Schouten 1984): 1. Western or intermediate raised bogs, and 2. True midland or eastern raised bogs, based on phytosociological and morphological characteristics. In terms of overall morphology, the main difference between these two raised bog types is that while eastern raised bogs tended to stay more confined to the depressions in which they were formed, western raised bogs tended to grow out beyond their original basin, presumably a result of the higher rainfall levels (Cross 1990). In terms of vegetation differences the most obvious difference between the two bog types is the presence of a number of oceanic plant species on western raised bogs which are absent from the true midland raised bogs. The liverwort species *Pleurozia purpurea*[1] and the moss species *Campylopus atrovirens* grow on western raised bogs but not on eastern raised bogs; similarly, *Carex panicea* is generally more common on the high bog surfaces of western raised bogs (Schouten 1984). All of these plant species are widespread in the low-level Atlantic blanket bogs and their presence in western raised bogs is presumed to be due to the higher rainfall levels and greater rain-derived nutrient fluxes.

Exploitation has been extensive and none of the remaining Irish raised bogs are completely intact (Cross 1990). It is estimated that less than 10% of the original raised bog habitat in Ireland is in a near intact state (uncut), with less than 0.5% continuing to support ARB (DAHG 2014). Excavated face banks, whether active or inactive, are a common feature around the margins. Any areas where part of the bog has been removed are termed cutover bog, with the remaining area referred to as high bog or intact bog. In a natural state, raised bogs are circled by a wetland fringe, known as the lagg zone, which is usually characterised by fen

[1] Note on species nomenclature: *In the case of plant species, only scientific names are used throughout the main text while common English names are included in tables. In the case of faunal species, common English names are used throughout the text (where known) together with scientific names.*

communities. In Ireland, most laggs have been lost through drainage and land reclamation (Fossitt 2000).

The surface of a relatively intact raised bog is typically wet, acid, deficient in plant nutrients, and supports specialised plant communities that are low in overall diversity and comprising species adapted to the biologically harsh conditions. The vegetation is open, treeless and bog mosses or *Sphagnum* species dominate the ground layer. Small-scale mosaics of plant communities are characteristic and reflect the complex microtopography of hummocks and hollows on the bog surface (see Section 1.1.1 below). Raised bogs are driest at the margins and wetness generally increases towards the centre of the peat mass where well-developed pool systems are most likely to occur.

Raised bogs may also contain soaks and flushes (wet 'active' or dry 'inactive') due to the increased supply of nutrients over time through concentrated surface flows, or where there are links with regional groundwater or the underlying mineral substratum. Slight mineral enrichment and / or constant through flow of water provide conditions suitable for a range of species that are not typically associated with other areas of raised bog.

When damaged by peat extraction or drainage, the water table in the peat drops and the bog surface becomes relatively dry; pools are rare or absent, cover of bog mosses is greatly reduced and *Calluna vulgaris* increases in abundance. The drop in water table causes the peat to compress under its own weight causing the bog surface to deform. Greater deformation occurs closest to areas where the water table has dropped. This increases the slope of the bog surface causing rain falling on the ground surface to flow off the bog more quickly. The effect is normally greatest around the margins and in a typical situation surface wetness increases towards the centre of the bog. Trees such as *Betula pubescens* and *Pinus sylvestris* frequently invade the drier cut margins, but may also occur in flushed areas.

In Ireland, the Annex I habitat ARB is currently considered to be in unfavourable bad conservation status principally as a result of marginal turf cutting, more recent semi-industrial peat extraction, and associated drainage effects caused by these activities (NPWS 2008; 2013). The lowering of regional groundwater levels are also known to have had an effect on some sites. Fires associated with turf cutting, dumping, or agricultural activities may also adversely affect the condition of the habitat.

1.1.1 Raised Bogs Microtopography

Raised bogs are typically treeless and are characterised by a distinctive vegetation dominated by bog mosses (*Sphagnum*), sedges, and dwarf shrubs, all of which are adapted to waterlogged, acidic and exposed conditions. Bog mosses, which have unique properties, are the principal component of peat, and are largely responsible for the typical surface features of hummocks, hollows, lawns, and pools. The wettest bogs, which have extensive pool systems, have the greatest variety of plant and animal life and support a range of specialist species.

The following terms that describe microtopography are generally accepted in the study of mire ecology (Gore 1983). A schematic diagram showing the typical microtopographical divisions is presented in Figure 1.

Pools

Depressions in the bog surface where the water table remains above the surface level all year around or below surface level for only a very short period of time. They are characterised by the presence of aquatic plant species such as *Sphagnum cuspidatum*, *S. denticulatum*, and *Cladopodiella fluitans*. In more degraded scenarios or where high seasonal water fluctuation occurs, the pools contain open water and/or algae. Tear pools are

found on bogs where internal tensions, due to mass movement of peat, has taken place within the high bog and has caused the development of elongated pools. These are frequently found on western bogs and may be natural or anthropogenic in origin.

Hollows

These are shallow depressions (less than 5cm deep) on the bog surface where surface water collects, or where the water table reaches or lies just above ground level, depending on seasonal conditions. They are often filled with *Sphagnum* species such as *S. papillosum* and *S. cuspidatum*. They take many forms but are often eye shaped. Marginal hollows tend to be elongated as they are focused points for surface water run-off. They are often dominated by *Narthecium ossifragum*.

Lawns

These are shallow hollows or flat areas where one species dominates to form a lawn. This is frequently a *Sphagnum* species, such as *Sphagnum magellanicum,* or *S. papillosum* which can completely fill in a hollow to form a small lawn.

Flats

These are more or less flat areas which are intermediate between hollow and hummock communities. They tend to be drier than the above situations.

Hummocks

These are mounds on the bog surface which can range from a few centimetres to more than one metre in height. They are usually composed mainly of *Sphagnum* species, such as *Sphagnum magellanicum, S. capillifolium, S. austinii* and *S. fuscum* but other bryophyte species such as *Hypnum jutlandicum* and *Leucobryum glaucum* are also important, especially as the hummock grows taller and becomes drier. *Calluna vulgaris* is another important element, as it flourishes where the water table is not at surface level (Kelly & Schouten 2002).

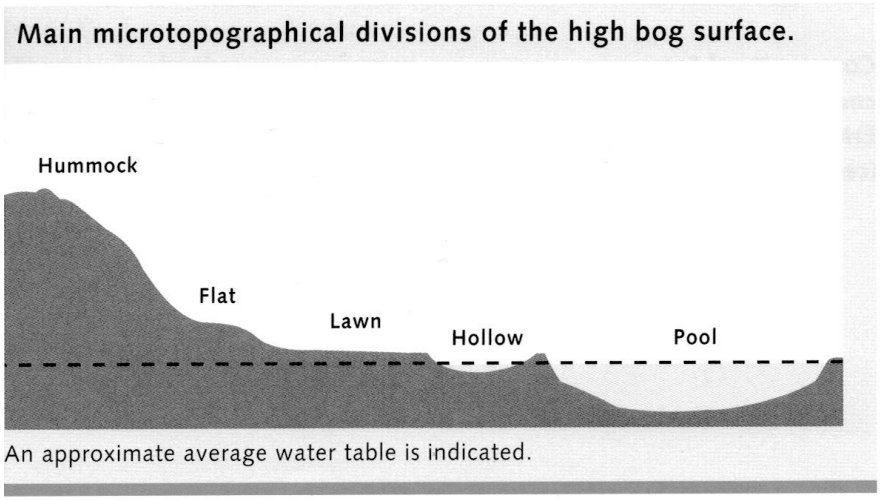

Figure 1 Raised bog microtopographical divisions on the high bog surface (reproduced from Kelly & Schouten 2002).

1.1.2 Typical Flora of Irish Raised Bogs

Raised bogs are characterised by a distinctive vegetation dominated by a variety of mosses (e.g. *Sphagnum spp., Hypnum spp., Racomitrium spp.*), sedges and grass-like species (e.g. *Eriophorum spp., Rhynchospora spp., Narthecium ossifragum, Molinia caerulea* and *Carex spp.*), and dwarf shrubs (e.g. *Calluna vulgaris, Erica tetralix, Vaccinium spp.* and *Empetrum nigrum*). In addition to these groups, a number of other species characterise raised bogs including carnivorous plants (e.g. *Drosera spp., Utricularia spp.*), lichens of both the bog surface and epiphytes on the stems of dwarf shrubs and the occasional trees on bogs (e.g. *Cladonia* spp*., Usnea* spp.). Herbaceous plants are not a significant element on raised bogs and include a few commonly occurring species such as *Menyanthes trifoliata, Pedicularis sylvatica*, and *Potentilla erecta* (Cross 1990).

Drier areas and hummocks usually support *Calluna vulgaris*, *Eriophorum vaginatum*, *Trichophorum germanicum*, *Erica tetralix*, lichens (*Cladonia* spp.), bog mosses (*Sphagnum capillifolium*, *S. austinii*, *S. fuscum*, *S. papillosum*) and other mosses (*Dicranum scoparium*, *Leucobryum glaucum*). Wet hollow areas and pools are characterised by *Eriophorum angustifolium*, *Rhynchospora alba*, *Narthecium ossifragum*, *Drosera* spp., *Menyanthes trifoliata*, bladderworts (*Utricularia* spp.) and bog mosses (*Sphagnum cuspidatum, S. denticulatum and S. magellanicum*).

A list of flora species that are regarded as being typical of ARB habitat in Ireland is presented in Table 1. A number of these typical species would have a restricted distribution and do not occur throughout the range of the habitat in Ireland (see above), therefore only a subset of these species would be expected to be present on any individual bog.

Table 1 Flora species typically associated with active raised bog in Ireland (after NPWS 2013). *Species list is based on vegetation communities defined by Kelly (1993) and Kelly & Schouten (2002).*

Common name	Scientific Name
Bog rosemary	Andromeda polifolia
Bog bead moss	*Aulacomnium palustre*
Bristly Swan-neck moss*	*Campylopus atrovirens**
Lichen	*Cladonia ciliata*
Lichen	*Cladonia portentosa*
Long leaved sundew	*Drosera anglica*
Intermediate leaved sundew*	*Drosera intermedia**
Round leaved sundew	*Drosera rotundifolia*
Common cotton grass	*Eriophorum angustifolium*
Hare's tail cotton grass	*Eriophorum vaginatum*
Large white moss	*Leucobryum glaucum*
Bogbean	*Menyanthes trifoliata*
Bog asphodel	*Narthecium ossifragum*
Purple spoonwort*	*Pleurozia purpurea**
Woolly fringe moss*	*Racomitrium lanuginosum**
White beak-sedge	*Rhynchospora alba*
Austin's bog moss	*Sphagnum austinii*
Red bog moss	*Sphagnum capillifolium*
Feathery bog moss	*Sphagnum cuspidatum*
Cow-horn bog moss*	*Sphagnum denticulatum**
Rusty bog moss	*Sphagnum fuscum*
Magellanic bog moss	*Sphagnum magellanicum*
Papillose bog moss	*Sphagnum papillosum*
Golden bog moss*	*Sphagnum pulchrum**
Lustrous bog moss	*Sphagnum subnitens*
Bladderwort	*Utricularia minor*
Cranberry	*Vaccinium oxycoccos*

*Notes: * Species more typical of western raised bog sites.*

1.1.3 Typical Fauna of Irish Raised Bogs

Raised bogs are extremely nutrient poor ecosystems. Acidic, waterlogged and exposed conditions make them an unattractive habitat for animal life. As a consequence they are relatively poor both in terms of species diversity and population densities. Many species are opportunists, vagrant or temporary rather than specialists, but nonetheless may have an important impact on the ecosystem through nutrient imports and exports or other interactions (Cross 1990). A list of fauna species that would be typically associated with raised bog habitat in Ireland is presented in Table 2. The species listed are not confined to ARB and most, if not all, will use other areas of the bog and surrounding habitats.

Raised bog is unsuitable habitat for many vertebrates due to the lack of available foraging and suitable breeding places. The Irish hare is the only mammal commonly occurring. The common frog is the most common vertebrate predator.

Although 18 species of birds have been reported breeding on raised bogs (Wilson 1990) many of these species utilise the bog as a nesting habitat only. They are dependent on other neighbouring habitats such as open water bodies, callows and wet grassland particularly for feeding. Just a few species of bird, including meadow pipit (*Anthus pratensis*), skylark

(*Alauda arvensis*) and curlew (*Numenius arquata*) complete their full breeding cycle on the bog and the first two species are the commonest species occurring (Bracken *et al.* 2008). Red grouse (*Lagopus lagopus*) must also be included as a typical bog species, occurring year round as a resident. Red grouse and curlew have declined significantly on raised bogs in recent times. BirdWatch Ireland have published an Action Plan for Raised Bog Birds in Ireland which lists 13 species of conservation concern that are associated with Raised Bogs (O'Connell 2011). A recent review of birds of conservation concern in Ireland has since added meadow pipit (*Anthus pratensis*) to the red (most endangered) list of Birds of Conservation Concern in Ireland (BoCCI) (Colhoun & Cummins 2013).

Our knowledge of the invertebrate assemblages associated with Irish raised bogs remains incomplete (particularly micro-invertebrate species) with few studies undertaken (Reynolds 1984a; Reynolds 1984b; Reynolds 1985; De Leeuw 1986; O Connor *et al*. 2001; Crushell *et al.* 2008; Hannigan & Kelly-Quinn 2011; Wisdom & Bolger 2011, Nolan 2013). Van Duinen (2013) highlights the importance of structural diversity at various spatial scales (e.g. micro-scale of hummock hollow topography to macro-scale which would include the landscape setting of the bog, see Schouten (2002)) as a prerequisite for hosting the full species diversity of raised bog landscapes.

A recent study of Lepidoptera associated with raised bogs identified two species that appear to be characteristic of higher quality raised bog habitat, namely bordered grey (*Selidosema brunnearia* (Villers, 1789)) and light knot grass (*Acronicta menyanthidis* (Esper, 1789)) (Flynn 2014).

Recent research on spiders has revealed that a number of species are known to occur in Ireland only on raised bog habitats, all of which are considered local/uncommon or rare across Europe (Myles Nolan pers. comm.). Five of these species that can be considered useful indicators of ARB include: *Glyphesis cottonae* (La Touche 1945), *Walckenaeria alticeps* (Denis 1952), *Satilatlas britteni* (Jackson 1913), *Pirata piscatorius* (Clerck 1757), and *Minicia marginella* (Wider 1834) (Myles Nolan pers. comm.).

The information currently available on other invertebrate groups of peatland systems in Ireland is not sufficient to allow a determination of many species that are typically associated with or may be characteristic of higher quality ARB. A selection of invertebrate species and species groups that are known to be typically associated with raised bogs are presented in Table 2.

Table 2 Fauna species typically associated with raised bog ecosystems in Ireland (after O'Connell 1987; Cross 1990; Renou-Wilson *et al.* 2011; Bracken & Smiddy 2012).

Common name	**Scientific name**
Mammal species	
Irish hare	*Lepus timidus hibernicus*
Otter	*Lutra lutra*
Pygmy shrew	*Sorex minutes*
Fox	*Vulpes vulpes*
Bird species	
Skylark	*Alauda arvensis*
Mallard	*Anas platyrhynchos*
Greenland white-fronted goose	*Anser albifrons flavirostris*
Meadow pipit	*Anthus pratensis*
Hen harrier	*Circus cyaneus*
Cuckoo	*Cuculus canorus*
Merlin	*Falco columbarius*
Kestrel	*Falco tinnunculus*
Snipe	*Gallinago gallinago*
Red grouse	*Lagopus lagopus*
Curlew	*Numenius arquata*
Golden plover	*Pluvialis apricaria*
Lapwing	*Vanellus vanellus*
Reptiles and amphibians	
Common lizard	*Lacerta vivipara*
Common frog	*Rana temporaria*
Typical invertebrates	
Black slug	*Arion ater*
Large heath butterfly	*Coenonympha tullia*
Marsh fritillary butterfly	*Euphydryas aurinia*
Bog-pool spider	*Dolomedes fimbriatus*
Water striders	*Gerris* and *Velia* species
Oak eggar moth	*Lasiocampa quercus*
Four-spotted chaser dragonfly	*Libellua quadrimaculata*
Fox moth	*Macrothylacia rubi*
Ant	*Myrmica ruginodis*
Emperor moth	*Saturnia pavonia*
Great green bog grasshopper	*Stethophyma grossa*
Other species groups that are well represented on raised bogs include:	Araneae (spiders and mites)
	Ceratopogonidae (biting-midges)
	Chironomids (non-biting midges)
	Coleoptera (beetles)
	Collembola (springtails)
	Diptera (true flies)
	Dytiscidae (water beetles)
	Hemiptera (true bugs)
	Hymenoptera (bees, wasps, ants and sawflies)
	Lepidoptera (butterflies and moths)
	Odonta (dragonflies and damselflies)
	Orthoptera (grasshoppers)
	Syrphidae (hoverflies)
	Tipulidae (craneflies)
	Tabanidae (horseflies)

1.2 Habitats Directive Raised Bog Habitats in Ireland

Four habitat types listed on Annex I of the EU Habitats Directive are typically associated with raised bogs in Ireland, two of which are priority habitats (*):

- 7110 Active raised bogs (ARB)*
- 7120 Degraded raised bogs still capable of natural regeneration (DRB)
- 7150 Depressions on peat substrates of the *Rhynchosporion*
- 91D0 Bog woodland*

The interpretation manual of EU habitats gives the following description for 'active raised bogs': "*Acid bogs, ombrotrophic, poor in mineral nutrients, sustained mainly by rainwater, with a water level generally higher than the surrounding water table, with perennial vegetation dominated by colourful Sphagna hummocks allowing for the growth of the bog (Erico-Sphagnetalia magellanici, Scheuchzerietalia palustris p., Utricularietalia intermedio-minoris p., Caricetalia fuscae p.). The term "active" must be taken to mean still supporting a significant area of vegetation that is normally peat forming, but bogs where active peat formation is temporarily at a standstill, such as after a fire or during a natural climatic cycle e.g., a period of drought, are also included*." (CEC 2007).

DRB should be, according to the interpretation manual capable of regeneration to 'Active Raised Bog' in 30 years if appropriate measures are put in place (i.e. no major impacting activities are present and any necessary restoration works are implemented).

In Ireland, the identification of ARB is made at ecotope level based on the vegetation classification developed by Kelly (1993) and Kelly & Schouten (2002).

Raised bog vegetation communities are grouped into a series of community complexes and these complexes are then amalgamated into a series of ecotopes characterised by different physical characteristics using the approach outlined by Kelly & Schouten (2002).

The main ecotopes that community complexes are grouped into include:

- Central ecotope
- Sub-central ecotope
- Active flushes and soaks
- Sub-marginal ecotope
- Marginal ecotope
- Inactive flushes
- Face-bank ecotope

Actively accumulating peat conditions occur within the sub-central and central ecotopes, which are the wettest on the bog and an indication of good quality ARB. Active flushes and soaks are also dominated by *Sphagnum* mosses and typically have wet conditions. These features are associated with ARB and contribute to the overall diversity of the habitat.

The adjacent surrounding marginal, sub-marginal, and face-bank bog areas typically have a supporting function for the central and sub-central communities but are not peat accumulating. These drier ecotopes may or may not correspond to the Annex I habitat DRB, as it depends on whether they are capable of regeneration to ARB. Other drier ecotopes recorded on the high bog that do not correspond to ARB include 'inactive flushes' which typically have a low *Sphagnum* cover.

The Annex I habitat Rhynchosporion depressions (7150) typically occurs along pool edges and on flats underlain by deep, wet and quaking peat. Typical plant species include *Rhynchospora alba*, *Drosera anglica*, *Narthecium ossifragum*, *Sphagnum cuspidatum*, *S. denticulatum*, *S. magellanicum*, *S. papillosum*, *Menyanthes trifoliata*, and *Eriophorum angustifolium*.

The priority Annex I habitat bog woodland is also actively peat-forming and overlaps with the ARB habitat. Such woodlands are usually dominated by *Betula pubescens* with a characteristic ground cover dominated by *Sphagnum* moss species, which often form deep carpets, and other mosses including species of *Polytrichum*. Woodland areas are occasionally found on raised bogs that have an absence of the characteristic moss layer and are not regarded as peat forming. Such areas do not correspond to the Annex I habitat.

1.2.1 Restoration of Active Raised Bog in Ireland

As already mentioned in the section 1.1, ARB is currently considered to be in unfavourable bad conservation status in Ireland. In addition, according to its definition, DRB should be capable of regeneration to ARB in a 30-year timescale. Thus, it follows that restoration measures are required in order to halt further losses and increase the area of ARB as well as to improve the condition of existing areas of the Annex I habitat.

Most of the restoration works undertaken so far in Ireland have concentrated on the high bog (e.g. Clara Bog, Mongan Bog, Sharavogue Bog and Raheenmore Bog) to prevent further losses as well as to restore areas to ARB. Nevertheless, some restoration works have also been undertaken on cutover areas such as at Ballykenny and Fisherstown Bogs and Killyconny Bog. Such work aims to do one or more of the following (depending on the bog in question): restore ARB on the high bog; reduce further ARB and DRB loss on the high bog; restore peat forming habitats (such as ARB, bog woodland, poor fen) on the cutover.

Works undertaken by the NPWS have indicated that there are significant differences, both ecological and economic, when comparing the effectiveness of works carried out on the cutover with those carried out on the high bog. Positive and significant results (i.e. expansion or development of ARB) can be achieved over a relatively short timeframe (10 years) on favourable areas of the high bog by blocking high bog drains. In contrast, a longer time period (30 years+) is required to achieve active peat formation on cutover areas, and even then the results are generally confined to smaller areas; i.e. flat areas (≤0.3% surface slope) or enclosed depressions that have sufficient water flow (minimum catchment 0.5ha) to maintain wet conditions throughout the year. A longer time period (minimum 50-100 years) is likely to be required for high quality ARB habitat (vegetation structure and species diversity) to develop on such cutover areas. In addition, costs of restoration measures on cutover areas are typically significantly higher than those on high bog areas.

1.3 Moneybeg and Clareisland Bogs SAC

The SAC includes the raised bog, known as Moneybeg and Clareisland Bogs and surrounding areas which include cutover bog, forestry, small areas of wet and improved grassland and scrub and bog woodland on cutover.

The SAC has been selected for three Annex I habitats:

- [7110] Active raised bogs*
- [7120] Degraded raised bogs still capable of natural regeneration
- [7150] Depressions on peat substrates of the *Rhynchosporion*

Moneybeg and Clareisland Bogs SAC is situated on the border of Counties Meath and Westmeath, 9 km east of the town of Granard. It is located mainly in the townlands of

Clareisland or Derrymacegan, Williamstown and Moneybeg in Co. Westmeath, and Ross in Co. Meath.

The SAC consists of two separate lowland raised bogs, situated on the southern shores of Lough Sheelin. An important feature of these bogs is that in some areas the transition from high bog to open water is intact and not separated by cutover bog as is the case in the majority of other Irish raised bogs.

The raised bog habitat includes both areas of high bog and cutover bog. The high bog at Moneybeg consists of a single small dome with extensive cutover areas to the east and west. Overall the high bog is flat, with slopes associated with the southern margin. There is a wet area with a characteristic microtopography of pools, hummocks, and hollows. The local road from Mount Nugent to Finnea runs through the bog and an isolated northern section adjoins the lake shore. There is also a large mineral mound adjoining the western extent of the high bog. The raised bog is surrounded by agricultural land, which in the east slopes steeply down to the cutover. There was conifer forestry to the south and south-west which has been recently clear-felled as part of a Coillte EU LIFE restoration project.

The raised bog at Clareisland consists of a small, linear high bog extending along the shore of Lough Sheelin with only limited cutover areas to the east and west. There is an extensive wet area with frequent pools on the high bog and there is a slight slope towards the lake margin. The local road described above runs by the southern margin of the high bog and there is conifer forestry on cutover south of the road. Recent peat cutting has occurred in the SAC.

Moneybeg and Clareisland Bog SAC is of considerable conservation significance as it comprises two raised bogs that grade into remnant semi-natural lake margins. The bogs are located at the north-eastern extreme of the range of raised bogs in Ireland.

1.3.1 Flora of Moneybeg and Clareisland Bog

At Moneybeg and Clareisland Bogs the high bogs have vegetation typical of a midland raised bog type consisting of *Calluna vulgaris*, *Eriophorum vaginatum*, *Rhynchospora alba*, and bog mosses (*Sphagnum* spp.), with *Vaccinium oxycoccos* and *Andromeda polifolia* also present. On Moneybeg Bog, the bog mosses *Sphagnum capillifolium, S. papillosum, S. tenellum* and *S. austinii* are plentiful in the extensive wet area, with many large pools lined by bog mosses, including *Sphagnum fuscum*. *Drosera anglica* is present in some pools, along with the bog moss *Sphagnum cuspidatum.* A few of the pools are completely infilled with bog mosses and *Eriophorum angustifolium*.

A general summary of the habitats and flora associated with each of the bogs is described in the following sections.

1.3.1.1 Moneybeg Bog

ARB includes only sub-central ecotope and is found on the main lobe of high bog (Crowley & Crushell 2015b).

Sub-central ecotope is found at three locations and three community complex types are recorded. The largest area (1.2ha) of ARB is found in the east of the high bog. Two community complexes are found here. The best quality vegetation type recorded contains well defined long linear pools supporting an almost complete cover of *Sphagnum cuspidatum* with *S. denticulatum* also present and *S. magellanicum* and *S. papillosum* found at the pool edges. These pools are in fact of central ecotope quality, but the vegetation in the inter-pool areas particularly the *Sphagnum* hummocks displayed signs of degradation with *S. tenellum* common, which is often an indicator of past burning (Cross 1990). The

overall *Sphagnum* cover ranges from 51-75% and the pool cover was 34-50%. *Calluna vulgaris*, *Rhynchospora alba*, *Eriophorum vaginatum*, and *E. angustifolium* are the most dominant vascular plants with *Vaccinium oxycoccos* also present. A small number of *Pinus sylvestris* of ca. 3m in height are also recorded. Towards the north, this complex graded into a slightly more degraded sub-central complex. The main difference being that the *Sphagnum* cover in the pools was not as complete (with algae being more prominent) and the inter-pool areas were more degraded with a higher cover of *Narthecium ossifragum*. The overall *Sphagnum* cover ranged from 34-50% and the pool cover is 11-25% (Crowley & Crushell 2015b).

Two small areas of ARB (0.3ha and 0.1ha) are located in the north-west and west of the main lobe of high bog. These areas have possibly developed as a result of secondary re-wetting having formed in depressions in areas around old infilled drains where water is ponding. The overall *Sphagnum* cover is 34-75%. Scattered large hummocks of *Leucobryum glaucum* are recorded as well as frequent hummocks of *Sphagnum austinii*, which appeared to be actively growing. Overall, the microtopography is poorly developed and fairly uniform with small *Sphagnum*-filled hollows and lawns, low poorly developed hummocks and an absence of pools. *Calluna vulgaris* and *Eriophorum vaginatum* are the dominant vascular plants with *Sphagnum capillifolium*, *S. magellanicum*, and *S. cuspidatum* the dominant *Sphagna*. Evidence of past burns was also recorded in these areas such as a low cover of *Cladonia portentosa* and frequent *Campylopus introflexus*.

DRB at Moneybeg Bog mainly overlaps with sub-marginal ecotope. Detailed descriptions of the non-active raised bog ecotopes recorded on the high bog are presented in the following paragraphs.

The sub-marginal ecotope (31.1ha) featured the most developed microtopography within non-active raised bog ecotopes. Four community complexes were recorded within the sub-marginal ecotope.

The first complex is the best quality sub-marginal complex and thus occasionally had some sub-central characteristics. It was found in the north-east, mid-east and the mid-south of the main lobe of high bog. Although well defined pools cover 11-25% of this complex, the *Sphagnum* cover in them is generally patchy (although there are some isolated exceptions) and they displayed a reduced water level with a high frequency of algae. Furthermore, the inter-pool areas are poor in quality and often dominated by *Narthecium ossifragum*, the cover of which increases in poorer quality areas and decreases in better quality areas. The overall *Sphagnum* cover is 11-25%, but the presence of numerous degraded (apparently dead) *Sphagnum* hummocks indicated that this was much higher in the past. Patches of bare peat are also present and this together with the high frequency of *Campylopus introflexus* and the low cover of *Cladonia portentosa* suggest that these areas suffered from disturbance/fire in the past. *Calluna vulgaris*, *Narthecium ossifragum*, and *Eriophorum vaginatum* are the dominant vascular plants (Crowley & Crushell 2015b).

The second complex is recorded mainly in the north-west and west of the high bog. Pools are absent and the overall *Sphagnum* cover ranged from 11-33%. The presence of numerous degraded (apparently dead) *Sphagnum* hummocks again indicates that the *Sphagnum* cover was much higher in the past. *Calluna vulgaris* and *Eriophorum vaginatum* are the dominant vascular plants and *Sphagnum capillifolium* is the dominant *Sphagna* although *S. papillosum*, *S. austinii* and *S. tenellum* are all recorded.

The third complex was the most common complex on the high bog and is found over most of the high bog surface, but is largely absent from the mid-east, the south-east and the south-west. The overall *Sphagnum* cover ranges from 11-25%. The microtopography is poorly developed and fairly uniform with low hummocks, algal hollows, flats and, in general, an

absence of pools. *Calluna vulgaris*, *Narthecium ossifragum* and *Eriophorum vaginatum* are the dominant vascular plants. *Sphagnum capillifolium* and *S. papillosum* are the dominant *Sphagna* although *S. austinii*, *S. magellanicum*, *S. cuspidatum* and *S. tenellum* are all recorded.

The fourth complex is the poorest quality sub-marginal complex recorded on Moneybeg and thus had some marginal ecotope characteristics. This complex is found mostly in the mid-west and mid-east of the high bog. The overall *Sphagnum* cover ranges from 4-25%. The microtopography is poorly developed and fairly uniform with low hummocks, algal hollows, flats and an absence of pools. *Calluna vulgaris* and *Narthecium ossifragum* are the dominant vascular plants. *Sphagnum capillifolium* was the dominant *Sphagna* although *S. papillosum* and *S. tenellum* are also recorded.

Marginal ecotope (36.12ha) is slightly drier than sub-marginal ecotope and is mainly recorded as a narrow band near the margin of the high bog.

1.3.1.2 Clareisland Bog

Clareisland Bog has a semi-natural margin with Lough Sheelin and an extensive wet area with a high cover of bog mosses and pools. Most of the pools are infilling with *Narthecium ossifragum*, *Rhynchospora alba* and bog mosses. *Drosera anglica* and the bog moss *Sphagnum cuspidatum* occur in the pools and other bog moss species occur at the pool edges, especially *S. capillifolium, S. papillosum, S. magellanicum* and *Sphagnum fuscum*. The lichen *Cladonia portentosa* is common, along with *Andromeda polifolia* and *Vaccinium oxycoccos* growing through the bog mosses. The semi-natural margin is dominated by tall *Calluna vulgaris* with lush carpets of the moss *Hypnum jutlandicum* and large hummocks of *Sphagnum capillifolium*. There are many deep cracks in the peat due to subsidence at the lake margin. A thin margin of *Ulex europaeus* and *Betula pubescens* scrub occurs at the lake edge (Crowley & Crushell 2015a).

At Clareisland Bog, ARB includes central and sub-central ecotope.

Central ecotope is found in two very small areas. Only one community complex type is recorded, consisting of high and low hummocks, hollows and pools. The pools cover 11-25% of the area and are filled with *Sphagnum cuspidatum* as well as supporting *Drosera* spp and *Rhynchospora alba*. The overall *Sphagnum* cover ranges from 51-75% composed mostly of *S. cuspidatum* in pools and *S. capillifolium* in hummocks. However, *S. magellanicum* is also recorded in lawns and around the pools as well as *S. papillosum* and hummocks of *S. austinii* and *S. fuscum*. *Calluna vulgaris* dominates on hummocks and *Eriophorum vaginatum* is also frequent. Hummocks of *Leucobryum glaucum* are also recorded as well as *Andromeda polifolia*, *Vaccinium oxycoccos* and *V. myrtillus*.

Sub-central ecotope is found in only one area (3.7ha) of the high bog surrounding the two small areas of central ecotope. Two community complex types are recorded (Crowley & Crushell 2015a).

The first complex covers the largest area and has a 4-10% cover of pools. These pools, however, are not clearly defined and in places are more like *Sphagnum*-filled depressions. The overall *Sphagnum* cover ranges from 34-50% composed mostly of hummocks of *S. capillifolium* with *S. cuspidatum* frequent in pools and *S. papillosum* and *S. magellanicum* frequent at pool edges. Hummocks of *S. austinii* and *S. fuscum* are also recorded as well as *S. tenellum*. *Calluna vulgaris* dominates on hummocks and *Eriophorum vaginatum* is also frequent. The cover of *Rhynchospora alba* is variable, but generally less than in central ecotope while the cover of *Narthecium ossifragum* is greater.

The second complex is recorded in a small area in the north of the sub-central extent. The

micro-topography here is poorly developed with the area essentially being a continuous low hummock. The overall *Sphagnum* cover ranges from 51-75% composed mostly of hummocks of *S. capillifolium* though hummocks of *S. papillosum* and *S. austinii* are frequent. *S. magellanicum* and *S. cuspidatum* are recorded in hollows. *Calluna vulgaris* and *Eriophorum vaginatum* dominate the vegetation with *Narthecium ossifragum* largely absent in this complex. *Andromeda polifolia*, *Vaccinium oxycoccos*, *Aulacomnium palustre* and *Polytrichum* spp. are also recorded.

DRB at Clareisland Bog mainly overlaps with sub-marginal ecotope. Detailed descriptions of the non-active raised bog ecotopes recorded on the high bog are presented in the following paragraphs (Crowley & Crushell 2015a).

The sub-marginal ecotope (38.6ha) features the most developed microtopography within the non-active raised bog ecotopes. However, pools are largely absent. Four community complexes are recorded within the sub-marginal ecotope.

The first complex is the best quality sub-marginal complex and thus occasionally has some sub-central characteristics. It is found mainly in the north of the site. Pools are absent and the overall *Sphagnum* cover ranges from 26-33%. The presence of numerous degraded (apparently dead) *Sphagnum* hummocks again indicates that the *Sphagnum* cover was much higher in the past. *Calluna vulgaris* and *Eriophorum vaginatum* are the dominant vascular plants and *Sphagnum capillifolium* is the dominant *Sphagna* although *S. papillosum*, *S. austinii*, *S. magellanicum*, *S. cuspidatum,* and *S. tenellum* are all recorded. This complex grades into the sub-central complex and the difference between the two can be subtle and difficult to distinguish at times.

The second complex is the most common complex on the high bog and is found over most of the high bog surface. The overall *Sphagnum* cover ranges from 11-25%. The microtopography is poorly developed and fairly uniform with low hummocks, algal hollows, flats and, in general, an absence of pools. *Calluna vulgaris*, *Narthecium ossifragum* and *Eriophorum vaginatum* are the dominant vascular plants. *Sphagnum capillifolium* is the dominant *Sphagna* although *S. austinii*, *S. magellanicum*, *S. papillosum*, *S. cuspidatum,* and *S. tenellum* are all recorded.

The third complex is found to the south of the area of ARB. The overall *Sphagnum* cover ranges from 11-25% and the vegetation is characterised by a prominence of *Eriophorum angustifolium.*

The fourth complex is the poorest quality sub-marginal complex recorded on Clareisland Bog and thus had some marginal ecotope characteristics. The overall *Sphagnum* cover ranges from 4-25%. The microtopography is poorly developed and fairly uniform with low hummocks, algal hollows, flats and an absence of pools. *Calluna vulgaris* and *Narthecium ossifragum* are the dominant vascular plants. *Sphagnum capillifolium* is the dominant *Sphagna* although *S. papillosum*, *S. austinii* and *S. tenellum* are also recorded (Crowley & Crushell 2015a).

1.3.2 Fauna of Moneybeg and Clareisland Bogs

The common frog (*Rana temporaria*) and the common lizard (*Lacerta vivipara*) have been recorded on Moneybeg and Clareisland Bogs. Mammal species that have been recorded from the marginal areas (and watercourses) surrounding the bog include otter (*Lutra lutra*), red squirrel (*Sciurus vulgaris*), Irish hare (*Lepus timidus hibernicus*) and stoat (*Mustela erminea hibernica*).

(DEHLG 2004).

The following birds have been recorded in the SAC: merlin (*Falco columbarius*); peregrine (*Falco peregrinus*); skylark (*Alauda arvensis*) – probably breeding on site; sandmartin (*Riparia riparia*) – nesting in cut turf face-bank on Clareisland Bog; meadow Pipit (*Anthus pratensis*) – probably breeding on site; grey heron (*Ardea cinerea*) – resident along lake shore; reed bunting (*Emberiza schoeniclus*) – frequent along northern boundary near lake shore and snipe (*Gallinago gallinago*) – probably breeding on site (DEHLG 2004).

2 Conservation objectives

A site-specific conservation objective aims to define the favourable conservation condition of a habitat or species at site level. The maintenance of habitats and species within sites at favourable condition will contribute to the maintenance of favourable conservation status of those habitats and species at a national level.

Conservation objectives for habitats are defined using attributes and targets that are based on parameters as set out in the Habitats Directive for defining favourable status, namely area, range, and structure and functions. Attributes and targets may change or become more refined as further information becomes available.

National Conservation Objectives for raised bog SACs have recently been published in the Draft National Raised Bog SAC Management Plan (DAHG 2014). The various attributes and the justification of appropriate targets used to define favourable conservation condition for ARB relevant to Moneybeg and Clareisland Bogs SAC are discussed in the following sections.

2.1 Area

NPWS has commissioned a number of raised bog surveys between 1993 and the present-Kelly *et al*. (1995); Derwin & MacGowan (2000); Fernandez *et al*. (2005); Fernandez *et al*. (2006); Fernandez *et al*. (2014); Crowley and Crushell (2015a,b). Mapping from these surveys has been used to derive the area of ARB for each bog as shown in Table 3. More recent surveys have been able to employ more precise and detailed mapping techniques and more standardised ecotope descriptions. NPWS undertook a review of data from earlier surveys in 2014 taking into account these improved techniques with the aim of providing more accurate figures for ARB. This in some cases has resulted in a change in ARB area for these earlier time periods (NPWS, unpublished data).

The national SAC target for the attribute 'habitat area' has been set at 2,590ha (DAHG 2014). This target is based on the estimated area of ARB (1,940ha) and DRB (650ha) present within the SAC network in 1994 (when the Habitats Directive came into effect).

The area of ARB at Moneybeg and Clareisland Bogs in 1994 is not known as the bog was first surveyed in 2000. The area of ARB in 2000 is estimated to have been 23.8ha (see Table 3). Due to lack of data it is not possible to use the same approach that has been adopted in setting the national SAC target (sum of ARB and DRB in 1994). However, it can be assumed (based on the known trend at other sites) that a proportion of ARB is likely to have been lost from the site during the period 1994 – 2000.

In setting the site-specific target, the current hydro-ecological conditions on the bog (including cutover) have been considered in order to ensure that the target being set is based on a realistic appraisal of what is achievable as set out below.

The most recent monitoring survey of the bog estimated the area of ARB to be 5.3ha (Crowley & Crushell 2015a,b). This represents a decrease of 18.5ha (78%) during the period 2000-2015. The current extent of DRB as estimated using a recently developed hydrological

modelling technique, based largely on Light Detection and Ranging (LiDAR)[2] data is 25.5ha (see DAHG 2014 for further details of the technique). This represents the area of the high bog, which does not currently contain ARB but has topographical conditions deemed suitable to support ARB (see Map 1 which shows the total area of current and modelled potential ARB). This area was further refined to 14.8ha by estimating the area that could be restored by blocking drains on the high bog. This refinement was based on applying an efficacy factor (see DAHG 2014).

Based on the current assessment of the bog, it is therefore concluded that the maximum achievable target for ARB on the high bog is 20.1ha. However, it is important to note that this assumes no further decline of ARB due to impacting activities. Similarly, should the bog be significantly dependent on regional groundwater levels then any deepening of drains in the cutover could further impact the potential restoration of ARB on the high bog.

Table 3 Area of ARB and DRB recorded on the high bog at Moneybeg and Clareisland Bogs in 2000, and 2015 (Source: NPWS, unpublished data; Crowley & Crushell 2015a,b).

2000		**2015 (DRB from 2012)**	
ARB (ha)	DRB (ha)	ARB (ha)	DRB (ha)
23.8	Unknown	5.3	14.8

A recent eco-hydrological assessment of the cutover surrounding the high bog undertaken as part of the restoration planning process estimates that, by implementing appropriate management, an additional 11.6ha of ARB could be restored in this area. The long term achievable target for ARB on Moneybeg and Clareisland Bogs is therefore set at 31.7ha.

In conclusion, the site-specific target for the attribute habitat area is: **Restore area of active raised bog to 31.7ha, subject to natural processes.**

2.2 Range

At a national scale, range represents the geographic range that encompasses all significant ecological variations of the ARB habitat. The national SAC target for the attribute 'range' has been set as 'not less than current range subject to natural processes'.

However, range, in the form of habitat distribution, may also be important at the site level, particularly within larger SACs, including those containing a number of individual bogs (i.e. complexes). The attribute therefore under the parameter of range is 'habitat distribution'. At the local level, it is important to conserve the variability and distribution of ARB across a raised bog SAC. This will help to ensure the diversity of the habitat is maintained while lessening the impact of localised damaging activities such as fire.

The conservation of ARB within Moneybeg and Clareisland Bogs as set out in Section 2.1 above will contribute to safeguarding the national range of the habitat.

The ARB habitat at Moneybeg and Clareisland Bogs includes central and sub-central ecotopes. A map showing the most recent distribution of ecotopes throughout Moneybeg and Clareisland Bogs is presented in Map 2.

The site-specific target for the attribute habitat distribution is: **Restore the distribution and**

[2] LiDAR is a remote sensing technology that measures vertical surface elevation by illuminating a target with a laser and analysing the reflected light. This provides much more detailed topographical maps than can be collected by traditional surveying techniques.

variability of active raised bog across the SAC.

2.3 Structure and functions

Structure and functions relates to the physical components of a habitat ("structure") and the ecological processes that drive it ("functions"). For ARB these include attributes such as the hydrological regime, water quality, habitat quality, species occurrence, elements of local distinctiveness, marginal habitats, negative physical indicators, and negative species occurrence. As several of these attributes are inter-connected, they are all included in order to better define habitat quality in a meaningful way. In some cases, attribute targets are not quantified; however, as more detailed information becomes available (for example through further research), more measurable site-specific targets may be developed. Structure and functions attributes are expanded on in the sections below.

2.3.1 High bog area

On individual raised bogs adequate high bog is required to support the development and maintenance of ARB. Raised bog habitat that is classified as neither ARB nor DRB is still important particularly as a supporting habitat for those listed in Annex I of the Habitats Directive. It is an essential part of the hydrological unit which supports the ARB and DRB habitats. High bog is of value in its own right as a refuge for species characteristic of drier bog conditions as well as for providing a transitional zone between the Annex I habitats of the high bog and surrounding areas. Additional values for the maintenance of high bog include the preservation of its record of past environmental conditions and carbon storage. The area of high bog in the entire SAC network in 1994 was 10,740ha. The corresponding area in 2012 is 10,515ha – indicating that there has been a 225ha loss of high bog since 1994.

The national target for the attribute 'high bog' habitat is to ensure no decline in extent of high bog to support the development and maintenance of ARB.

The area of high bog within Moneybeg and Clareisland Bogs SAC in 1994 was mapped as 149.8ha, while the corresponding area in 2012 is 141.5ha (based on interpretation of LiDAR and aerial photography flown in 2012), representing a loss of 8.3ha of high bog (DAHG 2014). The extent of high bog within the SAC in 2012 is illustrated on Map 1.

The site-specific target for the attribute high bog is: **No decline in extent of high bog necessary to support the development and maintenance of active raised bog.**

2.3.2 Hydrological regime: water levels

Hydrological processes are key drivers of raised bog ecology. The different raised bog communities, assemblages and species are affected by various hydrological attributes. For ARB, mean water levels need to be near or above the surface of bog lawns for most of the year. Seasonal fluctuations should not exceed 20cm, and water level should be within 10cm of the surface, except for very short periods of time (Kelly & Schouten 2002). Gentle slopes that limit intermittent lateral losses of water (through surface run-off) and encourage sustained waterlogging are the most favourable to achieve these conditions. Such conditions may be maintained on steeper slopes in areas of focused flow (flushes).

The traditional view of water flowing across the bog laterally has been recently refined to also consider that water flows vertically through peat into the underlying substrate. Water loss, by this route, depends on the permeability of the material through which the water must flow and the difference in head (water level elevation) in the bog and underlying mineral substrate; larger differences encountered in higher permeability materials will result

in greater losses. Although the proportion of water lost in this manner may be small, the sustained loss during prolonged dry periods may be sufficient to impact bog ecotopes. Drains extending into the mineral substrate in marginal areas surrounding the bog can lead to an increased gradient between the head in the peat and the head in the underlying substrate resulting in increased vertical water losses from the bog.

The most recent description of drainage at Moneybeg and Clareisland Bogs is presented in Crowley & Crushell (2015a,b) who reported that there are 7.1km of drains impacting on high bog habitats. 4.5km of these drains are reported as reduced functional and 2.6km of drains reported as functional. In addition, a further 6.2km of unblocked drains were reported as non-functional, however, it is not known whether these drains are likely to be impacting upon the hydrology of the bog. In addition to high bog drainage both Moneybeg and Clareisland Bogs are surrounded by a dense network of cutover drains, running perpendicular to the facebanks to facilitate adequate drainage of the spreading-grounds. There are also road drains running parallel to the Ross – Finnea road, which crosses through both Moneybeg and Clareisland Bogs.

A survey of hydrochemistry within the main drainage channels surrounding Moneybeg Bog was carried out in January 2015. The focus of this survey was to identify areas of upwelling groundwater, to assist with identifying whether drainage intercepts the regional groundwater table. At Moneybeg Bog there are two key drainage channels surrounding the bog, one drain flows from the south-east of the bog towards the south-west and then north-west into Lough Sheelin. The second drain flows from the eastern side of the bog towards the north-east before flowing north towards Lough Sheelin. The western drain shows a pattern of increasing contributions from mineralised groundwater from the south-eastern side of the bog towards the south-western side of the bog with Electrical Conductivity (EC) values increasing from 246µS/cm to 497µS/cm. As the drain flows north, EC values gradually decrease to a minimum of 435µS/cm before the drain reaches the Ross – Finnea road. This indicates that contributions of bog water from the cutover drains is diluting the mineralised regional groundwater within the drain. At the road EC drops to 286µS/cm indicating very significant dilution by bog water, most likely as a result of considerable flow entering the main drain from the drain along the road. Flow within the main drain recorded north of the road bridge was 0.32m^3/s on the day of the survey.

Within the drain to the east of the bog, very low ECs were encountered initially (56-81µS/cm), which is indicative of bog water that has not been in contact with mineral substrate. However, before the drain begins to flow towards the north, ECs increased rapidly to a maximum of 515µS/cm indicating significant regional groundwater contributions. As the drain flows towards the north EC values decrease slightly to a minimum of 499µS/cm at the road, indicating dilution by bog water contributions. Flow within the drain at the road was 0.27 m^3/s on the day of the survey.

Elevated EC measurements were noted within the drains along the road, though it is believed that this is due to bog water reacting with the limestone gravel used as part of the road construction, rather than upwelling regional groundwater.

Regional groundwater heads are likely to have been impacted by drainage schemes on the Inny River system and it is believed that the level in Lough Sheelin is lower than it would have been in the past. This may have contributed to lowering water levels within the peat and therefore contributed to subsidence at Moneybeg and Clareisland Bogs. The risk of subsidence depends on the permeability of the underlying mineral substrate, which will influence the extent of impacts from changes to groundwater heads. Geological mapping indicates that the bog is underlain by dark limestone and shale bedrock; this is typically classified as a locally important aquifer, which is moderately productive only in local zones.

Subsoil mapping indicates the presence of limestone till surrounding the peat. Coring undertaken as part of the survey carried out in January 2015 identified several locations at Moneybeg Bog where a highly permeable gravel or sand substrate was encountered. If groundwater heads within this layer have declined it is very likely that this would have contributed to subsidence on the surface of Moneybeg Bog.

The site-specific target for the attribute hydrological regime – water levels is: **Restore appropriate water levels throughout the site.**

2.3.3 Hydrological regime: flow patterns

As outlined above, ARB depends on water levels being near or above the surface of bog lawns for most of the year. Long and gentle slopes are the most favourable to achieve these conditions. Changes to flow directions due to subsidence of bogs can radically change water regimes and cause drying out of high quality ARB areas and soak systems.

A map illustrating the slopes and drainage patterns on Moneybeg and Clareisland Bogs based on a digital elevation model generated from LiDAR imagery flown in 2012 is presented in Map 3.

The flow patterns on Moneybeg Bog illustrate that the main drain running south to north through the centre of the bog has had a significant impact on the drainage of the high bog, as a large proportion of the flow is directed through this area. The drain has resulted in subsidence with very steep slopes (>1.0%) occurring in adjacent areas. There are some areas where slopes are more gentle, particularly further east and west of the main drain (<0.5%). In general, the topography appears to be have been impacted significantly by subsidence across large parts of the site. In contrast, slopes across Clareisland Bog are much more gentle across a large area of the bog. A significant proportion of the flow on Clareisland Bog is directed to the north-east towards Lough Sheelin. Turf-cutting has had an evident impact on slopes across Clareisland Bog, this is particularly obvious from the steep slopes extending further into the centre of the bog as a result of turf cutting at two plots along the western margin of the bog. Changes to flow patterns or slope arising from subsidence associated either with high bog or marginal drainage are likely to have a significant impact on the areas of active raised bog.

The site-specific target for the attribute hydrological regime – flow patterns is: **Restore, where possible, appropriate high bog topography, flow directions and slopes.**

2.3.4 Transitional areas between high bog and surrounding mineral soils (includes cutover areas)

Transitional zones between raised bogs and surrounding mineral soils are typically cutover bog and drained lagg zones. The maintenance / restoration of these areas will help to maintain hydrological integrity of ARB and DRB, and support a diversity of other wetland habitats (e.g. wet woodland, swamp and fen) as well as species that they sustain. In some cases, these areas may assist in reducing further losses of ARB / DRB on the high bog and in time could develop into active peat forming habitats (including ARB - see Section 2.1 above). These transitional zones, once restored, can provide ecosystem services through flood attenuation and water purification to downstream areas and potentially increase the carbon storage / sink function of the bog. The estimated extent of such transitional areas within the SAC network is 3,000ha (DAHG 2014). The national target for these transitional areas is to maintain / restore semi-natural habitats with high water levels around as much of the bog margins as necessary.

The transitional areas at Moneybeg and Clareisland Bogs include a range of different habitat

types (e.g. wet grassland, cutover bog and scrub). The total area of cutover bog within the Moneybeg and Clareisland Bogs SAC is estimated to be circa 140ha. The development of habitats within cutover areas depends on a number of factors including prevailing land-use, topography, up-welling regional groundwater, and drainage.

At Moneybeg Bog there are extensive areas of cutover to the east and west. Sections of old cutover are dominated by *Calluna vulgaris*, *Molinia caerulea* and *Ulex europaeus* scrub. These areas are bordered by *Betula pubescens* scrub and woodland. Across the road on the slope to the lake there is old cutover dominated by *Molinia caerulea* grading into *Betula pubescens* scrub at the shoreline. The presence of a large wooded mineral mound, (unknown whether natural or anthropogenic origin) adds to the interest of this raised bog. At Clareisland Bog there are abandoned peat-cuttings in the north-west dominated by *Calluna vulgaris* and to the east there is cutover dominated by *Molinia caerulea* with encroaching *Ulex europaeus* scrub. Recent peat cutting has occurred at Moneybeg and Clareisland Bogs.

A former forestry plantation on the cutover to the west of Moneybeg Bog has been felled as part of a Coillte-led EU LIFE restoration project. Forestry occurs in marginal areas to the south of Clareisland Bog.

Bog woodland (non-Annex I habitat) is found along parts of the bog margins, and is dominated by *Betula pubescens*, with *Salix* spp., with *Alnus glutinosa* and occasional *Sorbus aucuparia*. *Lonicera periclymenum* is frequent. The shrub layer is dominated by *Rubus fruticosus* and *Pteridium aquilinum* with a ground flora of low-growing *Vaccinium myrtillus*, *Calluna vulgaris*, and *Luzula sylvatica*. Non-native *Fagus sylvatica* is found occasionally as an understorey species.

Scrub of *Betula pubescens* with *Salix* spp. fringes much of the bog margin, and grades into woodland. *Ulex europaeus* is locally dominant in some areas of scrub. A small strip of *Corylus avellana* and *Prunus spinosa* scrub is found on a sloping bank of mineral soil in the south-west of the site.

Two small areas of semi-improved grassland are included in the SAC as they occur within the hydrological unit of the raised bogs. They are currently managed as pasture, and are dominated by grasses such as *Poa* spp. with *Ranunculus repens* and *Ranunculus acris*, with occasional *Juncus effusus*. A small amount of wet grassland is found at the margins of the SAC, grading into areas of cutover bog. It is dominated by grasses such as *Agrostis stolonifera* and *Festuca rubra* with *Juncus effusus*. *Carex flacca*, *Cirsium palustre*, and *Ranunculus flammula* are frequent throughout.

The site-specific target for the attribute transitional areas is: **Restore adequate transitional areas to support / protect active raised bog and the services it provides.**

2.3.5 Vegetation quality: central ecotope, active flush, soaks, bog woodland

A diverse good quality microtopography on raised bogs consists of *Sphagnum* dominated pools, hollows, lawns and hummocks, which support the highest diversity of species including hummock indicators: *Sphagnum fuscum* and *S. austinii*; pool indicators: *S. cuspidatum*, *S. denticulatum*, and indicators of lack of burning events e.g. some lichen species (*Cladonia* spp.) (Cross 1990).

The national target for the attribute vegetation quality has been set as “to maintain / restore sufficient high quality bog vegetation (i.e. central ecotope and / or flushes / soaks). At least 50% of ARB habitat should be central ecotope and / or flush / soaks.” Bog woodland is also regarded as a desirable variant of ARB as it adds species and structural diversity to the habitat and therefore, where relevant, also contributes to the 50% target at site level.

A summary description of the vegetation of Moneybeg and Clareisland Bogs is presented in Section 1.3.1 above. The vegetation and habitats of the bog have been described in more detail by Derwin & MacGowan (2000), and Crowley & Crushell (2015a,b).

The extent of the different ecotopes that correspond with ARB based on the most recent surveys is presented in Table 4 and on Map 2. During the most recent surveys the entire area of ARB comprised sub-central and central ecotopes. It is clear that there has been a significant recent reduction in the proportion of ARB made up of central ecotope (see Table 4). The target for this attribute is 15.9ha of high quality ARB (50% of ARB target area (31.7ha)). This requires an increase from the current area of 0.1ha.

Table 4 Extent of ecotopes classified as ARB in 2004 and 2014 (modified from Crowley & Crushell 2015).

Ecotope	2000		2015	
	ha	% of total ARB	ha	% of total ARB
Sub-central ecotope	14.9	62.6	5.2	98.1
Central ecotope	8.9	37.4	0.1	1.9
Total ARB	**23.8**		**5.3**	

The site-specific target for the attribute vegetation quality is: **Restore 15.9ha of central ecotope/active flush/soaks/bog woodland as appropriate.**

2.3.6 Vegetation quality: microtopographical features

The characteristic microtopographical features of raised bogs are described in Section 1.1.1 above.

Hummock and hollow microtopography is well developed on Moneybeg and Clareisland Bogs (Derwin & MacGowan 2000; Crowley & Crushell 2015a,b).

The site-specific target for the attribute microtopographical features is: **Restore adequate cover of high quality microtopographical features.**

2.3.7 Vegetation quality: bog moss (*Sphagnum*) species

Bog mosses, which have unique properties, are the principal component of peat, and are largely responsible for the typical microtopographical features as described in Section 2.3.6 above.

The vegetation of a typical raised bog that is still hydrologically intact is characterised by the dominance of several species of Sphagna and dwarf ericoid shrubs. The most abundant species are *Sphagnum capillifolium, S. austinii* and *S. papillosum* which form hummocks or low ridges. *Sphagnum fuscum* may also form hummocks (Cross 1990). On the flats *Sphagnum magellanicum, S. papillosum, S. tenellum,* and *S. subnitens* are the key species. *Sphagnum pulchrum* may also be dominant in flats on western raised bogs. In permanently waterlogged hollows *Sphagnum cuspidatum* and *S. denticulatum* (western bogs) occur. *Sphagnum fallax* is common where there is slight flushing (Cross 1990). The most commonly occurring *Sphagnum* moss species that occur on raised bogs in Ireland are presented in Table 5 along with a summary of their ecology and typical contribution to peat formation.

Crushell & Crowley (2015) and Derwin & MacGowan (2000) provide further information on the occurrence of *Sphagnum* species throughout Moneybeg and Clareisland Bogs.

Table 5 *Sphagnum* species typically associated with raised bog ecosystems in Ireland. Ecology as described by Laine *et al.* (2009) with minor modifications.

Species	Ecology	Peat forming capacity
Sphagnum austinii	Hummock species	High
Sphagnum capillifolium	Forms small hummocks and carpets	Moderate
Sphagnum cuspidatum	Pool and hollow species	Low
Sphagnum denticulatum	Pool and hollow species	Low
Sphagnum fallax	Occurs in lawns and carpets, shade tolerant. Indicative of some nutrient enrichment (soaks and active flushes)	Low
Sphagnum fuscum	Forms dense low and wide, and occasionally high hummocks	High
Sphagnum magellanicum	Lawn species forming carpets and low hummocks	Moderate
Sphagnum palustre	Forms hummocks and dense carpets, often in shaded conditions. Indicative of nutrient enrichment (soaks and active flushes)	Low
Sphagnum papillosum	Lawn , hollow, and low hummock species	Moderate
Sphagnum pulchrum	Grows in lawns and hollows, more typical of western bogs	Moderate
Sphagnum squarrosum	Forms carpets and small mounds. Indicative of nutrient enrichment (soaks and active flushes)	Low
Sphagnum subnitens	Occurs as individual shoots or small cushions and lawns. Tolerant of minerotrophic conditions	Moderate
Sphagnum tenellum	Occurs as single shoots or weak cushions, typically in disturbed patches of the bog surface	Low

The site-specific target for the attribute bog moss (*Sphagnum*) species is: **Restore adequate cover of bog moss (*Sphagnum*) species to ensure peat-forming capacity.**

2.3.8 Typical ARB species: flora

Moneybeg and Clareisland Bogs supports the full complement of plant species typically associated with a true midland raised bog (see Section 1.1.2 above).

The key typical species that are indicative of high quality raised bog include *Sphagnum fuscum* and *S. austinii* which are associated with hummocks and *S. cuspidatum* and *S. denticulatum* which are associated with pools and hollows. All of these species have been reported from Moneybeg and Clareisland Bogs (Crowley & Crushell 2015a,b).

The site-specific target for the attribute typical bog flora is: **Restore, where appropriate, typical active raised bog flora.**

2.3.9 Typical ARB species: fauna

As mentioned in section 1.1.3, a list of typical fauna specific to ARB has not been developed and the table contains species that use the wider raised bog habitat. This may be refined as more information becomes available.

Moneybeg and Clareisland Bogs are likely to support a wide range of fauna species that are typically associated with raised bog habitat (see Section 1.1.3 above).

The site-specific target for the attribute typical bog fauna is: **Restore, where appropriate, typical active raised bog fauna.**

2.3.10 Elements of local distinctiveness

A range of features may be associated with raised bogs which add to the scientific, historical, or conservation value of a bog. These can include geological, topographical, archaeological and hydrological features (e.g. soaks, lakes, flushes) and noteworthy species of flora and fauna (Cross 1990). Notable species of flora and fauna include those listed in the Habitats and Birds Directives, Red-listed species, and other rare or localised species. For this attribute, features that are particularly associated with ARB are relevant.

2.3.10.1 Site features

The main feature of local distinctiveness on Moneybeg and Clareisland Bogs is the lakeside location at Lough Sheelin and semi-natural edges along the north of the SAC, particularly in Clareisland Bog.

A small (0.3ha) but notable feature of the high bog on Moneybeg Bog is the presence of a mineral mound in the west of the SAC. The vegetation of this mound is described by Derwin & MacGowan (2000) and features a mature oak (*Quercus petraea*) estimated by them to be 500 years old.

2.3.10.2 Rare flora

No rare flora records have been reported from Moneybeg and Clareisland Bogs.

2.3.10.3 Rare fauna

As mentioned above, there is limited current documented site-specific data relating to species that are particularly associated with ARB, including rare species.

In conclusion, the site-specific target for the attribute elements of local distinctiveness is: **Maintain features of local distinctiveness, subject to natural processes.**

2.3.11 Negative physical indicators

Raised bogs that have been damaged by marginal cutting and drainage, reclamation for agriculture, forestry activities, fire, surface drainage, or the lowering of regional water tables show a range of negative physical indicators (Cross 1990). Such negative physical features of ARB include: bare peat, algae dominated pools and hollows, marginal cracks, tear patterns, subsidence features such as dry peat and / or mineral mounds / ridges emerging or expanding, and burning evidence.

Some activities that can lead to negative physical features have already been described in previous sections.

2.3.11.1 Clareisland Bog

At Clareisland Bog there has been a recent fire (2014) in the east of the site that severely burnt circa 3.0ha of the high bog vegetation. Another fire burned 1.2ha of the vegetation in the south of the high bog in 2012 while a more extensive fire occurred in 2010, which burnt 17.9ha of the high bog (of which 3.3ha was classed as ARB in 2000). This fire spread across the centre of the bog elongated in an east-west direction. Fernandez *et al*. (2006) reported that almost the entire high bog surface was burned in 2003. They also reported that most of the bog was badly damaged by fire in the 1980s.

The impacts of fire on raised bogs, which vary greatly depending on the type and frequency of fires are described in detail by Cross (1990) and include damage or destruction of the acrotelm and vegetation changes encompassing a trend towards a reduced *Sphagnum* cover

and an increased cover of herbs (particularly *Eriophorum vaginatum* and *Trichophorum germanicum*) and dwarf shrubs (principally *Calluna vulgaris*) as well as an increased abundance of *Narthecium ossifragum* in wetter areas.

It is likely that the repeated burning of the high bog at Clareisland has played, at least some role, in the degradation of the vegetation. This is supported by the fact that of the 4.0ha of ARB burned in 2003, only 0.5ha is mapped as ARB in 2015 and of the 3.3ha of ARB burned in 2010 only 1.2ha is mapped as ARB in 2015. Since fire events appear to be frequent at Clareisland Bog (and they have undoubtedly contributed to the degradation of the vegetation including areas of former ARB), they are considered to have had a high importance/impact on high bog habitats (Crowley & Crushell 2015a,b).

2.3.11.2 Moneybeg Bog

On Moneybeg Bog, Crowley & Crushell (2015a,b) reported that there has been no change in the length of functional drains on the high bog since 2000. 2.6km of drain remain functional and a further 1.7km reduced functional. Some of these run straight down the centre of the main lobe of high bog and are up to 2m deep and wide in places, with a significant flow of water recorded running north. The high bog dome has subsided along the length of this drain and the drain is having such an effect on the high bog vegetation that despite running close to the centre of the high bog, it is surrounded by a narrow band (ca. 5m wide) of marginal type vegetation.

The only other drains on the high bog classed as fully functional are the series of parallel drains in the north-west of the high bog. Here there are 13 functional drains totaling 1.6km running approximately NNW-SSE. High bog drainage is considered to have high importance/impact on high bog habitats. No blockage of high bog drains has occurred to date (2015).

During the period 2000-2012 peat cutting on Moneybeg Bog was relatively intensive as indicated by the loss of 5.1ha (7.3% of the total high bog present) and by the severe slumping, cracking and subsidence recorded along the high bog margin where cutting was taking place. Peat cutting activity is considered to have a high importance/impact on high bog habitats. In addition, old face banks and high bog and cutover drainage associated with cutting continue to cause negative impacts on the high bog habitats (Crowley & Crushell 2015a,b).

There is evidence of past burns spread across the entire high bog, and at least two significant fires occurred on the high bog from 2000-15. It is likely that past burns have played, at least some role, in the degradation of the vegetation at Moneybeg. Fire events are considered to have had a medium importance/impact on high bog habitats at Moneybeg Bog.

The site-specific target for the attribute negative physical indicators is: **Negative physical features absent or insignificant.**

2.3.12 Vegetation composition: native negative indicator species

Indicators of disturbance on a raised bog include species indicative of drying out conditions such as abundant *Narthecium ossifragum* and *Trichophorum germanicum*; *Eriophorum vaginatum* forming tussocks; abundant *Sphagnum magellanicum* in pools previously dominated by species typical of very wet conditions (e.g. *Sphagnum cuspidatum*). Indicators of frequent burning events include abundant *Cladonia floerkeana* and high cover of *Carex panicea* (particularly in the true midlands raised bog type).

At Clareisland Bog only one individual of *Pinus* sp. (likely to have been *Pinus sylvestris* but not confirmed) was recorded on the high bog. This was c. 1.25-1.5m in height and was found towards the northern margin of the high bog, close to drain D8 (Crowley & Crushell 2015a,b).

On Moneybeg Bog Derwin & MacGowan (2000) reported the presence of *Pinus sylvestris* across parts of the southern portion of the high bog describing it as frequent in one particular marginal complex. In the 2015 survey (Crowley & Crushell 2015a,b), again the only area with frequent *Pinus sylvestris* was the south of the high bog. Although scattered individuals of *Pinus sylvestris* were noted in the mid-east of the high bog in the 2015 survey, it can be seen from aerial photos that these were already present in 2000. Indeed, it is only in the south-west of the high bog that any significant numbers of young pines were recorded and it is here that the pines may be spreading. The spread of *Pinus* spp. is indicative of the high bog drying out and their presence is likely to result in further drying out of the site.

The site-specific target for the attribute native negative indicator species is: **Native negative indicator species at insignificant levels.**

2.3.13 Vegetation composition: non-native invasive species

Non-native invasive species that can commonly occur on raised bog habitats include: *Pinus contorta*, *Rhododendron ponticum*, and *Sarracenia purpurea* (Cross 1990).

At Clareisland Bog *Campylopus introflexus* has been recorded from many areas of the high bog, particularly towards the margins and areas that have suffered more from fires and drainage.

At Moneybeg Bog *Campylopus introflexus* has been recorded across most of the high bog, but is especially abundant towards the mid-eastern margins. This is part of the area of high bog that was burned in 2003 and 2010 and that is also suffering particularly badly from the effects of drainage and turf cutting as indicated by the severe slopes present in the area as well as the cracking and subsidence of the peat surface.

Non-native *Rhododendron ponticum* and *Prunus laurocerasus* are found in scrub areas in a few locations on cutover. Though not currently widespread, they could potentially spread on degraded bog or into woodland.

The site-specific target for the attribute non-native invasive species: **Non-native invasive species at insignificant levels and not more than 1% cover.**

2.3.14 Air quality: nitrogen deposition

Peatlands are highly sensitive to air pollution, particularly nitrogen deposition. Reactive nitrogen from fossil fuel combustion or intensive agriculture can contaminate rain and snow, causing soil acidification, nutrient enrichment, and a decline in species that are sensitive to these conditions. There is evidence that the combined impact of elevated nitrogen deposition and a warming climate could exceed the sum of the individual stressors and lead to a dramatic decline in the biodiversity of mosses, sensitive vascular plants, and microbes, potentially leading to catastrophic peat loss (PEATBOG project - http://www.sste.mmu.ac.uk).

Air pollution can change both the species composition and the functioning of peatlands. The primary atmospheric pollutant from the Industrial Revolution to the mid 1970s was sulphur deposition, but levels have since greatly declined. Reactive nitrogen (N) deposition (primarily NO3- and NH4+), which can both acidify and eutrophy, became significantly elevated over a

widespread area in the early to mid-20th century and is now the major pollutant in atmospheric deposition across most of Europe (Fowler *et al.* 2005).

Nitrogen is commonly a limiting terrestrial nutrient and in un-impacted peatlands it is tightly cycled. With long-term elevated N deposition, vegetation composition typically shifts toward species adapted to higher nutrient levels, with an overall loss of diversity (Malmer & Wallén 2005). In peatlands, field experiments with N additions within the current European range have shown significant declines in bryophyte species-richness and productivity, and shifts in composition toward vascular plants (Bobbink *et al.* 1998; Bubier *et al.* 2007). Community shifts toward more nitrophilous bryophytes in N-enriched regions such as parts of the Netherlands are also well documented (Greven 1992). In the UK, both a general survey of peatlands across the country (Smart *et al.* 2003), and a targeted study of *Calluna* moorland (Caporn *et al.* 2007) showed significant inverse relationships between levels of nitrogen deposition and species richness, with bryophytes particularly impacted. Changes in the vegetation also impact below-ground communities and biogeochemical processes.

Moderate increases in N deposition from a low level may increase *Sphagnum* and vascular plant productivity without an equal increase in decomposition rates, leading to enhanced carbon accumulation (Turunen *et al.* 2004). However, shifts in species composition from bryophytes to vascular plants may increase the production of easily-decomposable plant material, leading to higher rates of decomposition, and reduced carbon accumulation (Lamers *et al.* 2000; Bubier *et al.* 2007).

The particular sensitivity of nutrient-poor ombrotrophic peatlands to nitrogen enrichment is reflected in the low critical load threshold of between 5 and 10kg N/ha/yr for these ecosystems (Bobbink & Hettelingh 2011), a level which is exceeded over a significant portion of their range. An Irish study during the late 1990s undertaken by Aherne & Farrell (2000) concluded that total N deposition shows a strong east-west gradient, with lowest deposition in the west at 2kg N/ha/yr and highest in the east and south-east at 20kg N/ha/yr. Average N deposition over the Republic of Ireland was estimated to be approximately 12kg N/ha/yr. The study also concluded that the Critical Load Threshold for N was exceeded in at least 15% of ecosystems studied. The critical load applied to peatland ecosystems by Aherne & Farrell (2000) was 10kg N/ha/yr. This is in line with the recommendation by Bobbink & Hettelingh (2011) that the critical load should be set at the high end of the range in areas of high precipitation and at the low end of the range in areas of low precipitation assuming that Ireland represents a high precipitation area.

It is recommended in the case of Moneybeg and Clareisland Bogs that the level of N deposition should not exceed the low end of the range i.e. 5kg N/ha/yr. This recommendation is based on a precautionary approach, as the evidential basis for setting a higher level is not particularly strong as alluded to by Payne (2014). Total N deposition in the vicinity of Moneybeg and Clareisland Bogs as reported by Henry & Aherne (2014) is 19.3kg N/ha/yr.

The site-specific target for the attribute air quality is: **Air quality surrounding bog close to natural reference conditions. The level of N deposition should not exceed 5kg N/ha/yr.**

2.3.15 Water quality

Ombrotrophic peat waters found on the surface of raised bogs are characterised by low pH values (pH < 4.5) (Moore & Bellamy 1974) and also have low values of electrical conductivity. This is due to the fact that the raised bog system derives its mineral supply from precipitation, which is usually acidic and low in nutrients. Raised bog vegetation exchanges cations with protons to further reduce the pH.

Hydrochemistry varies in the areas surrounding a raised bog. Locally, conditions may be similar to the high bog due to a dominance of water originating from the bog. However, elsewhere in the marginal areas, there may be increased mineral and nutrient content of the water due to regional groundwater influences, run-off from surrounding mineral soils, and the release of nutrients through oxidation of peat resulting from reduced water levels.

A survey of hydrochemistry within the main drainage channels surrounding Moneybeg Bog was carried out in January 2015 as described in Section 2.3.2 above.

The site-specific target for the attribute water quality is: **Water quality on the high bog and in transitional areas close to natural reference conditions.**

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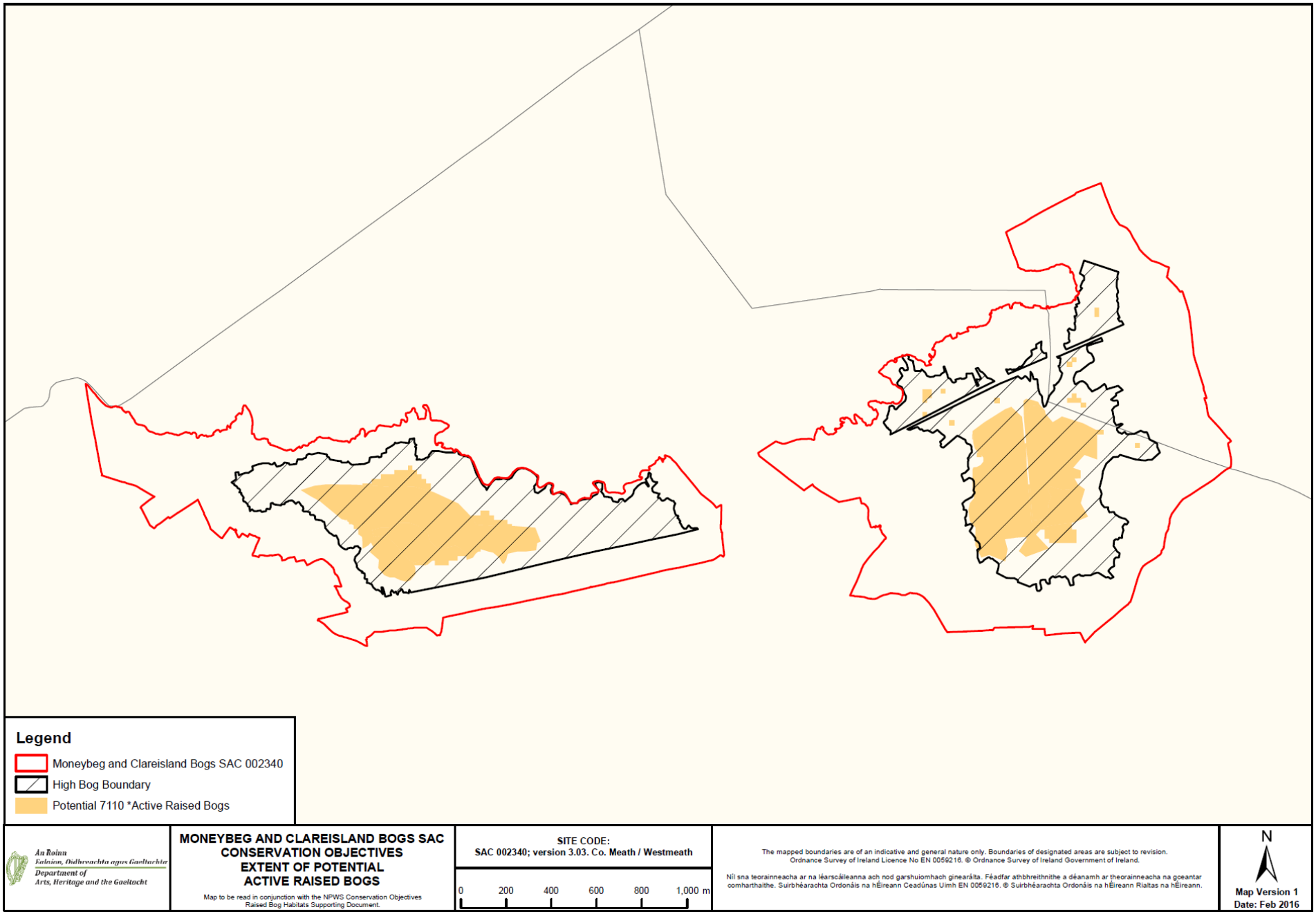
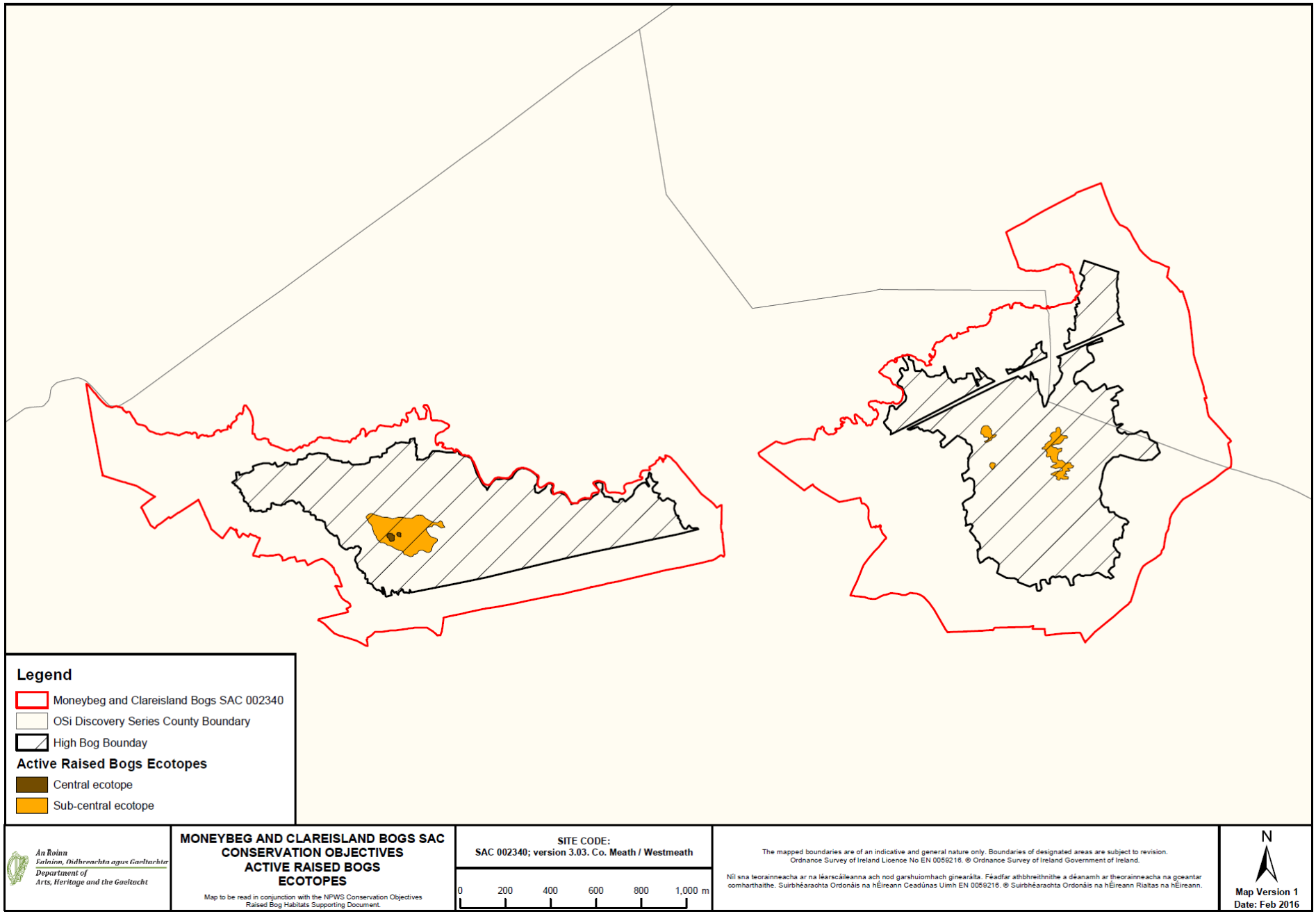
Map 1: Extent of potential active raised bog on Moneybeg and Clareisland Bogs.



Map 2: Distribution of raised bog ecotopes on Moneybeg and Clareisland Bogs.



Map 3: Digital elevation model and drainage patterns at Moneybeg and Clareisland Bogs.