National Parks & Wildlife Service

Barroughter Bog SAC
(site code 000231)

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 Barroughter Bog Special Area of Conservation (SAC) has been designated.

Barroughter Bog 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 based on phytosociological and morphological characteristics (Schouten 1984): 1. Western or intermediate raised bogs, and 2. True midland or eastern raised bogs. 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 communities. In Ireland, most laggs have been lost through drainage and land reclamation (Fossitt 2000).

[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 together with scientific names.*

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 is 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).

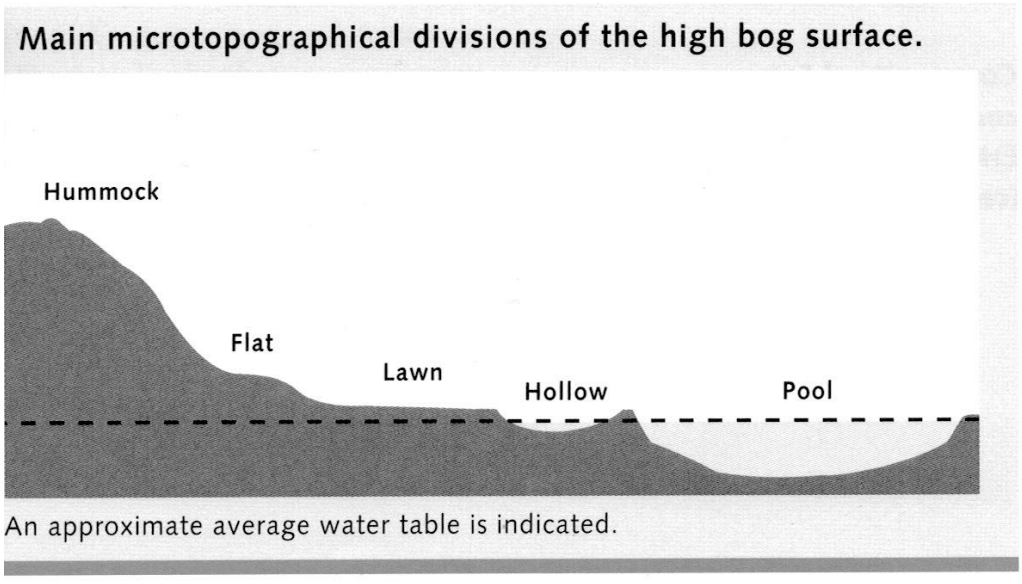

Figure 1 Raised bog microtopographical divisions on the high bog surface (reproduced from Kelly & Schouten 2002).

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 across 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*. A separate conservation objective has been prepared for bog woodland. 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 Barroughter Bog SAC

The SAC includes the raised bog, known as Barroughter Bog and surrounding areas which include cutover bog, a species-rich fen, *Betula pubescens* and *Ulex europaeus* scrub, wet grassland, dry grassland and a small area of *Betula pubescens* dominated woodland.

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*

Barroughter Bog is a relatively small raised bog, situated on the shores of Lough Derg in Co.

Galway, a few kilometres east of Woodford, and bounded to the north by the Cappagh River. The bog has a good dome, which is slightly hollowed towards the eastern side. The north-eastern corner (cut off by an old drain and track) and a narrow area in the south-east are fairly dry due to drainage and burning. During the 1994 survey of the bog, good quality central vegetation complexes were noted. However, by 2005 these areas had degraded significantly and only a small area of ARB remained. The decline in ARB is likely due to the effects of intensive peat cutting and drainage around the high bog margins. Known locally as Moannakeera, the bog has formed on the floodplain of Lough Derg and the Cappagh River.

The vegetation of the bog is characterised by an abundance of *Rhynchospora alba* and *Narthecium ossifragum*, along with *Carex panicea*. The wettest area occurs where the bog is widest. This area features shallow pools, with *Sphagnum cuspidatum,* and *Sphagnum* lawns with *Menyanthes trifoliata*. Barroughter Bog is one of the more south-westerly raised bogs in Ireland and supports species which are typical of western bogs (e.g. *Pleurozia purpurea* and *Racomitrium lanuginosum*) and midland bogs (e.g. *Andromeda polifolia* and *Sphagnum magellanicum*).

Between the bog and the Cappagh River there is a species-rich fen, with abundant sedges, bryophytes and other typical species such as *Schoenus nigricans*, *Myrica gale*, and *Succisa pratensis*. Other habitats within the SAC include: old areas of cutover, which are being colonised by *Betula pubescens*, *Calluna vulgaris* and *Ulex europaeus*; wet woodland, dominated by *Betula pubescens*; drainage ditches; and wet grassland. Notable flora on the raised bog includes large patches of the relatively rare moss, *Sphagnum pulchrum*.

Barroughter Bog is a raised bog of considerable conservation value although has been severely impacted by peat cutting in recent years. Its proximity to the shores of Lough Derg, with its succession from open water through extensive reed beds and marginal scrub, to raised bog, adds to its importance. It is also the only raised bog on the shores of Lough Derg.

1.3.1 Flora of Barroughter Bog

ARB on Barroughter Bog is confined to two locations in the northern section of the high bog, and is characterised by the presence of hummocks, pools and *Narthecium ossifragum* flats. The overall *Sphagnum* cover is moderate at 40% with *Sphagnum capillifolium* and *S. tenellum* hummocks present as well as relict hummocks of *S. fuscum* and *S. austinii*. The pools are dominated by *S. papillosum* and also contain *S. cuspidatum*, *S. denticulatum*, *Menyanthes trifoliata*, and *Rhynchospora alba.* The quality of the pools is moderately good, as the pool cover is 30% and contains 20% of the overall *Sphagnum* cover. Pools are shallow and algae are present in some of them as well as open water. *Cladonia portentosa* occurs prominently and the second ARB area contains a large pool filled with *Sphagnum cuspidatum* and *S. denticulatum* (Fernandez *et al*. 2005).

At Barroughter Bog, the 2005 survey noted that marginal and sub-marginal ecotopes and inactive flush accounted for 97% of the high bog area. The vegetation of these areas at Barroughter is characterised by a general dominance of *Narthecium ossifragum* (mainly in flats), *Calluna vulgaris*, *Erica tetralix* and *Eriophorum vaginatum*. *Carex panicea* and *Trichophorum germanicum* are particularly common on the most degraded complexes. The overall *Sphagnum* cover within these ecotopes is low. The western indicator *Racomitrium lanuginosum* was present, forming hummocks and the midland indicators *Andromeda polifolia* and *Sphagnum magellanicum* are also found. These areas include former ARB habitat that has declined in quality and these feature the best microtopography outside the current ARB with hummocks, flats, hollows and pools recorded. *Sphagnum austinii* and *S. fuscum* relict hummocks are also found. The pools within this degraded habitat occasionally contain *Sphagnum cuspidatum* and *Sphagnum pulchrum.* However, they are generally

dominated by open water and algae. The northern sections feature tear pools and may be associated with high intensity peat cutting around the northern margin of the high bog (Fernandez *et al*. 2005).

There are two small flushed areas outside the ARB areas. One is on the north-east section of the bog, which is associated with an old drain and the other is at the centre of the southern half of the high bog. Both are characterised by the presence of *Betula pubescens* trees (Fernandez *et al*. 2005).

Fernandez *et al.* (2005) recorded *Rhynchosporion* habitat at Barroughter Bog in both ARB, and supporting high bog habitats. It was usually associated with pools or hollows and occasionally with *Narthecium ossifragum* flats. *Rhynchospora alba* occurrence increases in those community complexes where a lowering in the water table had occurred, (i.e degraded complexes, particularly sub-marginal, but also in sub-central ecotope areas).

1.3.2 Fauna of Barroughter Bog

Only one faunal observation has been reported from Barroughter Bog SAC, that of snipe (*Gallingo gallingo*) being commonly found in the fen (DEHLG 2000). It is likely that the bog supports many of the species listed in section 1.1.3 above.

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 Barroughter Bog 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). 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 Barroughter Bog in 1994 is estimated to have been 21.0ha, while the area of DRB is estimated to have been 10.1ha at that time (see Table 3). Using the same approach

that has been adopted in setting the national SAC target, the site-specific target for Barroughter Bog would equate to 31.1ha (sum of ARB and DRB in 1994). However, 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 undertaken in 2005 estimated the area of ARB to be 2.4ha. This represents a decrease of 18.6ha (88.6%) during the period 1994-2005. The site has not been surveyed since 2005, however based on the obvious trend observed between 1994 and 2005 it is probable that area of ARB is likely to have declined further.

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 5.3ha (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 3.7ha 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 6.1ha, which is 25.0ha less than the estimated area at time of designation. 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 Barroughter Bog in 1994, 2005, and 2012 (Source: Fernandez *et al*. (2005), NPWS (unpublished data).

1994		**2005**		**2012**	
ARB (ha)	DRB (ha)	ARB (ha)	DRB (ha)	ARB (ha)	DRB (ha)
21.0	10.1	2.4	Unknown	2.4[3]	3.7

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 8.6 ha of ARB could be restored in this area. The long term achievable target for ARB on Barroughter Bog is therefore set at 14.7ha which is 16.4ha less than the estimated area of ARB and DRB in 1994.

In conclusion, the site-specific target for the attribute habitat area is: **Restore area of active raised bog to 14.7ha, subject to natural processes.**

[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.

[3] This data is based on the most recent vegetation survey of the bog (in this case 2005). Based on the trend recorded at other sites, the extent of ARB in 2012 is likely to be less.

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 Barroughter Bog as set out in Section 2.1 above will contribute to safeguarding the national range of the habitat.

The ARB habitat at Barroughter Bog is composed solely of sub-central ecotope. A map showing the most recent distribution of ecotopes throughout Barroughter Bog is presented in Map 2.

The site-specific target for the attribute habitat distribution is: **Restore the distribution and 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 Barroughter Bog SAC in 1994 was mapped as 84.2ha, while the corresponding area in 2012 is 73.5ha (based on interpretation of LiDAR and aerial photography flown in 2012), representing a significant loss of 10.8ha 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 runoff) 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 Barroughter Bog is presented in Fernandez *et al.* (2006), which is a follow-on from the Kelly *et al.* (1995) survey. Most of the drains on this bog are old and infilled or dry. Only one active drain transverses the bog in the north-east. Another old drain runs south-west/north-east at the north-western side and is mostly infilled. The remainder are short drains leading from the cutaover onto the bog associated with peat extraction. Around these short drains the peat has dried out and a*Calluna*-dominated face bank complex may be seen. There is a high density of drains (0.3m to 2m deep) on the cutover surrounding Barroughter Bog that moves water from the face bank to the cutover. These marginal drains all eventually discharge into Lough Derg either directly or indirectly via the Cappagh River.

Much of the knowledge regarding the hydrological requirements of raised bog communities in Ireland stems from the extensive ecological and hydrological work undertaken on Clara Bog since the early 1990s. The only available hydrological study for Barroughter Bog is the work carried out by Kelly *et al.* (1995). Upwelling of mineralised groundwater was identified at several locations in the cutover drains, as indicated by relatively high electrical conductivity (EC) values in most of the cutover drains surrounding the bog. EC values of up to 470µS/cm were recorded north of the bog, up to 280µS/cm east of the bog, and 360µS/cm west of the bog. These values are much higher than the EC values typically associated with bog water (<100µS/cm).

Most of the drains on the cutover are thought to intercept the shallow groundwater table and hence act as sites for groundwater discharge; this is evidenced by fen vegetation and a high electrical conductivity of drain water. The north-eastern cutover is affected by upwelling groundwater and is periodically inundated by the floodwaters of the Cappagh River, giving potential for the formation of a lagg zone.

Upwelling groundwater is likely to have resulted in impacts on groundwater heads, which in turn, has the potential to result in impacts on the high bog surface. The relatively small area of ARB at Barroughter and the lack of high bog drains suggests that the water levels in the

peat may have been impacted by a decline in the regional groundwater head. 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 sandstone till to the north-west, west and south of the bog, with limestone further north-east of the bog. There is also alluvium to the north associated with the Cappagh River. The potential presence of highly permeable substrate underlying the peat suggests that a decline in groundwater head may have contributed to subsidence on the high 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 Barroughter Bog based on a digital elevation model generated from LiDAR imagery flown in 2012 is presented in Map 3.

This map suggests that Barroughter Bog has a domed topography, with a flat central dome that slopes more steeply towards the margins. However, there is evidence that subsidence has affected the shape of the high bog, as reflected by the flow patterns to the northern and eastern sides of the bog, which suggests that they, in particular, have been impacted by subsidence. Further deepening or maintenance of marginal drains has the potential to generate further subsidence which could increase surface slope and change flow patterns, thus impacting on the ecology of the bog surface. As noted above, the extent of impacts will be determined by the nature of the substrate and the change in head in the peat substrate.

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 Barroughter Bog include a range of different habitat types (e.g. wet grassland, cutover bog, scrub etc.). The total area of cutover bog within the Barroughter Bog SAC is estimated to be circa 87ha. The development of habitats within cutover areas depends on a number of factors including prevailing land-use, topography, up-welling regional groundwater, and drainage.

The old cutover is colonised mainly by *Betula pubescens* and *Ulex europaeus*. In the areas close to the actively cut areas *Juncus effusus* and grass species predominate. Due to the influence of the lake and river the north-east edge has a large stand of *Phragmites australis*. Along the eastern edge the drains in the cutover bog are often colonised by mesotrophic indicators such as *Typha latifolia, Carex acutiformis* and *Phragmites australis*. *Pedicularis sylvatica*, *Polygala vulgaris* and *Cirsium dissectum* are also common on the drier parts. Behind the cutover bog along the east, the lake shore the area is fringed by *Phragmites australis* (Kelly *et al*. 1995).

To the north-east of the bog there is a small species rich fen between the bog and the river. The following species were noted: *Salix* spp.*; Betula pubescens; Ulex europaeus; Myrica gale; Carex paniculata; C. diandra; C. echinata; C. rostrata; C. lepidocarpa; Succisa pratensis; Juncus effusus; J. articulates; Ranunculus flammula; R. acris; Mentha aquatic; Valeriana officinalis; Cirsium dissectum; Menyanthes trifoliata; Molinia caerulea; Schoenus nigricans; Angelica sylvestris; Pedicularis palustris; Potamogeton polygonifolius; Potentilla palustris; Triglochin palustris; Hydrocotyle vulgaris; Osmunda regalis; Dryopteris sp.; Phragmites australis; Equisetum fluviatile; Cardamine pratensis; Epilobium sp.; Eriophorum angustifolium; Andromeda polifolia; Drosera rotundifolia; Hypericum tetrapterum; Rhytidiadelphus squarrosus; Calliergonella cuspidata; Scorpidium scorpioides; Fissidens* sp.; *Rhizomnium* sp.; *Campylium stellatum; Riccardia multifida; Pseudoscleropodium purum; Mylia anomala; Sphagnum capillifolium; S. austinii; S. papillosum* and *S. tenellum*. Some patches of more ombrotrophic vegetation also occur with *Calluna vulgaris, Potentilla erecta, Erica tetralix, Aulacomnium palustre, Pleurozium schreberi* and *Dicranum scoparium* (Kelly *et al*. 1995).

There is a small area of woodland in the north-western corner of the SAC. The dominant species of the canopy is *Betula pubescens*. Some *Pinus sylvestris* is also present. The shrub layer includes *Rubus fruticosus* agg. and *Ulex europaeus*, while the ground flora is dominated by *Hedera helix* (DEHLG, 2000).

Further along the northern edge in the cutover bog there is a small spring in shell marl colonised by *Typha latifolia* and *Carex vesicaria*. Along the river bank *Sparganium erectum*, *Scirpus lacustris, Filipendula ulmaria, Juncus conglomeratus, J. inflexus, Iris pseudacorus, Ranunculus repens* and *Nuphar lutea* are some of the species noted (Kelly *et al*. 1995).

Semi-improved wet grassland occurs in small fields at the western edge of the SAC. Species present include *Agrostis stolonifera*, *Holcus lanatus*, *Ranunculus acris*, *Juncus* spp. and *Cirsium vulgare*. These fields are grazed by cattle. Some unimproved wet grassland is associated with the fen but has not been mapped or described separately (DEHLG 2000).

There are patches of dry grassland associated with the northernmost part of the fen. These occur where limestone boulders are exposed. Species present include *Thymus praecox*, *Achillea millefolium*, and *Hieracium pilosella* (DEHLG 2000).

Barroughter Bog's proximity to the shores of Lough Derg, with its succession of transitional habitats from open water through extensive reed beds and marginal scrub to raised bog adds to its conservation importance.

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 Barroughter Bog is presented in Section 1.3.1 above. The vegetation and habitats of the bog have been described in more detail by Kelly *et al.* (1995), and Fernandez *et al.* (2005).

The extent of the different ecotopes that correspond with ARB based on the most recent survey is presented in Table 4 and on Map 2. During the most recent survey the entire area of ARB comprised sub-central ecotope. There had been a significant area of central ecotope present on the site during the 1994 survey of the site (estimated to have been 8.6ha (Fernandez *et al.* 2005)).

The target for this attribute is 7.4ha of high quality ARB (50% of ARB target area (14.7ha)).

Table 4 Extent of ecotopes classified as ARB in 2005 (Fernandez *et al.* 2005).

Ecotope	**2005**	
	ha	**% of total ARB**
Sub-central ecotope	2.4	100
Total ARB	**2.4**	**100**

The site-specific target for the attribute vegetation quality is: **Restore 7.4ha 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.

The microtopography of the remaining active areas on Barroughter Bog in the most recent survey of 2005 was recorded as still good with hummocks and pools present. However, *Sphagnum* lawns were absent and the wetness of the ground had decreased especially in the inter-pool areas (Fernandez *et al*. 2005).

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.

Kelly *et al.* (1995) and Fernandez *et al.* (2005) provide further information on the occurrence of *Sphagnum* species throughout Barroughter Bog.

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

Barroughter Bog supports many of the plant species typically associated with a true midland raised bog together with some western indicator species (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 Barroughter Bog (Fernandez *et al.* 2005).

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

There is little specific faunal data for Barroughter Bog. The bog is likely to support a wide range of fauna species that are typically associated with raised bog habitat (see Section 1.1.2 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 Barroughter Bog is its proximity to the shores of Lough Derg, and the associated succession of transitional habitats from open water through extensive reed beds and marginal scrub to raised bog. This transition is now degraded due to the effects of past peat cutting along the margin of the high bog.

2.3.10.2 Rare flora

No rare flora records have been reported from Barroughter Bog.

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.

Fire damage was recorded at Barroughter Bog in the 1994 survey (Kelly *et al.* 1995), however Fernandez *et al.* (2006) noted that no further fires had taken place since 1994.

Fernandez *et al.* (2005) noted that the microtopography of the remaining ARB was still good as hummocks and pools were present, however *Sphagnum* lawns were absent and the wetness of the ground has decreased especially in the inter-pool areas. The overall *Sphagnum* cover in the areas of most *Sphagnum* was noted to have declined from 70% in the 1994 survey to 40% in the 2005 survey. Fernandez *et al.* (2005) also recorded that the pools present in the high bog supporting habitat commonly contained algae and open water.

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).

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).

No non-native invasive species have been reported from Barrroughter Bog (Fernandez *et al.* 2005).

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 Barroughter Bog 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 Barroughter Bog as reported by Henry & Aherne (2014) is 12.2kg 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, runoff from surrounding mineral soils, and the release of nutrients through oxidation of peat resulting from reduced water levels.

The hydrochemistry of Barroughter Bog has not been studied in any detail. The only available hydrological study for Barroughter Bog is the work carried out by Kelly *et al.* (1995). Upwelling of mineralised groundwater was identified at several locations in the cutover drains, as indicated by relatively high electrical conductivity (EC) values. EC values of up to 470µS/cm were recorded north of the bog, up to 280µS/cm east of the bog and 360µS/cm west of the bog. These values are much higher than the EC values typically associated with bog water (<100µS/cm). The presence of alkaline fen within the site is indicative of the mineral rich conditions that locally prevail.

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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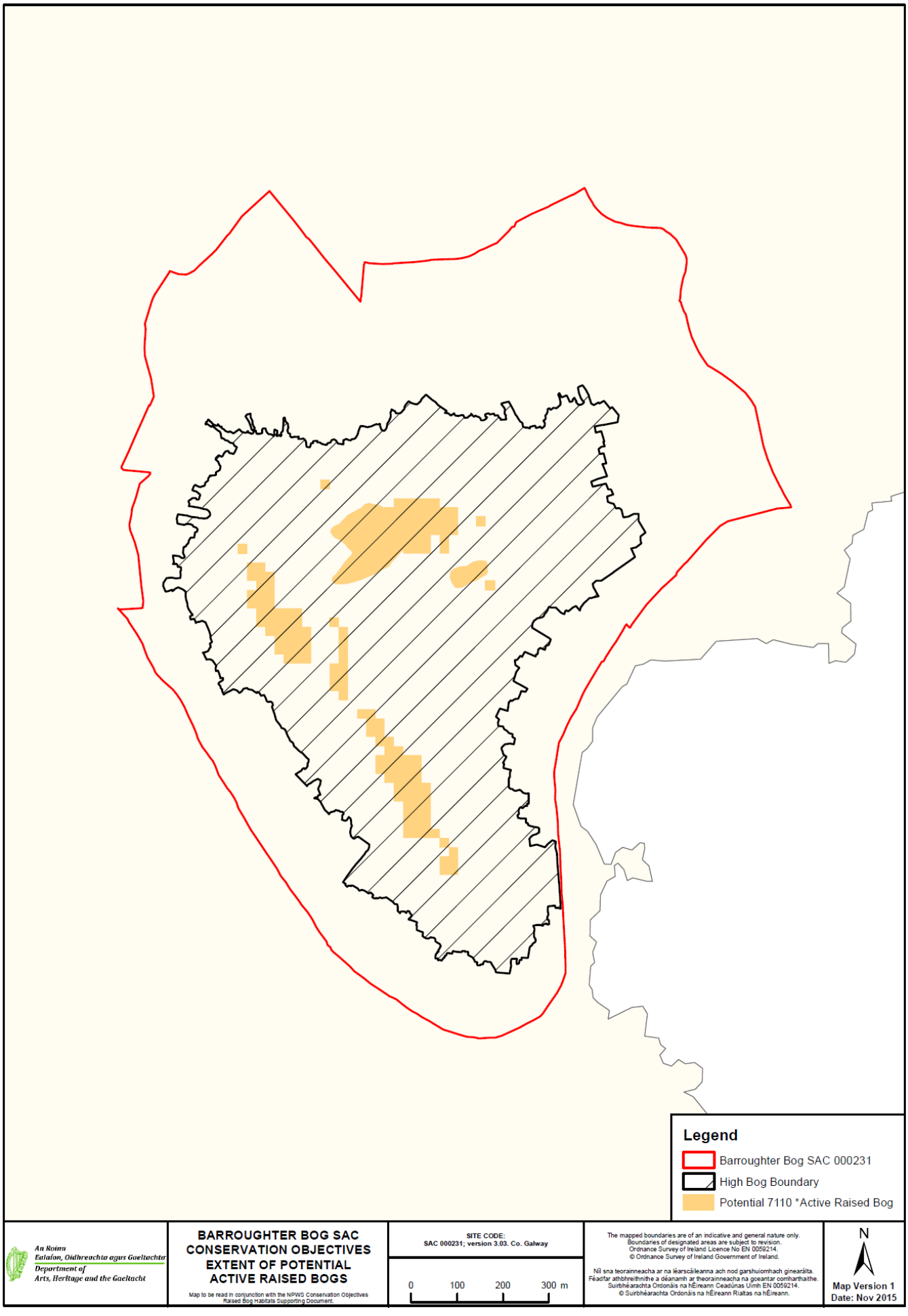
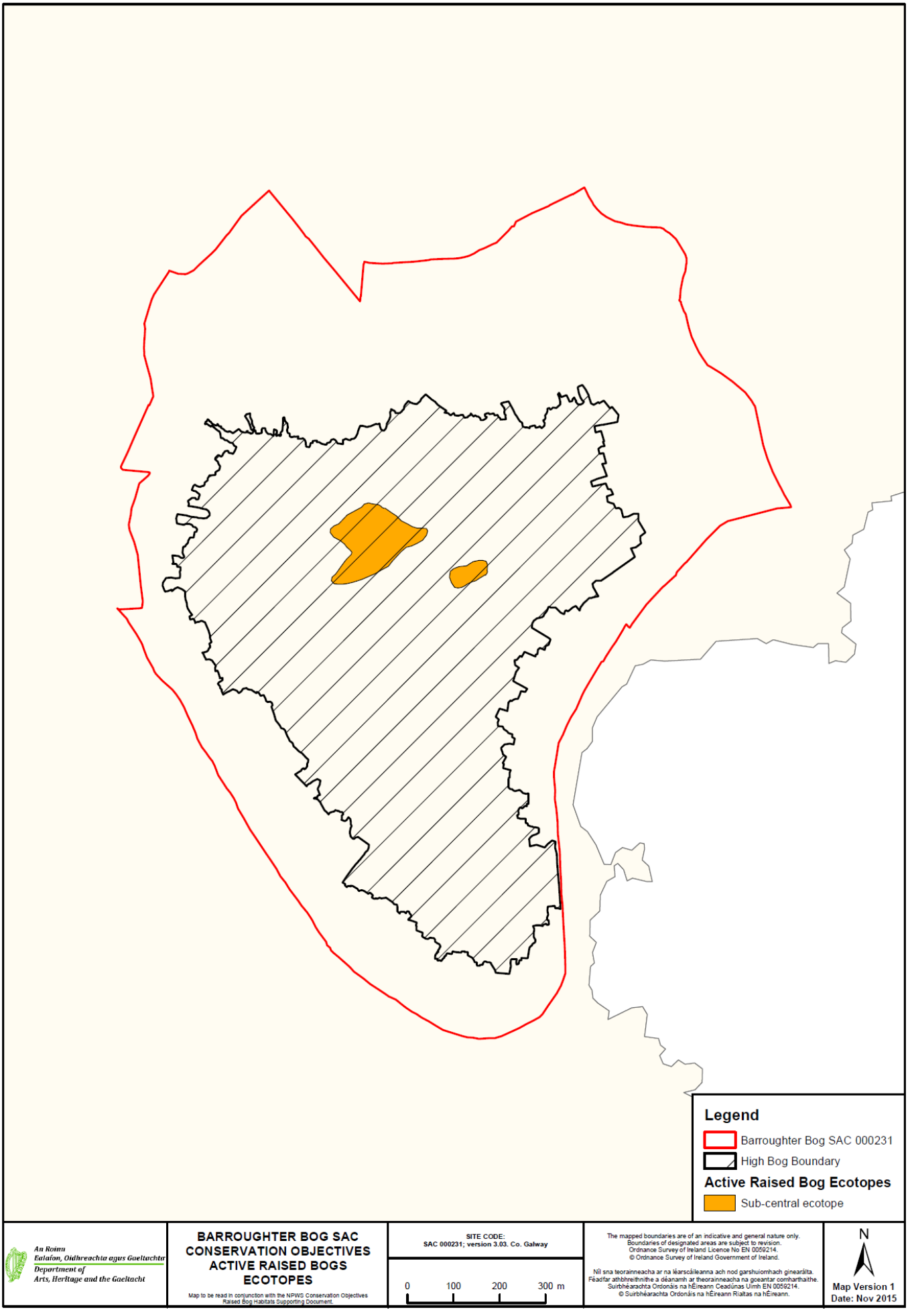
Map 1: Extent of potential active raised bog on Barroughter Bog.



Map 2: Distribution of raised bog ecotopes on Barroughter Bog.



Map 3: Digital elevation model and drainage patterns at Barroughter Bog.