

National Parks & Wildlife Service

Arragh More (Derrybreen) Bog SAC
(site code 002207)

**Conservation objectives supporting document -
raised bog habitats**

Version 1

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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 Habitats Directive Annex I habitat 'Degraded raised bogs still capable of natural regeneration' (habitat code 7120) (hereafter referred to as Degraded Raised Bog (DRB)), for which Arragh More (Derrybreen) Bog SAC has been designated.

Arragh More (Derrybreen) Bog SAC is entirely within Arragh More Bog Natural Heritage Area (NHA) (site code 000640).

Restoration works were undertaken on this SAC as part of the EU LIFE-funded project 'Demonstration Best Practice in Raised Bog Restoration' (LIFE09 NAT/IE/000222) implemented by Coillte.

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 active raised bogs (ARB) (NPWS 2017), see Section 1.2 for an explanation of Habitats Directive Annex I raised bog habitats. 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 lags 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 Bog 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).

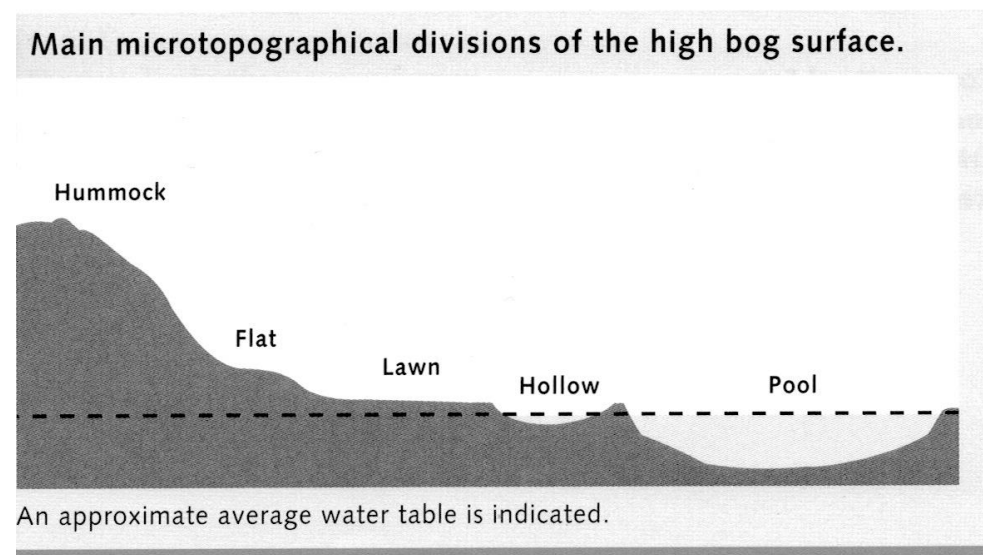


Figure 1 Raised bog microtopographical divisions on the high bog surface (reproduced from Kelly & Schouten 2002).

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

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.

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). Recent nationwide reviews (Colhoun & Cummins 2013; Gilbert *et al.* 2021) have since added several species, including meadow pipit and curlew to the red (most endangered) list of Birds of Conservation Concern in Ireland (BoCCI).

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 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), *Satlatlas 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	<i>Lepus timidus hibernicus</i>
Otter	<i>Lutra lutra</i>
Pygmy shrew	<i>Sorex minutes</i>
Fox	<i>Vulpes vulpes</i>
Bird species	
Skylark	<i>Alauda arvensis</i>
Mallard	<i>Anas platyrhynchos</i>
Greenland white-fronted goose	<i>Anser albifrons flavirostris</i>
Meadow pipit	<i>Anthus pratensis</i>
Hen harrier	<i>Circus cyaneus</i>
Cuckoo	<i>Cuculus canorus</i>
Merlin	<i>Falco columbarius</i>
Kestrel	<i>Falco tinnunculus</i>
Snipe	<i>Gallinago gallinago</i>
Red grouse	<i>Lagopus lagopus</i>
Curlew	<i>Numenius arquata</i>
Golden plover	<i>Pluvialis apricaria</i>
Lapwing	<i>Vanellus vanellus</i>
Reptiles and amphibians	
Common lizard	<i>Lacerta vivipara</i>
Common frog	<i>Rana temporaria</i>
Typical invertebrates	
Black slug	<i>Arion ater</i>
Large heath butterfly	<i>Coenonympha tullia</i>
Marsh fritillary butterfly	<i>Euphydryas aurinia</i>
Bog-pool spider	<i>Dolomedes fimbriatus</i>
Water striders	<i>Gerris</i> and <i>Velia</i> species
Oak eggar moth	<i>Lasiocampa quercus</i>
Four-spotted chaser dragonfly	<i>Libellula quadrimaculata</i>
Fox moth	<i>Macrothylacia rubi</i>
Ant	<i>Myrmica ruginodis</i>
Emperor moth	<i>Saturnia pavonia</i>
Great green bog grasshopper	<i>Stethophyma grossa</i>
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)
	Odonata (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 2013).

DRB is described in the interpretation manual as "*raised bogs where there has been disruption (usually anthropogenic) to the natural hydrology of the peat body, leading to surface desiccation and/or species change or loss. Vegetation on these sites usually contains species typical of active raised bog as the main component, but the relative abundance of individual species is different. Sites judged to be still capable of natural regeneration will include those areas where the hydrology can be repaired and where, with appropriate rehabilitation management, there is a reasonable expectation of re-establishing vegetation with peat-forming capability within 30 years....*" (CEC 2013).

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 of *Sphagnum* moss species which often form deep carpets, usually with *Polytrichum* mosses and occasional lichens. 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 in Ireland in the past 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. However, restoration works now focus on both high bog and cutover land since the commencement of the NPWS-led Raised Bog Restoration Project (LIFE14 NAT/IE/000032) in 2016. 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) and lagg vegetation on the cutover.

Works undertaken by 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 suitable areas of 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 ($\leq 0.3\%$ 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 Arragh More (Derrybreen) Bog SAC

The SAC has been selected for one Annex I habitat. The raised bog habitat for which the site has been selected is:

- [7120] Degraded raised bogs still capable of natural regeneration

Arragh More (Derrybreen) Bog SAC is located approximately 9.5km north-east of Borrisokane, mainly in the townlands of Arraghmore and Derrybreen in Co. Tipperary. The SAC includes both areas of high bog and cutover bog.

Arragh More (Derrybreen) Bog SAC comprises 90.6ha of raised bog (61.3ha of high bog and 29.2ha cutover) which occupies the north-western section of Arragh More Bog NHA (000640). Arragh More Bog developed originally in at least three basins, aligned in a north-south direction, which were initially separated by low ridges of relatively impermeable glacial till overlying limestone bedrock. As these bogs grew they eventually coalesced over these low ridges to form one bog with a very complex shape. The SAC occupies the western parts of the two most northerly basins. The surface of the high bog in the central basin is lower than that to the east and south and receives significant amounts of runoff from them resulting in the development of an internal flush system. The SAC is bordered by forest plantations on cutaway to the north, raised bog and cutover to the east and south, and agricultural grassland to the east.

Within the SAC two main areas of high bog covering 11.4ha have been identified as DRB and thus with potential to develop peat forming habitats. These consist of a large area (9.9ha) to the east with two large lobes and a much smaller one (1.5ha) in the south-east section of the SAC. The large area along the east of the site is showing significant indications of recovery. No major signs of recovery have been observed in the small and isolated area in the south-east of the site to date. The two main areas along the east are on two major water flow paths across the bog and now have standing surface water in the hollows and pools for most of the year and considerable areas of regenerating *Sphagnum* species. The larger and most easterly of these flow paths comes from areas of mineral soil and cutover bog to the east of the SAC. The areas fed by this flow path are likely to support vegetation characteristic of flushes and soaks and develop into areas of both ARB and bog woodland (91D0). The other main flow path derives from the high bog and cutover to the south and will supply mainly bog water and therefore support a more standard ARB habitat with bog woodland sections. It is therefore considered that both areas will support some areas of ARB within 10-20 years and that these will continue to develop and spread over the following decades. It is expected that most of the area will develop further into bog woodland as the birch woodland develops on the more flushed areas of the site. There is a small area of bog woodland to the east just outside the site to provide the characteristic species for that habitat. Another 0.5ha of ARB is expected to develop on a cutover area along the western section of the site, but in this case, over a 30 year period. In addition, it is estimated that restoration works carried out on this site will benefit the conservation of 3ha of ARB in the adjacent area of Arragh More Bog NHA (site code 000640).

Current landuse on the site within the SAC boundary consists of conservation management and all the major restoration activities required have been undertaken as part of the Coillte EU LIFE-funded project 'Demonstration Best Practice in Raised Bog Restoration' (LIFE09 NAT/IE/000222). The main restoration measures were clear felling and removal of the mature conifer crop, wind-rowing of the remaining brash, and blocking of drains with peat dams to raise water-levels.

Ongoing further conservation actions require the blocking of the remaining open drains adjacent to the SAC and the control of naturally regenerating lodgepole pine. The continued control of these species is included in the After LIFE plan for the site being developed by the landowner, Coillte.

1.3.1 Flora of Arragh More (Derrybreen) Bog

Arragh More Bog NHA was surveyed by O'Connell & Mooney (1983) in 1982 as part of a survey to locate raised bogs of scientific interest and was assigned an A rating. This survey found the site to be in excellent condition and an estimate of 20% (equating to 56ha) of the high bog as supporting excellent hummocks and pools was approximated at the time. However, threats to the site were noted including the pumping of farm slurry onto the centre of the bog. This was said to have affected a sizeable area and appeared to be seeping away in an easterly direction. It is unclear how long this practice continued for.

Cross (1990) assigned a *Bi* rating implying a good quality site where the hydrology was damaged but not seriously. This drop in rating was more than likely due to damaging activities such as peat-cutting and/or forestry having impacted on the site in the intervening years. The large scale peat exploitation operation within the eastern section of the bog but outside the SAC was likely to have started during this period and was thus likely to have been the main reason for the drop in rating.

Arragh More (Derrybreen) Bog was mostly afforested in the 1970s, with just over 12ha (13%) of high bog in the north-east and south of the site being left unplanted. The remaining areas of intact high bog have been affected by drying out but still have vegetation typical of a Midland Raised Bog, consisting of heather (*Calluna vulgaris*), cottongrasses (*Eriophorum vaginatum* and *E. angustifolium*), bog asphodel (*Narthecium ossifragum*) and white beak-sedge (*Rhynchospora alba*). Typical characteristic species for Midland raised bogs such as bog rosemary (*Andromeda polifolia*) and cranberry (*Vaccinium oxycoccos*) are present. In addition to the more common hummock-forming bog mosses (*Sphagnum capillifolium*, *S. papillosum* and *S. subnitens*) which are widespread, some hummocks of the relatively scarce *S. austinii* and *S. fuscum* have been recorded. In the small remnants of the flush system at the extreme east of the site, bog-myrtle (*Myrica gale*), bilberry (*Vaccinium myrtillus*), purple moor-grass (*Molinia caerulea*), soft rush (*Juncus effusus*) and the bog moss *Sphagnum recurvum* become more common. The most strongly flushed areas, which partly lie within the site, are dominated by wet woodland with birch (*Betula pubescens*), alder (*Alnus glutinosa*), willow (*Salix* spp.) and rowan (*Sorbus aucuparia*) with a ground layer of grasses and the bog species listed above. This area grades eastwards into a common reed (*Phragmites australis*) swamp which is within the NHA but outside the SAC.

With the clear felling of conifers and blocking of drains, the high bog is re-wetting, water-levels in some areas now remain high throughout the year and limited areas of wet flats and hollows are developing. As a consequence, raised bog vegetation has returned, with heather and hare's tail cotton-grass (*Eriophorum vaginatum*) dominating, while common cotton-grass (*Eriophorum angustifolium*), bog asphodel and white beak-sedge are locally common and small amounts of bilberry and cross-leaved heath (*Erica tetralix*) are widespread. Bog mosses that are regenerating include *Sphagnum papillosum*, *S. capillifolium*, *S. palustre* and *S. subnitens*, with *S. recurvum* in drains. In the more flushed areas, considerable amounts of purple moor-grass and soft rush are also present. However, the majority of the restored areas have not yet developed vegetation characteristic of wet bog conditions, and associated with the bog species there is the development of a considerable amount of ruderal vegetation such as bramble (*Rubus fruticosus*), willowherbs (*Epilobium* spp.) and conifer and birch regeneration.

Overall, it is estimated that restoration works carried out on the SAC will benefit the restoration of 11.4 ha of Active Raised Bog (7110). These are likely to largely correspond with bog woodland (91D0).

1.3.2 Fauna of Arragh More (Derrybreen) Bog

Only limited faunal observations have been reported from Arragh More (Derrybreen) Bog as part of the 2018 survey of the site (Crushell *et al.* 2019), although it is likely that the bog supports some of the species listed in section 1.1.3 above.

Crushell *et al.* (2019) recorded signs of badger (*Meles meles*), fox (*Vulpes vulpes*), deer (*Cervus* spp.), and Irish hare (*Lepus timidus hibernicus*), all species listed in Annex V of the Habitats Directive, on the bog. The 2018 survey also recorded sightings of skylark (*Alauda arvensis*) (amber listed on BoCCI) and snipe (*Gallinago gallinago*) (red listed on BoCCI).

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 the raised bog network of sites (SACs and NHAs) have been published in the National Raised Bog SAC Management Plan (NPWS 2017). The various attributes and the justification of appropriate targets used to define Favourable conservation condition for raised bog habitat relevant to Arragh More (Derrybreen) Bog SAC are discussed in the following sections.

As the long-term aim for DRB is that its peat-forming capability is re-established, the conservation objective for this habitat is inherently linked to that of ARB (7110), thus the attributes and targets set for DRB are the same as those for ARB.

2.1 Area

NPWS has commissioned a number of raised bog surveys between 1993 and the present; Derwin & MacGowan (2000), Fernandez *et al.* (2006), Crushell *et al.* (2019). Mapping from these surveys has been used to derive the Annex I habitat areas the 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.

The national SAC target for the attribute 'habitat area' has been set at 2,590ha (NPWS 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 and DRB at Arragh More (Derrybreen) Bog in 1994 is not known as the bog was first surveyed in detail in 2003. The area of ARB at Arragh More (Derrybreen) Bog in 2003 is estimated to have been 0.1ha (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 fact that all ARB present within the SAC in 2003 was lost) that a proportion of ARB is likely to have been lost from the site during the period 1994 – 2003.

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 survey of the bog (Crushell *et al.* 2019) has indicated that there is no ARB within the SAC. The current extent of DRB is 11.4ha. This estimate is based on field surveys carried out by ecologists working on the EU LIFE-funded Demonstration Best Practice in Raised Bog Restoration (LIFE09 NAT/IE/000222), combined with estimates from an eco-hydrological model (see NPWS 2017 for further details of the technique) and NPWS expert knowledge. 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 represents the area that could be restored by blocking drains on the high bog.

Based on the current assessment of the bog, it is therefore concluded that the maximum achievable target for ARB on the high bog is 11.4ha. 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 Arragh More (Derrybreen) Bog in 2003 and 2018 (Source: Fernandez *et al.* 2006; Crushell *et al.* 2019).

2003		2018	
ARB (ha)	DRB (ha)	ARB (ha)	DRB (ha)
0.1	Unknown	0.0	11.4

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 0.4ha of ARB could be restored in this area.

The long term achievable target for ARB on Arragh More (Derrybreen) Bog is therefore set at 11.8 ha.

In conclusion, the site-specific target for the attribute habitat area is: **Restore area of active raised bog to 11.8ha, 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 target for the attribute ‘range’ has been set as ‘not less than current range subject to natural processes’ (NPWS 2017).

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 restoration of ARB within Arragh More (Derrybreen) Bog SAC as set out in Section 2.1 above will contribute to safeguarding the national range of the habitat.

A map showing the distribution of ecotopes throughout Arragh More (Derrybreen) Bog is presented in Map 1.

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 capable of regeneration 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 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 Arragh More (Derrybreen) Bog SAC in 2005 was mapped as 61.3ha, the corresponding area in 2014 was also 61.3ha (based on field survey in 2018 and interpretation of aerial photography (flown in 2014), indicating no high bog losses within the period). The extent of high bog within the SAC in 2018 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 water logging are the most favourable to achieve these conditions. These 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 hydrological survey undertaken in 2019 noted the presence of functional drains in the SAC.

Deepening of drains is likely to reduce the hydraulic resistance (hydraulic conductivity x peat thickness) making it easier for groundwater to discharge, and thus lowering regional groundwater levels giving rise to increased vertical infiltration on the uncut bog. Increased vertical infiltration will alter the water balance on the bog and may cause further declines of ARB.

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 Arragh More (Derrybreen) Bog SAC based on a digital elevation model generated from LiDAR imagery flown in 2012 is presented in Map 2.

This map shows that the topography of Arragh More (Derrybreen) Bog SAC displays many characteristics typical of a raised bog with a flat central dome that slopes more steeply towards the margins.

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 adjacent mineral soils (including 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 the high bog 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 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 Arragh More (Derrybreen) Bog include a range of different habitat types (e.g. scrub across the western section of the SAC, agricultural grassland to the west and coniferous forestry in the north-west) depending on a number of factors including prevailing land-use, topography and drainage. The development of transitional habitats depends on a number of factors including prevailing land-use, topography, up-welling regional groundwater, and drainage. A large bog woodland (91D0) is found to the east of the SAC within Arragh More Bog NHA (000640).

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 Arragh More (Derrybreen) Bog is presented in Section 1.3.1 above. The vegetation and habitats of the bog have been described in more detail by Fernandez *et al.* (2006) and Crushell *et al.* (2019).

The extent of the different ecotopes that corresponded with ARB based on the most recent surveys is presented in Table 4.

The target for this attribute is 5.9ha of high quality ARB (50% of ARB target area (11.8ha)).

Table 4 Extent of ecotopes classified as ARB in 2003 (Fernandez *et al.* 2006) and 2018 (Crushell *et al.* 2019).

Ecotope	2003		2018	
	ha	% of total ARB	ha	% of total ARB
Sub-central ecotope	0.0	0.0	0.0	0.0
Central ecotope	0.0	0.0	0.0	0.0
Soaks / active flush	0.1	100.0	0.0	0.0
Bog woodland	0.0	0.0	0.0	0.0
Total ARB	0.1		0.00	

The site-specific target for the attribute vegetation quality is: **Restore 5.9ha 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.

Low hummocks and hollows are well developed on Arragh More (Derrybreen) Bog (Crushell *et al.* 2019).

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.

Fernandez *et al.* (2006) and Crushell *et al.* (2019) provide detailed information on the occurrence of *Sphagnum* species throughout Arragh More (Derrybreen) 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
<i>Sphagnum austinii</i>	Hummock species	High
<i>Sphagnum capillifolium</i>	Forms small hummocks and carpets	Moderate
<i>Sphagnum cuspidatum</i>	Pool and hollow species	Low
<i>Sphagnum denticulatum</i>	Pool and hollow species	Low
<i>Sphagnum fallax</i>	Occurs in lawns and carpets, shade tolerant. Indicative of some nutrient enrichment (soaks and active flushes)	Low
<i>Sphagnum fuscum</i>	Forms dense low and wide, and occasionally high hummocks	High
<i>Sphagnum magellanicum</i>	Lawn species forming carpets and low hummocks	Moderate
<i>Sphagnum palustre</i>	Forms hummocks and dense carpets, often in shaded conditions. Indicative of nutrient enrichment (soaks and active flushes)	Low
<i>Sphagnum papillosum</i>	Lawn , hollow, and low hummock species	Moderate
<i>Sphagnum pulchrum</i>	Grows in lawns and hollows, more typical of western bogs	Moderate
<i>Sphagnum squarrosum</i>	Forms carpets and small mounds. Indicative of nutrient enrichment (soaks and active flushes)	Low
<i>Sphagnum subnitens</i>	Occurs as individual shoots or small cushions and lawns. Tolerant of minerotrophic conditions	Moderate
<i>Sphagnum tenellum</i>	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

Arragh More (Derrybreen) Bog SAC supports a large proportion of the full complement of plant species typically associated with a true midland raised bog (see Section 1.1.2 & 1.3.1 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 the above *Sphagnum* species except *S. denticulatum* have been reported from Arragh More (Derrybreen) Bog (Fernandez *et al.* 2006; Crushell *et al.* 2019).

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.

Arragh More (Derrybreen) Bog SAC is likely to support a wide range of fauna species that are typically associated with raised bog habitat (see Section 1.1.3 above). Crushell *et al.* (2019) provides a brief list of faunal species recorded during the 2018 survey of the site.

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.

The SAC was mostly afforested in the 1970s, with just over 12ha of high bog in the north-east and south of the site being left unplanted. These plantations were mostly felled by 2013. All the intensive drainage systems associated with the plantation were blocked by 2014 as part of an EU-funded Coillte LIFE Project. Some of the DRB in the more flushed parts of the bog may eventually develop into the very rare priority EU-Annexed habitat Bog Woodland (91D0), which would add further to the scientific interest of the site.

2.3.10.1 Site features

Bog woodland (91D0) is developing now on some of the areas cleared of coniferous forestry. Mineral ridges separating elongated basins of raised bog are a feature of the local landscape and Arragh More Bog is separated by such mineral ridges from the adjacent SAC raised bog sites Kilcarren-Firville Bog SAC (000647) and Ballyduff-Clonfinane Bog SAC (000641). Furthermore, Arragh More (Derrybreen) Bog is itself also split into separate sections by mineral ridges.

2.3.10.2 Rare flora

Sphagnum beothuk (formerly *S. fuscum*) was recorded as frequently occurring in parts of the high bog, with *Sphagnum austinii* occasional to frequent within Arragh More Bog NHA (Crushell *et al.* 2019). *Racomitrium lanuginosum*, a species more commonly recorded in northern raised bogs, was recorded in Arragh More Bog NHA. Also *Pleurozia purpurea* was recorded - this species is more common in western raised bogs. *Leucobryum glaucum* hummocks were recorded, and so too was the clubmoss *Huperzia selago*. These species are expected to occur within the SAC section of the NHA.

2.3.10.3 Rare fauna

As mentioned above, there is a lack of documented site-specific data relating to the fauna of the bog. It is probable that the bog is utilised by a number of faunal species of conservation concern.

The 2018 survey recorded sightings of skylark (*Alauda arvensis*) (amber listed on BoCCI), snipe (*Gallinago gallinago*) (red listed on BoCCI) and Irish hare (*Lepus timidus hibernicus*), a species protected under the Wildlife Act (1976) and Annex V of the Habitats Directive.

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.

Although the large peat exploitation operation to the south-east of the site has ceased, the large drainage network associated with the operation persists and drains have not been blocked. These are likely to have a negative impact on the SAC raised bog habitats.

Farm slurry was noted to have been pumped onto the centre of the bog (O'Connell and Mooney 1983). This was said to have affected a sizeable area and appeared to be seeping away in an easterly direction. It is unclear how long this practice continued. Bog woodland now occurs in the area but it is of poor quality and considered borderline in terms of being assessed as 91D0. The vegetation is overgrazed by deer and evidence of eutrophication is noted with algae abundant in pools, probably because of the slurry that was spread immediately south of here in the 1980s (Crushell *et al.* 2019).

No turf cutting activities were observed on the site during the 2018 survey. Information from the NPWS also indicates that no cutting took place on the site in 2017 or 2018. Nevertheless, the old face banks and other high bog and cutover drainage associated with cutting continue to cause negative impacts on the high bog habitats.

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).

Pinus sylvestris was recorded as frequent in the north of the main lobe of Arragh More (Derrybreen) Bog close to the edge of the former plantation and along the big drain to the south of that during the 2018 survey. Saplings were recorded as being occasional to the east of this area. They are considered an indicator of drying or flushed conditions, rather than as a significant threat. They are considered to have a low impact on high bog habitats at present (Crushell *et al.* 2019).

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).

Despite efforts to control the natural regeneration of non-native conifers within the Coillte LIFE restoration area, *Pinus contorta* is still frequent in parts of this area, and continued control is necessary, particularly in areas where the Annex bog woodland habitat 91D0 may develop. No other non-native invasive species have been recorded from the high bog, apart from the moss *Campylopus introflexus*, which poses no real threat to Annex I habitats (Crushell *et al.* 2019).

The impact is considered to be of low importance in areas of ARB, DRB, Rhynchosporion depressions and bog 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 Arragh More (Derrybreen) 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 Arragh More (Derrybreen) Bog as reported by Henry & Aherne (2014) is 12.7kg N/ha/yr.

The site-specific target for the attribute air quality is: **Air quality surrounding bog close to natural reference conditions. The total 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 Arragh More (Derrybreen) Bog has not been studied in detail.

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.**

3 References

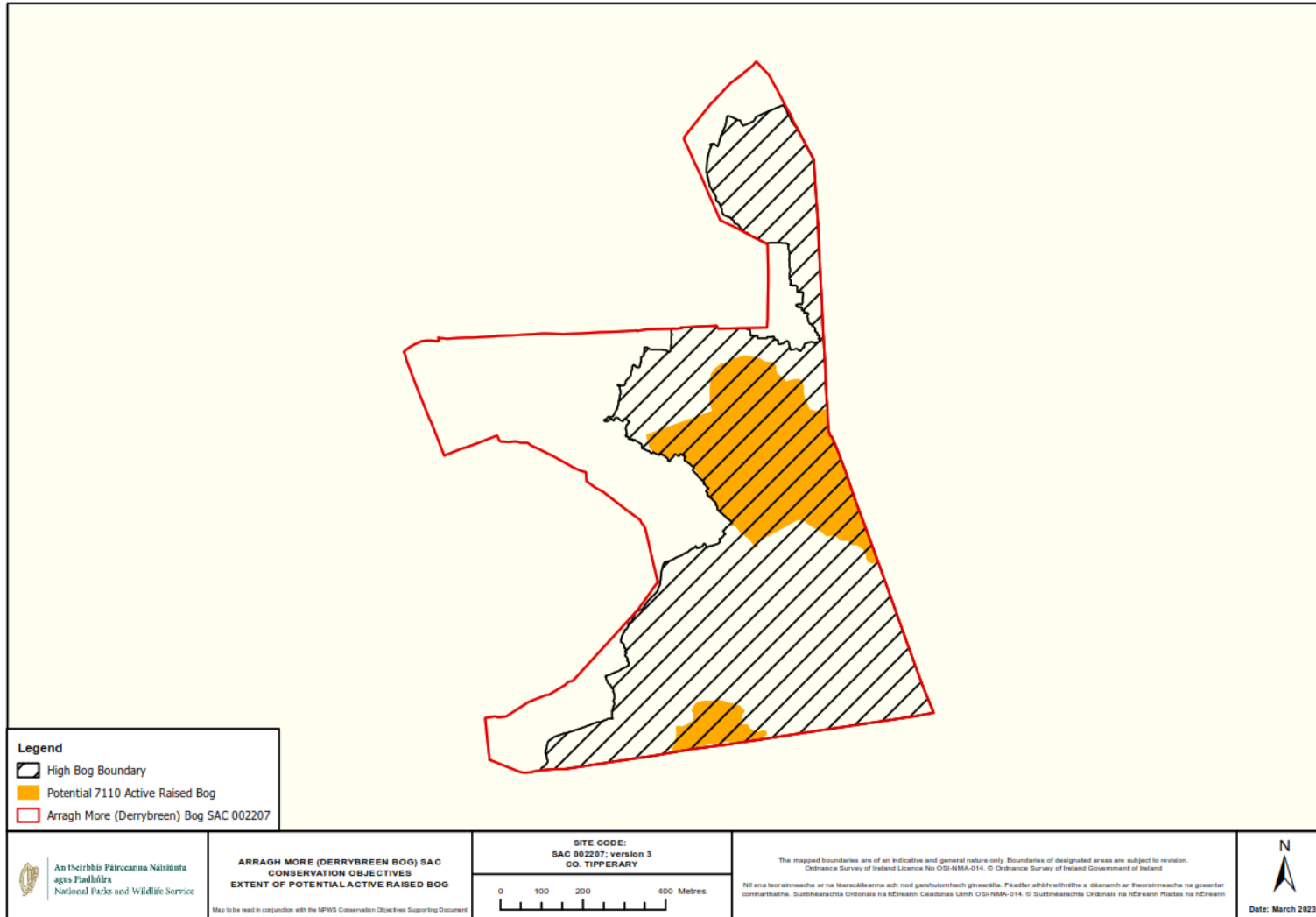
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Map 1: Extent of potential active raised bog on Arragh More (Derrybreen) Bog SAC



Map 2: Digital elevation model and drainage patterns on Arragh More (Derrybreen) Bog SAC

