National Parks & Wildlife Service

Clooneen Bog SAC
(site code 002348)

Conservation objectives supporting document - raised bog habitats

Version 2

October 2024

Contents

IMPORTANT: This 'Version 2' document includes updates based on the addition of QI Active raised bogs (habitat code 7110). The text relating to the other pre-existing QIs has only been updated where needed as a result of this change.

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 priority habitat 'Active raised bogs' (habitat code 7110) (hereafter referred to as (ARB)) for which Clooneen Bog Special Area of Conservation (SAC) has been designated.

Clooneen Bog SAC is also designated for two other closely 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 habitat types, it is not necessary to set specific Conservation Objectives for the 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.

Clooneen Bog SAC is also designated for the priority Annex I habitat 'Bog woodland' (habitat code 91D0). A separate site-specific conservation objective has been set for Bog woodland and therefore is not considered in this supporting document.

Note that there is potential for some DRB to develop into ARB following restoration measures. See Map 1 for potential extent of ARB.

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 tend to stay more confined to the depressions in which they were formed, western raised bogs tend to grow out beyond their original basin, presumably a result of the higher rainfall levels (Cross, 1990). In terms of vegetation, 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 low-level Atlantic blanket bogs and their presence in western raised bogs is presumed to be due to 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 (NPWS,

[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.*

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 laggs have been lost through drainage and land reclamation (Fossitt, 2000).

The surface of a relatively intact raised bog is typically wet, acid, deficient in plant nutrients, and supports specialised plant communities that are low in diversity and comprise of 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, 2007; 2013; 2019). The lowering of regional groundwater levels is also known to have had an effect on some sites. Fires associated with turf cutting, dumping, forestry, 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 round 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

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

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

Flats

Flat areas which are intermediate between hollow and hummock communities. They tend to be drier than the above situations.

Hummocks

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 medium, S. rubellum, S. austinii* and *S. beothuk* 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 and Schouten, 2002).

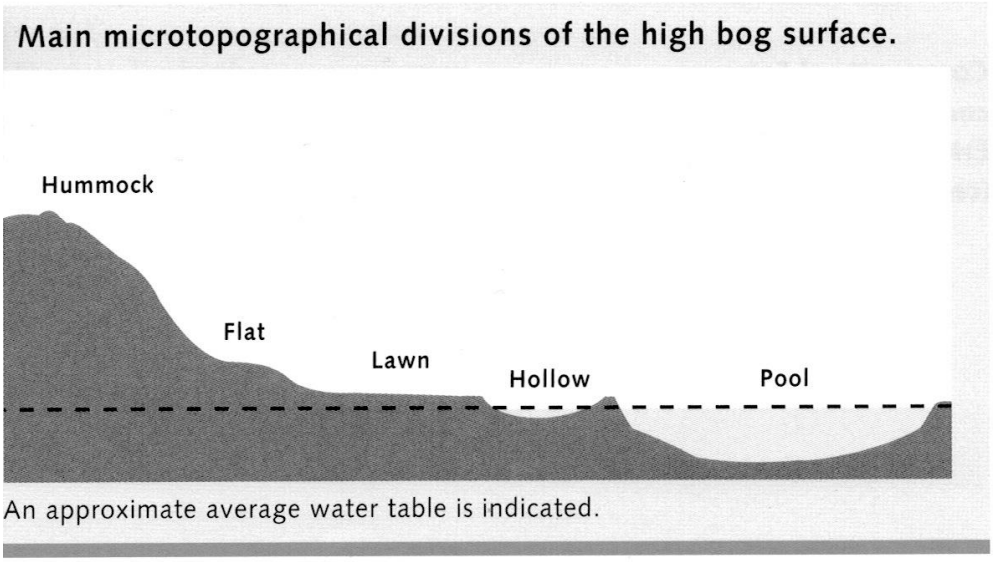


Figure 1 Raised bog microtopographical divisions on the high bog surface (reproduced from Kelly and Schouten, 2002).

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 on 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 rubellum*, *S. austinii*, *S. beothuk*, *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. medium*).

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 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 and 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 Cottongrass	*Eriophorum angustifolium*
Hare's-tail Cottongrass	*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 rubellum*
Feathery Bog-moss	*Sphagnum cuspidatum*
Cow-horn Bog-moss*	*Sphagnum denticulatum**
Rusty Bog-moss	*Sphagnum beothuk*
Magellanic Bog-moss	*Sphagnum medium*
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. A few bird species, including Meadow Pipit (*Anthus pratensis*), Skylark (*Alauda arvensis*) and Curlew (*Numenius arquata*) complete their full breeding cycle on the bog; the first two species are the commonest species occurring (Bracken *et al.,* 2008). Meadow Pipit

and Curlew are both listed as Red (most endangered) and Skylark as amber on the most recent list of Birds of Conservation Concern in Ireland (BoCCI) (Gilbert *et al*., 2021). Red Grouse (*Lagopus lagopus*), (also red listed) 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). These are listed in Table 2 below. Snipe (*Gallinago gallinago*) and Kestrel (*Falco tinnunculus*) have recently been added to the red list of BoCCI (Gilbert *et al*., 2021).

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 and Kelly-Quinn, 2011; Wisdom and 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, the moth species 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 and 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)
	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 and 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 and 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 area of Annex I DRB is estimated using an ecohydrological model that has recently been developed based on LiDAR (Light Detection and Ranging) data (NPWS, 2019). The model predicts where there is potential to restore active conditions on the high bog (Mackin *et al*., 2017a and 2017b; NPWS, 2017). As a result, only those areas with the right combination of physical conditions (including surface shape, slope and drainage patterns) ultimately capable of supporting ARB are now considered as DRB. These are the areas of raised bogs whose hydrology has been disturbed so that their surfaces have dried out and suffered some species change or loss. Bog species of drier conditions now dominate, and peat formation has ceased. The water level is generally 10cm or more below the surface and drops to 30+cm below during dry summer weather. To qualify as DRB, these areas must still be capable of natural regeneration to active bog within 30 years if their hydrology is repaired (usually after restoration works, particularly blocking of drains). The remainder of the high bog that is neither ARB nor DRB is now referred to as 'Supporting Raised bog habitat'.

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. medium*, *S. papillosum*, *Menyanthes trifoliata* and *Eriophorum angustifolium*. In raised bogs in Ireland, *Rhynchospora* vegetation communities are only considered Annex I type (sensu stricto) when they occur in their most developed form in the wettest sections of the Active raised bog (7110), which correspond with pools, *Sphagnum* lawns and hollows.

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, usually with *Polytrichum* mosses and occasional lichens. 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

ARB is currently considered to be in Unfavourable-Bad Conservation Status in Ireland (see Section 1.1). 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.

Up until recently most of the restoration works undertaken in Ireland were concentrated on high bog (*e.g.* Clara Bog, Mongan Bog, Sharavogue Bog and Raheenmore Bog), and restricted to drain blocking to prevent further losses as well as to restore areas to ARB with limited restoration works undertaken on cutover areas such as at Ballykenny and Fisherstown Bogs and Killyconny Bog (Crowley *et al*., 2021). 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. More recently NPWS are employing enhanced restoration works (see Mackin *et al.*, 2017a; Cushnan *et al.,* 2022) both on high bog and cutover, using techniques such as cell bunding on sites such as Cloncrow Bog (New Forest) NHA and Scohaboy Bog NHA.

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 favourable areas of the high bog by blocking high bog drains. Although active peat forming vegetation can also be achieved on cutover areas within a relatively short period of time (<10 years), this vegetation type is generally confined to small areas of cutover; *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, unless enhanced restoration works (*e.g*. cell bunding) are implemented. In general, a longer time period (minimum 50-100 years) is likely to be required for ARB to develop on cutover areas. Furthermore, costs of restoration measures on cutover areas are typically significantly higher than those on high bog areas.

1.3 Clooneen Bog SAC

The SAC includes the raised bog, known as Clooneen Bog and surrounding areas which include cutover bog and farmland.

The SAC has been selected for four Annex I habitats. The raised bog habitats for which the site has been selected are:

- [7110] Active raised bog*
- [7120] Degraded raised bogs still capable of natural regeneration
- [7150] Depressions on peat substrates of the *Rhynchosporion*
- [91D0] Bog woodland*

Clooneen Bog lies approximately 3km south-east of Roosky in Co. Longford on the east bank of the River Shannon, just north of Lough Forbes. It is located almost entirely in the townlands of Clooneen, Bunanass, Edercloon and Cloonart (North and South). The site comprises areas of high bog, including Bog woodland, and cutover bog, and is bounded by a mineral ridge to the east and agricultural fields to the north. Although it would have originally adjoined the River Shannon to the west and Lough Forbes to the south, it is now separated from these by a road and enclosed agricultural grassland.

This site consists of a narrow bog dome, with cutover bog to the north, south and west. An interesting feature is an area of Bog woodland growing on a flush in the northern section of the bog. There is also a large inactive flush to the south-east associated with a marginal area which slopes relatively steeply towards an expanse of old cutover. Wet grassland in this area is subject to periodic flooding from Lough Forbes.

Much of the high bog has vegetation typical of the midland raised bog type. In the narrow central area of the high bog there are small pools containing bog moss. These pools are associated with a depression and become algal-filled tear pools towards the margins of the high bog.

1.3.1 Flora of Clooneen Bog

Clooneen Bog was most recently surveyed in 2024 (Crushell *et al*., in prep). ARB covers 2.4ha (2.5%) of the high bog area and is restricted to the northern half of the site. It includes sub-central ecotope, as well as active flush with Bog woodland. No central ecotope and only three very small (totalling 0.2ha) and scattered fragments of sub-central ecotope (Sc1 to Sc3) are present. The main ecological feature of interest is the Bog woodland (91D0) (1.4ha) and associated active flush (0.8ha), which occur in the mid-north of the site. The habitat elsewhere on the high bog corresponds with non-active raised bog communities with extensive areas of sub-marginal ecotope.

The canopy cover of the Bog woodland (91D0) (which is almost exclusively of *Betula pubescens*) is 20-50% and the maximum height is c.8-10m. The surface is generally dry underfoot, but there are areas with a dense carpet/cushion of mosses including *Sphagna*. The best quality area is found in the mid-west of its extent. Here, the canopy has a 40-50% cover and the median tree height is 5-6m, while the bryophyte layer has a 90% cover of which 25% is *Sphagnum*, composed mostly of *S. palustre*, but also with *S. fallax*, *S. fimbriatum* and *S. rubellum*. Other bryophyte species recorded here include *Hylocomium splendens*, *Aulacomnium palustre*, *Pseudoscleropodium purum*, *Dicranum scoparium* and *Polytrichum commune*. The dwarf shrub layer is c.40% and is composed mostly of *Vaccinium myrtillus* and *Empetrum nigrum* with *Calluna vulgaris* a very minor component. Other species recorded at very low cover values include *Ilex aquifolium*, *Melampyrum pratense*, *Eriophorum vaginatum*, *Rubus fruticosus*, *Dryopteris dilatata*, *D. carthusiana*, *Molinia caerulea* and *Vaccinium oxycoccos*.

It is worth noting that in parts of the Bog woodland and active flush, the trees appear to be struggling, probably as a result of a past burn and drainage, and are displaying a poor growth form with long and slender trunks that have few branches. The woodland grades into active wooded flush and inactive flush, and the boundaries between these can be difficult to map as the vegetation is largely intermediate between the two. The vegetation of the flush is somewhat similar to sub-marginal Complex 9/7 with tall *Calluna vulgaris* and *Eriophorum vaginatum* characterising the vegetation with addition of species such as *Molinia caerulea*, *Hylocomnium splendens*, *Polytrichum strictum*, *Vaccinium oxycoccos* and young *Betula pubescens*. *Sphagnum rubellum* almost exclusively dominates the *Sphagna* layer, which is generally c.40%. Where the flush is drier it becomes more obviously inactive and *Molinia caerulea* becomes more prominent. *Sphagnum fimbriatum* becomes much scarcer and the *Sphagnum* cover in general is lower, particularly that of *S. palustre* and *S. fallax*. The canopy layer is absent from these areas and the tree cover is generally 10% or less. *Pteridium aquilinum* becomes more abundant in the inactive flush where it forms dense patches (>50% cover in places). This together with the abundance of *Rhododendron ponticum* (again in localised areas) together with *Ulex europaeus* indicates that the area is likely to be drying out (Daly *et al*., 2023).

The three small patches of sub-central ecotope named Sc1-3, range in size from 0.03ha (Sc3 in the north of the high bog) to 0.10ha (Sc1 in the mid-east of the high bog). All these areas are dominated by the community complex 9/10 and have possibly formed as a result of secondary re-wetting; having formed in depressions where water is ponding. The highest quality is found in Sc1. This is the only area of the high bog where there is any pool-like features. The moisture conditions are wetter in this area than the other sub-central areas and the *Sphagnum* cover is 76-90% with the cover of *S. cuspidatum* 11-25% and the cover of active hummocks of *S. austinii* 4-10%. The cover of *S. rubellum* (11-25%) was lower in this area as was the cover of *Calluna vulgaris* (11-25%) and *Eriophorum vaginatum* (4-10%) while that of *Rhynchospora alba* was higher (4-10%). *Drosera anglica* and *Menyanthes trifoliata* were present in *Sphagnum* filled lawn and pool-like features.

Old cutover to the north is dominated by *Molinia caerulea*, *Eriophorum angustifolium*, *Calluna vulgaris*, and *Carex panicea*. There is some regeneration of bog communities rich in *Sphagnum* in the north-east. *Betula pubescens* and *Ulex europaeus* scrub occurs on old cutover to the west and east. An extensive area of cutover to the south is dominated by *Molinia caerulea* and *Calluna vulgaris*, with *Myrica gale* occurring abundantly in places. This area forms a mosaic with wet grassland and there is some flooding from Lough Forbes.

1.3.2 Fauna of Clooneen Bog

Limited faunal observations have been reported from Clooneen Bog, although it is likely that the bog supports at least some of the species listed in Section 1.1.3 above. Common Kestrel (*Falco tinnunculus*), Large Heath (*Coenonympha tullia*), Common Lizard (*Lacerta vivipara*) and Common Frog (*Rana temporaria*) have all been reported from the site.

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 National Raised Bog SAC Management Plan (NPWS, 2017). The various attributes and the justification of appropriate targets used to define Favourable conservation condition for ARB relevant to Clooneen 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 and MacGowan (2000); Fernandez *et al*. (2005); Fernandez *et al*. (2006); Fernandez *et al*. (2014); Crushell *et al*. (2019). Mapping from these surveys has been used to derive the Annex I Habitat areas 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.

The national SAC target for the attribute 'habitat area' has been set at 2,590ha (NPWS, 2017). 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).

Clooneen Bog was first surveyed in 1999 (Derwin and MacGowan, 2000), therefore the area of ARB at Clooneen Bog in 1994 is not known. Based on data from the 1999 survey (which originally mapped the area of ARB as 11.2ha), the area of ARB in 1999 is now estimated to have been 10.0ha (NPWS internal files) (see Table 3). Due to a lack of data, it is not possible to use the same approach that has been adopted in setting the national SAC target (sum of ARB and DRB in 1994). However, it can be assumed (based on the known trend at other sites) that a proportion of ARB is likely to have been lost from the site during the period 1994-1999.

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 surveys of the bog estimated the area of ARB to be 2.4ha (Crushell *et al*., in prep.). This represents an estimated decrease of c.1.3ha during the period 2017-2024 (see Table 3 below).

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 8.8ha (see NPWS 2017 for further details of the technique). This represents the area of 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 4.4ha 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 NPWS, 2017).

Based on the current assessment of the bog, it is therefore concluded that the maximum achievable target for ARB on the high bog is 6.8ha, which is 3.2ha 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 Clooneen Bog in 1999 and 2024. (NPWS internal files; Crushell *et al*., in prep.)

1999		2017	
ARB (ha)	**DRB (ha)**	**ARB (ha)**	**DRB (ha)**
10.0[3]	Unknown	2.4	4.4

ARB habitat was mapped as 2.4ha by Crushell *et al.* (in prep). Area of DRB on the high bog potentially restorable to ARB by drain blocking was 4.4ha. The total potential ARB on the HB is therefore estimated to be 6.8ha. Ecohydrological assessments of the cutover estimates that an additional 1.2ha of bog forming habitats could be restored. The long term target for ARB is therefore 8.0ha.

In conclusion, the site-specific target for the attribute habitat area is: **Restore area of Active raised bog to 8.0ha, 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 conservation and potential restoration of ARB within Clooneen Bog as set out in Section 2.1 above will contribute to safeguarding the national range of the habitat.

The ARB habitat at Clooneen Bog includes sub-central ecotope, as well as active flush with Bog woodland. A map showing the most recent distribution of ecotopes throughout Clooneen Bog is presented in Map 2.

[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] Area estimate based on an internal review undertaken by NPWS in 2014 of the 1999 survey of the site.

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, 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 national SAC target for the attribute 'Habitat area' has been set at 2,590ha (NPWS, 2017).

The area of high bog within Clooneen Bog SAC in 1995 is estimated to have been 95.7ha, while the corresponding area in 2019 was 94.0ha, representing a loss of 1.7ha of high bog (Crushell *et al*., in prep). These figures were calculated using GIS techniques on aerial photography from 1995 and 2019. The extent of high bog within the SAC in 2019 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 and 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.

Detailed hydrological studies of Clooneen Bog have not been carried out to date, however, drainage was described during a survey in 2017 (NPWS internal files). There is a limited amount of high bog drainage but it is apparent that peat-cutting and marginal drainage has been continuing at the site in recent years. It is possible that marginal drainage has resulted in impacts on the high bog surface. The risk of subsidence depends on the permeability of the underlying mineral substrate, which will influence the extent of impacts from changes to groundwater heads. Geological mapping indicates that the bog is underlain by Argillaceous limestones (Visean) as well as dark muddy limestone and shale bedrock (GIS Map viewer[4]). Both units are considered locally important aquifers, as they are moderately productive only in local zones. Parts of the bog appear to be underlain by Visean limestone bedrock, which is a regionally important aquifer, as it is subject to karstification (conduit). Subsoil mapping indicates the presence of sandstone and shale till surrounding the peat. The presence of a highly productive bedrock unit as well as potentially permeable substrate 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 Clooneen Bog based on a digital elevation model generated from LiDAR imagery flown in 2012 is presented in Map 3.

The flow patterns on Clooneen Bog illustrate the presence of a domed topography as flow from the centre of the bog flows in a radial pattern towards the margins. However, there appears to be less flow towards the eastern margin of the bog than the western margin. In some areas there appears to be some focused flow, such as towards the south-western margin of the bog where peat-cutting has taken place. This would indicate the surface of the bog has been impacted by subsidence. Changes to flow patterns or slope arising from subsidence associated either with high bog or marginal drainage are likely to have a significant impact on the areas of Active raised bog, including the important area of Bog woodland.

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 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

[4] Source: https://www.gsi.ie/en-ie/data-and-maps/Pages/default.aspx

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.

This bog has been cut to some extent on all sides and recent peat-cutting has been reported. The transitional areas at Clooneen Bog include a range of different habitat types (*e.g*. wet grassland, improved grassland, cutover bog, scrub, deciduous woodland). The total area of cutover bog within the Clooneen Bog SAC is estimated to be circa 62ha. 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 site-specific target for the attribute transitional areas is: **Restore adequate transitional areas to support/protect the Active raised bog ecosystem 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 beothuk* 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 Clooneen Bog is presented in Section 1.3.1 above. The vegetation and habitats of the bog have been described in more detail in a 2017 survey (NPWS internal files) and Crushell *et al*. (in prep).

The extent of the different ecotopes that correspond with ARB based on the most recent survey data is presented in Table 4 and Map 2. The area of ARB comprised both sub-central ecotope, Bog woodland and active flush. The target for this attribute is 4.0ha of high quality ARB (50% of ARB target area (8.0ha)).

Table 4 Extent of ecotopes classified as ARB in 2017 (Crushell *et al*., in prep).

Ecotope	**2024**	
	ha	**% of total ARB**
Sub-central ecotope	0.21	9
Soaks/active flush	0.77	33
Bog woodland	1.38	58
Total ARB	**2.36**	

The site-specific target for the attribute vegetation quality is: **Restore 4.0ha of central ecotope/active flush/soaks/bog woodland as appropriate.**

2.3.6 Vegetation quality: microtopographical features

The characteristic microtopographical features of raised bogs are described in Section 1.1.1 above. Hummock, hollow and pool microtopography is moderately well developed on

Clooneen Bog (Derwin and MacGowan, 2000; Fernandez *et al.,* 2006; NPWS internal files; Crushell *et al*., in prep).

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 rubellum, S. austinii* and *S. papillosum* which form hummocks or low ridges. *Sphagnum beothuk* may also form hummocks (Cross, 1990). On the flats *Sphagnum medium, 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.

A survey in 2017 (NPWS internal files), and Derwin and MacGowan (2000) provide information on the occurrence of *Sphagnum* species throughout Clooneen 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 rubellum	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 beothuk	Forms dense low and wide, and occasionally high hummocks	High
Sphagnum medium	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

Clooneen Bog supports the full complement of plant species typically associated with a true midland raised bog (see Section 1.1.2 above).

The key typical species that are indicative of high quality raised bog include *Sphagnum beothuk* 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 Clooneen Bog with the exception of *Sphagnum denticulatum* (Crushell *et al*., in prep; NPWS internal files; Derwin and MacGowan, 2000).

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.

Clooneen Bog is likely to support a range of fauna species that are typically associated with raised bog habitat (see Section 1.1.3 above).

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

2.3.10 Elements of local distinctiveness

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

2.3.10.1 Site features

There is a large soak (active flush) on the northern end of high bog indicating that there is possibly some mineral input at this point of the high bog. Bog woodland (91D0) occurs within the centre of the flush. This type of flush is a rare feature on raised bogs (Fernandez *et al.,* 2006).

2.3.10.2 Rare flora

No rare flora records have been reported from Clooneen 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.

During a survey undertaken in 1999 fire damage, in the form of bare peat and damage to moss hummocks, was recorded (Derwin and MacGowan, 2000).

Cracking and slumping of the high bog was recorded, particularly in the south-west while steep slopes were recorded in the mid-north of the site from the Bog woodland down to the area of active peat cutting to its north during a 2017 survey (NPWS internal files; Crushell *et al*., in prep). Other negative physical features such as algal pools and hollows were also noted during the 2017 survey.

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 medium* 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).

Localised abundance of *Pteridium aquilinum* was recorded in and around the flush system in the north of the site by Crushell *et al*. (in prep) and Daly *et al*. (2023). This likely indicated that the system is being impacted by drainage and a lowered water table.

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).

Rhododendron ponticum bushes were noted as encroaching into the south-eastern part of Clooneen Bog (Fernandez *et al.,* 2006; Derwin and MacGowan, 2000) and in the north of the site during a survey in 2017 (NPWS internal files). In 2024, small areas with abundant *Rhododendron ponticum* and *Ulex europeaus* were mapped as scrub indicating that the area may be drying out.

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 and 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 5kg and 10kg N/ha/yr for these ecosystems (Bobbink and Hettelingh, 2011), a level which is exceeded over a significant portion of their range. An Irish study during the late 1990s undertaken by Aherne and 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 and Farrell (2000) was 10kg N/ha/yr. This is in line with the recommendation by Bobbink and 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.

In the case of Clooneen Bog, it is recommended 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 Clooneen Bog as reported by Henry and Aherne (2014) is 15.1kg 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 and 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 Clooneen Bog has not been reported.

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

Aherne, J. and Farrell, E.P. (2000) Final Report: Determination and mapping of critical loads for sulphur and nitrogen and critical levels for ozone in Ireland. Environmental Protection Agency, Dublin, 212pp.

Bobbink, R. and Hettelingh, J.P. (2011) Review and revision of empirical critical loads and dose-response relationships. Proceedings of an expert workshop, Noordwijkerhout, 23-25 June 2010. RIVM report 680359002, Coordination Centre for Effects, National Institute for Public Health and the Environment (RIVM).

Bobbink, R., Hornung, M. and Roelofs, J.G.M. (1998) The effects of air—borne nitrogen pollutants on species diversity and semi—natural European vegetation. Journal of Ecology 86: 717–738.

Bracken, F. and Smiddy, P. (2012) Lowland bogs, fens and reedswamps, pp. 73-89. In: Nairn, R., and O'Halloran, J. (eds.) Bird Habitats in Ireland. The Collins Press, Cork.

Bracken, F., McMahon, B. and Whelan, J. (2008) Breeding bird populations of Irish Peatlands: capsule peatlands are very important habitats for birds despite low species diversity. Bird Study 55 (2): 169-178.

Bubier, J., Moore, T. and Bledzki, L.A. (2007) Effects of nutrient addition on vegetation and carbon cycling in an ombrotrophic bog. Global Change Biology 13: 1168–1186.

Caporn, S.J.M., Edmondson, J., Carroll, J.A., Pilkington, M. and Ray, N. (2007) Long-term impacts of enhanced and reduced nitrogen deposition on semi-natural vegetation. Report to Defra. Terrestrial Umbrella. Work Package 2: Impacts, Recovery and Processes. Task 4. Defra London.

CEC (2013) Interpretation Manual of European Union Habitats. Version EUR 28. European Commission, DG Environment, Brussels. Nature and Biodiversity.

Cross, J. (1990) The Raised Bogs of Ireland, their ecology, status and conservation. Report to the Minister of State at the Department of Finance. The Stationery Office, Dublin.

Crowley, W., Smith, G.F., Mackin, F., Regan, S., Fernandez Valverde, F. and Eakin, M. (2021) Recovery of the vegetation of a cutover raised bog in Ireland following rewetting measures. *Biology and Environment: Proceedings of the Royal Irish Academy*, Vol. 121B, no. 2, 2021, pp. 95–121.

Crushell, P. H., Crowley, W., Denyer, J., Foss, P., Gallagher, M.C., MacGowan, F. and Smith, G. (2019) NHA Raised Bog Monitoring Project 2018 - Mount Jessop Bog (NHA 001450), County Longford - Site Report. National Parks & Wildlife Service, Department of Culture, Heritage and the Gaeltacht, Dublin.

Crushell, P., Crowley, W., Delaney, E., O'Sullivan, J., Overy, P., Smith, G. and Vanmechelen, A. (in prep.) Ecotope mapping within a sub-set of designated raised bogs – 2024. National Parks & Wildlife Service, Department of Housing, Local Government and Heritage, Dublin.

Crushell, P.H., Schouten, M.G.C., Robroak, B.J.M. and van Duinan, G-J. (2008) The contribution of soak lakes to macroinvertebrate diversity of raised bogs in Ireland. In: Crushell, P.H. (2008). Soak Systems of an Irish Raised Bog: a multidisciplinary study of their origin, ecology, conservation and restoration. PhD thesis, Wageningen University, with a summary in Dutch and Irish.

Cushnan, H., O'Hara., S., Kieran, P. and Mackin., F. (2022) Restoring Active Raised Bog in Ireland's SAC Network 2016 – 2020 (LIFE14 NAT/IE/000032): LIFE Technical Manual – Review of Best Practice Measures. The Living Bog Project/National Parks and Wildlife Service, Ireland.

(https://raisedbogs.ie/wp-content/uploads/2022/09/Appendix-23-E10-LIFE-Projects-Technique-Manual-D01.docx.pdf)

Daly, O.H., O'Neill, F.H., and Barron, S.J. (2023) The monitoring and assessment of four EU Habitats Directive Annex I woodland habitats. Irish Wildlife Manuals, No. 146. National Parks and Wildlife Service, Department of Housing, Local Government and Heritage, Ireland.

De Leeuw, J.P.M. (1986) Een onderzoek naar het voorkomen en de verspreiding van aquatische macro- en mirofauna in de Ierse hoogvenen. Deel 1: Macrofauna. Aquatische Oecologie, Katholieke Universiteit Nijmegen, Nijmegen, The Netherlands.

Derwin, J. and MacGowan, F. (2000) Raised bog restoration project: a continuation of the investigation into the conservation and restoration of selected raised bog sites in Ireland. Unpublished report, Dúchas the Heritage Service, Dublin.

Fernandez Valverde, F., Fanning, M., McCorry, M. and Crowley, W. (2005) Raised bog monitoring project 2004-2005. Document 3: Site Reports and Maps Volume 1-5. Unpublished Report. National Parks and Wildlife Service, Dublin.

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

Fernandez, F., Connolly, K., Crowley, W., Denyer J., Duff, K. and Smith, G. (2014) Raised bog monitoring and assessment survey 2013. Irish Wildlife Manuals, No. 81. National Parks and Wildlife Service, Department of Arts, Heritage and Gaeltacht, Dublin, Ireland.

Flynn, C. (2014) Nocturnal Lepidoptera of Midland Raised Bogs. A thesis submitted to the National University of Ireland, Maynooth for the Degree of Master of Science (MSc.).

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

Fowler, D., Smith, R.I., Muller, J.B.A., Hayman, G. and Vincent, K.J. (2005) Changes in the atmospheric deposition of acidifying compounds in the UK between 1986 and 2001. Environmental Pollution, 137: 15-25.

Gilbert G, Stanbury A and Lewis L (2021) "Birds of Conservation Concern in Ireland 2020 – 2026". *Irish Birds* **9**: 523—544.

Gore, A.J.P. (ed.) (1983) Ecosystems of the world 4A. Mires: Swamp, bog, fen and moor. General studies. Elsevier Scientific Publishing Company, Amsterdam.

Greven, H.C. (1992) Changes in the moss flora of the Netherlands. Biological Conservation 59: 133-137.

Hannigan, E., and Kelly-Quinn, M. (2011) Chapter 2.6 - Aquatic macro-invertebrate diversity. pp. 140-157 In: Renou-Wilson, F. (ed.) BOGLAND: Sustainable Management of Peatlands in Ireland. Environmental Protection Agency, Wexford.

Henry, J. and Aherne, J. (2014) Nitrogen deposition and exceedance of critical loads for nutrient nitrogen in Irish grasslands. Science of the Total Environment 470–471: 216–223.

Kelly, L. and Schouten, M.G.C. (2002) Vegetation. In: Schouten, M.G.C. (ed.), Conservation and restoration of raised bogs: geological, hydrological and ecological Studies. Dúchas – The Heritage Service of the Department of the Environment and Local Government, Ireland; Staatsbosbeheer, the Netherlands; Geological Survey of Ireland, Dublin. pp. 110-169.

Kelly, L., Doak, M. and Dromey, M. (1995) Raised Bog Restoration Project: An Investigation into the Conservation and Restoration of Selected Raised Bog Sites in Ireland. Part 1 Summary

Reports. National Parks & Wildlife Service, Department of Environment, Heritage and Local Government, Dublin.

Kelly, M.L. (1993) Hydrology, hydrochemistry and vegetation of two raised bogs in county Offaly. PhD thesis, Trinity College Dublin.

Laine, J., Harju, P., Timonen, T., Laine, A., Tuittila, E.S, Minkkinen, K. and Vasander, H. (2009) The Intricate beauty of Sphagnum mosses - A Finnish guide to identification. University of Helsinki Department of Forest Ecology Publications, 39: 1–190.

Lamers, L. P. M., Bobbink, R. and Roelofs, J. G. M. (2000) Natural nitrogen filter fails in polluted raised bogs. Global Change Biology, 6: 583–586.

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

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

Malmer, N. and Wallén, B. (2005) Nitrogen and phosphorus in mire plants: variation during 50 years in relation to supply rate and vegetation type. Oikos, 109: 539–554.

Moore, P.D. and Bellamy, D.J. (1974) Peatlands. Elek Science. London.

Nolan, M. (2013) Spiders (Araneae) of Irish raised bogs: Clara bog, Co. Offaly and Carrowbehy bog, Co. Roscommon. Bulletin of the Irish Biogeographical Society 37: 172-203.

NPWS (2007) The Status of EU Protected Habitats and Species in Ireland. National Parks and Wildlife Service, Ireland.

NPWS (2013) The Status of EU Protected Habitats and Species in Ireland. Version 1.0. Unpublished Report, National Parks and Wildlife Services. Department of Arts, Heritage and the Gaeltacht, Dublin, Ireland.

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

NPWS (2019) *The Status of EU Protected Habitats and Species in Ireland*. Volume 2: Habitat Assessments. Unpublished NPWS report. Edited by: Deirdre Lynn and Fionnuala O'Neill.

O'Connell C. (ed.) (1987) The IPCC Guide to Irish Peatlands. Irish Peatland Conservation Council, Dublin.

O'Connell, P. (2011) Action Plan for Raised Bog Birds in Ireland 2011-2020. BirdWatch Ireland, Kilcoole, Co Wicklow.

O Connor, Á., Reynolds, J.D. and Kavanagh, B. (2001) Aquatic macroinvertebrate colonisation of artificial water bodies in cutaway oceanic raised bog in Ireland. In: Rochfort, L. and Daigle, J.Y. (eds.), Proceedings of the 11th International Peat Congress. pp. 742-750.

Payne, R.J. (2014) The exposure of British peatlands to nitrogen deposition, 1900–2030. Mires and Peat 14: Art. 4.

Renou-Wilson, F., Bolger, T., Bullock, C., Convery, F., Curry, J., Ward, S., Wilson, D. and Müller, C. (2011) BOGLAND: Sustainable Management of Peatlands in Ireland. STRIVE Report Series No.75. Prepared for the Environmental Protection Agency. pp. 181.

Reynolds, J.D. (1984a) Invertebrate survey of Irish midlands raised bogs. Bulletin of the British Ecological Society 15: 81-82.

Reynolds, J.D. (1984b) Invertebrate fauna of Irish raised bogs. Part II: Odonata, aquatic Hemiptera and Trichoptera. Bulletin of the Irish Biogeographical Society 8: 98-102.

Reynolds, J.D. (1985) Invertebrates of Lough Roe, Co. Offaly; a rare and endangered bogland habitat. Bulletin of the Irish Biogeographical Society 9: 41-45.

Schouten, M.G.C. (1984) Some aspects of the ecogeographical gradient in the Irish ombrotrophic bogs, paper presented to 7th Int. Peat Congress, Dublin, vol. 1, pp. 414-432, The International Peat Society, Helsinki.

Schouten, M.G.C. (ed.) (2002) Conservation and Restoration of Raised Bogs – geological, hydrological and ecological studies. Dúchas – The Heritage Service of the Department of the Environment and Local Government, Ireland; Staatsbosheheer, The Netherlands; and The Geological Survey of Ireland. pp. 220.

Smart, S.M., Robertson, J., Shield, E.J. and van de Poll, M.H. (2003) Locating eutrophication effects across British vegetation between 1990 and 1998. Global Change Biology 9: 1763-1774.

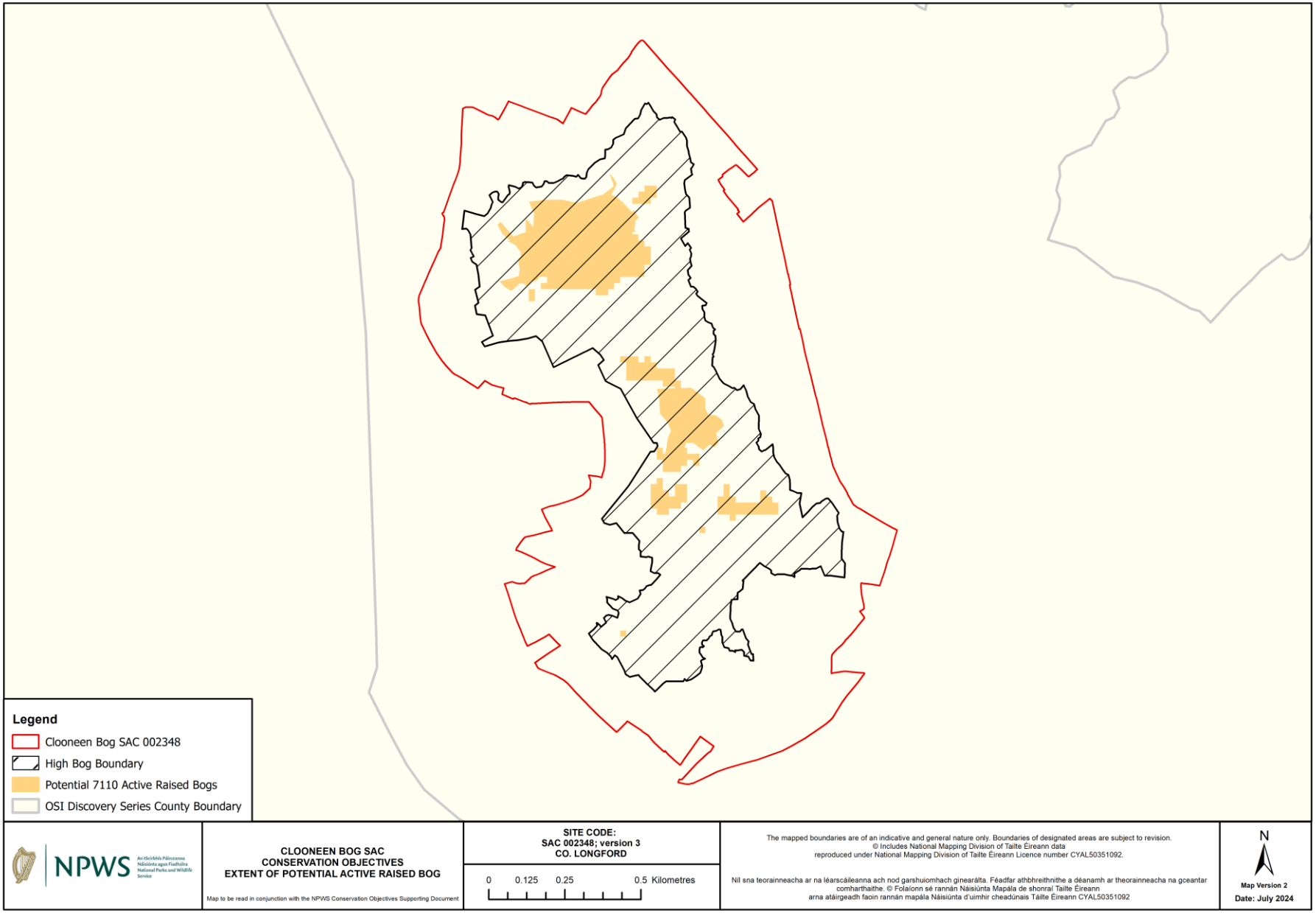
Turunen, J., Roulet, N.T., Moore, T.R. and Richard, P.J.H. (2004) Nitrogen deposition and increased carbon accumulation in ombrotrophic peatlands in eastern Canada. Global Biogeochemical Cycles. 18 (3): GB3002.

Van Duinen G.A. (2013) Rehabilitation of aquatic invertebrate communities in raised bog landscapes. PhD thesis, Radboud University Nijmegen, the Netherlands.

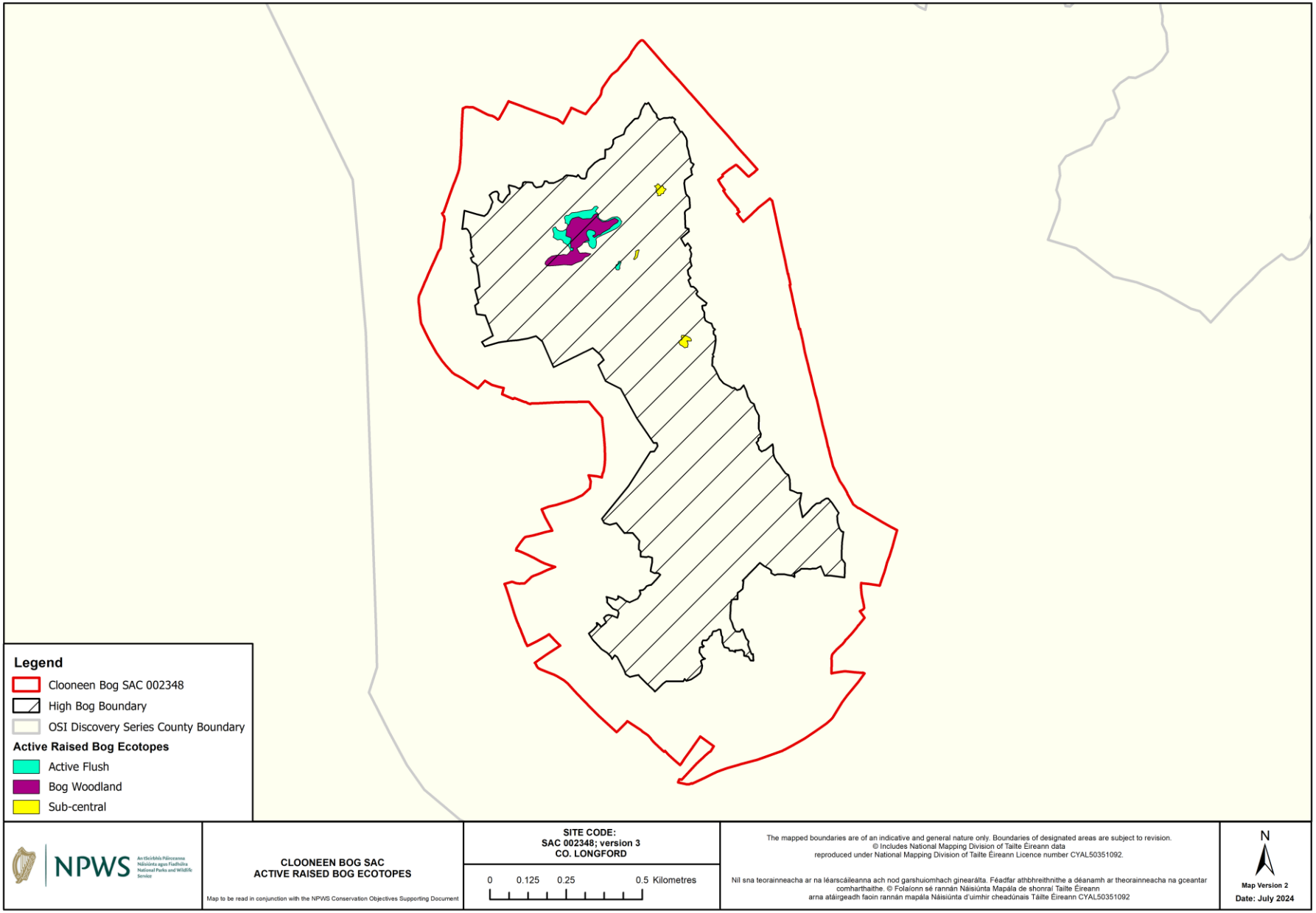
Wilson, H.J. (1990) Birds of raised bogs. pp. 29-36. In: Cross, J. (ed.) The Raised Bogs of Ireland, their ecology, status and conservation. Report to the Minister of State at the Department of Finance. The Stationery Office, Dublin.

Wisdom, R. and Bolger, T. (2011) Chapter 2.4 - Terrestrial invertebrate biodiversity. pp. 103-121 In: Renou-Wilson, F. (ed.) BOGLAND: Sustainable Management of Peatlands in Ireland. Environmental Protection Agency, Wexford.

Map 1: Extent of potential Active raised bog on Clooneen Bog.



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



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