National Parks & Wildlife Service

River Moy SAC
(site code 002298)

Conservation objectives supporting document - raised bog habitats

Version 1

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Contents

1 Introduction

This document presents a summary of the background information that has informed the process of setting the Site-Specific Conservation Objective in relation to the priority Annex I habitat 'active raised bogs' (habitat code 7110) (hereafter referred to as Active Raised Bog (ARB)), for which River Moy Special Area of Conservation (SAC) has been designated. Within the SAC, the raised bog habitat for which the SAC has been selected occurs at five locations, namely Cloongoonagh Bog and a bog cluster that comprises Derrynabrock Bog, Tawnaghbeg Bog, Kilgarriff Bog and Gowlaun Bog.

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

1.1 Raised Bogs

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

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

Exploitation has been extensive and none of the remaining Irish raised bogs are completely intact (Cross 1990). It is estimated that less than 10% of the original raised bog habitat in Ireland is in a near intact state (uncut), with less than 0.5% continuing to support ARB (DAHG 2014). Excavated face banks, whether active or inactive, are a common feature around the

[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 (where known) are used throughout the text together with scientific names.*

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 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 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, 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.

1.1.1 Raised Bogs Microtopography

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

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

Pools

Depressions in the bog surface where the water table remains above the surface level all year around or below surface level for only a very short period of time. They are characterised by the presence of aquatic plant species such as *Sphagnum cuspidatum*, *S. denticulatum*, and *Cladopodiella fluitans*. In more degraded scenarios or where high seasonal water fluctuation occurs, the pools contain open water and/or algae. Tear pools are found on bogs where internal tensions, due to mass movement of peat, has taken place within the high bog and has caused the development of elongated pools. These are frequently found on western bogs and may be natural or anthropogenic in origin.

Hollows

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

Lawns

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

Flats

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

Hummocks

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

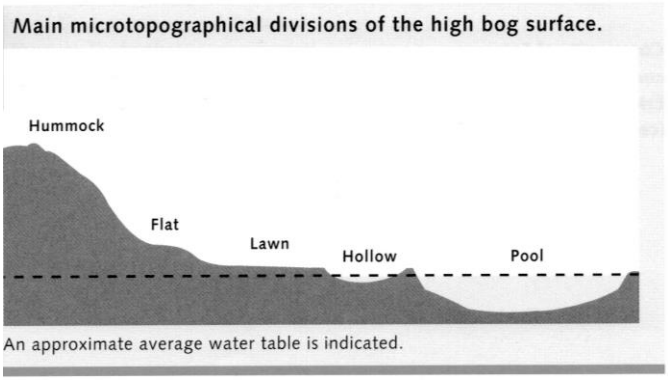

Figure 1 Raised bog microtopographical divisions on the high bog surface (reproduced from Kelly & Schouten 2002).

1.1.2 Typical Flora of Irish Raised Bogs

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

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

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

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

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

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

1.1.3 Typical Fauna of Irish Raised Bogs

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

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

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

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

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

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

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

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

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

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

1.2 Habitats Directive Raised Bog Habitats in Ireland

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

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

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

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

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

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

The main ecotopes that community complexes are grouped into include:

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

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

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

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

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

1.2.1 Restoration of Raised Bog habitats in Ireland

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

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

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

1.3 River Moy SAC

The River Moy system drains a catchment area of 805 square kilometers. Most of the SAC is in Co. Mayo, though parts are located in west Sligo and north Roscommon. Apart from the River Moy itself, other rivers included within the site are the Deel, Bar Deela, Castlehill, Addergoole, Clydagh and Manulla on the west side, and the Glenree, Yellow, Strade, Gweestion, Trimogue, Sonnagh, Mullaghanoe, Owengarve, Eighnagh and Owenaher on the east side. The underlying geology is mostly Carboniferous Limestone, though Carboniferous Sandstone is present at the extreme west of the SAC, with Dalradian quartzites and schists in the south-west. Some of the tributaries in the east, the south of Lough Conn and all of Lough Cullin are underlain by granite.

Within River Moy SAC, the raised bog habitat for which the SAC has been selected occurs at

five locations, namely Cloongoonagh Bog in the west and the bog cluster comprising Derrynabrock Bog, Tawnaghbeg Bog, Kilgarriff Bog and Gowlaun Bog in the east. These five bogs are described in further detail below.

The SAC has been selected for six Annex I habitats and five Annex II species. The peatland habitats for which the SAC has been selected are:

- [7110] Active raised bogs*
- [7120] Degraded raised bogs still capable of natural regeneration
- [7150] Depressions on peat substrates of the *Rhynchosporion*
- [7230] Alkaline fens

The bogs within River Moy SAC are examples of raised bogs at the north-western edge of the range in Ireland and possess many of the species typical of such, including an abundance of *Narthecium ossifragum*, *Carex panicea*, and the moss *Campylopus atrovirens*. Some of the bogs include significant areas of ARB and DRB. Well-developed pool and hummock systems with quaking mats of bog mosses (*Sphagnum* spp.) occur. Several of the hummock-forming mosses (e.g. *Sphagnum fuscum* and *S. austinii*) that occur here are quite rare in this region and add to the scientific interest of the bogs as a component of the overall SAC.

Depressions on the bogs and pool edges support the habitat 'Rhynchosporion vegetation'.

Non-active raised bog habitat is present where the hydrology of the uncut bogs has been affected by peat-cutting and other land use activities in the surrounding area, such as afforestation and associated drainage, and also the Moy arterial drainage scheme. Species typical of the ARB habitat may still be present but the relative abundances differ. A typical example of the degraded habitat, where drying has occurred at the edge of the high bog, contains an abundance and more uniform cover of *Calluna vulgaris*, *Carex panicea*, *Trichophorum germanicum* and sometimes *Myrica gale*.

Occurring in association with the uncut high bog are areas of wet regenerating cutover bog with species such as *Eriophorum angustifolium*, bog mosses and sundew, while on the drier areas, the vegetation is mostly dominated by *Molinia caerulea*. Natural regeneration with peat-forming capability will be possible over time with some restorative measures.

Tawnabeg Bog and Derrynabrock Bog were last surveyed in 2012 (Fernandez et al. 2014), while the other three were last surveyed in 1999 (Derwin & MacGowan 2000)

1.3.1 Cloongoonagh Bog

This is a medium sized raised bog situated immediately south of the meeting point between the rivers Moy and Owengarve. It is located 6km north-west of Charlestown, in the townlands of Cloongoonagh, Curraghbonaun, Coolrecuill and Coolrawer, Co. Sligo. The bog can be accessed off the local road linking Bellahy to Banada.

Habitats that occur in association with Cloongoonagh Bog include marginal areas of cutover bog, scrub, river, conifer forestry, wet grassland and improved grassland.

When last surveyed, the eastern section of this bog was relatively flat but the rest featured extensive slopes. In the north there are marginal slopes associated with the Owengarve River. The rest are internal slopes associated with a flush in the north-west and a bog-burst in the south-west (Derwin & MacGowan 2000).

To the north there is a narrow band of old cutover, dominated by *Molinia caerulea* and *Ulex europaeus* scrub. This slopes down to the Owengarve River. It is dominated by *Molinia caerulea* with *Ulex europaeus* scrub at the bog margin and *Betula pubescens* scrub by the

river. To the north-west, most of the old cutover has been reclaimed for agriculture and slopes down to the Moy River.

There is extensive cutover to the south, east and west. To the west, this slopes away from the high bog. An island of mineral soil, which originally occurred on the high bog, is now within old cutover. To the south of this outcrop there is coniferous forestry.

A stream runs close to the south of the high bog. There is extensive cutover on the southern side, which slopes down to the stream. This area is dominated by *Betula pubescens* and *Ulex europaeus* scrub.

The extensive cutover to the east is level. There are numerous turf banks and wet hollows and it is dominated by *Calluna vulgaris* and some *Betula* scrub. There is a section of old cutover stretching into the bog from the east. This is flooded in places with *Typha latifolia* present in some areas.

A large *Molinia caerulea*-dominated flush runs across the high bog towards the Moy River. The bog slopes towards this flush. To the south-west, an extensive tear-pool system occurs on the high bog marginal slope. This system however, has been impacted by drainage.

In addition to its diversity of species, this small raised bog is one of the most north-westerly of the Irish raised bogs.

1.3.1.1 Flora of Cloongoonagh Bog

At Cloongoonagh Bog only a very small area of central vegetation complex was found (Derwin & MacGowan 2000). This area of good quality habitat is surrounded to the east by a large area of sub-central ecotope. There is also abundant sub-marginal ecotope vegetation concentrated in the western half of the bog featuring a large complex of tear pools. Pockets of ARB are likely to be present within this, as indicated by features visible on the 2010 aerial photography which are likely to correspond with *Sphagnum*-dominated areas. Most of the bog vegetation conforms to marginal ecotope, which is found around the edges of the bog where it is associated with old peat-cutting. Apart from these vegetation types there are also two flushed areas.

The central ecotope has frequent pools, all of which are in-filling with *Sphagnum cuspidatum, Sphagnum magellanicum* and *Trichophorum germanicum* (10%). *Drosera anglica* and *Rhynchospora alba* also feature in the pools. Between the pools, the vegetation is dominated by *Sphagnum capillifolium* (60%), *Sphagnum magellanicum* (20%) and *Calluna vulgaris* (70%). *Erica tetralix* (10%), *Eriophorum vaginatum* (10%), *Eriophorum angustifolium* (10%), *Cladonia portentosa* (5%), and *Hypnum jutlandicum* (5%) are also common.

The main sub-central community complex, which dominates the only example of this ecotope type on the bog is characterised by abundant *Calluna vulgaris* (50%). *Cladonia portentosa* (50%) and *Eriophorum vaginatum* (20%) with occasional *E. angustifolium* and *Trichophorum germanicum* and *Vaccinium myrtillus*. The ground is very wet under the 50cm high *Calluna vulgaris* and 20cm deep *Cladonia portentosa*. Hummocks of *Pleurozium schreberi* are common with *Sphagnum capillifolium* and occasional *S. magellanicum.*

A further sub-central complex area occurs which had been recently burned at the time of survey. The *Calluna vulgaris* (60%) is still dominant but shorter (20cm) with *Cladonia* down to 15% cover and *Carex panicea* (20%). Also a new moss here is *Breutelia chrysocoma*. Good *Sphagnum* (60%) cover - mostly *Sphagnum capillifolium*. *Eriophorum vaginatum* (10%) and *E. angustifolium* are also present (Derwin & MacGowan 2000).

Two main flush areas occur on Cloongoonagh Bog. The first flush is marked by a change in vegetation colour - *Molinia caerulea* (60%) is dominant with *Calluna vulgaris* (30%) and a few

bushes of *Myrica gale* growing through it. *Eriophorum angustifolium* (10%), *Carex panicea* (15%), *Erica tetralix* (5%), *Eriophorum vaginatum* (5%), and *Cladonia portentosa* (5%) are common. *Potentilla erecta* and *Trichophorum germanicum* are present. The head of the flush is marked by a patch of *Calluna vulgaris* (1m high) and *Salix* sp. scrub growing over what appears to be a swallow-hole. The fern *Blechnum spicant* is also present. The acrotelm is variable with few *Sphagnum* species - the main species being *Sphagnum capillifolium* (10%). *Narthecium ossifragum* and an algal mat are growing on areas with no acrotelm.

The second flush has vegetation where *Molinia caerulea* is co-dominant with some *Myrica gale* close to the drain. This vegetation covers a wide area around intersecting drains. A few *Sphagnum papillosum* hummocks are present.

1.3.2 Derrynabrock Bog

Derrynabrock Bog is located approximately 10km east of Charlestown. The bog occurs in the townlands of Cloonlumey, Derrynabrock and Srah Upper and straddles the border between Co. Roscommon and Mayo. Rivers run to the north, west and south of the bog, connecting to form the Owenlobnaglaur River. The southern section of the bog is in Co. Roscommon. A number of small bog roads lead towards the southern and eastern sides of the bog where access may be obtained.

Other habitats associated with the high bog include areas of cutover bog, fen, a bog lake, and a soak system.

This is a western type raised bog indicating that it has many features similar to a blanket bog (Cross 1990). Derrynabrock Bog has also been classified as a ridge basin bog by Kelly *et al*. (1995). The most noticeable characteristic is the absence of a definite dome and the undulating nature of the bog. The whole of the northern lobe of the bog is approximately 2m lower than the rest of the bog with a pronounced slope towards the river to the north of the high bog. The bog occurs on a ridge between two rivers (Fernandez *et al.* 2014a, b).

1.3.2.1 Flora of Derrynabrock Bog

At Derrynabrock Bog ARB includes central, sub-central and active flush ecotopes. Central ecotope is found at three locations. Two of these areas are situated close together in the north-eastern part of the bog. The third is located in the western lobe of the bog. The western vegetation community complex characterises all of the central ecotope, which is located on flat ground, which is very wet and quaking with pools (11-25%) and also a mosaic of hummocks and hollows. There are pools (11-25%) and a good *Sphagnum* cover (50-75%), consisting of pool species notably *S. cuspidatum* but also *S. denticulatum* and at the pool edges *S. magellanicum*. Other pool species include *Menyanthes trifoliata* and *Drosera anglica*. The main hummock *Sphagnum* is *S. capillifolium.* The western indicators *Campylopus atrovirens* (<4%), *Pleurozia purpurea* (<4%), *Racomitrium lanuginosum* (<4%) are found especially where pools are more extensive (26-33%) (Fernandez *et al.* 2014a, b).

There are 12 areas of sub-central ecotope on Derrynabrock Bog. Although the total area of sub-central appeared to increase from the 2004 survey, this is believed to be due to more comprehensive survey and mapping and not a real change (Fernandez *et al.* 2014a, b). Two western-type community complexes typify this vegetation. The main one which characterises nearly all sub-central ecotope areas on the bog, has ground that is soft with pools (up to 25%) and hummocks and hollows. *Narthecium ossifragum* is widespread (26-33%) in the inter-pool areas. *Sphagnum* cover is generally 26-33% with a good diversity of *Sphagnum* spp: *S. capillifolium*, *S. tenellum*, *S. subnitens*, *S. austinii*, *S. fuscum*, *S. papillosum*, *S. magellanicum*, *S. denticulatum*, *S. cuspidatum* as well as western indicators *Campylopus atrovirens*, *Pleurozia purpurea*, *Racomitrium lanuginosum* and *Leucobryum glaucum*.

The other (better quality) sub-central community occurs in two localised areas. This complex has increased *Eriophorum vaginatum* and extends in a narrow band to the south where it appears to be flushed (possibly indicating water movement) as indicated by the presence of *Molinia caerulea*, *Sphagnum fallax*, *S. palustre* and *Aulacomnium palustre* (Fernandez *et al.* 2014a, b).

There is one active peat forming flush located in the north-west of the western lobe. This flush is essentially a large pool with close to 100% *Sphagnum* cover (mostly *S. cuspidatum*) surrounded by some large hummocks. Other species indicative of flushing included *Vaccinium oxycoccos* (<4%), *Aulacomnium palustre* (<4%) and *Polytrichum strictum.*

Non-active raised bog habitat at Derrynabrock Bog includes the sub-marginal, marginal, and inactive flush ecotopes. Although some areas have a relatively well-developed raised bog flora, they are affected by water loss to varying degrees, and are usually devoid of permanent pools.

The sub-marginal ecotope features the best developed microtopography in these areas. There are three community complexes, the most widespread of which is often a gradation between community complex types, has fewer pools (<4-10%) and less *Sphagnum* (11-25%) and a greater cover of *Narthecium ossifragum* of up to 34-50%, on the flats between pools and hummocks. One community complex is much more localised on the eastern side of the bog. It is characterised by the absence of pools and good *Sphagnum* cover (11-33%) of mainly hummock forming species notably *Sphagnum capillifolium* (11-25%) and with *Eriophorum vaginatum* a notable component of the vegetation (11-25%), forming tussocks and flats. This grades into a complex where *Sphagnum* cover decreases, and there is a greater cover of *Narthecium ossifragum*, and some pools may be present. On the northern side of the western lobe, hummocks of *Racomitrium lanuginosum* are up to 80cm high. Towards the centre of the bog, *Sphagnum* cover can be quite variable. This complex grades into a complex in places where *Carex panicea* (>4%) occurs.

1.3.3 Gowlaun Bog

Gowlaun Bog is located 11km north-west of Ballaghadereen and 9km north-east of Charlestown, in the townlands of Gowlaun, Srah Upper, Srah Lower and Rooskey, Co. Mayo. The bog can be accessed via a laneway off a local road linking Derrykinlough to Roosky. This road is off the Charlestown to Doocastle road.

Gowlaun Bog is surrounded by marginal areas of cutover bog, wet grassland, improved grassland, scrub, river and conifer forestry.

Gowlaun Bog is very dried out with poor active bog habitat found (Fernandez *et al.* 2006). The predominant ecotope type is sub-marginal with a significant amount of marginal ecotope also represented.

Peat-cutting, forestry, agricultural improvement and associated drainage are all activities associated with cutover areas. This bog contains a variety of bog features and has a good diversity of plant species. Several localised wet areas have well-formed hummock/hollow communities. Species of bog moss which are regionally rare are also found here (*Sphagnum austinii, S. fuscum, S. fallax* and *S. magellanicum*). *Carex limosa* an occasional but local species found mainly in the west and north, was also recorded here in 1989.

Along with typical raised bog communities, there are also areas of flushed channels containing *Molinia caerulea*, herb-rich dry and wet grassland, scrub woodland, and slowly meandering streams.

Although the north-east and south-west lobes are quite intact, much of the bog has been damaged by drainage and past peat-cutting and there are indications on the surface that it is

drying out rapidly. Small areas of conifer plantation have also infringed on the bog.

1.3.3.1 Flora of Gowlaun Bog

According to the last ecotope survey (Derwin & MacGowan 2000), ARB at Gowlaun Bog comprises sub-marginal and marginal ecotopes and active flush. However, the 2005 and more recent 2010 aerial photographs show features such as pools surrounded by light green/yellow colour vegetation, which suggests *Sphagnum* spp. dominance on the western section of the high bog. This indicates the presence of vegetation likely to correspond with ARB.

Much of the sub-marginal area appeared burned prior to most recent survey (2003) and it was also poached and grazed by cattle (Fernandez *et al.* 2006). The vegetation is dominated by *Calluna vulgaris* (60%) with *Trichophorum germanicum* (20%). All the *Calluna vulgaris* plants are depauperate with quite a good *Sphagnum* cover, although the hummocks are small. Several large hummocks of dead *Sphagnum* and *Racomitrium lanuginosum* are present. The ground is quite wet underfoot with a large algal mat cover. Some *Drosera rotundifolia* plants are present. *Narthecium ossifragum* (15%) is prominent in the hollows. The sedge *Carex panicea* (20%) is quite prominent with occasional occurrence of *Eriophorum angustifolium* and *E. vaginatum* (Derwin & MacGowan 2000).

In sub-marginal areas some *Sphagnum austinii* and *S. fuscum* are recorded and some pools have S. *cuspidatum*. *Sphagnum fallax* is recorded in the flush areas.

An active *Myrica gale* flush, not recorded in the previous survey, was recorded to the east of the centre lobe during the 2003 survey (Fernandez *et al.* 2006). However, this flush could be the result of secondary rewetting associated with the presence of a functional drain.

1.3.4 Tawnaghbeg Bog

Tawnaghbeg Bog is approximately 11.5km north-east of Charlestown, and 6km southeast of Tobercurry, and occurs in the townlands of Tawnaghbeg, Gowlaun and Kilgarriff, Co. Mayo. Access to this site may be gained at the southern end, where a track extends westwards from the road to Cloontia.

Tawnaghbeg Bog is surrounded by marginal areas of cutover bog, conifer forestry, river, wet grassland, improved grassland and scrub.

Tawnaghbeg is classed as a ridge basin bog. It is a western raised bog and thus shares features with blanket bogs. These types of bogs are characterised by the absence of a definitive dome and by the undulating nature of the topography (Kelly *et al*. 1995).

Peat-cutting has largely divided the high bog into two lobes, with a narrow central zone linking the two (Fernandez *et al.* 2014a, c).

1.3.4.1 Flora of Tawnaghbeg Bog

At Tawnaghbeg Bog ARB comprises central and sub-central ecotopes.

Central ecotope is found at two locations on Tawnaghbeg Bog. A single community complex is recorded in these two central areas. The complex consists of high and low hummocks, pools, hollows and lawns. Pools, which are mostly large and interconnecting, covered 34-50% of the complex area, and typically have a high cover of *Sphagnum* (circa 75%), most of which is accounted for by S. *cuspidatum*. *Sphagnum* cover varies, however, between the two central ecotope areas, with the more northerly having pools with more open water and algae and a correspondingly lower *Sphagnum* cover. *Sphagnum denticulatum* is also present but infrequent in pools, while *Campylopus atrovirens* and *Pleurozia purpurea* are occasional

at pool edges (Fernandez *et al.* 2014a, c).

The inter-pool areas have low hummocks, mostly dominated by *S. capillifolium*. Other *Sphagnum* species present include *S. papillosum* and *S. tenellum*. Small *Sphagnum fuscum* hummocks and *Racomitrium lanuginosum* hummocks are present, but rare, in the complex.

An occasional high hummock within the complex has tall *Calluna vulgaris*, abundant *Pleurozium schreberi*, and a generally high cover of *Cladonia portentosa*.

Sub-central ecotope is found at three locations on the bog. Only two sub-central community complex types are recorded. These complexes resemble the central complex described above, but are generally of lesser quality, having a lower cover of pools and lower *Sphagnum* cover.

The first complex consists of pools, low hummocks and hollows. Pools cover 11-25% of the complex, while *Sphagnum* cover is 34-50%. Pools have a generally high cover of *S. cuspidatum* (up to 70%), while *S. denticulatum* is also present, though quite infrequent. Pool edges have hummocks of *S. capillifolium* and/or *S. papillosum*, while *S. magellanicum* is also present, but rare, at pool edges. The inter-pool habitat have low hummocks, mostly of *S. capillifolium*, while occasional small hummocks of *Sphagnum austinii* and *S. fuscum* are also present. *Narthecium ossifragum* is particularly common in interpool flats, with *Calluna vulgaris* and *Eriophorum vaginatum* the other dominant species there.

The second complex differs mainly in the relative abundance of *Rhynchospora alba*. *Sphagnum* cover in pools, mostly *S. cuspidatum*, varies considerably in this complex, with some pools having a high cover and others very little (Fernandez *et al.* 2014a, c).

Non-active raised bog habitat includes the sub-marginal, marginal, and face bank ecotopes, as well as inactive flushes. Although some of these areas have a relatively well-developed raised bog flora, they are affected by water loss to varying degrees, and are usually devoid of permanent pools (Fernandez *et al.* 2014a, c). The sub-marginal ecotope features the most developed microtopography.

The sub-marginal ecotope at Tawnaghbeg Bog includes areas where pools are mostly absent, or at a total cover of <10%. *Sphagnum* cover in pools here is lower than in those in ARB, while *S. cuspidatum* and *S. papillosum* are the dominant pool species. The microtopography in sub-marginal ecotope generally consists of hummocks, hollows and flats and the overall *Sphagnum* cover is in the range of 11-25%. *Calluna vulgaris*, *Eriophorum vaginatum*, *E. angustifolium*, *Narthecium ossifragum* and *Carex panicea* are the most common species in the sub-marginal ecotope, while *Sphagnum* hummocks are dominated by *S. capillifolium*, with *S. papillosum*, *S. tenellum* and *S. subnitens* also present.

1.3.5 Kilgarriff Bog

Kilgarriff Bog is located just north of the Roscommon/Mayo county border, 10km south-east of Tobercurry, Co. Mayo and just east of Charlestown, Co. Mayo. The bog occurs in the townland of Derrynabrock, Co. Mayo. The bog can be accessed from a laneway to the east.

Kilgarriff Bog is surrounded by marginal areas of cutover bog, river, wet grassland, improved grassland, scrub and conifer forestry.

This bog is relatively intact with very little disturbance taking place on or immediately surrounding the high bog (Fernandez *et al.* 2006; Derwin & MacGowan 2000).

There is a good diversity of species and habitats on this small bog. The centre of the bog contains areas of pools and hummocks. The uniformity of the vegetation and small size of the hummocks indicates this area was probably burned in the past. At the time of survey in

1999 (Derwin & MacGowan 2000), it still however, contained a good complement of bog mosses (*Sphagnum* spp.), *Racomitrium lanuginosum* and *Cladonia sp*. lichens. There are also several sinuous tear pools containing *Menyanthes trifoliata* and *Sphagnum cuspidatum, S. papillosum* and *S. magellanicum.*

The edges of the bog are slightly dried out and contain a more uniform cover of low *Calluna vulgaris*, *Carex panicea*, *Trichophorum germanicum*, and *Narthecium ossifragum*.

1.3.5.1 Flora of Kilgarriff Bog

At Kilgarriff Bog ARB comprises central and sub-central ecotopes.

The central area is found in the very centre of this small bog and comprises a complex of hummocks and hollows with frequent pools.

A band of sub-central ecotope surrounds the inner central area of the bog. This complex comprises a mixture of *Calluna vulgaris* and a complex of scattered hummocks and hollows.

Sub-marginal ecotope type forms the transitional habitat between the ARB and the bog edge and comprises a complex of mixed *Calluna vulgaris* and *Eriophorum angustifolium.*

1.3.6 Fauna of the bogs in River Moy SAC

Many of the typical fauna associated with raised bog habitats are likely to occur in the five raised bogs listed for River Moy SAC (see Section 1.1.3 above). However, there is a lack of documented site-specific data relating to the fauna of each bog. Breeding red grouse (*Lagopus lagopus*) and breeding curlew (*Numenius arquata*) have been recorded on bogs within the SAC during the latest national surveys for each species (Cummins et al. 2010; NPWS unpublished data).

2 Conservation objectives

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

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

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

2.1 Area

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

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

The total area of ARB in the River Moy SAC in 1994 is not known as the high bog at Kilgarriff, Gowlaun, and Cloongoonagh was only first surveyed in 1999 (Tawnabeg Bog and Derrynabrock Bog were surveyed in 1994). 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).

In setting the site-specific target the current hydro-ecological conditions on the bogs (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.

As there is an absence of more recent data for three of the bogs within the SAC (Kilgarriff, Gowlaun Bog, Cloongoonagh Bog), the 1999 area figure for these bogs has been used for the ARB target (see Table 3 below). Based on the most recent monitoring survey for each bog, the total area of ARB within the SAC is estimated to be 45.3ha.

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 152.4ha (see DAHG 2014 for further details of the technique). This represents the area of the high bog, which does not currently contain ARB but has topographical conditions deemed suitable to support

[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.

ARB (see Map 1 which shows the total area of current and modelled potential ARB). This area was refined to 82.1ha by estimating the area that could be restored by blocking drains on the high bog. This refinement was based on applying an efficacy factor (see DAHG 2014).

Based on the current assessment of the bogs above, it is therefore concluded that the maximum achievable target for ARB on the high bog is 127.4ha. However, it is important to note that this assumes no further decline of ARB due to losses of high bog caused by peat-cutting and drainage activities associated with same (Fernandez *et al*. 2014a, b, c). Similarly, should any of the bogs 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 in the River Moy SAC in 1994, 1999, and 2012 (Source: Kelly *et al*. 1995; Derwin & MacGowan 2000; Fernandez *et al.* 2014; NPWS unpublished data)

	1994		**1999**		**2012**	
	ARB (ha)	DRB (ha)	ARB (ha)	DRB (ha)	ARB (ha)	DRB (ha)
Cloongoonagh Bog	Unknown	Unknown	20.0	Unknown	20.0[3]	22.7
Derrynabrock Bog	17.9	4.9	Unknown	Unknown	6.6	16.2
Gowlaun Bog	Unknown	Unknown	1.8	Unknown	1.8[4]	30.8
Tawnaghbeg Bog	12.8	5.0	Unknown	Unknown	9.9	8.0
Kilgarriff Bog	Unknown	Unknown	7.0	Unknown	7.0[4]	4.5
River Moy SAC					**45.3**	**82.1**

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 5.0ha of ARB could be restored in this area. The long term achievable target for ARB in the River Moy SAC is therefore set at 132.4ha.

In conclusion, the site-specific target for the attribute habitat area is: **Restore area of active raised bog to 132.4ha, subject to natural processes.**

2.2 Range

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

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

The conservation of ARB within each of the raised bogs in the River Moy SAC Bog as set out in Section 2.1 above will contribute to safeguarding the national range of the habitat.

The ARB habitat in the River Moy SAC includes central and sub-central ecotopes, as well as active flush. A map showing distribution of ecotopes throughout the bogs, based on the

[3] This data is based on a review of the most recent vegetation survey of the bog (in this case 1999). Based on the trend recorded at other sites, the extent of ARB in 2012 is likely to be less.

most recent surveys of each bog (as outlined above) in the River Moy SAC is presented in Map 2.

The site-specific target for the attribute habitat distribution is: **Restore the distribution and variability of active raised bog across the SAC.**

2.3 Structure and functions

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

2.3.1 High bog area

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

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

The area of high bog within the bogs in the River Moy SAC in 1994 was mapped as 499.0ha, while the corresponding area in 2012 is 498.4ha (based on interpretation of LiDAR and Aerial Photography flown in 2012), representing a loss of 0.6ha of high bog (DAHG 2014). The extent of high bog within the bogs in the River Moy SAC in 2012 is illustrated on Map 1.

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

2.3.2 Hydrological regime: water levels

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

Much of the knowledge regarding the hydrological requirements of raised bog communities in Ireland stems from the extensive ecological and hydrological work undertaken on Clara Bog since the early 1990s. Detailed hydrological studies of the bogs listed for River Moy SAC have not been carried out to date; however, it is likely that marginal drainage and forestry has contributed to subsidence on the high bogs' 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.

2.3.2.1 Cloongoonagh Bog

The most recent description of drainage at Cloongoonagh Bog is presented in Derwin and MacGowan (2000), who reported that 2.1km of functional drains were impacting on raised bog habitats. Most of the drains were described as old and infilling. A recent estimate of high bog drainage based on interpretation of 2010 aerial photography suggests that there may be up to 3.6km of high bog drains; however, it is not known whether all of these drains are functional. It is likely that most of these drains were present at the time of the last survey but were only identified through the use of higher resolution aerial photography.

The high bog is surrounded by extensive cutover bog, mainly to the south of the high bog. There is an extensive network of drains associated with this cutover. A river flows along the northern margin of the bog (Owengarve River, feeding into the River Moy) and a stream flows along the south of the high bog, through the cutover area isolating an area that is a mosaic of high bog and cutover to the south. There are also drains associated with agricultural reclamation, particularly along the northern and eastern margin.

Detailed hydrological studies of Cloongoonagh Bog have not been carried out to date; however, it is likely that high bog drains, marginal drainage and forestry has contributed to subsidence 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 was underlain by a thin-bedded calcareous shale, limestone bedrock unit, which is a locally important aquifer, as it is moderately productive only in local zones. To the west of the bog there is a pale grey massive limestone bedrock unit which is a regionally important aquifer as it is subject to karstification (conduit). Subsoil mapping indicates that Sandstone and shale till is the main mineral subsoil in the surrounding area, although there is also alluvium to the north of the bog associated with the River Moy. The presence of a permeable bedrock unit as well as permeable substrate suggests that a decline in groundwater head may contribute to subsidence on the high bog.

2.3.2.2 Derrynabrock Bog

The most recent description of drainage at Derrynabrock Bog is presented in Fernandez *et al*. (2014b) who reported that 4.0km of unblocked drains are impacting upon raised bog habitats with the majority of these classed as functional (3.2km), and the remaining classified as reduced functional (0.8km). In addition 0.5km of unblocked drains were reported to be in-filled with vegetation; it is not known whether these drains are having any impact upon high bog habitats.

There are drains associated with peat-cutting in cutover areas around some margins of the bog. Although Fernandez *et al*. (2014b) did not survey the cutover areas for drains during the 2012 survey, they note that it is likely that such drains are likely to have been maintained in the reporting period. There is also extensive drainage associated with agriculture in the margins of the bog; although Fernandez *et al*. (2014b) report that there was no obvious drainage maintenance on adjoining agricultural land based on the 2010 aerial photography. There are two river channels along the boundary of the bog, one flowing along the north and one along the south of the bog. The channel to the north isolates Derrynabrock Bog from the other bogs within this complex. There is a conifer plantation on cutover bog to the north-east of the bog, which is likely to be further lowering water levels in the margins.

The only available hydrological study for Derrynabrock Bog is the work carried out by Kelly *et al*. (1995). The hydrochemistry survey identified electrical conductivity (EC) values of between 73 - 100µS/cm in the cutover drains along the southern margin of the bog. These EC values are similar to EC values typically associated with rain water, reflecting the inert properties of the peat. This suggests little groundwater influence despite some of these drains cutting into the mineral substrate underlying the peat. As would be expected elevated EC values (240µS/cm) were recorded in the river channel to the south of the site suggesting more significant groundwater influence in this channel.

Although upwelling groundwater was not identified within the drains it is possible that there has been a decline in regional groundwater heads. This may have had an impact on the surface of the bog through subsidence. The risk of subsidence depends on the permeability of the underlying substrate, which will influence the extents of impacts from changes to groundwater head. Geological maps show that Derrynabrock bog is underlain by a number of different bedrock units including a sandstone, siltstone, black mudstone unit, a dark nodular calcarenite and shale unit and a thin-bedded calcareous shale, limestone unit. All three bedrock units are classified as locally important aquifers which are moderately productive only in local zones. Subsoil mapping indicates that sandstone till is the main mineral subsoil in the surrounding area, although there is also alluvium to the north and west of the bog associated with the river channel. The presence of a potentially permeable bedrock unit as well as permeable substrate suggests that a decline in groundwater head may contribute to subsidence on the high bog.

2.3.2.3 Gowlaun Bog

The most recent description of drainage at Gowlaun Bog is presented in Derwin & MacGowan (2000), who reported that 7.1km of functional drains were impacting on raised bog habitats. A recent estimate of high bog drainage based on interpretation of 2010 aerial photography suggests that there may be up to 16.0km of high bog drains; however, it is not known whether all of these drains are functional. It is likely that most of these drains were present at the time of the last survey but were only identified through the use of higher resolution aerial photography. Two streams in the margins of the bog it from the other bogs within this complex. Derwin and MacGowan (2000) note that there was very little active peat cutting around the margins of the bog at the time of their survey and investigations using aerial photography indicates little peat cutting at this bog since 1995. However, large areas of this bog have been exploited in the past and the cutover areas reclaimed for agriculture and forestry. There is an extensive network of drains in the margins surrounding the bog associated with these activities.

Geological mapping indicates that there are three bedrock units underlying sections of the bog including a thin-bedded calcareous shale unit (locally important aquifer – moderately productive only in local zones), a sandstone, pebbly conglomerate (locally important aquifer – generally moderately productive) and a bioclastic cherty limestone unit (locally important

aquifer – karstified). Subsoil mapping indicates that sandstone till is the main mineral subsoil in the surrounding area, although there is also alluvium to the south of the bog associated with the river channel. The presence of a permeable bedrock unit as well as permeable substrate suggests that a decline in groundwater head may contribute to subsidence on the high bog.

2.3.2.4 Tawnaghbeg Bog

The most recent description of drainage at Tawnaghbeg Bog is presented in Fernandez *et al*. (2014c) who reported that 3.7km of unblocked drains are impacting upon raised bog habitats with the majority of these classed as functional 3.6km, and the remaining classified as reduced functional (0.1km). There is also a conifer plantation to the north of the bog that extends from the margins onto the high bog, which is likely to be contributing to lowering the water levels in the high bog.

Drains associated with the former peat-cutting areas are present in the cutover, particularly on the cutover on the south-east of the bog. In addition to cutover drains there is an extensive network of agricultural drains, many of which are being actively maintained. Fernandez *et al*. (2014c) report that 1km of peripheral agriculture land drainage was maintained to the south-west of the bog based on the 2010 aerial photographs. A stream in this area separates Tawnaghbeg Bog from Gowlaun Bog. In addition to drainage for agricultural purposes there are several conifer plantations in the margins immediately adjacent to the high bog along the northern, western and southern boundaries. Maintenance of high bog drains associated with the conifer plantation was reported by Fernandez *et al*. (2014c). Previously, Fernandez *et al*. (2005) reported that drains inserted within the conifer plantations in the north of the high bog werelikely to be impacting on water levels within the high bog.

The only available hydrological study for Tawnaghbeg Bog is the work carried out by Kelly *et al*. (1995). The hydrochemistry survey identified electrical conductivity (EC) values of between 68 – 100µS/cm in the high bog drains along the east of the bog. EC values of < 100µS/cm typically indicate bog water, as this is similar to rain water, reflecting the inert properties of the peat. This suggests little groundwater influence in this area. However, high EC values were identified in the main channels draining the bog. In the drain to the north-east the EC was 209µS/cm, to the north-west EC values were 240µS/cm. In the main peripheral drain along the south-west EC values ranged from 180 - 205µS/cm. These elevated EC values indicate some groundwater influence in these channels.

Although upwelling groundwater was not identified within the cutover drains, there was groundwater identified within the main drainage channels around the bog. It is possible that deepening of these drains has resulted in a decline in regional groundwater head. This may have had an impact on the surface of the bog through subsidence. The risk of subsidence depends on the permeability of the underlying substrate, which will influence the extents of impacts from changes to groundwater head. Geological maps indicate that Tawnaghbeg Bog is underlain by a thin-bedded calcareous shale, limestone bedrock unit. This is a locally important aquifer which is moderately productive only in local zones. Subsoil mapping indicates that sandstone till is the main mineral subsoil in the surrounding area. The presence of a potentially permeable bedrock unit and potentially permeable substrate suggests that a decline in groundwater head may contribute to subsidence on the high bog.

2.3.2.5 Kilgarriff Bog

The most recent description of drainage at Kilgarriff Bog is presented in Derwin & MacGowan (2000), who reported no high bog drainage on Kilgarriff Bog. However, more recent data (high resolution 2010 aerial photography) indicate the presence of 2.9km of

drains on the high bog associated with peat-cutting, which were likely to have been present in 2000. Two streams in the margins of the bog isolate this bog from the others in this complex. There is a semi-natural margin between the bog and the stream to the north, although there are drains in the margins to the north-west. There are drains along the western margin, associated with a coniferous forestry plantation on cutover which is also likely to be contributing to lowering water levels in the margins. Along the southern margin there are drains associated with agricultural reclamation. Peat-cutting has been most extensive in the south-east and east, with significant drainage between the bog and the adjacent stream.

Geological mapping indicates that the bog is predominantly underlain by a thin-bedded calcareous shale limestone bedrock unit; this is a locally important aquifer as it is moderately productive only in local zones. A small part of the bog to the south is underlain by a pale grey massive limestone unit, which is a locally important aquifer as it is subject to karstification. Subsoil mapping indicates that sandstone till is the main mineral subsoil in the surrounding area, although there is also alluvium to the south of the bog associated with the river channel. The presence of a permeable bedrock unit as well as permeable substrate suggests that a decline in groundwater head may contribute 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 the five bogs based on a digital elevation model generated from LiDAR imagery flown in 2012 is presented in Map 3.

The slopes and flow patterns on these bogs illustrate that this they are western-type raised bogs, with features and characteristics similar to blanket bog. Slopes are relatively steep across most of the bogs, with large areas where slopes are in excess of 1%.

2.3.3.1 Cloongoonagh Bog

It is evident on Cloongoonagh Bog that there is focused flow towards the northern and north-western margin. Although steeper slopes and focused flow may be natural characteristics of this bog, it is likely that extensive marginal drainage has resulted in increased slopes and therefore drying out effects on the bog. Changes to flow patterns or slopes arising from subsidence due to peat-cutting and drainage are likely to have a significant impact on raised bog habitats.

2.3.3.2 Derrynabrock Bog

It is evident on Derrynabrock Bog that there is focused flow towards the north-western and western margin. Although steeper slopes and focused flow may be natural characteristics of this bog, it is likely that high bog and marginal drainage has resulted in increased slopes and therefore drying out effects on the bog. Changes to flow patterns or slopes arising from subsidence due to peat cutting and drainage are likely to have a significant impact on raised bog habitats.

2.3.3.3 Gowlaun Bog

On Gowlaun Bog, it is evident that there is focused flow towards the south-western margin and northern/north-eastern margin. Although steeper slopes and focused flow may be natural characteristics of this bog, it is evident that focused flow towards the north-east is related to high bog drainage. In addition marginal drainage and forestry are likely to have resulted in steeper slopes and focused flow. This is clear from the vegetation survey of Gowlaun Bog that there is very little ARB habitat present on the high bog, even in areas some distance from high bog drains. This would suggest the hydrology has been significantly affected by factors other than high bog drainage. Changes to flow patterns or slopes arising from subsidence due to peat-cutting and drainage are likely to have a significant impact on raised bog habitats.

2.3.3.4 Tawnaghbeg Bog

It is evident on Tawnabeg Bog that there is focused flow towards the north-western and south-western margin. Although steeper slopes and focused flow may be natural characteristics of this bog, it is likely that high bog and marginal drainage has resulted in increased slopes and therefore drying out effects on the bog. Changes to flow patterns or slopes arising from subsidence due to peat-cutting and drainage are likely to have a significant impact on raised bog habitats.

2.3.3.5 Kilgarriff Bog

On Kilgarriff Bog, it is evident that there is focused flow towards the northern margin. Although steeper slopes and focused flow may be natural characteristics of this bog, it is likely that they have been impacted to some extent by marginal drainage and turf-cutting. Changes to flow patterns or slopes arising from subsidence due to peat-cutting and drainage are likely to have a significant impact on raised bog habitats.

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

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

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

The transitional areas on the bogs in the River Moy SAC include a range of different habitat types (e.g. cutover bog, river, scrub, deciduous woodland, conifer forestry, flush, reed swamp, wet grassland and improved grassland). The total area of cutover bog is estimated to be approximately 309ha. 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 habitats and vegetation of transitional areas surrounding each of the bogs are described by Kelly *et al.* (1995) (Tawnaghbeg and Derrynabrock) and Derwin & MacGowan (2000) (Kilgarriff, Cloongoonagh, and Gowlaun).

The site-specific target for the attribute transitional areas is: **Restore adequate transitional areas to support / protect the 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 on the bogs in the River Moy SAC is presented in Section 1.3.1 above. The vegetation and habitats of the bog have been described in more detail by Kelly *et al.* (1995), Derwin & MacGowan (2000) and Fernandez *et al.* (2005, 2014a, b, c).

The extent of the different ecotopes that correspond with ARB based on the most recent surveys is presented in Table 4 and on Map 2. Data is only shown for Tawnaghbeg Bog and Derrynabrock Bog in Table 4 as there is a high degree of uncertainty with regards the extent of the different ecotopes present on the other bogs within the SAC due to a lack of recent survey data. It can be seen from Table 4 that the proportion of the high quality ARB ecotopes has remained stable across these two bogs since 2004. The target for this attribute in the SAC is 66.2ha of high quality ARB (50% of ARB target area (132.4ha)).

Table 4 Extent of ecotopes classified as ARB 2004-05 and 2012 on Tawnaghbeg Bog and Derrynabrock Bog (Fernandez *et al.* 2014a, b, c).

Bog Name / Ecotope	2004-05		2012	
	ha	% of total ARB	ha	% of total ARB
Tawnaghbeg Bog				
Sub-central ecotope	7.04	71.3	7.04	71.3
Central ecotope	2.83	28.7	2.83	28.7
Derrynabrock Bog				
Sub-central ecotope	5.01	75.9	5.01	75.9
Central ecotope	1.55	23.5	1.55	23.5
Soaks / active flush	0.04	0.6	0.04	0.6

The site-specific target for the attribute vegetation quality is: **Restore 66.2ha 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.

Well-developed microtopography occurs in the central, sub-central and sub-marginal ecotopes on parts of the bogs in the River Moy SAC (Fernandez *et al.* 2014a, b, c; Derwin & MacGowan 2000; Kelly *et al.* 1995).

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 1.1.1 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.

The distribution of *Sphagnum* species across the bogs within the River Moy cSAC is described by Fernandez *et al.*(2014a, b, c), Derwin & MacGowan (2000), and Kelly *et al.* (1995).

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

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

Species	Ecology	Peat forming capacity
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

The bogs in the River Moy SAC support the full complement of plant species typically associated with a western raised bog (see Table 1 and Section 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 of these species have been reported from the bogs in the River Moy SAC (Kelly *et al.* 1995; Fernandez *et al.* 2014a, b ,c Derwin & 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.

It is likely that most species groups referred to in Section 1.1.3 above occur on the bogs.

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

2.3.10 Elements of local distinctiveness

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

2.3.10.1 Site features

The main feature of interest on the bogs in the River Moy SAC is the fact that these bogs occur at the north-western edge of the geographic range of the habitat in Ireland and therefore support many of the species typical of such western bogs.

2.3.10.2 Rare flora

No rare flora records have been reported from the bogs in the River Moy SAC.

2.3.10.3 Rare fauna

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

Breeding red grouse (*Lagopus lagopus*) have been recorded on bogs within the SAC (Cummins *et al.* 2010), as have breeding curlew (*Numenius arquata*) (NPWS unpublished data).

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

2.3.11 Negative physical indicators

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

Fire has been reported in the past (Douglas & Grogan 1985; Kelly *et al.* 1995) although in more recent times there no evidence of fire events (Fernandez *et al.* 2014a, b, c)

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

2.3.12 Vegetation composition: native negative indicator species

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

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

2.3.13 Vegetation composition: non-native invasive species

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

Pinus contorta seedlings have been reported from Tawnaghbeg Bog (Fernandez *et al.* 2014a, b, c)

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 the bogs in the River Moy SAC 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 the bogs in the River Moy SAC as reported by Henry & Aherne (2014) is 8.5kg N/ha/yr.

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

2.3.15 Water quality

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

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

Hydrochemistry data has only been reported from two of the bogs within the River Moy SAC; Derrynabrock Bog and Tawnaghbeg Bog (Kelly *et al.* 1995).

The hydrochemistry survey at Derrynabrock identified relatively low electrical conductivity (EC) values in drains within the cutover to the south of the bog suggesting little if any mineral ground water influence.

Similarly at Tawnaghbeg Bog, the hydrochemistry survey identified relatively low EC values in drains on the high bog and in drains along the east of the bog. However, more elevated EC values were recorded in the main channels draining the bog suggesting some mineral enriched groundwater influence in these channels (Kelly *et al.* 1995).

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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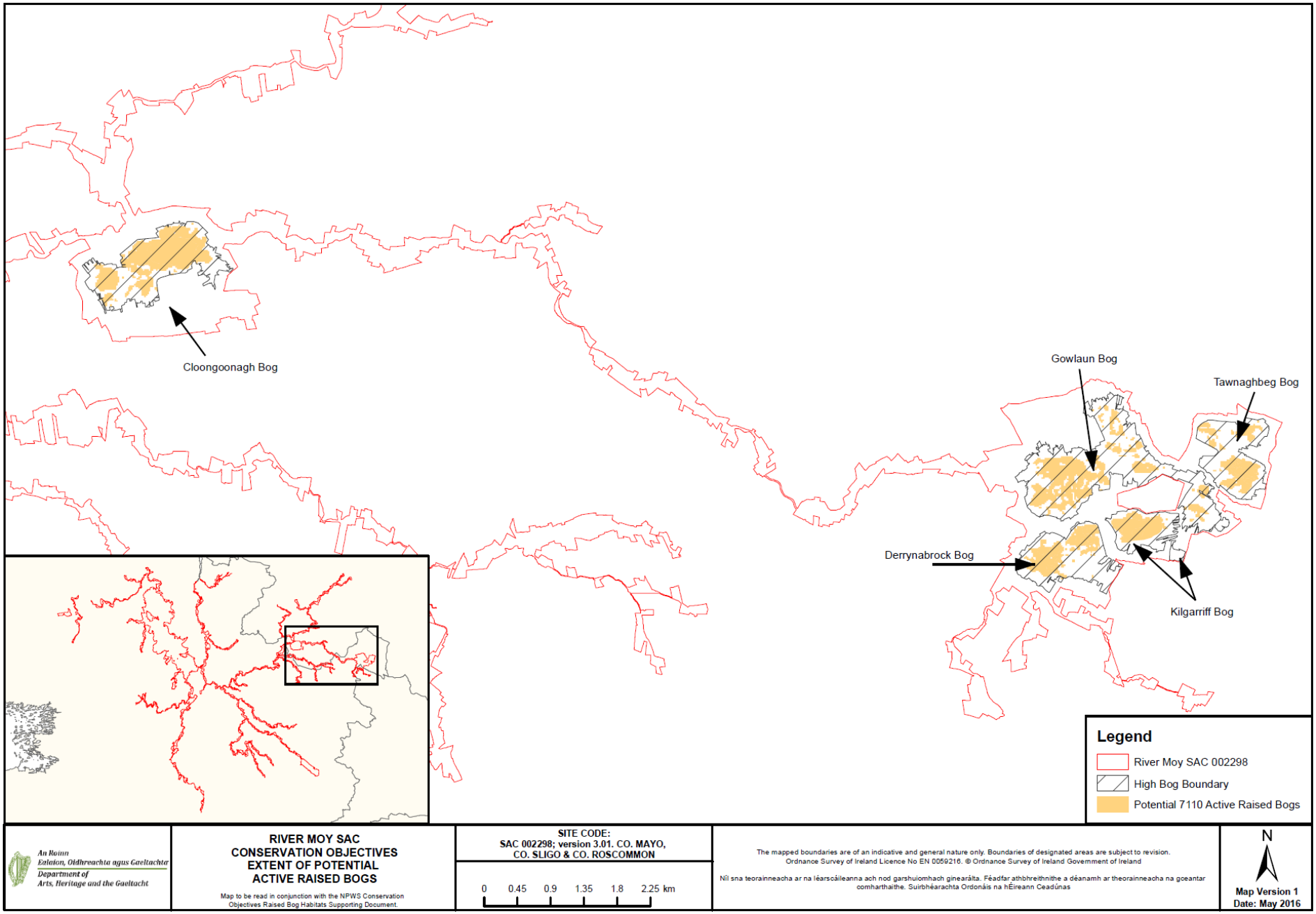
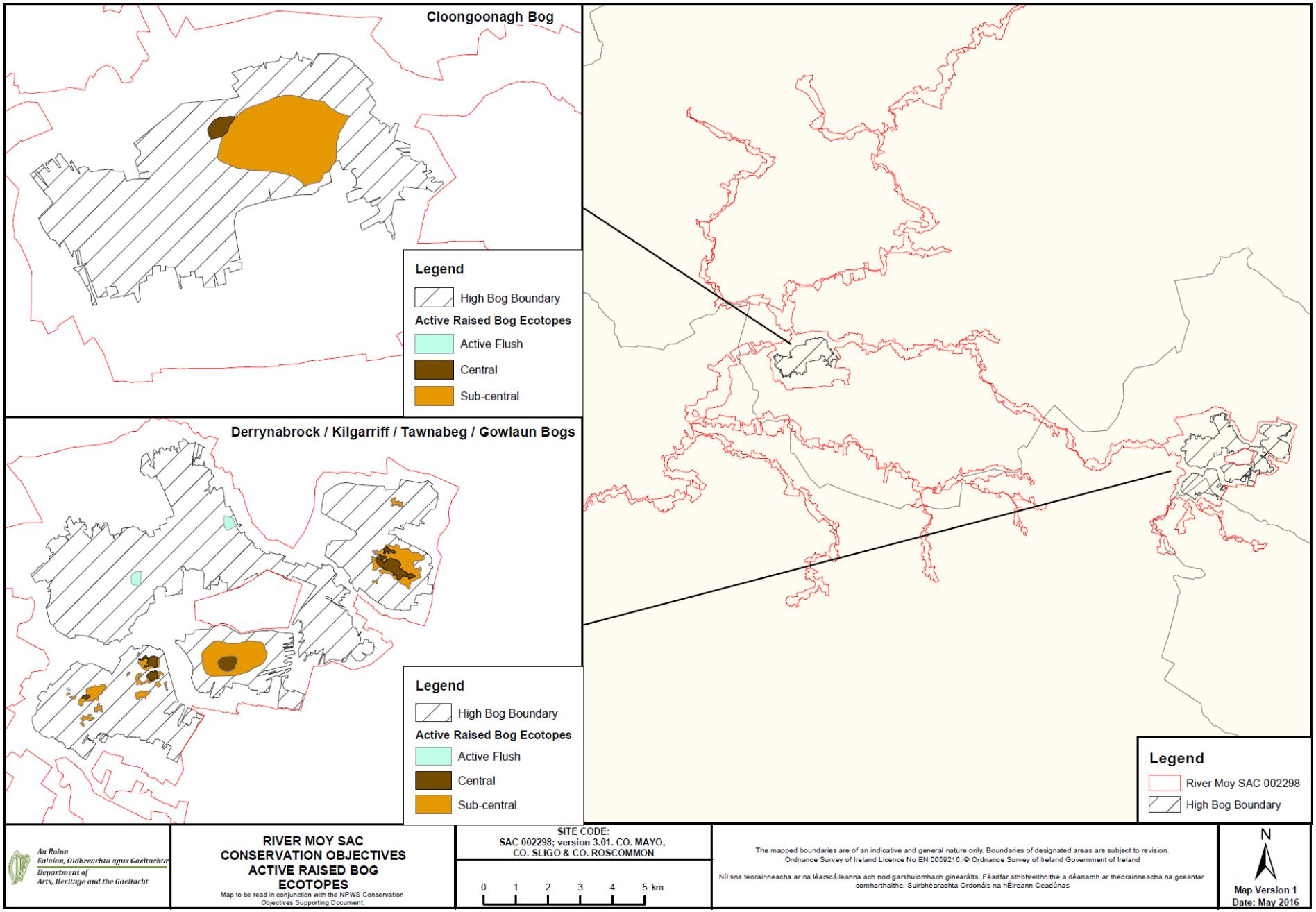
Map 1: Extent of potential active raised bog on the bogs in the River Moy SAC.



Map 2: Distribution of raised bog ecotopes on the bogs in the River Moy SAC.



Map 3: Digital elevation model and drainage patterns on the bogs in the River Moy SAC.