NPWS

The Gearagh SAC

(site code 108)

Conservation objectives supporting document -

Water courses of plain to montane levels with the Ranunculion fluitantis and Callitricho-Batrachion vegetation

and

Rivers with muddy banks with Chenopodion rubri p.p. and Bidention p.p. vegetation

Version 1

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Contents

1. Introduction

1.1 The Gearagh SAC

The Gearagh SAC is an area of woodland, river and reservoir in a wide, flat valley of the River Lee. It is noted for its alluvial and wet woodland within an anastomosing channel and is the only such site remaining in Ireland or Great Britain. The alluvial woodland occurs on islands between the streams. The SAC is selected for four habitats listed on Annex I of the EU Habitats Directive, one of which, alluvial woodland (91E0), is a priority habitat. It is also an SAC for old oak woodlands (91A0), water courses of plain to montane levels with the Ranunculion fluitantis and Callitricho-Batrachion vegetation (3260) and rivers with muddy banks with Chenopodion rubri p.p. and Bidention p.p. vegetation (3270), and for the Annex II species, the otter (*Lutra lutra*).

The Gearagh woodland formerly extended to Lee Bridge, however, the area between that bridge and upstream of Annahala Bridge was felled and subsequently flooded for the River Lee hydro-electric scheme. The scheme was constructed during the period 1952 to 1957 and includes dams at Inishcarra and Carrigadrohid that created reservoirs stretching for approximately 23 km from the Gearagh to Inishcarra.

FitzGerald (1984) provides a useful introduction to the Gearagh and botanical survey of the area, while White (1985a) gives a comprehensive account, including the results of unpublished surveys. Praeger (1907) described the Gearagh as 'a unique and interesting place', but did not provide a detailed botanical account (White, 1985a). O'Reilly (1955) explains that it was the search for an example of a river floodplain hydrosere with climax forest[1] described by Tansley (1939) as theoretically possible but unknown from Britain or Ireland that attracted the 9th International Plant Geography excursion to the Gearagh in 1949. The group visited the area around Annahala Bridge briefly, however, the hydro-electric scheme on the River Lee had been initiated before their results were published (Braun-Blanquet and Tüxen, 1952; Lüdi, 1952). During the construction of the hydro-electric scheme, the Royal Irish Academy, at the instigation of Professor D.A. Webb of Trinity College, Dublin, funded a survey of the Gearagh. The survey took place in January, March and late April to early May 1954 and the botanical data, which largely dated from the April/May visit, are reported in O'Reilly (1955). As a large area of the woodland (between Annahala and Lee Bridges) had been clear-felled before the survey, work concentrated on the area that is wooded today (O'Reilly, 1955). O'Reilly (1955) recorded signs of woodland management, unconnected with the hydro-electric scheme, including selective felling of large oak and ash trees, coppicing of willow and hazel, rough grazing by cattle and tracks/rights-of-way.

O'Reilly (1955) indicated that much of the area downstream of Toon Bridge had been cleared[2]. It appears that this statement was not checked and the scientific community believed the woodland destroyed, until a Young Scientist project by Tim Hickey in 1983 (McGough, 1983; White, 1985a). This revitalised interest in the Gearagh and culminated in a visit by the Irish Biogeographical Society in 1983 (McGough, 1983; FitzGerald, 1984; White, 1985 a and b). White (1985a) described the Gearagh woodland as 'a substantial remnant of the pre-1950 forest, unique floristically, structurally

[1] equivalent to the Continental 'Auenwald' type

[2] O'Reilly mapped the Gearagh (her Fig. 1) dividing it into four sections, A to D. She said 'The latest report from the area gives C and D as completely, and B partially, cleared. A is undisturbed.'

and ecologically in Ireland', with no comparable examples in Great Britain. Accounts remain unclear as to the extent of felling in the 1950s downstream of Toon Bridge, however the orthophotograph from July 1973 shows woodland/scrub covering most of the area from Toon Bridge to the western margin of the reservoir, more or less equivalent to the area that is currently wooded and that illustrated as woodland on the 2nd edition six-inch maps.

1.2 Water courses of plain to montane levels with the Ranunculion fluitantis and Callitricho-Batrachion vegetation (3260)

"Water courses of plain to montane levels with the Ranunculion fluitantis and Callitricho-Batrachion vegetation" (habitat code 3260) is a habitat listed on Annex I of the EU Habitats Directive. The description of the habitat is broad, covering rivers from upland bryophyte and macroalgal dominated stretches, to lowland depositing rivers with pondweeds and starworts (European Commission, 2013; Hatton-Ellis and Grieve, 2003). Selection of Special Areas of Conservation (SACs) for the habitat in Ireland has used this broad interpretation. Thus, it must be recognised that a number of sub-types of this habitat exist in Ireland. As in the UK, it is considered that the habitat as defined is too broad for a single set of conservation guidelines to cover it (Hatton-Ellis and Grieve, 2003). Site-specific conservation objectives for the habitat aim to identify and concentrate upon the high-conservation value sub-types.

Data on the vegetation of the river channels within The Gearagh SAC are limited and, therefore, the distribution of this habitat and the sub-types/communities that occur in the site are currently unknown. The basis for the selection of the SAC for the habitat was records from O'Reilly (1955), surveys by NPWS staff and the Irish Biogeographical Society survey of 1983 (McGough, 1983; FitzGerald, 1984; White, 1985a). While aquatics were not the focus of these surveys, *Callitriche* spp., *Myriophyllum* spp., *Potamogeton* spp., *Ranunculus* cf. *penicillatus* and *Fontinalis antipyretica* were recorded and these taxa are listed as characteristic of the habitat (European Commission, 2013). The conservation importance of The Gearagh SAC streams is attributable to the geomorphology (anastomosing channels) and mosaic of stream, woodland and wetland communities. It is likely that the river and stream channels, which are almost entirely within the woodland, have limited vascular plants and are dominated by bryophytes.

1.3 Rivers with muddy banks with Chenopodion rubri p.p. and Bidention p.p. vegetation (3270)

"Rivers with muddy banks with Chenopodion rubri p.p. and Bidention p.p. vegetation" (habitat code 3270) is a habitat listed on Annex I of the EU Habitats Directive. In Ireland, it is mainly found within turloughs that have areas from which the flood water recedes late and that are prone to summer flooding. In the rest of Europe, the habitat is found on muddy banks of rivers in late-receding river floodplains (European Commission, 2013). The Gearagh SAC is the only known Irish example of Rivers with muddy banks with Chenopodion rubri p.p. and Bidention p.p. vegetation occurring in the floodplain of a 'surface' river. The occurrence of the habitat in some turloughs is perhaps unsurprising when they are considered as the floodplains of underground rivers (Goodwillie, 2007).

Rivers with muddy banks with Chenopodion rubri p.p. and Bidention p.p. vegetation is a dynamic habitat found on damp, fine, mineral soils (typically alluvial muds). Typical species are small, short-lived, fast-growing annuals that are poor competitors. Colonisation of the habitat by perennial

species is prevented by its exposure late in the growing season for a short period. The persistence of the habitat is dependent on a continuous supply of fine sediment.

Little if any grazing is required for habitat 3270 Rivers with muddy banks with Chenopodion rubri p.p. and Bidention p.p. vegetation. It is important that this high conservation value habitat, dominated by rare species, is not confused with the wet annual community of common, 'weedy' species found on damp tracks and trampled/poached mineral soil. Natural disturbance by flooding and sediment deposition is the main ecological driver of habitat 3270.

At low water levels, a diverse ephemeral flora develops on the exposed mud at The Gearagh SAC, most notable among which are extensive swards of Mudwort (*Limosella aquatica*), a rare plant listed in the Red Data Book (Curtis and McGough, 1988) and on the Flora (Protection) Order, 2015. White (1985b) provides a detailed account of the habitat, as recorded at the Gearagh in 1983.

1.4 The relationship between habitats 3260 and 3270 at the Gearagh

Hydrology is a key ecological driver of both habitats (Water courses of plain to montane levels with the Ranunculion fluitantis and Callitricho-Batrachion vegetation (3260) and Rivers with muddy banks with Chenopodion rubri p.p. and Bidention p.p. vegetation (3270)). The co-occurrence of these habitats is to be expected in naturally functioning river systems, however The Gearagh SAC is unique in Ireland in this regard. This is most likely a result of the rarity of alluvial and riparian woodland and the extent of drainage schemes in Ireland. The modern hydrological regime of The Gearagh SAC is not natural, but rather strongly influenced by the operation of the dams at Carrigadrohid and Inishcarra. The full extent of the changes to the hydrological regime of the SAC does not appear to have been documented and it is reasonable to expect that the influence of the hydroelectric scheme is less in the woodland and to the west of the SAC (upstream), where the higher conservation value examples of Water courses of plain to montane levels with the Ranunculion fluitantis and Callitricho-Batrachion vegetation (3260) are expected to occur. Rivers with muddy banks with Chenopodion rubri p.p. and Bidention p.p. vegetation (3270) is associated with the reservoir, to the east of the SAC (downstream) and a significantly modified hydrological regime. Examination of the second edition six-inch maps shows that large and extensive floodplains ('Liable to Flood') naturally occurred along the Lee Valley from Toon Bridge to downstream of Lee Bridge, before the reservoir was created, and it is possible that habitat 3270 was a natural component of parts of the floodplains from which water receded in summer. White (1985b) said 'we cannot rule out the presence of suitable habitats' for *Limosella aquatica* before the flooding in 1954, but also acknowledged the possibility that it was a recent introduction, as did Goodwillie (2007).

1.5 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 (FCS) of those habitats and species at a national level.

Conservation objectives 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/become more refined as further information becomes available.

For attributes in this supporting document, the habitat code is given in parenthesis in the heading indicating whether the attribute applies to Water courses of plain to montane levels with the Ranunculion fluitantis and Callitricho-Batrachion vegetation (habitat code **3260**) and/or to Rivers with muddy banks with Chenopodion rubri p.p. and Bidention p.p. vegetation" (habitat code **3270**) — e.g. "Area (**3260**, **3270**). The targets are also habitat-specific. Colour coding (**3260**, **3270**) is used to aid the reader.

2. Area (3260, 3270)

It is not possible to quantify the area of Water courses of plain to montane levels with the Ranunculion fluitantis and Callitricho-Batrachion (**3260**) vegetation in a site, as rivers are linear features of variable width, along which the habitat varies both spatially and temporally in its extent. Consequently, NPWS generally use length of occupied channel in kilometres as the quantitative measure for habitat area. The anastomosing streams in The Gearagh SAC are not, however, well mapped.

The area of habitat **3270** is expected to vary, naturally, inter-annually, with flooding regime. The timing of observations will also significantly influence measurement of the area of habitat **3270**. McGough (1983) reported that the green sward made up of *Limosella aquatica* and *Elatine hexandra* dominated all of the exposed reservoir bed (several km^2 in extent). FitzGerald (1984) estimated that c. 40 ha of mud were exposed in summer 1983 covered with habitat **3270**. White (1985b) refers to *Limosella aquatica* growing in 'great profusion', with 'millions' of plants 'over many hectares'.

The **target** for habitat area for Water courses of plain to montane levels with the Ranunculion fluitantis and Callitricho-Batrachion vegetation (**3260**) and Rivers with muddy banks with Chenopodion rubri p.p. and Bidention p.p. vegetation (**3270**) is: stable or increasing, subject to natural processes.

3. Range (3260, 3270)

The distribution of both habitats, particularly of **3260**, is poorly understood. Potential distributions of habitats **3260** and **3270** in The Gearagh SAC are shown in Appendices 1 and 2.

The **target** for the habitat distribution attribute for Water courses of plain to montane levels with the Ranunculion fluitantis and Callitricho-Batrachion vegetation (**3260**) and Rivers with muddy banks with Chenopodion rubri p.p. and Bidention p.p. vegetation (**3270**) is: no decline, subject to natural processes.

4. Structure and functions (3260, 3270)

Structure and functions relates to the physical components of a habitat ("structure") and the ecological processes that drive it ("functions"). For Water courses of plain to montane levels with the Ranunculion fluitantis and Callitricho-Batrachion vegetation (**3260**) and Rivers with muddy banks with Chenopodion rubri p.p. and Bidention p.p. vegetation (**3270**) these include attributes such as hydrology, soils and various water quality attributes.

4.1 Hydrological regime (3260, 3270)

Hydrology is a key ecological driver of both habitats. The different communities, assemblages and species are affected by various hydrological attributes.

River flow is often the most important hydrological attribute for habitat **3260** (see section 4.1.1 below), however other attributes, including those described for **3270**, may also be relevant. White (1985a) said the bases of trees at the Gearagh are subject to submergence, based on the bryophytes that are characteristic of flooding, such as *Leskea polycarpa*. A frequent feature of accounts of the Gearagh is commentary on the inaccessibility of the woodland owing to flooding, including by O'Reilly (1955), before the dams were constructed for the hydro-electric scheme. Consequently, the ecology of the streams and habitat **3260** at The Gearagh SAC may be strongly influenced by flooding regime.

Rivers with muddy banks with Chenopodion rubri p.p. and Bidention p.p. vegetation (**3270**) is flooded for an extended period of time each year, becoming exposed late in summer. The flood water supplies fine sediment that is also essential to the habitat's persistence, and wave action may be important in maintaining bare mud through erosion, re-suspension and deposition of sediment within the basin. The soils of habitat **3270** usually remain saturated for a significant period of time after becoming exposed, through a combination of local water table level and the water retention capacity/permeability of the soils (NPWS, 2013).

As discussed in section 1.4 above, the hydrological regime of The Gearagh SAC has been significantly modified by the hydro-electric scheme. It is most modified to the east of the SAC where the reservoir replaced anastomosing channels interspersed with native woodland. FitzGerald (1984) noted that the low water levels of summer 1983 left areas of felled and drowned woodland and the former anastomosing channels exposed. To the west of the SAC, however, woodland and anastomosing streams persist and the degree of hydrological modification is uncertain. Consequently, it appears that habitat **3260** in the SAC is dependent on a regime more representative of the natural hydrology of the system, whereas habitat **3270** appears to be highly dependent on the modified hydrology of the reservoir.

4.1.1 Hydrological regime: River flow (3260)

Owing to regular disturbance (through variations in flow), river macrophytes rarely reach a climax condition, but frequently occur as transient communities. A natural (relatively unmodified) flow regime is required for both plant communities and channel geomorphology to be in favourable condition, exhibiting typical dynamics for the river type (Hatton-Ellis and Grieve, 2003). For many of the sub-types of this habitat, high flows are required to maintain the substratum necessary for the characteristic species (see section 4.6). Flow variation is particularly important, with high and flood flows being critical to the hydromorphology. Other aspects of hydrological regime, such as groundwater discharge and tidal regime are important for certain sub-types of the habitat.

The anastomosing streams of the Gearagh are mostly narrow and their flow was described by Praeger (1907) as 'swift'. O'Reilly's account of gravely stream substratum in the west, moving to silt substratum in the east, suggests faster flow in the west (O'Reilly, 1955).

The **target** for hydrological regime, river flow for Water courses of plain to montane levels with the Ranunculion fluitantis and Callitricho-Batrachion vegetation (**3260**) is: maintain appropriate hydrological regimes necessary to support the typical species and vegetation composition.

4.1.2 Hydrological regime: groundwater contribution (3260, 3270)

The wide flat valley of the River Lee lies on limestone and while the sandstone underlying much of the catchment means surface flows are dominant, an important groundwater contribution cannot be ruled out. More base-rich groundwaters can strongly influence aquatic and wetland vegetation, even where that contribution is small relative to surface waters.

It is essential that the appropriate groundwater contribution necessary for the natural functioning of the habitats be maintained and that there is no significant disturbance of the catchment's groundwater regime.

The **target** for the attribute hydrological regime: groundwater contribution for Water courses of plain to montane levels with the Ranunculion fluitantis and Callitricho-Batrachion vegetation (**3260**) and Rivers with muddy banks with Chenopodion rubri p.p. and Bidention p.p. vegetation (**3270**) is: Maintain appropriate groundwater contribution necessary to support the typical species and vegetation composition.

4.1.3 Hydrological regime: flood duration (3270)

As noted above, the habitat Rivers with muddy banks with Chenopodion rubri p.p. and Bidention p.p. vegetation (**3270**) is flooded for an extended period each year, becoming exposed in summer, and this allows the annual, short-lived species that typify the habitat to grow, while preventing perennial species from completing their lifecycles. Data for habitat **3270** at Coole indicates it is continuously flooded for around 250 days/year (Owen Naughton pers. comm.). Goodwillie (2007) observed that habitat **3270** does not need to dry out every year.

As discussed in section 1.4 above, it is possible that the habitat existed at the Gearagh prior to the hydro-electric scheme, on floodplains from which water receded in summer. The occurrence of the habitat in the SAC is now, however, dependent on the operation of the hydro-electric scheme. Goodwillie (2007) said that the Gearagh does not dry out every year. As a pioneer habitat, **3270** does not require flood duration and timing of recession to be consistent among years. The characteristic species have seed dormancy and will rapidly colonise exposed mud when available at the correct time of the year (see White, 1985b). The correct 'muddy' conditions must occur with sufficient frequency to ensure all of the recorded typical species of **3270** can persist at The Gearagh SAC.

The **target** for the attribute hydrological regime, flood duration for Rivers with muddy banks with Chenopodion rubri p.p. and Bidention p.p. vegetation (**3270**) is: Maintain appropriate hydrological regime necessary to support the typical species and vegetation composition.

4.1.4 Hydrological regime: flood frequency (3270)

The habitat Rivers with muddy banks with Chenopodion rubri p.p. and Bidention p.p. vegetation (**3270**) must flood at least once per year, however it is likely that a second, summer flood is required

at lower frequency (perhaps once every five years) in order to exclude perennials (NPWS, 2013). Alternatively, persistent, year-round flooding every few years could prevent the establishment of perennials. Habitat 3270 at The Gearagh SAC is an example of the latter situation, remaining permanently flooded in some years (Goodwillie, 2007).

The **target** for the attribute hydrological regime, flood frequency for Rivers with muddy banks with Chenopodion rubri p.p. and Bidention p.p. vegetation (3270) is: Maintain natural annual temporal patterns in flood frequency necessary to support the typical species and vegetation composition.

4.1.5 Hydrological regime: flood area and depth (3270)

The area of flooding and the extent of the mud exposed by the draw-down determine the area of habitat 3270. The depth of water level fluctuations (likely to be from 2 m up to 6 m plus) and average water depth during flooding may be significant factors in limiting the colonisation of the habitat by perennial species (NPWS, 2013).

Both the area of mud exposed in summer and the flood depth in other seasons are likely to vary among years at The Gearagh SAC, with the operation of the hydro-electric scheme.

The **target** for the attribute hydrological regime, flood area and depth for Rivers with muddy banks with Chenopodion rubri p.p. and Bidention p.p. vegetation (3270) is: Maintain temporal and spatial patterns in flood area and depth necessary to support the typical species and vegetation composition.

4.2 Substratum (3260, 3270)

The size and distribution of substratum particles in rivers is largely determined by the flow. Different habitat 3260 sub-types and species have different substratum requirements. O'Reilly (1955) said that the streams at the Gearagh at the western extent (areas mapped as 'A' and 'B' [currently woodland] had a gravel ('pebble') substratum composed of Old Red Sandstone, but the substratum became more silty as the streams moved eastwards (through 'C' and 'D' [now reservoir]) towards Annahala Bridge. She said that where the streams had soft, shifting beds there was no vegetation, in other areas the stream vegetation was 'extremely luxuriant' (O'Reilly, 1955).

Rivers with muddy banks with Chenopodion rubri p.p. and Bidention p.p. vegetation (3270) is found on damp, fine, mineral soils (typically alluvial muds). When floodwaters recede, fertile, bare mud is exposed and rapidly colonised (NPWS, 2013). The on-going development of the habitat depends on a continuous supply of fine sediment, which may be derived from an external source and delivered through surface water (or groundwater in turloughs), or an internal supply resulting from natural sediment dynamics within the water body. The soils of habitat 3270 usually remain saturated for a significant period of time after exposure, allowing the characteristic species to become established, but can dry out showing superficial cracking in late summer/autumn. Moisture is retained in the soils through a combination of local water table level and the water retention capacity/permeability of the soils.

White (1985b) says the swards of *Limosella aquatica* and *Elatine hexandra* found at the Gearagh occurred on both fine sand substratum and mud. The *Polygonum* spp.-dominated community of the

upper levels were on stony or sandy substrates, probably indicative of wave action along the shoreline.

The **target** for the attribute substratum for Water courses of plain to montane levels with the Ranunculion fluitantis and Callitricho-Batrachion vegetation (**3260**) and Rivers with muddy banks with Chenopodion rubri p.p. and Bidention p.p. vegetation (**3270**) is: Maintain variety and extent of substratum necessary to support the typical species and vegetation composition.

4.3 Soil/substratum nutrient status (3270)

Rivers with muddy banks with Chenopodion rubri p.p. and Bidention p.p. vegetation (**3270**) appears to be associated with relatively fertile soils/substratum and Goodwillie (2007) says the vegetation requires 'nutrient-rich soils'.

The **target** for the attribute soil nutrient status for Rivers with muddy banks with Chenopodion rubri p.p. and Bidention p.p. vegetation is (**3270**): Maintain nutrient status (phosphorus and nitrogen concentrations) necessary to support the typical species and vegetation composition.

4.4 Physical structure: Bare ground (3270)

Bare ground occurs at The Gearagh SAC in draw-down areas within the reservoir. Bare ground is important for habitat **3270**, as it is dominated by short-lived annuals, including the rare *Limosella aquatica*. It may also be important for invertebrate communities.

The **target** for the attribute Physical structure, bare ground for Rivers with muddy banks with Chenopodion rubri p.p. and Bidention p.p. vegetation (**3270**) is: Maintain sufficient wet bare ground to support the typical species and vegetation composition.

4.5 Water quality (3260, 3270)

For habitat **3260**, water quality should reach a minimum of Water Framework Directive (WFD) good status, in terms of nutrient and oxygenation standards, and EQRs (Ecological Quality Ratios) for macroinvertebrates and phytobenthos. For certain sub-types of habitat **3260**, high status may be required, and/or other aspects of water quality, such as suspended sediment and minerals, should be considered.

Habitat **3270** appears to tolerate, and may even in places require, enriched water (Goodwillie, 2007; NPWS, 2013).

The water quality attributes below are based on elements/metrics used under the WFD, or other water quality legislation and guidance.

4.5.1 Water quality: nutrients (3260, 3270)

Habitat **3260** requires relatively low nutrient concentrations and WFD good status, or for more sensitive elements, high status, standards and targets may be applied. Phosphorus (MRP) is typically the limiting nutrient in rivers, however increased nitrogen (NO_3^-) may negatively impacts upon some aquatic plant communities. Nutrient enrichment leads to increased filamentous-green-algal biomass,

and consequent changes in other algae, bryophyte and macrophyte species composition and abundance. Standards for total ammonia and molybdate reactive phosphorus in rivers were established by Schedule Five of the European Communities Environmental Objectives (Surface Water) Regulations (S.I. 272 of 2009). Mean annual total ammonia must be ≤ 0.040 mg/l N for high status and ≤ 0.065 mg/l N for good status, and the annual 95th percentile must be ≤ 0.090 mg/l N (high) and ≤ 0.140 mg/l N (good). Mean molybdate reactive phosphorus must be ≤ 25 µg/l P (high) or ≤ 35 µg/l P (good) and the annual 95th percentile must be ≤ 45 µg/l P (high) and ≤ 75 µg/l P (good).

The River Lee water quality monitoring station at Dromcarra Bridge, upstream of The Gearagh SAC, passed the general physico-chemical standards in 2010-2012 (Bradley *et al*., 2015).

Goodwillie (2007) said that habitat **3270** can be associated with high nutrient concentrations in water, which may supply nutrients to the substratum, and he suggests that eutrophication may favour the habitat.

Carrigadrohid Reservoir had moderate nutrient status in the period 2010–2012 (Bradley *et al*., 2015). Nutrient enrichment of the reservoir may be an ecological driver of habitat **3270** at The Gearagh SAC.

The **target** for the attribute water quality, nutrients for Water courses of plain to montane levels with the Ranunculion fluitantis and Callitricho-Batrachion vegetation (**3260**) and Rivers with muddy banks with Chenopodion rubri p.p. and Bidention p.p. vegetation (**3270**) is: Maintain the concentration of nutrients in the water column necessary to support the typical species and vegetation composition.

4.5.2 Water quality: biological indicators (3260)

In Ireland, an aquatic macroinvertebrate indicator metric ('the Q-value system') has been used by the EPA to monitor river water quality since the 1970s. This method detects impacts from organic pollution and other enrichment, has been 'intercalibrated' for WFD purposes and provides key information for determining the WFD status of a river water body. Schedule Five of the European Communities Environmental Objectives (Surface Water) Regulations (S.I. 272 of 2009) defines high status as a Q value of Q5 or Q4-5 (EQR of 0.85 or higher) and good status as Q4 (EQR of 0.75). Q values of Q4-5, high status, have been recorded by the EPA on most monitoring occasions since 1990 at Cooncaum Bridge on the Toon River, upstream of the SAC. Dromcarra Bridge on the River Lee, upstream of The Gearagh SAC, has been monitored since 1971. It has also achieved high status on most occasions (Q5 in most of the earlier monitoring periods and Q4-5 more recently (2011 and 2014)), but declined to Q4 for the period 1999 to 2008.

The biological status of rivers can also be determined by macrophytes, phytobenthos, and fish. EQRs have been set for phytobenthos status in Schedule Five of the European Communities Environmental Objectives (Surface Water) Regulations (S.I. 272 of 2009). The fish metric is not considered relevant to the river habitat at this time.

The **target** for the attribute water quality, nutrients for Water courses of plain to montane levels with the Ranunculion fluitantis and Callitricho-Batrachion vegetation (**3260**) is: Maintain good or high biological status, as necessary to support the typical species and vegetation composition.

4.5.3 Water quality: phytoplankton biomass (3270)

Nutrient enrichment (with phosphorus and/or nitrogen) commonly promotes phytoplankton growth in standing waters leading to reduced light penetration and shading of submerged vegetation. This shading may be important in preventing colonisation by submerged perennials and maintaining the bare mud substratum required by habitat **3270**. Phytoplankton biomass is commonly measured as chlorophyll *a*. Schedule Five of the European Communities Environmental Objectives (Surface Waters) Regulations (S.I. 272 of 2009) establishes the criteria for calculating lake status using chlorophyll *a* and the WFD aims to achieve at least good status for all waters. Carrigadrohid Reservoir had moderate chlorophyll *a* status in the period 2010-2012 (Bradley *et al*., 2015) and was mesotrophic in 2007-2009 (McGarrigle *et al*., 2010) and 2004-2006 (Clabby *et al*., 2008), so that the phytoplankton biomass may be an ecological driver of habitat **3270** at The Gearagh SAC. As well as limiting submerged aquatic vegetation through shading, deposition of phytoplankton (and of filamentous algae) on the exposed substratum during draw-down may be an important mechanism for transferring nutrients from the water column to the substratum.

The **target** for the attribute water quality, phytoplankton biomass for Rivers with muddy banks with Chenopodion rubri p.p. and Bidention p.p. vegetation (**3270**) is: Maintain the phytoplankton biomass necessary to support the typical species and vegetation composition.

4.6 Typical species (3260, 3270)

The sub-types of habitat **3260** are poorly understood and their typical species have not yet been fully defined. The typical species may include higher plants, bryophytes, macroalgae and microalgae, and invertebrates.

There has been limited recording of the aquatic species of the Gearagh's anastomosing streams. Within the shade of the woodland, macrophytes may largely be excluded and the stream communities may be dominated by bryophytes. White (1985a) provided a floristic inventory based on a variety of accounts, but unfortunately excluded aquatics. He says 'Where the channels are sufficiently wide so that they are not entirely overhung by trees several aquatic species grow' (White, 1985a). His list does, however, provide a useful account of the wetland species that might be expected along the margins of the streams and indicates the importance of bryophytes.

The true aquatics reported by Irish Biogeographical excursion appear to have been associated with the reservoir, downstream of the woodland (McGough, 1983; FitzGerald, 1984). McGough (1983) recorded *Elodea canadensis, Potamogeton gramineus*, *P. berchtoldii*, *P. perfoliatus*, *P. praelongus* and *P. natans* in channels and pools remaining within the exposed area of reservoir. FitzGerald (1984) said that these pondweeds were 'stranded' in the former anastomosing channels, exposed as a result of the low water levels in summer 1983. O'Reilly (1955) recorded *Myriophyllum* sp., *Callitriche stagnalis*, *C. intermedia*, *Apium inundatum*, *Persicaria amphibia*, *Potamogeton natans*, *Juncus bulbosus* var. *fluitans*, and ?*Nuphar lutea* in streams at the Gearagh.

Aquatic and marginal (e.g. stream-edge) bryophytes recorded at the Gearagh include *Brachythecium rivulare, Calliergon cordifolium, Climacium dendroides, Conocephalum conicum, Fissidens taxifolius* var. *taxifolius, Fontinalis antipyretica, Hygroamblystegium* (*Amblystegium*) *tenax, Kindbergia* (*Eurhynchium*) *praelonga, Leskea polycarpa, Marchantia polymorpha, Pellia epiphylla, Plagiomnium*

rostratum, Rhizomnium punctatum, and *Sciuro-hypnum* (*Brachythecium*) *plumosum* (White, 1985a). None of these are threatened (red-listed) bryophytes (see Lockhart *et al*., 2012 a and b).

Table 1 lists the typical plant species of Rivers with muddy banks with Chenopodion rubri p.p. and Bidention p.p. vegetation (**3270**) (NPWS, 2013). Other species associated with habitat **3270** include *Atriplex prostrata*, *Gnaphalium uliginosum*, *Rorippa palustris*, *Persicaria hydropiper*, *Chenopodium rubrum*, *Juncus bufonius* and *Bidens tripartita*.

No specific linkages have yet been made between invertebrates and habitat **3270** Rivers with muddy banks with Chenopodion rubri p.p. and Bidention p.p. vegetation. The habitat may be used by terrestrial wetland invertebrates when dry.

Table 1 The typical plant species of Chenopodion rubri p.p. and Bidention p.p. vegetation (**3270**)

Angiosperms:
Dicots: *Callitriche palustris*, *Limosella aquatica*, *Persicaria minor*, *Rorippa islandica*
Monocots: *Alopecurus aequalis*, *Eleocharis acicularis*
Bryophytes:
Liverworts: *Riccia cavernosa*

Habitat **3270** Rivers with muddy banks *with Chenopodion rubri p.p. and Bidention p*.p. vegetation is characterised at The Gearagh SAC by extensive swards of the rare and protected species *Limosella aquatica* (McGough, 1983; FitzGerald, 1984; White, 1985b). The species was first recorded at the Gearagh in 1976 when a single plant was found with a pondweed (McMillan, 1977). White (1985b) gives a comprehensive account of the **3270** vegetation growing on the exposed mud, based on ten relevés. He described the communities as ephemeral, growing 'for some undetermined period during the summer when lowered water levels permit'. The vegetation was dominated by annuals, with perennials, other than *Littorella uniflora*, sparse where they occurred and *Juncus bulbosus* behaving as an annual (based on its morphology) (White, 1985b). White (1985b) recorded the following species in three or more of the ten relevés: *Agrostis stolonifera, Alisma plantago-aquatica, Bidens tripartita†, Elatine hexandra, Gnaphalium uliginosum†, Juncus bufonius†, J. bulbosus, Limosella aquatica** (relatively high cover abundance in most relevés), *Lythrum portula, Persicaria hydropiper†*, *Persicaria lapathifolia, Persicaria minor*, Plantago major, Polygonum aviculare, P. persicaria, Littorella uniflora* and *Rorippa palustris†* (* indicates typical 3270 species, † indicates associated species). He lists another 14 species that occurred in one or two relevés: *Anagallis tenella, Apium inundatum, Botrydium granulatum, Callitriche* sp*., Equisetum arvense, Galium palustre, Isolepis setacea, Poa annua, Potamogeton natans, Potentilla anserina, P. reptans, Riccia cavernosa*, Rumex crispus* and *Spergula arvensis* (White, 1985b). Goodwille (2007) noted that the habitat at The Gearagh SAC differed from the turlough examples of **3270** in having common *Bidens tripartita*, and *Elatine hexandra* and *Limosella aquatica.*

White (1985b) said the *Limosella-Elatine* sward, with other species of moist, intermittently available habitats, was widespread on the remnants of the islands that would have been wooded before the reservoir was created. *Limosella* covered up to 60% in places and plants were typically 4-6 cm tall and flowering profusely (White, 1985b). A 'notable variant' of the *Limosella-Elatine* sward was found

in a dried-out pool (relevé 4) which had 'small discs of *Riccia crystallina*' (now *Riccia cavernosa*) and 'numerous blobs' of the alga *Botrydium granulatum* (White, 1985b).

White (1985b) discusses the biological features of mud floras and concludes 'one may expect fluctuations in both absolute and relative abundances of species and in floristic composition of the mud flora of The Gearagh reservoir from year to year'.

An Irish Field Club Union excursion to the Gearagh in 1907 collected invertebrates, but there are no records for rare or threatened species, or evidence for a characteristic fauna (Balfour Browne, 1907; Stelfox and Milne, 1907). Further investigation is required of the aquatic and wetland invertebrates of the woodland and streams and of habitat **3270** at The Gearagh SAC.

The **target** for the attribute typical species for Water courses of plain to montane levels with the Ranunculion fluitantis and Callitricho-Batrachion vegetation (**3260**) and Rivers with muddy banks with Chenopodion rubri p.p. and Bidention p.p. vegetation (**3270**) is: Maintain typical species in good condition, including appropriate distribution and abundance.

4.7 Vegetation composition: vegetation zonation (3260, 3270)

The phytosociology and characteristic vegetation patterns of habitat **3260** in Ireland are poorly understood. Hatton-Ellis and Grieve (2003) describe the typical river communities for the UK, however not all of these occur in Ireland. They say "More than many other habitats, river plant communities are in constant flux, with physical disturbance resulting in short-term interactions, and cycles (see Haslam 1978 for several examples). These seasonal and successional effects often mask wider-scale ecological patterns and make reliable identification of distinct communities difficult" (Hatton-Ellis and Grieve, 2003). Rivers are often characterised by vegetation patches with few- or single-species that are largely determined by the flow and morphological conditions. Longitudinal vegetation patterns may be evident at scales such as reaches, over tens, hundreds or even thousands of metres. River vegetation may also show lateral zonation: gradation from fully submerged, to emergent to fringing communities. Marginal communities frequently have ecological drivers that are not related to the river, e.g. grazing or other land management, or may not be characteristic of rivers, being found in many 'damp' situations.

The natural transition from submerged river vegetation through marginal communities to woodland within The Gearagh SAC is unknown from elsewhere in Ireland and absent from Great Britain, is one of the most important features of this SAC.

The vegetation community of Rivers with muddy banks with Chenopodion rubri p.p. and Bidention p.p. vegetation **3270** is composed of small, short-lived, fast-growing annuals that are poor competitors and includes a number of rare species (see typical species, section 4.6 above). In conducting the conservation assessment, Goodwillie (2007) examined the phytosociological context of the habitat and concluded the following: "Schaminée *et al* 1998 divide the ***Bidention tripartitae*** in the Netherlands into the ***Polygono-Bidentetum*** (3-110 days of inundation), the ***Chenopodietum rubri*** (50-250 days) and the ***Eleocharito acicularis – Limoselletum*** (130-300). This system has definite parallels in Ireland. All three communities may be recognized in turloughs and at the Gearagh . . . ".

The Biogeographical Society field excursion recorded distinct zonation amongst the mud colonising (3270) species (McGough, 1983; FitzGerald, 1984; White, 1985b). McGough (1983) described the lowest points in the exposed reservoir bed as having pools and channels with *Elodea canadensis* and pondweeds including *Potamogeton gramineus*, *P. berchtoldii*, *P. perfoliatus*, *P. praelongus* and *P. natans*; most of the exposed bed was dominated by *Limosella aquatica* and *Elatine hexandra*; and 'an interesting community of *Polygonum* species' occurred 'at the normal reservoir high water line'. FitzGerald (1984) further described the 'normal shoreline' community as having abundant '*Polygonum'* species (many now in the genus *Persicaria*), particularly *Persicaria minor*, with *Bidens tripartita* and *Rorippa palustris*. She also said that *Littorella uniflora* occupied the intermediate zone, while the lower muds were covered with 'green swards' of *Limosella aquatica*, with 'undergrowth' of *Elatine hexandra*. *Gnaphalium uliginosum* occurred in all mud zones (FitzGerald, 1984). White (1985b) provides the most detailed account of the vegetation changes gradually from the *Limosella aquatica* – *Elatine hexandra* dominated swards that characterised extensive areas of the exposed reservoir (relevés 1 and 2), becoming 'progressively augmented by further species (relevés 3, 4 and 5), changing in floristic composition and structure as one moves up-slope (relevés 6-10). The upper levels (relevés 9 and 10) were 'dominated by no fewer than five species of *Polygonum'*, with *Limosella* persisting but with much less vigorous growth and *Elatine* and *Lythrum* all but disappearing. White (1985b) refers the *Limosella aquatica* – *Elatine hexandra* dominated sward (relevés 1-5) to the *Elatino-Limoselletum* association (*nom. nov*. for Irish vicariant of *Cypero-Limoselletum*) and the *Polygonum* species dominated shoreline (relevés 7-10) to the *Bidentiti-Polygonetum hydropiperis* association. This was the first record for the former association, whilst the latter association was previously known 'only in fragmentary form in turloughs in the Burren' (White, 1985b).

The **target** for the attribute vegetation composition, vegetation zonation for Water courses of plain to montane levels with the Ranunculion fluitantis and Callitricho-Batrachion vegetation (3260) and Rivers with muddy banks with Chenopodion rubri p.p. and Bidention p.p. vegetation (3270) is: Maintain the vegetation zonation/mosaic characteristic of the site.

4.8 Fringing habitats (3260, 3270)

For many modern Irish rivers, much of the lateral connectivity is lost and there is a relatively sharp transition to terrestrial communities, with or without some emergent vegetation. The Gearagh SAC represents a more natural situation, with submerged aquatic communities intergrading with emergent and marsh communities, wet and dry woodland communities and wet and dry grassland communities.

River and stream channels in The Gearagh SAC are fringed by woodland that has been described in O'Reilly (1955), McGough (1983), FitzGerald (1984), White (1985a), Perrin *et al*. (2008a, b and c), Perrin and Daly (2010) and O'Neill and Barron (2013). White (1985a) provides a detailed account of species recorded within the woodland, excluding 'typical aquatic plants'. The SAC has been designated to protect two Annex I woodland habitats: Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (Alno-Padion, Alnion incanae, Salicion albae) (91E0) and Old sessile oak woods with *Ilex* and *Blechnum* in the British Isles (91A0). Protection of the woodland and other habitats and communities that fringe the anastomosing streams is essential to the structure, functioning and

conservation importance of habitat **3260** at the Gearagh. See also site-specific conservation objectives for habitats 91A0 and 91E0.

O'Reilly (1955) recorded the following species along the stream edges within the Gearagh woodland: *Caltha palustris, Dryopteris ameula, Mentha aquatica, Osmunda regalis* and *Salix cinerea* subsp. *oleifolia*. She noted oak trees arching over streams in places and said '*Mentha aquatica* and *Caltha palustris* locally abundant where debris accumulation raised mud over the average water level' (O'Reilly, 1955). She recorded *Apium inundatum, Persicaria amphibia*, and *Equisetum hyemale*, which may also have been associated with streams (O'Reilly, 1955). Tim Hickey recorded *Equisetum hyemale* (near Toon Bridge), but it wasn't found during the Biogeographical Society excursion (McGough, 1983). McGough (1983) described *Oenanthe crocata* as abundant, especially near the channel margins. White (1985a) lists species typical of wetter parts of the woodland and notes that *Oenanthe crocata* and *Osmunda regalis* as conspicuous at the margins of many islands.

These fringing habitats are also likely to be important for invertebrates, including as feeding or mating habitat, and as pupation sites.

While the relationship between fringing habitats and habitat **3270** Rivers with muddy banks with Chenopodion rubri p.p. and Bidention p.p. vegetation, has not yet been established, it is likely that any terrestrial invertebrates associated with the habitat in late summer are reliant on fringing habitat for over-wintering.

The **target** for the attribute fringing habitats for Water courses of plain to montane levels with the Ranunculion fluitantis and Callitricho-Batrachion vegetation (**3260**) and Rivers with muddy banks with Chenopodion rubri p.p. and Bidention p.p. vegetation (**3270**) is: Maintain marginal fringing habitats that support the typical species and vegetation composition.

4.9 Floodplain connectivity (3260, 3270)

River connectivity with the floodplain is important for the functioning of both habitats. Channels with a naturally functioning floodplain are better able to maintain habitat and water quality (Hatton-Ellis and Grieve, 2003). Floodplain connectivity is particularly important in terms of sediment sorting and nutrient deposition. High-conservation-value rivers are intimately connected to floodplain habitats and function as important wildlife corridors, connecting otherwise isolated or fragmented habitats in the wider countryside (Hatton-Ellis and Grieve, 2003; Mainstone *et al*., 2016).

As detailed above in sections 1.4 and 4.1, the hydrological regime of The Gearagh SAC is modified by the hydro-electric scheme. Some natural floodplain connectivity appears to be associated with the anastomosing streams within the woodland and, hence, is likely to be important to habitat **3260** at The Gearagh SAC. Habitat **3270**, by contrast, may have been found in the Lee floodplain before the hydro-electric scheme, but is now associated with the flood-/draw-down- zone for the reservoir.

The **target** for floodplain connectivity for Water courses of plain to montane levels with the Ranunculion fluitantis and Callitricho-Batrachion vegetation (**3260**) and Rivers with muddy banks with Chenopodion rubri p.p. and Bidention p.p. vegetation (**3270**) is: Maintain floodplain connectivity at and upstream of the habitats necessary to support the typical species and vegetation composition.

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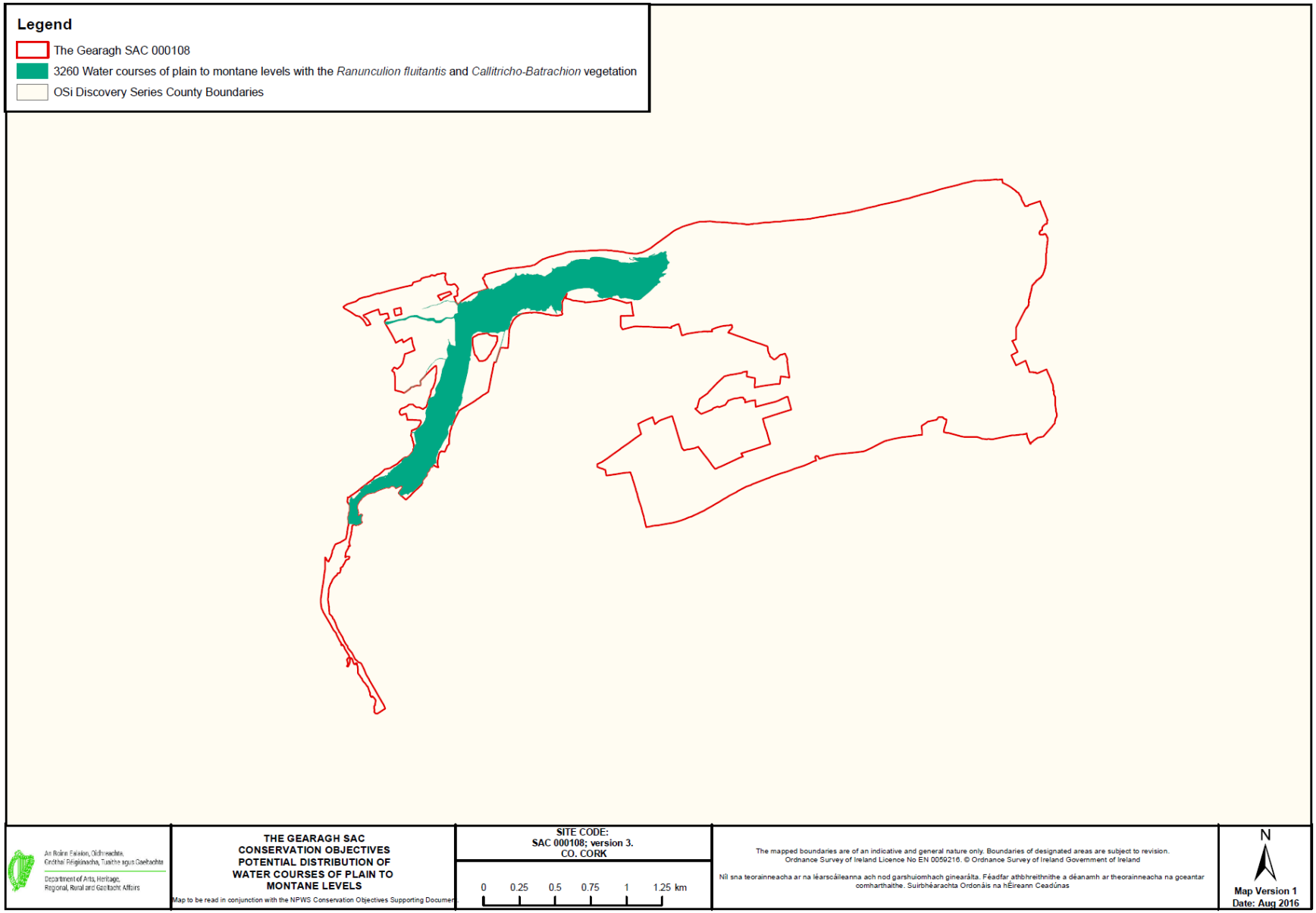
Appendix 1 Map of potential distribution of Water courses of plain to montane levels with the Ranunculion fluitantis and Callitricho-Batrachion vegetation (3260) at The Gearagh SAC



Appendix 2 Map of potential distribution of Rivers with muddy banks with *Chenopodion rubri* p.p. and *Bidention* p.p. vegetation (3270) at The Gearagh SAC