

NPWS

Killarney National Park, Macgillicuddy's
Reeks and Caragh River Catchment SAC
(site code 000365)

**Conservation objectives supporting document-
Najas flexilis (Willd.) Rostk. & W.L.E. Schmidt**

Version 1

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Please note that this document should be read in conjunction with the following report: NPWS (2017) Conservation Objectives: Killarney National Park, Macgillycuddy's Reeks and Caragh River Catchment SAC 000365. Version 1.0. National Parks and Wildlife Service, Department of Arts, Culture and the Gaeltacht.

1. Introduction

1.1 *Najas flexilis*

Najas flexilis (Willd.) Rostk. & Schmidt (EU Habitat Directive species code 1833) is a small, annual, submerged macrophyte of freshwater lakes that is listed on Annexes II and IV of the Habitats Directive. In Ireland, the species is also protected under the Wildlife Acts (1976 and 2000), being listed on the Flora (Protection) Order, 2015 (Statutory Instrument No. 356 of 2015¹). It has been assessed as *Near Threatened* in Ireland and *Vulnerable* in Europe (Wyse Jackson *et al.*, 2016; Bilz *et al.*, 2011).

Globally, *Najas flexilis* (slender naiad) has a somewhat disjunct distribution that can be described as circumboreal (Preston and Croft, 2001). It is much more frequent in North America than in Eurasia (Godwin, 1975; Haynes, 1979; Preston and Croft, 2001). It has a northerly distribution in Europe, extending south to the Alps, but fossil evidence shows it was formerly much more widespread (Godwin, 1975; Preston and Croft, 2001; Wingfield *et al.*, 2004). It is recognised as a rare and declining species in many countries (Preston and Croft, 2001). The core of the species' European range is in Scotland and Ireland (Wingfield *et al.*, 2004, 2005; Roden, 2007).

The species was first recorded in Ireland by Daniel Oliver in Cregduff Lough, Co. Galway in 1850 (*Botanical Gazette*, No. 22, October, 1850) and since then it has been recorded in approximately 65 lakes in counties Donegal, Leitrim, Mayo, Galway and Kerry. Since the review of its distribution in 2013, which considered it likely to be extant in 58 lakes and extinct from three others (NPWS, 2013b; O Connor, 2013), *Najas flexilis* has been found in four additional lakes in Connemara (Roden, 2013; Roden and Murphy, 2014). Roden and Murphy (2014) provided new information indicating that the species has been lost from an additional three lakes and suggesting that records from six may have been erroneous. Currently, therefore, the species is considered extant in approximately 53 lakes. Connemara appears to be the species' Irish stronghold, having records from approximately 36 lakes (see Figure 1).

A fragile, relatively short (rarely >30cm) and permanently submerged species of the lower euphotic depths, the plant is often overlooked (Preston and Croft, 2001; Roden, 2004; Wingfield *et al.*, 2004). *Najas flexilis* is typically found on flat to gently sloping areas of the lake bed with soft substrata of mud, silt or fine sand (Preston and Croft, 2001; Roden, 2002, 2004). It can occur at all depths between 0.5m and 10m, but is frequently associated with the lower depths of macrophyte growth, with scattered plants gradually giving way to bare mud or silt (Preston and Croft, 2001; Roden, 2002). The well-documented patchy distribution of the species within lakes is considered to be primarily determined by wave action, sediment type and competition; the first two being closely interlinked (Roden, 2004, 2007; Wingfield *et al.*, 2004). Unsurprisingly for an annual species, *Najas flexilis* is an early coloniser and a relatively poor competitor and, therefore, may be associated with naturally disturbed conditions (Wingfield *et al.*, 2004).

Najas flexilis is usually found in clear-water, lowland lakes (Preston and Croft, 2001). It shows a clear association with mixed geology, typically having peatland dominated catchments with some base-rich bedrock (basalt, limestone, marble or sedimentary deposits) or calcareous sand (Preston and

¹ This updates S.I. 94 of 1999, through amendments to the listed bryophytes

Croft, 2001; Roden, 2004; Wingfield *et al.*, 2004). Catchment geology may influence the distribution of the species through substratum type, as well as through nutrient and mineral chemistry. Roden (2004) noted that the species does not prosper in Old Red Sandstone catchments, possibly owing to the coarser sands that form the lake substratum in these areas.

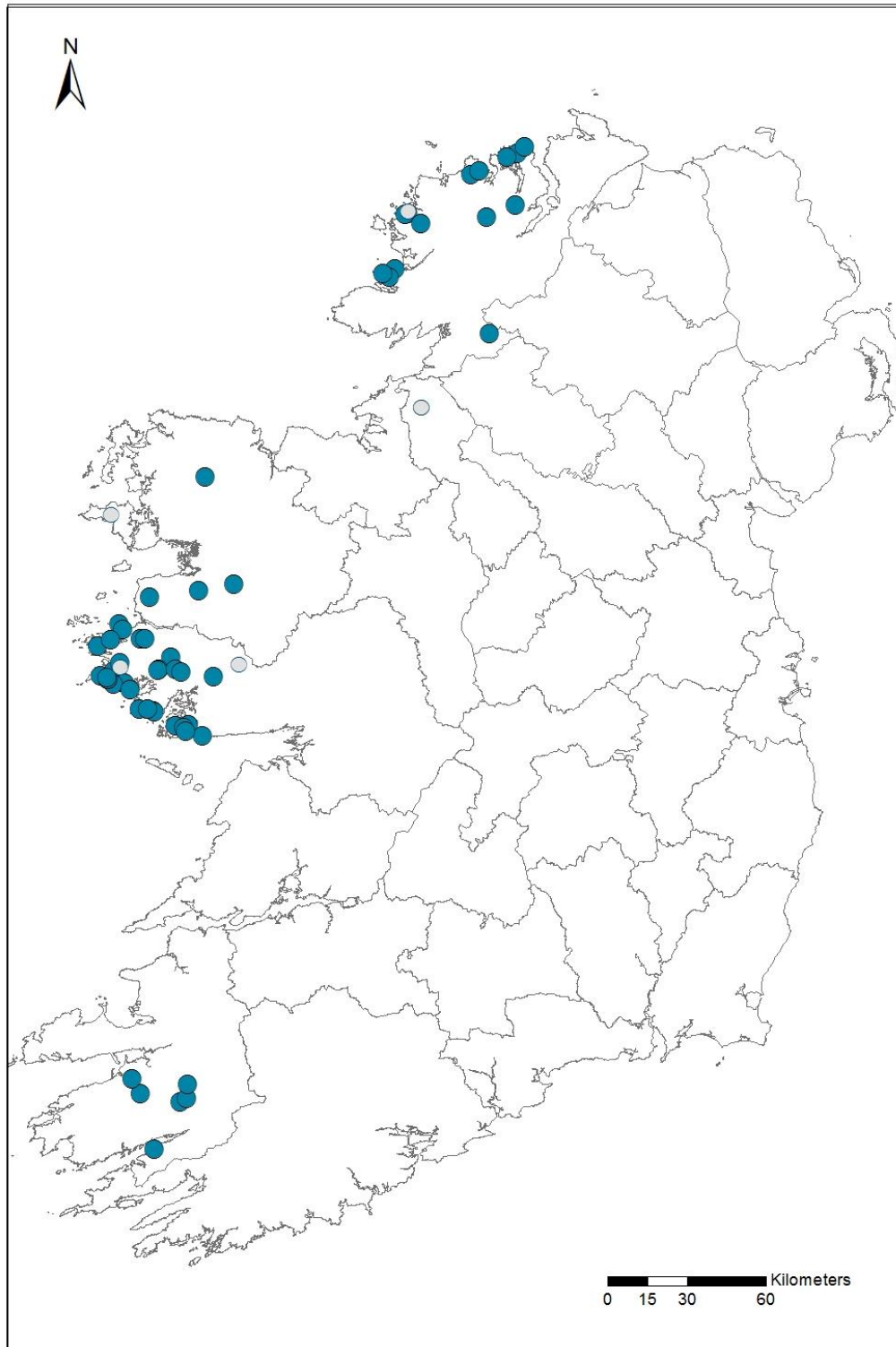


Figure 1. The distribution of *Najas flexilis* in Ireland. Based on lake centroids for 53 lakes considered to hold extant populations of the species (solid blue discs) and six lakes where it is considered extinct (light grey discs).

Najas flexilis is not found in marl or other hard water lakes (EU Habitats Directive, Annex I habitat code 3140) (Roden, 2007). Neither does *Najas flexilis* occur in dystrophic, peaty lakes (Roden, 2002). In Ireland, *Najas flexilis* appears to be associated with the Habitats Directive Annex I habitat 3130 (Oligotrophic to mesotrophic standing waters with vegetation of the Littorelletea uniflorae and/or Isoëto-Nanojuncetea) (O Connor, 2015).

Roden (2004) noted the frequent co-occurrence of *Potamogeton perfoliatus* and *Isoetes lacustris* in *Najas flexilis* lakes, which is indicative of the mixed geological conditions favoured by the latter species (the pondweed being common in hard water lakes; the quillwort is characteristic of soft-water, oligotrophic lakes). N.F. Stewart (pers. comm.) has noted its common association with *Nitella confervacea*. Roden (2004) described two distinct groups of associated species in Irish *Najas flexilis* lakes; the first group included *Callitriche hermaphroditica*, several *Chara* species and broad-leaved pondweeds (*Potamogeton* spp.). A similar list of associated species was noted by Preston and Croft (2001) and in lake Groups 2, 3 and 4 of Wingfield *et al.* (2004). The second group of associated species identified by Dr Cilian Roden included *Elatine hexandra* and *Nitella translucens* (Roden, 2004). Wingfield *et al.* (2004) Group 1 lakes appear to have similar associated species. In some Irish lakes, both groups of associated species occurred and these accounted for the most species-rich *Najas flexilis* lakes, having a number of species that are rare or scarce along the west coast of Ireland (e.g. Ballynakill Lough, which is also home to *Hydrilla verticillata*) (Roden, 2004). *Hydrilla verticillata* is known only from two Irish lakes, both of which also contain *Najas flexilis* (Roden, 2007). Roden and Murphy (2014) re-examined relevé data for Ireland and identified four groups: group 1 was shallow water with *Chara virgata*; groups 2 and 3 were more species-rich and differentiated, in part, by *Elatine hexandra*, *Nitella translucens* and *Hydrilla verticillata* and group 4 had low species richness, low *Najas flexilis* abundance and was found in deeper water.

Eutrophication is considered a significant pressure on the species, which grows at the lower levels of the euphotic zone and can easily be out-competed by perennials such as pondweeds (*Potamogeton* spp.) and 'shaded' by abundant phytoplankton (Preston and Croft, 2001; Roden, 2004, 2007; Wingfield *et al.*, 2004; Roden and Murphy, 2014). Acidification is also considered to be a threat to the species (Roden, 2004; Wingfield *et al.*, 2004).

In Ireland, *Najas flexilis* is considered to be in poor/inadequate conservation status as a result of eutrophication and impacts linked to peatland damage (Roden, 2007; NPWS, 2008; O Connor, 2013). Diffuse losses from agriculture and domestic wastewater systems (septic tanks) and point sources from urban wastewater treatment plants are considered the principal sources of nutrients in *Najas flexilis* catchments (O Connor, 2013).

1.2 Killarney National Park, Macgillycuddy's Reeks and Caragh River Catchment SAC

Killarney National Park, Macgillycuddy's Reeks and Caragh River Catchment SAC is a very large SAC that extends from the mountains west of Millstreet in Cork to Waterville on the western coast of the Iveragh Peninsula in Kerry. The SAC includes the lakes and woodlands of Killarney, large areas of peatland and extensive uplands. Upland areas include Macgillycuddy's Reeks, with Carrauntoohil, the highest peak in Ireland at 1,040m, Mullaghanattin, Broaghbabinnia, Purple and Tomies Mountains, Mangerton and the Paps. The SAC is selected for 14 habitats listed in Annex I of the Habitats Directive, including lake habitats 3110 and 3130. It is also selected for 12 Annex II species, including *Margaritifera margaritifera* (freshwater pearl mussel) and *Najas flexilis*. The SAC contains a

large number of lakes at a wide range of altitudes. Upland lakes and ponds, including corrie lakes, are frequent and are typically highly oligotrophic in nature. These are likely to be dominated by lake habitat 3110; however, lake habitat 3160 may also occur (see O Connor, 2015). Larger low-lying lakes are also oligotrophic, but can have some base-rich influences (e.g. Lough Leane, where limestone outcrops) and higher species richness, and lake habitat 3130 can also occur.

Records for *Najas flexilis* exist for seven lakes in the SAC: Acoose, Adoolig, Caragh, Leane, Muckcross, Upper Lake and The Long Range. Roden and Murphy (2014) considered the status of the species at two of these lakes, Adoolig and Muckcross, uncertain and rejected the previous records. Each lake is dealt with below, chronologically by date of first record.

Caragh – On the 18th of September 1877, A.G. More recorded *Najas flexilis* in Lough Caragh, at the south-east corner of the lake close to “the reed beds which surround the mouth of the river Caragh”. This was the second Irish locality for the species. He reported “while dragging in Lough Caragh for a fishing-rod which had been dropped overboard the previous evening, I brought up, together with a large mass of *Chara flexilis*, some bright green fragments, and on close examination I was much pleased to recognise them as *Naias flexilis*, Rostk,.” (More, 1877).

R.W. Scully recorded the species at More’s location in 1906 (“Still there in two or three spots, in water six feet and deeper”) and “In the south-west corner of Caragh Lake, Glencar, 1896-1906” (Scully, 1916). A 1906 specimen for Lough Caragh was lodged at the British Museum by F.J. Hanbury. The next record was in 1977 (09/10/1977) by H. Heuff and J. Ryan for the western shore (relevé 44) of Lough Caragh, in the bay just north-east of Lough Beg. In 1994, Lady R. FitzGerald, P. Foley and C.D. Preston recorded *Najas flexilis* at three locations at the south end of Lough Caragh, but did not find it along the western shoreline (FitzGerald and Preston, 1994). “The large beds each side of the river influx” corresponded to More’s and Scully’s locations (FitzGerald and Preston, 1994). Their third location, “in bay SE of Sugarloaf Island”, was new. On 17/08/2000, R.A. Wingfield recorded the species at V717905 (i.e. near the H. Heuff and J. Ryan record) (Wingfield *et al.*, 2004). Environmental Protection Agency (EPA) biologists, G. Free and R. Caroni, recorded it on 14/08/2002, again at the south-west corner of the lake. C. Roden found it in this same general area on the 31/08/2004 (see Appendix II). EPA biologists (unnamed) recorded it again in 2011 at three positions on two transects: transect 3 - a new location on the eastern shore; and transect 4 - again in the south-western corner.

Lough Leane - *Najas flexilis* was first recorded in 1886 in Lough Leane, “along the northern edge of the extreme west point of Ross Island”, by the Revs E.F. and W.R. Linton (Linton, 1886). In July and August 1887, R.W. Scully recorded the species at several locations in Lough Leane: 1) to the south-east of Castlough Bay near Muckcross House (he stayed at the Muckcross Hotel, Cloghereen and travelled by boat from the hotel’s boathouse, finding *Najas flexilis* “in the bay just outside our starting-point”); 2) several spots along the south side of Ross Bay (which he equated to the Lintons’ location); and 3) in Victoria Bay (Scully, 1888). In his Flora of County Kerry, Scully (1916) says “Still in Ross Bay and in several other localities in the Lower Lake, Killarney, as in Victoria Bay, in a sandy bay south-east of Ross Island, abundant in a boggy bay outside the Muckcross Hotel boat-house and sparingly in the boat-harbour adjoining: *R.W.S. 1888*, and in 1907.” Other late nineteenth/early twentieth centuries records for Lough Leane include: H. and J. Groves, 1892 (herbarium specimen at Museum of Wales); Rev. E.S. Marshall, 1902 (specimen at Cambridge); F.J. Hanbury, 1906 (specimen at the British Museum); N.D. Simpson, 1935 (specimen at the British Museum). A specimen at the National Botanic Gardens (DBN, Glasnevin) was provided by Mrs A. Casement, who noted collecting

it at Bog Bay on 28/10/1976 on peaty substratum (V965867). FitzGerald and Preston (1994) recorded *Najas flexilis* at three locations in Lough Leane on 27/07/1994: Ross Bay ('Linton's 1886 site'); 'Bay SE of Ross Island' from Scully (1888); and 'Small bay NE of Governor's Rock'. On the 29/07/1994 they also found it 'Between Mahony's Point and Killenalougha' along the north shore of Lough Leane (just west of Victoria Bay).

Upper Lake – the first record for *Najas flexilis* at the Upper Lake was by F.J. Hanbury and R.W. Scully in 1906. The record is reported in Scully (1916) as district II "south of Roynane's Island, 1906—locality extending into VI." Mrs A. Casement provided a specimen to DBN, Glasnevin for the Upper Lake on 28/10/1976 for 'Tower Bay' (V925825) (the grid reference corresponds to Newfoundland Bay, near the 'Tower Lodge'). It is not clear whether this material was from a drift specimen or taken from the substratum. FitzGerald and Preston (1994) recorded *Najas flexilis* at two locations ("S. of Ronayne's Island. V897915½" and "ESE of Duck Island. V897½814"), "both within the area of Hanbury and Scully's 1906 record". Roden and Murphy (2014) found a localised population of *Najas flexilis* on the 04/09/2014 between Roynane's Island and Duck Island (i.e. corresponding to the localities reported in 1906 and 1994).

Acoose – G. Visser and J.A. Zoer recorded *Najas flexilis* in Lough Acoose on 28/07/1971 (Visser and Zoer, 1972, 1976). They found the species at V754848, near the southern end of the lake. Lady R. FitzGerald and P. Foley recorded *Najas flexilis* at the north-east of Lough Acoose on 08/09/1994. C. Roden also found *Najas flexilis* at the north-east corner of Lough Acoose on 31/08/2004 (see Appendix II). EPA biologists (unnamed) recorded it again in 2011 at three positions on transect 3 towards the south-west of the lake. An 1899 record for Acoose attributed to R.W. Scully on an NPWS database, appears to have been an error and does not appear in Scully (1916).

Adoolig – T. Curtis recorded *Najas flexilis* from a drift specimen at Lough Adoolig. The date of this record is uncertain, but appears to be August 1985. It was searched for on 26/10/1995 by Clare Byrne (in very poor weather conditions) but not found. Roden and Murphy (2014) surveyed the western part of Adoolig on 13/08/2014 and did not find the species, concluding "Vegetation suggests an environment too oligotrophic for large populations of *Najas*". They suggested removing Adoolig from the list of *Najas flexilis* lakes, pending further investigation. Roden and Murphy (2014) highlighted the importance of Lough Adoolig for rare charophytes.

Muckross - A single record for Muckross Lake exists, made by E.C. Mhic Daeid (01/08/1976). It has been suggested by Roden and Murphy (2014) that the specimen was "drift material from the abundant populations in Leane and The Long Range" or that intermittent populations establish in Muckross Lake from these local sources. It is also possible that this record was incorrectly assigned to Muckross Lake and that the plant was found in Lough Leane. Muckross House adjoins both lakes and the bay of Leane adjacent to Muckross House is a well-known site for the species. Roden and Murphy (2014) noted that records listed by R.W. Scully have been incorrectly assigned to the boathouse of Muckross House in Muckross Lake, when they were made by the boathouse of Muckross Hotel in Lough Leane.

The Long Range – *Najas flexilis* was first recorded from The Long Range by Lady R. FitzGerald and C.D. Preston on 26/07/1994 (FitzGerald and Preston, 1994). The material was trawled up "during a hurried boat journey" and time did not allow for the location of the population to be pin-pointed.

Roden and Murphy (2014) recorded a very large population at the north-eastern end of The Long Range on 05/09/2014.

1.3 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 are defined using attributes and targets that are based on parameters as set out in the Habitats Directive for defining favourable status, namely population, range, and habitat for the species.

Note that the attributes and targets may change/become more refined as further information becomes available.

2. Population

There are significant issues with quantifying *Najas flexilis* populations (see below). *Najas flexilis* is abundant in Lough Caragh, Lough Leane and The Long Range (Roden, 2004, 2007; Roden and Murphy, 2014). The distribution of records indicates that the species is widespread in Loughs Leane and Caragh, respectively the largest and third largest lakes in the SAC. It is widespread in The Long Range. The population is widespread but small at Acoose. The Upper Lake appears to hold a small, isolated but persistent population.

Roden (2004) noted that the population in Lough Caragh is very large and dense, and in places *Najas flexilis* is the dominant species (see Appendix II). He described a scattered population of more than 100 plants in Lough Acoose (Roden, 2004) (see Appendix II). Roden (2004) recorded a cover abundance score of '4' in 1m x 1m relevés in Lough Caragh and '1' in Acoose. In 2011, EPA biologists recorded it as 'Rare', 'Occasional' and 'Frequent' in Caragh and 'Rare' and 'Occasional' in Acoose, using the 'DAFOR' scale. Roden and Murphy (2014) noted over 1,000 plants in The Long Range with cover abundance exceeding 50% in places. Further information on population size and density may be available in the sources listed in Section 1.2. Roden (2007) considered Lough Caragh to support a 'Very Large' population, Leane to support a 'Large' population and Acoose to support a 'Small' population, on his five point scale from 'Very Large' to 'Extinct'; however, he acknowledged that these were subjective categories and that it is very difficult to estimate population size or propose any robust or repeatable abundance estimate for the species. Wingfield *et al.* (2004) also said that accurately measuring plant abundance to assess the condition of the population in deep water communities is extremely difficult.

The problems with estimating the population size of *Najas flexilis* at lake and national scale are discussed in O Connor (2013), and include:

1. *Najas flexilis* is difficult to survey as it grows under water at depths of up to 10m. It is often commonest and most abundant in the lower depths of the euphotic zones, where it is most difficult to survey (Roden, 2002)

2. Counting the number of individuals can only be done by snorkelling or scuba diving
3. It is generally only possible to sub-sample a population using snorkelling or scuba diving
4. The potential habitat in a lake is difficult to quantify, particularly in the absence of bathymetric data and substratum characterisation
5. The density of the plant is likely to vary within a lake², depending on factors from substratum particle size and geochemistry, to light penetration, to wave exposure and competition from other macrophytes, epiphyton or phytoplankton
6. There is a limited season for the survey of this annual species. Seedlings have been noted to begin to germinate in Scotland in June (Wingfield *et al.*, 2004) and the plant can survive until October; however, August is generally cited as the time to survey (of the 277 records on the NPWS *Najas flexilis* database for which a month is provided, 98 were made in August and 129 in July (see O Connor, 2013))
7. The plant is fragile and easily uprooted by storm events, so the density can vary within a single growing season
8. Added to that is the evidence that inter-annual fluctuations in population size occur naturally, as well as driven by anthropogenic pressures, and are linked to factors such as seed-germination (Roden, 2007)

As a result, it is likely to be impossible to make statistically robust estimates of the number of mature individuals for a population of *Najas flexilis*. This means that using estimates of the number of mature individuals is not an appropriate method for assessing changes in the condition of *Najas flexilis* populations.

Surveying for *Najas flexilis* is challenging, given that it lives fully submerged (no floating or emergent leaves or flowers). Snorkelling is considered the best method for estimating the cover abundance of the species (Roden, 2007; Wingfield *et al.*, 2004) and is the method recommended by NPWS. The issues associated with, and lower reliability of, shoreline and boat surveys are documented by O Connor (2013).

Further research is required to develop detailed methods, attributes and targets for *Najas flexilis* populations. The objectives below may, therefore, be subject to change in the future.

2.1 Population extent

While the spatial extent of *Najas flexilis* within a lake may be subject to some temporal/inter-annual variations, in viable populations it should not change significantly over time. Replacement of *Najas flexilis* with other rooted macrophytes (e.g. *Potamogeton* spp. or *Elodea canadensis*) would indicate a decline in the *Najas flexilis* population. Both the area and the spatial distribution of the population should be considered. The full extent of *Najas flexilis* in the lakes in the SAC has not been mapped; however, data indicate that it is widespread in Acoose, Caragh, Leane, and The Long Range, but more localised in the Upper Lake.

² Roden (2002) noted that the plant can occur both as scattered individuals and as dense stands.

The target for population extent is: Maintain the spatial extent of *Najas flexilis* within the lakes, subject to natural processes.

2.2 Population depth

Najas flexilis can occur at all depths between 0.5m and 10m, but is frequently associated with the lower depths of macrophyte growth, with scattered plants gradually giving way to bare mud or silt (Preston and Croft, 2001; Roden, 2002). Roden (2007) highlighted that depths between 1m and 5m are particularly important for the species. Data from individual records demonstrate that the plant occurred at depths of 2–5m in Acoose, 1.8–6m in Caragh and from 3m to at least 4m in the Upper Lake (see sources listed in Section 1.2). Roden and Murphy (2014) recorded *Najas flexilis* between 2–3.5m in The Long Range. There are few data on the depth distribution in Lough Leane, other than R.W. Scully's observation that his first record was for it "growing in great luxuriance in about six feet of water" (Scully, 1888). A number of anthropogenic impacts can affect light penetration and lead to decreases in the depths to which *Najas flexilis* can grow. These impacts include increasing phytoplankton biomass, water colour or turbidity. Changes to water level fluctuations as a result of abstractions or drainage can also affect *Najas flexilis* growth in more shallow water, owing to exposure and increased wave action. Consequently, the full depth range (i.e. minimum/most shallow to maximum/deepest) of the *Najas flexilis* population should be considered.

The target for population depth is: Maintain the depth range of *Najas flexilis* within the lakes, subject to natural processes.

2.3 Population viability

Wingfield *et al.* (2004) used certain traits (leaf area/shoot length x reproductive number/shoot length) to assess plant fitness and indicated a score of less than one would give rise to concern. The use of plant traits to assess population fitness is recommended for *Najas flexilis* monitoring programmes. Measurement of traits can be done in the field, e.g. presence of flowers/seeds on plants, or by removing specimens, e.g. leaf area, shoot length and number of reproductive structures (Wingfield *et al.*, 2004; Benthic Solutions, 2007). Note that *Najas flexilis* is protected under the Flora (Protection) Order, 2015 and a Section 21 licence is required to collect specimens of all or part of a plant, as well as to alter or interfere with its habitat. Plant fitness is an indicator of the viability of the population. Seed production in *Najas flexilis* appears to be reduced by both eutrophication and acidification (Wingfield *et al.*, 2004).

The target for population viability is: Maintain the fitness of *Najas flexilis*, subject to natural processes.

2.4 Population abundance

As noted above, it is extremely difficult, if not impossible, to get reliable, repeatable estimates of *Najas flexilis* population size. It is, however, desirable to record an estimate of the species cover abundance at all sites. Use of the DAFOR or similar categorical scale for recording the cover per square metre is advisable. Cover abundance is likely to vary within a lake, with depth, substratum and exposure. It may also vary inter-annually. Sustained, significant declines in the cover abundance of *Najas flexilis*, however, would indicate a population decline. Changes in cover abundance over time should be monitored at a number of stations, covering a range of natural abundances, within each lake.

The target for population abundance is: Maintain the cover abundance of *Najas flexilis*, subject to natural processes.

3. Range

The known distribution of *Najas flexilis* in Killarney National Park, Macgillycuddy's Reeks and Caragh River Catchment SAC is shown in Appendix I. The species is known from Acoose, Caragh, Leane, Upper Lake and The Long Range in the SAC. As noted in Section 2, *Najas flexilis* is very widespread in these lakes, notably Leane, Caragh, The Long Range and Acoose. The species may be even more widespread in the SAC. While records for Muckross Lake and Lough Adoolig have been rejected (Roden and Murphy, 2014), the possibility that the species may occur in these or other lakes, including as small, isolated and/or intermittent populations, cannot be entirely ruled out.

The target for the attribute species distribution is: maintain current range, subject to natural processes.

4. Habitat for the species

Habitat for the species relates to the area and quality of the available habitat for the species. For freshwater species in Ireland, however, the area of the habitat is generally an insensitive measure of its conservation condition. In general, *Najas flexilis* habitat is more likely to be damaged rather than destroyed/lost. While lakes can be reduced in area by drainage or, for small and shallow lakes, by processes of natural succession, the most common impacts in Irish *Najas flexilis* lakes are nutrient enrichment and peat staining/deposition. As a result, most of the objectives detailed below relate to the quality of the species' habitat and include attributes such as hydrology and water quality.

4.1 Habitat extent

It is acknowledged that it is likely to be difficult to map and measure the area of *Najas flexilis* habitat in a lake. Both the lake area and the area of available habitat for the species within that lake should be considered. Further survey is required to document the extent of *Najas flexilis* and its habitat in the lakes in this SAC, but as noted above, the habitat appears to be widespread and cover a relatively large area of Leane, Caragh, The Long Range and Acoose. While the available habitat appears to be limited in the Upper Lake (Roden and Murphy, 2014), further investigation is advisable.

The target for the attribute habitat extent is: Maintain the habitat for *Najas flexilis*, subject to natural processes.

4.2 Hydrological regime

Fluctuations in lake water level are almost ubiquitous in Ireland owing to the highly seasonal rainfall patterns. Water level fluctuations can, however, be amplified by a variety of anthropogenic activities including water abstractions, drainage of the lake outflow and drainage of the upstream catchment. Upstream drainage leads to more rapid run-off and is associated with other significant pressures, notably the degradation of peatlands, which causes the release of organic acids, ammonia and other organic matter, and the direct transport of nutrients and other pollutants to lakes.

Increased water level fluctuations can impact on *Najas flexilis*, particularly at the upper depths of growth (see also 2.2 above). The area of lake bed influenced by wave action typically increases and, hence, the substratum can be significantly altered. The results include loss of macrophyte habitat, up-rooting of plants through wave action and contraction of submerged vegetation zones. Increased fluctuations can also lead to nutrient releases from the littoral sediments, as a result of exposure and re-wetting, and consequent changes in species composition. Nutrient release leading to increased phytoplankton biomass, as well as increased wave actions leading to re-suspension of fine sediment, could decrease light penetration and impact on *Najas flexilis* at the lower depths of growth.

The hydrological regime of the lake must be maintained so that the area, distribution and depth of the *Najas flexilis* habitats are not reduced.

The target for the attribute hydrological regime, water level fluctuations is: Maintain appropriate natural hydrological regime necessary to support the habitat for *Najas flexilis*.

4.3 Lake substratum quality

Najas flexilis is typically found on soft substrata of mud, silt or fine sand (Preston and Croft, 2001; Roden, 2002, 2004). An association with relatively organic, flocculent sediment is noted in the UK (Wingfield *et al.*, 2004). The sediment chemistry of *Najas flexilis* lakes is described by Wingfield *et al.* (2004). *Najas flexilis* almost exclusively utilises phosphorus from the sediment; however, enrichment of the sediment appears to lead to declines/losses of the species (Wingfield *et al.*, 2004). Calcium and iron concentrations in the lake sediment are also likely to influence the species distribution. Research is required to further characterise the substratum type (particle size and origin) and substratum quality (notably pH, calcium, iron and nutrient concentrations) favoured by the species in Ireland.

Some specific information on the substratum of Acoose, Caragh, Leane, Upper Lake and The Long Range is available in the sources listed in Section 1.2.

The target for the attribute lake substratum quality is: Maintain appropriate substratum type, extent and chemistry to support the populations of *Najas flexilis*.

4.4 Water quality

Najas flexilis is typically associated with high water quality, i.e. the absence of eutrophication impacts. This is demonstrated by naturally low dissolved nutrients, clear water and low algal growth. Water quality can be measured by the following attributes: nutrient concentrations, phytoplankton biomass, phytoplankton composition, phytobenthos status and macrophyte status. Phytoplankton biomass and composition, phytobenthos status and macrophyte status all demonstrate biological responses to nutrient enrichment.

Significant quantities of data are available on lake water quality (eutrophication) in Ireland from the Environmental Protection Agency (EPA) and Local Authorities; however, these data are classified in accordance with general environmental (water quality) objectives and do not take consideration of the specific requirements of protected species. As a consequence, the attributes (variables/quality elements) or the targets (thresholds/standards) used may be inappropriate for assessing the quality of the habitat for *Najas flexilis*. In particular, it is thought likely that *Najas flexilis* may tolerate or even reach optimal densities in lakes that are above the oligotrophic boundary in terms of dissolved

nutrients. In the absence of species-specific variables and thresholds, however, the targets adopted are 'High Status' or oligotrophic. Hence, the targets may be overly stringent. A schema is presented in Figure 2 below indicating the likely target for *Najas flexilis* within the water quality classification system required by the Water Framework Directive (WFD). The more stringent targets are preferable to adopting the alternative target of the good-moderate (or eutrophic) boundary, as it is clear that *Najas flexilis* can be impacted by eutrophication well below the latter threshold. Also, when one considers that lakes regarded as in reference condition had summer chlorophyll *a* concentrations of c. 4µg/l (Free *et al.*, 2006) and given that *Najas flexilis* was formerly much more widespread in Ireland and Europe (Godwin, 1975), it is reasonable to assume that favourable and viable populations of the species existed in oligotrophic lakes before large-scale anthropogenic land-use change.

Further surveillance of population and habitat condition is necessary to determine whether the WFD quality elements are appropriate measures for the habitat of *Najas flexilis* and whether the WFD boundaries can be used to determine that habitat's condition.

Najas flexilis is usually found in clear-water, lowland lakes (Preston and Croft, 2001). The species has been described by a number of authors as characteristic of 'mesotrophic' lakes (Preston and Croft, 2001; Wingfield *et al.*, 2004, 2005; Roden, 2007). This demonstrates a disparity in the use of the term 'trophic' amongst the fields of ecological science, with botanical and phytosociological scientists using 'mesotrophic' to indicate the species' requirement for plant nutrients generally, whereas freshwater ecologists have a more restrictive definition of trophy, first established by the OECD and based primarily on concentrations of the macronutrient phosphorus in the water column (total phosphorus or TP) and the biomass of single-celled, planktonic algae (chlorophyll *a*) (OECD, 1982). The mesotrophy noted by botanists and phytosociologists reflects a requirement for certain cations, perhaps calcium and magnesium, as evidenced by the species' association with circum-neutral waters, rather than a need for significant concentrations of phosphorus or nitrogen in the lake water. As noted above, the species' association with mixed geology, including some base-enrichment, is well-documented (Preston and Croft, 2001; Roden, 2004; Wingfield *et al.*, 2004). The species, in Ireland at least, appears to be strongly associated with lakes that are naturally oligotrophic, as defined by freshwater ecologists, that is, naturally low in dissolved and particulate forms of phosphorus and nitrogen.

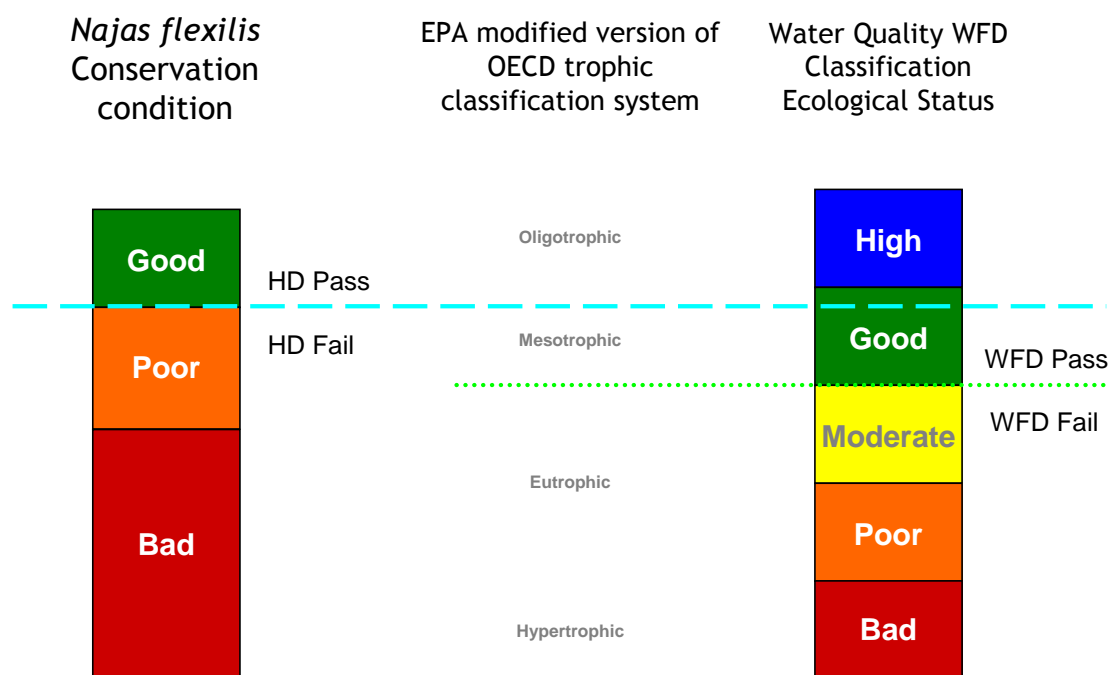


Figure 2. The use of Water Framework Directive (WFD) water quality targets for the habitat of *Najas flexilis*. It is likely that the most appropriate target for *Najas flexilis* water quality lies somewhere below the high-good boundary, within the slightly-mesotrophic band (based on chlorophyll *a* and/or total phosphorus measurements) (indicated by dashed blue line). This target is still significantly higher than the basic WFD pass of the good-moderate boundary (dotted green line); hence, the targets used here are equivalent to high status.

Enrichment of lake water and sediments with phosphorus and nitrogen (eutrophication) is considered a significant pressure on the species (Preston and Croft, 2001; Roden, 2004, 2007; Wingfield *et al.*, 2004). Nutrient enrichment increases primary production in phytoplankton, epiphytic and epipelagic algae and in vascular plants (macrophytes). All of these can compete with *Najas flexilis* for the available resources, notably light, carbon dioxide, nutrients and space/substratum. *Najas flexilis* is generally recognised as a poor competitor (Roden, 2007; Wingfield *et al.*, 2004). As *Najas flexilis* is frequently found at the lower levels of the euphotic zone, “shading” by phytoplankton, taller rooted species or attached algae is a particular problem. Alkalinity, pH, calcium, magnesium and total phosphorus were all significantly higher in seven Scottish lakes from which *Najas flexilis* had been lost, where eutrophication was the suspected cause of the extinction (Wingfield *et al.*, 2004).

The most common nutrient sources documented in the Irish *Najas flexilis* catchments are:

1. Agriculture
2. Domestic wastewaters from on-site systems
3. Discharges from urban wastewater treatment plants

4. Other wastewater discharges
5. Golf courses
6. Forestry

(O Connor, 2013).

4.4.1 Water quality: nutrients

Eutrophication is considered to have a significant negative impact on *Najas flexilis* (Preston and Croft, 2001; Roden, 2004, 2007; Wingfield *et al.*, 2004). As discussed above, in the absence of specific nutrient targets for *Najas flexilis*, the default target used here is oligotrophic or high status for general nutrient conditions.

No standards have yet been set for total phosphorus in Irish lakes; however, the Irish EPA used an interim high status value of annual mean total phosphorus (TP) of less than 10 µg/l for 2007–2009 and 2010–2012 status classification (Tierney *et al.*, 2010; Bradley *et al.*, 2015). This same threshold was used as the oligotrophic lake standard in the Phosphorus Regulations (McGarrigle *et al.*, 2002) and is the boundary used by the OECD system (OECD, 1982). As a result, an annual mean TP of less than 10µg/l is considered necessary for *Najas flexilis* lakes. Where the mean TP concentrations are lower than this standard, there should be no increase in annual mean, i.e. no upward trends.

Total ammonia in *Najas flexilis* lakes should also be in high status as defined by Schedule Five of the European Communities Environmental Objectives (Surface Waters) Regulations (S.I. 272 of 2009), that is, mean annual total ammonia of ≤ 0.040mg/l N or annual 95th percentile of ≤ 0.090mg/l N.

Acoose, Caragh, Leane and Upper Lakes are WFD monitoring lakes. The Upper Lake had high nutrient status, but Acoose, Caragh and Leane failed to reach high nutrient status (all had ‘good’ nutrient status) in the most recent WFD monitoring period, 2010–2012 (Bradley *et al.*, 2015). Only Leane had less than high nutrient status in the 2007–2009 period (Tierney *et al.*, 2010).

The target for the attribute water quality, nutrients is: Maintain/restore average annual TP concentration of ≤10µg/l TP, average annual total ammonia concentration of ≤0.040mg/l N and annual 95th percentile for total ammonia concentration of ≤0.090mg/l N.

4.4.2 Water quality: phytoplankton biomass

Nutrient enrichment (with phosphorus and/or nitrogen) can promote phytoplankton growth leading to shading of *Najas flexilis* and reduced light penetration. 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*. Two sets of thresholds are given, linked to lake types. The thresholds established for the moderate and higher alkalinity types (7, 8, 11 and 12) are considered more appropriate for *Najas flexilis* lakes. The target for *Najas flexilis* lakes is currently considered to be high status or oligotrophic conditions and, therefore, the mean chlorophyll *a* concentration should be less than 5.8µg/l during the growing season (March-October). Where the chlorophyll *a* concentrations are lower than this threshold in a *Najas flexilis* lake, however, there should be no increase in growing season means, i.e. no upward trends.

Caragh, Leane and Upper Lake had high chlorophyll *a* status in both the 2010–2012 and 2007–2009 monitoring periods, but Acoose failed, having moderate chlorophyll *a* status (Tierney *et al.*, 2010; Bradley *et al.*, 2015).

The target for the attribute water quality, phytoplankton biomass is: Maintain/restore average growing season (March–October) chlorophyll *a* concentration of < 5.8µg/l.

4.4.3 Water quality: phytoplankton composition

The EPA has developed a phytoplankton composition metric for nutrient enrichment of Irish lakes. As for the other water quality attributes, the target for phytoplankton composition status is high.

Phytoplankton composition was monitored at Caragh, Leane and Upper Lake in the 2010–2012 period and Caragh and Leane had high status, but the Upper Lake had good status (Bradley *et al.*, 2015).

The target for the attribute water quality, phytoplankton composition is: Maintain/restore high phytoplankton composition status.

4.4.4 Water quality: attached algal biomass

Nutrient enrichment can favour epiphytic (attached to plants) and epipellic (attached to substratum) algal communities that can out-compete *Najas flexilis*. The cover abundance of attached algae should, therefore, be low.

The EPA monitors the phytobenthos status of Irish lakes for Water Framework Directive (WFD) purposes. Phytobenthos status can be used as an indicator of increases in attached algal biomass. As discussed above, in the absence of targets for *Najas flexilis*, the default target used here is high status. Phytobenthos status was high at the Upper Lake in the 2010–2012 period, but only good at Acoose, Caragh and Leane (Bradley *et al.*, 2015).

The target for the attribute water quality, attached algal biomass is: Maintain/restore trace/absent attached algal biomass (< 5% cover) and high phytobenthos status.

4.4.5 Water quality: macrophyte status

Nutrient enrichment can also favour more competitive submerged macrophyte species that can out-compete *Najas flexilis*. The EPA monitors macrophyte status for Water Framework Directive purposes using the 'Free Index'. As discussed above, the default target for *Najas flexilis* adopted here is high status, defined in Schedule Five of the European Communities Environmental Objectives (Surface Waters) Regulations (S.I. 272 of 2009) as having an Ecological Quality Ratio (EQR) of ≤ 0.90.

Macrophyte status was high at Acoose and Upper Lake, but only good at Caragh and Leane in the 2010–2012 monitoring period (Bradley *et al.*, 2015). In the 2007–2009 period, it was high at Acoose, Caragh and Upper, and good at Leane (Tierney *et al.*, 2010).

The target for the attribute water quality, macrophyte status is: Maintain/restore high macrophyte status.

O Connor (2013) used these five indicators ('quality elements') (sections 4.4.1–4.4.5) of water quality to assess the national conservation status of the habitat for *Najas flexilis*. For the habitat quality to be in favourable condition in terms of nutrients and eutrophication, the target was for all five elements to reach high status. This use of a lowest common denominator approach was in keeping with classification under the WFD, which is based on the lowest status classes for a range of specified biological, physico-chemical and hydromorphological quality elements (Tierney *et al.*, 2010).

4.5 Acidification status

Acidification is considered to be a significant threat to *Najas flexilis* (Preston and Croft, 2001; Roden, 2004; Wingfield *et al.*, 2004). Wingfield *et al.* (2004) noted that at pH of less than 7, the abundance of *Najas flexilis* is low. They also documented reduced reproductive capacity in more acidic conditions (pH 6.46–6.98), with seeds low in number or absent (Wingfield *et al.*, 2004). The annual nature of *Najas flexilis* makes it particularly sensitive to environmental change, and year to year fluctuations in pH, alkalinity and calcium could affect seed production, promoting genetic drift and loss of genetic diversity (Wingfield *et al.*, 2004). However, little is known about the seed longevity and if the seedbank is persistent, the species may be able to survive some perturbations. Wingfield *et al.* (2004) observed that pH, conductivity, alkalinity, calcium and potassium were significantly lower in two lakes from which the species appeared to have been lost owing to acidification, while sediment iron was significantly higher (Wingfield *et al.*, 2004). The likely causes of acidification in Irish *Najas flexilis* catchments may include a complex mix of natural, as well as anthropogenic, factors and are discussed in detail in O Connor (2013).

Wingfield *et al.* (2004) considered that *Najas flexilis* has rather specific environmental requirements and occupies a relatively narrow realised niche in Britain and Ireland. The pH of the water ranged from 6.62–8.3 (median of 7.46) and conductivity ranged from 55–447 μ S/cm (median of 235 μ S/cm) at 42 lakes studied (Wingfield *et al.*, 2004). Alkalinity ranged from 6.71–69.71mg/l (median of 23.45mg/l) at 29 lakes, and calcium concentration in the water had a range of 2.06–33.4mg/l (median of 9.59mg/l) at 30 lakes (Wingfield *et al.*, 2004). Alkalinity data are available for 18 *Najas flexilis* lakes from the Irish EPA 2007–2009 water quality report (Tierney *et al.*, 2010) demonstrating a wider range of 2.5–106mg/l, with a median of 13.2mg/l and average of 25mg/l. Summary data are provided in Table 1 for five Donegal lakes (Loughs Akibbon, Anure, Derg, Port and Shannagh), having overall averages of pH 7.12, conductivity of 133.6 μ S/cm and total alkalinity of 24.4mg/l. These are based on data provided by Donegal County Council covering the period 2006–2012. Interestingly, Wingfield *et al.* (2004) found that the calcium concentration of the sediment was a good predictor for the number of reproductive structures, an indicator of plant fitness and population viability.

Median pH values should be greater than 7 pH units. Water and sediment alkalinity and concentrations of cations (notably calcium) should be appropriate to the *Najas flexilis* habitat. Further research is required to establish more specific targets for the species, including study of intra-annual variations. The EPA also classifies Acidification/Alkalisiation status in lakes and uses it in overall Water Framework Directive (WFD) status. In line with the other WFD attributes used, the target for WFD Acidification/Alkalisiation status is high.

The target for the attribute acidification status is: Maintain appropriate water and sediment pH, alkalinity and cation concentrations to support the populations of *Najas flexilis*, subject to natural processes.

Table 1 Physico-chemical data for five *Najas flexilis* Donegal lakes. Data courtesy of Donegal County Council.

Lake	Summary	pH	Conductivity µS/cm	Total Alkalinity mg/l	Total Hardness mg/l	Calcium mg/l
Akibbon	Range	6.39-8.15	90-203	19-60		7.4-23.6
	Median	7.21	138	36		12.3
	Average	7.24	136.0	38.2		12.8
	n	31	31	31		30
Anure	Range	6.89-7.26	86.4-137.2	14-14	16.2-18.1	
	Median	7.17	91.8	14	18.1	
	Average	7.12	101.8	14.0	17.4	
	n	4	4	3	3	
Derg	Range	5.73-7.42	43.2-68.8	1-34		1.3-4.8
	Median	6.57	52	6		1.9
	Average	6.61	53.6	8.4	8.82	2.1
	n	43	43	43	1	30
Port	Range	7.73-7.85	181-359	40-94	50-120.1	
	Median	7.79	184.3	40	52.5	
	Average	7.79	241.4	58.0	74.2	
	n	3	3	3	3	
Shannagh	Range	5.16-8.44	166-265	16-52	50-52.5	
	Median	7.6	205.5	31.5		
	Average	7.5	202.5	31.8	51.3	
	n	44	46	26	2	
Overall	Range	5.16-8.44	43.2-359	1-94	8.8-120.1	1.3-23.6
	Median	7.21	139	28	50	6.1
	Average	7.12	133.6	24.4	42.9	7.5
	n	125	127	106	9	60

4.6 Water quality: colour

Increased water colour and turbidity decrease light penetration and can reduce the area of available *Najas flexilis* habitat, particularly at the lower euphotic depths. The primary source of increased water colour in Ireland is disturbance to peatland. Drainage of peatland for peat-cutting, agriculture and forestry, as well as overgrazing by sheep, are the primary causes of such disturbance in Ireland.

No species-specific or national standards for water colour currently exist. It is likely that the water colour in *Najas flexilis* lakes would naturally be <50mg/l PtCo. Of the 197 lakes nationally for which data on colour were available in Free *et al.* (2006), the average and median concentrations were

41mg/l PtCo and 33mg/l PtCo, respectively. Free *et al.* (2006) recorded colour of 23mg/l PtCo in Lough Caragh and 22mg/l PtCo in the Upper Lake.

The target for the attribute water quality, colour is: Maintain appropriate water colour to support the populations of *Najas flexilis*.

The use of the attribute water transparency and a species-specific target (in metres) would also be a useful measure of changes in light penetration. Secchi disk measurements could be used, with a target of no decrease in Secchi disk transparency.

4.7 Associated species

As detailed in section 1.1, *Najas flexilis* is typically associated with a more diverse range of macrophyte species than found in the more base-poor lakes in peatland catchments.

Caragh – More (1877) dredged *Najas flexilis* up with a “mass of *Chara* [*Nitella*] *flexilis*”. He also listed other species growing in Lough Caragh (*Isoetes lacustris*, *Lobelia dortmanna* and *Eriocaulon aquaticum*). See Scully (1916) for other records for Lough Caragh. Heuff (1984) recorded *Isoetes lacustris* and *Potamogeton berchtoldii* in the relevé (44) with *Najas flexilis*. Visser and Zoer (1972, 1976) surveyed the vegetation of an area of Lough Caragh, but did not record *Najas flexilis*. FitzGerald and Preston (1994) noted that populations at the south of the lake were located “outside *Schoenoplectus* beds”, with *Potamogeton perfoliatus*, *P. berchtoldii*, *Utricularia intermedia*, *Nitella translucens* and *Nitella confervacea*. At Sugarloaf Island, *Najas flexilis* was found with *Potamogeton perfoliatus* and *Nitella translucens* (FitzGerald and Preston, 1994). Wingfield *et al.* (2004) placed Lough Caragh in their Group 1, more oligotrophic plant associations. Roden (2004) described the submerged flora of Lough Caragh as abundant but not species-rich, describing the zonation as Isoetids followed by *Potamogeton* spp., then *Najas flexilis* and *Nitella translucens* (see also Appendix II). He recorded *P. berchtoldii*, *Sparganium angustifolium* and *Utricularia* sp. in the relevé with *Najas flexilis*, and noted *Elatine hexandra*, *Isoetes echinospora* and *I. lacustris*.

Lough Leane - the Revs E.F. and W.R. Linton collected *Najas flexilis* with *Callitriche* (Linton, 1886). Scully (1888 and 1916) provides significant data on the species associated with *Najas flexilis* in Lough Leane and the wider aquatic flora of the lake. FitzGerald and Preston (1994) recorded *Callitriche hermaphroditica*, *Ceratophyllum demersum*, *Potamogeton berchtoldii* and *Nitella flexilis* with *Najas flexilis* at Ross Bay; *Littorella uniflora*, *Myriophyllum alterniflorum*, *P. perfoliatus* and *Nitella flexilis* at the ‘Bay SE of Ross Island’; and *Callitriche hermaphroditica*, *P. berchtoldii*, *P. perfoliatus* and *Nitella flexilis* at ‘Small bay NE of Governor’s Rock’. With the single specimen of *Najas flexilis* trawled up ‘Between Mahony’s Point and Killenalougha’, *Callitriche hermaphroditica*, *Ceratophyllum demersum*, *Potamogeton perfoliatus*, *Nitella flexilis* and *Fontinalis antipyretica* were recorded (FitzGerald and Preston, 1994). A survey by C. Roden and P. Murphy also produced additional records for associated species in Lough Leane. Note, a number of records for *Luronium natans* have been made in Lough Leane and elsewhere in the site (e.g. Druce, 1910; Linton and Linton, 1886; Moore and More, 1866; Rich *et al.*, 1995; Scully, 1916). These are almost certainly the creeping form of *Baldellia ranunculoides*: *B. ranunculoides* subsp. *repens* (see Kozłowski *et al.*, 2008; Jones, 2006, 2015; Scully, 1888, 1916) and the only confirmed location for *Luronium natans* in Ireland remains the Invermore area of south Connemara (see Rich *et al.*, 1995; Roden and Murphy, 2012).

Upper Lake – FitzGerald and Preston (1994) recorded *Nitella flexilis* and *N. translucens* with *Najas flexilis* at “S. of Ronayne’s Island” and *Nitella sp.* and *Potamogeton berchtoldii* at “ESE of Duck Island”. Roden and Murphy (2014) described a ‘very unusual’ community south of Roynane Island with four charophytes, *Nitella translucens*, *N. confervacea*, *N. gracilis* and an unusual form of *Chara virgata*, covering much of the ground with *Najas flexilis*, *Urticularia sp.* and *Potamogeton berchtoldii*. They considered that an underwater spring might be the driver of this community and said that “In general the Upper Lake has a typical oligotrophic flora and vegetation. *Lobelia* and *Littorella* are found in shallow water with *Isoetes lacustris* and then *Nitella translucens*” (Roden and Murphy, 2014). As for all Kerry lakes, Scully (1916) is an extremely useful source of records.

Acoose – G. Visser and J.A. Zoer recorded the following species in Lough Acoose: *Carex rostrata*, *Equisetum fluviatile*, *Elatine hexandra*, *Eleocharis palustris*, *Isoetes lacustris*, *Littorella uniflora*, *Lobelia dortmanna*, *Nuphar lutea*, *Nymphaea alba*, *Potamogeton natans*, *Schoenoplectus lacustris* and *Sparganium angustifolium* (Visser and Zoer, 1972, 1976). They also provided a vegetation map for the area surveyed (Visser and Zoer, 1972, 1976). FitzGerald and Preston (1994) describe finding one ‘narrow bed’ of *Najas flexilis* just outside a *Potamogeton natans*/*Equisetum fluviatile* zone. The species associated with *Najas flexilis* were *P. perfoliatus* and *Nitella sp.* C. Roden describes *Najas flexilis* “growing in a scattered or open community of *Potamogeton berchtoldii*, *Nitella translucens* and rare *Isoetes lacustris*” (Roden, 2004; see Appendix II). He also recorded *Littorella uniflora*, *Lobelia dortmanna*, *P. natans* and *Nitella flexilis* (Roden, 2004).

The Long Range – Species associated with *Najas flexilis* in The Long Range were *Nitella flexilis* and *Juncus bulbosus* (FitzGerald and Preston, 1994). Roden and Murphy (2014) recorded *Najas flexilis* with *Potamogeton berchtoldii*, *Isoetes lacustris* and *Nitella translucens*. They described the flora as “typical of Old Red Sandstone lakes with mainly oligotrophic species including *Isoetes lacustris*, *Juncus bulbosus* and *Callitriche hamulata*” (Roden and Murphy, 2014). They also recorded *Nitella confervacea* (Roden and Murphy, 2014).

In addition, every three years, macrophytes are monitored by the EPA at Acoose, Caragh, Leane and Upper Lake for WFD purposes. The data will include species associated with *Najas flexilis* along monitoring transects.

Competition from both native and non-native species is a potential threat to *Najas flexilis*. Wingfield *et al.* (2004) noted competition by the native species *Myriophyllum alterniflorum* and *Chara spp.* as possibly impacting on *Najas flexilis* in a Scottish Loch. Competition from native species could be part of a natural lake-succession or, more likely, promoted by environmental disturbances such as eutrophication. Eutrophication will inevitably convey an advantage on invasive non-native and native perennial species. Wingfield *et al.* (2004) observed that competition is not always a problem, but is more likely to be where nutrients and light promote excessive growth. The issue of competition from both native and non-native species is discussed further in O Connor (2013).

The target for the attribute associated species is: Maintain appropriate associated species and vegetation communities to support the populations of *Najas flexilis*.

4.8 Fringing habitat

Fringing habitats are an integral part of the structure and functioning of lake systems. Most lake shorelines have fringing habitats of reedswamp, other swamp, fen, marsh or wet woodland that intergrade with and support the lake habitat. Fringing habitats can contribute to the aquatic food web (e.g. allochthonous matter such as leaf fall), provide habitat (refuge and resources) for certain life-stages of fish, birds and aquatic invertebrates, assist in the settlement of fine suspended material, protect lake shores from erosion and contribute to nutrient cycling. Equally, fringing habitats are dependent on the lake, particularly its water levels, and support wetland communities and species of conservation concern.

The target for the attribute fringing habitat is: Maintain the area and condition of fringing habitats necessary to support the populations of *Najas flexilis*.

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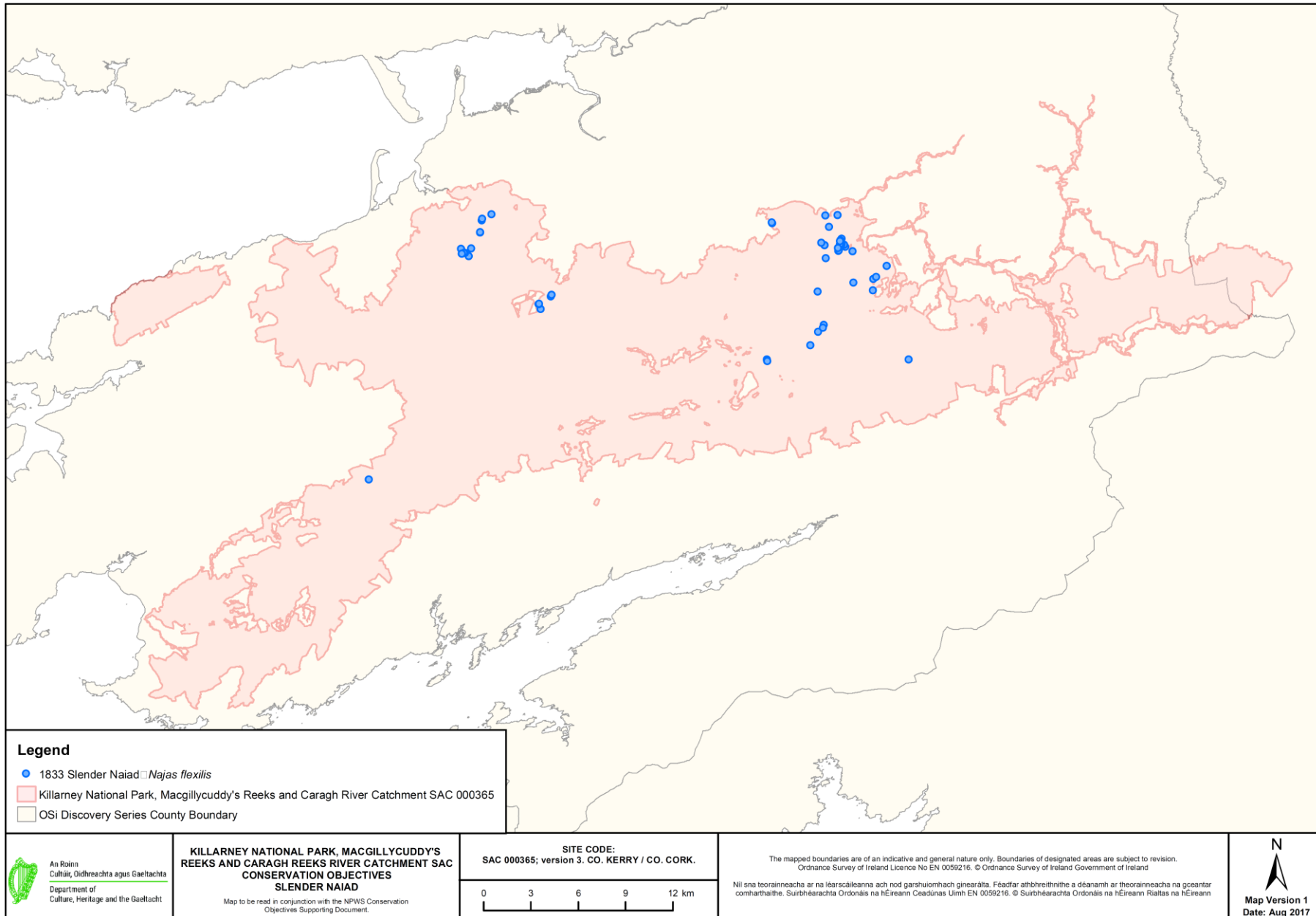
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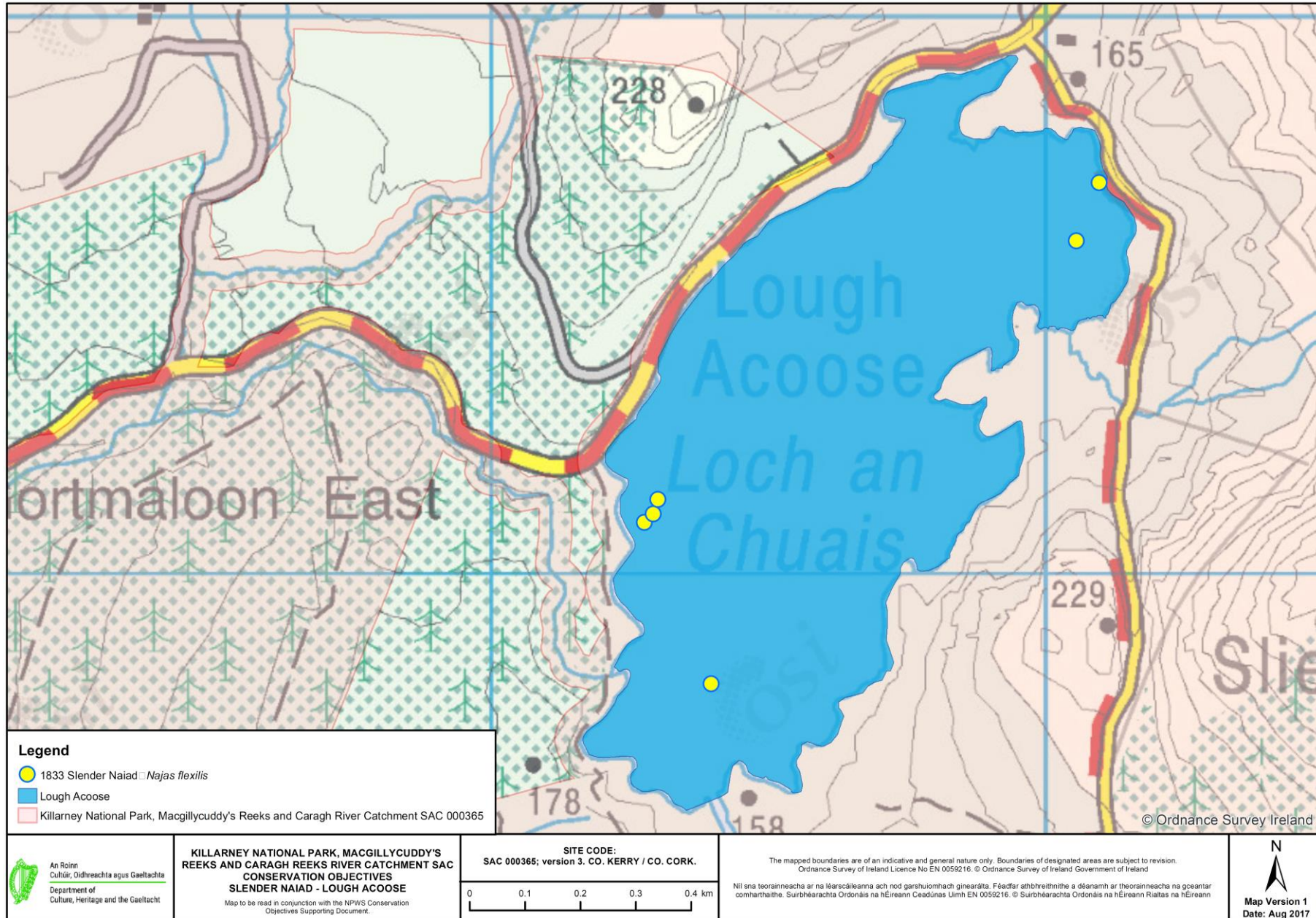
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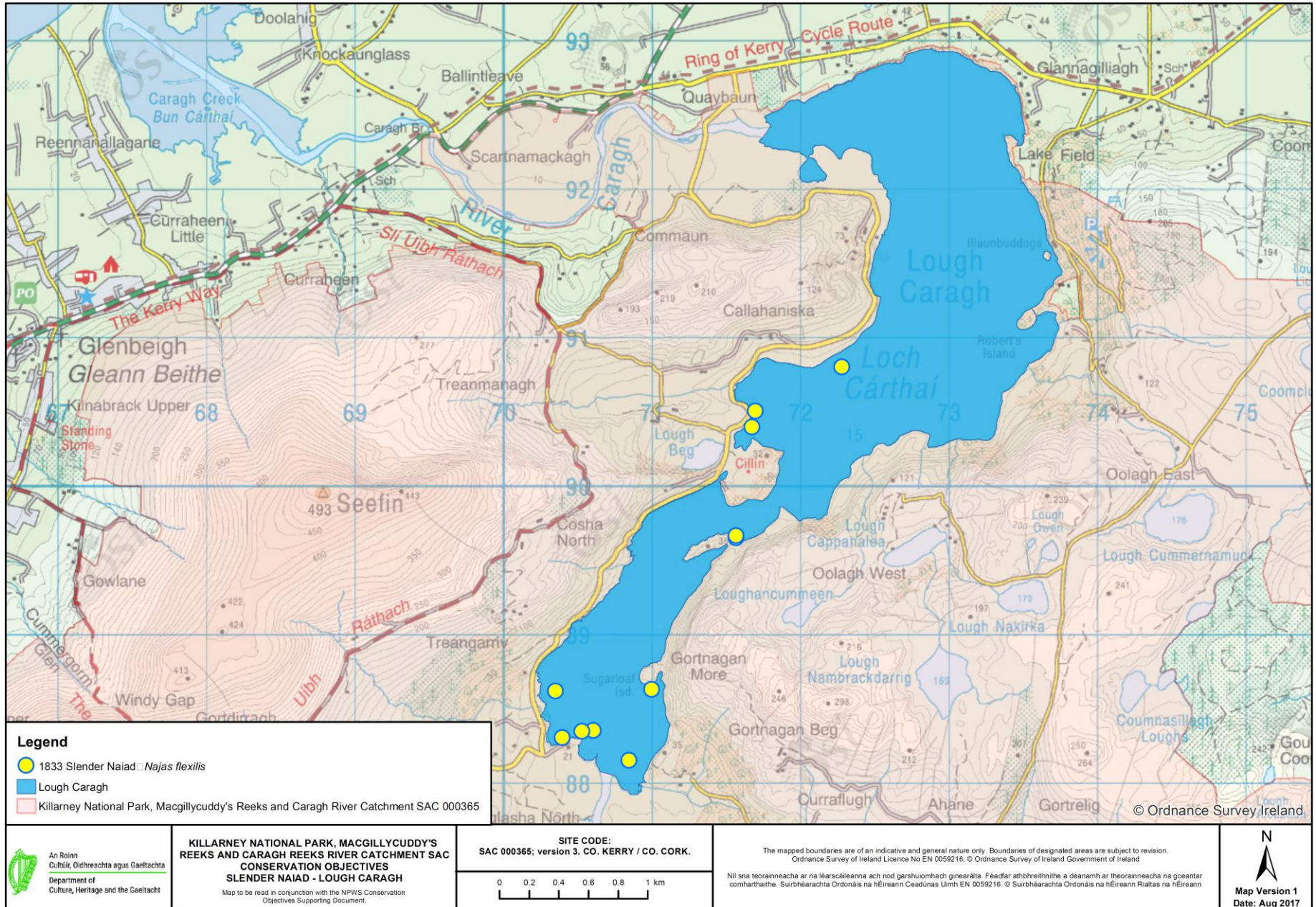
Appendix I Distribution maps of *Najas flexilis* in Killarney National Park, Macgillycuddy's Reeks and Caragh River Catchment SAC



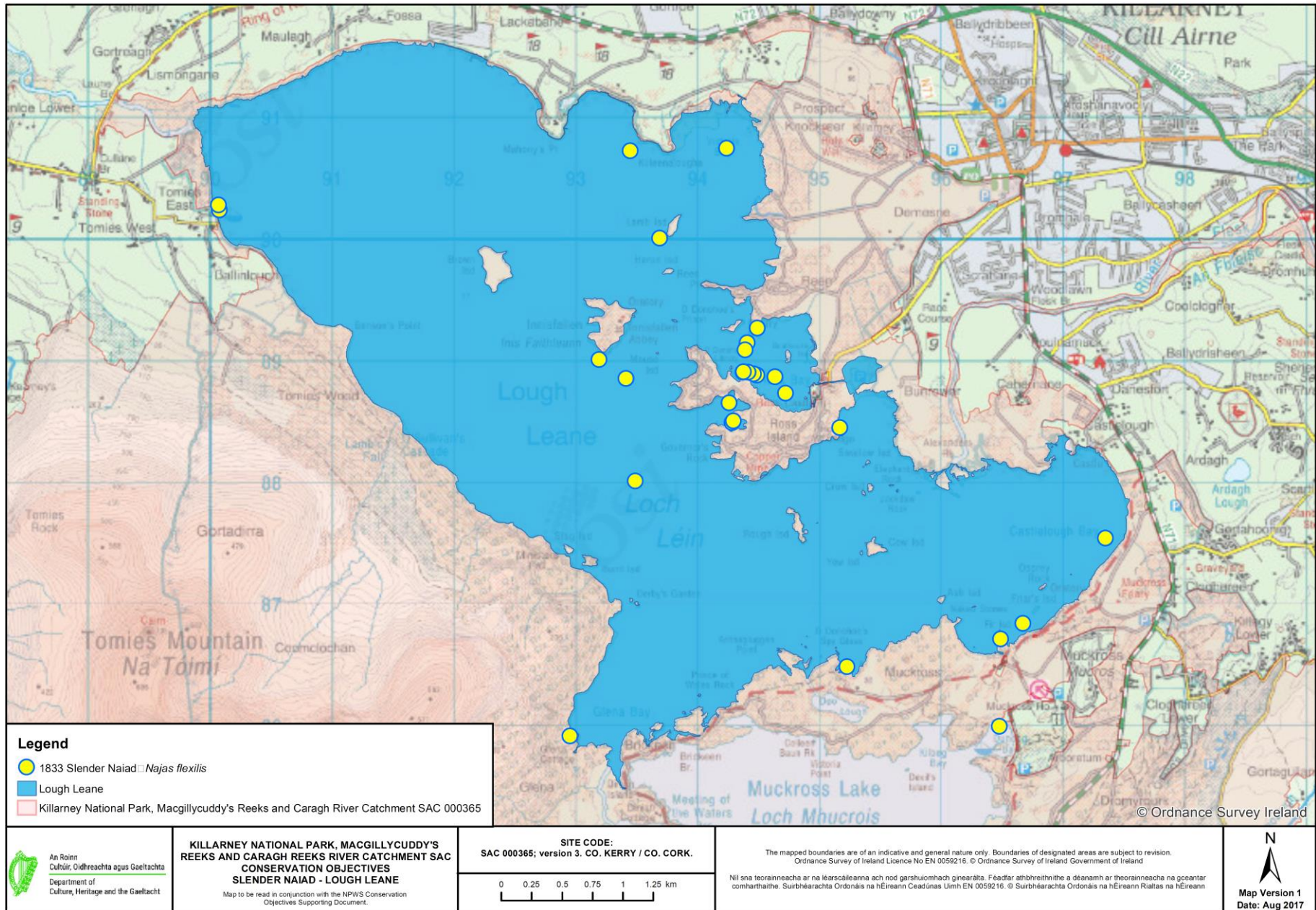
Distribution map of *Najas flexilis* in Lough Acoose in Killarney National Park, Macgillycuddy's Reeks and Caragh River Catchment SAC



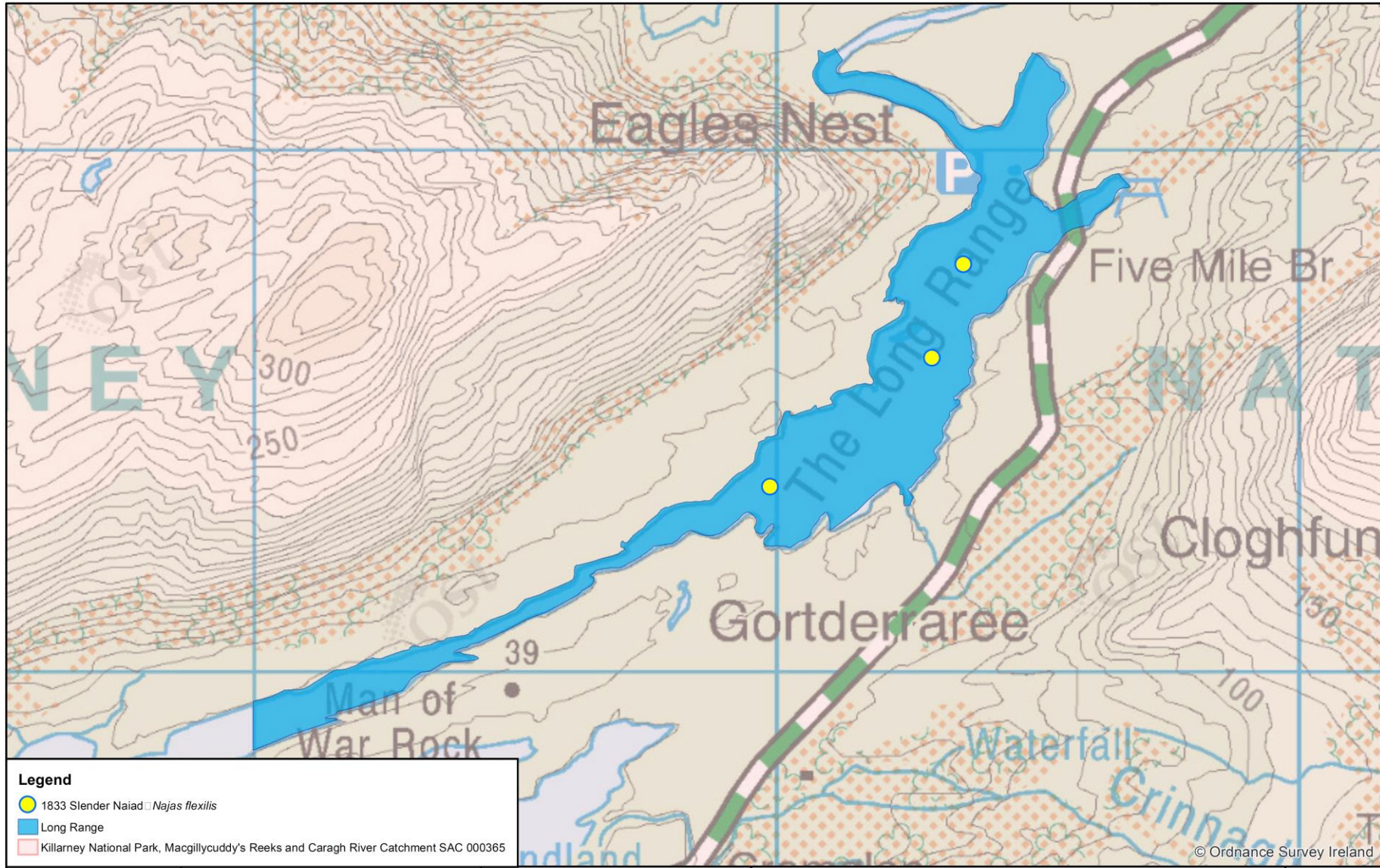
Distribution map of *Najas flexilis* in Lough Caragh in Killarney National Park, Macgillycuddy's Reeks and Caragh River Catchment SAC


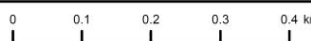


Distribution map of *Najas flexilis* in Lough Leane in Killarney National Park, Macgillycuddy's Reeks and Caragh River Catchment SAC

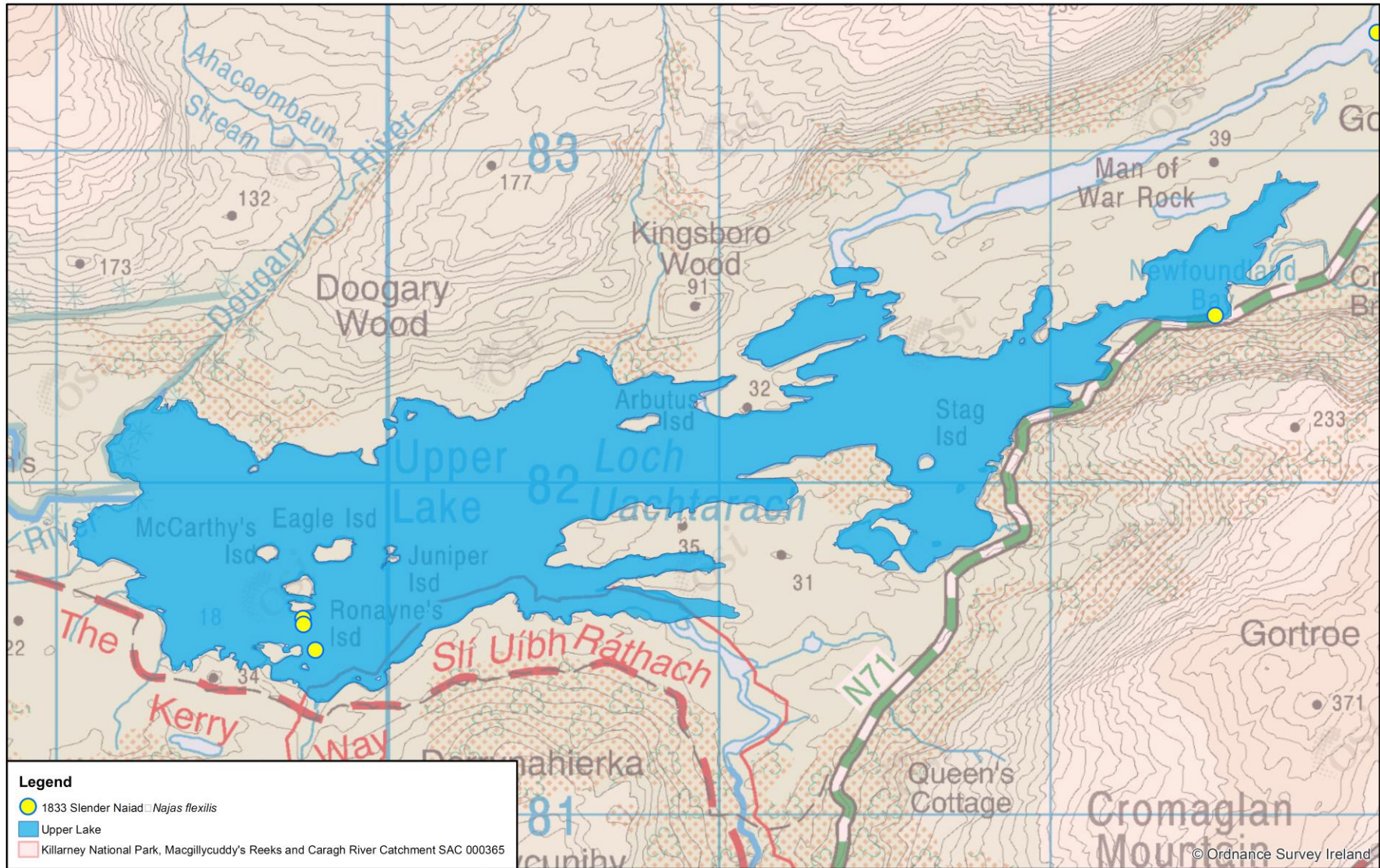


Distribution map of *Najas flexilis* in The Long Range in Killarney National Park, Macgillicuddy's Reeks and Caragh River Catchment SAC



 <p>An Roinn Cultúir, Oidhreacht agus Gaeltachta Department of Culture, Heritage and the Gaeltacht</p>	<p>KILLARNEY NATIONAL PARK, MACGILLYCUDDY'S REEKS AND CARAGH REEKS RIVER CATCHMENT SAC CONSERVATION OBJECTIVES SLENDER NAIAD - LONG RANGE Map to be read in conjunction with the NPWS Conservation Objectives Supporting Document.</p>	<p>SITE CODE: SAC 000365; version 3. CO. KERRY / CO. CORK.</p> 	<p>The mapped boundaries are of an indicative and general nature only. Boundaries of designated areas are subject to revision. Ordnance Survey of Ireland Licence No EN 0059216. © Ordnance Survey of Ireland Government of Ireland</p> <p>Níl sna teorainneacha ar na léarscáileanna ach nod garshuíomhach ginearálta. Féadfar athbheithnithe a déanamh ar theorainneacha na gceantar comharthaíthe. Suirbhéarachta Ordoínáis na hÉireann Ceadóinas Uimh EN 0059216. © Suirbhéarachta Ordoínáis na hÉireann Rialtas na hÉireann</p>	<p>N ▲ Map Version 1 Date: Aug 2017</p>
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Distribution map of *Najas flexilis* in the Upper Lake in Killarney National Park, Macgillycuddy's Reeks and Caragh River Catchment SAC



Legend

- 1833 Slender Naiad *Najas flexilis*
- Upper Lake
- Killarney National Park, Macgillycuddy's Reeks and Caragh River Catchment SAC 000365

An Roinn
Cultúir, Oidhreacht agus Gaeltachta
Department of
Culture, Heritage and the Gaeltacht

KILLARNEY NATIONAL PARK, MACGILLYCUDDY'S REEKS AND CARAGH REEKS RIVER CATCHMENT SAC CONSERVATION OBJECTIVES
SLENDER NAIDAD - UPPER LAKE
Map to be read in conjunction with the NPWS Conservation Objectives Supporting Document.

SITE CODE:
SAC 000365; version 3. CO. KERRY / CO. CORK.

0 0.1 0.2 0.3 0.4 0.5 km

The mapped boundaries are of an indicative and general nature only. Boundaries of designated areas are subject to revision.
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Map Version 1
Date: Aug 2017

Appendix II Notes of *Najas flexilis* survey of Loughs Caragh and Acoose in 2004 by Dr Cilian Roden

Species: *Najas flexilis*

Discovery series map: 78

Grid reference:
V704863

Locality: Lough Caragh

Vice county: H1

SAC/NHA no.: 365.

Date: 31/08/2004

Recorder: Cilian Roden

Altitude: 15m

Site description: A large lake (600ha) situated on the Devonian Carboniferous border. Underlying rocks include sandstone, siltstone and limestone. The river Caragh flows into the southern end of the lake. The surrounding land includes heath, woodland, pasture and gardens.

Population: The lake bed at the southwest end of the lake was examined. There is a very large and dense population of *Najas* growing on sand and silt at a depth of 1.5m and deeper. In many places *Najas* is the dominant species with smaller populations of *Potamogeton berchtoldii* and *Urticularia* sp.

Vegetation: Sub littoral vegetation is abundant but not species rich. Isoetids are followed by *Potamogeton* spp., *Najas* and *Nitella translucens*.

Management:

Threats: No obvious threat

Access: by track leading to boat harbour west of Caragh river inflow.

Conservation: The largest population of *Najas* in southwest Ireland

Remarks: The abundance of *Najas* may be related to sediments carried down by the Caragh river.

Species: *Najas flexilis*

Discovery series map: 78

Grid reference:
V761857

Locality: Lough Acoose

Vice county: H1

SAC/NHA no.: 365.

Date: 31/08/2004

Recorder: Cilian Roden

Altitude: 152m

Site description: An upland lake of about 80 ha lying on Devonian sandstone of the Lough Acoose formation. It is fed by streams from the surrounding sandstone mountains. Surrounding land is mainly pasture and rough grazing. The lake shelves steeply to depths >8m. Water transparency is good, the bottom is mainly sand with some silt.

Population: The northeast corner was examined. A population of *Najas* (>100 plants) was found at 5m near the lower limit of macrophyte vegetation growing in a scattered or open community of *Potamogeton berchtoldii*, *Nitella translucens* and rare *Isoetes lacustris*. The substrate was silt resting on sand.

Vegetation: The flora was very poor with only 6 species of submerged macrophyte recorded. An isoetid community is followed by *Najas*, *Nitella flexilis* and *P. berchtoldii*.

Management:

Threats: No obvious threat

Access: is by the cul de sac leading to Derrynafeana.

Conservation: *Najas* seems less widely distributed in Kerry than in Connemara or Donegal, consequently this station is of interest. It is also one of the highest stations for *Najas* at 152m.

Remarks: Like other Kerry lakes on Old Red Sandstone the substrate is more sandy than silty.