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MONITORING OF THE ANNEX V CLUBMOSS GROUP (*LYCOPODIUM* SPP.) IN IRELAND 2015–2018

Fionnuala H. O'Neill, Maria P. Long and Rory L. Hodd

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

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Front cover, small photographs from top row:

Coastal heath, Howth Head, Co. Dublin, Maurice Eakin; **Red Squirrel** *Sciurus vulgaris*, Eddie Dunne, NPWS Image Library; **Marsh Fritillary** *Euphydryas aurinia*, Brian Nelson; **Puffin** *Fratercula arctica*, Mike Brown, NPWS Image Library; **Long Range and Upper Lake**, Killarney National Park, NPWS Image Library; **Limestone pavement**, Bricklieve Mountains, Co. Sligo, Andy Bleasdale; **Meadow Saffron** *Colchicum autumnale*, Lorcan Scott; **Barn Owl** *Tyto alba*, Mike Brown, NPWS Image Library; **A deep water fly trap anemone** *Phelliactis* sp., Yvonne Leahy; **Violet Crystalwort** *Riccia huebeneriana*, Robert Thompson

Main photograph:

Diphasiastrum alpinum, Maumturk Mountains, Orla Daly

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Fionnuala H. O'Neill, Maria P. Long and Rory L. Hodd

BEC Consultants Ltd., 43 Herbert Lane, Dublin 2, D02 TE86

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The NPWS Project Officer for this report was: Deirdre Lynn; Deirdre.Lynn@chg.gov.ie

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Department of Culture, Heritage and the Gaeltacht, 90 North King Street, Smithfield, Dublin 7, D07 N7CV

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Executive Summary

This report presents details of a monitoring survey conducted between 2015 and 2018 to assess the conservation status of the Habitats Directive Annex V species group *Lycopodium* spp. (EU code 1413). In Ireland, this is understood to comprise the four clubmoss species *Diphasiastrum alpinum*, *Huperzia selago*, *Lycopodium clavatum* and *Lycopodiella inundata*. The aims of the survey were to assess these four target species in terms of three parameters: *Population*, *Habitat for the species* and *Future prospects*. A total of 25 sites were surveyed: five *D. alpinum*, ten *H. selago*, five *L. clavatum* and five *L. inundata* sites. A review of the survey methodology and assessment criteria was undertaken.

For all four species, *Population* was assessed at each site by five criteria: total number of occupied square metres (OSMs), population extent in square metres, percent cover of target species (obtained from the average percent cover across all monitoring stops), estimated number of target species shoots (extrapolated up from average shoot counts across all monitoring stops) and presence of sporing plants.

Habitat for the species was assessed differently for each species. For *D. alpinum* it was assessed by means of three criteria: percent cover of *Calluna vulgaris*, percent cover of disturbed bare ground and impact of negative pressures on habitat. For *H. selago* it was assessed using one criterion: impact of negative pressures on habitat. For *L. clavatum* it was assessed using three criteria: percent cover of *Calluna vulgaris,* percent cover of disturbed bare soil, and impact of negative pressures on habitat. For *L. inundata* it was assessed using five criteria: average sward height across all plots, cover of *Nardus stricta,* percent cover of bare ground, wetness of substrate, and impact of negative pressures.

Positive and negative activities were recorded at sites where they occurred. The main negative impacts recorded at *D. alpinum* sites were sheep grazing and damage due to trampling from walkers. These were regarded as being of low importance and not seriously damaging to the plant or its habitat. For *H. selago*, pressures from overgrazing were high across five of the ten sites surveyed. Negative impacts at *L. clavatum* sites included both overgrazing and undergrazing, as well as some damage due to walkers. *L. inundata* sites were generally found to be managed appropriately and negative impacts were of low intensity or absent. Drainage, noted in the baseline survey as one of the most severe impacts affecting *L. inundata* sites, did not appear to be a problem at any of the five *L. inundata* sites visited during the current survey.

Nine of the ten *H. selago* sites received a Favourable assessment for *Population*, and one received an Unfavourable-Inadequate assessment. Five sites received a Favourable assessment for *Habitat for the species* and five were assessed as Unfavourable-Inadequate. Future prospects for four of the sites were assessed as Favourable, while six were Unfavourable-Inadequate. An overall conservation status assessment of Favourable was achieved by four sites, with six receiving an overall conservation status assessment of Unfavourable-Inadequate.

At one of the *L. clavatum* sites surveyed, the target species was not located. Therefore this site received a *Population* assessment of Unfavourable-Bad. The other four sites were Favourable for *Population*. *Habitat for the species* was assessed as Favourable at three sites, one was Unfavourable-Inadequate, and at the fifth site (where *L. clavatum* was absent) the habitat was not assessed, therefore the assessment result is Unknown. *Future prospects* were assessed as Favourable at three sites, Unfavourable-Inadequate at one and Unfavourable-Bad at the fifth. Overall, three sites were assessed as Favourable and one each was assessed as Unfavourable-Inadequate and Unfavourable-Bad.

All five *L. inundata* and *D. alpinum* sites received a Favourable assessment for *Population*, *Habitat for the species* and *Future prospects*; therefore all five sites for both species received an overall conservation status assessment of Favourable.

The report concludes with a discussion of the results and recommendations for future monitoring of the species.

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1 Introduction

1.1 The Rare Plants Monitoring Survey 2015-18

The National Parks and Wildlife Service (NPWS) of the Department of Culture, Heritage and the Gaeltacht commissioned BEC Consultants Ltd to carry out the Rare Plants Monitoring Survey (RPMS), a three-year survey conducted in 2015-18 to monitor and assess eight species listed on Annexes of the EU Habitats Directive (92/43/EEC). Species listed on Annex II require the designation of Special Areas of Conservation (SAC) for their conservation. Annex V of the Directive relates to species of European interest whose taking in the wild and exploitation may be subject to management measures.

Four of the survey's target species are Annex II species: *Hamatocaulis vernicosus* (Slender Green Feather-moss), *Petalophyllum ralfsii* (Petalwort), *Saxifraga hirculus* (Marsh Saxifrage) and *Vandenboschia speciosa* (Killarney Fern). The other four are Annex V species: *Diphasiastrum alpinum* (Alpine Clubmoss), *Huperzia selago* (Fir Clubmoss), *Lycopodium clavatum* (Stag's-horn Clubmoss) and *Lycopodiella inundata* (Marsh Clubmoss), collectively listed as "*Lycopodium* spp." on the Annex.

Under Article 17 of the Habitats Directive, all EU Member States that are signatories of the Directive have a legal obligation to report on the conservation status of the Annex II and Annex V species that occur within their boundaries. These national conservation status assessment reports are produced every six years. The most recent report, covering the period 2013-2018, was submitted in 2019 (NPWS, 2019). This is the third round of reporting carried out under Article 17 where the conservation status is assessed.

The results of the Rare Plants Monitoring Survey were used to inform Ireland's 2019 Article 17 report.

The aims of the Rare Plants Monitoring Survey in relation to clubmosses, as set out by NPWS, were as follows

- Review and, where necessary, revise the monitoring methods developed by Smyth *et al*. (2015)
- Undertake monitoring of the conservation status of a representative sample of the populations across the country in 25 selected sites, most of which were surveyed by Smyth *et al*. (2015)
- Complete a National Conservation Status Assessment for each of the species, using the latest available European Commission and NPWS guidance.

The survey was required to gather assessment data on the four clubmoss species in Ireland. Data from the 25 sites surveyed between 2015 and 2018 were used to evaluate the current conservation status of clubmosses at these sites. The assessment process is outlined in this report. These data and available information on other sites not covered in the survey were used to evaluate the current overall conservation status of clubmosses in Ireland (NPWS, 2019).

1.2 Assessment of Annex II and Annex V species

Annex II and Annex V species are assessed under four parameters of conservation status: *Range*, *Population*, *Habitat for the species* and *Future prospects*. Guidance on assessment is provided by the EU (DG Environment, 2017). Evaluation of conservation status requires the separate assessment of the four parameters.

The range of a species is defined as "the outer limits of the overall area in which a species is found at present" and it can be considered as an envelope within which areas actually occupied occur (DG Environment, 2017). The range is based on the actual distribution of the species and in general the

surface area of the range is provided in 10 km x 10 km (hectad) resolution, with a minimum value of 100 km^2 (DG Environment, 2017).

This survey assessed three parameters at the site level: *Population*, *Habitat for the species* and *Future prospects*. *Range* is assessed at a national level.

Population size is generally expressed in terms of a particular reporting unit, e.g. individuals. However, several clubmoss species are rhizomatous, making the enumeration of individuals very difficult, if not impossible, without destructive sampling. For clubmosses and other groups such as bryophytes which do not lend themselves to counts of individuals, the reporting unit is number of occupied 1 km x 1 km grids, and this is the unit used for the clubmosses' population assessments in the National Conservation Status Assessment report (NPWS, 2019). For the purposes of this report, however, the population size at each site is estimated in terms of the number of shoots.

The reporting guidelines (DG Environment, 2017) describe *Habitat for the species* as referring to the "resources necessary at all stages in the life cycle of the species", with a species needing a "sufficiently large area of habitat of suitable quality and spatial distribution" to survive and flourish. This is assessed by means of criteria that quantify certain aspects of the habitat, such as niche availability, competition from other species and suitable hydrology. In this monitoring survey, as in species monitoring projects such as. Daly & Barron (2015) and Long & Brophy (2019), such criteria are measured at monitoring stops. A monitoring stop is usually a plot of fixed size delimited on the ground using a measuring tape or quadrat square. The dimensions of the plot and the number of monitoring stops recorded vary depending on the type and extent of the species and habitat being assessed.

The *Future prospects* assessment at each site requires an examination of the stability of the species in terms of its population and supporting habitat, in the context of the impacts and activities taking place where the species occurs across the site. The balance between positive management and negative impacts is weighed up and the prospects for the species at the site over the next two reporting periods (12 years) are evaluated.

Each parameter can receive an assessment of Favourable (green), Unfavourable-Inadequate (amber) or Unfavourable-Bad (red). The individual parameter assessments are then combined, with the aid of an evaluation matrix (Table 1), to give an overall assessment of conservation status for the species.

The reporting requirements for Annex V species groups are less stringent than those for Annex II species, as explained in the reporting guidelines (DG Environment, 2017). Nevertheless, there is still a requirement to assess the individual parameters to make an overall assessment of conservation status. The assessment of these parameters will therefore be detailed in this report.

1.3 Scope of this report

1.3.1 Scope and format of this report

This report details the monitoring methodology and results for the four clubmoss species surveyed as part of the Rare Plants Monitoring Survey 2015-18. A review of the survey methodology and assessment criteria was also carried out for each species, as required by the project aims. The criteria and methodology review, survey methodology, results and discussion are presented first for *Diphasiastrum alpinum* (Chapter 2), followed in turn by *Huperzia selago* (Chapter 3), *Lycopodium clavatum* (Chapter 4) and *Lycopodiella inundata* (Chapter 5). General recommendations are made at the end of the report. Individual site reports have been produced and are included as an appendix at the end of this report (Appendix 4).

Separate Irish Wildlife Manual reports have been produced for each of the four EU Habitats Directive Annex II species surveyed as part of this project: *Hamatocaulis vernicosus* (Campbell *et al*., 2019a),

Petalophyllum ralfsii (Campbell *et al.*, 2019b), *Saxifraga hirculus* (O'Neill *et al.*, 2019) and *Vandenboschia speciosa* (Ní Dhúill *et al.*, in prep.).

Table 1 General evaluation matrix for assessment of Conservation Status of a species (adapted from DG Environment, 2016).

	Conservation Status			
Parameter	**Favourable ('green')**	**Unfavourable – Inadequate ('amber')**	**Unfavourable - Bad ('red')**	**Unknown**
Range	Stable (loss and expansion in balance) or increasing AND not smaller than the 'favourable reference range'	Any other combination	Large decline: equivalent to a loss of more than 1% per year within period specified by Member State OR more than 10% below 'favourable reference range'	No or insufficient reliable information available
Population	Population(s) not lower than 'favourable reference population' AND reproduction, mortality and age structure not deviating from normal (if data available)	Any other combination	Large decline: equivalent to a loss of more than 1% per year (indicative value Member State may deviate from if duly justified) within period specified by Member State AND below 'favourable reference population' OR more than 25% below 'favourable reference population' OR reproduction, mortality and age structure strongly deviating from normal (if data available)	No or insufficient reliable information available
Habitat for the species	Area of habitat is sufficiently large (and stable or increasing) AND habitat quality is suitable for the long-term survival of the species	Any other combination	Area of habitat is clearly not sufficiently large to ensure the long-term survival of the species OR habitat quality is bad, clearly not allowing long-term survival of the species	No or insufficient reliable information available
Future prospects (with regard to population, range and habitat availability)	Main pressures and threats to the species not significant; species will remain viable on the long-term	Any other combination	Severe influence of pressures and threats to the species; very bad prospects for its future, long-term viability at risk.	No or insufficient reliable information available
Overall assessment of Conservation Status	All 'green' OR three 'green' and one 'unknown'	One or more 'amber' but no 'red'	One or more 'red'	Two or more 'unknown' combined with green or all 'unknown'

1.3.2 Conventions used throughout this report

The terms *Range*, *Population*, *Habitat for the species* and *Future prospects* are capitalised and italicised when they refer directly to the four parameters being assessed. The assessment result terms Favourable, Unfavourable-Inadequate and Unfavourable-Bad are capitalised when they refer directly to assessment results achieved by parameters.

The terms "site" and "population" are used interchangeably in this report. Each site supports one population of a species.

1.4 The target species

Clubmosses (family Lycopodiaceae) are an ancient group of vascular plants that, like ferns, produce spores rather than seeds. The four clubmoss species surveyed during this project were formerly treated as members of the genus *Lycopodium*, and are listed as such on Annex V of the EU Habitats Directive under species code 1413; however, the current taxonomic treatment of the group places them in four different genera, *Diphasiastrum*, *Huperzia*, *Lycopodiella* and *Lycopodium* (see, for example, Stace, 2019). Each species is described and assessed separately in Chapters 2 to 5.

1.5 Clubmoss surveys in Ireland

There have been few dedicated clubmoss surveys in Ireland to date. Many of the clubmoss records available were made during surveys with a different focus, for example, the National Survey of Upland Habitats 2009-2014 (see Perrin *et al*., 2014); Botanical Society of Britain and Ireland (BSBI) distribution atlas recording schemes (Perring & Walters, 1962; Jermy *et al*., 1978; Preston *et al*., 2002); recording for county floras; and site, habitat and species surveys by NPWS staff, among others.

A baseline clubmoss survey was carried out for the four target clubmoss species between 2009 and 2014 (Smyth *et al*., 2015). Baseline data were recorded from 21 populations and a monitoring protocol was established for the assessment of the four species. These data allowed population sizes to be estimated and the condition of the species' habitats to be documented and assessed. Other parameters such as *Range* and *Future prospects* for the species were also assessed. These data were used to determine the conservation status of the clubmoss group for the 2007-2012 monitoring period, and the overall assessment result given in the 2013 Article 17 report (NPWS, 2013) was Unfavourable-Inadequate.

Since 2015, the BSBI (via the Irish Officer, vice-county recorders and member effort) has carried out dedicated surveys of clubmoss populations at many sites across Ireland (BSBI, 2015-2018). These surveys cover the four species listed on Annex V, and data collected include population locations, population size estimates, presence/absence of sporing shoots, main associated species, site description, and negative pressures, as well as conservation measures needed.

2 *Diphasiastrum alpinum*

2.1 Species description

Diphasiastrum alpinum (Alpine Clubmoss) is found in montane habitats in Ireland, and its distribution is mainly in counties from Wicklow and Galway northwards (Parnell & Curtis, 2012), with recent finds also made in Waterford (Roche & Perrin, 2010) and Kerry (Hodd & Roche, 2015). The plant occurs on bare peat on mountain ridges and summits, typically montane heath (Parnell & Curtis, 2012; Smyth *et al*., 2015), habitat category HH4 under the Heritage Council's classification of Irish habitats (Fossitt, 2000). The population in Waterford was found in rocky montane heath dominated by *Calluna vulgaris* and *Racomitrium lanuginosum* (Roche & Perrin, 2010). The Kerry population was found in *Racomitrium lanuginosum*-dominated montane heath interspersed with bare rock and soil (Hodd & Roche, 2015).

D. alpinum is rare in Ireland. The all-Ireland population of the species was assessed as Near Threatened, based on a decline in its area of occupancy between the two assessment periods 1930-1969 and 1987-1999 (Wyse Jackson *et al*., 2016). Its global population does not appear to be threatened, however, as it is not listed on the IUCN Red List of Threatened Species (IUCN, 2019). Distribution data collated from NPWS (2018), BSBI (2015-2018; 2018) and the National Biodiversity Data Centre (NBDC, 2018) for the Article 17 report on the *Lycopodium* spp. group (NPWS, 2019) show that the species, once recorded from 33 hectads in the Republic of Ireland, was confirmed from 24 hectads after 1969 and just 17 since 2002. Baseline surveys carried out in 2009 (Smyth *et al*., 2015) failed to find the plant at two of the six sites searched, although surveyors noted that the habitat at these sites was still suitable for the species and its presence was not completely ruled out. The apparent decline may be at least partly due to under-recording in the Irish uplands (Roche, 2011).

The plant is sensitive to trampling and overgrazing (although a certain amount of bare ground is beneficial for the species), and is threatened by habitat loss (Smyth *et al*., 2015) and potentially threatened also by climate change (Roche, 2011; Hodd *et al*., 2014; Hodd & Roche, 2015).

Figure 1 *Diphasiastrum alpinum* on the Maumturk Mountains. Photo by Orla Daly.

2.2 Review of survey methodology and assessment criteria

2.2.1 Definition of a colony

In Smyth *et al*. (2015), a colony was taken as the basic unit of a clubmoss population, being defined as a "discrete, unconnected, measurable patch of the species", and this was the reporting unit used in the previous monitoring period (2007-2012) (NPWS, 2013). However, there are a number of practical problems with using this unit. Firstly, there is no easy way of extrapolating measures such as the number of shoots from the number of colonies up to population, as colony size varies. Population extent is more useful in this regard, but the extent may include unoccupied as well as occupied areas of habitat. Secondly, without damaging the plants it is difficult to determine if clubmoss patches are connected or completely separate, particularly for rhizomatous species such as *D. alpinum*, whose stems may be covered by soil or leaf litter, thus making it difficult to identify an individual in the field. Thirdly, making such a determination could become very time-consuming, especially for large populations. In practice, during the first year of the survey it was soon found to be difficult to determine whether or not seemingly isolated colonies were connected without undue disturbance of the plants. There were also difficulties with recording the total area occupied by the species, mainly because of the patchy distribution.

For these reasons, the colony concept was dropped in favour of a more spatially centred method using occupied square metres (OSMs) of habitat, which allowed quantification of the extent of the target species and which should be more reproducible for comparison in future monitoring periods. This method has the advantage of easy extrapolation from monitoring stop to population, as the unit of measurement (1 m^2) is the same as the size of the monitoring plot. Within each OSM, even if several small patches of the plant were present, the count of squares was still only one; conversely, if there was a continuous swathe of the plant covering more than a square metre, the number of occupied square metres was more than one (see Figure 2). It is acknowledged that this method is not the same as counting colonies: the number of occupied square metres is lower than the number of colonies if the latter are small and situated relatively close together (Figure 2 (a)), and is higher than the number of colonies if colonies are large (Figure 2 (b)). It was, nevertheless, deemed to be a more consistent method of quantification for fieldworkers to follow within and between surveys, and also allowed a better estimation of the area covered by the plant and the number of shoots in the population when extrapolating data from monitoring stops to the overall population.

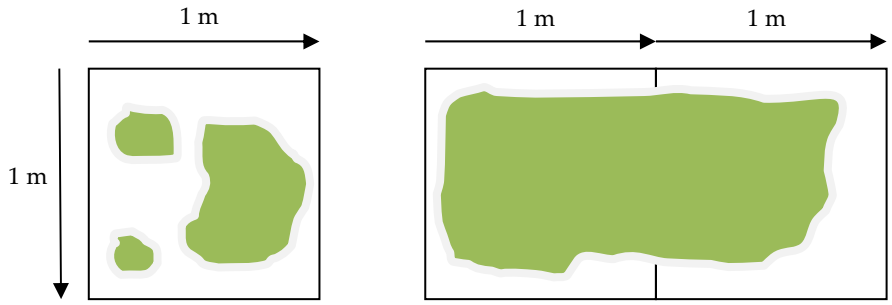

Figure 2 (a) Several small colonies within 1 m^2 = 1 occupied square metre (OSM), (b) One large colony extending across almost 2 m^2 = 2 OSMs

To calculate the total area covered by *D. alpinum* and number of shoots in the population the following procedure was used

- Count the number of occupied square metres
- Record the appropriate number of 1 m^2 monitoring stops, up to a maximum of ten

- Estimate the total area covered by *D. alpinum* in square metres as the average percent cover of *D. alpinum* per monitoring stop multiplied by the total number of occupied square metres counted
- Estimate the total number of shoots as the average number of shoots per monitoring stop multiplied by the total number of occupied square metres counted.

2.2.2 Review of *Population* assessment criteria

The *Population* assessment criteria used by Smyth *et al.* (2015) for *D. alpinum* were reviewed

- Total number of colonies
- Population extent (combined area of occupancy of colonies)
- Domin cover of *D. alpinum* species in the monitoring stop
- Estimated number of *D. alpinum* shoots (as population size class), and
- Presence of sporing *D. alpinum* plants.

2.2.2.1 Total number of colonies

Section 2.2.1 described the revised method used to quantify the extent of the plant in the current survey, i.e. using occupied square metres rather than colonies. The site-specific targets for colony numbers set in the baseline survey therefore no longer apply and, if the population was considered to be favourable at the time of the baseline survey, the number of occupied square metres counted during the current survey can be used as the basis for new targets. To allow for surveyor variability between monitoring periods, a minimum of 80% of the current number of occupied square metres should be used as the target number of occupied square metres to be attained in the next period. A higher target may be deemed more suitable if the population is considered to be in decline.

2.2.2.2 Population extent

The dimensions of each population's extent were approximated during the baseline survey as a single broad envelope encompassing the entire population (e.g. 25 m x 25 m) rather than defined more precisely by GIS mapping. While this enables a broad-brush comparison to be made between population extents measured over two successive monitoring periods, mapping the population envelope more accurately using GIS is a more useful gauge of the extent of the population and also defines the search area for surveyors in the next monitoring period. In future monitoring periods it is recommended that comparisons be made with the current mapped area of the habitat occupied by *D. alpinum* rather than with the more approximate extents used in the baseline survey. To allow for minor differences in GPS accuracy or mapping between surveyors, a target of 90% of the mapped area should be set for sites, the same procedure followed by Muldoon *et al.* (2015) for comparing mapped areas of *Saxifraga hirculus* between monitoring periods.

2.2.2.3 Domin cover of Diphasiastrum alpinum

Cover of *D. alpinum* was recorded as a Domin value in monitoring stops by Smyth *et al.* (2015) and this was used as the target to be met by successive monitoring assessments. The current survey recorded cover values as percentage of the plot, rather than as Domin. The baseline Domin targets were retained as targets for the current survey but converted to their equivalent percent values.

2.2.2.4 Number of shoots

The target for the number of shoots per population was to meet or exceed the number of shoots recorded during the baseline survey (Smyth *et al.*, 2015). Shoot targets were expressed in terms of population size classes, which were determined according to the scale proposed by Evans & Arvela (2011), shown in Table 2. Population size class was judged following this review to be an appropriate method of measuring and comparing population shoot numbers between monitoring periods.

Table 2 Classes for reporting population size (adapted from Evans & Arvela, 2011).

Class	Number of shoots
1	1-50
2	51-100
3	101-500
4	501-1,000
5	1,001-5,000
6	5,001-10,000
7	10,001-50,000
8	50,001-100,000
9	100,001-500,000
10	500,001-1,000,000

2.2.2.5 Presence of sporing plants

The presence of sporing *D. alpinum* plants (fertile cones seen in the population) is an additional indicator of population health and this criterion was retained.

2.2.2.6 Revised Population *assessment criteria for* Diphasiastrum alpinum

The following is the revised list of criteria

- Total number of colonies or occupied square metres (OSMs): For the current monitoring period, comparison will be made with the total number of colonies recorded during the baseline survey, but from next monitoring period onwards, comparison will be made with the number of occupied square metres recorded during the current survey
- Population extent: For the current monitoring period, comparison will be made with the approximate population envelope dimensions given in the baseline survey, but from next monitoring period onwards, the comparison will be made with the mapped extent recorded during the current survey
- Percent cover of *D. alpinum* in the monitoring stop
- Estimated number of *D. alpinum* shoots (as population size class), and
- Presence of sporing *D. alpinum* plants.

2.2.3 Review of *Habitat for the species* assessment criteria

The *Habitat for the species* assessment criteria used by Smyth *et al.* (2015) for *D. alpinum* were reviewed

- Average shoot length across all plots
- Domin cover of *Calluna vulgaris*
- Domin cover of bare rock
- Domin cover of total vegetation, and
- Fossitt (2000) habitat.

2.2.3.1 Average shoot length

The average length of five shoots in each monitoring plot was used in the baseline survey as a proxy for grazing pressure. However, in view of the robust and generally unpalatable nature of *D. alpinum*, the plant itself is not considered to be under direct threat from grazers, unless by mechanical damage from trampling. It is also difficult to measure shoot length consistently, both within and between surveys, as stems are rhizomatous and often covered by a layer of soil, peat or plant debris that makes it difficult to

locate the base of the plant without damaging it. Therefore shoot length is not considered to be a reliable criterion with which to gauge grazing pressure.

Average sward height was considered for use as a substitute criterion for shoot length. However, given the frequently wind-clipped nature of the upland habitats in which *D. alpinum* preferentially grows, it was concluded that using sward height as a measure of overgrazing could be misleading: very short vegetation is frequent in montane heath even in the absence of grazing.

It is proposed that average shoot length be dropped as a criterion to assess *Habitat for the species.* Grazing pressure may best be assessed in the context of *D. alpinum* and its habitat by recording the pressures and threats operating at the site rather than by using proxy measures such as shoot length or sward height.

Shoot length data should still be gathered during monitoring as some trends may only become evident after several monitoring periods.

2.2.3.2 Domin cover of Calluna vulgaris

Following analysis of baseline survey data, Smyth *et al*. (2015) reported that *D. alpinum* populations were more abundant where the cover of *Calluna vulgaris* had values up to 50%. A target for *C. vulgaris* cover of Domin 5-7, which corresponds to 11-50%, was set in the baseline survey (Smyth *et al*., 2015).

In view of the fact that *D. alpinum* can also occur in 6150 Siliceous Alpine and Boreal grasslands, where *Calluna vulgaris* is not a characteristic species, an amended target of ≤50% is proposed. Therefore the criterion is designed to identify sites where cover of *C. vulgaris* is considered to be too high for *D. alpinum*.

2.2.3.3 Domin cover of bare rock

Smyth *et al.* (2015) reported, following analysis of baseline data, that *D. alpinum* populations were found where the cover of "bare surface/rock" had values up to 10%. However, the amount of bare rock in a habitat may be due to landscape factors such as exposure and slope rather than unsuitable management, and therefore may not be indicative of habitat which is unsuitable for *D. alpinum;* nor is it amenable to improvement by conservation measures, particularly in exposed upland montane heath.

Diphasiastrum alpinum is an upland species that habitually occupies exposed and wind-clipped habitat, primarily montane heath. Fossitt (2000) describes montane heath as being associated with shallow mineral soils or peats that are eroding and unstable, but also found on areas of loose rock and coarse sediment on mountain tops and ridges. Therefore bare rock is considered to be an intrinsic characteristic of montane heath and there is no requirement to set an upper limit on its cover. Criteria targets should serve to identify *D. alpinum* habitat that is under pressure from an impact (such as overgrazing) that can be addressed by appropriate conservation measures. While cover of bare rock may not be suitable to assess this, cover of disturbed bare ground would be. It is proposed that the bare rock criterion be replaced with "%cover of disturbed bare ground" and that an upper limit of 10% (Domin 4) be set for the current assessment period. This should be reviewed in future monitoring periods to assess its continued suitability with the collection of more data from *D. alpinum* habitat.

2.2.3.4 Domin cover of total vegetation

Total vegetation cover is the corollary of total cover of bare rock/bare ground in that the two combined should reach 100%. As it is not considered necessary to assess rock cover because neither high nor low values prove that the habitat is under pressure, for the same reason it is considered unnecessary to assess vegetation cover. It is therefore proposed that this criterion be dropped.

2.2.3.5 Fossitt (2000) habitat

Habitat type according to Fossitt (2000) was not listed under the *Habitat for the species* criteria in the main report of Smyth *et al.* (2015) but was included in the individual site reports. It is proposed that this criterion be dropped, as the conditions in which *D. alpinum* occurs are identical to the conditions that form HH4 Montane heath; to a large extent the presence of *D. alpinum* in a habitat helps to define it as HH4.

2.2.3.6 Additional criteria

EU reporting guidelines state that it is often enough to assess the quality of the species' habitat via the pressures operating on it, with the "direct measurement of the physical quality of the species' environment" not always necessary (DG Environment, 2017). Therefore, it is proposed that the impact of pressures operating on the habitat be added as an additional assessment criterion for the habitat for the species, with a target of "low or absent".

2.2.3.7 *Revised* Habitat for the species *assessment criteria for* Diphasiastrum alpinum

The revised list of *Habitat for the species* criteria for *D. alpinum* is as follows (targets in parentheses)

- Percent cover of *Calluna vulgaris* (≤50%)
- Percent cover of disturbed bare ground (≤10%), and
- Impact of negative pressures on habitat (low or absent).

2.3 Methodology

2.3.1 Site selection

Sites to be surveyed were selected by NPWS to reflect the geographical spread of the species, as well as to address data-deficient populations. Table 3 lists the sites and Figure 3 shows their distribution. Five *D. alpinum* populations were surveyed. Four had been surveyed by Smyth *et al*. (2015) and required a monitoring survey. One site had not been previously surveyed and required a baseline survey. Note that some site names have been updated to reflect their location more accurately. The name by which it was identified in the baseline survey is indicated in parentheses.

Table 3 *Diphasiastrum alpinum* sites surveyed for the Rare Plants Monitoring Survey 2015-18.

Site ID	Site name	County	Survey type	SAC code	SAC name
DA01	Edenadooish, Derryveagh Mountains	Donegal	Monitoring	002047	Cloghernagore Bog and Glenveagh National Park
DA02	Mullach Glas (Maumturk Mountains)	Galway	Monitoring	002008	Maumturk Mountains
DA03	Turlough Hill, north of reservoir (Camaderry)	Wicklow	Monitoring	002122	Wicklow Mountains
DA04	Kippure	Wicklow	Monitoring	002122	Wicklow Mountains
DA05	Purple/Shehy Mountain	Kerry	Baseline	000365	Killarney National Park, Macgillycuddy's Reeks and Caragh River Catchment

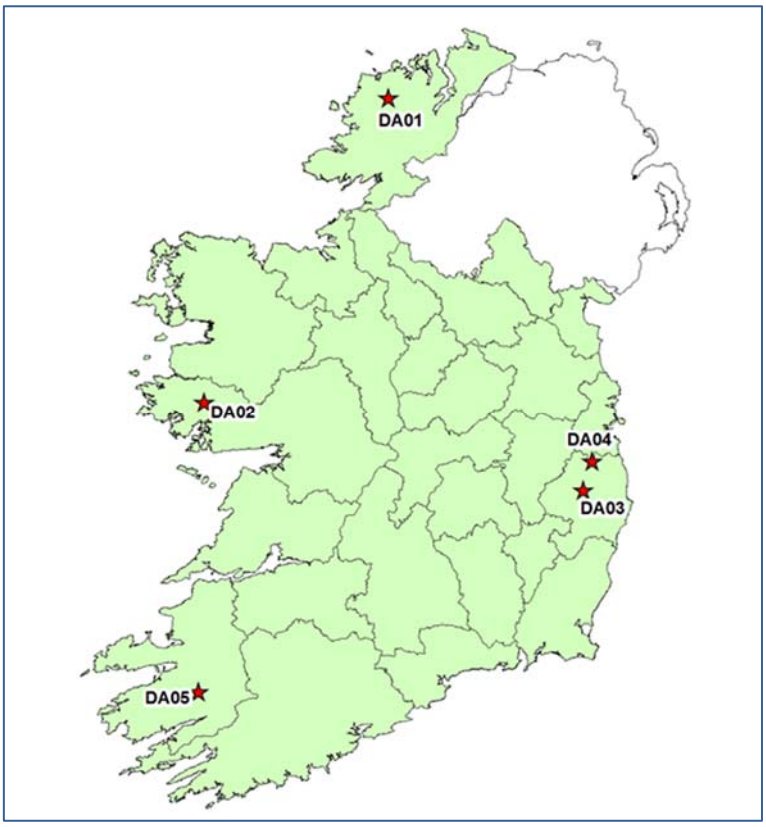

Figure 3 Location of *Diphasiastrum alpinum* sites surveyed for the Rare Plants Monitoring Survey 2015-18.

2.3.2 Survey preparation

2.3.2.1 Site packs

A site pack was assembled for each site, containing the baseline site report produced by Smyth *et al*. (2015) or, where this was not available, any information on previous records for the species at the site. Also included was an aerial photograph showing the location of the species recorded in previous surveys at the site. Finally, a blank site summary data sheet was attached, to be completed by the ecologists at the end of the site survey (see Appendix 1).

2.3.2.2 Trimble Nomads

Hand-held Trimble Nomads were set up to record GPS waypoints in ArcPad and to record monitoring stop and vegetation data in Turboveg CE [Alterra, The Netherlands]. The shapefiles created during the baseline survey were uploaded onto the Trimbles to enable the surveyors to navigate directly to the monitoring stops. Any additional points recorded on other surveys were also uploaded as a shapefile.

2.3.3 Site surveys

Sites were surveyed between 18 April 2016 and 17 August 2018. Survey teams consisted of two ecologists.

The survey methodology for *D. alpinum* can be broadly divided into four main tasks

- Conduct count of square-metre patches of the species to calculate population-specific data
- Establish and map the extent of the population
- Record monitoring stop data, and
- Complete the site summary data sheet including impact recording.

During all stages of the survey, surveyors also recorded any features or species of interest, botanical or otherwise, although these were not the focus of the survey. Where possible, these were photographed. Photographs of site features (e.g. impacts, management) were taken, as appropriate, for inclusion in the project's Image Databank.

2.3.3.1 Count of occupied square metres

The number of occupied square metres of *D. alpinum* in each site was determined as described in Section 2.2.1.

2.3.3.2 Population extent

The outer envelope of the species extent was recorded as waypoints on the Trimble's GPS. This involved walking through the site and recording the occurrence of the species. The outer limits of the population were digitised with the aid of these points.

2.3.3.3 Monitoring stops

Monitoring stops measuring 1 m x 1 m were delineated on the ground using a measured rope and metal pegs. A GPS waypoint was recorded on the Trimble at every monitoring stop, and photographs were taken, including at least one close-up of the plot's vegetation and another more general view to show the plot in the context of the landscape. Where baseline surveys had previously been carried out, monitoring stops were generally located as close as possible to the original baseline stops, using the baseline stop shapefile on the Trimble to navigate directly to them. Relocation of stops was sometimes necessary, e.g. to achieve a better spread of recording.

Data to assess *Population* and *Habitat for the species* were recorded at every monitoring stop, together with a full relevé (plant species list and species abundances). Monitoring stop data specifically required for carrying out assessments were: cover of *D. alpinum*, number of shoots, presence of fertile cones, cover of *Calluna vulgaris* and cover of disturbed bare ground. When counting shoots, individual shoots were traced back to the base of the plant, rather than from a division occurring part-way along the stem (branches).

Other structural data, such as cover of bryophytes and presence of leaf litter, were also recorded but not used in the assessment. Appendix 2 gives the full list of data items recorded in Turboveg at each *D. alpinum* monitoring stop.

2.3.3.4 Site summary data

The site summary data sheet (Appendix 1) was filled out by the surveyors after each site survey was concluded.

Site-level criteria included general population data. The total number of occupied square metres (OSMs) was entered in place of the total number of colonies. Population extent was filled out after the site had been digitally mapped in GIS. "Sporing plants present" was marked "Y" if any fertile plants had been seen in the population, regardless of whether these were inside or outside of monitoring stops. Unless the population was small enough for a full count of shoots to be carried out, the estimated number of shoots was calculated as:

(Average number of shoots of *D. alpinum* from plots) x (number of OSMs)

Population size class was determined according to the scale proposed by Evans & Arvela (2011) (see Table 2 in Section 2.2.2.4) and used by Smyth *et al.* (2015).

Impacts and activities occurring on site in the vicinity of the target species were recorded on the site summary sheet. The impact codes from the 2007-2012 monitoring period (Ssymank, 2011) were used because the codes for the 2013-2018 reporting period were not available at the commencement of this project. Activity details logged comprised

- a description of the activity
- its influence (positive, negative or neutral)
- intensity (high, medium or low)
- the percentage of the supporting habitat affected, and
- the source of the impact, whether originating from within or outside of the habitat.

2.3.4 Assessments

2.3.4.1 Population *assessment*

Following the review of criteria in Section 2.2.2, the *Population* parameter for *D. alpinum* was assessed using five criteria, which are shown, together with their targets, in Table 4. Occupied square metres rather than colonies were counted in this survey. Therefore criterion 1 (a) *No. of colonies* should be discontinued after the current monitoring period and criterion 1 (b) *No. of occupied square metres* should be used instead, with the targets set at 80% of the occupied square metre counts recorded in the current survey to allow for surveyor variability.

Table 4 *Population* criteria and targets for *Diphasiastrum alpinum* sites surveyed in the Rare Plants Monitoring Survey 2015-18.

	Criterion	Scale of assessment	Target
1 (a)	No. of colonies	Population	No decrease from previous monitoring period
1 (b)	No. of OSMs*	Population	No decrease from previous monitoring period
2	Population extent (m^2)	Population	No decrease from previous monitoring period
3	Cover of *D. alpinum*	Average percent cover across monitoring stops	No decrease from previous monitoring period
4	Population size class	Population (based on average shoot count from monitoring stops)	No decrease from previous monitoring period
5	Fertile cones	Population	Present
Population assessment			Favourable (Green): 4-5 passes
			Unfavourable-Inadequate (Amber): 2-3 passes
			Unfavourable-Bad (Red): 0-1 pass

* Future monitoring periods should use this criterion occupied square metres (OSMs) rather than the number of colonies to assess population

Targets for the first four criteria were set on a site-specific basis, based on the analysis of data from baseline surveys (Smyth *et al.*, 2015). Site-specific targets are shown in the individual site reports in Appendix 4.

Site DA05 Purple/Shehy Mountain had not been surveyed by Smyth *et al*. (2015) and therefore had no site-specific targets set. Following the procedure used by Smyth *et al*. (2015), the targets to be met by DA05 in the next monitoring period were set after the site was surveyed during the current survey. The target for the number of occupied square metres was set at 80% of the count recorded in the current survey. The target for the population extent was set at 90% of the extent digitised in the current survey.

Expert judgement could be exercised to pass a marginally failing criterion where deemed appropriate, such as where all other attributes were passing and there were no obvious anthropogenic causes for failure, or due to prior knowledge of the site.

2.3.4.2 Habitat for the species *assessment*

Following the review of criteria described in Section 2.2.3, the habitat for *D. alpinum* was assessed using three criteria, the targets for which are shown in Table 5.

As for the *Population* assessment, expert judgement was applied to pass a marginally failing criterion where appropriate.

Table 5 Assessment criteria and targets for *Habitat for the species* for *Diphasiastrum alpinum* sites surveyed in the Rare Plants Monitoring Survey 2015-18.

	Criterion	Scale of assessment	Target
1	Cover of *Calluna*	Average percent cover across monitoring stops	≤50%
2	Cover of bare ground	Average percent cover across monitoring stops	≤10%
3	Impact of negative pressures	Population extent	Low or absent
Habitat for the species assessment		Favourable (Green): 3 passes	
		Unfavourable-Inadequate (Amber): 2 passes	
		Unfavourable-Bad (Red): 0-1 pass	

2.3.4.3 Future prospects *assessment*

EU guidance states that the *Future prospects* parameter "should be evaluated by individually assessing the expected future trends and subsequently future prospects of each of the other three parameters [*Range*, *Population* and *Habitat for the species*], taking primarily into account the current conservation status of the parameter, threats (related to the parameter assessed) and the conservation measures being taken or planned for the future. Once the future prospects of each of the other three parameters have been evaluated, they should be combined to give the overall assessment of *Future prospects*" (DG Environment, 2017).

Future prospects were assessed at the site level by evaluating the future prospects and future expected trend of *Population* and *Habitat for the species* at each site, and examining the current pressures, future threats and other activities (e.g. beneficial management practices) operating on the species and its habitat. Guidance provided by the EU (DG Environment, 2017) was followed to determine the future trends and future prospects of each parameter. The evaluation matrices from the guidance document were used and are shown in Tables 6 and 7.

It is important to note that these activities are recorded in the context of the effect on the species rather than on its habitat *per se*. For example, some activities, such as disturbance in heath, might be damaging to the heath habitat in which the species is growing but beneficial to the species itself (e.g. by creating niches for germination or by reducing competition).

For a species to be assessed as having Favourable *Future prospects*, its prospects had to be judged to be good, with no severe impacts expected from threats and the population and its habitat expected to be stable or improving in the long term. For it to be assessed with Unfavourable-Bad *Future prospects*, its prospects were judged to be bad, with severe impacts expected from threats and the species and/or its habitat expected to decline or disappear in the long term. An assessment of Unfavourable-Inadequate *Future prospects* was between these two extremes.

To help evaluate *Future prospects* according to the above guidance, the pressures, threats (all current pressures were also regarded as threats) and positive activities occurring on each site were recorded according to the impact codes of Ssymank (2011) (the 2017 impact codes were not available at the commencement of the project). The magnitude of the impact (high, medium or low), influence (positive, negative or neutral) and percentage area of habitat affected were also noted.

Table 6 Assessing the future prospects of a parameter (Steps 1 and 2) (reproduced from DG Environment, 2017).

Step 1 Future trends of parameters			**Step 2 *Future prospects* of a parameter**	
Balance between threats and measures	Predicted future trend reflects balance between threats and measures	Current conservation status of parameter	Resulting future prospects of parameter (over next 12 years)	
Balance between threats acting on the parameter (mostly threats with insignificant impact and/or Medium impact threats) and conservation measures; no real change in status of the parameter expected	overall stable	Favourable	good	
		Unfavourable-inadequate	poor	
		Unfavourable-bad	bad	
		Unknown	unknown	
Threats expected to have negative influence on the status of the parameter (mostly High or Medium impact threats), irrespective of measures taken	negative / very negative	Favourable	poor (negative)	bad (very negative)
		Unfavourable-inadequate	poor (negative)	bad (very negative)
		Unfavourable-bad	bad	
		Unknown	poor (negative)	bad (very negative)
None (or only threats with insignificant impact) and/or effective measures taken: positive influence on the status of the parameter expected	positive / very positive	Favourable	good	
		Unfavourable-inadequate	poor (positive)	good (very positive)
		Unfavourable-bad	poor (positive)	good (very positive)
		Unknown	poor (positive)	good (very positive)
Threats and/or measures taken unknown or interaction not possible to predict	unknown	Favourable	unknown	
		Unfavourable-inadequate		
		Unfavourable-bad		
		Unknown		

Table 7 Combining the evaluation of the three parameters to give *Future prospects* for a species (reproduced from DG Environment, 2017).

Assessment of *Future prospects*	Favourable	Unfavourable-inadequate	Unfavourable-bad	Unknown
Prospects of parameter: *Range*, *Population* and *Habitat for the species*	All parameters have 'good' prospects OR prospects of one parameter 'unknown', the other prospects' good'	Other combination	One or more parameters have 'bad' prospects	Two or more 'unknown' and no parameter with 'bad' prospects

2.3.4.4 Site conservation status and overall conservation status assessment

The conservation status assessment for *D. alpinum* at each site was evaluated based on the results of all three parameters, according to the matrix in Table 1. The overall conservation status of *D. alpinum* at sites surveyed during the Rare Plants Monitoring Survey was then assessed using the guidance provided by the EU (DG Environment, 2017).

2.4 Results

2.4.1 *Population* assessment

The *Population* assessment results for *D. alpinum* sites are shown in Table 8. All sites received a Favourable assessment. Recorded values for all criteria and sites are given in the site reports in Appendix 4.

Table 8 Population assessment results for *Diphasiastrum alpinum* sites surveyed during the Rare Plants Monitoring Survey 2015-18. n = number of stops. OSMs = occupied square metres. Fav = Favourable.

	Criterion	DA01 (*n*=2)	DA02 (*n*=4)	DA03 (*n*=2)	DA04 (*n*=3)	DA05 (*n*=3)
1	No. of colonies/ OSMs	Pass	Pass	Pass	Pass	Pass
2	Population extent	Pass	Pass	Pass	Pass	Pass
3	Cover of *D. alpinum*	Fail*	Fail*	Fail*	Fail*	Pass
4	Population size class	Fail*	Pass	Pass	Pass	Pass
5	Fertile cones	Pass	Pass	Pass	Pass	Pass
	No. of passes	3	4	4	4	5
	Passed on expert judgement	5	5	5	5	5
	Population assessment	Fav	Fav	Fav	Fav	Fav

* Failure to meet targets considered to be due to surveyor variability rather than genuine decreases; passed on expert judgement.

2.4.1.1 Number of colonies / Number of occupied square metres

While a direct comparison between the number of colonies counted during the baseline and the number of occupied square metres counted in the current survey could not always be made, it was nevertheless generally evident in the field if the target number of colonies had been met. For example, at DA01 Edenadooish the target number of colonies set during the baseline survey (Smyth *et al*., 2015) was ten, while the total number of occupied square metres counted in the current survey was 23. This figure was deemed to be sufficiently high to encompass at least ten separate colonies. An additional colony was recorded at DA03 Turlough Hill (Camaderry) in the current survey, compared to the baseline. All sites passed this criterion.

2.4.1.2 Population extent

Current extents of populations were found to be broadly similar to the extents recorded in the baseline survey. In two of the four cases where baseline data were available, the population extent was actually higher than recorded during the baseline, due to either genuine expansion, higher success in locating the plant, or slight differences in mapping accuracy/area estimation between the two surveys. While a difference in mapping accuracy may be the case for DA03 Turlough Hill (Camaderry) (increase in population extent from 2.25 m^2 to 3.7 m^2), it is certainly not the case for DA04 Kippure, where the extent of 75 m^2 mapped during the current survey was significantly higher than the area of 8 m^2 mapped in the

baseline survey. However, it is unlikely that the population has expanded to such a degree in less than 10 years and is probably due to searching a larger area for the plant. All sites passed this criterion.

2.4.1.3 *Cover of* Diphasiastrum alpinum

None of the four sites that required monitoring reached the target for percent cover of *D. alpinum* that had been set by the baseline survey. The target was ≥ 11% (i.e. Domin of 5 or higher). Percent cover of the species recorded during the current survey ranged between 2% in DA03 Turlough Hill (Camaderry) to 5% in DA01 Edenadooish. However, one surveyor in the current survey was already familiar with the *D. alpinum* population at DA01 from Ph.D. fieldwork (Hodd, 2012) conducted before the baseline survey was conducted in 2009 and had not seen a decline in species cover over the last ten years, so it is more likely that these shortfalls in cover are due to surveyor variability rather than genuine differences. As clear evidence for a decline was lacking, and no obvious pressures could account for a significant loss in cover, a discretionary pass based on expert judgement was awarded to all four monitoring sites for this criterion.

The only site to achieve a cover greater than 10% in the current survey was the previously unsurveyed DA05 Purple/Shehy Mountain, in which the cover of *D. alpinum* averaged 15% across the three stops recorded.

2.4.1.4 *Population size class (number of shoots)*

An issue was identified in relation to the population size class criterion at one site in particular, DA01 Edenadooish. The number of shoots counted in the baseline survey was significantly higher than the current survey. As noted above, one of the current surveyors was already familiar with the *D. alpinum* population here and had not observed decreases in cover in several visits over the last ten years. On examination of both sets of survey data for the site, including measurements of shoot length, it was thought that the disparity might have arisen due to a difference in how shoots were measured and counted at this site, whether from the base of the plant or counting branches that had divided part way along the stem as separate shoots. The fact that average shoot length recorded in the baseline survey at this site was significantly shorter than that in the current survey lends support to this hypothesis. As *D. alpinum* shoots are often covered by a thin layer of soil, peat or leaf litter, it can be difficult to pin-point the base of the plant. In the absence of an obvious pressure to cause such a severe decline in shoot numbers, and in view of the surveyors having prior knowledge of the site, the disparity was ascribed to surveyor variability and expert judgement was exercised to allow the site to pass this criterion.

The population size class target was ambiguous at site DA02 Mullach Glas (Maumturk Mountains). In the baseline site report the target was "4 (500-1000)" but the result obtained was reported as 3 and given a Pass (Smyth *et al*., 2015). The result obtained in the current survey was also 3 (100-500). As this size class had been allowed to pass in the baseline survey and assessment, the population size class target for the site was adjusted to 3 and the criterion was deemed to have been passed.

2.4.1.5 *Fertile cones*

Fertile cones were recorded at all sites. All sites therefore passed this criterion.

2.4.2 *Habitat for the species* assessment

The *Habitat for the species* assessment results for *D. alpinum* are shown in Table 9. All sites received a Favourable assessment. Recorded values for all sites and criteria are given in the site reports in Appendix 4.

Table 9 Habitat for the species assessment results for *Diphasiastrum alpinum* sites surveyed during the Rare Plants Monitoring Survey 2015-18. Fav = Favourable.

	Criterion	DA01	DA02	DA03	DA04	DA05
1	Cover of *Calluna*	Pass	Pass	Pass	Pass	Pass
2	Cover of bare ground	Pass	Pass	Pass	Pass	Pass
3	Impact of negative pressures	Pass	Pass	Pass	Pass	Pass
	No. of passes	3	3	3	3	3
	Habitat for the species assessment	Fav	Fav	Fav	Fav	Fav

2.4.2.1 *Cover of* Calluna vulgaris

Cover of *Calluna vulgaris* was below the 50% threshold for all populations of *D. alpinum* surveyed. Most of the stops were recorded in 4060 Alpine and Boreal heath habitat, where *C. vulgaris* is a characteristic species. However, two of the monitoring stops at DA05 Purple/Shehy Mountain were recorded in 6150 Alpine and Boreal grassland habitat, and *C. vulgaris* was absent from these two stops.

2.4.2.2 *Cover of bare ground*

All sites passed the cover of bare ground criterion. The highest cover of bare ground was noted at DA02 Mullach Glas (Maumturk Mountains), where the average bare ground cover across the monitoring plots was 5.4%. Some overgrazing by sheep was noted at the site but most of the bare ground recorded was due to exposure.

2.4.2.3 *Impact of negative pressures*

Pressures operating on *D. alpinum* habitat were judged to be low and not impacting severely on the populations surveyed.

2.4.3 *Future prospects* assessment

2.4.3.1 *Pressures, threats and other activities*

Prior to evaluating the *Future prospects* parameter, the activities, both positive and negative, recorded in the *D. alpinum* habitat were examined.

No positive management activities were observed at any of the five *D. alpinum* sites. Non-intensive sheep grazing (A04.02.02) was judged to be having a neutral rather than damaging effect at DA01 Edenadooish and DA03 Turlough Hill (Camaderry). Paths, tracks and cycling tracks (D01.01) were noted outside of the habitat at DA03 but were not deemed currently to be having any effect on the habitat for the species. All other activities noted were considered to be having a negative effect on the species or its habitat. These impacts are shown in Table 10, together with the intensity (high, medium or low), percentage of the habitat affected, and total frequency for each of the activities.

Sheep grazing (A04.02.02) was recorded at all sites, but as a negative impact only at three; while the intensity was never high, it nevertheless affected the entire habitat and is not considered necessary for the management of HH4 Montane heath / 4060 Alpine and Boreal heath habitat, which is usually maintained by exposure rather than grazing.

Walking/Hiking (under code G01.02) was observed at three sites, but always at a low intensity, even though it was noted throughout the entire habitat at all three. As most walkers will stay on the access tracks and the plant generally grows away from these (although this may be because of the effects of trampling), any negative effects from hiking are expected to remain low overall on the remaining plants. Part of the population at DA02 Mullach Glas (Maumturk Mountains), which occurs along the general route of the Maamturks Challenge, is more at risk from trampling by runners during this annual challenge race, but there was no obvious evidence of damage to *D. alpinum*, and no bare ground created as a result of the activity, and it is regarded as a potential threat, probably of low intensity, rather than an actual pressure on the species at present.

Table 10 Frequency of negative impacts, by intensity and percentage (%) of the habitat affected, recorded in the five *Diphasiastrum alpinum* sites. Impact codes are according to Ssymank (2011).

Impact code	Impact description	Intensity				% habitat affected			Total
		High	Medium	Low	Unknown	≤25%	26-75%	>75%	
A04.02.02	Non-intensive sheep grazing		1	2				3	3
G01.02	Walking, horse-riding, non-motorised vehicles		2	1				3	3
K01.01	Erosion	2				1	1		2
M	Climate change				5			5	5
	Total	2	3	3	5	1	1	11	

High-intensity erosion (K01.01) of blanket bog was noted at two sites, possibly as a consequence of historical land-use such as overgrazing or drainage. As this pressure mainly affected blanket bog rather than the primary montane heath habitat of *D. alpinum*, it was not regarded as a significant pressure on the species. Indeed, there is a possibility that montane heath will replace the eroded bog, so in some respects the effect may be slightly positive for *D. alpinum*.

Climate change was recorded at all sites as a negative impact for this upland species. Although the intensity of the impact is unknown, it is nevertheless recognised as a factor that could affect the survival and distribution of the species in the long term. However, the exact time-frame over which this impact will have visible effects is unknown.

2.4.3.2 Future prospects of Population *and* Habitat for the species *parameters*

The future prospects for *Population* and *Habitat for the species* were examined for each of the five *D. alpinum* sites surveyed during the current project. Table 11 shows the results. All sites received a Favourable assessment.

Table 11 *Future prospects* (FP) assessment for the five *Diphasiastrum alpinum* sites surveyed during the Rare Plants Monitoring Survey 2015-18. Pop = Population, HfS = Habitat for the species. Fav = Favourable.

Site	FP of Pop	FP of HfS	FP of *D. alpinum*	Rationale
DA01	Fav	Fav	Fav	No negative pressures noted on this site
DA02	Fav	Fav	Fav	Sheep grazing a negative impact but low level. Potential annual threat of trampling from Maamturks Challenge runners, but no damage currently observed. Overall shoot numbers comparable to baseline values
DA03	Fav	Fav	Fav	Sheep grazing occurring but not having a negative effect on the species. Erosion of blanket bog peat is not adversely affecting *D. alpinum*. Small population but overall shoot numbers are comparable to baseline values
DA04	Fav	Fav	Fav	Sheep grazing a negative impact but low level. Trampling by walkers not thought to be having a direct effect on the species. Overall shoot numbers comparable to baseline values
DA05	Fav	Fav	Fav	Healthy population, suitable habitat in good condition with low disturbance

2.4.4 Conservation status assessment for individual sites

The assessments of the individual parameters at each site were combined according to the evaluation matrix in Table 1 to obtain the conservation assessment for *D. alpinum* at each site (Table 12). This resulted in all five populations receiving a Favourable assessment.

Table 12 Assessment results for the five *Diphasiastrum alpinum* sites surveyed during the Rare Plants Monitoring Survey 2015-18. Fav = Favourable.

Site	*Population*	*Habitat for the species*	*Future prospects*	Overall (site)
DA01	Fav	Fav	Fav	Fav
DA02	Fav	Fav	Fav	Fav
DA03	Fav	Fav	Fav	Fav
DA04	Fav	Fav	Fav	Fav
DA05	Fav	Fav	Fav	Fav

2.4.5 Overall conservation status assessment for Rare Plants Monitoring Survey sites

The assessments of the individual parameters were combined according to the evaluation matrix in Table 1 to obtain the overall conservation assessment for *D. alpinum* at sites surveyed during the Rare Plants Monitoring Survey. Table 13 summarises this result.

Table 13 Summary of the overall conservation status assessment of *D. alpinum* at sites surveyed during the Rare Plants Monitoring Survey (RPMS) 2015-18. FP = Future prospects

Parameter	Conservation status	Trend	FP of parameter
Population	Favourable	Stable	Good
Habitat for the species	Favourable	Stable	Good
Future prospects	Favourable		
Overall Conservation Status Assessment for RPMS sites	**Favourable**	**Stable**	

Following the guidelines for species assessment at a national level (DG Environment, 2017), based on the results presented here and taking into account the estimated future trends of the species populations and habitat based on the threats and positive activities in place, the overall conservation status assessment result for *D. alpinum* at sites surveyed during the Rare Plants Monitoring Survey is **Favourable** and the trend is ***stable***. The following data detailed in this report were used to arrive at this result

- Population numbers remaining stable since the baseline survey
- *Habitat for the species* receiving a Favourable assessment
- Relatively minor pressures occurring on the sites which do not generally appear to be impacting significantly on the habitat in the long term. The issues of grazing and trampling by hikers at some sites in Wicklow, however, will need to be monitored and, if necessary, addressed to ensure that this remains the case.

It should be noted that the overall conservation status assessment for Rare Plants Monitoring Survey sites does not include an assessment of the *Range* parameter. This was assessed in the national conservation assessment of the *Lycopodium* spp. group (NPWS, 2019), which incorporated the combined results of the assessments of *Population*, *Habitat for the species* and *Future prospects* for *Diphasiastrum alpinum*, *Huperzia selago*, *Lycopodiella inundata* and *Lycopodium clavatum*, along with data from other recent surveys of these species.

2.5 Discussion

The overall conservation status assessment of *D. alpinum* at sites surveyed during the Rare Plants Monitoring Survey is Favourable, based on the assessment of population and habitat for the species, and their future prospects, as described in the preceding sections. While there were a number of minor issues with the assessment procedure arising as a consequence of changes to methodology and surveyors, it was considered that overall the populations were in good condition. The number of populations surveyed was small, however, and two were in Co. Wicklow, so further surveys should be carried out to ascertain if this situation is reflected by other populations throughout the rest of the country.

Following the review of the criteria used by Smyth *et al*. (2015) to assess *Population*, all criteria were found to be generally suitable, with minor adjustments made to facilitate comparisons in future monitoring surveys. For example, it is recommended that the number of occupied square metres of habitat be used in future in preference to the number of colonies because of the difficulty in identifying separate colonies in the field. Population extent should be mapped using GIS rather than estimated by eye to give a more accurate picture of the location and extent of occurrence of the species. The other three criteria – average cover of *D. alpinum* (as percentage rather than Domin value), population size class for the number of shoots in the population, and presence of fertile cones – were all retained. On the basis of these criteria, the four populations which had been surveyed during the baseline survey by Smyth *et al*. (2015) were deemed to be essentially unchanged since the previous monitoring period. Some variations were noted in scoring of cover of the species, but as this is the first time the sites have been resurveyed, and by different surveyors, it was considered that the differences could be due to worker variability and sites should not be summarily failed at this time, particularly as there was strong evidence that at least one site well known to one of the current survey team had remained stable since before the baseline survey. Future surveys should help to clarify if this is the case. Targets were set for *Population* assessment criteria for the fifth population, DA05 Purple/Shehy Mountain, surveyed for the first time during the current survey, so that similar comparisons can be made with data from future monitoring periods.

Assessment of habitat for *D. alpinum* is less straightforward as it is not always clear why the species is present in one location but absent from another, even where conditions appear to be similar. To a degree, one can conclude that, if *D. alpinum* is present in an area, then the habitat is suitable. However, one of the purposes of assessing habitat for the species is to try to detect changes that may affect the future occurrence of the species in that habitat. That was the approach taken here in relation to the review of the *Habitat for the species* assessment criteria for *D. alpinum*.

Assessment criteria are usually derived from an analysis of data gathered from locations where a species is already occurring, not from locations where it is absent. Sometimes the reasons for its absence are obvious. For example, *D. alpinum* is an upland species, and the first requirement for the species is high altitude. However, the factors associated with altitude that make a location suitable for *D. alpinum* are less clear – whether these are exposure, maximum/minimum monthly temperatures, lack of competition or some other factor. In other cases, *D. alpinum* is absent from areas that appear to be similar in all other respects to occupied habitat elsewhere. The difference may simply be that spores of *D. alpinum* never reached there, or there could be other factors at play, such as presence of a mycorrhizal associate, known in other clubmoss species to be critical to their survival (Byfield & Stewart, 2007). *D. alpinum* tends to occur in 4060 Alpine and Boreal heath habitat, or the less heathy 6150 Siliceous Alpine and Boreal grasslands. Both habitats occur at high altitudes where exposure is a common feature and vegetation is kept short by wind-clipping rather than by grazing. Grazing may occur but is not required to maintain the habitat, unlike similar habitats at lower altitudes. Exposed, often eroding, peat and soil are often present, though these may be shallow, and high rainfall and humidity keep the heath damp and humid even if soils are freely draining or rocky (Fossitt, 2000). In such a habitat, only plants adapted to tolerate harsh conditions will survive. Competition is likely to be low from more generalist competitors, such as larger grasses and shrub species, so conditions will suit species that are poorer competitors, such as *D. alpinum*. In assessing habitat for the species, the aim is not only to identify suitable habitat but also to flag changes that may affect the occurrence of the species in that habitat in the future.

The first criterion – average shoot length – was designed to act as a proxy measurement of grazing pressure on *D. alpinum*. However, evidence from the current survey does not bear out the premise that increased grazing pressure on *D. alpinum* habitat results in reduced shoot length of the species. There was no evidence that animals preferentially grazed *D. alpinum* plants. Even in sites where grazing was judged by surveyors to be a negative pressure, shoot lengths had not diminished between the baseline survey and the current survey and were not found to be a reliable predictor of grazing pressure. Longer shoot lengths were sometimes found in the current survey (compared to the baseline) where grazing was considered to be a medium-intensity negative pressure, and shorter shoot lengths were found

where it was deemed to be neutral. Difficulties with consistency in measuring shoot length may have been an added complicating factor. While shoot length is not recommended for use as an assessment criterion for *Habitat for the species*, it is nevertheless recommended that it continue to be recorded as structural data that may give further insight into *D. alpinum* population health in future monitoring periods.

The decision by Smyth *et al*. (2015) to impose an upper limit on *C. vulgaris* cover was supported by the current survey, and the threshold of 50% was maintained. However, the current survey had recorded *D. alpinum* in both 4060 Alpine and Boreal heath and 6150 Siliceous Alpine and Boreal grassland habitats. While *C. vulgaris* is a characteristic species of the former, the latter is defined partly by the absence of *C. vulgaris*. Therefore the lower threshold of 11% *C. vulgaris* cover set by Smyth *et al*. (2015) was not appropriate for all cases, hence the decision to remove the requirement for *C. vulgaris* to be present by changing the lower threshold to 0%.

The cover of bare rock criterion was replaced by Cover of disturbed bare ground as the latter is more likely to be caused by negative pressure on the habitat and its species. It is important that disturbance be taken into account when estimating cover of bare ground, although it is acknowledged that the distinction between naturally occurring bare ground and that caused by disturbance is not always clear. This criterion aims to assess occurrence of bare ground created by pressures such as high levels of grazing or excessive trampling from hikers. The upper limit of 10% used in the current assessment is based on a small pool of monitoring plots and should be subject to review in the next monitoring period.

The Fossitt (2000) habitat criterion was not included as an assessment criterion in the main report by Smyth *et al*. (2015) but was listed as a criterion in the site reports, with a target of HH4 Montane heath set for the four *D. alpinum* sites previously surveyed. This is not a habitat characteristic that can be changed by the implementation of conservation measures, and *D. alpinum* can also occur in GS3 Dry-humid acid grassland-type habitat, in situations where 6150 develops. Furthermore, the occurrence of *D. alpinum* in high-altitude heath will help to define HH4 Montane heath habitat, so the logic of assessing the habitat according to Fossitt (2000) habitat is, in this case at least, circular. However, the habitat category, both according to Fossitt (2000) and to EU Annex I category, should continue to be recorded as additional relevant information on the species, though not used in the assessment.

Habitat for the species was further assessed by examining the pressures on the species and its habitat at the five sites, and at all sites the pressures were considered low enough to have no significant impact on *D. alpinum*. The two main current pressures noted were sheep grazing and walking/hiking. The former was observed at all five sites, but as a negative impact only at three sites. The latter was observed at three sites and recorded as a negative at all three; however, the impact was always regarded as low.

Future prospects were based on a combination of the *Population* and *Habitat for the species* assessments and the threats operating on the species and its habitat. A number of potential threats were identified that might have an impact on the populations in the future, such as that posed by the annual Maamturks Challenge, but there was no evidence that these were currently a serious pressure on the species or its habitat as no negative effects were noted during the current survey. Because *D. alpinum* was generally found growing away from the main trails, it is considered that, as long as the trails do not expand further, the impact should be minimal. There is, of course, the possibility that the plant is growing away from the main trails because of the impact of trampling, which would clearly indicate a negative impact if it were found to be true. It would be a worthwhile exercise to impose some small barrier or exclosure to prevent walkers or grazers from accessing small areas that are currently trampled, to observe if *D. alpinum* would re-establish in these locations. If it did, this would be proof that trampling is having a measurable negative effect on the species. In the meantime, both grazing and hiking continue to be regarded as threats, and future monitoring surveys should elucidate whether or not they are having a long-term negative impact on the species.

The overall conservation status assessment of *D. alpinum* at sites surveyed during the Rare Plants Monitoring Survey based on *Population*, *Habitat for the species* and *Future prospects* is evaluated as

Favourable as the populations appeared to be stable (i.e. similar to the baseline survey), key characteristics of the species' habitat were within the thresholds defined by the assessment criteria, and the predicted effects of threats to the species within its habitat niche were not thought to be of sufficient severity to bring about a decline in the species.

General recommendations regarding the future surveying of this species are mainly related to further refinements to the assessment criteria. The new *Habitat for the species* criteria and their thresholds should be re-evaluated in the next monitoring period, particularly if more populations can be surveyed. Data relating to cover of the species should also be reviewed comparing this survey's data with future surveys to assess how big a part is played by surveyor variability. If it is thought to be an issue, the use of less subjective measures, such as frequency within a 25-square or 100-square 1 m^2 grid, could be considered, although it is more time consuming to record this way. Permanent plots and fixed point photography are other measures that could be explored to try to reduce variability between surveys.

3 *Huperzia selago*

3.1 Species description

Of the four clubmoss target species for this project, *Huperzia selago* (Fir Clubmoss) is the most widespread and frequent, but the number of sites at which it has been recorded over the years has declined due to pressures such as habitat loss, overgrazing, burning and agricultural improvement (NPWS, 2013). It occurs in a much wider range of habitats than *Diphasiastrum alpinum*, although it does co-occur with both *D. alpinum* and *L. clavatum* (see Appendix 3); unlike them, however, it also occurs in more lowland situations. In Ireland, *H. selago* is mainly found in the western half of the country and occurs on mountain cliffs, montane heath, wet heath and lowland bogs (Parnell & Curtis, 2012; Smyth *et al*., 2015), as well as raised bog and woodland. Preston *et al*. (2002) describe its overall distribution in Britain and Ireland as stable, however, there is evidence of decline in the midlands of Ireland in particular, where there are many pre-1970 records for the species but few dated after this.

H. selago is listed as Least Concern in the most recent Red List (Wyse Jackson *et al*., 2016) and neither does it appear to be threatened globally, as it is not listed on the IUCN Red List of Threatened Species (IUCN, 2019). An examination of distribution data collated for the most recent Article 17 report on the *Lycopodium* spp. group in Ireland (NPWS, 2019) shows that it has been recorded from 170 hectads, 126 of these since 2002 (BSBI, 2015-2018, 2018; NBDC, 2018; NPWS, 2018). While the species is not particularly rare in Ireland and can extend over large areas of habitat where it occurs, there is nevertheless a dearth of information regarding its populations, possibly because of this relative lack of rarity compared to other clubmoss species. Because such information is lacking, the 2007-2012 national population assessment for the species used the number of hectads in which it occurred as a measure of the number of individual populations (NPWS, 2013; Smyth *et al*., 2015). More information has been forthcoming during the current monitoring period, with recording surveys by the BSBI in particular helping to fill some of the gaps in distribution (BSBI, 2018).

Figure 4 *Huperzia selago* on eroding peat at Turlough Hill (Camaderry). Photo by Rory Hodd.

3.2 Review of survey methodology and assessment criteria

3.2.1 Definition of a colony

In Smyth *et al*. (2015), a colony was taken as the basic unit of a clubmoss population, being defined as a "discrete, unconnected, measurable patch of the species." While the problem with counting colonies of *D. alpinum* lies in the connection between plants by underground stems, the issue with *H. selago* is the reverse in that it occurs as many individuals or small clumps which may, under the definition above, be regarded as separate colonies. Full counts of colonies of *H. selago*, therefore, could be extremely time-consuming and beyond the scope of the current survey.

For this reason, the same procedure of counting occupied square metres as described in Section 2.2.1 for *D. alpinum* was adopted. Within each occupied square metre, even if several small patches of the plant were present, the count of squares was still only one; conversely, if there was a continuous swathe of the plant covering more than one square metre, the number of occupied square metres was more than one (see Figure 2). This was deemed to be the most consistent method for fieldworkers to follow within and between surveys, and also allowed better estimation of the area covered by the plant and the number of shoots in the population when data were extrapolated from monitoring stops to population level.

To calculate the total area covered by *H. selago* and number of shoots in the population the following procedure was used

- Count the number of occupied square metres
- Record the appropriate number of 1 m^2 monitoring stops, up to a maximum of ten
- Estimate the total area covered by *H. selago* in square metres as the average percent cover of *H. selago* per monitoring stop multiplied by the total number of occupied square metres counted
- Estimate the total number of shoots as the average number of shoots per monitoring stop multiplied by the total number of occupied square metres counted.

3.2.2 Review of *Population* assessment criteria

The *Population* assessment criteria used by Smyth *et al.* (2015) for *H. selago* were reviewed

- Total number of colonies
- Population extent (combined area of occupancy of colonies)
- Domin cover of *H. selago* species in the monitoring stop
- Estimated number of *H. selago* shoots (as population size class), and
- Presence of sporing *H. selago* plants.

3.2.2.1 Total number of colonies

Section 2.2.1 described the revised method used to quantify the extent of the plant in the current survey, i.e. using occupied square metres rather than colonies. The site-specific targets for colony numbers set in the baseline survey therefore no longer apply, and the number of occupied square metres counted during the current survey can be used as the basis for new targets. To allow for surveyor variability between monitoring periods, a threshold of 80% of the current number of occupied square metres should be used as the target number of occupied square metres to be attained in the next period.

3.2.2.2 Population extent

The dimensions of each population's extent were approximated during the baseline survey as a single broad envelope encompassing the entire population (e.g. 100 m x 50 m) rather than defined exactly by GIS mapping. While this enables a broad-brush comparison to be made between population extents measured over two successive monitoring periods, mapping the population envelope more precisely

using GIS is a more useful gauge of the extent of the population and also defines the search area for the next monitoring period. In future monitoring periods it is recommended that comparisons be made with the current mapped area of the habitat occupied by *H. selago* rather than with the more approximate extents used in the baseline survey. However, it should be noted that, for *H. selago* in particular, defining population extent can be problematic as the species often has a continuous distribution over whole mountain sides and in some cases arbitrary stopping points may need to be chosen, such as the edge of a cliff or plateau. Thus, the presence of *H. selago* outside the mapped population extent in future monitoring periods may not necessarily signify an expansion of the population.

To allow for minor differences in GPS accuracy or mapping between surveyors, a target of 90% of the mapped area should be set for sites, the same procedure followed by Muldoon *et al.* (2015) for comparing mapped areas of *Saxifraga hirculus* habitat between monitoring periods.

3.2.2.3 Domin cover of Huperzia selago

Cover of *H. selago* was recorded as a Domin value in monitoring stops by Smyth *et al*. (2015). This was used as the target to be met by successive monitoring assessments. The current survey recorded cover values as percentage of the plot, rather than as Domin. The baseline Domin targets were retained as targets for the current survey but converted to their equivalent percent values.

3.2.2.4 Number of shoots

The target for the number of shoots per population was to meet or exceed the number of shoots recorded during the baseline survey (Smyth *et al*., 2015). Shoot targets were expressed in terms of population size classes, which were determined according to the scale proposed by Evans & Arvela (2011), shown in Table 2 (see Section 2.2.2.4). Population size class was judged following this review to be an appropriate method of measuring and comparing population shoot numbers between monitoring periods.

3.2.2.5 Presence of sporing plants

The presence of sporing *H. selago* plants (fertile shoots seen in the population) is an additional indicator of population health and this criterion was retained.

3.2.2.6 Revised Population *assessment criteria for* Huperzia selago

The following is the revised list of criteria

- Total number of colonies or occupied square metres (OSMs): For the current monitoring period, comparison will be made with the total number of colonies recorded during the baseline survey, but from the next monitoring period onwards, comparison will be made with the number of occupied square metres recorded during the current survey
- Population extent: For the current monitoring period, comparison will be made with the approximate population envelope dimensions given in the baseline survey, but from next monitoring period onwards, the comparison will be made with the mapped extent recorded during the current survey
- Percent cover of *H. selago* in the monitoring stop
- Estimated number of *H. selago* shoots (as population size class) and
- Presence of sporing *H. selago* plants.

3.2.3 Review of *Habitat for the species* assessment criteria

The *Habitat for the species* assessment criteria used by Smyth *et al.* (2015) for *H. selago* were reviewed

- Average shoot length across all plots
- Domin cover of *Calluna vulgaris*
- Domin cover of bare rock
- Domin cover of total vegetation, and
- Fossitt (2000) habitat.

3.2.3.1 Average shoot length

In Smyth *et al*. (2015), the average length of five shoots in each monitoring plot was calculated and used as a proxy for assessing grazing pressure. The validity or otherwise of using shoot length as an assessment criterion for *H. selago* was tested after survey data were gathered. As for *Diphasiastrum alpinum*, shoot length did not appear to be a reliable attribute by which to gauge grazing pressure. A drop in shoot length was sometimes noted between the baseline survey and the current survey, even in the absence of grazing pressure, but conversely, heavy grazing at some sites did not bring about a reduction in average shoot length. Furthermore, because of their erect growth habit, shallow roots and non-rhizomatous growth, *H. selago* plants tend to be uprooted easily by grazers rather than remaining rooted in the ground with grazed shoot tips (O. Daly, pers. comm.); therefore the same grazed plants cannot be measured over several years. Average sward height was likewise variable and, as for *D. alpinum* sites, many upland *H. selago* sites surveyed had short swards because of the effects of exposure rather than as a result of grazing.

Therefore, it is proposed that shoot length be dropped as a criterion to assess habitat for *H. selago*. Grazing pressure is best assessed in the context of the species and its habitat as a whole by recording the pressures and threats operating on the species at the site level rather than by using proxy measures such as shoot length or sward height. However, as for *D. alpinum*, it is recommended that average shoot length continue to be recorded over successive monitoring periods as part of the structure of the population.

3.2.3.2 Domin cover of Calluna vulgaris

Following analysis of baseline survey data, Smyth *et al*. (2015) reported that *H. selago* occurs in higher densities where "*Calluna vulgaris* is a dominant feature of the vegetation occurring with a cover value up to 50%". However, this was not consistently borne out by the data recorded during the current survey: the amounts of *H. selago* recorded were generally low, and the cover values of *C. vulgaris* varied widely, even between populations with similar cover of *H. selago*.

In view of the fact that *H. selago* can occur in such a wide range of habitats, ranging from heath to scree, it is not considered that the occurrence or cover of *Calluna vulgaris* is a reliable indicator of good *H. selago* habitat. Therefore it is proposed that this criterion be dropped.

3.2.3.3 Domin cover of bare rock

Smyth *et al.* (2015) reported, following analysis of baseline data, that *H. selago* occurred in higher densities where the vegetation cover was intact and there was less than 10% bare surface. However, *H. selago* will frequently occupy niches in rock, or in soil or peat at the base of rocks in heathy habitats, and can occur even on scree and cliffs where other vegetation is absent. Conversely, it can also grow where vegetation cover is almost complete. Therefore, as *H. selago* occupies such a wide range of habitats, with vastly differing cover of bare rock (or bare rock/bare soil), the cover of bare rock is not considered to be a consistent measure of habitat suitability. It is therefore proposed that this criterion be dropped.

3.2.3.4 Domin cover of total vegetation

Total vegetation cover is the corollary of total cover of bare rock/bare ground in that the two combined should reach 100%. As vegetation cover varies as widely as bare rock in *H. selago* habitat, the same reservations apply to its use as a gauge of habitat suitability. It is proposed that this criterion also be dropped.

3.2.3.5 Fossitt (2000) habitat

This criterion was not listed under the *Habitat for the species* criteria for *H. selago* in the main report of Smyth *et al.* (2015) but was listed as a criterion in site reports. The target given in all cases was HH4 Montane heath. However, *H. selago* is known to occur in many habitats other than HH4, such as ER1 Exposed siliceous rock, HH1 Dry siliceous heath, HH3 Wet heath, PB1 Raised bog, PB2 Upland blanket bog and WN1 Oak-birch-holly woodland. As no single habitat defines the preferred habitat of *H. selago*, it is proposed that this criterion be dropped.

3.2.3.6 Additional criteria

EU reporting guidelines state that it is often enough to assess the quality of the species' habitat via the pressures operating on it, with the "direct measurement of the physical quality of the species' environment" not always necessary (DG Environment, 2017). Therefore, it is proposed that the impact of pressures operating on the habitat be added as an additional assessment criterion for the habitat for the species, with a target of "low or absent".

3.2.3.7 *Revised* Habitat for the species *criteria for* Huperzia selago

Because of the wide range of habitats in which *H. selago* grows, it was not possible, or indeed desirable, to derive a set of generally applicable criteria that would usefully assess the condition of the habitat for the species. Site-specific targets were considered but because of the large number of potential sites for the species this was not thought to be practicable. Therefore, until further data become available from a wider range of *H. selago* sites, it is proposed that *Habitat for the species* for *H. selago* be assessed by examining the pressures, threats and other activities that operate on the habitat and weigh these up on an overall site basis to assess whether there are any issues that affect the continued existence or success of *H. selago* in the habitat. This is in line with EU reporting guidance (DG Environment, 2017) in which it is stated: "In many cases it will be enough to assess the 'Sufficiency of area and quality of occupied habitat' … in relation to the reported pressures. The direct measurement of the physical quality of the species' environment will not be necessary". The revised *Habitat for the species* assessment is therefore carried out by one criterion:

- Impact of negative pressures on habitat (low or absent).

3.3 Methodology

3.3.1 Site selection

Sites to be surveyed were selected by NPWS to reflect the geographical spread of the species. Table 14 lists the sites and Figure 5 shows their distribution. Ten *H. selago* populations were surveyed; all had previously been surveyed during the baseline survey of Smyth *et al.* (2015). Note that some site names have been updated to reflect their location more accurately. The name used in the baseline survey is indicated in parentheses.

Table 14 *Huperzia selago* sites surveyed for the Rare Plants Monitoring Survey 2015-18.

Site ID	Site name	County	Survey type	SAC code	SAC name
HS01	Healy Pass	Cork	Monitoring	000093	Caha Mountains (slight overlap)
HS02	Knockowen	Cork	Monitoring	000093	Caha Mountains
HS03	Meenagoppoge (Derryveagh Mountain)	Donegal	Monitoring	002047	Cloghernagore Bog and Glenveagh National Park
HS04	Muckish Mountain	Donegal	Monitoring	001179	Muckish Mountain
HS05	Tully Mountain	Galway	Monitoring	000330	Tully Mountain
HS06	Lough Doon (Connor Pass)	Kerry	Monitoring	000375	Mount Brandon
HS07	Lough Cruite	Kerry	Monitoring	000375	Mount Brandon
HS08	Skeltia (Maumtrasna Mountain)	Galway	Monitoring	n/a	n/a
HS09	Turlough Hill, north of reservoir (Camaderry, left of reservoir)	Wicklow	Monitoring	002122	Wicklow Mountains
HS10	Kippure	Wicklow	Monitoring	002122	Wicklow Mountains

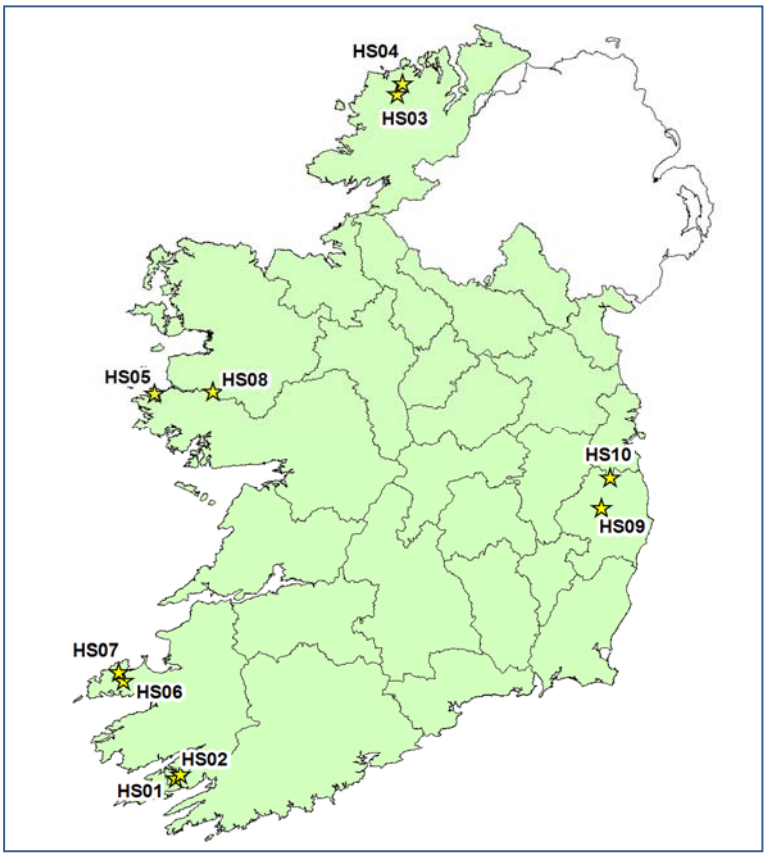

Figure 5 Location of *Huperzia selago* sites surveyed during the Rare Plants Monitoring Survey 2015-18.

3.3.2 Survey preparation

Site packs and Trimble Nomads for *H. selago* surveys were prepared as for *Diphasiastrum alpinum* surveys; see Section 2.3.2.

3.3.3 Site surveys

Sites were surveyed between 18 April 2016 and 13 June 2018. Survey teams consisted of two ecologists. The survey methodology for *H. selago* can be divided into four main tasks

- Conduct count of square-metre patches of the species to calculate population-specific data
- Establish and map the extent of the population
- Record monitoring stop data, and
- Complete the site summary data sheet including impact recording.

During all stages of the survey, surveyors also recorded any features or species of interest, botanical or otherwise, although these were not the focus of the survey. Where possible, these were photographed. Photographs of site features (e.g. impacts, management) were taken, as appropriate, for inclusion in the project's Image Databank.

3.3.3.1 Count of occupied square metres

The number of occupied square metres of *H. selago* in each site was determined as described for *D. alpinum* in Section 2.2.1.

3.3.3.2 Population extent

Where possible, the outer envelope of the species extent was recorded as waypoints on the Trimble's GPS. This involved walking through the site and recording the occurrence of the species. The outer limits of the population were digitised with the aid of these points. In some cases, however, the population was continuous over an entire mountain side with no end in sight, so arbitrary stopping points sometimes had to be chosen for practical reasons. These were based, for example, on changes in topography, such as the edge of a plateau or cliff, or covering approximately the same area indicated by the baseline survey. In such cases, *H. selago* was also present outside of the mapped extent, a fact that future monitoring surveys should be aware of, as finding the species outside the mapped extent at these sites will not necessarily mean that it is expanding.

3.3.3.3 Monitoring stops

Monitoring stops measuring 1 m x 1 m were delineated on the ground using a measured rope and metal pegs. A GPS waypoint was recorded on the Trimble at every monitoring stop, and photographs were taken, including at least one close-up of the plot's vegetation and another more general view to show the plot in the context of the landscape.

The number of monitoring stops recommended by Smyth *et al.* (2015) was one per colony up to a maximum of 10. With the discontinuation of colony numbers in favour of occupied square metres this was no longer applicable but the plots recorded in the baseline survey were used as the basis for plots recorded in the current survey. Monitoring stops were generally located as close as possible to the original baseline stops, using the baseline stop shapefile on the Trimble to navigate directly to them. Relocation of stops was sometimes necessary, e.g. to achieve a better spread of recording. In some cases, however, the number of stops was found to be unnecessarily high, with plots located very close to each other and/or with very similar data being recorded. For this reason, the number of plots recorded in the current survey did not always match that recorded in the baseline survey.

Data to assess *Population* were recorded at every monitoring stop, together with a full relevé (plant species list and species abundance). Monitoring stop data specifically required for carrying out assessments were: cover of *H. selago*, number of shoots and presence of fertile cones. Individual shoots

were traced back to the base of the plant. No specific data were recorded to assess *Habitat for the species* at monitoring stops as this was assessed by means of pressures operating across the population extent.

Other structural data, such as average *H. selago* shoot length, sward height, cover of dwarf shrubs, forbs and bryophytes, were also recorded for information on the structure of the vegetation but were not used in the assessment. Appendix 2 gives the full list of data items recorded in Turboveg at each *H. selago* monitoring stop.

3.3.3.4 Site summary data

The site summary data sheet (Appendix 1) was filled out by the surveyors after each site survey was concluded.

Site-level criteria included general population data. The total number of occupied square metres (OSMs) was entered in place of the total number of colonies. Population extent was filled out after the site had been digitally mapped in GIS. "Sporing plants present" was marked "Y" if any fertile plants had been seen in the population, regardless of whether these were inside or outside of monitoring stops. Unless the population was small enough for a full count of shoots to be carried out, the estimated number of shoots was calculated as:

(Average number of shoots of *H. selago* from plots) x (number of OSMs)

Population size class was determined according to the scale proposed by Evans & Arvela (2011) (see Table 2 in Section 2.2.2.4) and used by Smyth *et al*. (2015).

Impacts and activities occurring on site in the vicinity of the target species were recorded on the site summary sheet. The impact codes from the 2007-2012 monitoring period (Ssymank, 2011) were used because the codes for the 2013-2018 reporting period were not available at the commencement of this project. Activity details logged comprised:

- a description of the activity,
- its influence (positive, negative or neutral),
- intensity (high, medium or low),
- the percentage of the supporting habitat affected, and
- the source of the impact, whether originating from within or outside of the habitat.

3.3.4 Assessments

3.3.4.1 Population *assessment*

Following the review of criteria in Section 3.2.3, the *Population* parameter for *H. selago* was assessed using five criteria, which are shown, together with their targets, in Table 15. Occupied square metres rather than colonies were counted in this survey. Therefore criterion 1 (a) *No. of colonies* should be discontinued after the current monitoring period and criterion 1 (b) *No. of occupied square metres* should be used instead, with the targets set at 80% of the occupied square metre counts recorded in the current survey to allow for surveyor variability.

Targets for the first four criteria were set on a site-specific basis, based on the analysis of data from baseline surveys (Smyth *et al.*, 2015). Site-specific targets are shown in the individual site reports in Appendix 4.

Expert judgement was allowed to pass a marginally failing criterion where deemed appropriate, such as where all other criteria were passing and there were no anthropogenic causes for failure.

Table 15 *Population* criteria and targets for *Huperzia selago* sites surveyed in the Rare Plants Monitoring Survey 2015-18.

	Criterion	Scale of assessment	Target
1 (a)	No. of colonies	Population	No decrease from previous monitoring period
1 (b)	No. of OSMs*	Population	No decrease from previous monitoring period
2	Population extent (m^2)	Population	No decrease from previous monitoring period
3	Cover of *H. selago*	Average % cover across monitoring stops	No decrease from previous monitoring period
4	Population size class	Population (based on average shoot count from monitoring stops)	No decrease from previous monitoring period
5	Fertile cones	Population	Present
Population assessment			Favourable (Green): 4-5 passes
			Unfavourable-Inadequate (Amber): 2-3 passes
			Unfavourable-Bad (Red): 0-1 pass

* Future monitoring periods should use this criterion, occupied square metres (OSMs), rather than the number of colonies to assess population.

3.3.4.2 Habitat for the species *assessment*

Following the review of criteria described in Section 3.2.3, the *Habitat for the species* parameter was assessed for *H. selago* by examining the pressures operating on the habitat and considering their effects in the context of the *H. selago* population occupying that habitat. Data from the baseline survey were also taken into account for comparison. The assessment result, whether Favourable, Unfavourable-Inadequate or Unfavourable-Bad, was determined by expert judgement.

3.3.4.3 Future prospects *assessment*

The evaluation of the *Future prospects* parameter is as for *Diphasiastrum alpinum*, and is detailed in Section 2.3.4.3.

3.3.4.4 *Site conservation status and overall conservation status assessment*

The conservation status assessment for *H. selago* at each site was evaluated based on the results of all three parameters, according to the matrix in Table 1. The overall conservation status of *H. selago* at sites surveyed during the Rare Plants Monitoring Survey was then assessed using the guidance provided by the EU (DG Environment, 2017).

3.4 Results

3.4.1 *Population* assessment

The *Population* assessment results for the ten *H. selago* populations are shown in Table 16. All sites had been surveyed in the baseline survey (Smyth *et al*., 2015) and therefore required comparison with the baseline values. Recorded values for all criteria and sites are given in the site reports in Appendix 4. Nine of the ten sites received a Favourable assessment, with one site receiving an Unfavourable-Inadequate assessment.

Table 16 *Population* assessment results for *Huperzia selago* sites surveyed during the Rare Plants Monitoring Survey 2015-18. *n* = number of stops. OSMs = occupied square metres. Fav = Favourable; U-I = Unfavourable-Inadequate.

	Criterion	HS01 (*n*=5)	HS02 (*n*=5)	HS03 (*n*=5)	HS04 (*n*=5)	HS05 (*n*=5)	HS06 (*n*=5)	HS07 (*n*=4)	HS08 (*n*=5)	HS09 (*n*=10)	HS10 (*n*=10)
1	No. of colonies/ OSMs	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
2	Population extent	Pass	Pass	Pass	Pass	Pass	Pass	Fail*	Pass	Pass	Pass
3	Cover of *H. selago*	Fail†	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
4	Population size class	Pass	Pass	Pass	Pass	Pass	Pass	Fail*	Pass	Pass	Pass
5	Fertile cones	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
	No. of passes	4	5	5	5	5	5	3	5	5	5
	Passed on expert judgement	5	5	5	5	5	5	3	5	5	5
	Population assessment	Fav	Fav	Fav	Fav	Fav	Fav	U-I*	Fav	Fav	Fav

* Uncertainty regarding actual site extent due to grid reference error; criteria failures may be due to survey of wrong/insufficient area

† Marginal fail; passed on expert judgment

3.4.1.1 Number of colonies / Number of occupied square metres

Due to the difference in how colonies were counted it was not possible to make a direct comparison between the number of colonies recorded in the baseline survey and the number of occupied square metres counted in the current survey. However, as the number of occupied square metres counted in all cases far exceeded the number of colonies, in most cases by at least a factor of 10, it was assumed that the number of colonies was maintained since the baseline survey.

3.4.1.2 Population extent

Nine of the ten populations maintained their population extent between this monitoring period and the last; slightly smaller areas mapped during the current survey can be ascribed to more accurate determination of area by GIS, but the overall dimensions of the extents were similar between the two surveys. The tenth population, HS07 Lough Cruite, appeared to have reduced significantly in size, but as one of the plots had been recorded with an inaccurate grid reference during the baseline survey (the grid reference given placed the plot in the sea, 800 m north of the site), it is unclear whether this was a genuine contraction or merely that the correct area was not searched. Comparison with the baseline extent was made more difficult by not having a defined population envelope to search. As there was not enough evidence that the species was present over a larger area, HS07 failed this criterion.

3.4.1.3 Cover of Huperzia selago

The cover of *H. selago* was generally maintained from the baseline to the current survey, across the ten sites surveyed. Amounts recorded were low in both surveys. An increase was noted in HS09 Turlough Hill (Camaderry), where the target value of just below 1% cover per square metre (Domin of 2) was exceeded, with an average cover of 2.5% attained across the ten monitoring stops. A failure was noted in HS01 Healy Pass, where an average cover of 0.3% was attained, somewhat short of the target of 1%. However this could be attributed to surveyor variability, as the amounts involved are small and the actual difference between 0.3% and 1% in a 1 m^2 plot is relatively minor. On this basis, a discretionary pass was awarded.

3.4.1.4 Population size class (number of shoots)

An issue was noted concerning the targets for this criterion when comparing population size classes between the baseline and the current survey. Inconsistencies were found in site reports between the target size classes and the population they represented, e.g. for HS06 Lough Doon (Connor Pass) the target was written in the site report as "2 (500-1000)", whereas size class 2 should indicate a population of 51-100. It was therefore unclear whether the true target was 51-100 or 500-1000. Efforts to resolve this issue by consulting raw data or other parts of the site report were not always conclusive.

As far as can be ascertained, the population size class recorded in the baseline survey was maintained or exceeded in all except one case, HS07 Lough Cruite. Here, a decrease from size class 4 (501-1000) to size class 1 (1-50) was recorded, a drop of three size classes, despite the population here maintaining its average cover of *H. selago*. As there were only two baseline plots recorded here, and there is nothing in the baseline data to suggest high numbers of shoots in the plots recorded, this disparity between the two may be explained by a difference in the extent of the area searched (as noted above in Section 3.4.1.2), a factor that would affect the total number of shoots estimated when extrapolated up from plot averages. However, this could not be assumed and so HS07 failed the criterion.

3.4.1.5 Fertile cones

Fertile cones were recorded at all ten *H. selago* sites. Therefore all sites passed this criterion.

3.4.2 *Habitat for the species* assessment

Devising assessment criteria that would be applicable across the broad range of habitats in which *H. selago* occurs was found to be difficult: *H. selago* was recorded from scree, bog, montane heath, wet heath, dry heath and grassland during the current survey. Therefore a monitoring stop-based assessment approach was found to be inappropriate for this species, the emphasis instead being extended to an all-site basis. Ten populations were assessed in this monitoring period by assessing damage or loss of potential *H. selago* habitat based on the pressures operating on the habitat.

For the ten sites surveyed, which all had baseline data for comparison available on the area of habitat occupied by the species, no anthropogenic losses of habitat had occurred. However, pressures from overgrazing were high across five of the ten sites surveyed during the current monitoring period and the species was frequently found in more inaccessible niches such as rock crevices rather than in more open, grazed vegetation. These sites were assessed as Unfavourable-Inadequate. Table 17 shows the results.

Table 17 Habitat for the species assessment results for *Huperzia selago* sites surveyed during the Rare Plants Monitoring Survey 2015-18. Fav = Favourable; U-I = Unfavourable-Inadequate.

Site	Observation	Assessment
HS01	Heavily overgrazed, small percentage of habitat trampled by hikers	U-I
HS02	Heavily overgrazed, small percentage of habitat trampled by hikers	U-I
HS03	Grazing positive, extensive population indicates suitable habitat	Fav
HS04	Grazing positive, extensive population indicates suitable habitat	Fav
HS05	Overgrazed, small percentage of habitat trampled by hikers	U-I
HS06	Grazing neutral, low damage from hikers	Fav
HS07	Grazing and impacts from hikers neutral	Fav
HS08	Heavily overgrazed	U-I
HS09	Grazing neutral, positive effects of erosion provide niches for colonisation	Fav
HS10	Disturbance from hikers and overgrazing; erosion damaging to *H. selago* in grassland	U-I

3.4.3 *Future prospects* assessment

3.4.3.1 Pressures, threats and other activities

Prior to evaluating the *Future prospects* parameter, the activities, both positive and negative, recorded in the *H. selago* habitat were examined. The positive and negative impacts on the species and its habitat are shown in Tables 18 and 19 respectively.

Table 18 Frequency of positive impacts, by intensity and percentage (%) of the habitat affected, recorded in the ten *Huperzia selago* sites. Impact codes are according to Ssymank (2011).

Impact code	Impact description	Intensity				% habitat affected			Total
		High	Medium	Low	Unknown	≤25%	26-75%	>75%	
A04.02.02	Non-intensive sheep grazing		1					1	1
A04.02.05	Non-intensive mixed animal grazing			1				1	1
K01.01	Erosion	1						1	1
	Total	1	1	1				3	

Table 19 Frequency of negative impacts, by intensity and percentage (%) of the habitat affected, recorded in the ten *Huperzia selago* sites. Impact codes are according to Ssymank (2011).

Impact code	Impact description	Intensity				% habitat affected			Total
		High	Medium	Low	Unknown	≤25%	26-75%	>75%	
A04.02.02	Non-intensive sheep grazing	3	1	1				5	5
G01.02	Walking, horse-riding, non-motorised vehicles	2	2	1		3	1	1	5
K01.01	Erosion	3					2	1	3
M	Climate change				10			10	10
	Total	8	4	1	10	3	3	17	

Erosion (K01.01) of blanket bog at HS09 Turlough Hill (Camaderry), while negative for the blanket bog habitat, was seen as positive for *H. selago* in that it was providing niches that were being colonised by the species. In three other sites, however, erosion was deemed to be having a negative impact on the species, particularly for plants growing in grassland, e.g. HS10 Kippure, where walkers are also active.

Non-intensive grazing, predominantly by sheep (A04.02.02), was recorded at all ten sites. Grazing is generally seen as a negative pressure on upland habitats but the effects on the habitat for *H. selago* were variable. Grazing was seen as beneficial for the species at HS03 Meenagoppoge (Derryveagh Mountains) and HS04 Muckish Mountain, but negative at HS01 Healy Pass, HS02 Knockowen, HS05 Tully Mountain, HS08 Skeltia (Maumtrasna Mountain) and HS10 Kippure. The effects of grazing were considered to be neutral at HS06 Lough Doon (Connor Pass), HS07 Lough Cruite and HS09 Turlough Hill (Camaderry).

Five of the sites are frequented by hikers to some extent, and Walking (G01.02) was recorded as a negative pressure on the species' habitat, although in three of the five instances the percent of the habitat affected was low, just 5% or less.

Climate change (M) was recorded as a negative impact over all ten *H. selago* sites, but the intensity and exact consequences of the impact on the species and its habitat are unknown.

3.4.3.2 *Future prospects of* Population *and* Habitat for the species *parameters*

The future prospects for *Population* and *Habitat for the species* were examined for each of the ten *H. selago* sites surveyed during the current project, taking into account the current assessments of *Population* and *Habitat for the species* and the threats likely to operate on the species and its habitat over the next two monitoring periods (12 years). Six sites were assessed as Unfavourable-Inadequate. Four sites received a Favourable assessment. Table 20 shows the results.

Table 20 *Future prospects* (FP) assessment for the ten *Huperzia selago* sites surveyed during the Rare Plants Monitoring Survey 2015-18. Pop = Population, HfS = Habitat for the species. Fav = Favourable, U-I = Unfavourable-Inadequate.

Site	FP of Pop.	FP of HfS.	FP of *H. selago*	Rationale
HS01	Fav	U-I	U-I	Impacts are having a negative effect on the species and its habitat
HS02	Fav	U-I	U-I	Impacts are having a negative effect on the species and its habitat.
HS03	Fav	Fav	Fav	Population and habitat are both favourable, impacts are not considered to be having a negative effect on the species or its habitat
HS04	Fav	Fav	Fav	Population and habitat are both favourable, impacts are not considered to be having a negative effect on the species or its habitat
HS05	Fav	U-I	U-I	Impacts are having a negative effect on the species and its habitat
HS06	Fav	Fav	Fav	Population and habitat are both favourable, impacts are not considered to be having a negative effect on the species or its habitat
HS07	U-I	Fav	U-I	Impacts are neutral but there is some evidence that the population may have declined since baseline survey
HS08	Fav	U-I	U-I	Impacts are having a negative effect on the species and its habitat
HS09	Fav	Fav	Fav	Population and habitat are both favourable, impacts are not considered to be having a negative effect on the species or its habitat
HS10	Fav	U-I	U-I	Impacts are having a negative effect on the habitat

3.4.4 Conservation status assessment for individual sites

The assessments of the individual parameters at each site were combined according to the evaluation matrix in Table 1 to obtain the conservation assessment for *H. selago* at each site (Table 21). This resulted in populations at four sites receiving a Favourable assessment and six populations receiving an Unfavourable-Inadequate assessment due to negative pressures from grazing and hikers.

Table 21 Assessment results for the ten *Huperzia selago* sites surveyed during the Rare Plants Monitoring Survey 2015-18. Fav = Favourable, U-I = Unfavourable-Inadequate.

Site	Population	Habitat for the species	Future prospects	Overall assessment
HS01	Fav	U-I	U-I	U-I
HS02	Fav	U-I	U-I	U-I
HS03	Fav	Fav	Fav	Fav
HS04	Fav	Fav	Fav	Fav
HS05	Fav	U-I	U-I	U-I
HS06	Fav	Fav	Fav	Fav
HS07	U-I	Fav	U-I	U-I
HS08	Fav	U-I	U-I	U-I
HS09	Fav	Fav	Fav	Fav
HS10	Fav	U-I	U-I	U-I

3.4.5 Overall conservation status assessment for Rare Plants Monitoring Survey sites

The assessments of the individual parameters were combined according to the evaluation matrix in Table 1 to obtain the overall conservation assessment for *H. selago* at sites surveyed during the Rare Plants Monitoring Survey.

Following the guidelines for species assessment at a national level (DG Environment, 2017), based on the results presented here and taking into account the estimated future trends of the species populations and habitat based on the threats and positive activities in place, the overall conservation status assessment result for *H. selago* at sites surveyed during the Rare Plants Monitoring Survey is **Unfavourable-Inadequate** and the trend is **stable**. Table 22 summarises this result. The following data detailed in this report were used to arrive at this result

- Overall population numbers were maintained at most sites since the previous monitoring period, so *Population* trend was assessed as stable
- Pressures from overgrazing were high across five of the ten sites surveyed, with the species frequently found in more inaccessible niches such as rock crevices rather than in more open, grazed vegetation, so *Habitat for the species* was assessed as Unfavourable-Inadequate
- Area of occupied habitat was maintained at most sites since the previous monitoring period, so the trend for *Habitat for the species* area was assessed as stable
- As far as could be ascertained, the quality of occupied habitat was similar at all sites since the previous monitoring period, so the trend for *Habitat for the species* quality was assessed as stable.

Table 22 Summary of the overall conservation status assessment of *H. selago* at sites surveyed during the Rare Plants Monitoring Survey (RPMS) 2015-18. FP = Future prospects.

Parameter	Conservation status	Trend	FP of parameter
Population	Favourable	Stable	Good
Habitat for the species	Unfavourable-Inadequate	Stable	Poor
Future prospects	Unfavourable-Inadequate		
Overall Conservation Status Assessment for RPMS sites	**Unfavourable-Inadequate**	**Stable**	

It should be noted that the overall conservation status assessment for Rare Plants Monitoring Survey sites does not include an assessment of the *Range* parameter. This was assessed in the national conservation assessment of the *Lycopodium* spp. group (NPWS, 2019), which incorporated the combined results of the assessments of *Population*, *Habitat for the species* and *Future prospects* for *Diphasiastrum alpinum*, *Huperzia selago*, *Lycopodiella inundata* and *Lycopodium clavatum*, along with data from other recent surveys of these species.

3.5 Discussion

The overall conservation status assessment of *H. selago* at sites surveyed during the Rare Plants Monitoring Survey is Unfavourable-Inadequate, based on the assessment of population and habitat for the species, and their future prospects, as described in the preceding sections. Population assessments for *H. selago* were carried out using similar criteria to Smyth *et al.* (2015). The review of population assessment criteria found them generally to be suitable, with provisos similar to those proposed in Section 2.5 for *Diphasiastrum alpinum* applying here also. Specifically these are the use of occupied square metres of habitat to help quantify the area covered by *H. selago* and the number of shoots, based on average values within the 1 m² monitoring stops; and accurate mapping of the population envelope of the species, with the aid of waypoints recorded during surveys. The latter in particular helps to delineate the core area to be searched for the plant. The drawback to using only monitoring stops to define the area, as in the baseline survey, was highlighted at HS07 Lough Cruite where the grid reference for the second monitoring stop was incorrect, possibly due to a transposed digit. Lack of a mapped population envelope meant that the exact area to be searched was not defined and, while surveyors searched the wider area, they could not be certain that the core area searched during the baseline survey was being targeted. Possibly as a consequence of this, the results for the assessment criteria at this site were down on the baseline values, leaving doubt as to whether this was due to a genuine decline (although there was no evidence of severe pressures that might have caused this) or to differences in the extent of area surveyed.

Habitat for *H. selago* was difficult to assess using general criteria as the species occurs across a broad range of habitats and nationally is not particularly rare. The species occurs in both lowland and upland situations, across heath, bog and acid grassland, and even on scree and rocky slopes. For this reason, the assessment criteria used to assess the habitat in the baseline survey were not used in the current survey; instead the habitat was viewed in a more general way, without the use of specific criteria or thresholds, to assess the species' habitat suitability and condition on a site-by-site basis. Given a larger dataset with more examples of populations from the different habitat types in which *H. selago* grows, it might have been possible to devise a set of criteria that could assess the different types of habitat for the species in a more habitat-specific way, but this was not possible with the current dataset. It is recommended that additional lowland sites, from the full range of habitats, be surveyed in future monitoring periods to add to the predominantly upland sites surveyed in this monitoring period and the last.

Walking by hikers and grazing by sheep were, as for *D. alpinum*, the two main issues noted during the *H. selago* surveys. Both are regarded as negative pressures on the habitat for the species, with both causing trampling of the habitat and, in the case of grazing, occasional destruction of clumps of the plant. Identification of the critical point at which grazing or walking cause actual damage to the plant is difficult and further research may be needed to elucidate their effects by, for example, removing some areas from the influence of trampling or grazing (e.g. by fencing or exclosures) and observing the effects on *H. selago*. Overall, the populations of *H. selago* surveyed during the Rare Plants Monitoring Survey are in good condition and not in immediate danger of decline, but the habitat shows signs of being under pressure from negative impacts that may affect the future survival of *H. selago* and conservation management may be required to improve its status.

General recommendations regarding the future surveying of this species relate to greater surveying, particularly across a wider range of habitats, including lowland habitats, to provide more data to refine the assessment criteria. Currently *Habitat for the species* is assessed by taking into account damage to the habitat from pressures. While this is an adequate measure of habitat quality, it would be useful if other supporting criteria could be defined to assess whether the habitat is in decline. It remains to be seen whether the wide habitat range of *H. selago* makes this a realistic goal or not.

4 *Lycopodium clavatum*

4.1 Species description

Lycopodium clavatum (Stag's-horn Clubmoss) is found on wet heaths and grassy mountain slopes (Parnell & Curtis, 2012), and has a scattered distribution in Ireland (Preston *et al.*, 2002). It is described in Parnell & Curtis (2012) as "rare and declining", largely due to pressures on its habitat such as overgrazing, burning and agricultural improvement (NPWS, 2013). The all-Ireland population of the species was assessed as Near Threatened, based on a decline in its area of occupancy between the two assessment periods 1930-1969 and 1987-1999 and suspected future decline (Wyse Jackson *et al.*, 2016). In Ireland, based on data collated for the most recent Article 17 report on the *Lycopodium* spp. group (NPWS, 2019), it has been recorded from 17 hectads since 1970, but only nine of these have been confirmed as still present since 2000 (BSBI, 2015-2018, 2018; NBDC, 2018; NPWS, 2018). *L. clavatum* is listed on the IUCN Red List of Threatened Species as Least Concern within Europe and the EU as it is widespread and common throughout Arctic and mountainous areas in Europe (Christenhusz *et al.*, 2017). In some parts of northern Europe in particular, the species is stable, but in parts of central and southern Europe it is threatened by habitat loss, which has caused populations to decline. *L. clavatum* is a weak competitor and factors such as abandonment of traditional land management and eutrophication from forestry and agriculture can lead to changes in vegetation dynamics that result in *L. clavatum* being out-competed by more vigorous species (Christenhusz *et al.*, 2017).

Figure 6 *Lycopodium clavatum* on Kippure Mountain. Photo by Philip Perrin.

Lycopodium clavatum occurs in a similar ecological niche to *Diphasiastrum alpinum* (Smyth *et al.*, 2015; see also Appendix 3). Christenhusz *et al.* (2017) describe *L. clavatum* as a long-lived species but a slow coloniser, only able to compete successfully in open situations with short vegetation; it prefers relatively open, moist or slightly dry places in heathy vegetation, peatland, and montane heath and grassland, and frequently forms large patches. The species grows slowly and a complete life cycle from spore to gametophyte to reproducing sporophyte may take up to 20 years (Nauertz & Zasada, 2001;

Christenhusz *et al*., 2017). In the USA and Canada, however, the species often grows in forests from where it may be harvested for seasonal decorative use (Nauertz & Zasada, 2001). There is no evidence that the plant is collected in Ireland (Smyth *et al*., 2015).

L. clavatum is characterised by above-ground rhizomes with forking, non-branching aerial stems that give rise to one or two cones when the aerial stems are mature, usually about 4 to 6 years of age (Nauertz & Zasada, 2001). Due to its clonal nature it is difficult to count numbers of individuals in a population and a single plant can cover a fairly large area (Christenhusz *et al*., 2017). Rhizomes may be multi-aged, and in general, the bigger and more branching the patch, the older it is (Nauertz & Zasada, 2001). Spread of the plant is by two means, spore germination and rhizome expansion. Spore release generally occurs in the autumn and may potentially lead to a new patch and an increase in frequency, while rhizome growth and expansion will increase the overall area covered by an existing patch (Nauertz & Zasada, 2001). Spores germinate best in disturbed soil and Preston *et al*. (2002) note that, while propagation is mostly vegetative, spores can colonise new sites, particularly the disturbed soil of roadside embankments and quarries. However, while disturbance is beneficial to spore germination, the gametophyte that forms as a result may be susceptible to severe disturbance (Nauertz & Zasada, 2001), so a balance must be maintained between disturbance that creates new niches for colonisation, and stable conditions that allow gametophytes to complete their life cycle into mature sporophytes.

4.2 Review of survey methodology and assessment criteria

4.2.1 Definition of a colony

In Smyth *et al*. (2015), a colony was taken as the basic unit of a clubmoss population, being defined as a "discrete, unconnected, measurable patch of the species." During the current survey the same problem was found for *L. clavatum* as for *D. alpinum* in identifying and counting separate colonies. Therefore, the same procedure was followed as for *D. alpinum* in counting occupied square metres of *L. clavatum* instead of individual colonies (see Section 2.2.1).

To calculate the total area covered by *L. clavatum* and the number of shoots in the population the following procedure was used

- Count the number of occupied square metres
- Record the appropriate number of 1 m^2 monitoring stops, up to a maximum of ten
- Estimate the total area covered by *L. clavatum* in square metres as the average percent cover of *L. clavatum* per monitoring stop multiplied by the total number of occupied square metres counted
- Estimate the total number of shoots as the average number of shoots per monitoring stop multiplied by the total number of occupied square metres counted.

4.2.2 Review of *Population* assessment criteria

The population assessment criteria used by Smyth *et al.* (2015) for *L. clavatum* were reviewed

- Total number of colonies
- Population extent (combined area of occupancy of colonies)
- Domin cover of *L. clavatum* species in the monitoring stop
- Estimated number of *L. clavatum* shoots (as population size class), and
- Presence of sporing *L. clavatum* plants.

4.2.2.1 Total number of colonies

Section 2.2.1 described the revised method used to quantify the extent of the plant in the current survey, i.e. using occupied square metres rather than colonies. The site-specific targets for colony numbers set

in the baseline survey therefore no longer apply, and the number of occupied square metres counted during the current survey should be used as the basis for new targets. To allow for surveyor variability between monitoring periods a threshold of 80% of the current number of occupied square metres should be used as the target number of occupied square metres to be attained in the next period.

4.2.2.2 Population extent

The dimensions of each population's extent were approximated during the baseline survey as a single broad envelope encompassing the entire population (e.g. 200 m x 100 m) rather than defined exactly by GIS mapping. While this enables a broad-brush comparison to be made between population extents measured over two successive monitoring periods, mapping the population envelope more precisely using GIS is a more useful gauge of the extent of the population and also defines the search area for the next monitoring period. In future monitoring periods it is recommended that comparisons be made with the current mapped area of the habitat occupied by *L. clavatum* rather than with the more approximate extents used in the baseline survey. To allow for minor differences in GPS accuracy or mapping between surveyors, a target of 90% of the mapped area should be set for sites, the same procedure followed by Muldoon *et al*. (2015) for comparing mapped areas of *Saxifraga hirculus* habitat between monitoring periods.

4.2.2.3 Domin cover of Lycopodium clavatum

Cover of *L. clavatum* was recorded as a Domin value in monitoring stops by Smyth *et al*. (2015). This was used as the target to be met in successive monitoring assessments. The current survey recorded cover values as percentage of the plot, rather than as Domin. The baseline Domin targets were retained as targets for the current survey but converted to their equivalent percent values.

4.2.2.4 Number of shoots

The target for the population size class (number of shoots per population) was to meet or exceed the population size class recorded during the baseline survey (Smyth *et al.*, 2015). Population size classes were according to the scale proposed by Evans & Arvela (2011), shown in Table 2 (see Section 2.2.2.4). Population size class was judged following this review to be an appropriate method of measuring and comparing population shoot numbers between monitoring periods.

4.2.2.5 Presence of sporing plants

The presence of sporing *L. clavatum* plants (fertile cones seen in the population) is an additional indicator of population health and this criterion was retained.

4.2.2.6 Revised Population *assessment criteria for* Lycopodium clavatum

The revised list of *Population* criteria for *L. clavatum* is as follows

- Total number of colonies or occupied square metres (OSMs): For the current monitoring period, the comparison will be made with the total number of colonies recorded during the baseline survey, but from next monitoring period onwards, the comparison will be made with the number of occupied square metres recorded during the current survey
- Population extent: For the current monitoring period the comparison will be made with the approximate population envelope dimensions given in the baseline survey, but from next monitoring period onwards, the comparison will be made with the mapped extent recorded during the current survey
- Percent cover of *L. clavatum* in the monitoring stop
- Estimated number of *L. clavatum* shoots (as population size class), and
- Presence of sporing *L. clavatum* plants.

4.2.3 Review of *Habitat for the species* assessment criteria

The *Habitat for the species* assessment criteria used by Smyth *et al.* (2015) for *L. clavatum* were reviewed

- Average shoot length across all plots
- Domin cover of *Calluna vulgaris*
- Domin cover of bare rock, and
- Domin cover of bryophytes.

4.2.3.1 Average shoot length

The average length of five shoots in each monitoring plot was calculated and used in the baseline survey as a proxy for grazing pressure. As shoots are quite long-lived in this species, it is reasonable to expect that the shoots measured in one monitoring period should still be present in the next. Each rhizome may have aerial branches that vary in age from one to six years; and in general, the bigger and more branching the patch, the older it is (Nauertz & Zasada, 2001). However, due to the rhizomatous growth of the plant it may be difficult to identify the true base of the plant from which to measure shoot length. Also, rhizomes are a method of seeking out new resources by the plant, but if a section of the plant cannot find and exploit new resources, it will be cut off physiologically and a different section of the plant will grow instead (Nauertz & Zasada, 2001). Thus, shorter shoot lengths may be caused by factors other than grazing, such as locally limited resources. It is therefore considered that shoot length is not a reliable measure of grazing pressure, and the criterion should be dropped.

Because shoot length may indicate patch age and resource availability, it should continue to be recorded as part of the structural data of the population. Future trends may emerge as more data become available over a series of monitoring periods.

Height of vegetation was considered as an alternative to shoot length to assess grazing pressure, but because many *L. clavatum* sites are in montane heath and therefore exposed, similar to *D. alpinum* sites, it was ruled out as an assessment criterion for similar reasons as for *D. alpinum*, i.e. low sward height could be due to factors other than overgrazing. Insufficient data are currently available to set an upper threshold that would indicate undergrazing. This should be assessed by recording the impacts and activities occurring on the site.

4.2.3.2 Domin cover of Calluna vulgaris

Following analysis of baseline survey data, Smyth *et al*. (2015) reported higher cover of *L. clavatum* where there was a lower cover of *Calluna vulgaris* (up to 10%). This was generally found to be the case in the current survey also, with frequency *of C. vulgaris* low among *L. clavatum* plots. It is proposed that the current Cover of *Calluna vulgaris* criterion be retained and the target changed to percent cover rather than Domin, i.e. ≤10%.

Two other dwarf shrub species, *Vaccinium myrtillus* and *Empetrum nigrum*, were frequently found with *L. clavatum*, particularly *V. myrtillus*, which was found in all 23 plots. While the current dataset is too restricted to allow a firm conclusion to be drawn on the possibility of using these species as indicators of habitat health for *L. clavatum*, it is possible that a trend could emerge if more species data were to be recorded over successive future monitoring periods.

4.2.3.3 Domin cover of bare rock

Smyth *et al.* (2015) reported, following analysis of their baseline data, that higher cover of *L. clavatum* occurred where there was higher cover of bare ground/rock (10-75%). However, Smyth *et al*. (2015) commented on the need for more data as their criteria were based on just three sites. The current survey did not find a particular association between the cover of *L. clavatum* and the presence or cover of bare ground or bare rock, either separately or in combination: high cover (≥ 10%) of *L. clavatum* occurred both in the presence and absence of bare soil and/or rock. This could be due to clonal spread by rhizomes rather than germination of spores to create new patches.

However, it is thought advisable that an upper threshold should be imposed on the occurrence of disturbed bare ground (excluding bare rock). Bare ground may provide a useful niche for spore germination for *L. clavatum* but too high a percentage could indicate unwanted disturbance that might be damaging to the plant. For this reason, an upper threshold of 10% is proposed, as for *D. alpinum.*

4.2.3.4 *Domin cover of bryophytes*

Smyth *et al*. (2015) set a target of Domin 5-8 (11-75%) for bryophyte cover in *L. clavatum* habitat. The current survey did not find a particularly strong association between *L. clavatum* cover and bryophyte cover, with high cover (≥ 10%) of *L. clavatum* occurring where bryophyte cover was both low (≤15%) and high (≥80%). Therefore it is proposed that this criterion be dropped.

While total bryophyte cover was not particularly indicative of *L. clavatum* habitat in good condition, *Racomitrium lanuginosum* was found in almost all plots where *L. clavatum* was recorded, which is consistent with the species' predominant occurrence in HH4 Montane heath. However, it was notable that the only *L. clavatum* plot from which *R. lanuginosum* was absent was recorded in an area with a high level of disturbance from hikers. Therefore loss of *R. lanuginosum* may be an early indicator of decline in habitat where *L. clavatum* continues to grow. The data collected thus far are insufficient to conclude beyond doubt that this is the case, but the possibility of using *R. lanuginosum* as a criterion of habitat health for *L. clavatum* should be investigated in future monitoring periods as more data become available.

4.2.3.5 *Additional criteria*

EU reporting guidelines state that it is often enough to assess the quality of the species' habitat via the pressures operating on it, with the "direct measurement of the physical quality of the species' environment" not always necessary (DG Environment, 2017). Therefore, it is proposed that the impact of pressures operating on the habitat be added as an additional assessment criterion for the habitat for the species, with a target of "low or absent".

4.2.3.6 *Revised* Habitat for the species *assessment criteria for* Lycopodium clavatum

The revised list of *Habitat for the species* criteria for *L. clavatum* is as follows (targets in parentheses)

- Percent cover of *Calluna vulgaris* (≤10%)
- Percent cover of disturbed bare soil (≤10%), and
- Impact of negative pressures on habitat (low or absent).

4.3 Methodology

4.3.1 Site selection

Sites to be surveyed were selected by NPWS to reflect the geographical spread of the species, as well as to address data-deficient populations. Table 23 lists the sites and Figure 7 shows their distribution. Five *L. clavatum* populations were surveyed, three monitoring surveys and two baseline surveys. Note that one site name has been updated to reflect its location more accurately. The name by which it was identified in the baseline survey is indicated in parentheses.

4.3.2 Survey preparation

Site packs and Trimble Nomads for *L. clavatum* surveys were prepared as for *D. alpinum* surveys; see Section 2.3.2.

Table 23 *Lycopodium clavatum* sites surveyed for the Rare Plants Monitoring Survey 2015-18.

Site ID	Site name	County	Survey type	SAC code	SAC name
LC01	Clohernagh Mountain	Wicklow	Monitoring	002122	Wicklow Mountains
LC02	Kippure	Wicklow	Monitoring	002122	Wicklow Mountains
LC03	Turlough Hill, north of reservoir (Camaderry, left of reservoir)	Wicklow	Monitoring	002122	Wicklow Mountains
LC04	Corlisbannan	Cavan	Baseline	n/a	n/a
LC05	Lavagh More - N & E of Lough Asgarha	Donegal	Baseline	n/a	n/a

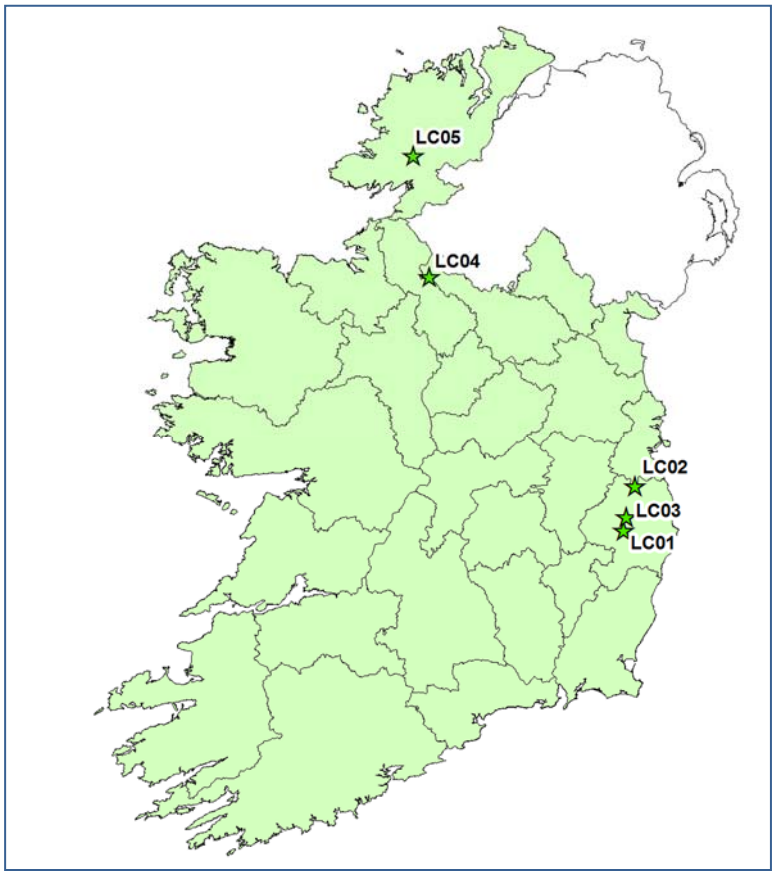

Figure 7 Location of *Lycopodium clavatum* sites surveyed during the Rare Plants Monitoring Survey 2015-18.

4.3.3 Site surveys

Sites were surveyed between 18 April 2016 and 12 June 2018. Survey teams consisted of two ecologists. The survey methodology for *L. clavatum* can be divided into four main tasks

- Conduct count of square-metre patches of the species to calculate population-specific data
- Establish and map the extent of the population
- Record monitoring stop data, and
- Complete the site summary data sheet including impact recording.

During all stages of the survey, surveyors also recorded any features or species of interest, botanical or otherwise, although these were not the focus of the survey. Where possible, these were photographed.

Photographs of site features (e.g. impacts, management) were taken, as appropriate, for inclusion in the project's Image Databank.

4.3.3.1 Count of occupied square metres

The number of occupied square metres of *L. clavatum* in each site was determined as described for *D. alpinum* in Section 2.2.1.

4.3.3.2 Population extent

The outer envelope of the species extent was recorded as waypoints on the Trimble's GPS. This involved walking through the site and recording the occurrence of the species. The outer limits of the population were digitised with the aid of these points.

4.3.3.3 Monitoring stops

Monitoring stops measuring 1 m x 1 m were delineated on the ground using a measured rope and metal pegs. A GPS waypoint was recorded on the Trimble at every monitoring stop, and photographs were taken, including at least one close-up of the plot's vegetation and another more general view to show the plot in the context of the landscape. Where baseline surveys had previously been carried out, monitoring stops were generally located as close as possible to the original baseline stops, using the baseline stop shapefile on the Trimble to navigate directly to them. Relocation of stops was sometimes necessary, e.g. to achieve a better spread of recording.

Data to assess *Population* and *Habitat for the species* were recorded at every monitoring stop, together with a full relevé (plant species list and species abundances). Monitoring stop data specifically required for carrying out assessments were: cover of *L. clavatum*, number of shoots, presence of fertile cones, cover of *Calluna vulgaris* and cover of disturbed bare ground. When counting shoots, individual shoots were traced back to the base of the plant rather than from any divisions occurring part-way along the stem (side branches).

Other structural data, such as cover of bryophytes and cover of leaf litter, were recorded for information purposes but were not used in the assessment. Appendix 2 gives the full list of data items recorded in Turboveg at each *L. clavatum* monitoring stop.

4.3.3.4 Site summary data

The site summary data sheet (Appendix 1) was filled out by the surveyors after each site survey was concluded.

Site-level criteria included general population data. The total number of occupied square metres (OSMs) was entered in place of the total number of colonies. Population extent was filled out after the site had been digitally mapped in GIS. "Sporing plants present" was marked "Y" if any fertile plants had been seen in the population, regardless of whether these were inside or outside of monitoring stops. Unless the population was small enough for a full count of shoots to be carried out, the estimated number of shoots was calculated as:

(Average number of shoots of *L. clavatum* from plots) x (number of OSMs)

Population size class was determined according to the scale proposed by Evans & Arvela (2011) (see Table 2 in Section 2.2.2.4) and used by Smyth *et al*. (2015).

Impacts and activities occurring on site in the vicinity of the target species were also recorded on the site summary sheet. The impact codes from the 2007-2012 monitoring period (Ssymank, 2011) were used because the codes for the 2013-2018 reporting period were not available at the commencement of this project. Activity details logged comprised

- a description of the activity

- its influence (positive, negative or neutral)
- intensity (high, medium or low)
- the percentage of the supporting habitat affected, and
- the source of the impact, whether originating from within or outside of the habitat.

4.3.4 Assessments

4.3.4.1 Population *assessment*

Following the review of criteria in Section 4.2.3, *L. clavatum* populations were assessed using five criteria, which are shown, together with their targets, in Table 24. Occupied square metres rather than colonies were counted in this survey, so it was not always possible to compare the occupied square metre counts directly with previous colony counts. Therefore criterion 1 (a) *No. of colonies* should be discontinued after the current monitoring period and criterion 1 (b) *No. of occupied square metres* should be used instead, with the targets set at 80% of the occupied square metre counts recorded in the current survey.

Table 24 *Population* criteria and targets for *Lycopodium clavatum* sites surveyed in the Rare Plants Monitoring Survey 2015-18.

	Criterion	Scale of assessment	Target
1 (a)	No. of colonies	Population	No decrease from previous monitoring period
1 (b)	No. of OSMs*	Population	No decrease from previous monitoring period
2	Population extent (m^2)	Population	No decrease from previous monitoring period
3	Cover of *L. clavatum*	Average % cover across monitoring stops	No decrease from previous monitoring period
4	Population size class	Population (based on average shoot count from monitoring stops)	No decrease from previous monitoring period
5	Fertile cones	Population	Present
Population assessment			Favourable (Green): 4-5 passes
			Unfavourable-Inadequate (Amber): 2-3 passes
			Unfavourable-Bad (Red): 0-1 pass

* Future monitoring periods should use this criterion, occupied square metres (OSMs), rather than the number of colonies to assess population.

Targets for the first four criteria were set on a site-specific basis, based on the analysis of data from baseline surveys (Smyth *et al.*, 2015). Site-specific targets are shown in the individual site reports in Appendix 4.

Two sites, LC04 Corlisbannan and LC05 Lavagh More, had not previously been surveyed by Smyth *et al*. (2015) and therefore had no targets set for some of the criteria. Following the procedure used by Smyth *et al*. (2015), the targets to be met by LC04 and LC05 in the next monitoring period were set after the sites were surveyed during the current survey. The target for the number of occupied square metres was set at 80% of the count recorded in the current survey. The target for the population extent was set at 90% of the extent digitised in the current survey.

Expert judgement was allowed to pass a marginally failing criterion where deemed appropriate, such as where all other attributes were passing and there were no obvious anthropogenic causes for failure.

4.3.4.2 Habitat for the species *assessment*

Following the review of criteria described in Section 4.2.3, *Habitat for the species* was assessed for *L. clavatum* by means of four criteria, which are shown, together with their targets, in Table 25. As for the *Population* assessment, expert judgement was applied to pass a marginally failing criterion where appropriate.

Table 25 *Habitat for the species* criteria and targets for *Lycopodium clavatum* sites surveyed in 2015-18.

	Criterion	Scale of assessment	Target
1	Cover of *Calluna vulgaris*	Average across all monitoring stops	≤10%
2	Cover of bare ground	Average across all monitoring stops	≤10%
3	Impact of negative pressures	Population extent	Low or absent
Habitat for the species assessment			Favourable (Green): 3 passes
			Unfavourable-Inadequate (Amber): 2 passes
			Unfavourable-Bad (Red): 0-1 pass

4.3.4.3 Future prospects *assessment*

The evaluation of the *Future prospects* parameter is as for *Diphasiastrum alpinum*, and is detailed in Section 2.3.4.3.

4.3.4.4 *Site conservation status and overall conservation status assessment*

The overall conservation status assessment for *L. clavatum* at each site was evaluated based on the results of all three parameters, according to the matrix in Table 1. The overall conservation status of *L. clavatum* at sites surveyed during the Rare Plants Monitoring Survey was then assessed using the guidance provided by the EU (DG Environment, 2017).

4.4 Results

4.4.1 *Population* assessment

The results of the *Population* assessment of *L. clavatum* are shown in Table 26. Recorded values for all criteria and sites are given in the site reports in Appendix 4. Four sites received a Favourable assessment, and one was assessed as Unfavourable-Bad.

The population at LC04 Corlisbannan had not previously been surveyed in the baseline survey. When it was first recorded in 2011 it was described as a "low-level population" (NPWS, 2018). Despite an intensive search during the current survey the population was not relocated. Surveyors noted that the habitat was probably still suitable and was being grazed, so the possibility of the species either re-establishing here or colonising elsewhere in the area was not entirely discounted. However, the current *Population* assessment for LC04 is Unfavourable-Bad.

LC05 had not previously been surveyed and therefore no targets were set prior to this survey. Following the procedure followed by Smyth *et al.* (2015), the targets to be met by LC05 in the next monitoring period were set after the site was surveyed during the current survey. The only general applicable criterion, presence of sporing plants, was passed. Therefore this site passed all criteria, and its *Population* assessment is Favourable.

Table 26 *Population* assessment results for *Lycopodium clavatum* sites surveyed during the Rare Plants Monitoring Survey 2015-18. *n* = number of stops. OSMs = occupied square metres. Fav = Favourable, U-B = Unfavourable-Bad.

	Site	LC01 (*n*=10)	LC02 (*n*=9)	LC03 (*n*=1)	LC04 (*n*=0)	LC05 (*n*=3)
1	No. colonies/ OSMs	Pass	Pass	Pass	Not found	Pass
2	Population extent (m^2)	Pass	Pass	Pass	Not found	Pass
3	Cover *L. clavatum*	Fail*	Fail*	Pass	Not found	Pass
4	Population size class	Pass	Pass	Pass	Not found	Pass
5	Fertile cones	Pass	Pass	Fail	Not found	Pass
	No. of passes	4	4	4	0	5
	Passed on expert judgement	5	5	4	0	5
	Population assessment	Fav	Fav	Fav	U-B	Fav

* Fail within margin of error expected from cover estimation; Passed on expert judgement.

Comparisons between the current survey and the baseline survey are made below.

4.4.1.1 *Number of colonies*

Due to the difference in how colonies were counted it was not possible to make a direct comparison between the number of colonies recorded in the baseline survey and the number of occupied square metres counted in the current survey. However, as the number of occupied square metres counted far exceeded the number of colonies in the two larger populations at LC01 and LC02, in one case by at least a factor of 10, it was assumed that the number of colonies was maintained since the baseline survey. The third population was small, covering less than a square metre, so the single colony recorded in the baseline survey was maintained. Therefore all sites passed this criterion.

4.4.1.2 *Population extent*

Population extent remained unchanged across the three monitoring populations, with neither an increase nor a decrease noted at any of them. Therefore these three sites passed the criterion.

4.4.1.3 *Cover of* Lycopodium clavatum

Average percent cover of *L. clavatum* recorded during the current survey was lower than the baseline values at LC01 Clohernagh Mountain and LC02 Kippure Mountain, the cover values of 7% and 5% respectively failing to meet the target of 11% set for both sites. Both results were judged to be within the margin of error to be expected from different surveyors and were awarded a discretionary pass. Conversely, cover of the species at the third site, LC03 Turlough Hill (Camaderry), was 1% during the current survey, which was higher than the baseline survey, in which just a single individual of the species was recorded, a Domin value of +. Therefore this also passed.

4.4.1.4 *Population size class*

As for *Huperzia selago*, some ambiguities were noted regarding the targets for population size class in the baseline report (Smyth *et al*., 2015). The site reports for LC01 Clohernagh Mountain and LC02 Kippure Mountain gave the target for population size class as "4 (5000-10000)"; however, size class 4 should refer to the range 501-1000, according to the scheme of Evans & Arvela (2011) in Table 2. The baseline site report of LC01 Clohernagh Mountain refers to a "very large population of 3000 – 1000", giving rise to uncertainty as to whether the actual range should be 1,000-3,000 or 3,000-10,000; however, neither range corresponds to a size class in the table. It is therefore unclear exactly what the targets are for LC01 and LC02. Raw baseline data suggest that population size class 5 (1,001-5,000) is most appropriate, so this was the target used for comparison in the current survey. Both LC01 and LC02 met

this target. The population at LC03 Turlough Hill (Camaderry) appears to have increased slightly since the baseline survey (up from three stems to 19), although the size class remains unchanged. All three monitoring sites therefore passed this criterion.

4.4.1.5 *Fertile cones*

Fertile cones were recorded at the large populations at LC01 Clohernagh Mountain, LC02 Kippure Mountain and LC05 Lavagh More. No fertile individuals were found in the small population at LC03 Turlough Hill (Camaderry), which therefore failed the criterion.

4.4.2 *Habitat for the species* assessment

The results of the *Habitat for the species* assessment for *L. clavatum* are shown in Table 27. Recorded values for all sites and criteria are given in the site reports in Appendix 4. Three sites were assessed as Favourable, one was Unfavourable-Inadequate and the fifth was assessed as Unknown due to insufficient data.

Table 27 *Habitat for the species* assessment results for *Lycopodium clavatum* sites surveyed during the Rare Plants Monitoring Survey 2015-18. n/a = Not assessed. Fav = Favourable, U - I = Unfavourable-Inadequate.

	Criterion	LC01	LC02	LC03	LC04	LC05
1	Cover of *Calluna vulgaris*	Pass	Pass	Pass	n/a	Pass
2	Cover of bare ground	Pass	Pass	Pass	n/a	Pass
3	Impact of negative pressures	Pass	Pass	Fail	n/a	Pass
	No. of passes	3	3	2	0	3
	Habitat for the species assessment	Fav	Fav	U-I	Unknown	Fav

4.4.2.1 *Cover of* Calluna vulgaris

Calluna vulgaris was only recorded in seven out of 23 monitoring stops. While cover was occasionally high in individual monitoring stops, reaching 75% in one stop in LC01 Clohernagh, the average cover over all stops was well below the threshold of 10% at all four sites. Therefore all sites passed this criterion.

4.4.2.2 *Cover of bare ground*

Bare ground was recorded at all sites except LC03 Turlough Hill (Camaderry), which has the smallest population of *L. clavatum* surveyed and where only one monitoring stop could be recorded. This may indicate that opportunities for colonisation by spore germination are restricted, although spread by rhizomes should still be possible. Cover of bare ground was low on average across each of the other three sites, but a single plot at LC02 Kippure was recorded with cover of bare ground of 20%, a possible sign of excessive disturbance. This stop was located in acid grassland close to the trig point at Kippure, where walkers along the route frequently gather, so this area is prone to disturbance. Across monitoring stops for the site, however, the average bare ground at LC02 was 3.5%, well within the limits set for the criterion. All sites passed this criterion.

4.4.2.3 *Impact of negative pressures*

Site LC03 Turlough Hill (Camaderry) contains a small population (population extent <1 m^2) of *L. clavatum*. The habitat here was assessed as being undergrazed. Therefore the risk of extinction of this population is high, given that the species is not a good competitor.

4.4.3 *Future prospects* assessment

4.4.3.1 *Pressures, threats and other activities*

Prior to evaluating the *Future prospects* parameter, the activities, both positive and negative, recorded in the *L. clavatum* habitat were examined. Table 28 shows the positive activities that were recorded in *L. clavatum* habitat during the current survey. Table 29 shows the negative pressures recorded.

Table 28 Frequency of positive impacts, by intensity and percentage (%) of the habitat affected, recorded in the five *Lycopodium clavatum* sites. Impact codes are according to Ssymank (2011).

Impact code	Impact description	Intensity				% habitat affected			Total.
		High	Medium	Low	Unknown	≤25%	26-75%	>75%	
A04.02.02	Non-intensive sheep grazing			1				1	1
	Total			1				1	

Table 29 Frequency of negative impacts, by intensity and percentage (%) of the habitat affected, recorded in the five *Lycopodium clavatum* sites.

Impact code	Impact description	Intensity				% habitat affected			Total
		High	Medium	Low	Unknown	≤25%	26-75%	>75%	
A04.02.02	Non-intensive sheep grazing			1				1	1
A04.03	Abandonment, lack of grazing		1					1	1
G01.02	Walking, horse-riding and non-motorised vehicles			1				1	
G05.01	Trampling/overuse		1			1			2
K01.01	Erosion	1					1		1
M	Climate change				5			5	5
	Total	1	2	2	5	1	1	8	

Only one positive measure was noted; this was low-intensity sheep grazing (A04.02.02) at LC03 Turlough Hill (Camaderry), which was seen as beneficial for the species, although negative for the associated heath habitat. Sheep grazing was also recorded at LC01 Clohernagh Mountain and LC05 Lavagh More, but in both cases it was regarded as a neutral impact.

Negative impacts were more in evidence. Non-intensive sheep grazing (A04.02.02) was seen as a low-intensity negative impact at one site, LC02 Kippure. Abandonment/lack of (or insufficient) grazing (A04.03) was regarded as an issue at LC03, the positive effects of grazing here being somewhat outweighed by the negative effects of encroaching vegetation. The issue of grazing in the uplands is complex, as many heath habitats suffer from overgrazing (NPWS, 2013) but some individual species benefit because it creates opportunities for colonisation, through disturbance and by reducing pressures from more competitive species. It is possible that *L. clavatum* colonisation at this site was facilitated by overgrazing which has since been relaxed, resulting in expansion of more competitive species. The level of grazing at LC03, while too high for the surrounding heath habitat, was considered to be slightly too low for *L. clavatum* because encroachment of other species was occurring in its vicinity; however, as these included less palatable species such as *Nardus stricta* and *Juncus squarrosus*, there is no guarantee

that increasing grazing would solve the problem, and it would likely be damaging to the surrounding Annex I habitats.

Walking, horse-riding and non-motorised vehicles (G01.02) and Trampling/overuse (G05.01) were impacts seen at sites which are close to routes frequented by walkers. The latter code was used for the damage seen at LC01 Clohernagh Mountain because the level of damage was severe (though relatively localised), with a trampled/eroded route created across the heath by hikers.

Climate change, as for the other two upland clubmoss species, is recorded as a probable negative impact of unknown intensity affecting the entire habitat for the species.

4.4.3.2 *Future prospects of* Population *and* Habitat for the species *parameters*

The future prospects for the *Population* and *Habitat for the species* parameters were examined for each of the five *L. clavatum* sites surveyed during the current project. Table 30 shows the results. Three sites were assessed as Favourable, one as Unfavourable-Inadequate and one as Unfavourable-Bad.

LC01 Clohernagh Mountain, LC02 Kippure and LC05 Lavagh More all received Favourable assessments for *Future prospects* as the *Population* and *Habitat for the species* assessments were Favourable and the pressures and threats recorded at the sites were considered to be low. The *Future prospects* of *Habitat for the species* for LC03 Turlough Hill (Camaderry) were assessed as Unfavourable-Inadequate as species composition change is occurring here and there is a risk that the small population of *L. clavatum* at this site – less than 1 m² – will be out-competed by other species.

Table 30 *Future prospects* (FP) assessment for the five Lycopodium clavatum sites surveyed during the Rare Plants Monitoring Survey 2015-18. Pop = *Population*, HfS = *Habitat for the species*. Fav = Favourable, U-I = Unfavourable-Inadequate, U-B = Unfavourable-Bad.

Site	FP of Pop.	FP of HfS.	FP of *L. clavatum*	Rationale
LC01	Fav	Fav	Fav	Some negative effects from grazing and hiking, but these are not severe
LC02	Fav	Fav	Fav	Some negative effects from grazing and hiking, but these are not severe
LC03	Fav	U-I	U-I	Negative effects from encroachment by competitive species with potentially serious impact on this small population
LC04	U-B	Unknown	U-B	Population was not refound at the site during the current survey; HfS was not assessed. There is only a slight possibility that the species may recolonise from spores in soil; it was likely a transient colony that may not have persisted for long
LC05	Fav	Fav	Fav	Relatively small population but grazing is occurring at appropriate level

4.4.4 Conservation status assessment for individual sites

The assessments of the individual parameters at each site were combined according to the evaluation matrix in Table 1 to obtain the conservation assessment for *L. clavatum* at each site (Table 31). Three sites received a Favourable assessment: LC01 Clohernagh Mountain, LC02 Kippure and LC05 Lavagh More. LC03 Turlough Hill (Camaderry) received an Unfavourable-Inadequate assessment because of the risks posed by undergrazing to such a small population. LC04 Corlisbannan was searched for *L. clavatum* but none was found, so the assessment was Unfavourable-Bad.

Table 31 Assessment results for the five *Lycopodium clavatum* sites surveyed during the Rare Plants Monitoring Survey 2015-18. Fav = Favourable, U-I = Unfavourable-Inadequate, U-B = Unfavourable-Bad. CS = Conservation status.

Site	Population	Habitat for Species	Future prospects	Overall CS
LC01	Fav	Fav	Fav	Fav
LC02	Fav	Fav	Fav	Fav
LC03	Fav	U-I	U-I	U-I
LC04	U-B	Unknown	U-B	U-B
LC05	Fav	Fav	Fav	Fav

4.4.5 Overall conservation status assessment for Rare Plants Monitoring Survey sites

The assessments of the individual parameters were combined according to the evaluation matrix in Table 1 to obtain the overall conservation assessment for *L. clavatum* at sites surveyed during the Rare Plants Monitoring Survey.

Following the guidelines for species assessment at a national level (DG Environment, 2017), based on the results presented here and taking into account the estimated future trends of the species populations and habitat based on the threats and positive activities in place, the overall conservation status assessment result for *L. clavatum* at sites surveyed during the Rare Plants Monitoring Survey is **Unfavourable-Inadequate** and the trend is **declining**. Table 32 summarises this result. The following data detailed in this report were used to arrive at this result

- *Population* is Unfavourable-Inadequate as one small population present in the last monitoring period was not refound, although marginally suitable habitat is thought still to exist there; three other populations remain stable since the baseline and the fifth is still extant; trend is declining as this was assessed as Favourable in the previous monitoring period (Smyth *et al*., 2015)
- *Habitat for the species* is generally favourable but one population is vulnerable due to undergrazing and habitat at the site where a small population was not relocated is only marginally suitable; the same assessment was given as in the last monitoring period for *Habitat for the species*, i.e. Unfavourable-Inadequate, so trend is stable
- *Future prospects* are poor; one site is undergrazed, putting further pressure on an already small population; one small transient site has disappeared; threats such as forestry are more likely to occur in the future, which will impact significantly on the habitat in the long term. The issues of grazing and trampling by hikers at some sites in Wicklow, while not thought to be having a significant impact on the species, will need to be monitored and, if necessary, addressed to ensure that this remains the case.

Table 32 Summary of the overall conservation status assessment of *L. clavatum* at sites surveyed during the Rare Plants Monitoring Survey (RPMS) 2015-18. FP = Future prospects.

Parameter	Conservation status	Trend	FP of parameter
Population	Unfavourable-Inadequate	Declining	Poor
Habitat for the species	Unfavourable-Inadequate	Stable	Poor
Future prospects	Unfavourable-Inadequate		
Overall Conservation Status Assessment for RPMS sites	**Unfavourable-Inadequate**	**Declining**	

It should be noted that the overall conservation status assessment for Rare Plants Monitoring Survey sites does not include an assessment of the *Range* parameter. This was assessed in the national conservation assessment of the *Lycopodium* spp. group (NPWS, 2019), which incorporated the combined results of the assessments of *Population*, *Habitat for the species* and *Future prospects* for *Diphasiastrum alpinum*, *Huperzia selago*, *Lycopodiella inundata* and *Lycopodium clavatum*, along with data from other recent surveys of these species.

4.5 Discussion

The overall conservation status assessment of *L. clavatum* at sites surveyed during the Rare Plants Monitoring Survey is Unfavourable-Inadequate, based on unfavourable results for the habitat for the species and poor future prospects. Vegetative spread of the plant by rhizomes is probably the main way it increases its cover, and this may have occurred at LC03 Turlough Hill (Camaderry), where the cover of the plant appears to have increased slightly since the baseline survey. However, as there was only one colony observed here during both the baseline and current surveys it is in a vulnerable situation, particularly as no fertile cones were seen in the population, either during the current survey or the baseline survey, so it is entirely reliant upon vegetative spread at this site. Occurrence of bare soil is low here and grazing was considered to be slightly too low for the species (although too high for surrounding Annex I habitats), with dense vegetation growing in the vicinity of the *L. clavatum* patch surveyed, so opportunities for the establishment of new patches by spore germination are limited. However, surveyors did note the presence of two small additional *L. clavatum* colonies on leaving the site after the survey had been concluded so these should be added to the area to be surveyed in the next round of monitoring. The likelihood of the future viability of this small population can only be improved by the presence of these additional colonies in the vicinity, as well as further large sporing populations 7-8 km to the north and south.

LC04 Corlisbannan, on the other hand, does not appear to support the plant any more. The correct area was searched intensively by three ecologists with guidance from the ecologist who originally recorded the population (J. Conaghan, pers. comm.). When the population was recorded in 2011 it had been described as "low-level". The habitat is not typical, and this may just have been a transient occurrence of *L. clavatum* in sub-optimal habitat, perhaps established from a larger undetected population in more suitable habitat nearby, from which this small colony established. No obvious negative pressures, such as excessive disturbance, were noted. The possibility of *L. clavatum* spores remaining viable in the soil has not been ruled out, however, and as habitat remains marginally suitable the site has not yet been removed from the range. It is recommended that the site be searched again in the next monitoring period. If the plant has been recorded as absent over two monitoring periods – this period and the next – then the population should be declared extinct. (This may affect the assessment of the *Range* parameter if it proves to be the only population recorded for that 10 km square.) However, Preston *et al*. (2002) say of the plant that "[non-lowland] populations … are somewhat transient, with losses owing to overgrazing, heather burning, conversion to scrub and agricultural improvement being offset by the establishment of new populations", so there is a slight possibility that, if viable spores are present in the soil, spore germination could result in establishment of a new patch in the vicinity of the old. It is also possible that this represents a chance discovery of a short-lived, transient population: the population was originally found on the lower slopes of The Playbank mountain, the peak of which is less than 2 km to the southeast. It may be that another, larger population exists undetected nearby, potentially in more suitable habitat.

One possible threat to this site, should *L. clavatum* be recorded here in the future, is the proximity of existing forestry plantation close to the site. With the planned expansion of forestry as a national goal by the Irish government (DAFM, 2014, 2015), this and other sites like it which occur on marginal agricultural land are at risk of being converted from heath to forestry, with the consequent loss of suitable *L. clavatum* habitat.

The population at LC05 Lavagh More was found in largely undisturbed montane heath and was comprised of two separate patches. There were signs of recovery from overgrazing in the general area here and sheep grazing, though occurring throughout the habitat, was not deemed to be a negative pressure. No other pressures, threats or activities were recorded (apart from climate change, which was recorded for every *L. clavatum* site) and the population here is expected to have good prospects of future viability and so was assessed as Favourable. Climate change will likely have a negative impact on this and other upland species (Hodd *et al*., 2014), but the intensity of the impact is as yet unknown.

Because the number of sites surveyed in the current monitoring period was small, only five sites (four with the species present), it is recommended that further sites be selected from the plant's range in the next monitoring period so that a more accurate picture may be gained of the national condition of the plant.

General recommendations regarding the future surveying of this species concern updating distribution records in locations where the species has not been confirmed for some time, e.g. since 2000. Additional data would also be useful to test the assessment criteria more rigorously, or to refine criteria targets.

5 *Lycopodiella inundata*

5.1 Species description

Lycopodiella inundata (Marsh Clubmoss) has a restricted distribution in Ireland. Its core area is at a number of geographically clustered locations to the west of Loughs Mask and Corrib, in counties Mayo and Galway. There are also isolated populations in Armagh (the only known population in Northern Ireland), Donegal and on the Cork/Kerry border. There are older records from counties Offaly, Wicklow and other parts of Cork and Kerry, but the species has not been seen in these areas for over 30 years. Distribution data collated for the most recent Article 17 report on the *Lycopodium* spp. group (NPWS, 2019) show that the species has been recorded from 21 hectads in total, 15 since 1970 but only five hectads since 2000. Information on distribution was collated from data provided by BSBI (2015-2018, 2018) and NPWS (2018), as well as data available online on the website of the NBDC (2018).

Smyth *et al.* (2015) noted that the species was found in a distinctly different habitat from the other three clubmoss target species, mostly occupying habitats in lowland situations. This was confirmed by a preliminary analysis of the data gathered in the current survey (Appendix 3). *L. inundata* is also the rarest of the four species and is protected in Ireland under the Flora (Protection) Order, 2015 (S.I. 356 of 2015).

Globally, *L. inundata* is found mainly in North America and Europe. It has a scattered distribution across much of northern Europe, with strongholds in the UK (particularly the New Forest) and France but is considered rare and declining across much of its range, and is particularly vulnerable in lowland heathlands (Byfield & Stewart, 2007). The IUCN Red List of Threatened Species notes that this species appears to be declining throughout much of its range, mainly as a result of loss and degradation of its habitat, but it is widespread and is still sufficiently abundant to class it as Least Concern (Lansdown, 2014).

Figure 8 *Lycopodiella inundata* at Cornamona. Photo by Maria Long.

In Ireland, *L. inundata* is found on lake margins and on open patches on peaty soil in heathland, flushes and bog (Parnell & Curtis, 2012; Smyth *et al.*, 2015). Habitats are typically lowland, and open damp

ground is a necessity. Thus moderate levels of disturbance are both beneficial and necessary. The disturbance can be natural or anthropogenic, such as periodic inundation, grazing, trampling, footpaths or vehicle tracks. The species is a poor competitor and is quickly lost where management or hydrological regime shifts result in vigorous growth of vegetation or succession. Work by Rasmussen & Lawesson (2002) also suggests that it is intolerant of eutrophication, but can tolerate a wide range of soil pH and soil moisture conditions. Many of its sites in Ireland are known to flood, in some years for considerable periods of time, though in the UK, it appears that most sites do not flood. According to Byfield & Stewart (2007), *L. inundata* typically occurs in three habitat types in Britain: open areas in wet heathland (particularly in sites in lowland England), at the edges of oligotrophic lakes (mostly in more upland situations in Scotland and Wales), and on abandoned sand, gravel or granitic china clay quarries (lowland England heathlands). For detailed information on the ecology of this species, see Rasmussen & Lawesson (2002) and Byfield & Stewart (2007).

Like other clubmosses (and ferns) *L. inundata* has two principal life stages. The most commonly encountered is the sporophyte phase, and the usually less obvious phase is the gametophyte. Most clubmosses have an underground saprophytic gametophyte, but *L. inundata* differs in having a green, above-ground, photosynthetic gametophyte (Byfield & Stewart, 2007). To our knowledge, this has not yet been recorded in the wild in Britain or Ireland.

In common with several other species of clubmoss, *L. inundata* is known to require at least one fungal partner, particularly in its gametophyte stage. This, along with its slow growth rate, may help it to survive in relatively hostile and sometimes infertile sites (Byfield & Stewart, 2007; Gilman, 2004). While relatively little is known about this partnership, it has been shown in growth and translocation trials that plants do not survive long without fungal associations (Ivanova & Natcheva, 2016; D. Price, Species Recovery Trust, pers. comm.). It has been suggested that the fungal partner of *L. inundata* requires dead wood, and that as such, in Ireland, the species is nearly always found where there are old/ancient tree stumps in the surrounding peat (M. Jebb, Director National Botanic Gardens, pers. comm.). Work in the UK suggests that the species relies on a fungus that only occurs in the roots of other plants, such as *Molinia caerulea* (D. Price, pers. comm.). See Pressel *et al.* (2016) for an overview of work on fungal associates of pteridophytes and *L. inundata*, and Fuchs & Haselwandter (2004) for a detailed look at fungal partners of *L. inundata* at a small number of study sites.

In Ireland, *L. inundata* is the rarest of the four Annex V clubmosses and is listed on Ireland's Flora (Protection) Order, 2015. It is listed as Vulnerable in the recent Red List for vascular plants in Ireland (Wyse Jackson *et al,* 2016) due to declines in area of occupancy, extent of occurrence and habitat quality. There have clearly been substantial losses to this species over the years, illustrated by the decline in occupied hectads. Detailed monitoring, such as this current project, will help elucidate how individual sites and populations are faring. The main threats to the species in Ireland are thought to be loss of open habitat, often through lack or relaxation of management. Other issues include drainage and land use change, with forestry possibly becoming one of the most serious issues in these wet habitats, as well as changes in nutrient status and eutrophication. In the future, climate change could have an impact on this species also by causing drying out of habitats or changes in the hydrological regime (e.g. reduction in frequency of flooding). In the UK, the main threats listed in the UK Action Plan for the species are habitat loss, drainage, cessation of traditional management practices and associated succession, nitrate and phosphate pollution and associated growth of competitive vegetation, atmospheric pollution, and afforestation (UK Biodiversity Group, 1998). Trials on translocation and habitat/gap creation (via scrapes in suitable peatland habitat) demonstrate that the plant is difficult to reintroduce to an area once lost (D. Price, pers. comm.), therefore conservation of existing sites of *L. inundata* should be a priority.

5.2 Review of survey methodology and assessment criteria

5.2.1 Definition of a colony

In Smyth *et al*. (2015), a colony was taken as the basic unit of a clubmoss population, being defined as a "discrete, unconnected, measurable patch of the species." During the current survey the same problem was found for *L. inundata* as for the other clubmosses in identifying and counting separate colonies. Therefore, the same procedure was followed as for *Diphasiastrum alpinum* in counting occupied square metres of *L. inundata* instead of individual colonies (see Section 2.2.1).

To calculate the total area covered by *L. inundata* and total number of shoots in the population the following procedure was used

- Count the number of occupied square metres
- Record the appropriate number of 1 m^2 monitoring stops, up to a maximum of ten
- Estimate the total area covered by *L. inundata* in square metres as the average percent cover of *L. inundata* per monitoring stop multiplied by the total number of occupied square metres counted
- Estimate the total number of shoots as the average number of shoots per monitoring stop multiplied by the total number of occupied square metres counted.

5.2.2 Review of *Population* assessment criteria

The following population assessment criteria used by Smyth *et al.* (2015) for *L. inundata* were reviewed

- Total number of colonies
- Population extent (combined area of occupancy of colonies)
- Domin cover of *L. inundata* species in the monitoring stop
- Estimated number of *L. inundata* shoots (as population size class), and
- Presence of sporing *L. inundata* plants.

5.2.2.1 Total number of colonies

Section 2.2.1 described the revised method used to quantify the extent of the plant in the current survey, i.e. using occupied square metres rather than colonies. The site-specific targets for colony numbers set in the baseline survey therefore no longer apply, and the number of occupied square metres counted during the current survey should be used as the basis for new targets. To allow for surveyor variability between monitoring periods (and following a similar procedure used in other species monitoring protocols, e.g. Muldoon *et al*. (2015)), a threshold of 80% of the current number of occupied square metres should be used as the target number of occupied square metres to be attained in the next period.

5.2.2.2 Population extent

The dimensions of each population's extent were approximated during the baseline survey as a single broad envelope encompassing the entire population (e.g. 10 m x 50 m) rather than defined exactly by GIS mapping. While this enables a broad-brush comparison to be made between population extents measured over two successive monitoring periods, mapping the population envelope more precisely using GIS is a more useful gauge of the extent of the population and also defines the search area for the next monitoring period. In future monitoring periods it is recommended that comparisons be made with the current mapped area of the habitat occupied by *L. inundata* rather than with the more approximate extents used in the baseline survey. To allow for minor differences in GPS accuracy or mapping between surveyors, a target of 90% of the mapped area should be set for sites, as in Muldoon *et al*. (2015) for mapped habitat of *Saxifraga hirculus*.

5.2.2.3 *Domin cover of* Lycopodiella inundata

Cover of *L. inundata* was recorded as a Domin value in monitoring stops by Smyth *et al*. (2015). This was used as the target to be met by successive monitoring assessments. The current survey recorded cover values as percentage of the plot, rather than as Domin. The baseline Domin targets were retained as targets for the current survey but converted to their equivalent percent values.

5.2.2.4 *Number of shoots*

The target for the population size class (number of shoots per population) was to meet or exceed the population size class recorded during the baseline survey (Smyth *et al.*, 2015). Population size classes were according to the scale proposed by Evans & Arvela (2011), shown in Table 2 (see Section 2.2.2.4). Population size class was judged following this review to be an appropriate method of measuring and comparing population shoot numbers between monitoring periods.

5.2.2.5 *Presence of sporing plants*

The presence of sporing *L. inundata* plants (fertile cones seen in the population) is an additional indicator of population health and this criterion was retained.

5.2.2.6 *Revised* Population *assessment criteria for* Lycopodiella inundata

The revised list of population assessment criteria for *L. inundata* is as follows

- Total number of colonies or occupied square metres (OSMs): For the current monitoring period the comparison will be made with the total number of colonies recorded during the baseline survey, but from next monitoring period onwards, the comparison will be made with the number of occupied square metres recorded during the current survey
- Population extent: For the current monitoring period the comparison will be made with the approximate population envelope dimensions given in the baseline survey, but from next monitoring period onwards, the comparison will be made with the mapped extent recorded during the current survey
- Percent cover of *L. inundata* in the monitoring stop
- Estimated number of *L. inundata* shoots (as population size class), and
- Presence of sporing *L. inundata* plants: Present or Absent.

5.2.3 Review of *Habitat for the species* assessment criteria

The following *Habitat for the species* assessment criteria used by Smyth *et al.* (2015) for *L. inundata* were reviewed

- Average shoot length across all plots
- Domin cover of *Schoenus nigricans* + *Nardus stricta*
- Domin cover of bare rock/bare ground
- Domin cover of bryophytes, and
- Hydrology (wetness of substrate).

5.2.3.1 *Average shoot length*

The average length of five shoots in each monitoring plot was calculated and used in the baseline survey as a proxy for grazing pressure. However, Byfield & Stewart (2007) note that, while the plant grows at the tips, typically by about 3 cm every year, the older parts of the plant die off so that branches become separate individuals, and in some cases, die-back can occur almost to the tip during the winter. Therefore, variation in shoot length may be due to factors that have little or nothing to do with grazing pressure. For this reason, it is proposed that this criterion be dropped.

In the lowland habitats favoured by *L. inundata*, average sward height could be used as a suitable substitute criterion to assess grazing level (particularly undergrazing) in combination with the observation of grazing effects as part of the recording of pressures, threats and conservation activities on the site. From an examination of the current survey's data, *L. inundata* favours a short sward and a target of 4-10 cm average sward height across all plots within a site seems suitable. This target will require review in future monitoring periods as more data become available.

5.2.3.2 Domin cover of Schoenus nigricans *and* Nardus stricta

Following analysis of baseline survey data, Smyth *et al*. (2015) concluded that *L. inundata* was associated with *Schoenus nigricans* and *Nardus stricta* and a target of Domin 5-8 (11-50%) was set for the criterion. This was based on analysis of data from ten plots, although data from only three of these plots (from one site) were available for comparison with the current survey. The current survey did not find a strong relationship between *L. inundata* and these two species in combination. However, a negative trend was found between *L. inundata* and *N. stricta*, i.e. higher cover of *N. stricta* was generally associated with lower cover of *L. inundata*. On the basis of these findings, it is proposed that the criterion Cover of *Schoenus+Nardus* be dropped. As a substitute, Cover of *N. stricta* is proposed instead, with an upper threshold of 35% imposed, on the basis that higher cover of *N. stricta* is unfavourable for *L. inundata*. This criterion is defined on the basis of a relatively small dataset so it may need adjustment as more data become available on *L. inundata* and its habitats. It may also be found necessary in the future to define an upper threshold for other competitive species such as *Molinia caerulea*.

Some positive trends were noted between *L. inundata* and other species, such as *Carex panicea*, which was present in all 16 plots and whose trend in cover generally followed that of *L. inundata*. However, data are insufficient at this time to determine whether any conclusions on habitat suitability can be made for *L. inundata* based on the presence and abundance of *C. panicea*. Further trends may emerge as more data are gathered in the future.

5.2.3.3 Domin cover of bare rock/bare ground

Smyth *et al.* (2015) set a target for bare rock/bare ground of Domin 4-8, i.e. 5-75%, following analysis of baseline data from two sites. Byfield & Stewart (2007) noted that *L. inundata* "needs to grow in open vegetation, often 30-60% bare ground". From the data recorded during the current survey, there was always some bare rock or bare ground in *L. inundata* plots, ranging from 0.5 to 35%, and the site averages for the two combined ranged between 9.6% and 23%. However, the ability of the plant to colonise an area is likely to be better on bare ground (such as soil or peat) rather than bare rock. According to Byfield & Stewart (2007), *L. inundata* tends to grow where a thin covering of peat occurs over a firm sandy or gravelly base.

For this reason, it is proposed that the criterion refer to bare ground (such as soil or peat) only, rather than bare ground and rock combined, and a proposed target of 3-20% is set based on data from the current survey; a higher target is not recommended at this time as it could indicate habitat degradation due, for example, to overgrazing or excessive disturbance, but further data may provide clarity on a more suitable upper threshold.

5.2.3.4 Domin cover of bryophytes

A target of Domin 5-7 (11-50%) was set by Smyth *et al.* (2015) for bryophyte cover. The current survey's data found an overall negative association between *L. inundata* cover and bryophyte cover, with the highest cover of *L. inundata* occurring where bryophyte cover was relatively low; however, there were also several instances where *L. inundata* was abundant even where bryophyte cover was high. Therefore this does not appear to be a consistent factor in habitat suitability for *L. inundata*, so it is proposed that cover of bryophytes be dropped as a criterion. There is some indication from the current data that cover of sedges may prove to be a suitable substitute criterion, if one is needed, but more data are required to ascertain if this is the case and it is not proposed as a criterion at this time.

5.2.3.5 Hydrology (wetness of substrate)

This was defined by Smyth *et al*. (2015) as dampness of ground. It is acknowledged that this is subject to variation depending on weather conditions; however, it is retained as a criterion for *L. inundata* as wet habitat is a prerequisite for the species. For the site to pass the criterion it is required that at least one stop be sufficiently wet.

5.2.3.6 Additional criteria

EU reporting guidelines state that it is often enough to assess the quality of the species' habitat via the pressures operating on it, with the "direct measurement of the physical quality of the species' environment" not always necessary (DG Environment, 2017). Therefore, it is proposed that the impact of pressures operating on the habitat be added as an additional assessment criterion for the habitat for the species, with a target of "low or absent".

5.2.3.7 *Revised* Habitat for the species *assessment criteria for* Lycopodiella inundata

The revised list of criteria for *Habitat for the species* for *L. inundata* is as follows (targets in parentheses)

- Average sward height across all plots (4-10 cm)
- Cover of *Nardus stricta* (≤35%)
- Percent cover of bare ground (3-20%)
- Wetness of substrate: ground damp to touch (yes), and
- Impact of negative pressures (low or absent).

5.3 Methodology

5.3.1 Site selection

Sites to be surveyed were selected by NPWS primarily to address data-deficient populations. Table 33 lists the sites and Figure 9 shows their distribution. Five *L. inundata* populations were surveyed. Two had been surveyed by Smyth *et al*. (2015) and required monitoring surveys. The remaining three had not previously been surveyed and required baseline surveys.

Table 33 *Lycopodiella inundata* sites surveyed for the Rare Plants Monitoring Survey 2015-18.

Site ID	Site name	County	Survey type	SAC code	SAC name
LI01	Cornamona	Galway	Monitoring	n/a	n/a
LI02	Capnagower, Clare Island	Mayo	Monitoring	n/a	n/a
LI03	Oorid Lough	Galway	Baseline	002034	Connemara Bog Complex
LI04	Glenasaul	Mayo	Baseline	n/a	n/a
LI05	Lough Corrib, E. of Lackavrea Hill	Galway	Baseline	000297	Lough Corrib

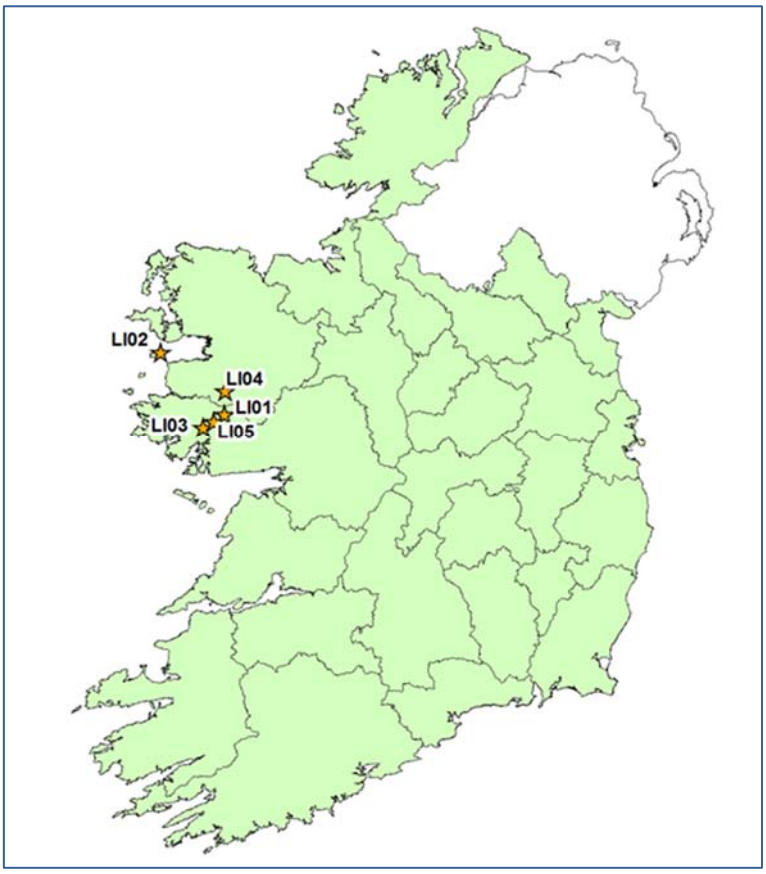

Figure 9 Location of *Lycopodiella inundata* sites surveyed during the Rare Plants Monitoring Survey 2015-18

5.3.2 Survey preparation

Site packs and Trimble Nomads for *L. inundata* surveys were prepared as for *Diphasiastrum alpinum* surveys; see Section 2.3.2.

5.3.3 Site surveys

Sites were surveyed between 13 October 2016 and 26 May 2017. Survey teams consisted of two ecologists. As for the other three clubmosses, the survey methodology for *L. inundata* can be broadly divided into four main tasks

- Conduct count of colony patches to record population-specific data
- Establish and map the extent of the population
- Record monitoring stop data, and
- Complete the site summary data sheet including impact recording.

During all stages of the survey, surveyors recorded any information of interest or relevance, including features or species of interest, botanical or otherwise. Where possible, these were photographed. Photographs of site features (e.g. impacts, management) were taken, as appropriate, for inclusion in the project's Image Databank.

5.3.3.1 Count of occupied square metres

The number of occupied square metres of *L. inundata* in each site was determined as described for *Diphasiastrum alpinum* in Section 2.2.1.

5.3.3.2 Population extent

The outer envelope of the species extent was recorded as waypoints on the Trimble's GPS. This involved walking through the site and recording the occurrence of the species. The outer limits of the population were digitised with the aid of these points.

5.3.3.3 Monitoring stops

Monitoring stops measuring 1 m x 1 m were delineated on the ground using a measured rope and metal pegs. A GPS waypoint was recorded on the Trimble at every monitoring stop, and photographs were taken, including at least one close-up of the plot's vegetation and another more general view to show the plot in the context of the landscape. Where baseline surveys had previously been carried out, monitoring stops were generally located as close as possible to the original baseline stops, using the baseline stop shapefile on the Trimble to navigate directly to them. Relocation of stops was sometimes necessary, e.g. to achieve a better spread of recording.

Data to assess *Population* and *Habitat for the species* were recorded at every monitoring stop, as well as a full relevé (plant species list and species abundances). Monitoring stop data specifically required for carrying out assessments were: cover of *L. inundata*, number of shoots, presence of fertile cones, cover of *Nardus stricta*, cover of disturbed bare ground and wetness of substrate. When counting shoots, individual shoots were traced, insofar as possible, back to the base of the plant rather than from any divisions occurring part-way along the stem.

Other structural data, such as cover of bare rock, bryophytes and dwarf shrub, were also recorded for information purposes but were not used in the assessment. Appendix 2 gives the full list of data items recorded in Turboveg at each monitoring stop.

5.3.3.4 Site summary data

The site summary data sheet (Appendix 1) was filled out by the surveyors after each site survey was concluded.

Site-level criteria included general population data. The total number of occupied square metres (OSMs) was entered in place of the total number of colonies. Population extent was filled out after the site had been digitally mapped in GIS. "Sporing plants present" was marked "Y" if any fertile plants had been seen in the population, regardless of whether these were inside or outside of monitoring stops. Unless the population was small enough for a full count of shoots to be carried out, the estimated number of shoots was calculated as:

(Average number of shoots of *L. inundata* from plots) x (number of OSMs)

Population size class was determined according to the scale proposed by Evans & Arvela (2011) (see Table 2 in Section 2.2.2.4) and used by Smyth *et al*. (2015).

Impacts and activities occurring on site in the vicinity of the target species were recorded on the site summary sheet. The impact codes from the 2007-2012 monitoring period (Ssymank, 2011) were used because the codes for the 2013-2018 reporting period were not available at the commencement of this project. Activity details logged comprised

- a description of the activity
- its influence (positive, negative or neutral)
- intensity (high, medium or low)
- the percentage of the supporting habitat affected and
- the source of the impact, whether originating from within or outside of the habitat.

5.3.4 Assessments

5.3.4.1 Population *assessment*

Following the review of criteria in Section 5.2.2, *L. inundata* populations were assessed using five criteria, which are shown, together with their targets, in Table 34. occupied square metres rather than colonies were counted in this survey, so it was not always possible to compare the occupied square metre counts directly with previous colony counts. Therefore criterion 1 (a) *No. of colonies* should be discontinued after the current monitoring period and criterion 1 (b) *No. of occupied square metres* should be used instead, with the targets set at 80% of the occupied square metre counts recorded in the current survey to allow for surveyor variability.

Targets for the first four criteria were set on a site-specific basis, based on the analysis of data from baseline surveys (Smyth *et al.*, 2015). Site-specific targets are shown in the individual site reports in Appendix 4.

Three populations, LI03 Oorid Lough, LI04 Glenasaul and LI05 Lough Corrib E. of Lackavrea Hill, had not previously been surveyed by Smyth *et al*. (2015) and therefore had no targets set for some of the criteria. Following the procedure used by Smyth *et al*. (2015), the targets to be met by these populations in the next monitoring period were set after the sites were surveyed during the current survey. The target for the number of occupied square metres was set at 80% of the count recorded in the current survey. The target for the population extent was set at 90% of the extent digitised in the current survey.

Table 34 Population criteria and targets for *Lycopodiella inundata* sites surveyed in the Rare Plants Monitoring Survey 2015-18. OSMs = occupied square metres.

	Criterion	Scale of assessment	Target
1 (a)	No. of colonies	Population	No change from previous monitoring period
1 (b)	No. of OSMs*	Population	No change from previous monitoring period
2	Population extent (m^2)	Population	No change from previous monitoring period
3	Cover of *L. inundata*	Average % cover across monitoring stops	No change from previous monitoring period
4	Population size class	Population (based on average shoot count from monitoring stops)	No change from previous monitoring period
5	Fertile cones	Population	Present
Population assessment			Favourable (Green): 4-5 passes
			Unfavourable-Inadequate (Amber): 2-3 passes
			Unfavourable-Bad (Red): 0-1 pass

* Future monitoring periods should use this criterion rather than the number of colonies to assess population.

5.3.4.2 Habitat for the species *assessment*

Following the review of criteria described in Section 5.2.3, *Habitat for the species* for *L. inundata* was assessed using five criteria, which are shown, together with their targets, in Table 35. Targets for the criteria were the same for all sites.

Table 35 *Habitat for the species* assessment criteria and targets for the *Lycopodiella inundata* sites surveyed in 2015-18.

	Criterion	Scale of assessment	Target
1	Sward height	Average of all stops within site	4-10 cm
2	Cover of *Nardus stricta*	Average of all stops within site	≤35%
3	Cover of bare ground	Average of stops within site	3-20%
4	Wetness of substrate	Any stop within site	Ground damp to touch
5	Impacts of negative pressures	Population extent	Low or absent
Habitat for the species assessment			Favourable (Green): 5 passes
			Unfavourable-Inadequate (Amber): 3-4 passes
			Unfavourable-Bad (Red): 0-2 passes

5.3.4.3 Future prospects *assessment*

The evaluation of the *Future prospects* parameter for *L. inundata* is as detailed in Section 2.3.4.3 for *Diphasiastrum alpinum*.

5.3.4.4 Site conservation status and overall conservation status assessment

The overall conservation status assessment for *L. inundata* at each site was evaluated based on the results of all three parameters, according to the matrix in Table 1. The overall conservation status of the species across all sites surveyed during the Rare Plants Monitoring Survey was then assessed using the guidance provided by the EU (DG Environment, 2017).

5.4 Results

5.4.1 *Population* assessment

Table 36 shows the *Population* assessment results for *L. inundata*. All sites received a Favourable assessment. Recorded values for all criteria and sites are given in the site reports in Appendix 4.

Table 36 *Population* assessment results for *Lycopodiella inundata* sites surveyed during the Rare Plants Monitoring Survey 2015-18. *n* = number of stops. OSMs = occupied square metres. Fav = Favourable.

	Criterion	LI01 (*n*=3)	LI02 (*n*=4)	LI03 (*n*=3)	LI04 (*n*=3)	LI05 (*n*=3)
1	No. colonies or OSMs	Pass	Pass	Pass	Pass	Pass
2	Population extent (m²)	Pass	Pass	Pass	Pass	Pass
3	Cover of *L. inundata*	Fail	Fail	Pass	Pass	Pass
4	Population size class	Pass	Pass	Pass	Pass	Pass
5	Fertile cones	Pass	Pass	Pass	Pass	Pass
	No. of passes	4	4	5	5	5
	Population assessment	Fav	Fav	Fav	Fav	Fav

5.4.1.1 Number of colonies

At least the same number of colonies were found in LI01 Cornamona and LI02 Capnagower during the current survey as in the baseline surveys of the sites. At LI02 Capnagower, the number of colonies was likely even greater than the two recorded during the baseline survey as conditions were ideal for seeing the plant. The two main colonies identified in the baseline survey were found to be contiguous, with smaller colonies, made up of a few to many individuals, present continuously between the two main colonies indicated in the baseline site map.

Occupied square metres of habitat were counted for the other three sites for which baseline surveys were required. Of the five sites surveyed, LI03 Oorid Lough had the greatest spread of the species, with 254 occupied square metres counted. LI04 Glenasaul had 56 occupied square metres, while LI05 had the lowest, at just four occupied square metres.

5.4.1.2 Population extent

Population extent remained more or less unchanged at LI01 Cornamona. However, the extent of the habitat at LI02 Capnagower was significantly higher than that reported in the baseline survey, largely owing to low water levels that permitted a more comprehensive survey of the area and a better view of the plant.

For the other three populations, the population of the populations was mapped using waypoints, to be used as a comparison in future monitoring periods.

5.4.1.3 *Cover of* Lycopodiella inundata

Average percent cover of *L. inundata* recorded during the current survey was significantly lower than the baseline values at LI01 Cornamona and LI02 Capnagower, the average cover values of 3.8% and 6.5% respectively falling far short of the target of 26% (Domin 6) set for both sites. Both populations were variable in density, with cover scores in plots ranging from 0.5% to 10% for LI01, and from 0.3% to 20% in LI02. All monitoring stops at LI01 and two monitoring stops at LI02 were recorded in the same positions as in the baseline survey (two additional monitoring stops were recorded at LI02 in the current survey). There was no obvious reason for a collapse in species cover in either population as pressures at both sites were deemed to be low and conditions for assessing the plant were excellent. Numbers of shoots were high and similar to the baseline survey (see below) but the plants themselves were small so the cover scores were proportionately low. While the differences could be due in part to surveyor variability, the differences noted here are too significant to be dismissed entirely as surveyor variability. Survey timing could be one reason for the disparity, at least for LI02: baseline visits there were made in successive years in May, July, August and September respectively (the year in which the relevés were recorded is not specified), while the assessment for the current survey was conducted relatively early in the year, in May. A comparison of photographs taken at LI02 during the two surveys shows a definite difference in cover and character of the plants, with greater cover, longer shoots and yellower plants seen in the baseline survey compared to the short, fresh green shoots seen in the current survey. There was more visible bare ground in the baseline photographs also, indicating higher levels of disturbance, probably from grazing. For both sites, therefore, it may be that some sort of disturbance occurred between the two surveys, causing significant loss of cover from which the species is still recovering, or else that natural phenology and turnover of the plant is responsible for the different cover scores.

As both sites differed so significantly from their baseline *L. inundata* cover targets, the Fail results were left to stand. Future surveys should help to determine whether the differences at both sites are due to genuine declines in cover, survey timing or surveyor variability.

5.4.1.4 Population size class

The population size class recorded in the current survey for LI01 was, despite the decline in cover noted above, unchanged. The population at LI02 Capnagower was several classes higher in the current survey than the baseline, probably due largely to the much larger population extent mapped. Population size

classes for the other three sites were determined, to be used as baseline targets in future monitoring surveys.

5.4.1.5 *Fertile cones*

Fertile cones were recorded in all populations of *L. inundata* during the current survey. Therefore all sites passed this criterion.

5.4.2 *Habitat for the species* assessment

The results for the *Habitat for the species* assessment for *L. inundata* are shown in Table 37. All sites received a Favourable assessment.

Table 37 *Habitat for the species* assessment results for *Lycopodiella inundata* sites surveyed during the Rare Plants Monitoring Survey 2015-18. Fav = Favourable.

	Criterion	LI01	LI02	LI03	LI04	LI05
1	Sward height	Pass	Pass	Pass	Pass	Pass
2	Cover of *Nardus stricta*	Pass	Pass	Pass	Pass	Pass
3	Cover of bare ground	Pass	Pass	Pass	Pass	Pass
4	Wetness of substrate	Pass	Pass	Pass	Pass	Pass
5	Impact of negative pressures	Pass	Pass	Pass	Pass	Pass
	No. of passes	5	5	5	5	5
	Habitat for the species assessment	Fav	Fav	Fav	Fav	Fav

5.4.2.1 *Sward height*

The highest value for sward height, 8.5 cm, was found at LI04 Glenasaul, where *Molinia caerulea* was particularly frequent. One of the plots here was recorded with a sward height of 11 cm, which is slightly above the recommended threshold; overall, however, sward height at all sites was found to be satisfactory on a site level for *L. inundata* to grow well.

5.4.2.2 *Cover of* Nardus stricta

Average cover of *N. stricta* within the five sites ranged between 0% and 32%, with some individual stops at LI02 Capnagower and LI05 Lough Corrib recorded with 35% cover. The upper limit of 35% average cover across the site was set for *N. stricta* as this species can compete with *L. inundata* by colonising the bare ground that the latter prefers. Therefore, all sites passed this criterion.

5.4.2.3 *Cover of bare ground*

L. inundata prefers more open habitats and tends to grow where a thin covering of peat occurs over a firm sandy or gravelly base (Byfield & Stewart, 2007). Therefore a small amount of bare ground is likely to benefit the plant. Bare ground was recorded at all *L. inundata* sites, so all sites passed this criterion.

5.4.2.4 *Wetness of substrate*

Hydrology did not appear to be a problem at any of the five sites surveyed and all passed the wetness assessment criterion. Seepage of groundwater from under the surface of the habitat was noted at three sites. Two sites were subject to lakeside inundation.

5.4.2.5 *Impact of negative pressures*

No habitat degradation due to negative pressures was noted at any of the five sites surveyed. Therefore all sites passed this criterion.

5.4.3 *Future prospects* assessment

5.4.3.1 *Pressures, threats and other activities*

Prior to evaluating the *Future prospects* parameter, the activities, both positive and negative, recorded for *L. inundata* were examined.

In contrast to the three upland clubmoss species, the lowland *L. inundata* does not appear to be under undue pressure from poor management practices. No negative impacts were recorded at any of the five sites where *L. inundata* was surveyed; a drainage ditch was noted at one site, LI02 Clare Island, but it did not appear to be causing the site to dry out as the water was pooling at surface level across the habitat. LI02 is also grazed heavily, but this is beneficial to the species. Table 38 shows the positive activities that were recorded at *L. inundata* sites. Non-intensive sheep grazing (A04.02.02) was regarded as beneficial to the species habitat in one instance and as neutral at two other sites. At a fourth site, cattle rather than sheep were the main grazers, but again the effects of these animals were judged to be neutral rather than damaging. The fifth *L. inundata* site was suitably maintained solely by inundation from the nearby lake rather than by grazing.

Table 38 Frequency of positive impacts, by intensity and percentage (%) of the habitat affected, recorded in the five *Lycopodiella inundata* sites. Impact codes are according to Ssymank (2011).

Impact code	Impact description	Intensity				% habitat affected			Total
		High	Medium	Low	Unknown	≤25%	26-75%	>75%	
A04.02.02	Non-intensive sheep grazing		1					1	1
L08	Inundation (natural)		1					1	1
	Total		2					2	

5.4.3.2 *Future prospects of* Population *and* Habitat for the species *parameters*

The future prospects for *Population* and *Habitat for the species* were examined for each of the five *L. inundata* sites surveyed during the current project. Table 39 shows the results. All sites received a Favourable assessment.

Table 39 *Future prospects* (FP) assessment for the five *Lycopodiella inundata* sites surveyed during the Rare Plants Monitoring Survey 2015-18. Pop = Population, HfS = Habitat for the species. Fav = Favourable.

Site	FP of Pop.	FP of HfS.	FP of *L. inundata*	Rationale
LI01	Fav	Fav	Fav	Significantly lower cover of *L. inundata* in current survey compared to baseline. No current pressures or future threats noted, and population, if disturbed in the past, is recovering well
LI02	Fav	Fav	Fav	Significantly lower cover of *L. inundata* in current survey compared to baseline. No current pressures or future threats noted, and population, if disturbed in the past, is recovering well
LI03	Fav	Fav	Fav	No pressures or threats recorded. Population is extensive
LI04	Fav	Fav	Fav	No pressures or threats recorded. Population is extensive
LI05	Fav	Fav	Fav	No pressures or threats recorded. Population is small but dense

5.4.4 Conservation status assessment for individual sites

The assessments of the individual parameters at each site were combined according to the evaluation matrix in Table 1 to obtain the conservation assessment for *L. inundata* at each site (Table 40). This resulted in all populations receiving a Favourable assessment.

Table 40 Assessment results for the five *Lycopodiella inundata* sites surveyed during the Rare Plants Monitoring Survey 2015-18. Fav = Favourable, U-I = Unfavourable-Inadequate.

Site	Population	Habitat for the species	Future prospects	Overall (site)
LI01	Fav	Fav	Fav	Fav
LI02	Fav	Fav	Fav	Fav
LI03	Fav	Fav	Fav	Fav
LI04	Fav	Fav	Fav	Fav
LI05	Fav	Fav	Fav	Fav

5.4.5 Overall conservation status assessment for Rare Plants Monitoring Survey sites

The assessments of the individual parameters were combined according to the evaluation matrix in Table 1 to obtain the overall conservation status assessment for *L. inundata* at sites surveyed during the Rare Plants Monitoring Survey.

Following the guidelines for species assessment at a national level (DG Environment, 2017), based on the results presented here and taking into account the estimated future trends of the species populations and habitat based on the threats and positive activities in place, the overall conservation status assessment result for *L. inundata* at sites surveyed during the Rare Plants Monitoring Survey is **Favourable** and the trend is **stable**. The following data detailed in this report were used to arrive at this result

- Overall stable population numbers since the baseline survey; apparent decrease in species cover for LI01 Cornamona and LI02 Capnagower but populations have high shoot numbers and population numbers in these and the other three sites are high
- *Habitat for the species* received a Favourable assessment;
- No negative pressures noted; hydrology at all sites, even where drainage ditches were seen, appeared to be adequate. Grazing was appropriate overall
- The *stable* future trend is based on available data from the last two monitoring periods.

Table 41 summarises this result.

Table 41 Summary of the overall conservation status assessment of *L. inundata* at sites surveyed during the Rare Plants Monitoring Survey (RPMS) 2015-18.

Parameter	Conservation status	Trend	Future prospects
Population	Favourable	Stable	Good
Habitat for the species	Favourable	Stable	Good
Future prospects	Favourable		
Overall Conservation Status Assessment for RPMS sites	**Favourable**	**Stable**	

It should be noted that the overall conservation status assessment for Rare Plants Monitoring Survey sites does not include an assessment of the *Range* parameter. This was assessed in the national conservation assessment of the *Lycopodium* spp. group (NPWS, 2019), which incorporated the combined results of the assessments of *Population*, *Habitat for the species* and *Future prospects* for *Diphasiastrum alpinum*, *Huperzia selago*, *Lycopodiella inundata* and *Lycopodium clavatum*, along with data from other recent surveys of these species.

5.5 Discussion

The overall conservation status assessment of *L. inundata* at sites surveyed during the Rare Plants Monitoring Survey is Favourable.

The two sites resurveyed since the baseline survey were found to have experienced a significant decrease in cover between the two surveys. This was despite monitoring plots being recorded at the same locations as before. While this could be attributed to surveyor variability, the magnitude of the difference in cover (average of 4% in the current survey *versus* average of 26-33% in the baseline survey) makes this explanation unlikely. Therefore the possible cause could be a past disturbance or impact that is no longer operating on the population, as the surveyors did not observe any obvious current pressures. They did, however, note signs that grazing in the past may have been heavier, but it is unclear whether this contributed to the higher cover noted in the baseline survey (heavy grazing providing a shorter sward and reducing competition from other species), or to the possible decline noted during the current survey (too high a grazing level proving damaging for *L. inundata*), from which the habitat and species appeared to be recovering. Grazing at the time of survey was considered to be appropriate, however, and the cover of *L. inundata* appeared to be increasing, so this population is deemed to be recovering and the general trend at this site is improving.

Populations of *L. inundata* at the other four sites were assessed as Favourable, habitat for the species was in good condition overall and pressures and threats at the sites were absent.

One potential threat that may impinge on the species and its habitat nationally is the expansion of forestry in Ireland, as envisaged by Ireland's Forestry Programme 2014-2020 (DAFM, 2014, 2015). The fact that three of the five *L. inundata* populations do not occur within an SAC means that their habitats lack the rigorous protection to protected areas provided under EU legislation. Marginal sites, such as lowland wet heath sites where *L. inundata* might be present, are often targeted for forestry plantation, thus threatening the habitat for the species either directly, through habitat conversion, or indirectly, through drainage and eutrophication. Trials on translocation and habitat/gap creation (via scrapes in suitable peatland habitat) have been taking place for over 15 years in the UK by the Species Recovery Trust, among others (D. Price, pers. comm.), but with limited success. Plants have in some cases regenerated in these areas, but usually disappear after a short time. Lack of fungal partners is one theory for the lack of success. Rasmussen & Lawesson (2002) suggest that eutrophication may be partly responsible for the species' general decline across Europe. Given the work noted above, along with that by others such as Ivanova & Natcheva (2016), conservation of existing sites should be given priority as this is a species that is exceedingly hard to translocate or return successfully to a site from which it has been lost.

As *L. inundata* is nationally rare, the pool from which sites can be selected for survey is necessarily small. Nevertheless it should be acknowledged that this favourable overall conservation status assessment of *L. inundata* at sites surveyed during the Rare Plants Monitoring Survey is based solely on an analysis of five populations. Neither does it include an assessment of *Range*: the *Range* parameter for *L. inundata* is addressed in the national conservation status assessment report for the *Lycopodium* spp. group (NPWS, 2019). Assessment of *Range* is based on the locations of sites from which *L. inundata* has been recorded. Some of these records are several decades old. It would be useful for future monitoring periods if it could be determined if populations for which only old records exist (but which are still included in the species' range) are still extant. Not only would the data from any extant populations feed into the

national assessments for population and habitat for the species, but it would also provide more up-to-date information on the range of the species.

Population criteria used in the baseline survey by Smyth *et al.* (2015) were reviewed and generally found to be suitable. Because of the possible effects of surveyor variability it may be necessary to consider other less subjective methods of quantification of the plant than simple visual estimation of percentage cover, such as the use of sub-divided grids, as noted in the discussions of other clubmoss species. This should be considered in the next monitoring period, when a comparison of results obtained at sites across a number of different periods should help to determine if this is a genuine issue or not.

Habitat for the species criteria were reviewed and amended. As the criteria used were based to some extent on the results from the current survey, it is likely that these thresholds and targets may need to be adjusted or refined in the next monitoring period. However, it was evident to surveyors during the current survey that the habitat at the sites where *L. inundata* was found was generally satisfactory and populations as a result were doing well. It was assumed, when devising criteria and setting targets based on the data gathered during the current survey, that the populations were in favourable condition at the time of survey and thus any significant deviation from the thresholds imposed should indicate deterioration in habitat quality. Data from future monitoring periods and a wider range of sites should help to determine if these criteria and targets are suitable or should be broadened. For example, data analysis carried out for the review of criteria found high *Nardus stricta* cover to be negatively associated with *L. inundata* cover. Future monitoring surveys should seek to refine this criterion further, e.g. to determine if the current threshold of ≤35% should be narrowed or expanded.

On further examination of the data from the current survey it was apparent that the two lakeside sites, LI03 Oorid Lough and LI05 Lough Corrib, had slightly different species assemblages from the other three sites, which were present in more open, flushed wet heath. This is in line with observations of the species in the UK by Byfield & Stewart (2007), who noted that *L. inundata* typically occurs in open areas in wet heathland, at the edges of oligotrophic lakes and on abandoned sand, gravel or granitic china clay quarries. To the authors' knowledge, no occurrences of the species in quarry habitats have been noted in Ireland, but the first two habitats are represented in the current survey. It is expected that the availability of data from future surveys will provide further information on the different habitat types, both in terms of associated species and optimal conditions for *L. inundata* to thrive.

6 Recommendations

A number of recommendations are put forward to improve the process of assessing the four clubmoss species surveyed in the Rare Plants Monitoring Survey. These recommendations apply equally to all four species.

- Survey more sites and record more relevés to get more data on the four species (e.g. associated species, type of habitats where they are found, conditions where they flourish or where they are in difficulties), and analyse these data with a clear view to testing, and if necessary improving, the assessment criteria. Lowland sites for *H. selago* should be targeted, to gather information to complement that collected in the previous monitoring period surveys, which were largely focused on upland sites.
- Survey sites from a greater geographical range. This should allow a more statistically robust assessment to be made. It will also allow for a great range of impacts to be recorded, as the concentration of several sites in Wicklow made it difficult to gauge whether or not the impacts recorded (e.g. trampling from hikers) were occurring to the same extent in other parts of the country.
- Survey sites for which recent (e.g. post-2000) records are lacking. This will help to give a better idea of the current ranges of the four species, and whether these have contracted over the last number of monitoring periods.
- Review the assessment criteria and refine them further if necessary. This is particularly important for the new *Habitat for the species* criteria used in the current report, which were based on a relatively small dataset. The inclusion of a wider geographical range and greater number of sites would provide a bigger pool of data from which to draw conclusions relating to habitat condition and suitability and associated species.

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Appendix 1 Site summary data sheet

This data sheet was used as a front sheet for all site packs. Some information, such as the target species, site number, name and grid reference, was printed on the sheet prior to survey. “Type of survey” was either “Monitoring” or “Baseline”.

The Survey results and Survey notes sections, including positive and negative activities occurring on site, were filled out by surveyors after the survey had been completed.

bec CONSULTANTS

Date surveyed: _____
Surveyed by: _____

Rare Plants Monitoring 2015-18

Clubmosses: <Species>

Site no:	[Autofilled prior to survey]	**Disco. map:**	[Autofilled prior to survey]
Site name:	[Autofilled prior to survey]	**AP no. (2005):**	[Autofilled prior to survey]
Grid ref:	[Autofilled prior to survey]	**Type of survey:**	[Autofilled prior to survey]
SAC:	[Autofilled prior to survey]		

Survey results: Site-level criteria

Total no. of patches: _____	***Population extent (m^2):*** _____
No. of plots recorded: _____	***Population envelope (m^2):*** _____
Sporing plants present: _____	***Estimated population size class:*** _____
Avg. no. stems per relevé: _____	***Avg. %cover clubmoss per relevé:*** _____

Survey notes:

Site description or changes since baseline:

Impact code / description e.g. A04.01 intensive grazing	**Location** inside / outside pop. extent	**Influence (+/-/0)**	**Intensity (H/M/L)**	**% pop. extent affected** (<1%; 1-25%; 26-50%; 51-75%; 76-99%; 100%)

Comments on condition/management:

Other remarks:

Data entry/checking:

GPS points downloaded: INITIALS _____ DATE _____
Turboveg checked: INITIALS _____ DATE _____
Photos labelled correctly: INITIALS _____ DATE _____
Data checked & complete: INITIALS _____ DATE _____

Appendix 2 Turboveg header data recorded at each monitoring stop

The following header information was recorded at each monitoring stop in the vegetation database recording program Turboveg [Compact Edition for use on hand-held devices; Alterra, The Netherlands]:

	Field name	Description
1.	Cover abundance scale	Percentage (code 00) was always selected
2.	Date	Date the plot was recorded
3.	Releve area (m²)	Relevé size: 1
4.	X-coordinate	X-coordinate of plot
5.	Y-coordinate	Y-coordinate of plot
6.	Site_no	Site number, e.g. DA04
7.	Site_name	Site name
8.	Relevé	Monitoring plot number. 1, 2, etc.
9.	Ecologists	Initials of ecologist(s) recording the stop
10.	Fossitt	Fossitt code of the habitat in which stop is recorded, e.g. HH4
11.	Annex_1	Annex I habitat in which stop is recorded, e.g. 4060
12.	Target_sp	2-character code of target species: DA, HS, LC or LI
13.	Topography	Description of topography where stop is recorded, e.g. mid-slope, flat
14.	Slope	Slope in degrees determined by clinometer; 0 if flat
15.	Aspect	Cardinal or ordinal compass point (N, NW, etc.) of stop's aspect if on a slope, otherwise "None"
16.	Soil_type	Type of soil on which plot recorded, e.g. upland peat
17.	Bare_soil	Percent cover of bare soil in the plot
18.	Bare_rock	Percent cover of bare rock in the plot
19.	Open_water	Percent cover of open water in the plot
20.	Litter	Percent cover of leaf litter in the plot
21.	Bryo_cover	Percent cover of bryophytes in the plot
22.	Total_veg	Percent cover of total vegetation in the plot
23.	Forb_cover	Percent cover of forbs (broadleaf herbs) in the plot
24.	Grass_covr	Percent cover of grasses in the plot
25.	Sedge_covr	Percent cover of sedges in the plot
26.	Dwarf_shrb	Percent cover of dwarf shrubs in the plot
27.	Sward_ht	Average sward height in cm
28.	Shoot_cm_1	Length of shoot1 of target species
29.	Shoot_cm_2	Length of shoot2 of target species
30.	Shoot_cm_3	Length of shoot3 of target species
31.	Shoot_cm_4	Length of shoot4 of target species
32.	Shoot_cm_5	Length of shoot5 of target species
33.	No_shoots	Number of shoots of target species counted in plot
34.	Sporing	Presence of sporing plants
35.	Remarks	Other pertinent data, e.g. hydrology

Appendix 3 Preliminary analysis of data recorded in the 2015-2018 survey

Methods

A preliminary analysis of the plot data for the four clubmoss species was carried out to explore the differences among them in terms of their vegetation communities and habitats. This was conducted using a non-metric multi-dimensional scaling (NMDS) ordination calculated with function *metaMDS* in package *vegan* in R (Oksanen *et al.*, 2017). A total of 112 plots were analysed. Species occurring in fewer than four plots were omitted from the analysis. The following parameters were used: a 2-dimensional solution was sought, with 1000 random starts, using the Bray-Curtis dissimilarity measure, a Wisconsin double standardisation and a square root transformation. To aid in interpretation, the data variables recorded in the field at each plot by surveyors (slope, altitude, %total vegetation, %bare rock, %bare soil and vegetation height) were taken and function *envfit* was used to find the directions in the ordination space towards which these environmental and structural vectors changed most rapidly and to which they had maximal correlations with the ordination configuration (Oksanen *et al.*, 2017). This allowed construction of a biplot. Plots were individually classified to habitat type in the field according to Fossitt (2000) and the plots were also analysed in relation to this variable.

Results

The NMDS ordination of vegetation data is presented in Figures A1 and A2. Stress on the final solution was 0.214, which is reasonable for ecological datasets. The points show the distribution of the plots in ordination space, coloured according to Fossitt (2000) habitat in Figure A1 and coloured according to its target clubmoss species in Figure A2. It is notable that the graph in Figure A1 shows little overlap in terms of habitat between *Lycopodiella inundata* and the other three species, while *Diphasiastrum alpinum* and *Lycopodium clavatum* overlap significantly. The high degree of variation in the vegetation of the *Huperzia selago* plots is demonstrated by the large ellipse required to encompass the plots, and also by the wide variety of habitats in which the species was recorded. In contrast, *D. alpinum* plots are shown to be reasonably similar in that they are clustered together on the graph and the majority of the plots are recorded in HH4 Montane heath. *L. inundata* plots are likewise shown to be relatively uniform in terms of habitat in that they all occur in HH3 Wet heath and occupy a discrete area of the graph characterised by low altitude and high vegetation cover.

Axis 1 of the ordination represents a decreasing altitudinal gradient. At the higher end of this axis (i.e. lower altitude) are found the lowland *L. inundata* plots. The upland *D. alpinum* plots are at the opposite end of the axis. Axis 2 represents a vegetation cover gradient, being positively correlated with high vegetation cover and negatively correlated with cover of bare rock. The majority of plots with *D. alpinum*, *L. clavatum* and *L. inundata* occur at the higher end of this axis (i.e., greater cover of vegetation including bryophytes), while the only plots with any significant occurrence in the lower part of the axis are the *H. selago* plots that occur in habitats with a higher proportion of exposed rock such as scree and eroded peat.

Figure A2 shows the species most commonly associated with the four clubmoss species in the recorded relevés, and also shows the ecological preferences of all species in the dataset, including the clubmosses. *Lycopodiella inundata* occurs among a distinct assemblage of species, with wet heath species such as *Calliergon sarmentosum, Campylium stellatum, Rhynchospora alba, Eleocharis multicaulis, Drepanocladus revolvens, Carex panicea* and *Erica tetralix* commonly occurring with *L. inundata*. In this dataset, these species, including *L. inundata*, tend to occur in habitats at low altitude and with high vegetation cover. There is considerably more overlap in vegetation composition among the other three clubmoss species, as shown by the close proximity on the graph of the species themselves and the dense clustering of other species around them. From the graph it is evident that *Diphasiastrum alpinum* and *Lycopodium clavatum* in particular are primarily associated with high altitudes and generally well-vegetated habitats, while *Huperzia selago* occurs at slightly lower altitudes. Although *H. selago* was also recorded in plots in less vegetated habitats such as scree, with species such as *Saxifraga spathularis* (which occurs near the lowest

end of the graph), the large distance between these two species on the graph show that this is not a frequent association, and indeed, the cover of *H. selago* in these situations is much lower, indicating that these conditions are less than optimal for it.

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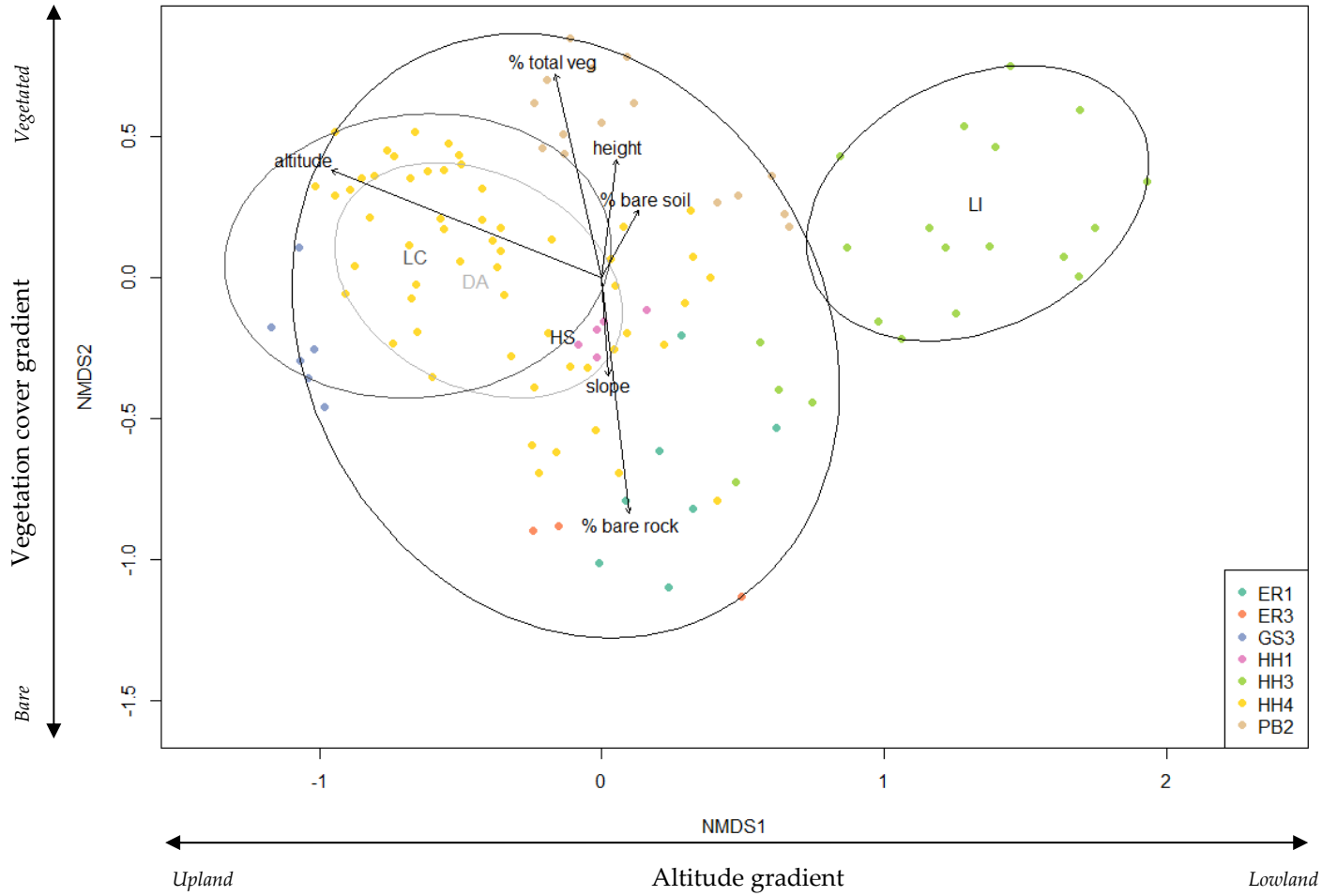

Figure A1 NMDS ordination of vegetation data from 112 plots coloured by Fossitt (2000) habitat. Ellipses show the spread of plots of each of the four species: DA=*Diphasiastrum alpinum*; HS=*Huperzia selago*; LC=*Lycopodium clavatum*; LI=*Lycopodiella inundata*. Vectors indicate correlations with ordination space. Longer lines indicate stronger correlations. Variables are header data recorded in the field at each plot. Fossitt (2000) codes are as follows: ER1=Exposed siliceous rock; ER3=Siliceous scree and loose rock; GS3=Dry-humid acid grassland; HH1=Dry siliceous heath; HH3=Wet heath; HH4=Montane heath; PB2=Upland blanket bog.

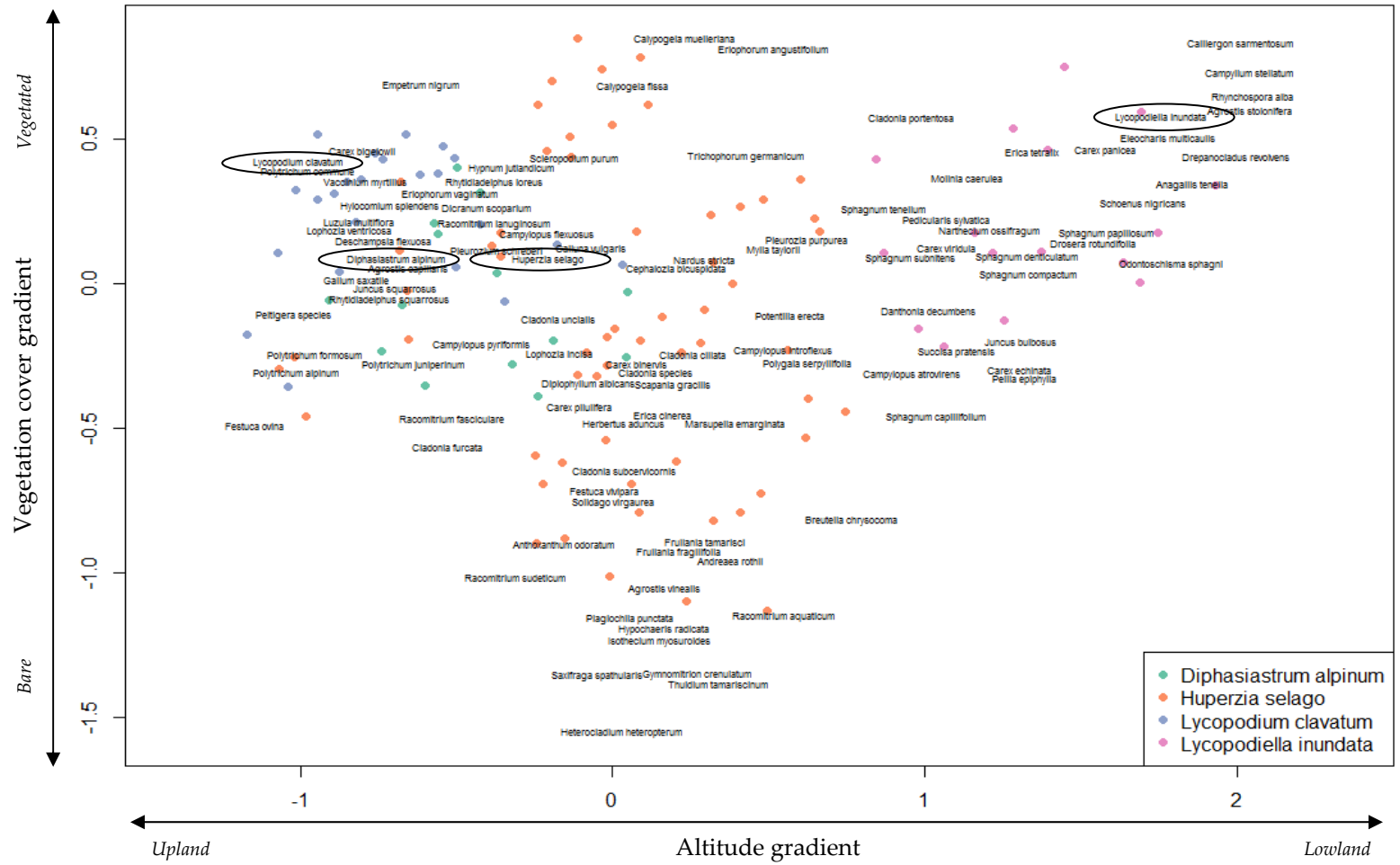

Figure A2 NMDS ordination of vegetation data from 112 plots with species overlay – limited to species occurring in four or more plots (total of 102 species). The four clubmoss species are circled

Appendix 4 Individual site reports

Individual site reports were compiled from the following:

- the summary paragraphs written by ecologists after each survey,
- the impacts recorded during the survey, and
- the results of the different components of the species assessment.

Site ID	Site name (name by which the site was referred to in the baseline survey is in parentheses)	County
Diphasiastrum alpinum sites		
DA01	Edenadooish, Derryveagh Mountains	Donegal
DA02	Mullach Glas (Maumturk Mountains)	Galway
DA03	Turlough Hill, north of reservoir (Camaderry)	Wicklow
DA04	Kippure	Wicklow
DA05	Purple/Shehy Mountain	Kerry
Huperzia selago sites		
HS01	Healy Pass	Cork
HS02	Knockowen	Cork
HS03	Meenagoppoge (Derryveagh Mountain)	Donegal
HS04	Muckish Mountain	Donegal
HS05	Tully Mountain	Galway
HS06	Lough Doon (Connor Pass)	Kerry
HS07	Lough Cruite	Kerry
HS08	Skeltia (Maumtrasna Mountain)	Galway
HS09	Turlough Hill, north of reservoir (Camaderry, left of reservoir)	Wicklow
HS10	Kippure	Wicklow
Lycopodium clavatum sites		
LC01	Clohernagh Mountain	Wicklow
LC02	Kippure	Wicklow
LC03	Turlough Hill, north of reservoir (Camaderry, left of reservoir)	Wicklow
LC04	Corlisbannan	Cavan
LC05	Lavagh More - N & E of Lough Asgarha	Donegal
Lycopodiella inundata sites		
LI01	Cornamona	Galway
LI02	Capnagower, Clare Island	Mayo
LI03	Oorid Lough	Galway
LI04	Glenasaul	Mayo
LI05	Lough Corrib, E. of Lackavrea Hill	Galway

Site report - Rare Plant Monitoring Surveys

Lycopodium group (Clubmosses)

DA01 Edenadooish (Derryveagh Mountains), Co. Donegal

Irish Grid ref.: 197000 420600; Altitude: 525m; SAC: 002047

Monitoring Period:	2013-2018	**Survey start date:**	17/08/2018	**No. of monitoring stops:**	2
Surveyed by:	RH/ML	**Survey end date:**	17/08/2018	**Survey type:**	Monitoring

Comments on site:

Rocky plateau with montane heath interspersed along wide ridge. Population is beside cairn with remains of small mast nearby. Scattered patches of Diphasiastrum over 25x25m, same extent as previous survey.

Comments on condition/management:

A number of plants were dead or dying, possibly due to drought. Sheep grazing occurring on site, considered to be having a neutral impact.

Other notes:

No photographs taken due to poor weather.

Population assessment criteria

Mon. period	Site	Indicator description	Target	Result	Outcome	Notes
2013-2018	DA 01	Total number of colonies/OSMs	>=10	23	Pass	Target was set as no. of colonies, but Occupied Square Metres (OSMs) were counted and appear in the Result column
2013-2018	DA 01	Population extent (sq. metres)	>=25 x 25	25 x 25	Pass	
2013-2018	DA 01	Mean % cover of target species across all stops	>=11	5	Pass	This site well known to one surveyor who said site had remained stable over the last 10 years, since before baseline survey
2013-2018	DA 01	Population size class	>=5 (1,001-5,000)	3 (101-500)	Pass	This site well known to one surveyor who said site had remained stable over the last 10 years, since before baseline survey
2013-2018	DA 01	Fertile cones present	Fertile cones present	Fertile cones present	Pass	

Habitat for the species criteria

Mon. period	Site	Indicator description	Target	Result	Outcome	Notes
2013-2018	DA 01	Mean % cover of Calluna vulgaris across all stops	<=50	17.5	Pass	
2013-2018	DA 01	Mean % cover of bare ground across all stops	<=10	4	Pass	
2013-2018	DA 01	Impact of negative pressures	Low or absent	Low	Pass	

Impacts and activities

Mon. period	Site	Activity code / Description		Intensity	Effect	% Habitat affected	sq. m affected	Notes
2013-2018	DA 01	A04.02.02	Non-intensive sheep grazing	L	Neutral	100	625	
2013-2018	DA 01	K04.05	Damage by herbivores (including game species)	L	Neutral	100	625	Deer grazing - not damaging
2013-2018	DA 01	M	Climate change	XX	Negative	100	625	

Parameter assessment results

Mon. period	Site	Population	Habitat for the species	Future prospects	Overall
2013-2018	DA 01	Favourable	Favourable	Favourable	Favourable
Trend (if known):		n/a	n/a		n/a

DA02 Mullach Glas (Maumturk Mountains), Co. Galway

Irish Grid ref.: 93243 249228; Altitude: 610m; SAC: 002008

Monitoring Period:	2013-2018	**Survey start date:**	25/05/2017	**No. of monitoring stops:**	4
Surveyed by:	OD/RH	**Survey end date:**	25/05/2017	**Survey type:**	Monitoring

Comments on site:

This site comprises two small populations of Diphasiastrum alpinum located at the south-eastern end of the Maumturk Mountains. The two populations occur on separate summits at an altitude of c. 625 m and 610 m respectively. Each population consists of two patches. The four relevés were recorded across the four patches. The habitat they were recorded in were rocky areas of montane heath with Calluna vulgaris, Racomitrium lanuginosum, Agrostis capillaris, Nardus stricta, Erica cinerea and Cladonia spp. Huperzia selago was also widespread and frequent on this part of the Maumturks.

Comments on condition/management:

Sheep grazing is a feature of the site. Both populations due to their locations on or near summits have the potential to be subject to trampling by hikers. Their small size also makes them particularly vulnerable, although it should be noted that no bare ground associated with this activity was recorded during the survey. Suitable habitat in the area surrounding each population was searched for additional patches but none were found. The Maumturk Challenge poses a potential threat to these populations as the route passes through these areas.

Other notes:

The relevés at this site were not numbered in the baseline survey so they were arbitrarily assigned numbers 1-4 for the current survey. In the western population the two baseline plots were recorded within 1 m of each other, according to their grid coordinates, so in 2017 relevé 4 was relocated approximately 20 m further south.

Population assessment criteria

Mon. period	Site	Indicator description	Target	Result	Outcome	Notes
2013-2018	DA 02	Total number of colonies/OSMs	>=4	10	Pass	Target was set as no. of colonies, but Occupied Square Metres (OSMs) were counted and appear in the Result column
2013-2018	DA 02	Population extent (sq. metres)	>=10 x 10	78	Pass	Target was estimated by eye
2013-2018	DA 02	Mean % cover of target species across all stops	>=11	3.6	Pass	Surveyor variability
2013-2018	DA 02	Population size class	>=3 (101-500)	3 (101-500)	Pass	Site report put target at 4 (500-1000) but put result in as 3. Target reset to 3 (100-500) so as not to exceed baseline result
2013-2018	DA 02	Fertile cones present	Fertile cones present	Fertile cones present	Pass	

Habitat for the species criteria

Mon. period	Site	Indicator description	Target	Result	Outcome	Notes
2013-2018	DA 02	Mean % cover of Calluna vulgaris across all stops	<=50	26.3	Pass	
2013-2018	DA 02	Mean % cover of bare ground across all stops	<=10	5.4	Pass	
2013-2018	DA 02	Impact of negative pressures	Low or absent	Low	Pass	

Impacts and activities

Mon. period	Site	Activity code / Description		Intensity	Effect	% Habitat affected	sq. m affected	Notes
2013-2018	DA 02	A04.02.02	Non-intensive sheep grazing	M	Negative	100	78	
2013-2018	DA 02	G05.01	Trampling, overuse	M	Negative	100	78	
2013-2018	DA 02	M	Climate change	XX	Negative	100	78	

Parameter assessment results

Mon. period	Site	Population	Habitat for the species	Future prospects	Overall
2013-2018	DA 02	Favourable	Favourable	Favourable	Favourable
Trend (if known):		n/a	n/a		n/a

DA03 Turlough Hill, north of reservoir (Camaderry), Co. Wicklow

Irish Grid ref.: 306824 199123; Altitude: 640m; SAC: 002122

Monitoring Period:	2013-2018	**Survey start date:**	19/04/2016	**No. of monitoring stops:**	2
Surveyed by:	PP/RH	**Survey end date:**	19/04/2016	**Survey type:**	Monitoring

Comments on site:

This population is found just north of the reservoir on top of Turlough Hill: it is not on Camaderry itself, which is the 698m peak east of the reservoir. The population consists of two colonies, one from the baseline survey and an additional one found during this survey. Both colonies are in montane heath (HH4), which corresponds with Annex I habitat 4060. The main plants are Calluna vulgaris, Racomitrium lanuginosum and Hypnum jutlandicum. The location is at the end of a track where spoil has been bulldozed in the past. There is no evident change since the baseline. The population extent was estimated at 0.04 sq. m and the population envelope was about 10 sq. m.

Comments on condition/management:

The area is sheep-grazed but the intensity is low and does not appear to be problematic. There is erosion of the peat in the area, including the bulldozed spoil on which at least one of the two colonies appears to occur. Further bulldozing could be catastrophic. The impact of climate change on this population is unclear but is likely to be negative.

Other notes:

An additional colony of Diphasiastrum alpinum was found adjacent to the roadway that provides access to the reservoir at the following grid reference: IG 306745 199309. The site was accessed from the north, parking at the Wicklow Gap car park.

Population assessment criteria

Mon. period	Site	Indicator description	Target	Result	Outcome	Notes
2013-2018	DA 03	Total number of colonies/OSMs	>=1	2	Pass	Target was set as no. of colonies, but Occupied Square Metres (OSMs) were counted and appear in the Result column
2013-2018	DA 03	Population extent (sq. metres)	>=2.25	10	Pass	
2013-2018	DA 03	Mean % cover of target species across all stops	>=11	2	Pass	Surveyor variability
2013-2018	DA 03	Population size class	>=2 (51-100)	>=2 (51-100)	Pass	
2013-2018	DA 03	Fertile cones present	Fertile cones present	Fertile cones not found	Fail	

Habitat for the species criteria

Mon. period	Site	Indicator description	Target	Result	Outcome	Notes
2013-2018	DA 03	Mean % cover of Calluna vulgaris across all stops	<=50	30	Pass	
2013-2018	DA 03	Mean % cover of bare ground across all stops	<=10	0.5	Pass	
2013-2018	DA 03	Impact of negative pressures	Low or absent	Low	Pass	

Impacts and activities

Mon. period	Site	Activity code / Description		Intensity	Effect	% Habitat affected	sq. m affected	Notes
2013-2018	DA 03	A04.02.02	Non-intensive sheep grazing	L	Neutral	100	10	
2013-2018	DA 03	D01.01	Paths, tracks, cycling tracks			0	0	
2013-2018	DA 03	K01.01	Erosion	H	Negative	26-50	3-5	
2013-2018	DA 03	M	Climate change	XX	Negative	100	10	

Parameter assessment results

Mon. period	Site	Population	Habitat for the species	Future prospects	Overall
2013-2018	DA 03	Favourable	Favourable	Favourable	Favourable
Trend (if known):		n/a	n/a		n/a

DA04 Kippure, Co. Wicklow

Irish Grid ref.: 311730 215300; Altitude: 750m; SAC: 002122

Monitoring Period:	2013-2018	**Survey start date:**	18/04/2016	**No. of monitoring stops:**	3
Surveyed by:	PP/RH/OD	**Survey end date:**	09/05/2017	**Survey type:**	Monitoring

Comments on site:

The main part of the population is found about 250m southeast of the mast on the top of Kippure in an area of montane heath (HH4) that corresponds with Annex I habitat 4060. It is just north and east of the access road, at about 740m. The low-growing vegetation is mainly Calluna vulgaris, Racomitrium lanuginosum, Hypnum jutlandicum, Vaccinium myrtillus, Deschampsia flexuosa and Agrostis capillaris. Both baseline plots were refound and an additional one recorded. Outlying colonies were also found further north on the summit, in montane heath (HH4) and in upland grassland (GS3/6150) near the Trig point.

Comments on condition/management:

The montane heath occurs in association with eroding remnant blanket bog and areas of bare peat. The heath itself is not eroding and indeed may expand to replace the bog in time. Kippure is a fairly popular climb for walkers. However most will stick to the access road so impact is likely to be low. The impact of climate change is unclear but is likely to be negative. Plants near the Trig point are more vulnerable to disturbance/erosion.

Other notes:

Parked at Kippure gate and walked up access road.

Population assessment criteria

Mon. period	Site	Indicator description	Target	Result	Outcome	Notes
2013-2018	DA 04	Total number of colonies/OSMs	>=2	11	Pass	Target was set as no. of colonies, but Occupied Square Metres (OSMs) were counted and appear in the Result column
2013-2018	DA 04	Population extent (sq. metres)	>=8	75	Pass	
2013-2018	DA 04	Mean % cover of target species across all stops	>=11	4	Pass	Surveyor variability
2013-2018	DA 04	Population size class	>=3 (101-500)	4 (501-1,000)	Pass	
2013-2018	DA 04	Fertile cones present	Fertile cones present	Fertile cones present	Pass	

Habitat for the species criteria

Mon. period	Site	Indicator description	Target	Result	Outcome	Notes
2013-2018	DA 04	Mean % cover of Calluna vulgaris across all stops	<=50	38.3	Pass	
2013-2018	DA 04	Mean % cover of bare ground across all stops	<=10	0	Pass	
2013-2018	DA 04	Impact of negative pressures	Low or absent	Low	Pass	

Impacts and activities

Mon. period	Site	Activity code / Description		Intensity	Effect	% Habitat affected	sq. m affected	Notes
2013-2018	DA 04	A04.02.02	Non-intensive sheep grazing	L	Negative	100	75	
2013-2018	DA 04	G01.02	Walking, horseriding and non-motorised vehicles	L	Negative	100	75	
2013-2018	DA 04	K01.01	Erosion	H	Negative	1-25	1-19	
2013-2018	DA 04	M	Climate change	XX	Negative	100	75	

Parameter assessment results

Mon. period	Site	Population	Habitat for the species	Future prospects	Overall
2013-2018	DA 04	Favourable	Favourable	Favourable	Favourable
Trend (if known):		n/a	n/a		n/a

DA05 Purple/Shehy Mountain, Co. Kerry

Irish Grid ref.: 89696 85592; Altitude: 730m; SAC: 000365

Monitoring Period:	2013-2018	**Survey start date:**	11/05/2017	**No. of monitoring stops:**	3
Surveyed by:	PP/RH	**Survey end date:**	11/05/2017	**Survey type:**	Baseline

Comments on site:

This population occurs at around 740 m, just east of a saddle that lies between Purple Mountain NE top (757 m) to the west and Shehy Mountain (762 m) to the east. The main population is fairly tightly clustered within an area less than 40 m across, but there are some outlying plants on lower slopes to the west. Most of the plants are growing in a rocky moss heath dominated by Racomitrium lanuginosum with Agrostis capillaris and Galium saxatile, but some patches occur in more Calluna-rich vegetation. Shoot density is high.

Comments on condition/management:

The area is not on one of the main hiking trails, so impact from walkers is likely to be minimal. The effects of climate change are unknown but likely to be negative. The area is grazed by sheep, which probably have a negative impact as this type of montane vegetation does not require grazing.

Other notes:

Parked at Kate Kearney's cottage and came up through gap. Descended via recognised track via Tomies summit, regaining the road near Doora's animal feeds.

Population assessment criteria

Mon. period	Site	Indicator description	Target	Result	Outcome	Notes
2013-2018	DA 05	Total number of Occupied Square Metres	>=103	129	Pass	Baseline survey; target is set at 80% of current value
2013-2018	DA 05	Population extent (sq. metres)	>=738	820	Pass	Baseline survey; target is set at 90% of current value
2013-2018	DA 05	Mean % cover of target species across all stops	>=11	15	Pass	Baseline survey; targets are set at current values
2013-2018	DA 05	Population size class	>=6 (5,001-10,000)	6 (5,001-10,000)	Pass	Baseline survey; targets are set at current values
2013-2018	DA 05	Fertile cones present	Fertile cones present	Fertile cones present	Pass	

Habitat for the species criteria

Mon. period	Site	Indicator description	Target	Result	Outcome	Notes
2013-2018	DA 05	Mean % cover of Calluna vulgaris across all stops	<=50	30	Pass	
2013-2018	DA 05	Mean % cover of bare ground across all stops	<=10	0.2	Pass	
2013-2018	DA 05	Impact of negative pressures	Low or absent	Low	Pass	

Impacts and activities

Mon. period	Site	Activity code / Description		Intensity	Effect	% Habitat affected	sq. m affected	Notes
2013-2018	DA 05	A04.02.02	Non-intensive sheep grazing	L	Negative	100	820	
2013-2018	DA 05	G01.02	Walking, horseriding and non-motorised vehicles	M	Negative	100	820	
2013-2018	DA 05	M	Climate change	XX	Negative	100	820	

Parameter assessment results

Mon. period	Site	Population	Habitat for the species	Future prospects	Overall
2013-2018	DA 05	Favourable	Favourable	Favourable	Favourable
Trend (if known):		n/a	n/a		n/a

HS01 Healy Pass, Co. Cork

Irish Grid ref.: 78590 53540; Altitude: 320m; SAC: None

Monitoring Period:	2013-2018	**Survey start date:**	28/08/2017	**No. of monitoring stops:**	5
Surveyed by:	OD/RH	**Survey end date:**	30/08/2017	**Survey type:**	Monitoring

Comments on site:

This population is present just above the Healy Pass road. The habitat in the area is mostly non-Annex acidic grassland and Annex I Wet heath (4010) with non-Annex siliceous rocky outcrops. The Huperzia selago was typically found growing within and along the cracks and crevices of these rocks. The main associated species include Racomitrium lanuginosum, Calluna vulgaris, Campylopus atrovirens, Agrostis capillaris, Nardus stricta, Festuca vivipara, Carex viridula and Trichophorum germanicum.

Comments on condition/management:

The hills in this area are over-grazed by sheep. This area is popular for walking as it is just above the Healy Pass parking area and is used by tourists as an unofficial viewing point as 360-degree views can be got from the top.

Other notes:

None

Population assessment criteria

Mon. period	Site	Indicator description	Target	Result	Outcome	Notes
2013-2018	HS 01	Total number of colonies/OSMs	>=7	85	Pass	Target was set as no. of colonies, but Occupied Square Metres (OSMs) were counted and appear in the Result column
2013-2018	HS 01	Population extent (sq. metres)	>=100 x 50	6,357	Pass	
2013-2018	HS 01	Mean % cover of target species across all stops	>=1	0.3	Pass	Surveyor variability
2013-2018	HS 01	Population size class	>=4 (501-1,000)	4 (501-1,000)	Pass	
2013-2018	HS 01	Fertile cones present	Fertile cones present	Fertile cones present	Pass	

Habitat for the species criteria

Mon. period	Site	Indicator description	Target	Result	Outcome	Notes
2013-2018	HS 01	Impact of negative pressures	Low or absent	Heavily overgrazed, small percentage of habitat trampled by hikers	Fail	

Impacts and activities

Mon. period	Site	Activity code / Description		Intensity	Effect	Habitat affected %	Habitat affected sq. m	Notes
2013-2018	HS 01	A04.02.02	Non-intensive sheep grazing	H	Negative	100	6357	
2013-2018	HS 01	G01.02	Walking, horseriding and non-motorised vehicles	M	Negative	5	318	
2013-2018	HS 01	M	Climate change	XX	Negative	100	6357	

Parameter assessment results

Mon. period	Site	Population	Habitat for the species	Future prospects	Overall
2013-2018	HS 01	Favourable	Unfavourable-Inadequate	Unfavourable-Inadequate	Unfavourable-Inadequate
Trend (if known):		n/a	n/a		n/a

HS02 Knockowen, Co. Cork

Irish Grid ref.: 80957 55453; Altitude: 658m; SAC: 000093

Monitoring Period:	2013-2018	**Survey start date:**	29/08/2017	**No. of monitoring stops:**	5
Surveyed by:	OD/RH	**Survey end date:**	29/08/2017	**Survey type:**	Monitoring

Comments on site:

This population is present on the summit of Knockowen Mountain. The summit is characterised by rocky outcrops and a grassy montane heath community. Huperzia selago is typically found growing on or along the edges of the rocky outcrops. The main associated species include Racomitrium lanuginosum, Calluna vulgaris, Nardus stricta, Agrostis capillaris and Carex viridula ssp. oedocarpa.

Comments on condition/management:

The hills are over-grazed by sheep. There is some trampling by walkers.

Other notes:

None

Population assessment criteria

Mon. period	Site	Indicator description	Target	Result	Outcome	Notes
2013-2018	HS 02	Total number of colonies/OSMs	>=10	350	Pass	Target was set as no. of colonies, but Occupied Square Metres (OSMs) were counted and appear in the Result column
2013-2018	HS 02	Population extent (sq. metres)	>=150 x 50	18,518	Pass	
2013-2018	HS 02	Mean % cover of target species across all stops	>=0.3	0.4	Pass	
2013-2018	HS 02	Population size class	>=4 (501-1,000)	5 (1,001-5,000)	Pass	
2013-2018	HS 02	Fertile cones present	Fertile cones present	Fertile cones present	Pass	

Habitat for the species criteria

Mon. period	Site	Indicator description	Target	Result	Outcome	Notes
2013-2018	HS 02	Impact of negative pressures	Low or absent	Heavily overgrazed, small percentage of habitat trampled by hikers	Fail	

Impacts and activities

Mon. period	Site	Activity code / Description		Intensity	Effect	% Habitat affected	sq. m affected	Notes
2013-2018	HS 02	A04.02.02	Non-intensive sheep grazing	H	Negative	100	18518	
2013-2018	HS 02	G01.02	Walking, horseriding and non-motorised vehicles	M	Negative	3	556	
2013-2018	HS 02	M	Climate change	XX	Negative	100	18518	

Parameter assessment results

Mon. period	Site	Population	Habitat for the species	Future prospects	Overall
2013-2018	HS 02	Favourable	Unfavourable-Inadequate	Unfavourable-Inadequate	Unfavourable-Inadequate
Trend (if known):		n/a	n/a		n/a

HS03 Meenagoppoge (Derryveagh Mountains), Co. Donegal

Irish Grid ref.: 197384 422278; Altitude: 240m; SAC: 002047

Monitoring Period: 2013-2018 **Survey start date:** 11/06/2018 **No. of monitoring stops:** 5

Surveyed by: RH/ML **Survey end date:** 11/06/2018 **Survey type:** Monitoring

Comments on site:

Open area of bog/heath with Molinia dominant. Very degraded (e.g. low Sphagnum cover). Unlikely to have changed much in recent years; site well known to RH.

Comments on condition/management:

As bog habitat this is quite degraded, but this provides opportunities for Huperzia to colonise (e.g. along old cutting banks). Deer and possibly sheep grazing occurring; grazing deemed to be having a positive effect.

Other notes:

Huperzia likely to be common throughout the broader area. Note: Plot size of 2x2m used. Counts were adjusted to get counts per square metre. Percentage covers were not adjusted.

Population assessment criteria

Mon. period	Site	Indicator description	Target	Result	Outcome	Notes
2013-2018	HS 03	Total number of colonies/OSMs	>=10	2,000	Pass	Target was set as no. of colonies, but Occupied Square Metres (OSMs) were counted and appear in the Result column
2013-2018	HS 03	Population extent (sq. metres)	>=300 x 50	32,780	Pass	
2013-2018	HS 03	Mean % cover of target species across all stops	>=1	0.5	Pass	Marginal fail, within margin of error for visual estimation
2013-2018	HS 03	Population size class	>=5 (1,001-5,000)	5 (1,001-5,000)	Pass	
2013-2018	HS 03	Fertile cones present	Fertile cones present	Fertile cones present	Pass	

Habitat for the species criteria

Mon. period	Site	Indicator description	Target	Result	Outcome	Notes
2013-2018	HS 03	Impact of negative pressures	Low or absent	Grazing positive, extensive population indicates suitable habitat	Pass	

Impacts and activities

Mon. period	Site	Activity code / Description		Intensity	Effect	% Habitat affected	sq. m affected	Notes
2013-2018	HS 03	A04.02.05	Non-intensive mixed animal grazing	L	Positive	100	32780	Includes grazing by deer and sheep
2013-2018	HS 03	H05.01	Garbage and solid waste	L	Negative	<1	163.9	Dumping
2013-2018	HS 03	M	Climate change	XX	Negative	100	32780	

Parameter assessment results

Mon. period	Site	Population	Habitat for the species	Future prospects	Overall
2013-2018	HS 03	Favourable	Favourable	Favourable	Favourable
Trend (if known):		n/a	n/a		n/a

HS04 Muckish Mountain, Co. Donegal

Irish Grid ref.: 200110 428118; Altitude: 500m; SAC: 001179

Monitoring Period: 2013-2018 **Survey start date:** 13/06/2018 **No. of monitoring stops:** 5

Surveyed by: RH/ML **Survey end date:** 13/06/2018 **Survey type:** Monitoring

Comments on site:

Unlikely to have changed since baseline. Steep slope with scree and low heath. Huperzia frequent and widespread across the area surveyed.

Comments on condition/management:

Grazing level borderline okay for Huperzia but a little too high for the heath vegetation overall.

Other notes:

Juniper occasional on slope. Silene uniflora seen. Lots of Huperzia was dead or yellow, possibly due to recent drought. Note: Plot size of 2x2m used. Counts were adjusted to get counts per square metre. Percentage covers were not adjusted.

Population assessment criteria

Mon. period	Site	Indicator description	Target	Result	Outcome	Notes
2013-2018	HS 04	Total number of colonies/OSMs	>=10	60,000	Pass	Target was set as no. of colonies, but Occupied Square Metres (OSMs) were counted and appear in the Result column
2013-2018	HS 04	Population extent (sq. metres)	>=800 x 400	302,100	Pass	Target was estimated
2013-2018	HS 04	Mean % cover of target species across all stops	>=1	0.7	Pass	Marginal fail, well within margin of error for visual estimation
2013-2018	HS 04	Population size class	>=8 (50,001-100,000)	9 (100,001-500,000)	Pass	
2013-2018	HS 04	Fertile cones present	Fertile cones present	Fertile cones present	Pass	

Habitat for the species criteria

Mon. period	Site	Indicator description	Target	Result	Outcome	Notes
2013-2018	HS 04	Impact of negative pressures	Low or absent	Grazing positive, extensive population indicates suitable habitat	Pass	

Impacts and activities

Mon. period	Site	Activity code / Description		Intensity	Effect	% Habitat affected	sq. m affected	Notes
2013-2018	HS 04	A04.02.02	Non-intensive sheep grazing	M	Positive	100	302100	
2013-2018	HS 04	M	Climate change	XX	Negative	100	302100	

Parameter assessment results

Mon. period	Site	Population	Habitat for the species	Future prospects	Overall
2013-2018	HS 04	Favourable	Favourable	Favourable	Favourable
Trend (if known):		n/a	n/a		n/a

HS05 Tully Mountain, Co. Galway

Irish Grid ref.: 67242 261200; Altitude: 350m; SAC: 000330

Monitoring Period:	2013-2018	**Survey start date:**	24/05/2017	**No. of monitoring stops:**	5
Surveyed by:	OD/RH	**Survey end date:**	24/05/2017	**Survey type:**	Monitoring

Comments on site:

This population occurs on the summit of Tully Mountain. The habitat is rocky montane heath with Calluna vulgaris, Erica cinerea, Arctostaphylos uva-ursi, Juniperus communis, Racomitrium lanuginosum with scattered occasional Huperzia selago. The population occurs at an altitude of c. 350 m. It is considered high quality montane heath due to the presence of the notable species Juniperus communis and Arctostaphylos uva-ursi.

Comments on condition/management:

Moderate sheep grazing and trampling by walkers occurs, as evidenced by bare peat and paths. The Trig point of the mountain is present within the survey polygon.

Other notes:

Juniper formations were present on the summit and south-east slopes of Tully Mountain. Huperzia selago is also present on the slopes below the summit. There is a good population of Arctostaphylos uva-ursi on the mountain.

Population assessment criteria

Mon. period	Site	Indicator description	Target	Result	Outcome	Notes
2013-2018	HS 05	Total number of colonies/OSMs	>=10	225	Pass	Target was set as no. of colonies, but Occupied Square Metres (OSMs) were counted and appear in the Result column
2013-2018	HS 05	Population extent (sq. metres)	>=150 x 100	9,000	Pass	Target was estimated
2013-2018	HS 05	Mean % cover of target species across all stops	>=0.1	0.3	Pass	
2013-2018	HS 05	Population size class	>=4 (501-1,000)	4 (501-1,000)	Pass	
2013-2018	HS 05	Fertile cones present	Fertile cones present	Fertile cones present	Pass	

Habitat for the species criteria

Mon. period	Site	Indicator description	Target	Result	Outcome	Notes
2013-2018	HS 05	Impact of negative pressures	Low or absent	Overgrazed, small percentage of habitat trampled by hikers	Fail	

Impacts and activities

Mon. period	Site	Activity code / Description		Intensity	Effect	Habitat affected %	Habitat affected sq. m	Notes
2013-2018	HS 05	A04.02.02	Non-intensive sheep grazing	M	Negative	100	9000	
2013-2018	HS 05	G05.01	Trampling, overuse	H	Negative	5	450	
2013-2018	HS 05	M	Climate change	XX	Negative	100	9000	

Parameter assessment results

Mon. period	Site	Population	Habitat for the species	Future prospects	Overall
2013-2018	HS 05	Favourable	Unfavourable-Inadequate	Unfavourable-Inadequate	Unfavourable-Inadequate
Trend (if known):		n/a	n/a		n/a

HS06 Lough Doon (Connor Pass), Co. Kerry

Irish Grid ref.: 50333 106077; Altitude: 350m; SAC: 000375

Monitoring Period:	2013-2018	**Survey start date:**	06/05/2016	**No. of monitoring stops:**	5
Surveyed by:	PP/RH	**Survey end date:**	06/05/2016	**Survey type:**	Monitoring

Comments on site:

This population occurs near Lough Doon/Pedlar's Lake in the Connor Pass. The plants occur on the rocky ground between the car park/viewpoint and the lake. Most plants occur south of the stream that exits the lake, with a few plants north of the stream. The plants are typically diminutive and found in association with ER1 Exposed siliceous rock or ER3 Siliceous loose rock and scree, growing with Calluna vulgaris, Erica cinerea, Racomitrium lanuginosum, Deschampsia flexuosa and Diplophyllum albicans. Some plants are found in rocky HH3 Wet heath / PB2 Upland bog with Trichophorum germanicum and Sphagnum spp. Four plots were recorded in the vicinity of the four baseline plots; all were clustered close to the stream, so an additional plot was recorded to the south. Actual cover of the population is only about 0.1 sq m, but the population envelope is much larger, with Huperzia scattered within it. A full count of stems was carried out and 188 stems were recorded.

Comments on condition/management:

The site is very popular with tourists who walk up from the car park to the lake. The bog and heath in this area are badly eroded as a result. This impacts on plants growing on accessible ground; however, a significant proportion of plants grow on rock faces where they are unlikely to be affected. There is some sheep grazing in the area, but it is fairly light. The impact of climate change on the population is unclear but is likely to be negative given the relatively low altitude of the site (310-360m).

Other notes:

It is highly likely that further colonies occur outside the surveyed area as the corrie is full of suitable habitat. Some of the habitats in which Huperzia occurs at this site are Annex I (8110, 4030, 7130).

Population assessment criteria

Mon. period	Site	Indicator description	Target	Result	Outcome	Notes
2013-2018	HS 06	Total number of colonies/OSMs	>=4	47	Pass	Target was set as no. of colonies, but Occupied Square Metres (OSMs) were counted and appear in the Result column
2013-2018	HS 06	Population extent (sq. metres)	>=100 x 50	13,600	Pass	
2013-2018	HS 06	Mean % cover of target species across all stops	>=0.1	0.2	Pass	
2013-2018	HS 06	Population size class	>=3 (101-500)	3 (101-500)	Pass	
2013-2018	HS 06	Fertile cones present	Fertile cones present	Fertile cones present	Pass	

Habitat for the species criteria

Mon. period	Site	Indicator description	Target	Result	Outcome	Notes
2013-2018	HS 06	Impact of negative pressures	Low or absent	Grazing neutral, low damage from hikers	Pass	

Impacts and activities

Mon. period	Site	Activity code / Description		Intensity	Effect	% Habitat affected	sq. m affected	Notes
2013-2018	HS 06	A04.02.02	Non-intensive sheep grazing	L	Neutral	100	13600	
2013-2018	HS 06	G01.02	Walking, horseriding and non-motorised vehicles	H	Negative	50	6800	
2013-2018	HS 06	K01.01	Erosion	H	Negative	30	4080	
2013-2018	HS 06	M	Climate change	XX	Negative	100	13600	

Parameter assessment results

Mon. period	Site	Population	Habitat for the species	Future prospects	Overall
2013-2018	HS 06	Favourable	Favourable	Favourable	Favourable
Trend (if known):		n/a	n/a		n/a

HS07 Lough Cruite, Co. Kerry

Irish Grid ref.: 47760 110590; Altitude: 300m; SAC: 000375

Monitoring Period:	2013-2018	**Survey start date:**	05/05/2016	**No. of monitoring stops:**	4
Surveyed by:	PP/RH	**Survey end date:**	05/05/2016	**Survey type:**	Monitoring

Comments on site:

This population occurs on steep, rocky ground between Lough Cruite and Lough Nalacken on the lower slopes (240-290m) of Brandon Mountain. The plants occur either side of the stream flowing between the two lakes, on ER3 Siliceous scree and loose rock, ER1 Exposed siliceous rock, or rocky ledges of HH3 Wet heath. Most of the habitat matrix is GS3 Dry-humid acid grassland. Species occurring with Huperzia include Erica cinerea, Racomitrium langinosum, Calluna vulgaris, Diplophyllum albicans, Saxifraga spathularis and Nardus stricta. Only one of the two baseline plots was relocated (this may have been due to recorder error). Far fewer stems were recorded this time than in the baseline but it is not clear if this is a genuine decline. Three new plots were recorded. Actual cover of the population is only about 0.04 sq m, but the population envelope is much larger, with Huperzia scattered within it. A full count of stems was carried out and 29 stems were recorded.

Comments on condition/management:

The site is well grazed by sheep but Huperzia is growing in fairly inaccessible niches so the impact on the extant plants is likely to be low. The valley is visited by hillwalkers but impact is likely to be low. The impact of climate change is unclear but is likely to be negative, especially given the low altitude of the site.

Other notes:

None

Population assessment criteria

Mon. period	Site	Indicator description	Target	Result	Outcome	Notes
2013-2018	HS 07	Total number of colonies/OSMs	>=2	10	Pass	Target was set as no. of colonies, but Occupied Square Metres (OSMs) were counted and appear in the Result column
2013-2018	HS 07	Population extent (sq. metres)	>=200 x 200	7,800	Fail	
2013-2018	HS 07	Mean % cover of target species across all stops	>=0.1	0.3	Pass	
2013-2018	HS 07	Population size class	>=4 (501-1,000)	1 (1-50)	Fail	
2013-2018	HS 07	Fertile cones present	Fertile cones present	Fertile cones present	Pass	

Habitat for the species criteria

Mon. period	Site	Indicator description	Target	Result	Outcome	Notes
2013-2018	HS 07	Impact of negative pressures	Low or absent	Grazing and impacts from hikers neutral	Pass	

Impacts and activities

Mon. period	Site	Activity code / Description		Intensity	Effect	% Habitat affected	sq. m affected	Notes
2013-2018	HS 07	A04.02.02	Non-intensive sheep grazing	L	Neutral	100	7800	
2013-2018	HS 07	G01.02	Walking, horseriding and non-motorised vehicles	L	Neutral	50	3900	
2013-2018	HS 07	M	Climate change	XX	Negative	100	7800	

Parameter assessment results

Mon. period	Site	Population	Habitat for the species	Future prospects	Overall
2013-2018	HS 07	Unfavourable-Inadequate	Favourable	Unfavourable-Inadequate	Unfavourable-Inadequate
Trend (if known):		n/a	n/a		n/a

HS08 Skeltia (Maumtrasna Mountain), Co. Mayo

Irish Grid ref.: 98354 262283; Altitude: 525m; SAC: None

Monitoring Period:	2013-2018	**Survey start date:**	23/05/2017	**No. of monitoring stops:**	5
Surveyed by:	OD/RH	**Survey end date:**	23/05/2017	**Survey type:**	Monitoring

Comments on site:

Exposed spur on a broad ridge leading down from a plateau, close to the top of a vertical cliff. The habitat is a mosaic of rock, montane heath and small pockets of blanket bog with frequent bare peat. Huperzia is mostly found in damp montane heath with Calluna vulgaris, Nardus stricta, Trichophorum germanicum and Racomitrium lanuginosum. Cover of Huperzia is sparse and absent from many places within the area of occupancy.

Comments on condition/management:

Sheep are having a major negative impact on the vegetation. Much of the Huperzia has been uprooted and most plants present are low and damaged. Also negatively impacted by exposure working in tandem with overgrazing.

Other notes:

Grazing should be reduced at this site to allow recovery of vegetation. Juniper was present within one of the relevés and scattered throughout the survey polygon.

Population assessment criteria

Mon. period	Site	Indicator description	Target	Result	Outcome	Notes
2013-2018	HS 08	Total number of colonies/OSMs	>=10	150	Pass	Target was set as no. of colonies, but Occupied Square Metres (OSMs) were counted and appear in the Result column
2013-2018	HS 08	Population extent (sq. metres)	>=200 x 100	18,000	Pass	Target was estimated
2013-2018	HS 08	Mean % cover of target species across all stops	>=0.3	0.3	Pass	
2013-2018	HS 08	Population size class	>=4 (501-1,000)	4 (501-1,000)	Pass	
2013-2018	HS 08	Fertile cones present	Fertile cones present	Fertile cones present	Pass	

Habitat for the species criteria

Mon. period	Site	Indicator description	Target	Result	Outcome	Notes
2013-2018	HS 08	Impact of negative pressures	Low or absent	Heavily overgrazed	Fail	

Impacts and activities

Mon. period	Site	Activity code / Description		Intensity	Effect	% Habitat affected	sq. m affected	Notes
2013-2018	HS 08	A04.02.02	Non-intensive sheep grazing	H	Negative	100	18000	
2013-2018	HS 08	K01.01	Erosion	H	Negative	100	18000	
2013-2018	HS 08	M	Climate change	XX	Negative	100	18000	

Parameter assessment results

Mon. period	Site	Population	Habitat for the species	Future prospects	Overall
2013-2018	HS 08	Favourable	Unfavourable-Inadequate	Unfavourable-Inadequate	Unfavourable-Inadequate
Trend (if known):		n/a	n/a		n/a

HS09 Turlough Hill, north of reservoir (Camaderry), Co. Wicklow

Irish Grid ref.: 306763 199049; Altitude: 640m; SAC: 002122

Monitoring Period:	2013-2018	**Survey start date:**	19/04/2016	**No. of monitoring stops:**	10
Surveyed by:	PP/RH	**Survey end date:**	19/04/2016	**Survey type:**	Monitoring

Comments on site:

This population of Huperzia selago is found just north of the reservoir on top of Turlough Hill. It is not on Camaderry itself, which is the 698m peak to the east of the reservoir. It occurs to the east of the road leading to the reservoir in an area of badly eroded PB2 Upland blanket bog; note that the original survey recorded the habitat as HH4 Montane heath. Some colonies occur on top of the peat haggs, but the majority occur on the eroding sides, where the peat has dried out somewhat. The chief species are Racomitrium lanuginosum, Calluna vulgaris, Hypnum jutlandicum, Trichophorum germanicum, Empetrum nigrum and Eriophorum angustifolium.

Comments on condition/management:

Erosion of the blanket bog appears to be providing H. selago with suitable niches to colonise. While erosion of the bog may, in the long term, have a negative impact on the species, in the 12 years assessed for Future Prospects, erosion is probably positive. Sheep grazing is low intensity and is not problematic. The impacts of climate change are unclear but probably negative.

Other notes:

Two of the locations of baseline stops appear to have eroded away, but H. selago was present nearby and stops were recorded in these new locations. Additional colonies were observed at several places along the access road which leads north to the Wicklow Gap car park, from which the site was accessed.

Population assessment criteria

Mon. period	Site	Indicator description	Target	Result	Outcome	Notes
2013-2018	HS 09	Total number of colonies/OSMs	>=10	68	Pass	Target was set as no. of colonies, but Occupied Square Metres (OSMs) were counted and appear in the Result column
2013-2018	HS 09	Population extent (sq. metres)	>=200 x 100	7,000	Pass	H. selago present throughout area where baseline plots recorded; population envelope maps core area, further colonies recorded 200m to north
2013-2018	HS 09	Mean % cover of target species across all stops	>=0.3	2.5	Pass	Surveyor variability
2013-2018	HS 09	Population size class	>=5 (1,001-5,000)	5 (1,001-5,000)	Pass	
2013-2018	HS 09	Fertile cones present	Fertile cones present	Fertile cones present	Pass	

Habitat for the species criteria

Mon. period	Site	Indicator description	Target	Result	Outcome	Notes
2013-2018	HS 09	Impact of negative pressures	Low or absent	Grazing neutral, positive effects of erosion provide niches for colonisation	Pass	

Impacts and activities

Mon. period	Site	Activity code / Description		Intensity	Effect	% Habitat affected	sq. m affected	Notes
2013-2018	HS 09	A04.02.02	Non-intensive sheep grazing	L	Neutral	100	7000	
2013-2018	HS 09	K01.01	Erosion	H	Positive	100	7000	
2013-2018	HS 09	M	Climate change	XX	Negative	100	7000	

Parameter assessment results

Mon. period	Site	Population	Habitat for the species	Future prospects	Overall
2013-2018	HS 09	Favourable	Favourable	Favourable	Favourable
Trend (if known):		n/a	n/a		n/a

HS10 Kippure, Co. Wicklow

Irish Grid ref.: 311679 215400; Altitude: 750m; SAC: 002122

Monitoring Period:	2013-2018	**Survey start date:**	18/04/2016	**No. of monitoring stops:**	10
Surveyed by:	OD/RH/PP	**Survey end date:**	09/05/2017	**Survey type:**	Monitoring

Comments on site:

The monitored population occurs mainly on the east side of the summit close to the transmission tower at about 730-745 m. The colonies at the southern end of this area are in montane heath (HH4/4060) with Calluna vulgaris, Racomitrium lanuginosum, Vaccinium myrtillus and Deschampsia flexuosa. Colonies at the northern end are largely in upland grassland (GS3) with Agrostis capillaris and Festuca ovina agg. All 10 baseline plots were resurveyed.

Comments on condition/management:

Plants are typically very small (2-5 cm tall). Plants growing in grassland are vulnerable to erosion. Impacts of climate change are unknown but deemed to be negative.

Other notes:

Parked at the Kippure gates and walked up. Jo Denyer (pers. comm.) noted that Huperzia selago also grows to the west of the road near the summit outside the monitoring area.

Population assessment criteria

Mon. period	Site	Indicator description	Target	Result	Outcome	Notes
2013-2018	HS 10	Total number of colonies/OSMs	>=10	127	Pass	Target was set as no. of colonies, but Occupied Square Metres (OSMs) were counted and appear in the Result column
2013-2018	HS 10	Population extent (sq. metres)	>=150 x 50	7,500	Pass	
2013-2018	HS 10	Mean % cover of target species across all stops	>=1	1	Pass	Surveyor variability
2013-2018	HS 10	Population size class	>=4 (501-1,000)	5 (1,001-5,000)	Pass	
2013-2018	HS 10	Fertile cones present	Fertile cones present	Fertile cones present	Pass	

Habitat for the species criteria

Mon. period	Site	Indicator description	Target	Result	Outcome	Notes
2013-2018	HS 10	Impact of negative pressures	Low or absent	Disturbance from hikers and overgrazing; erosion damaging to H. selago in grassland	Fail	

Impacts and activities

Mon. period	Site	Activity code / Description		Intensity	Effect	Habitat affected %	Habitat affected sq. m	Notes
2013-2018	HS 10	A04.02.02	Non-intensive sheep grazing	L	Negative	100	7500	
2013-2018	HS 10	G01.02	Walking, horseriding and non-motorised vehicles	L	Negative	100	7500	
2013-2018	HS 10	K01.01	Erosion	H	Negative	26-50	1950-3750	
2013-2018	HS 10	M	Climate change	XX	Negative	100	7500	

Parameter assessment results

Mon. period	Site	Population	Habitat for the species	Future prospects	Overall
2013-2018	HS 10	Favourable	Unfavourable-Inadequate	Unfavourable-Inadequate	Unfavourable-Inadequate
Trend (if known):		n/a	n/a		n/a

LC01 Clohernagh Mountain, Co. Wicklow

Irish Grid ref.: 305420 192023; Altitude: 800m; SAC: 002122

Monitoring Period:	2013-2018	**Survey start date:**	20/04/2016	**No. of monitoring stops:**	10
Surveyed by:	PP/RH	**Survey end date:**	20/04/2016	**Survey type:**	Monitoring

Comments on site:

Cloghernagh is the eastern spur of Lugnaquilla. The population here occurs in a shallow saddle just to the west of the highest point on the spur at about 790m. Most of the population is to be found on the northern side of the walker's path that runs along the centre of the spur, but a few plants occur on the southern side, close to the path. The Fossitt habitat is HH4 Montane heath and it corresponds to Annex I habitat 4060. The vegetation is largely composed of Racomitrium lanuginosum, Empetrum nigrum, Vaccinium myrtillus, Deschampsia flexuosa and Agrostis capillaris. There is an extensive population of Diphasiastrum alpinum here also.

Comments on condition/management:

The site is sheep grazed but the level of intensity is low and does not seem problematic. The path through the site is heavily used by walkers. It is not surfaced or defined in any way; rather it is just a trampled/eroded route across the heath. There is potential for plants near the path to be impacted on if this path widens. The impact of climate change on this population is unclear but is likely to be negative.

Other notes:

The extent of the population is fairly well defined by the plot locations. It extends slightly further in the north-west and south-east. Most of the population occurs on almost flat ground, but the population does extend down the northern slope a little. The vegetation is very low growing (approx 8 cm tall). There is no evident change since the baseline. The site was accessed from the east, parking on the Glenmalure Road and coming up "the Zig-zags".

Population assessment criteria

Mon. period	Site	Indicator description	Target	Result	Outcome	Notes
2013-2018	LC 01	Total number of colonies/OSMs	>=10	86	Pass	
2013-2018	LC 01	Population extent (sq. metres)	>=200 x 100	8,500	Pass	Yes; overall dimensions of 2018 polygon are consistent with target
2013-2018	LC 01	Mean % cover of target species across all stops	>=11	7	Pass	Within margin of error to be expected for visual estimation
2013-2018	LC 01	Population size class	>=5 (1,001-5,000)	5 (1,001-5,000)	Pass	
2013-2018	LC 01	Fertile cones present	Fertile cones present	Fertile cones present	Pass	

Habitat for the species criteria

Mon. period	Site	Indicator description	Target	Result	Outcome	Notes
2013-2018	LC 01	Mean % cover of Calluna vulgaris across all stops	<=10	7.8	Pass	
2013-2018	LC 01	Mean % cover of bare ground across all stops	<=10	0.01	Pass	
2013-2018	LC 01	Impact of negative pressures	Low or absent	Low	Pass	

Impacts and activities

Mon. period	Site	Activity code / Description		Intensity	Effect	% Habitat affected	sq. m affected	Notes
2013-2018	LC 01	A04.02.02	Non-intensive sheep grazing	L	Neutral	100	8500	
2013-2018	LC 01	D01.01	Paths, tracks, cycling tracks	M	Negative	1-25	85-2125	
2013-2018	LC 01	M	Climate change	XX	Negative	100	8500	

Parameter assessment results

Mon. period	Site	Population	Habitat for the species	Future prospects	Overall
2013-2018	LC 01	Favourable	Favourable	Favourable	Favourable
Trend (if known):		n/a	n/a		n/a

LC02 Kippure, Co. Wicklow

Irish Grid ref.: 311683 215393; Altitude: 750m; SAC: 002122

Monitoring Period:	2013-2018	**Survey start date:**	18/04/2016	**No. of monitoring stops:**	9
Surveyed by:	OD/RH/PP	**Survey end date:**	09/05/2017	**Survey type:**	Monitoring

Comments on site:

The monitored population occurs mainly on the east side of the summit close to the transmission tower at about 730-745 m. The colonies at the southern end of this area are in montane heath (HH4/4060) with Calluna vulgaris, Racomitrium lanuginosum, Vaccinium myrtillus, Polytrichum commune and Deschampsia flexuosa. Colonies at the northern end are largely in upland grassland (GS3/possible 6150) with Agrostis capillaris, Festuca ovina agg. and Racomitrium lanuginosum. All nine baseline plots were resurveyed.

Comments on condition/management:

The montane heath occurs in association with eroding blanket bog and areas of bare peat. The heath itself is not eroding and may expand to replace the bog in time. Walkers are unlikely to have a major impact as they chiefly keep to the access road, although plants near the Trig point are more vulnerable. The impact of climate change is unclear but is likely to be negative. There are significant areas of bare ground in a number of the stops.

Other notes:

Parked at Kippure gate and walked up access road. Jo Denyer (pers. comm.) noted that Lycopodium clavatum also grows to the west of the road near the summit outside the monitoring area.

Population assessment criteria

Mon. period	Site	Indicator description	Target	Result	Outcome	Notes
2013-2018	LC 02	Total number of colonies/OSMs	>=10	162	Pass	
2013-2018	LC 02	Population extent (sq. metres)	>=150 x 50	7,500	Pass	
2013-2018	LC 02	Mean % cover of target species across all stops	>=11	5	Fail	
2013-2018	LC 02	Population size class	>=5 (1,001-5,000)	5 (1,001-5,000)	Pass	
2013-2018	LC 02	Fertile cones present	Fertile cones present	Fertile cones present	Pass	

Habitat for the species criteria

Mon. period	Site	Indicator description	Target	Result	Outcome	Notes
2013-2018	LC 02	Mean % cover of Calluna vulgaris across all stops	<=10	4.9	Pass	
2013-2018	LC 02	Mean % cover of bare ground across all stops	<=10	3.5	Pass	
2013-2018	LC 02	Impact of negative pressures	Low or absent	Low	Pass	

Impacts and activities

Mon. period	Site	Activity code / Description		Intensity	Effect	% Habitat affected	sq. m affected	Notes
2013-2018	LC 02	A04.02.02	Non-intensive sheep grazing	L	Negative	100	7500	
2013-2018	LC 02	G01.02	Walking, horseriding and non-motorised vehicles	L	Negative	100	7500	
2013-2018	LC 02	K01.01	Erosion	H	Negative	26-50	1950-3750	
2013-2018	LC 02	M	Climate change	XX	Negative	100	7500	

Parameter assessment results

Mon. period	Site	Population	Habitat for the species	Future prospects	Overall
2013-2018	LC 02	Favourable	Favourable	Favourable	Favourable
Trend (if known):		n/a	n/a		n/a

LC03 Turlough Hill, north of reservoir (Camaderry, left of reservoir), Co. Wicklow

Irish Grid ref.: 306774 199125; Altitude: 650m; SAC: 002122

Monitoring Period:	2013-2018	**Survey start date:**	19/04/2016	**No. of monitoring stops:**	1
Surveyed by:	PP/RH	**Survey end date:**	19/04/2016	**Survey type:**	Monitoring

Comments on site:

This population is found just north of the reservoir on top of Turlough Hill: it is not on Camaderry itself, which is the 698m peak east of the reservoir. The population consists of a single colony located close to the end of a rough track where rock and peat have been bulldozed into piles in the past. The colony appears to occur on a revegetated area of this spoil. The vegetation is quite rank and consists mainly of Deschampsia flexuosa with Juncus squarrosus, Vaccinium myrtillus, Hylocomium splendens, Hypnum jutlandicum and Polytrichum cf. commune. It was classified as GS3 Dry-humid acid grassland. There is no evident change since the baseline.

Comments on condition/management:

The vegetation is dense, making the stems of Lycopodium clavatum difficult to spot. The area is grazed by sheep, but the intensity may be too low: the species often occurs in low-growing heath. There is some erosion in the area which could affect the target species in the future, as would further bulldozing of the track. The impact of climate change on this population is unclear but is likely to be negative.

Other notes:

Further colonies of L. clavatum were found adjacent to the roadway which provides access to the reservoir at the following grid refs (Irish grid): 306621 19177 (approx 20 stems) and 306689 199280. The site was accessed from the north, parking at the Wicklow Gap car park.

Population assessment criteria

Mon. period	Site	Indicator description	Target	Result	Outcome	Notes
2013-2018	LC 03	Total number of colonies/OSMs	>=1	1	Pass	
2013-2018	LC 03	Population extent (sq. metres)	>=0.1	1	Pass	
2013-2018	LC 03	Mean % cover of target species across all stops	>=0.1	1	Pass	
2013-2018	LC 03	Population size class	>=1 (1-50)	1 (1-50)	Pass	
2013-2018	LC 03	Fertile cones present	Fertile cones present	Fertile cones not found	Fail	

Habitat for the species criteria

Mon. period	Site	Indicator description	Target	Result	Outcome	Notes
2013-2018	LC 03	Mean % cover of Calluna vulgaris across all stops	<=10	0.3	Pass	
2013-2018	LC 03	Mean % cover of bare ground across all stops	<=10	0	Pass	
2013-2018	LC 03	Impact of negative pressures	Low or absent	Undergrazed	Fail	

Impacts and activities

Mon. period	Site	Activity code / Description		Intensity	Effect	% Habitat affected	sq. m affected	Notes
2013-2018	LC 03	A04.02.02	Non-intensive sheep grazing	L	Positive	100	1	
2013-2018	LC 03	A04.03	Abandonment of pastoral systems, lack of grazing	M	Negative	100	1	
2013-2018	LC 03	D01.01	Paths, tracks, cycling tracks			0	0	
2013-2018	LC 03	K01.01	Erosion			0	0	
2013-2018	LC 03	M	Climate change	XX	Negative	100	1	

Parameter assessment results

Mon. period	Site	Population	Habitat for the species	Future prospects	Overall
2013-2018	LC 03	Favourable	Unfavourable-Inadequate	Unfavourable-Inadequate	Unfavourable-Inadequate
Trend (if known):		n/a	n/a		n/a

LC04 Corlisbannan, Co. Cavan

Irish Grid ref.: 202041 327133; Altitude: 180m; SAC: None

Monitoring Period:	2013-2018	**Survey start date:**	11/04/2018	**No. of monitoring stops:**	0
Surveyed by:	RH/ML	**Survey end date:**	11/04/2018	**Survey type:**	Baseline

Comments on site:

Despite 10-figure grid ref, suitable habitat apparently present and three people searching for 3 hours (=9 person hours), L. clavatum was not found. Habitat appeared to be in good condition and there was no evidence of any negative impacts since the record was made in 2011.

Comments on condition/management:

Grazed optimally - some trampling in places but some long vegetation growth elsewhere.

Other notes:

Vulnerable to forestry planting in the future, perhaps.

Population assessment criteria

Mon. period	Site	Indicator description	Target	Result	Outcome	Notes
2013-2018	LC 04	Total number of colonies/OSMs	>=1	0	Fail	
2013-2018	LC 04	Population extent (sq. metres)	>=1	0	Fail	
2013-2018	LC 04	Mean % cover of target species across all stops	>=0.1	0	Fail	
2013-2018	LC 04	Population size class	>=1	0	Fail	
2013-2018	LC 04	Fertile cones present	Fertile cones present	No L. clavatum found	Fail	

Habitat for the species criteria

Mon. period	Site	Indicator description	Target	Result	Outcome	Notes
2013-2018	LC 04	Mean % cover of Calluna vulgaris across all stops	<=10	N/A	N/A	
2013-2018	LC 04	Mean % cover of bare ground across all stops	<=10	N/A	N/A	
2013-2018	LC 04	Impact of negative pressures	Low or absent	N/A	N/A	

Impacts and activities

Mon. period	Site	Activity code / Description	Intensity	Effect	% Habitat affected	sq. m affected	Notes
2013-2018	LC 04	M Climate change	XX	Negative	100	0	

Parameter assessment results

Mon. period	Site	Population	Habitat for the species	Future prospects	Overall
2013-2018	LC 04	Unfavourable-Bad	Unknown	Unfavourable-Bad	Unfavourable-Bad
Trend (if known):		n/a	n/a		n/a

LC05 Lavagh More, N and E of Lough Asgarha, Co. Donegal

Irish Grid ref.: 193244 391006; Altitude: 480m; SAC: None

Monitoring Period:	2013-2018	**Survey start date:**	12/06/2018	**No. of monitoring stops:**	3
Surveyed by:	RH/ML	**Survey end date:**	12/06/2018	**Survey type:**	Baseline

Comments on site:

Two patches of L. clavatum 15m apart, on montane heath-covered knolls beside small lake, on plateau south of Lavagh More to west of L. Asgarha. Western patch is 5x5m in area with scattered plants. Eastern patch is over 8x8m with moderately dense L. clavatum. Main species in vegetation include Racomitrium lanuginosum, Vaccinium myrtillus, Nardus stricta and Carex binervis.

Comments on condition/management:

Low levels of grazing and signs of recovery in general area from previous overgrazing.

Other notes:

Note: Plot size of 2x2m used. Counts were adjusted to get counts per square metre.

Population assessment criteria

Mon. period	Site	Indicator description	Target	Result	Outcome	Notes
2013-2018	LC 05	Total number of Occupied Square Metres	>=22	28	Pass	
2013-2018	LC 05	Population extent (sq. metres)	>=70	89	Pass	
2013-2018	LC 05	Mean % cover of target species across all stops	>=3	3	Pass	
2013-2018	LC 05	Population size class	>=2 (51-100)	2 (51-100)	Pass	
2013-2018	LC 05	Fertile cones present	Fertile cones present	Fertile cones present	Pass	

Habitat for the species criteria

Mon. period	Site	Indicator description	Target	Result	Outcome	Notes
2013-2018	LC 05	Mean % cover of Calluna vulgaris across all stops	<=10	1	Pass	
2013-2018	LC 05	Mean % cover of bare ground across all stops	<=10	0.4	Pass	
2013-2018	LC 05	Impact of negative pressures	Low or absent	Low	Pass	

Impacts and activities

Mon. period	Site	Activity code / Description		Intensity	Effect	% Habitat affected	sq. m affected	Notes
2013-2018	LC 05	A04.02.02	Non-intensive sheep grazing	L	Neutral	100	89	
2013-2018	LC 05	M	Climate change	XX	Negative	100	89	

Parameter assessment results

Mon. period	Site	Population	Habitat for the species	Future prospects	Overall
2013-2018	LC 05	Favourable	Favourable	Favourable	Favourable
Trend (if known):		n/a	n/a		n/a

LI01 Cornamona, Co. Galway

Irish Grid ref.: 105016 253219; Altitude: 120m; SAC: None

Monitoring Period:	2013-2018	**Survey start date:**	13/10/2016	**No. of monitoring stops:**	3
Surveyed by:	OD/ML	**Survey end date:**	13/10/2016	**Survey type:**	Monitoring

Comments on site:

Lycopodiella inundata occurs in wet flushed heathy grassland on the southern slopes of Benlevy, approximately 15 m north of a small road/track. Nearby areas support dense bracken or scrub/woodland. The small population of L. inundata occurs on south-facing rocky slopes (80-85m altitude) on the edges of flushed areas. Vegetation is largely composed of Nardus stricta, Schoenus nigricans, Racomitrium lanuginosum, Sphagnum denticulatum, Narthecium ossifragum and Carex panicea. The population appears to have decreased since the baseline.

Comments on condition/management:

The site is grazed by sheep. Judging by the very small size of heath plants, grazing may have been very heavy in the past. Small Nardus stricta plants are common - this may be problematic in the future if density increases. Some patches of bare ground were noted, due both to water movement and grazers.

Other notes:

Dense bracken is present in the adjacent area but not encroaching on the population. The baseline report stated "immediately threatened by vegetation encroachment (grass, heather)", but this does not appear to have become a problem. It is difficult to discern if the site is drying out, but the presence of Nardus may indicate, or become, a problem.

Population assessment criteria

Mon. period	Site	Indicator description	Target	Result	Outcome	Notes
2013-2018	LI 01	Total number of colonies/OSMs	>=3	6	Pass	
2013-2018	LI 01	Population extent (sq. metres)	>=10 x 50	131	Pass	
2013-2018	LI 01	Mean % cover of target species across all stops	>=26	3.8	Fail	Likely due to different time of year
2013-2018	LI 01	Population size class	>=3 (101-500)	3 (101-500)	Pass	
2013-2018	LI 01	Fertile cones present	Fertile cones present	Fertile cones present	Pass	

Habitat for the species criteria

Mon. period	Site	Indicator description	Target	Result	Outcome	Notes
2013-2018	LI 01	Sward height (cm)	4-10	4.8	Pass	
2013-2018	LI 01	Mean % cover of Nardus stricta across all stops	<=35	7.7	Pass	
2013-2018	LI 01	Mean % cover of bare ground across all stops	3-20	13.3	Pass	
2013-2018	LI 01	Wetness of substrate	Ground damp to touch	Ground damp to touch	Pass	
2013-2018	LI 01	Impact of negative pressures	Low or absent	Low	Pass	

Impacts and activities

Mon. period	Site	Activity code / Description		Intensity	Effect	Habitat affected %	Habitat affected sq. m	Notes
2013-2018	LI 01	A04.02.02	Non-intensive sheep grazing	M	Neutral	100	131	

Parameter assessment results

Mon. period	Site	Population	Habitat for the species	Future prospects	Overall
2013-2018	LI 01	Favourable	Favourable	Favourable	Favourable
Trend (if known):		n/a	n/a		n/a

LI02 Capnagower, Clare Island, Co. Mayo

Irish Grid ref.: 71126 286312; Altitude: 30m; SAC: None

Monitoring Period:	2013-2018	**Survey start date:**	25/05/2017	**No. of monitoring stops:**	4
Surveyed by:	ML/FON	**Survey end date:**	26/05/2017	**Survey type:**	Monitoring

Comments on site:

Lycopodiella inundata covers a much larger area than reported in the baseline survey. This may be because conditions in 2017 were very dry, with consequently low water levels that enabled easier sighting of the plant. Plants were visible as fresh green, newly emerging shoots, the longest no more than 4 cm. It was determined using the baseline photographs that the grid reference for the smaller colony in the baseline was incorrect and a corrected grid reference was recorded. However, this colony is more or less contiguous with the larger colony as L. inundata occurs consistently between them.

Comments on condition/management:

The plant is flourishing, so management appears to be suitable. The area was quite dry overall due to recent dry weather but some areas nearby were still very wet and boggy. However, Lycopodiella was absent from these wetter areas.

Other notes:

The plants were unevenly distributed, being very clustered in some areas and more dispersed in others. Efforts were concentrated on determining the extent of the population and recording relevés.

Population assessment criteria

Mon. period	Site	Indicator description	Target	Result	Outcome	Notes
2013-2018	LI 02	Total number of colonies/OSMs	>=2	2	Pass	
2013-2018	LI 02	Population extent (sq. metres)	>=54	817	Pass	
2013-2018	LI 02	Mean % cover of target species across all stops	>=26	6.5	Fail	Likely due to different time of year
2013-2018	LI 02	Population size class	>=3 (101-500)	6 (5,001-10,000)	Pass	
2013-2018	LI 02	Fertile cones present	Fertile cones present	Fertile cones present	Pass	

Habitat for the species criteria

Mon. period	Site	Indicator description	Target	Result	Outcome	Notes
2013-2018	LI 02	Sward height (cm)	4-10	4.6	Pass	
2013-2018	LI 02	Mean % cover of Nardus stricta across all stops	<=35	23.8	Pass	
2013-2018	LI 02	Mean % cover of bare ground across all stops	3-20	3.4	Pass	
2013-2018	LI 02	Wetness of substrate	Ground damp to touch	Ground damp to touch	Pass	
2013-2018	LI 02	Impact of negative pressures	Low or absent	Low	Pass	

Impacts and activities

Mon. period	Site	Activity code / Description	Intensity	Effect	% Habitat affected	sq. m affected	Notes
2013-2018	LI 02	A04.02.02 Non-intensive sheep grazing	M	Positive	100	817	

Parameter assessment results

Mon. period	Site	Population	Habitat for the species	Future prospects	Overall
2013-2018	LI 02	Favourable	Favourable	Favourable	Favourable
Trend (if known):		n/a	n/a		n/a

LI03 Oorid Lough, Co. Galway

Irish Grid ref.: 93621 246300; Altitude: 50m; SAC: 002034

Monitoring Period:	2013-2018	**Survey start date:**	07/11/2016	**No. of monitoring stops:**	3
Surveyed by:	OD/ML	**Survey end date:**	07/11/2016	**Survey type:**	Baseline

Comments on site:

This is a lakeshore site. Lycopodiella inundata occurs on the edge of a lakeshore that is likely to be inundated in the winter months. It is in a transition zone between the stones at the water's edge and a Molinia wet heath. Bare ground is a feature of this transition zone. Associated species include Molinia caerulea, Carex panicea, Carex viridula and Eleocharis multicaulis.

Comments on condition/management:

The site was previously grazed by sheep (from J. Conaghan's original site report) but these grazers are no longer present. The site does not appear to be undergoing management but flooding keeps the site in suitable condition. Self-seedling conifers were noted in the local vicinity but these trees are unlikely to survive in the inundation zone and are not therefore considered a threat/impact.

Other notes:

Deschampsia setacea was found growing within a monitoring stop. One of the waypoints mapped in the original survey on the eastern side of the river appears to have been transcribed incorrectly as tussocks of Molinia (which did not support the target species) were in this position.

Population assessment criteria

Mon. period	Site	Indicator description	Target	Result	Outcome	Notes
2013-2018	LI 03	Total number of Occupied Square Metres	>=254	318	Pass	
2013-2018	LI 03	Population extent (sq. metres)	>=568	711	Pass	
2013-2018	LI 03	Mean % cover of target species across all stops	>=11	25	Pass	
2013-2018	LI 03	Population size class	>=8 (50,001-100,000)	8 (50,001-100,000)	Pass	
2013-2018	LI 03	Fertile cones present	Fertile cones present	Fertile cones present	Pass	

Habitat for the species criteria

Mon. period	Site	Indicator description	Target	Result	Outcome	Notes
2013-2018	LI 03	Sward height (cm)	4-10	7.2	Pass	
2013-2018	LI 03	Mean % cover of Nardus stricta across all stops	<=35	1.5	Pass	
2013-2018	LI 03	Mean % cover of bare ground across all stops	3-20	13.5	Pass	
2013-2018	LI 03	Wetness of substrate	Ground damp to touch	Ground damp to touch	Pass	
2013-2018	LI 03	Impact of negative pressures	Low or absent	Low	Pass	

Impacts and activities

Mon. period	Site	Activity code / Description		Intensity	Effect	% Habitat affected	sq. m affected	Notes
2013-2018	LI 03	L08	Inundation (natural processes)	M	Positive	100	711	

Parameter assessment results

Mon. period	Site	Population	Habitat for the species	Future prospects	Overall
2013-2018	LI 03	Favourable	Favourable	Favourable	Favourable
Trend (if known):		n/a	n/a		n/a

LI04 Glenasaul, Co. Mayo

Irish Grid ref.: 105578 265983; Altitude: 100m; SAC: None

Monitoring Period:	2013-2018	**Survey start date:**	08/11/2016	**No. of monitoring stops:**	3
Surveyed by:	OD/ML	**Survey end date:**	08/11/2016	**Survey type:**	Baseline

Comments on site:

The area surveyed is in the field behind Glenasaul National School. Lycopodiella inundata occurs in flushed wet heath on the mid-slopes (95-100m) of the field. Three distinct flushes occur across the field, with L. inundata occuring within and adjacent to these areas on wet ground supporting low-growing vegetation. Associated species include Carex panicea, Molinia caerulea, Erica tetralix, Calluna vulgaris, Trichophorum germanicum, Racomitrium lanuginosum and Sphagnum spp.

Comments on condition/management:

The previous survey stated that the site was at risk due to sheep trampling and overgrazing; these grazers were absent during the current survey, but a herd of cattle was present. Poaching was occurring as a result but was localised, occurring in the areas adjacent to the road. Therefore this impact was assessed as high intensity but having a neutral impact on L. inundata.

Other notes:

None

Population assessment criteria

Mon. period	Site	Indicator description	Target	Result	Outcome	Notes
2013-2018	LI 04	Total number of Occupied Square Metres	>=56	70	Pass	
2013-2018	LI 04	Population extent (sq. metres)	>=5,040	6,300	Pass	
2013-2018	LI 04	Mean % cover of target species across all stops	>=11	23	Pass	
2013-2018	LI 04	Population size class	>=7 (10,001-50,000)	7 (10,001-50,000)	Pass	
2013-2018	LI 04	Fertile cones present	Fertile cones present	Fertile cones present	Pass	

Habitat for the species criteria

Mon. period	Site	Indicator description	Target	Result	Outcome	Notes
2013-2018	LI 04	Sward height (cm)	4-10	8.5	Pass	
2013-2018	LI 04	Mean % cover of Nardus stricta across all stops	<=35	0	Pass	
2013-2018	LI 04	Mean % cover of bare ground across all stops	3-20	6	Pass	
2013-2018	LI 04	Wetness of substrate	Ground damp to touch	Ground damp to touch	Pass	
2013-2018	LI 04	Impact of negative pressures	Low or absent	Low	Pass	

Impacts and activities

						%	sq. m	
Mon. period	Site	Activity code / Description		Intensity	Effect	Habitat affected		Notes
2013-2018	LI 04	A04.02.01	Non-intensive cattle grazing	H	Neutral	100	6300	

Parameter assessment results

Mon. period	Site	Population	Habitat for the species	Future prospects	Overall
2013-2018	LI 04	Favourable	Favourable	Favourable	Favourable
Trend (if known):		n/a	n/a		n/a

LI05 Lough Corrib, E. of Lackavrea Hill, Co. Galway

Irish Grid ref.: 99362 249632; Altitude: 10m; SAC: 002008

Monitoring Period:	2013-2018	**Survey start date:**	14/10/2016	**No. of monitoring stops:**	3
Surveyed by:	OD/ML	**Survey end date:**	14/10/2016	**Survey type:**	Baseline

Comments on site:

Three relevés were recorded in the same locations as the baseline relevés by John Conaghan. The colonies occur along a stony shoreline on Lough Corrib. The habitat suitable for Lycopodiella inundata is a transitional flushed grassy wet heath (HH3) with Nardus stricta, Molinia caerulea, Erica tetralix, Carex panicea, Carex viridula subsp. oedocarpa, Potentilla erecta, Anagallis tenella and Drepanocladus revolvens. The previous survey noted that the species was recorded from three locations along the shoreline, corresponding to where the three relevés were recorded. During this survey an additional colony was recorded to the south.

Comments on condition/management:

Sheep dung was noted along the shoreline, with grazing intensity deemed to be low. Betula pubescens seedlings were noted wihin the habitat. These pose a potential threat, although it is unlikely that they can survive this close to the floodline. Therefore their influence was deemed to be neutral.

Other notes:

The species habitat is a thin band measuring 1.5-2m across. A stretch of approximately 320m of shoreline was searched, from the rocky wooded cliffs in the south to the stream/lake confluence in the north. Parts of the shoreline were very wet due to flushes coming off the hillside but L. inundata was not found in these locations, so it appears to prefer the drier parts of the shoreline that are less flushed.

Population assessment criteria

Mon. period	Site	Indicator description	Target	Result	Outcome	Notes
2013-2018	LI 05	Total number of Occupied Square Metres	>=4	5	Pass	
2013-2018	LI 05	Population extent (sq. metres)	>=369	461	Pass	
2013-2018	LI 05	Mean % cover of target species across all stops	>=11	12.5	Pass	
2013-2018	LI 05	Population size class	>=4 (501-1,000)	4 (501-1,000)	Pass	
2013-2018	LI 05	Fertile cones present	Fertile cones present	Fertile cones present	Pass	

Habitat for the species criteria

Mon. period	Site	Indicator description	Target	Result	Outcome	Notes
2013-2018	LI 05	Sward height (cm)	4-10	6.7	Pass	
2013-2018	LI 05	Mean % cover of Nardus stricta across all stops	<=35	31.7	Pass	
2013-2018	LI 05	Mean % cover of bare ground across all stops	3-20	5.7	Pass	
2013-2018	LI 05	Wetness of substrate	Ground damp to touch	Ground damp to touch	Pass	
2013-2018	LI 05	Impact of negative pressures	Low or absent	Low	Pass	

Impacts and activities

Mon. period	Site	Activity code / Description		Intensity	Effect	% Habitat affected	sq. m affected	Notes
2013-2018	LI 05	A04.02.02	Non-intensive sheep grazing	L	Neutral	100	461	
2013-2018	LI 05	K02.01	Species composition change (succession)	L	Neutral	70	323	

Parameter assessment results

Mon. period	Site	Population	Habitat for the species	Future prospects	Overall
2013-2018	LI 05	Favourable	Favourable	Favourable	Favourable
Trend (if known):		n/a	n/a		n/a