Conservation Objectives Supporting Document: Breeding Hen Harrier

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Cover Photograph:

Taken by **John Ballinger** at Mount Eagle, part of the Stack's to Mullaghareirk Mountains, West Limerick Hills and Mount Eagle SPA.

Contents

Glossary of Terms

Annex I	Under the EU Birds Directive 2009/147/EC (as Amended in 2009), a total of 194 species and sub-species are considered to be particularly threatened and included on Annex I of the Directive. Member States must designate Special Protection Areas for their survival and for all migratory bird species.
CMs	Conservation Measures – a series of measures required to maintain or restore the natural habitats and the populations of species of wild fauna and flora at a favourable status.
CO	Conservation Objective – a conservation objective is the specification of the overall target for the species and/or habitat types for which a site is designated in order for it to contribute to maintaining or reaching Favourable Conservation Status.
DAFM	Department of Agriculture, Food and the Marine
DHLGH	Department of Housing, Local Government and Heritage
EU	European Union
FCS	The maintenance of habitats and species within sites at favourable condition will contribute to the maintenance of Favourable Conservation Status (FCS) of those habitats and species at a national level.
FS DAFM	Forest Service, DAFM
HHP	Hen Harrier Project is an European Innovation Partnership, Locally Led Scheme funded by DAFM
HHTRP	Hen Harrier Threat Response Plan
Natura 2000	A network of core breeding and resting sites for rare and threatened species, and some rare natural habitat types. Please refer to the online viewer (https://natura2000.eea.europa.eu/#).
NHA	Natural Heritage Area
NPWS	National Parks & Wildlife Service
SAC	Special Area of Conservation
SPA	Special Protection Area
SSCO	Site Specific Conservation Objective – A site-specific conservation objective aims to define the favourable conservation condition of a habitat or species at site level.
UCC	University College Cork, National University of Ireland

1 Introduction

1.1 Hen harrier

The hen harrier (*Circus cyaneus*) is a territorial ground-nesting bird of prey, and, in Ireland, was considered fairly widespread in the mid-19th century, typically nesting in open upland habitats (Thompson, 1849 described in Watson, 1977). More recently, O'Donoghue (2004) described the modern landscape of breeding hen harrier in Ireland as upland (typically >100m above sea level) and dominated by pastoral-based livestock farming, with holdings often covered in rushes (*Juncus* spp.), bordered by hedgerows, peatland, scrub and commercial forestry of different age-classes.

The hen harrier is listed on Annex 1 of the Birds Directive (2009/147/EC)[1]. The 2015 national survey recorded the breeding population at 108–157 confirmed and confirmed/possible pairs and estimated a 9.7% decline in the total number of territorial pairs (*i.e.* confirmed/possible) over the previous 10 years (Ruddock *et al.*, 2016). Estimating historical changes in the national population with high levels of precision and accuracy is constrained by the level of evidence available prior to the first national breeding survey of 1998 – 2001 by Norriss *et al.* (2002). Informed by the first breeding bird atlas (Sharrock, 1976), the most recent Birds Directive Article 12 assessment estimated a national population decline of 28.6% since 1972 (NPWS, 2019).

Since the 1950s, the extensive afforestation of uplands in Ireland has resulted in widespread changes to the traditional breeding grounds of hen harrier (Wilson *et al*., 2012a; NPWS, 2015a). The national population was considered to be at a low ebb in the early 20th century, with few breeding pairs (O'Flynn, 1983). Widespread persecution was considered to be largely responsible for the decline in the late 19th century, with targeting of hen harrier, 'the enemy of red grouse' (*Lagopus lagopus*), by sport hunters, gamekeepers and collectors (Thompson, 1849 in Watson, 1977). From the 1950s onwards, a population recovery began, climbing to an estimated 75 breeding pairs by 1964 (Hutchinson, 1989) and to a purported 200 – 300 pairs on the island of Ireland by the early to mid-1970s (Sharrock, 1976; D. Scott *in litt.* in Watson, 1976). The all-Ireland estimate of 200-300 pairs of the first breeding bird atlas 1968-72 (Sharrock, 1976) was derived using an approximation of two nests for every 10km square that had records of hen harrier (Gibbons *et al.*, 1993). The criteria used by these atlases to determine evidence of possible breeding, in particular, were less rigorous than the equivalent criteria set out by the national hen harrier surveys that followed (*e.g.* Ruddock *et al*., 2016). O'Flynn (1983) considered that Ireland's afforestation had aided the recovery of the harrier population in the 1950s and 1960s. Yet he also considered the maturation of the forest estate, along with the clearance of marginal land for agricultural intensification, to be the primary driver of the hen

[1] The Birds Directive 2009/147/EC of the European Parliament and of the Council on the conservation of wild birds.

harrier population decline of the late 1970s (NPWS, 2015a), totalling just 70 pairs by 1982 (Clark & Watson, 1990). Subsequently, the second breeding bird atlas of 1988-91 (Gibbons *et al*., 1993) derived an all-Ireland estimate of 180 pairs, extrapolated using species-specific survey data from mainland Britain.

Today, heath, bog, less-intensively farmed grassland with well-established hedgerows and areas of scrub that support preferred prey species, including meadow pipit (*Anthus pratensis*) and skylark (*Alauda arvensis*) (O'Donoghue, 2004, 2010; Barton *et al*., 2006; Irwin *et al*., 2012), are the main non-forested habitats used by foraging harriers in Ireland's uplands (Irwin *et al*., 2012). Meadow pipit is now red-listed and skylark is amber-listed on the latest Birds of Conservation Concern in Ireland (Gilbert *et al*., 2021). Forested habitats used by harriers include **pre-thicket forest habitats,** *i.e.* those that have yet to develop a closed canopy, are generally < 5 m in height and are up to 12 years old, as defined in Wilson *et al*. (2009); Wilson *et al.* (2012a); Ruddock *et al.* (2016) and Carravaggi *et al*. (2020). This habitat is known to be one of the most utilised for nesting by harriers, as described in Norris *et al*. (2002), Barton *et al*. (2006), Ruddock *et al*. (2012) and Ruddock *et al*. (2016).

1.2 Pressures acting on the population

A number of landscape-scale changes have altered the availability and quality of habitats in the hen harrier's traditional breeding range, since its 10 km distribution was first mapped in the Breeding Bird Atlas of 1968-72 (Sharrock, 1976). A wide suite of anthropogenic pressures impact negatively upon this species and its habitats within its breeding range (NPWS, 2019; Caravaggi *et al*., 2019a). These pressures include activities connected with forestry, agriculture, and wind energy developments as well as associated land-use pressures, including removal of hedges, copses and scrub, predation by mammals and birds, human intrusions and recreation (off-road driving, walking, horse-riding and cycling), and mechanical removal of peat (Caravaggi *et al*., 2019a). Those currently considered to be of most significance to the conservation of hen harrier in Ireland are linked to forestry, agriculture and wind energy developments and so these are the primary focus of the *Hen Harrier Threat Response Plan* (HHTRP). Further information on these pressures and interactions with the hen harrier are set out in the following reports:

- *Hen harrier conservation and the forestry sector in Ireland (NPWS, 2015a)*
- *Hen harrier conservation and the agricultural sector in Ireland (NPWS, 2015b)*
- *Hen harrier conservation and the wind energy sector in Ireland (NPWS, in prep.).*

As part of reporting obligations, Ireland provides relevant updates to the EU Commission every six years. The most recent update by Ireland in 2019 set out the pressures (and future threats) considered most relevant to hen harrier conservation and included those related to the agriculture, forestry and wind energy sectors. This update also highlighted the potential implications of changes to our climate on hen harrier breeding success, particularly with respect to likely changes to weather (*i.e.* more climatic instability such as wetter springs and

drier summers) and climate-modelled predictions of contractions in range of preferred prey species (*e.g*. meadow pipit, Renwick *et al*., 2012).

The traditional habitat of the hen harrier is open heath and bog, with areas of low-intensity farmed grassland also favoured. Ireland had less than one percent forest cover in 1900, but the *Forestry Act* of 1928 lead to a sustained afforestation State-led programme that increased forest cover dramatically from the 1950s to the mid-1980s, when private-led, grant-aided afforestation began (DAFM, 2020). At present, 11% of the national land resource is under forestry (DAFM, 2020). This State-led afforestation programme supported an increasing number of hen harrier, as availability of small mammals and birds increased with the extensive planting of conifers (Watson, 1977). However, pre-thicket forest (depending on the species involved and its soil productivity category) is only useful to nesting harriers for approximately 6 to 10 years of investment cycles of 40 + years (NPWS, 2015a). With forest maturation, clear felling and replanting, it is now largely second-rotation pre-thicket forestry that is available to hen harrier. High cover of this habitat in the surrounding landscape has been linked with low levels of breeding success (Wilson *et al.,* 2012a).

During the SPA selection process, Wilson *et al.* (2006) predicted that the carrying capacity of nine Important Areas (IAs) for hen harrier would likely decrease, in the order of 30% by 2015, with maturation of the forest estate. Wilson *et al.* (2006) also predicted that the impact of forest maturation on the hen harrier population could be more severe, as second rotation habitat is of lower quality than first rotation. Subsequently, Ruddock *et al.* (2016) recorded a decline in numbers of territorial pairs by almost 27% in the SPAs between 2005 and 2015.

The planting of conifers into traditional hen harrier habitat that would previously have occurred in large, contiguous expanses (Wilson *et al.,* 2012b) has also led to habitat fragmentation. The resulting increase in 'edge' habitat between traditional habitats and forestry is likely to increase the vulnerability of ground-nesting birds, such as hen harrier, to predation by animals associated with forestry *e.g.* red fox (*Vulples vulpes*), pine marten (*Martes martes*) and corvids (*Corvidae*) (*e.g.* Thompson *et al*., 1998; Monaghan, NPWS unpublished reports 2010-2016; O'Donoghue, 2010; Irwin *et al*., 2011; Wilson *et al*., 2014; Hancock *et al*., 2020; Sheridan *et al.,* 2020). The potential negative consequences of such habitat fragmentation, particularly on a ground-nesting bird such as the hen harrier, include a significant effect on nest site selection, breeding success and productivity (Wilson *et al.,* 2012a; Sheridan *et al.,* 2020). As detailed in NPWS (2015a) and Caravaggi *et al*. (2020), forestry-related impacts on hen harrier can be caused by afforestation and forest replanting, thinning of tree-layer, modification of water levels or bodies, forestry fertilisation, predation by birds and mammals, and human intrusions.

Wilson *et al.* (2006) highlighted that agricultural intensification likely had "*a real and pronounced negative effect on the value of land to hen harriers*". Habitat loss, fragmentation, and

degradation due to changing agricultural practices[2] have significantly reduced the availability and quality of unenclosed heath, bog and open grazed wet grassland habitats in areas important for breeding hen harrier in Ireland (NPWS, 2015b).

There is considerable overlap between the breeding range of hen harrier and the upland areas in which wind energy development has occurred in Ireland. The "WindHarrier" project, carried out by University College Cork (UCC), examined a range of potential impacts of these developments on hen harrier (Wilson *et al.*, 2015). The study showed that bird densities were lower at wind energy development sites than at control sites, and at wind energy development sites, densities were lower closer to turbines than further away. This shows possible indirect negative effects from wind energy development on hen harrier prey species. Further research by UCC (Fernández-Bellon *et al*., 2015) observed lower nest success within one kilometre of wind turbines, compared to the success of all nests more than one kilometre from wind turbines. While the relationship was close to, but not of, statistical significance, the authors nonetheless considered it to be of biological relevance, given the challenges in carrying out field-based research on a widely-dispersed and uncommon species with sufficient statistical power to detect significant changes.

1.3 SPAs for hen harrier

Six breeding hen harrier sites were designated as Special Protection Areas (SPAs) in accordance with the Birds Directive[3] (see Table 1-1 and Figure 1-1). Totalling 167,225 ha, these sites are largely made up of mosaics of blanket bog, heath, semi-improved pasture (including rushy fields, scattered gorse and scrub, and hedgerows) and conifer plantations. The extents, but not condition, of these broad habitat types, as determined by Moran & Wilson-Parr (2015) in the *Hen Harrier Special Protection Area (SPA) Habitat Mapping Project 2014*), is provided in Section 3. In the first two national surveys (Norriss *et al*., 2002; Barton *et al*., 2006), the majority of recorded nests were located in pre-thicket forestry, which is also an important foraging resource for the hen harrier. At the time, core foraging areas of pairs in Ireland were recognised as extending further than had been previously shown by radio-tracking research in Scotland (Arroyo *et al*., 2006). The more fragmented mosaic of usable habitats in the Irish landscape, together with the dependence of the hen harrier on pre-thicket plantation at the time, resulted in larger foraging areas. Pre-thicket forestry is a transitional, rather than climax, phase in the overall forestry growth cycle. Forestry plantations were expected to move through their growth, clear-felling and replanting cycle over time. Therefore, all forestry age cohorts were included in the SPAs so that a pre-thicket forest resource would persist within each SPA into the future. Improved grassland, larger lakes and the majority of buildings and

[2] Agricultural practices such as intensification, increased grazing pressure, scrub clearance, agricultural burning or abandonment.

[3] The Habitats and Birds Directives are transposed in Ireland by the EUROPEAN COMMUNITIES (BIRDS AND NATURAL HABITATS) REGULATIONS 2011-2021, *inter alia*.

farmyards were largely excluded from the SPAs. The SPAs straddle nine counties. Slieve Beagh SPA, the smallest in area, adjoins Northern Ireland's Slieve Beagh-Mullaghfad-Lisnaskea SPA, which also lists hen harrier as a conservation interest. Furthermore, four of the hen harrier SPAs overlap (in whole/part) with Special Areas of Conservation (SAC), as designated under the EU Habitats Directive 1992/43/EEC[4], with separate Conservation Objectives for SACs also published.

Table 1-1. Special Protection Areas (SPAs) for breeding hen harrier in Ireland.

Site Code	Site Name	Area (ha)	Date of Public Notification	Statutory Instrument (S.I.)	Date of S.I.
004167	Slieve Beagh SPA	3,457	05/11/2007	617 of 2011	29/11/2011
004160	Slieve Bloom Mountains SPA	21,784	05/11/2007	184 of 2012	29/05/2012
004168	Slieve Aughty Mountains SPA	59,482	05/11/2007	83 of 2012	21/03/2012
004165	Slievefelim to Silvermines Mountains SPA	20,922	05/11/2007	587 of 2011	15/11/2011
004161	Stack's to Mullaghareirk Mountains, West Limerick Hills and Mount Eagle SPA	56,673	05/11/2007	591 of 2012	23/11/2012
004162	Mullaghanish to Musheramore Mountains SPA	4,978	05/11/2007	627 of 2011	23/11/2012

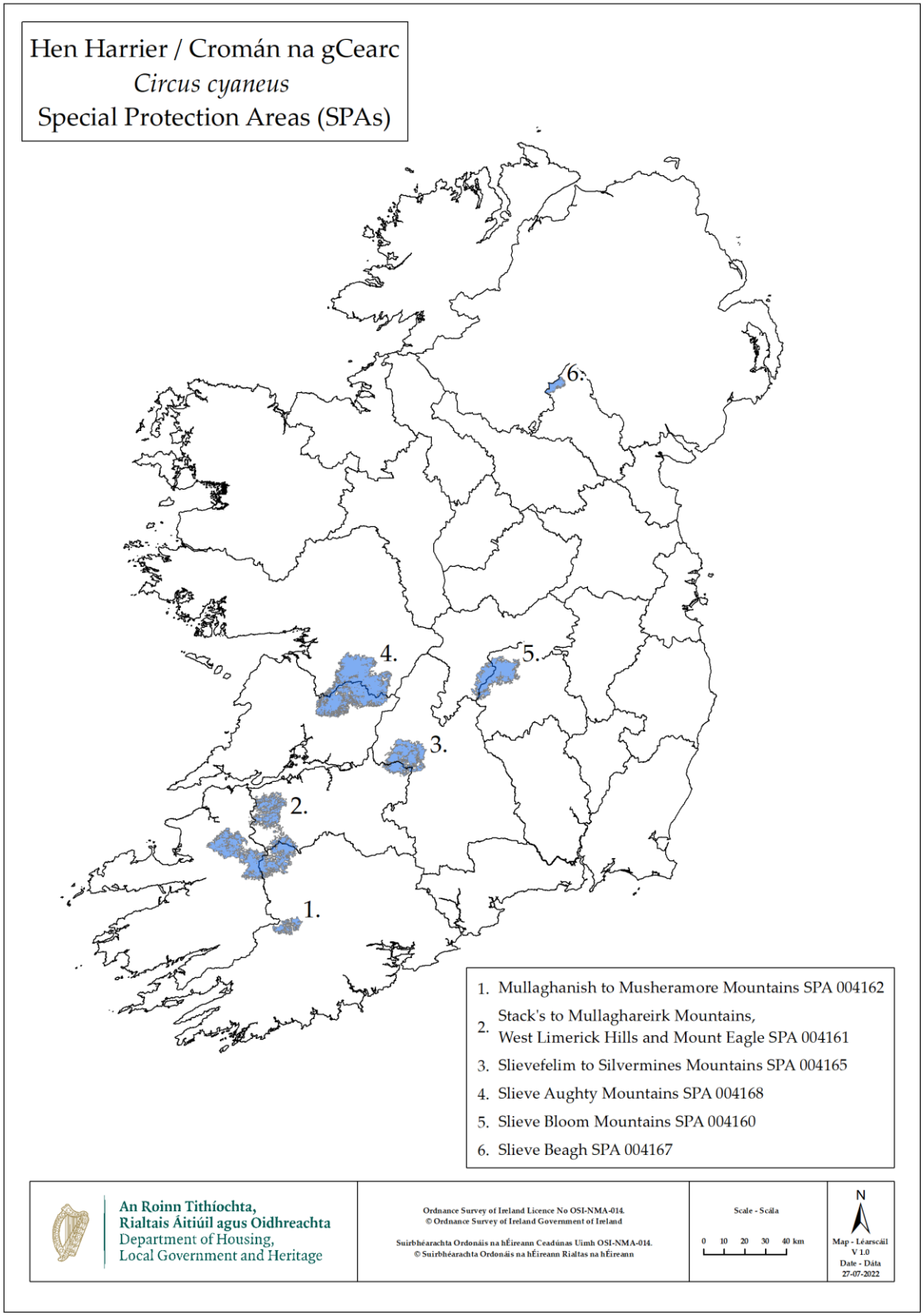

Figure 1-1. The Irish SPA network for breeding hen harrier.

Boundaries for each SPA can be viewed on the NPWS Protected Site map-viewer https://dahg.maps.arcgis.com/apps/webappviewer/index.html?id=8f7060450de3485fa1c1085536d477ba, with boundary data also available to download from https://www.npws.ie/maps-and-data; full descriptions of each site are available from https://www.npws.ie/protected-sites/spa.

1.4 Conservation objectives

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

Conservation objectives are defined using attributes and targets that are based on parameters set out in the Habitats Directive[4] for defining favourable status, namely population, range, and habitat for the species. Attributes should not be considered in isolation from the others listed. Attributes and targets may change and become more refined as further information becomes available.

The conservation objective for breeding hen harrier is framed by attributes with targets that are necessary for the restoration of the species within the SPA network. This, in turn, informs the setting of targets for each of the six SPAs.

It is important to acknowledge that, despite the significant progress made in recent years in understanding hen harrier ecology, the knowledge-base is not yet complete and the species' interactions with the landscape are complex. As such, it has not been possible, when setting these Conservation Objectives, to always provide precise numerical targets that must be met in order to achieve the restoration of the species to favourable conservation condition (at the site level) or status (at the network level). In those cases where scientific uncertainty or knowledge gaps remain, target ranges are employed and explained to assist the user in their application. Efforts will continue, primarily through the mechanism of the Threat Response Plan, to address the outstanding questions concerning hen harrier ecology and to inform the future refinement of these Conservation Objectives and the conservation measures necessary to support its restoration.

1.5 Conservation measures

Conservation measures have been described by the European Commission as "the actual mechanisms and actions to be put in place for a Natura 2000 site with the aim of achieving the site's conservation objectives". A range of conservation measures are required in order to achieve the conservation objectives for the individual SPAs and the SPA network, as a whole. While conservation objectives and measures are clearly interconnected, they are also distinct

[4] The Habitats Directive 1992/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora.

from each other. This document concerns the conservation objectives for hen harrier; the *Hen Harrier Threat Response Plan* is designed to address the primary threats that have been identified as contributing to the decline of the species and will set out the requisite conservation measures, based on the best available scientific information.

2 Demographics and range attributes

As set out in the introduction, the pressures that are currently considered to be of most relevance to the conservation of hen harrier in Ireland are linked to forestry, agriculture and wind energy developments (NPWS, 2015a; NPWS, 2015b; NPWS, in prep.). The targets for each of the demographics and range attributes are described in this section, *i.e*. population size, productivity and spatial utilisation of the SPAs by breeding pairs. Although these targets are described separately here, they are also intrinsically linked with attributes relating to supporting habitats and disturbance. Further details on the direct and indirect effects of these land uses and types of disturbance on hen harrier are described later in this document in more detail. However, such effects, if significant, will drive changes over time to the size, productivity and spatial utilisation of the SPA's breeding population.

2.1 Population size

There have, so far, been four national surveys of breeding hen harrier, carried out in 1998–2001[5] (Norris *et al.,* 2002); in 2005 (Barton *et al.,* 2006); in 2010 (Ruddock *et al.,* 2012); and in 2015 (Ruddock *et al.,* 2016). The aims of the national surveys are to quantify the size and distribution of the breeding population and, since 2005, to report changes that have occurred from previous surveys. It is important to note that, when assessing estimates of breeding population size through time, survey effort increased with each subsequent national survey (see Figure 3 of Ruddock *et al.,* 2016 and reproduced as Figure 1 in Appendix 1).

A number of parameters could be used to estimate breeding hen harrier populations, including numbers of breeding females, numbers of territories or numbers of confirmed, or confirmed and possible, pairs. For the purposes of setting a conservation objective for the SPAs, the attribute 'confirmed pair' has been chosen as the most appropriate and includes only those breeding pairs that successfully attempt to breed (*i.e.* proven). Note, some territories may be occupied early in the season by pairs or single birds displaying (*i.e.* possibles), or in possible suitable breeding habitat or they may be observed visiting known sites once, but they may or may not attempt to breed. The criteria used to define a 'confirmed pair' (also referred to as 'confirmed territorial pair' by Barton *et al.,* 2006) are outlined in Barton *et al.* 2006 (and subsequently Ruddock *et al.,* 2012 and Ruddock *et al.,* 2016) and reproduced in Table 2-A in Appendix 2.

[5] The first national survey was undertaken in 1998–1999, with additional fieldwork undertaken in 2000 and 2001 to provide additional coverage for some sites (Norriss *et al*., 2002). This survey is referred to as the 2000 national survey here.

Table 2-1. Estimated numbers of confirmed breeding pairs of hen harrier within the SPAs.

	National Surveys				Annual Monitoring				
Site	**2000**	**2005**	**2010**	**2015**	**2017**	**2018**	**2019**	**2020**	**Mean ± SD**
Slieve Beagh SPA	3	4	4	3	3	5	3	2	3.3 ± 1.1
Slieve Bloom Mountains SPA	10	5	9	12	10	10	10	10	10 ± 0.0
Slieve Aughty Mountains SPA	14	24	15	8	9	6	6	6	6.8 ± 1.3
Slievefelim to Silvermines Mountains SPA	8	4	6	4	7	8	7	5	6.8 ± 1.1
Stack's to Mullaghareirk Mountains, West Limerick and Mount Eagle SPA	39	38	19	23	27	22	28	30	26.8 ± 2.9
Mullaghanish to Musheramore Mountains SPA	3	3	2	1	2	2	2	5	2.8 ± 1.3
SPA Network Total	**77**	**78**	**55**	**51**	**58**	**53**	**56**	**58**	**56.3 ± 2.0**

Note 1 - Data sources include Norriss *et al*. (2002); Barton *et al*. (2006); Ruddock *et al*. (2012); Ruddock *et al*. (2016); and *Hen Harrier Project* annual reports available at henharrierproject.ie and include: *Hen Harrier Programme – Hen Harrier Monitoring 2020*; *Hen Harrier Programme – Hen Harrier Monitoring 2019*; *Hen Harrier Programme – Hen Harrier Monitoring 2018*; *Hen Harrier Programme – Hen Harrier Monitoring 2017*. Full details provided in References (See Section 6).

Table 2-1 sets out the numbers of confirmed breeding pairs in the six SPAs, informed by the four national surveys and the more recent monitoring data (2017 – 2020) from the Hen Harrier Project[6] (referred to as HHP in this document). The figures have been compiled for those confirmed pairs located inside the defined boundaries of the SPAs, using ArcGIS 10.8, and corroborated by original location details, *i.e.* townland names, provided. Thus, they may differ from previous totals published, *i.e*. SPAs are smaller, and boundaries differ, than those sites reported out in Norris *et al*. (2002) and Barton *et al*. (2006). For the 2000 and 2005 national surveys, the level of confidence in the precision at which locations of confirmed breeding pairs were recorded is lower than for subsequent surveys. Thus, for the first two national surveys, all records whose grid references lie over apparently unsuitable habitat, but within 75m of an SPA boundary, were moved to the nearest likely suitable nesting habitat inside the boundary

[6] The Hen Harrier Project EIP (2017–2022), funded by the Department of Agriculture, Food and the Marine (DAFM) under the European Innovation Partnership (EIP) for Agriculture Productivity and Sustainability (EIP-AGRI), is a results-based, locally-led scheme that has built strong partnerships with farmers and offers participants additional opportunities to earn an income from their land. The HHP specifically targets farmers with land in the six hen harrier SPAs to develop an effective model for the sustainable management of lands critical for breeding hen harrier.

and included in the overall population figures presented in Table 2-1. This has resulted in an increase in the SPA network population of four additional pairs in 2000, three in the Stack's to Mullaghareirk Mountains, West Limerick and Mount Eagle SPA and one in the Mullaghanish to Musheramore Mountains SPA. One additional pair for Mullaghanish to Musheramore Mountains SPA was included in 2005.

As shown in Table 2-1, the SPA network population has been in decline since 2005, with total numbers of confirmed pairs falling by almost 27% since then. There is significant variation in population trends at the site level, with the largest SPA in terms of area, the Slieve Aughties SPA, showing the greatest overall decline in numbers of confirmed breeding pairs (at 72%) compared to Mullaghanish to Musheramore SPA which has seen a recovery in total numbers within the SPA. Furthermore, the inter-annual variation at both the site and network level is noteworthy.

Known causes of mortality of adult breeding hen harrier include natural causes, collision with wind turbines (NPWS, in prep.; O'Donoghue *et al*., 2020) and deliberate persecution (O'Donoghue *et al*., 2020).

With regard to the setting of targets for this attribute, *i.e.* 'total numbers of confirmed pairs,' for each SPA, the lower and upper banded target values for each site have been informed by the first two national surveys. The choice of banded figures as reference values is due to the absence of annual monitoring for the network of SPAs prior to site selection and subsequent designation. More nuanced comparisons with contemporary population estimates can be made using this banded approach, rather than by using single-year reference figures, which would potentially lead to more erroneous assessment of population trends.

If the estimated population of the site lies within the banded target given for this attribute, it is considered to be 'favourable-adequate' for that site. Sites where total numbers exceed the banded target and are still increasing would be considered to be 'favourable-increasing'. Collectively, for the hen harrier SPA network, the target for achieving 'favourable-adequate' status is at least 77 confirmed pairs (Table 2-1). For the period 2017-2020, the SPA network is not meeting this target.

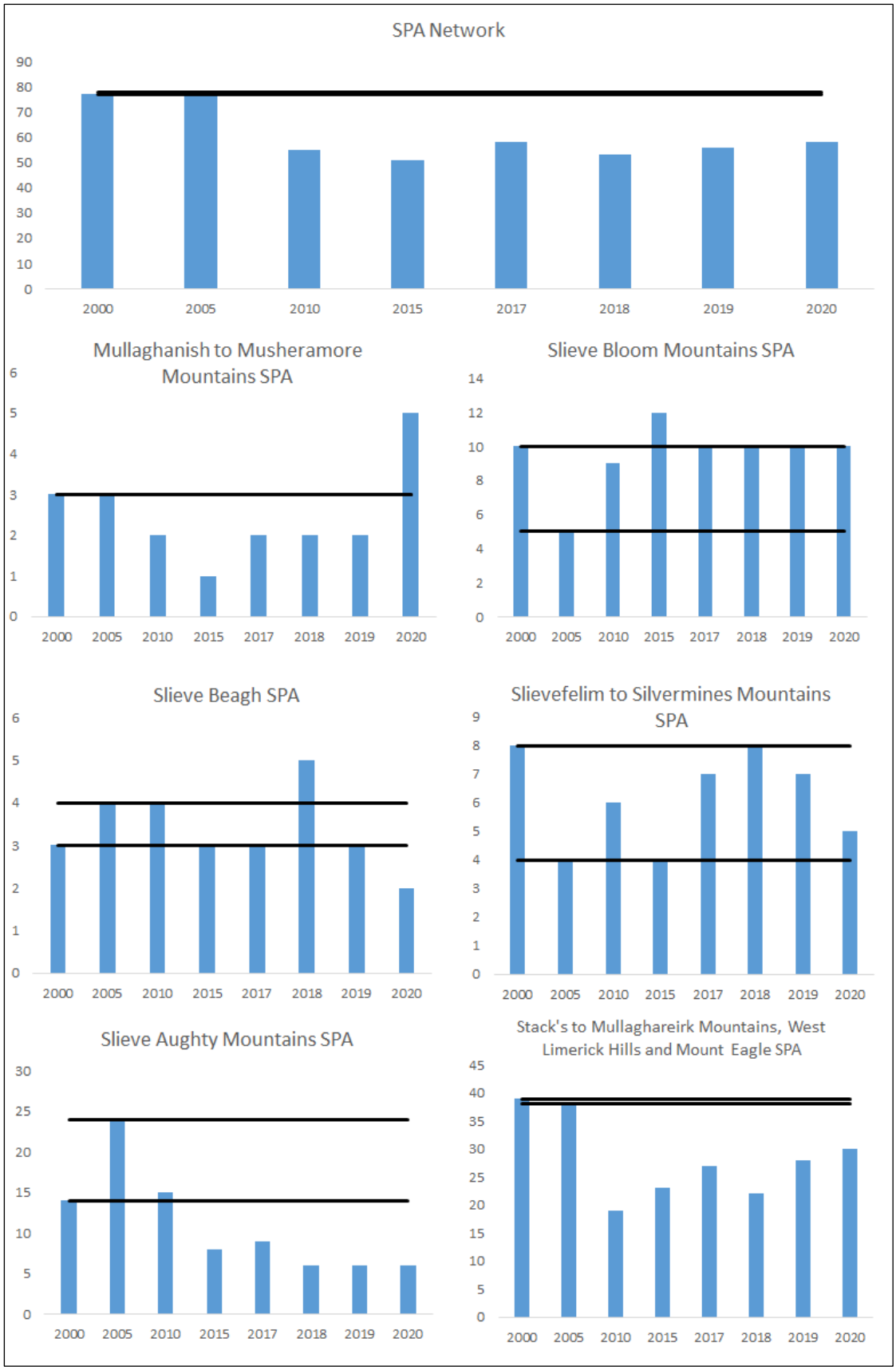

Figure 2-1. Numbers of confirmed pairs recorded at the six hen harrier SPAs and at the overall SPA network level through time. The black bands represent upper and lower target values informed by the first two national surveys.

The target for the attribute 'population size' is to restore the numbers of confirmed pairs for the hen harrier SPA network, informed by the review of national survey data for 2000 and 2005 (presented in Table 2-1 and Figure 2-1 above). In addition to the overall network target for this attribute, targets for each SPA are set out in Table 2-2 below.

*The SPA network **Target** for the attribute 'population size' is to restore the numbers of confirmed breeding pairs to at least 77 – 78 confirmed breeding pairs.*

Table 2-2. SPA targets for the attribute 'numbers of confirmed pairs'.

Site Code	Site Name	Target
004167	Slieve Beagh SPA	Maintain numbers at or above 3–4 confirmed breeding pairs
004160	Slieve Bloom Mountains SPA	Maintain numbers at or above 5–10 confirmed breeding pairs
004168	Slieve Aughty Mountains SPA	Restore the numbers of confirmed breeding pairs to at least 14–24 confirmed breeding pairs
004165	Slievefelim to Silvermines Mountains SPA	Maintain numbers at or above 4–8 confirmed breeding pairs
004161	Stack's to Mullaghareirk Mountains, West Limerick Hills and Mount Eagle SPA	Restore the numbers of confirmed breeding pairs to at least 38–39 confirmed breeding pairs
004162	Mullaghanish to Musheramore Mountains SPA	Maintain numbers at or above 3 confirmed breeding pairs

2.2 Productivity rate

Breeding success was not comprehensively estimated for the SPAs in the first two national surveys (Norriss *et al.*, 2002; Barton *et al.*, 2006). Since the 2010 national survey, a standardised presentation of data on productivity has been reported out for the six SPAs (separate and combined) and also for areas outside of the network (Ruddock *et al.*, 2012, 2016). Alongside the national surveys, a number of specific research and monitoring projects targeting other known hen harrier breeding areas have contributed to the national picture:

- Slieve Aughty Mountains SPA - monitoring 2004–05 (Duff, 2004; Oliver, 2005; unpublished reports for NPWS)
- Slieve Aughty Mountains SPA, West Clare, Kerry, Ballyhouras – monitoring 2007–2011 (UCC research including O'Donoghue, 2010; Irwin *et al.*, 2011; Wilson *et al.*, 2012a)
- Slieve Bloom Mountains SPA monitoring 2010–2016 (Monaghan, 2010–2017, unpublished NPWS reports – see summary data Table 3-A, Appendix 3)

- Mullagahareirks 2015–2019 - EU Nature RaptorLIFE project (2015-2019) (Mee, 2019)
- SPA Network (all sites) 2017–2020 (HHP).

For the purposes of the conservation objective, the 'productivity rate' attribute equates to the number of fledged young per confirmed breeding pair (after Barton *et al.,* 2006, Ruddock *et al.*, 2012, 2016; and HHP, 2020a).

The average productivity for the hen harrier SPA network for the period 2017–2020 is 1.17 (± 0.3 SD) young fledged per confirmed pair (Table 2-2). This is very similar to the 2015 national survey estimate of 1.09 given in Ruddock *et al.* (2016). It is clear from monitoring by the HHP across the SPAs, and from previous annual monitoring datasets (including Wilson *et al*., 2006), that productivity rates can vary significantly, both year on year and from site to site. For example, annual productivity monitoring in the Slieve Bloom Mountains SPA between 2010–2016 (Monaghan, unpublished NPWS reports) recorded a mean productivity rate of 1.2 but with significant inter-annual variation (range 0.4–2.1). Despite this variability, the number of confirmed breeding pairs for that site remained at 9 to 12 pairs for the period 2010-2020 (Table 2-1). As set out in Table 2-2 below, the mean productivity for the Slieve Bloom Mountains SPA is 1.0 (± 0.6 SD); this is marginally lower than the previous multi-year estimate and is the highest of the six SPAs for the period 2017–2020.

Wilson *et al.* (2012a) monitored four study sites (Slieve Aughties, West Clare, Kerry, Ballyhouras) for three years (2007 – 2009) and estimated the productivity rate at 1.5 (± 0.1 SD, range 0.40–2.5). Using a longer but overlapping time-series (2007–2011) for the Slieve Aughties, West Clare and the Ballyhouras, Irwin *et al.* (2011) monitored breeding productivity as the average number fledged across all nests at 1.4 (+/-0.3 SE) for 142 nests monitored; again, variation (1.0–1.9) was recorded across sites.

The Slieve Aughty Mountains SPA has the longest time-series of productivity data for any SPA (Oliver, 2005; O'Donoghue, 2010; Wilson *et al.,* 2012a; HHP monitoring 2017–2020) with the number of fledged young per confirmed breeding pair regularly well below 1.0 since the mid-2000s. The number of confirmed breeding pairs has fallen by 57% since 2000.

Evidence suggests, for some sites at least, that the numbers of young fledged in any given year is highly variable. Assigning proximate and ultimate causes to particular productivity rates remains a challenge. However, for some SPAs at least, the HHP (2020a) identifies likely contributing factors to include habitat quality, weather effects (*i.e.* cold wet springs, summer heat-waves), large wildfires, human disturbance and predation. Impacts on the overall productivity of breeding pairs may occur as a result of increased disturbance or predation (*e.g.* in second rotation pre-thicket forestry (Wilson *et al*., 2012a), increased predation of nest sites on heath and bog proximate to forest edge habitats (Sheridan *et al*., 2020), and/or via reduced prey-availability due to nesting-site choices (*e.g*. in second rotation pre-thicket or near wind turbines (Wilson *et al*., 2015; Fernandez-Bellon *et al*., 2015)). These are more fully described in the sections to follow.

Based on the 2015 national survey, the most contemporary estimate of productivity for the breeding population outside of the SPA network is 0.81 fledged young per confirmed breeding pair. This is marginally lower than the 2015 SPA network productivity estimate of 0.94 fledged young per confirmed pair (Ruddock *et al.*, 2016).

Table 2-3. Estimated hen harrier productivity rates 2017 – 2020 per SPA and for the overall SPA network.

	Annual Monitoring				
Site	**2017**	**2018**	**2019**	**2020**	**Mean ± SD**
Mullaghanish to Musheramore Mountains SPA	1.0	2.0	1.0	2.0	1.5 ± 0.5
Slieve Bloom Mountains SPA	1.6	0.5	1.6	0.3	1.0 ± 0.6
Slieve Beagh SPA	0.7	2.0	1.3	2.5	1.6 ± 0.7
Slievefelim to Silvermines Mountains SPA	0.9	0.5	0.1	0.6	0.5 ± 0.3
Slieve Aughty Mountains SPA	0.4	0.5	1.2	1.0	0.8 ± 0.3
Stacks to Mullaghareirks, West Limerick Hills and Mount Eagle SPA	1.2	0.6	1.82	1.1	1.2 ± 0.4
SPA network Total	**1.1**	**0.7**	**1.5**	**1.0**	**1.1 ± 0.3**

Please note the productivity data presented in the Table 2-3 above is based on data available at the time the SSCOs were being developed, and it is intended that the information presented in Table 2-3 will be updated in due course (*i.e.* to include 2022 National Hen Harrier Survey data) as set out in the *Hen Harrier Threat Response Plan*.

Figure 2-2. Estimated productivity rates (number of fledged young per confirmed pair) for the six hen harrier SPAs and for the SPA network, 2017 - 2020. The black bands represent upper and lower thresholds.

In Britain, productivity has also shown site, regional and annual variation (*e.g.* Etheridge *et al.*, 1997; Whitfield *et al.*, 2008; Whitfield & Fielding, 2009; Fielding *et al.*, 2011; Baines & Richardson, 2013; Challis *et al.*, 2019, 2020). Population modelling using empirical data from 14 hen harrier populations across defined Natural Heritage Zones (NHZ) in Scotland showed that "*populations should expand as long as the mean number of young fledged per pair is about one"* (Fielding *et al.*, 2011). Sim *et al.* (2007) noted that for many raptor populations, a proportion does not attempt to breed in any one year, often due to a lack of suitable nest sites or prey availability. However, this proportion is difficult to measure as non-breeding birds are likely to be more mobile than breeding birds, moving between areas to exploit temporarily abundant food sources (Newton, 1979).

Knowledge of hen harrier movements, *i.e.* juveniles post-fledging, adults post-breeding, and survival of juveniles and adults, is growing (Mee, 2019; O'Donoghue, 2010; 2021; McCarthy, 2022a). The survival of first-year birds[7], particularly males, is low (O'Donoghue, 2010; McCarthy 2022a); with levels of recruitment success of young birds into the adult breeding population also considered low, as informed by information gained from 31 Irish satellite-tagged individuals (McCarthy, 2022a). The age-profile of the breeding population is not known. The setting of a necessary threshold of productivity to ensure a stable or increasing population in a given area (site, region, national) depends upon the availability of robust estimates of rates of post-fledging survival, adult survival, immigration and emigration. The construction of population models to establish such thresholds is constrained by a lack of comprehensive Irish data.

In Wales, the mean number of fledglings per breeding attempt has been estimated at 1.42 (Whitfield *et al.*, 2008), using productivity data from nest visits during the period 1986–2004. The methods for this study included a strict standard of evidence for breeding, *i.e.* a higher standard of proof of breeding than that used in the United Kingdom national surveys (*e.g.* Sim *et al.*, 2007). This higher standard broadly overlapped with criteria regarding evidence of confirmed breeding as used in Ruddock *et al.* (2016), although the Welsh study did include data from replacement clutches. Whitfield & Fielding (2009), therefore, after correcting for replacements, recommended a minimum productivity target of '*1.2 young fledged per pair occupying a territory*' for the Welsh hen harrier population. Subsequently, Fielding *et al.* (2011), using population estimates and survival rates of birds from throughout the UK, stated that populations there '*should expand as long as the mean number of young fledged per pair is about one*' but concurred with Whitfield & Fielding (2009) in setting out a productivity threshold for '*favourable conservation status*' of at least 1.2 fledged young per breeding attempt. Survival rates of female harriers in Wales (at 0.362 for first-years, 0.774 for adults), estimated by Whitfield & Fielding (2009), were used. Yet a target of 'at least one fledged young per nest' was used to define Conservation Objectives for SPAs in Wales (*e.g.* Migneint-Arenig-Dduallt SAC/SPA, Evans et al., 2008); and no specific target or attribute for productivity was defined for example

[7] First-year - age category referring to the entire first year of life, from the first summer to the following.

in the Conservation Objectives for Bowland Fells SPA or South Pennine Moors SPA in England (Natural England, 2019a; 2019b). Measures of productivity and methods for determining productivity (*e.g.* where nest visits during the breeding season have been carried out) can vary across studies and this can lead to uncertainty, hindering like-for-like comparisons. To facilitate a more consistent approach in measuring breeding productivity for and across the SPAs in Ireland, numbers of 'fledged young per confirmed breeding pair' is being used to inform the assessment of the network's conservation status and a site's conservation condition.

A banded threshold of 1.0–1.4 young per confirmed breeding pair is defined for this attribute for the Irish SPA network and for each site. The use of a banded approach helps to frame some of the uncertainty outlined above, that would not be reflected by the use of a more precise threshold. This also takes into consideration the observed first-year survival rate, estimated at 0.25, of 18 female[8] harriers satellite-tagged as nestlings in Ireland between 2009–2019 (McCarthy, 2022a). These figures compare unfavourably with UK first-year female survival rate figures, *e.g.* at 0.361 for 592 nestlings wing-tagged on non-grouse moors (Etheridge *et al*., 1997) and at 0.362 for 35[9] nestlings wing-tagged in Wales (by Whitfield & Fielding (2009), that were used to inform the productivity threshold defined by Fielding *et al*., (2011). The upper figure of 1.4 largely coincides with that from Whitfield *et al*. (2008) which refers to the average productivity for the Welsh population, as determined from a long time-series of data (1986–2004), which was stable and/or increasing throughout.

If the population size of the SPA is not favourable, *i.e.* Slieve Aughty Mountains SPA and Stack's to Mullaghareirk Mountains, West Limerick Hills and Mount Eagle SPA, then the upper end of this productivity rate range should be sought, at least. In order for estimates to be sufficiently representative of the SPA, they need to be of sufficient sample size and ideally over multiple years in order to account for inter-annual variability.

The 2017–2020 mean for the overall SPA network, at 1.07 ± 0.4 SD, is just above the minimum threshold of 1.0. However, it is evident that, although collectively the six SPAs have met the minimum threshold for this attribute in three of the four years sampled, two of the six SPAs are not meeting the minimum requirements (See Table 2-3). The SPA network target for the attribute 'productivity rate' is set out below with the targets for each SPA detailed in Table 2-4.

*The SPA network **Target** for the 'productivity rate' is at least 1.0–1.4 fledged young per confirmed pair.*

[8] It was not possible to calculate first-year survival for males due to satellite-tag failures (McCarthy, 2022a).

[9] The Welsh population study by Whitfield & Fielding (2009) included four resightings of tagged females that were included as first-year resighted birds to derive the 0.362 first-year female survival figure presented above.

Table 2-4. SPA targets for the attribute 'productivity rate'.

Site Code	Site Name	Target
004167	Slieve Beagh SPA	Maintain at least 1.0 – 1.4 fledged young per confirmed pair.
004160	Slieve Bloom Mountains SPA	Maintain at least 1.0 – 1.4 fledged young per confirmed pair.
004168	Slieve Aughty Mountains SPA	Restore at least 1.0 – 1.4 fledged young per confirmed pair.
004165	Slievefelim to Silvermines Mountains SPA	Restore at least 1.0 – 1.4 fledged young per confirmed pair.
004161	Stack's to Mullaghareirk Mountains, West Limerick Hills and Mount Eagle SPA	Maintain at least 1.0 – 1.4 fledged young per confirmed pair.
004162	Mullaghanish to Musheramore Mountains SPA	Maintain at least 1.0 – 1.4 fledged young per confirmed pair.

2.3 Spatial utilisation of SPAs by breeding pairs

This attribute relates to defining a breeding population's resilience to both certain area-specific events, should they occur (*e.g*. human disturbance) and wider, *e.g.* climate change (Pearce-Higgins *et al*., 2008).

When boundaries of the SPAs were established, they sought to include all lands of relevant habitats (heath/bog, rough grassland[10] and forestry) within 5km of breeding harriers, as identified in the first national survey. The 5km radius applied around nest sites in order to define the SPA boundaries in Ireland was greater than those applied in other countries (see Enlander & Wright, 2016; and Whitfield & Madders, 2005). This was to take into account the more fragmented nature of the species' available foraging habitats in the Irish landscape. Research has since shown that foraging areas of nesting pairs are larger in Ireland than had been previously shown by radio-tracking research in Scotland (Irwin *et al*., 2012; Arroyo *et al*., 2006; Arroyo *et al*., 2014).

Core areas used by the hen harriers in the SPAs can be broadly and generically estimated by calculating the proportion of an SPA that lies within 5km of all of the recorded nest sites. This can indicate the vulnerability of a site's breeding population to local stochastic events, *e.g.* a wildfire, that could interrupt one or more breeding attempts in a given year. The efficacy of conservation management actions on the ground to restore the spatial utilisation by breeding pairs of a site, can be readily assessed if the centres of territories of breeding pairs in any given year are known. In addition, the 'spatial utilisation of SPAs by breeding pairs' is inextricably linked with the remaining attributes set out in this document *e.g*. meeting targets set out for

[10] As set out in Moran & Wilson-Parr (2015), rough grasslands are fields of low intensity or evidently unmanaged grasslands that have more than 50% cover of rushes.

the attribute 'extent and condition of heath and bog' will likely help support the target set out for the spatial utilisation by breeding pairs across the network.

If an SPA's breeding population is largely stable, a decrease in this metric indicates that pairs may be aggregating to particular sections within the SPA, thus becoming more vulnerable to local stochastic events. Conversely, if the estimated core areas equate to a relatively high proportion of the site, this indicates that the site's breeding population is likely to be more resilient to such localised events in the future. Table 2-3 and Figure 2-3 set out the proportions for each SPA that this area comprises, over time, as well as at the network level. As per the previous attributes, the targets are set using the values estimated by the first two national surveys.

It is important to note that this estimate of a site's utilised area is heavily influenced by changes in the overall number of confirmed breeding pairs, and therefore, Table 2-3 and Figure 2-3 need to be considered in conjunction with Table 2-1 and Figure 2-1.

Table 2-3. Proportion of each SPA that was within 5km of the centre of territories by year

Site	National Surveys				Annual Monitoring				
	2000	**2005**	**2010**	**2015**	**2017**	**2018**	**2019**	**2020**	**Mean ± SD**
Mullaghanish to Musheramore Mountains SPA	1.00	1.00	0.62	0.56	0.67	0.89	0.55	0.92	0.76 ± 0.15
Slieve Bloom Mountains SPA	0.97	0.82	0.95	0.96	0.97	0.96	0.95	0.93	0.95 ± 0.01
Slieve Beagh SPA	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00 ± 0.00
Slievefelim to Silvermines Mountains SPA	0.94	0.74	0.97	0.60	0.87	0.89	0.73	0.65	0.79 ± 0.10
Slieve Aughty Mountains SPA	0.68	0.92	0.80	0.65	0.67	0.48	0.50	0.36	0.50 ± 0.11
Stacks to Mullaghareirks, West Limerick Hills and Mount Eagle SPA	0.97	0.98	0.70	0.89	0.90	0.85	0.81	0.76	0.83 ± 0.05
SPA Network Total	**0.86**	**0.91**	**0.81**	**0.77**	**0.82**	**0.74**	**0.71**	**0.64**	**0.73 ± 0.06**

The estimated breeding population of the Slieve Bloom Mountains SPA has remained steady since 2010. The overall proportion of this SPA's area that is within 5km of the nesting pairs has also remained steady. Using this approach, there is no indication that this breeding population is aggregating or coalescing into smaller areas within the SPA. This suggests that its breeding population is likely to be reasonably resilient to future stochastic and localised pressures. The estimated proportion of use of Slieve Beagh SPA's footprint over the years (at 1.00) is also noteworthy.

The picture is less clear for the other SPAs and for the overall network, due to population fluctuations (*i.e.* largely declining) since 2000. Human-related disturbance (including from forestry, agriculture and wind energy development, human recreation, persecution, wildfires

and turf-cutting – and detailed in Section 5) can affect the spatial utilisation by breeding pairs of the SPAs through displacement and thus, potentially limit the maintenance or achievement of favourable conservation condition for this attribute.

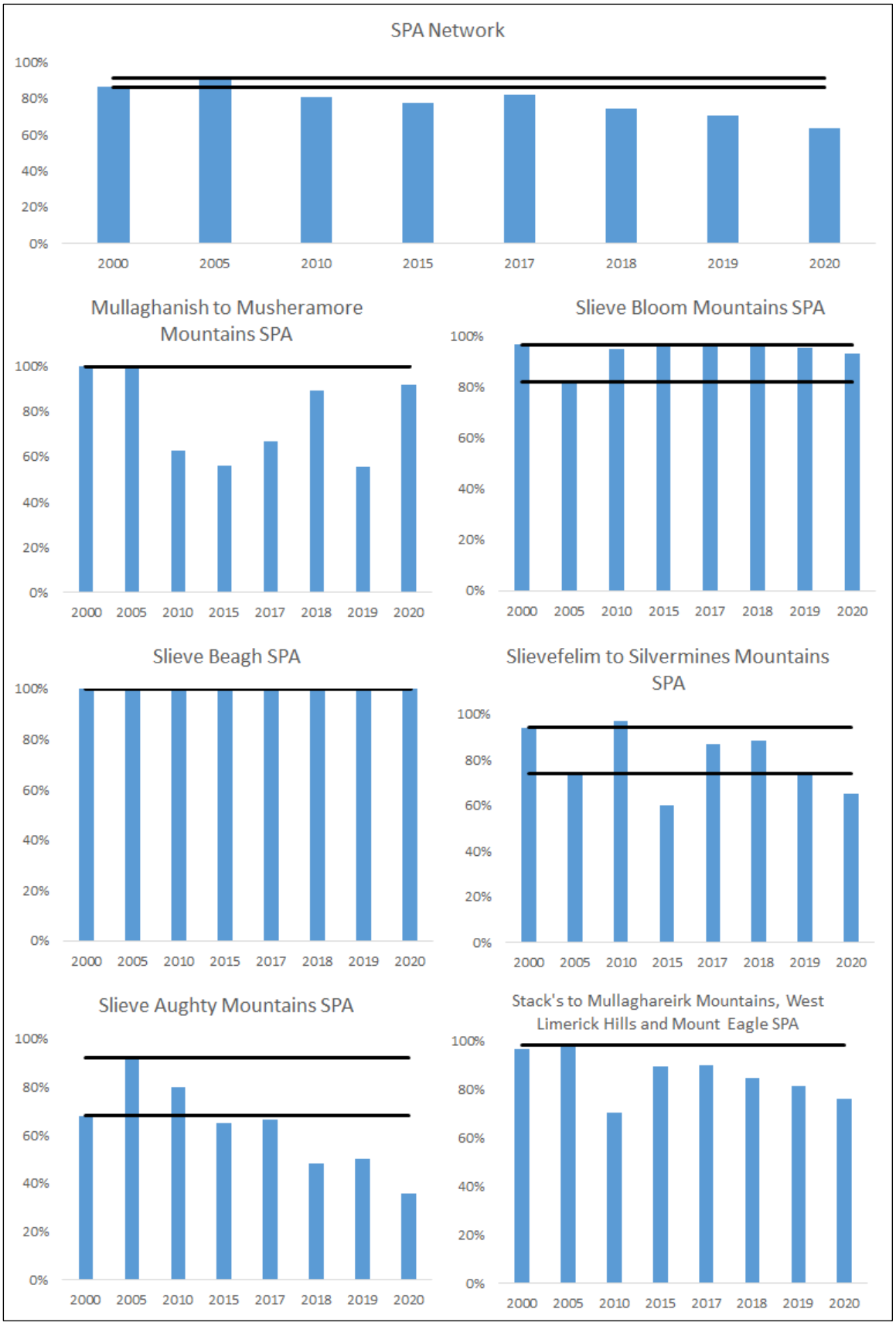

Figure 2-3. Changes (%) in the proportional area of the six hen harrier SPAs and at the overall SPA network within 5km of confirmed breeding pairs, over time. The black bands represent upper and lower thresholds.

The SPA network target for the attribute 'spatial utilisation of breeding pairs' is set out below, with the targets for each SPA detailed in Table 2-4.

*The **Target** for 'spatial utilisation of breeding pairs' is at least 86% of the total SPA network area.*

Table 2-4. SPA targets for the attribute 'spatial utilisation of breeding pairs' are set out below and are informed by Figure 2-3 above.

Site Code	Site Name	Target
004167	Slieve Beagh SPA	Maintain the spatial utilisation of the SPA by breeding pairs at 100%
004160	Slieve Bloom Mountains SPA	Maintain at least 82–97% spatial utilisation of the SPA by breeding pairs
004168	Slieve Aughty Mountains SPA	Restore the spatial utilisation of the SPA by breeding pairs to at least 68–92%
004165	Slievefelim to Silvermines Mountains SPA	Maintain at least 74–94% spatial utilisation of the SPA by breeding pairs
004161	Stack's to Mullaghareirk Mountains, West Limerick Hills and Mount Eagle SPA	Restore the spatial utilisation of the SPA by breeding pairs to at least 97–98%
004162	Mullaghanish to Musheramore Mountains SPA	Restore the spatial utilisation of the SPA by breeding pairs to 100%

3 Extent and condition of open habitats attributes

As part of the SPA selection process, a broad-scale habitat assessment was undertaken of the proposed hen harrier SPAs, using aerial imagery available at the time (*i.e.* Ordnance Survey Ireland (OSI) Orthophotography, Orthos 2000 photos mapped on OS 6 inch maps) and follow-up ground-truthing. Subsequently, the *Hen Harrier SPA Habitat Mapping Project 2014* (Moran & Wilson-Parr, 2015) set out to categorise the habitat cover of the SPAs using habitat categories that broadly corresponded to those set out in *A Guide to Habitats in Ireland* (Fossitt, 2000). This comprised a more intensive and precise habitat-mapping project, using 2011–2013 aerial imagery and additional sources of good quality habitat data, *i.e.* FORESTRY12 dataset (FS-DAFM), Forest Planting Rotation Dataset for the SPAs (Coillte) and existing NPWS datasets (*e.g.* NPWS Blanket Bog NHA dataset). It also involved the verification of some habitat classification by ground-truthing (Moran & Wilson-Parr, 2015). The types of semi-natural grasslands that support hen harrier and that are referred to as 'rough grassland'[10] in Moran & Wilson-Parr (2015) are usually wet grassland with variable species composition, though they may also include more typical improved grassland, but with relatively high cover of rushes.

A summary of the broad habitat types is presented in Figure 3-1; a tabular breakdown is also provided (see Table 3-1). A more detailed breakdown is set out in Table 4-A (Appendix 4). The spatial outputs from this project are also available via an online map viewer on the NPWS website[11].

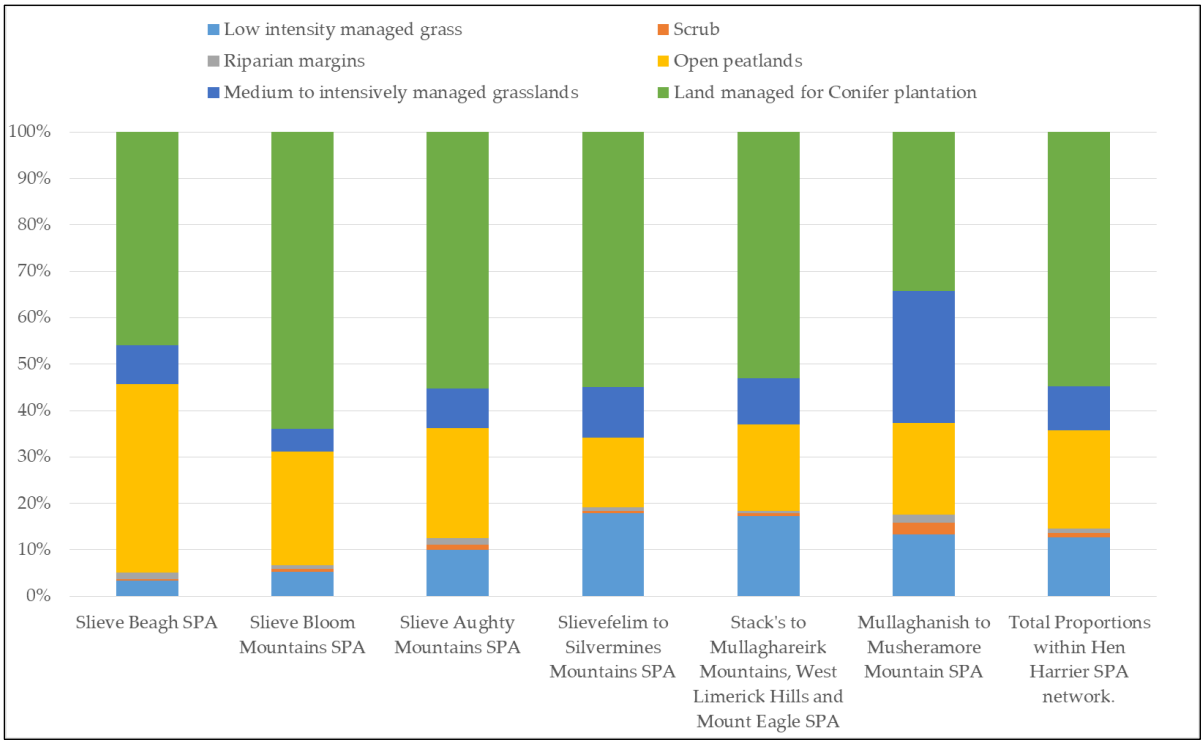

Figure 3-1. The percentage breakdown of the predominant habitat categories present in each SPA, adapted from the Hen Harrier Special Protection Area (SPA) Habitat Mapping Project 2014 (please refer to Moran & Wilson-Parr (2015) for further details).

Across the six breeding SPAs, Moran & Wilson-Parr (2015) estimate:

- the extent of conifer plantation ranges from 33 to 61% (52.3% for the network overall),
- for combined open peatlands, *i.e.* heath and bogs, ranges from 14 to 40% in extent (20% for the network overall),
- scrub, as a standalone category is estimated at 0.8% for the network overall,
- riparian margins (0.9% for the network overall),
- improved grassland at 2–12% (5.5% for the network overall),
- 3–17% low-intensity grassland, *i.e.* mostly 'rough grassland' and with some mosaic grassland with 40–49% rushes (*Juncus spp.*) cover (12% for the network overall).
- Overall, by 2013, the available open, potentially usable habitat for hen harrier across the network stood at approximately 34%, including scrub.

The 2014 Hen Harrier Special Protection Area Habitat Mapping Project (Moran & Wilson-Parr, 2015) focused on the broad structural and management aspects of the habitats, rather

[11] https://www.npws.ie/news/hen-harrier-spa-habitat-map-viewer-published, as of October 2021

than the species composition of habitats, as these aspects influence their ecological relevance for hen harrier (please refer to Attributes 3.1 – 3.3, described in Sections 3.1 – 3.3).

Table 3-1. The percentage (%) breakdown of the suitable semi-natural open habitats used by hen harrier in each Special Protection Area (SPA), adapted from the Hen Harrier Special Protection Area (SPA) Habitat Mapping Project 2014 (please refer to Moran & Wilson-Parr, 2015 for further details).

Habitat Category	**Slieve Beagh SPA**	**Slieve Bloom Mountains SPA**	**Slieve Aughty Mountains SPA**	**Slievefelim to Silvermines Mountains SPA**	**Stack's to Mullaghareirk Mountains, West Limerick Hills and Mount Eagle SPA**	**Mullaghanish to Musheramore Mountains SPA**	**Total proportions within hen harrier SPA network**
Scrub (& riparian woodland)	***1.7***	***1.***	***2.4***	***1.24***	***1.09***	***4.2***	***1.7***
Dry-humid acid grassland*	0.4	1.3	0.5	1.6	0.7	14.4	1.2
Mosaic grassland	1.4	0.6	1.0	1	1	1.3	1.2
Rough grassland	1.9	4.6	8.4	14.2	15.6	11.5	11.0
Low-intensity managed grasslands†	***2.9***	***5.1***	***9.3***	***16.5***	***16.9***	***11.9***	***12.2***
Heath	6.8	9.6	8.7	10.4	6.6	17.6	8.6
Bog	32.9	13.8	13.8	4.0	11.2	1.4	11.7
Total area of open peatlands	***39.7***	***23.8***	***22.5***	***14.4***	***17.8***	***19***	***20.3***
Total area of open habitats available*	***45.1***	***31.2***	***34.8***	***34.5***	***36.2***	***50.4***	***35.4***

*Note 1 – Dry-humid acid grassland is unimproved or semi-improved grassland that occurs on free-draining acid soils that may be dry or humid, but not waterlogged (see Fossitt, 2000) and can support ground-nesting birds including meadow pipit.

† Low-intensity managed grasslands, as set out in Moran & Wilson-Parr (2015), includes 'rough grassland' *Juncus spp.* cover is >50% and 'mosaic grassland' with *Juncus* spp. cover is 40-49%, both also listed separately above.

**As defined by area only, not quality. These habitat categories are the most widespread of the open semi-natural habitat categories described in Moran & Wilson-Parr (2015).

The suitability of heath and bog, grasslands and hedgerow habitat types for hen harrier across the six SPAs, and management thereof, is the focus of this section, *i.e.* extent and condition/ habitat quality of open habitats in the SPAs. As referenced in Caravaggi *et al*. (2019b), the hen harrier is unable to hunt effectively in closed canopy forests or agriculturally-improved

grassland habitats (Madders, 2000; Arroyo *et al*., 2009). Heath and bog habitats account for the largest portion of suitable open semi-natural habitats in the hen harrier SPA network and, along with semi-natural grassland habitats (refer to Table 3-1) and connected hedgerows and scrub, support the preferred prey species of hen harrier (Irwin *et al*., 2012; O'Donoghue, 2012). This could provide a more stable and important foraging and nesting habitat resource compared to an over-reliance on pre-thicket forestry. However, if a high proportion of available open semi-natural habitats are not supporting sufficient numbers of their prey species, their reproductive potential may be reduced, and ultimately, contribute to population-level declines (Caravaggi *et al*., 2019b). Thus, it is important for these habitats to offer adequate foraging opportunities (*i.e.* prey species) for hen harrier, and to support breeding success (Caravaggi *et al*., 2019b). As mentioned previously, meadow pipit is a staple of the hen harrier diet during the breeding season and possibly, it becomes more important as a prey item when abundance of young pipits increases through the breeding season (Madders, 2003). This species accounts for almost 25% of prey items of hen harrier during the breeding season, as determined by pellet analysis/prey remains, with avian species collectively accounting for 75% overall (O'Donoghue, 2010). The relative abundance of passerine bird species (*i.e.* putative prey species) across upland habitats and young conifer forests was found to be significantly higher on moorland (heather-dominated), with small mammal abundance higher in early pre-thicket forests *i.e.* 2 – 4 years post planting (McCarthy *et al*., 2021), but less so as the forestry matures (Thompson *et al*., 1988; Wilson *et al*., 2012a; McCarthy *et al*., 2021). The shift in land-use from heather moorland to forested habitat results in a lower prey abundance for those predators that rely more on bird species, including the hen harrier (Irwin *et al*., 2012). Conversely, the increases in small mammals in upland forests may lead to increased abundance of mammalian predators that could, in turn, lead to increased rates of predation of nests of ground-nesting birds (McCarthy *et al*., 2021).

As highlighted previously, overwinter survival of hen harrier populations in Ireland, is lower than in the UK, with prey availability and diet in the non-breeding season identified as potentially limiting factors (Ruddock *et al*., 2016). The influence of habitat on wintering diet of hen harrier was examined by McCarthy *et al.* (2022b) using pellets collected roosts sites during the non-breeding season at upland, lowland inland and lowland coastal roost sites. This study reaffirmed the importance of small birds and small mammals in the diet of hen harrier, along with medium-sized birds, such as redwing (*Turdus iliacus*) and snipe (*Gallinago gallinago*). In addition, this research highlighted the links between habitat composition at the landscape-scale and hen harrier diet. Small birds occurred more frequently in pellets in areas with higher proportions of arable crops, wild bird cover and low-intensity agriculture in the surrounding landscape and less frequently in areas of bog, young conifer forest and wetlands. By contrast, medium-sized birds featured more in the diet of hen harrier in areas with a higher proportion of bog and young conifer forest, and less so in areas of arable and wild bird cover. McCarthy *et al*. (2022b) also found this prey category, *i.e.* medium-sized birds, occurred significantly less frequently in the diet of hen harrier as winter advanced.

The interactions between the forestry sector and hen harrier conservation in Ireland have been described in various publications, including in *Hen Harrier Conservation and the Forestry Sector in Ireland* (NPWS, 2015a). Breeding hen harrier territories are associated with a considerable amount of unsuitable habitat, even in close proximity to nest sites, with foraging birds often needing to travel further during the breeding season to meet the energetic demands of growing chicks, thus exposing the nest to increased risk from predation and stochastic weather events (Caravaggi *et al*., 2019b). Key findings, largely from Irish research, are set out below, describing those interactions relevant to the attribute, *i.e.* 'extent and condition of heath and bog habitat' and, in particular, how the hen harrier may be subject to an ecological trap because of how it uses available breeding habitats in Ireland.

Along with Caravaggi *et al*. (2019b), other research in Ireland (Sheridan *et al*., 2020; Wilson *et al*., 2012a; Irwin *et al*., 2011; O'Donoghue, 2010; Monaghan 2010-2017; Ruddock *et al*., 2012, 2016) has demonstrated that nesting preferences may affect breeding outcomes for hen harrier. Wilson *et al*. (2012a) examined a dataset of three consecutive breeding seasons across four study sites in Ireland, and found that in a subset of areas (*i.e.* the Slieve Aughty Mountains), high cover of second-rotation pre-thicket forestry in the surrounding landscape was associated with low levels of breeding success. Wilson *et al.* (2012a) went on to describe such sub-optimal nesting choices as often resulting in poorer breeding outcomes and productivity, *i.e.* an 'ecological trap'. Wilson *et al*. (2012a) concluded that the area-specific relationship between breeding success of hen harrier and second-rotation pre-thicket forests illustrates that, especially in anthropogenically-altered landscapes, habitat use does not necessarily reflect habitat quality. This mismatch may be due to factors related to nest predation, disturbance or prey availability. Furthermore, Wilson *et al.* (2012a) notes that one factor that might lead to nest predation being more prevalent in landscapes with a high proportion of second-rotation forest is the positive relationship between this variable and the density of internal forest edges. Sheridan *et al*. (2020) investigated how habitat fragmentation and edge influences hen harrier breeding success in the Slieve Bloom Mountains. They found that habitat edge had a significant effect on nest site selection, breeding success and productivity for hen harrier, which are more likely to nest in areas of high edge/area ratio, but this was associated with lower breeding success and productivity, also suggesting a possible ecological trap scenario.

Caravaggi *et al*. (2019b), along with Arroyo *et al*. (2009), highlighted the importance of the maintenance and improvement of habitat mosaics of heather moorland, bog and shrub for the benefit of foraging hen harrier. Caravaggi *et al*. (2019b) investigated landscape-scale associations between habitat composition and hen harrier territory site selection, and explored the influence of habitat and climate on breeding success, using data from the last two national surveys (*i.e.* 2010 and 2015). Along with several climate-related factors, this study found a positive association between breeding success and heath/shrub habitat at the 1km scale, and with bog habitat at the 2km scale. Pre-thicket forests were not observed to have an effect on

breeding success. The fact that the findings of Caravaggi *et al*. (2019b) do not fully accord with those of Wilson *et al*. (2012a), highlights the difficulty in precisely identifying acceptable thresholds within the hen harrier SPA network for those habitat-based (or habitat-associated) pressures that can result in sub-optimal breeding success rates.

Nevertheless, there is a strong evidence-base from elsewhere that afforestation of extensive open landscapes can lead to negative biodiversity impact (*e.g.* Pálsdóttir *et al*., 2022). This includes habitat fragmentation, elevated mammalian predator activity or abundance near forestry creating potential negative 'edge effects', particularly for ground-nesting birds (Hancock *et al*., 2020). In the Flow Country in Scotland, Wilson *et al*. (2014) showed that wader densities (for golden plover *Pluvialis apricaria* and dunlin *Calidris alpina*) in suitable bog habitats were lowered within 700m of forestry, suggesting that predation, or perceived predation risk, were the likely drivers for these observed patterns. In Sweden, a study of corvid density and nest predation found that hooded crow (*Corvus cornix*), a habitat generalist, caused increased predation pressure close to forest-farmland edges and in small forest fragments that were surrounded by agricultural land (Andrén, 1992).

With respect to the question regarding "how much forest cover is optimal for the hen harrier within each SPA", Irwin *et al.* (2012) noted that hen harrier breeding success decreases noticeably when the percentage of second rotation pre-thicket forest in the surrounding landscape is greater than 10%. It goes on to conclude that "*in a forest landscape with a well-balanced age structure, approximately one quarter of the forest estate will be in pre-thicket stage at any one time. A maximum threshold of 40% for total forest cover in the landscape would therefore ensure that the percentage of pre-thicket forest did not regularly exceed 10%"*.

In order for the hen harrier population to persist at the required level at each SPA, an optimal level of open habitat coherence is required. This would ensure a continuity of open habitats of sufficient size as a resource for the breeding population through targeted forest removal, thereby increasing the habitat/edge ratio of heath and bog habitats in tandem with increasing its overall habitat quality.

The interactions between hen harrier conservation and the wind energy sector in Ireland have been described in *Hen Harrier Conservation and the Wind Energy Sector in Ireland* (NPWS, in prep.). The potential effects of wind energy developments on the condition of open habitats used by foraging and nesting hen harrier are described below, but are also cross-cutting with regards to the population demographics attributes within Sections 2.1–2.3 of this document.

Wind energy developments may act as barriers to movement for the hen harrier, causing increases in energy expenditure due to increased flights, and displacement, *i.e.* possible abandonment of nest sites and/or of preferred foraging areas, and may also result in fatalities (see NPWS, in prep.; O'Donoghue, 2011). As of 2016, there were 319 turbines inside four of the six SPA and 58 turbines within 1km of the SPAs (NPWS, in prep.). As set out in Wilson *et al*. (2015), densities of open habitat bird species (including meadow pipits) are significantly

lower at wind energy development sites than control sites and lower closer to turbines, than further away. In addition, Fernandez-Bellon *et al*. (2015) examined the interaction of wind farms and breeding hen harriers: no statistically significant relationships were found between various breeding parameters (*i.e.* nest success, fledged brood size and productivity) and distance of the nest from the nearest wind turbine. However, lower nest success rates within 1km of wind turbines than at greater distances were sufficiently close to statistical significance, and with a sufficiently small sample size, that this difference may be of biological relevance. These studies collectively highlight the potential indirect and direct effects of wind energy developments on breeding hen harrier up to 1km from turbines, similarly to other raptors (*e.g.* white-tailed eagle *Haliaeetus albicilla*, Bevanger *et al*., 2012).

3.1 Extent and condition of heath and bog

This attribute sets out to define the extent and condition of available heath and bog habitats across the hen harrier SPA network and whether they are sufficient to provide an adequate foraging and nesting resource throughout the breeding season. Heath, bog and associated habitats, *e.g.* scrub, hereafter referred to as heath and bog, occur in mosaics and along with semi-natural grassland habitats within the SPAs (refer to Table 3-1). These account for the largest portion of semi-natural habitats in the network, and support preferred prey species of hen harrier. Making up approximately 20% of the network area (Moran & Wilson-Parr, 2015), heath and bog habitats need to be of sufficient extent and quality to ensure that the targets for the attributes 'population size', 'productivity rate' and 'spatial utilisation' can be achieved.

The target for this attribute is particularly important given the projected level of future forest maturation in SPAs (see NPWS, 2015a) and the implications that has for hen harrier.

Territory selection by hen harrier at a number of spatial scales in the Irish landscape has been examined, using locations of confirmed territories from the 2010 and 2015 national surveys (Caravaggi *et al.*, 2019b). Territories were found to be positively influenced (at 1km scale) by the presence of heath/shrub[12], pre-thicket forestry and bog, as well as by elevation, and those choices were non-random. Of significant importance for the hen harrier conservation planning is the fact that breeding success was positively associated with heath/shrub habitat at the 1km scale and bog at 2km, with no significant relationship detected for any coniferous forests categories. At a landscape-scale, stands of dense heather and scrub on open habitats at a distance from forest edges provide safer nesting options for hen harrier. However, pine marten can utilise scrub habitats (O'Mahony *et al*., 2017) as resting places and as conduits for travel between forest patches (Caryl, 2008). Thus, it is important that these open habitats proximate to forest edges do not hold extensive dense stands of scrub that could attract pairs

[12] This study used CORINE 2012 land cover dataset (European Environment Agency, 2016), and data from Coillte (public forests in Ireland), NPWS (private forests in Ireland) and the Forest Service Northern Ireland (public and private forests in Northern Ireland).

of hen harrier to nest close to the forest edge, although, in some areas, alternative safer nesting options may not be available.

Scrub (particularly gorse *Ulex* species), although likely underrepresented as a standalone habitat category in Moran & Wilson-Parr (2015), is found across the six SPAs. Scrub is often associated with grasslands, heaths and on blanket bogs (especially on flushed sites, along rivers and on better-drained slopes) (Cross, 2006). In itself, it is regarded as an important foraging and sometimes nesting habitat for hen harrier in Ireland (O'Donoghue, 2010). However, excessive stands of scrub may not represent a net benefit to hen harrier in certain locations. Furthermore, for some habitats listed in the Habitats Directive[4], extent of scrub can be an indicator of unfavourable condition (*e.g.* more than 50% western gorse *Ulex gallii* on dry heath) (NPWS, 2017)). Thus, through appropriate management, scrub species should not dominate where they occur on certain selected habitats (*e.g.* habitats listed on Annex I of the Habitats Directive such as Northern Atlantic wet heaths with cross-leaved heath *Erica tetralix*; European dry heaths; Blanket bogs (* if active bog)). For the purposes of this attribute (*i.e.* extent and condition of heath and bog) and the next (*i.e.* extent and condition of low-intensity managed grasslands), the overall proportions of the scrub habitat as identified by Moran and Wilson-Parr (2015) have been equally apportioned to the heath and bog category and to the low-intensity managed grasslands category.

As set out previously in this section, research in Ireland has shown that the proximity of forestry and/or wind energy developments influence the quality of this resource and limit the achievement of favourable conservation condition for the attribute 'extent and quality of heath and bog'. Leaving aside any differences in the spatial configuration of forestry coupes and in the contiguity of supporting open habitats, across the SPA network, unpublished analyses from the HHP on the proximity of forestry to remaining open habitats indicates the percentage of open habitat areas more than 500m from forestry, ranges from circa 3% to 16% across the network.

Information on the current condition of heath and bog habitats across the hen harrier SPA network has been provided by the HHP. Unpublished data (September 2021) summarised by the HHP indicates that open heath and bog habitats make up over 46% of the lands included under the programme (currently 45,580 ha). The total footprint in the hen harrier SPAs of open heath and bog habitats assessed under the HHP stands at 12.7% and, based on Moran & Wilson-Parr (2015), this figure equates to 62.5% of the total extent of those habitats in the hen harrier SPA network. Thus, some inferences can be made with reasonable confidence as to the 'structural condition' of open heath and bog within the hen harrier SPA network. Using this unpublished data from the HHP, for 1,899 land parcels of heath and bog assessed in 2020, the median overall habitat condition score (using their scoring assessment) was seven out of a maximum score of 10. Meanwhile, the average habitat assessment scores of heath and bog habitats across the SPA network, under the HHP assessments, indicate an overall higher average habitat score for privately-owned lands (at 7.8 out of 10) compared to commonages

(at 5.3 out of 10). In terms of those habitat traits assessed that directly benefit hen harrier (*i.e.* sward structure), the majority of lands assessed under open heath and bog (89.2%) fall within the 'moderate to good' assessment criteria as described by the HHP.

For the purposes of establishing the overall condition of open heath and bog at a site (*i.e.* SPA) level, a broad summary approach for assessing habitat condition at a field/land parcel level has been adapted from scorecard outputs produced by the HHP (Hen Harrier Project, 2021a) and incorporates key ecological considerations for hen harrier (see Table 3-2). An additional important consideration with respect to habitat condition assessments for the SPAs is the concept of 'open habitat coherence or connectivity'. As described by Van der Sluis & Schmidt (2021), "*biological diversity is highly dependent on the quality, quantity, and spatial cohesion of natural areas, and thus, if wildlife is spread over a large area in small numbers, and if the remaining areas are too small, sooner or later wildlife species will disappear"*. The potential negative effects of land use should be considered in the condition assessment of open heath and bog-supporting habitats and low-intensity managed grasslands. Negative aspects attributed to forestry are of note (*e.g.* high edge to area ratio linked to lower breeding success and productivity (Sheridan *et al*., 2020), as well as wind energy developments (*e.g.* lower nest success within 1km of wind turbines, which was close to statistical significance (Fernández-Bellon *et al.*, 2015)).

Focusing on those habitat attributes most relevant to supporting hen harrier prey species, *i.e.* habitat structure, ground layer and soil integrity, the aim of this habitat assessment approach is to capture the aspects of habitat quality for open habitats associated with ongoing agricultural practices (*e.g.* impacts of overgrazing on sward structure and soil integrity). In addition, this approach takes into account other quality-related aspects with regard to open habitat coherence, including:

- contiguity of the heath and bog habitats available to hen harrier,
- plot size,
- area to edge ratio and
- proximity to forestry and wind energy developments (with associated higher likelihood of predation, lower productivity and prey availability, and higher risk of displacement and disturbance).

Table 3-2. Scoring to define condition of heath and bog supporting habitats for hen harrier in the SPAs.

Ecological Integrity **Score**	**1. Habitat Structure**	**2. Scrub Structure**	**3. Soil Integrity**	**4. Open habitat coherence**
Good	Bog Cotton, heathers, mosses (*Sphagnum* sp.) and *Cladonia* lichens throughout and abundant. Sward in good condition with undamaged Sphagnum layer, abundance of grass and sedge-like vegetation on blanket bog and a good mix of heathers and typical grasses and sedges on wet heath areas. On heath, all growth forms of heather present, with areas of mature heathers present (height > 45cm). Heterogeneity in vegetation height throughout.	No scrub OR some natural areas of Willow-dominated scrub in river valleys or on slopes OR some natural areas dominated by Bog myrtle (*Myrica gale*).	Little or no bare soil seen over the assessment area other than isolated hoof prints. Some bare soil at 'pinch' points along regularly used routes (*e.g.* gateways, gaps in walls) is acceptable as long as no signs of erosion are visible.	Large unfragmented areas of open heath/bog habitat in combination with grassland and riparian habitats (see Table 3-1) throughout; distant from large artificial structures such as wind turbines and masts.
Moderate	Bog Cotton, heathers, mosses (*Sphagnum* sp.) and *Cladonia* lichens occur but cover is low. Little mature heather present. Sphagnum occurs but not in large hummocks. Ground is soft or spongy to walk on. Very little or no evidence of grazing with litter building up. Heather becoming rank and high cover of purple moor grass (*Molinia caerulea*) OR signs of overgrazing present but not throughout. Heathers and other vegetation grazed to short carpet-like vegetation in places.	Small areas (<0.1ha) of Gorse-dominated scrub occur occasionally throughout the site.	Bare peat exceeds 5%, cumulatively, but is less than 10%.	Contiguous areas of heath/bog habitat in combination with grassland and riparian habitats, albeit with some fragmentation evident due to forestry and/or proximity to large artificial structures (as above), but not extensive.
Poor	Bog Cotton, heathers, mosses (*Sphagnum* sp.) and *Cladonia* lichens rare. Heather cover is low or absent. Parcel dominated by a single species, *e.g.* purple moor grass (*Molinia caerulea*). No heather taller than 30cm present. Areas of bare ground or peat hags frequent. High proportion of site recently (in last 12 months) burned.	Gorse-dominated scrub occurring throughout the site or concentrated in large areas (>0.2ha) with a clear impact on the hydrology.	Bare peat is greater than 10%, cumulatively.	Relatively small areas of heath/bog habitats fragmented by forestry and/or holding or adjacent to large artificial structures (as above).

Note 1- The above habitat variables and descriptions (1-3) above are adapted from the peatlands scorecard and associated guidance produced by the Hen Harrier Project.

Each variable *e.g.* Habitat Structure, Scrub Structure and so on, is scored as Good, Moderate or Poor. Combined scores which include all 'good' scores, indicate favourable-good condition; combined scores with at least one 'moderate' indicate favourable-adequate condition and combined scores with at least one 'poor' indicate overall unfavourable – inadequate conservation condition. 'Open Habitat Coherence' relates to the qualitative assessment of the contiguous extent of heath and bog.

The SPA network target for the attribute 'extent and condition of heath and bog habitats' is set out below and the individual extents of this habitat resource for each SPA and associated targets (informed by whether a site is meeting targets for Attributes 2.1 – 2.3, as described in Section 2) are detailed in Table 3-3.

*For the SPA network, the **Target** for the attribute 'extent and condition of heath and bog' is to restore the extent and quality of this resource to support the targets relating to population size, productivity rate and spatial utilisation.*

At present for Attribute 3.1, *i.e.* extent and condition of heath and bog and only informed by Attributes 2.1 – 2.3, (*i.e.* population size, productivity rate and spatial utilisation by breeding pairs), with the exception of Slieve Beagh SPA and Slieve Bloom Mountains SPA, the SPAs do not currently meet the requirements for favourable condition for this attribute. A proximity analysis of the ecological trait 'open habitat coherence' will have an important bearing on whether an SPA can achieve favourable condition for this attribute and support targets set out under Attributes 2.1 – 2.3, listed above.

Table 3-3. SPA targets for the attribute 'condition and extent of heath, bog and associated habitats'. Please note that the known extents of these habitats in each SPA are set out in Moran & Wilson-Parr (2015).

Site Code	Site Name	Extent	Target
004167	Slieve Beagh SPA	1,380 ha	Maintain the extent and quality of this resource to support the targets relating to population size, productivity rate and spatial utilisation
004160	Slieve Bloom Mountains SPA	5,169 ha	Maintain the extent and quality of this resource to support the targets relating to population size, productivity rate and spatial utilisation
004168	Slieve Aughty Mountains SPA	13,748 ha	Restore the extent and quality of this resource to support the targets relating to population size, productivity rate and spatial utilisation
004165	Slievefelim to Silvermines Mountains SPA	3,095 ha	Restore the extent and quality of this resource to support the targets relating to population size, productivity rate and spatial utilisation
004161	Stack's to Mullaghareirk Mountains, West Limerick Hills and Mount Eagle SPA	10,366 ha	Restore the extent and quality of this resource to support the targets relating to population size, productivity rate and spatial utilisation
004162	Mullaghanish to Musheramore Mountains SPA	1,022 ha	Restore the extent and quality of this resource to support the targets relating to population size, productivity rate and spatial utilisation

3.2 Extent and condition of low-intensity managed grasslands

This attribute defines the extent and condition of available low-intensity managed grassland habitats across the hen harrier SPA network and whether this resource is sufficient to provide adequate foraging habitat throughout the breeding season. Rough grassland, as described in Moran & Wilson-Parr (2015), is an umbrella category for those types of grasslands that support hen harrier and includes wet grassland and other low-intensity managed grasslands categories. Together, these grassland categories account for a total of 12% of the hen harrier SPA network area (Table 3-1). Grasslands are often intermingled with other heather, scrub, marsh, riparian and woodland habitats, creating important habitat mosaics that support prey communities important for hen harrier (Amar, 2001; O'Donoghue, 2004, 2010; NPWS, 2015b). As detailed under Attribute 3.1 above, scrub (often a supporting habitat for hen harrier and its prey species) within the SPA network is likely underrepresented in terms of extent by Moran & Wilson-Parr (2015), but for the purposes of defining targets for open supporting habitats, is considered to be equally associated with heath and bog and low-intensity managed grassland habitats. Thus, half of the total extent of scrub in the SPAs (*circa* 0.42% of a total of 0.85%), as described in Moran & Wilson-Parr (2015), is included under the target for this attribute extent and condition of low-intensity managed grasslands (and associated habitats, *e.g.* scrub), hereafter referred to as 'extent and condition of low-intensity managed grasslands'.

These low-intensity managed grasslands have been shown to be positively selected as a foraging habitat by hen harrier during the nesting period *e.g.* Orkney (Amar & Redpath, 2005) and mainland Scotland (Thirgood *et al*., 2003; Arroyo *et al*., 2009). Intensively-grazed grasslands support lower densities of meadow pipits (Evans *et al.,* 2006, 2007), likely explaining, in part, the avoidance of improved grasslands by foraging hen harrier (Wilson *et al.,* 2009; Arroyo *et al*., 2009; Irwin *et al.,* 2012; Caravaggi *et al.,* 2019b). Thus, it is important that the extent and condition integrity of semi-natural grasslands in the SPA network is maintained to support foraging hen harrier.

In relation to management of semi-natural grasslands, the level of abandonment must also be considered (NPWS, 2015b) at a landscape-scale, as it could lead to successional changes in vegetation structure, with subsequent effects on bird populations through (1) the loss of preferred breeding sites; (2) alteration of food supplies; and (3) predation pressure (Fuller & Gough, 1999). However, fields that are no longer farmed, which have extensive rush cover and are interspersed with patches of scrub, can be an important resource in both winter and the breeding season for hen harrier. As the intensity of agricultural management of grassland types within the SPAs is variable, the ratio of improved grasslands to low-intensity and unmanaged grasslands will vary through time and location, leading to some reversion of improved grass fields to more wet grassland, which is considered a more valuable foraging habitat for hen harrier. Conversely, these wet grasslands can be returned to improved grassland with very basic management (Moran & Wilson-Parr, 2015).

A similar approach to that described above for heath and bog should be taken with respect to habitat assessment requirements for low-intensity managed grassland. As stated earlier, these grasslands are largely wet grasslands (as defined by Fossitt, 2000) and the main threats include improvement, abandonment (rushes and/or scrub become too dominant) and changes to the flooding regime. The approach described here, which has been adapted from scorecard outputs produced by the HHP (Hen Harrier Project, 2021b), focuses primarily on those habitat attributes of grasslands most relevant to supporting prey species of hen harrier. The condition of these grassland types, *i.e.* wet grassland (common) and species-rich grasslands (more uncommon), are assessed by the HHP. Of approximately 16,200 grasslands assessed under the HHP in 2020, the median score for wet grasslands (which may include improved and semi-improved grasslands) was six out of 10, with this category accounting for 90% of fields assessed. For species-rich grasslands, the average score was eight out of 10.

From the most recent unpublished data summarised by HHP, wet grassland habitats make up 43.2% of the lands included under the programme, with species-rich grasslands accounting for 1.8% (as of late 2021, total programme area is 45,580 ha).

The total footprint of wet grassland assessed under the HHP stands at 11.8% of the hen harrier SPA network area and accounts for 96% in total area of the low-intensity managed grassland category described in Moran & Wilson-Parr (2015). Thus, inferences can be made with good confidence as to the structural habitat condition of wet grasslands and species-rich grasslands across the network. Again, using unpublished data from the HHP, for 16,200 grasslands assessed in 2020, 14,642 of which were classed as wet grassland, the median habitat condition score for wet grassland, the dominant grassland type, was six out of a maximum score of 10. Some of the criteria used to score habitat condition by the HHP are not as wholly relevant for hen harrier, as the project has wider environmental objectives. Looking more closely at sward structure, which is of relevance to hen harrier, 72.3% of fields had a good or very good sward structure. While the scoring for both wet grasslands and species-rich grasslands under the HHP includes additional scoring with respect to positive indicators to capture species diversity (due to its wider objectives), these may/may not directly benefit hen harrier. Thus, the assessment approach set out in Table 3-4 below does not take into account species diversity, but instead focuses on assessing all grassland types using relevant habitat attributes, as these are more directly relevant to hen harrier.

Earlier in this document (Section 3), research by UCC on the potential effects of forestry and wind energy developments on hen harrier on their breeding grounds was detailed. Summarising here, Wilson *et al*. (2015) showed that densities of open habitat bird species (including meadow pipits) are significantly lower at wind energy development sites. This is consistent with the findings of other studies (*e.g.* Pearce-Higgins *et al.*, 2009; Shaffer & Buhl, 2015). Thus, evidence indicates that the presence of a wind energy development causes a reduction in the quality of suitable foraging habitat up to 1000m of its footprint.

An important consideration with respect to habitat condition assessments is the concept of 'open habitat coherence or connectivity'. As described above, the HHP has assessed the habitat condition of significant parcels of low-intensity managed grasslands across the SPA network. However, the impacts of nearby forestry and/or wind energy developments also need to be analysed by the undertaking of a proximity analysis as part of the condition assessment. Given the findings of Sheridan *et al.* (2020), whereby the only nesting habitat available to breeding pairs is in high forest edge/area sites suggesting a possible 'ecological trap', the habitat configuration of a site is likely to play an important role in determining breeding outcomes for hen harrier. Thus, a condition assessment approach for low-intensity managed grasslands, as set out in Table 3-4 below, aims to support a qualitative assessment of the ecological importance of a site (*i.e*. SPA). This approach takes into account the ecological integrity of these habitats at a field/parcel level from the point of view of grassland vegetation structure, scrub diversity and structure, and continuity of these supporting open habitats for hen harrier.

Table 3-4. Scoring to define the condition of low-intensity managed grasslands and associated scrub (*i.e.* where it does not dominate) in the SPAs. If a field/land parcel is primarily grazed, the column 'Grazed' should be used to assess vegetation structure. If a field/land parcel is cut or mowed for silage, the 'Cut/Mowed' column should be used instead.

Ecological Integrity Score	**1. Vegetation Structure GRAZED**		**2. Vegetation Structure CUT/MOWED**	3. Scrub diversity and structure	4. Open habitat coherence
Very Good	**Tall and medium and short vegetation throughout. Tussocks abundant throughout. Some tall dense soft rush (*Juncus effusus*), some areas of shorter sharp-flowered rush (*Juncus acutiflorus*) and some grass/sedge dominated areas. Potential roost site.**			Scrub with a mix of several woody plant species of varied heights throughout. Highly structurally diverse with some compact inaccessible areas.	Large unfragmented areas of open heath/bog habitat in combination with grassland and riparian habitats (see Table 3-1) throughout; distant from large artificial structures such as wind turbines and masts.
Good	**Tall/medium and short vegetation throughout. May contain frequent tall tussocks or frequent sharp-flowered or jointed rush (*Juncus articulatus*). Some grass/sedge dominated areas also occur.**	**OR**	**Aftermath grazing takes place providing variations in height of sward; sward does not look uniform in appearance.**		
Moderate	**Tall vegetation cover is patchy. No areas with distinct tussocks. Grassy areas dominate field. Little variation in the height of vegetation. Dead standing leaves rare OR Uniform vegetation height throughout the field.**		**Low number of flowering plants and vegetation structure within the field margin poor to moderate. Some aftermath grazing providing some structural variation.**	Single-species scrub (often gorse) with diverse height and irregular edge. One or two other wood plant species may be present. Base sparsely vegetated. Suitable nesting area for small birds.	Contiguous areas of heath/bog habitat in combination with grassland and riparian habitats, albeit with some fragmentation evident due to forestry and/or proximity to large artificial structures (as above), but not extensive.
Poor	**All vegetation short OR excessively dominant unmanaged rush. Little evidence of grazing. Dead standing rushes throughout.**		**Field topped right up to the field boundary line. No aftermath grazing. Little or no variation in sward height.**	No scrub or isolated leggy gorse bushes.	Relatively small areas of heath/bog habitats fragmented by forestry and/or holding or adjacent to large artificial structures (as above).

Note 1- The above habitat variables and descriptions (1-3) above are adapted from the grasslands scorecards and associated guidance produced by the Hen Harrier Project.

Each variable *e.g.* 1. **Vegetation Structure - Grazed** or 2. **Vegetation Structure – Cut/Mowed**, and 3. Scrub Diversity & Structure and so on, is assessed as either Very Good, Good, Moderate or Poor. Combined scores which include all 'Very-good' and/or 'Good' scores, indicate favourable conservation condition; combined scores with at least one moderate, indicate favourable-adequate condition and combined scores with at least one 'poor', indicate overall unfavourable – inadequate conservation condition. Please note: where scrub is present and occurring in smaller patches or as linear features (<0.2ha), it can act as a complementary habitat for foraging and can be scored using 'Scrub diversity and structure' above. However, if scrub and/or bracken is encroaching on the grassland (and in blocks larger than 0.2ha), this should be factored into the overall condition assessment. 'Open Habitat Coherence' relates to the qualitative assessment of the contiguous extent of grasslands.

The SPA network target for the attribute 'extent and condition of low-intensity managed grasslands' is set out below and the individual extents of this habitat resource for each SPA and associated targets are detailed in Table 3-5.

*For the SPA network, the **Target** for the attribute 'extent and condition of low-intensity managed grassland habitat' is to restore the extent and quality of this resource to support the targets relating to population size, productivity rate and spatial utilisation.*

For the period 2017-2020, and informed by Attributes 2.1 – 2.3 (see Section 2), with the exception of Slieve Beagh SPA and Slieve Bloom Mountains SPA, the SPAs do not meet the requirements for favourable condition for this attribute.

Table 3-5. SPA targets for the attribute 'extent and condition of low-intensity managed grasslands and associated habitats', based on known extents of these habitats in each SPA, as detailed in Moran & Wilson-Parr (2015).

Site Code	Site Name	Extent (ha)	Target
004167	Slieve Beagh SPA	106 ha	Maintain the extent and quality of this resource to support the targets relating to population size, productivity rate and spatial utilisation
004160	Slieve Bloom Mountains SPA	1,209 ha	Maintain the extent and quality of this resource to support the targets relating to population size, productivity rate and spatial utilisation
004168	Slieve Aughty Mountains SPA	5,865 ha	Restore the extent and quality of this resource to support the targets relating to population size, productivity rate and spatial utilisation
004165	Slievefelim to Silvermines Mountains SPA	3,552 ha	Restore the extent and quality of this resource to support the targets relating to population size, productivity rate and spatial utilisation
004161	Stack's to Mullaghareirk Mountains, West Limerick Hills and Mount Eagle SPA	9,783 ha	Restore the extent and quality of this resource to support the targets relating to population size, productivity rate and spatial utilisation
004162	Mullaghanish to Musheramore Mountains SPA	688 ha	Restore the extent and quality of this resource to support the targets relating to population size, productivity rate and spatial utilisation

3.3 Extent and condition of hedgerows

Hedgerows are living field boundaries, designed to enclose (or exclude) livestock and often consisting of thorny tree and shrub species set in a linear, inter-connecting configuration (Collier, 2021). Performing multiple ecosystem functions and services, including mitigating biodiversity loss and climate change (Montgomery *et al*., 2020), these linear features connect a

variety of habitats (Moran & Wilson-Parr, 2015) and support hen harrier prey species, *i.e.* small birds and small mammals (Madders, 2000, 2003; O'Donoghue, 2010; Irwin *et al.*, 2012). Other field boundaries (such as dry stone walls, earth banks) can also provide shelter and breeding places for birds, mammals and insects (Bignal *et al*., 1996) and are used by hunting hen harrier (Thorpe, 1994) where cover of plants, such as heather, bilberry or grasses, is good. Hen harrier prefer to hunt along intact, densely-structured hedgerows, usually between three and four metres wide (Irwin *et al.*, 2012).

Changes in agricultural practices have resulted in hedgerow losses, as areas of semi-natural and marginal habitats were cleared (Tucker & Heath, 1994; Potter, 1997). Maintaining habitat heterogeneity, to include hedgerows and natural field margins (including earth banks, streams, drainage ditches, riparian margins), and adequate grazing pressure, is thought to be positive for most raptors that use agro-ecosystems (Amar & Redpath, 2005; Geary *et al.*, 2018).

The establishment of new, and improvement of existing, hedgerows in order to improve connectivity between land parcels and to support hen harrier prey species can be beneficial if they occur in the appropriate areas. However, such measures are not suitable for open peatland (*i.e.* bog, heath) habitats, where the creation of such line features may fragment the openness of an area and thereby increase the vulnerability of ground-nesting birds (including hen harrier) to ground-based and generalist avian predators. They are also not suitable as a replacement for valuable existing habitats on designated land, *e.g.* high-value vegetated earth banks (Hen Harrier Project, 2020).

While the assessment of linear features by Moran & Wilson-Parr (2015) included hedgerows, further subdivided across four categories characterised by structure (refer to Table 3-6), it did not include linear features such as earth banks. However, it is recognised that these traditional field boundaries, with good vegetative cover and structural heterogeneity, provide supporting foraging habitat for hen harrier. A study by O'Sullivan *et al*. (2013) of 32 farms in Co. Galway showed that field boundaries can contribute a considerable proportion of the semi-natural habitat area on farms. On those farms, the majority of earth banks, drainage ditches with aquatic vegetation, and hedgerows, were more than two metres in width; hedgerows accounted for almost 45% of field boundaries, with earth banks at almost 5%, stone walls over 10% and drainage ditches at more than 15%.

Hedgerows that are variable in structure and diverse in species will support different bird faunas that inhabit different parts of the hedge (Brophy, 1994) and so, hedgerow structure is important in determining its condition. Moran & Wilson-Parr (2015) identified four main categories for assessing the condition of hedgerows greater than 20m in length; these are summarised in Table 3-6. These categories were discerned using aerial imagery, and include hedgerows with an intact and dense structure (3–4m wide) and hedgerows with a boxed and moderate structure (between 1–3m wide); these broadly overlap with those structural characteristics of hedgerows (1.5–2.5m high and preferably 3–4m wide) preferred by hunting hen harrier (see Irwin *et al*., 2012). Combined, these two categories of hedgerow account for

22% of the total extent (m) of hedgerows across the hen harrier SPA network. The combined lengths of these two subcategories as a proportion of the total hedgerow length is used here as a proxy for habitat condition.

Table 3-6. Summary for each SPA of the percentage (%) of hedgerow categories, using data extracted from Moran & Wilson-Parr (2015), for all those hedgerows mapped within the SPA boundaries. Totals, *i.e.* total length of hedgerows in metres (m), for each SPA also given.

SPA **Hedgerow Category**	**Slieve Beagh**	**Slieve Bloom Mountains**	**Slieve Aughty Mountains**	**Slievefelim to Silvermines Mountains**	**Stack's to Mullaghareirk Mountains, West Limerick Hills and Mount Eagle**	**Mullaghanish to Musheramore Mountains**	**SPA network**
Intact and dense structure WL1_A 3–4m %	4.8 (3,060)	11.0 (21,229)	6.3 (119,224)	0.01 (81)	0.4 (11,0945)	2.5 (2,584)	2.9 (157,273)
Boxed or moderate structure WL1_B 1–3m %	38.3 (24,624)	35.2 (67,720)	29.8 (566,292)	9.8 (62,896)	12.3 (314,730)	20.7 (21,296)	19.4 (105,756)
Sparse – fragmented structure WL1_C <1m %	54.0 (34,712)	36.5 (70,151)	51.4 (977,259)	88.0 (564,446)	83.6 (2,140,958)	76.8 (79,213)	70.8 (3,866,73)
WL1_D – unmanaged and overgrown >5m %	2.9 (1,888)	17.3 (33,330)	12.6 (239,754)	2.2 (13,874)	3.6 (92,957)	0	6.9 (381,803)
Total length of hedgerow (m)	64,284	192,430	1,902,529	641,297	2,559,740	103,093	5,463,373

Thus, for the SPA network, the linear extent of the total hedgerow resource should be at least 'stable'. With regard to hedgerow condition, the combined lengths of 'boxed and moderate' and 'intact and dense' as a proportion of the overall resource should be, at least, maintained.

*The **Target** for the SPA network is to maintain, at least, the length and quality of this resource to support the targets relating to population size, productivity rate and spatial utilisation.*

Table 3-7 sets out the individual data that underpin the attribute 'extent and condition of hedgerows' for each SPA; these are informed by the known linear extents of those key supporting hedgerow categories identified above, *i.e.* boxed and moderate and intact and dense (with a more detailed breakdown of hedgerow categories provided in Table 3-6).

Table 3-7. SPA targets for the attribute 'extent and condition of hedgerow'.

Site Code	Site Name	Total Extent	Supporting hedgerow extent	Target
004167	Slieve Beagh SPA	64.2 km	43% *i.e.* 27.7 km	Maintain the length and quality of this resource to support the targets relating to population size, productivity rate and spatial utilisation
004160	Slieve Bloom Mountains SPA	192.4 km	46% *i.e.* 88.9 km	Maintain the length and quality of this resource to support the targets relating to population size, productivity rate and spatial utilisation
004168	Slieve Aughty Mountains SPA	1,902.5 km	36% *i.e.* 685.5 km	Maintain at least the length and quality of this resource to support the targets relating to population size, productivity rate and spatial utilisation
004165	Slievefelim to Silvermines Mountains SPA	641.3 km	10% *i.e.* 62.9 km	Maintain at least the length and quality of this resource to support the targets relating to population size, productivity rate and spatial utilisation
004161	Stack's to Mullaghareirk Mountains, West Limerick Hills and Mount Eagle SPA	2,599.7 km	13% *i.e.* 425.7 km	Maintain at least the length and quality of this resource to support the targets relating to population size, productivity rate and spatial utilisation
004162	Mullaghanish to Musheramore Mountains SPA	103.1 km	23% *i.e.* 23.9 km	Maintain at least the length and quality of this resource to support the targets relating to population size, productivity rate and spatial utilisation

Other linear features that also support foraging hen harrier (*i.e.* earth banks, drainage ditches, watercourses) are found across the SPAs, but without data on their extent, targets for these features cannot be prescribed at this time.

4 Forestry within the SPA network

4.1 Overview

Using data from the first two national surveys, Wilson *et al*. (2009) noted that the main nesting habitat selected by breeding hen harrier in Ireland was pre-thicket forestry. Indeed, this scenario has persisted, with the majority of the SPA network's nests sited within forestry plantations (Ruddock *et al*., 2012; Ruddock *et al*., 2016). Wilson *et al*. (2009) found no evidence that the area of post-closure plantations negatively affected hen harrier nest distribution. For the 2000 and 2005 national surveys, nests in post-closure were closer than expected to heath/bog. Furthermore, Wilson *et al.* (2009) state that it is probable that within post-closure and heath/bog habitats, hen harriers selected nest sites at a more refined scale than could be determined from the resolution of the data that was available for use in this study (*e.g*., Coillte forest inventory, Forestry Inventory Planning (FIPS) and landcover datasets).

Pre-thicket, as it is described here, and previously in Wilson *et al*. (2009), generally refers to all first rotation forest between 1–12 years of age and all commercial forests recorded as having been clearfelled 3–9 years previously, or originally planted 45 years previously. This simplistic classification does not consider the inherent variability in growth rates across the forest estate when tree species, soil type and site conditions (*e.g.* exposure) are taken into account[13]. Wilson *et al.* (2010) highlighted that as "closed canopy forest persists for about two thirds of the plantation forest cycle, afforestation of open habitats that are used by hen harriers will ultimately lead to a net loss of suitable habitat, even if they use forests at pre-thicket stage (Bibby & Etheridge 1993)".

Caravaggi *et al.* (2019b), using data from the 2010 and 2015 national surveys (Ruddock *et al*., 2012; Ruddock *et al.,* 2016), showed that hen harrier territories in Ireland were positively associated with heath/shrub, bogs, areas at high elevation and pre-thicket coniferous forests. Although breeding success was also positively associated with heath/shrub and bog, pre-thicket forests were not, *i.e.* no effect on breeding success was observed.

Based on the best available evidence at the time, all age-classes of forestry were included in Ireland's breeding hen harrier SPA network, along with heath/bog and low-intensity managed grasslands. However, at any one time, over two-thirds of the forest estate is closed canopy and therefore of little use to hen harriers (Wilson *et al.,* 2012a; O'Flynn, 1983; Bibby & Etheridge, 1993; Sim *et al*., 2001).

[13] For the purposes of this document, and taking into account the definitions used in previous hen harrier research, pre-thicket is defined using age-class, *inter alia*, as provided in Wilson *et al.* (2009) and in Section 1.1 and in Section 4.1 above. In the forestry sector, the term pre-thicket can include older trees for some species (*e.g.* noble fir *Abies procera*), under some conditions, that do not reach closed canopy until they are 20 years or more, and as defined in the National Forest Inventory (DAFM, 2017), where a "forest is established, but the green branches are not yet touching".

The *Hen Harrier SPA Habitat Mapping Project* estimated that 52.3% of the network was under forest cover at that time (Moran & Wilson-Parr, 2015). Figure 4-1 shows that forestry covers significant portions of all six of the SPAs and that the majority of afforestation occurred in these areas prior to the first national survey (1998-2001), which began the process of identifying suitable areas for hen harrier SPAs.

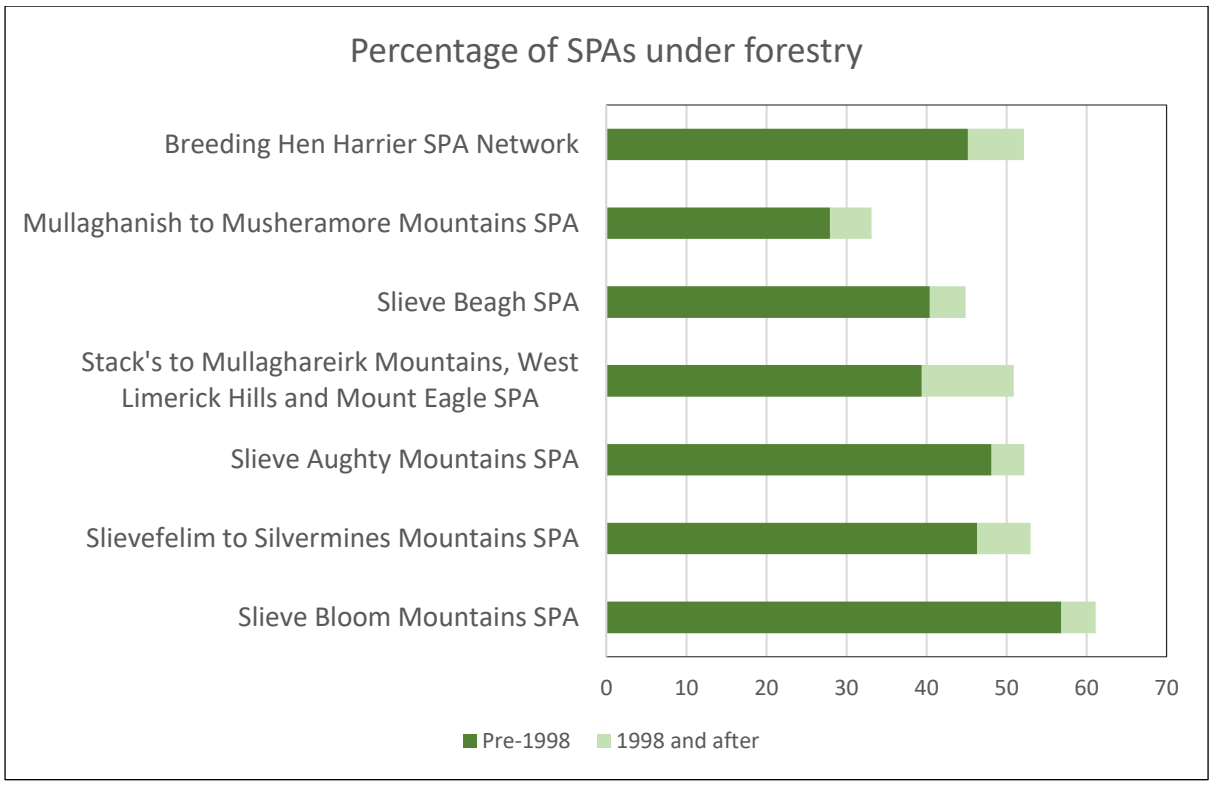

Figure 4-1. The extent of forestry within the breeding hen harrier SPA network approximately before and after the first national survey (Norriss *et al*., 2002).

Therefore, the conservation management of hen harrier populations in these areas is dependent on the appropriate management of the forest estate. In 2007, and coincident with the designation of the six breeding hen harrier SPAs, an agreement between the Forest Service and NPWS was reached (*i.e.* the Hen Harrier Protocol), that set out various conditions, including annual limits for afforestation rates at each of the SPAs. Based on the scientific data available at the time and using expert judgement, thresholds for annual afforestation were agreed in principle for a 15-year period (NPWS, 2015a), in order that each SPA contained at least 55% suitable habitat. To calculate this value, the then estimated extent of the heath/bog and the rough grassland in each SPA was combined with an area of forest (*i.e.* pre-thicket) that was considered to be suitable (*i.e.* first rotation plantations up to 12 years old and second rotation plantations aged between 3–8 years inclusive). This area of suitable forest was considered at the time to be one sixth of the total extant forest estate within the SPAs for the 15-year period. However, for various reasons (as outlined in NPWS, 2015a and as set out below *e.g.* Irwin *et al.*, 2012), this protocol for further afforestation was modified and

eventually suspended, with a resulting consequent decline in the afforestation rate within the network (Figure 4-2).

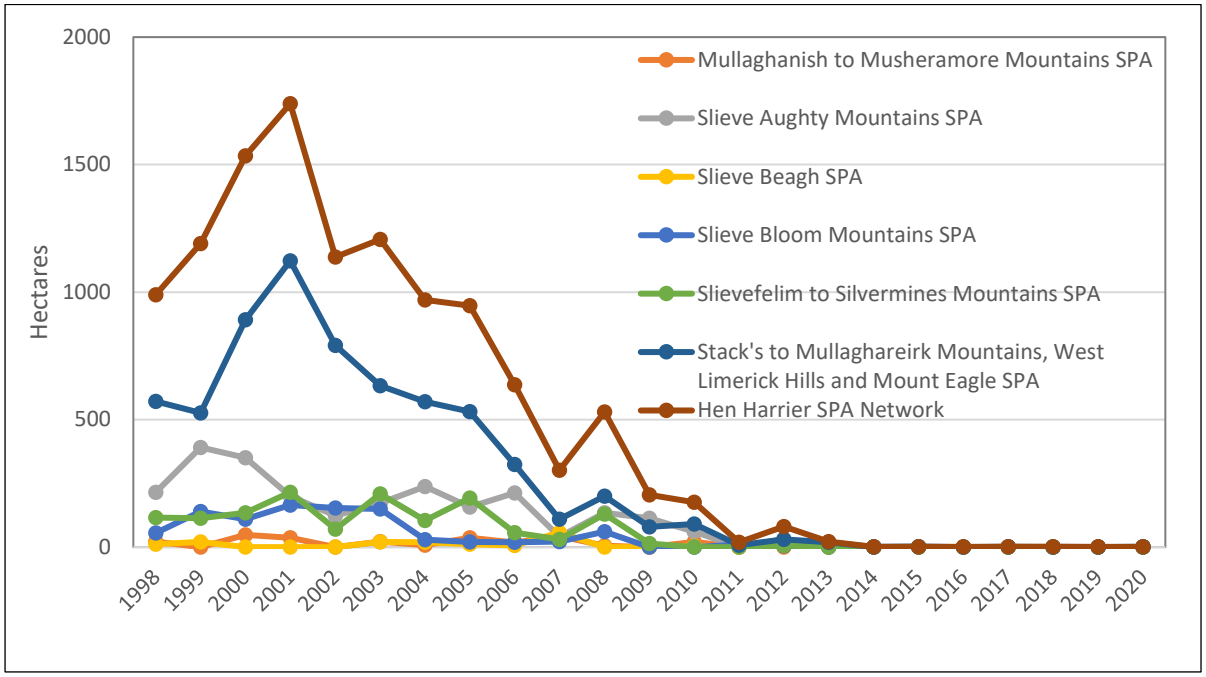

Figure 4-2. Afforestation rates (hectares per year) in the hen harrier SPA network pre- and post-designation. Unpublished data provided by the Forest Service (DAFM), 2021.

4.2 Age structure of the forest estate attribute

Figure 4-3 summarises an analysis from the *Hen Harrier SPA Habitat Mapping Project* (Moran & Wilson-Parr, 2015) and sets out the relative extents of the various forest coups that make up the forest estate, at both the SPA network level and at the individual SPA level.

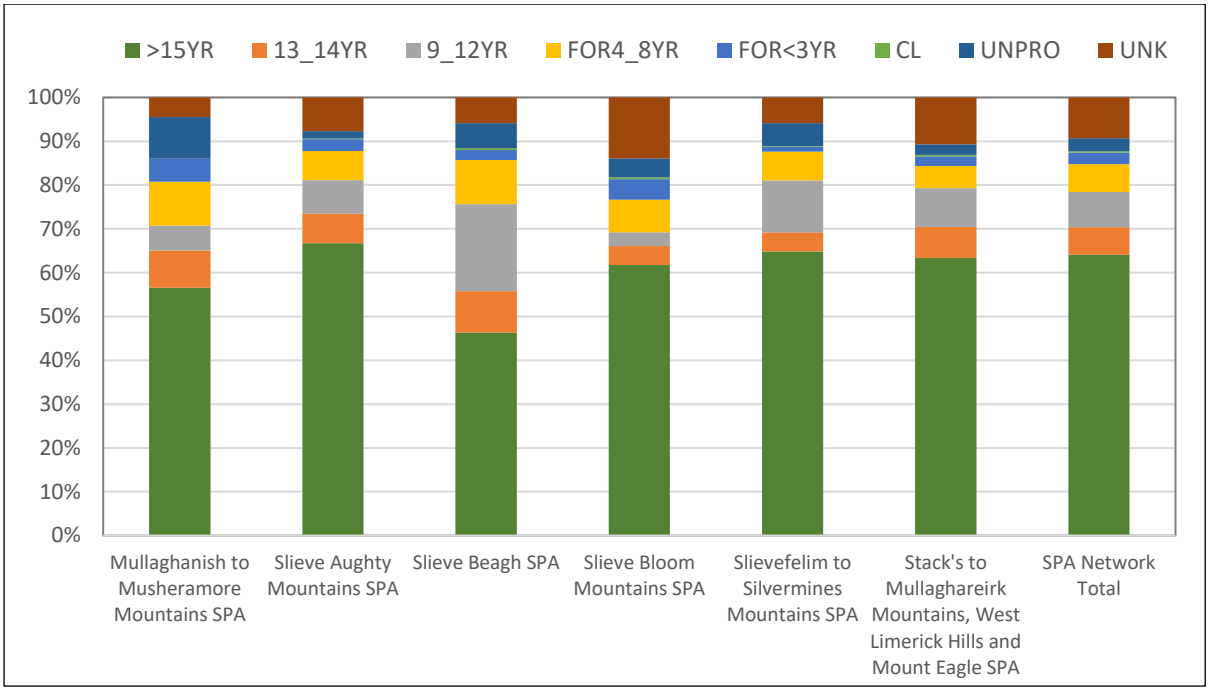

Figure 4-3. Proportion of various forestry habitat categories and age-classes per SPA and at the network level (UNK, Conifer plantation of unknown planting date; UNPRO, Unproductive sparse conifer plantation; CL, Clear-fell conifer plantation). Further details in Moran & Wilson-Parr (2015).

In the report *Hen Harrier Conservation and the Forestry Sector in Ireland* (NPWS, 2015a), the forest age-classes defined in Moran & Wilson-Parr (2015) were used, to hindcast and forecast estimated proportions of the age-classes of the forest estate over the period 2000–2045, that could be considered to be of use to hen harrier for nesting and foraging purposes. This indicative analysis is constrained by the precision of the forestry data available at the time[14]. The extent of pre-thicket forestry declined sharply for all SPAs during the period 2000–2012 with further declines predicted for all SPAs to circa 2025. Wilson *et al*. (2006) predicted a decline in carrying capacity and an associated decline in the hen harrier breeding population across its range in line with the envisaged reduction in the overall extent of pre-thicket resources as the plantations matured.

Irwin *et al.* (2012) noted that the long-term influence of forested areas on hen harrier is likely to be optimised by minimising fluctuations in the availability of forest growth stages over time, by ensuring that a consistent matrix of different-aged forest stands is maintained at the landscape level, and that such measures would help to avoid 'bottleneck' effects during periods where the landscape is dominated by closed canopy forest. Furthermore, maintaining a mix of forest growth stages in hen harrier areas would help to avoid periods in which cover of second rotation pre-thicket is dominant (*i.e.* avoid boom followed by bust scenario). In effect, achieving this 'consistent matrix' (Irwin *et al*., 2012) would promote a relatively constant

[14] Please refer to Tables 5-A and 5-B (in Appendix 5) for a breakdown of the projected extents of useable forest age-classes for nesting and foraging hen harriers, which are reproduced from NPWS (2015a).

amount of pre-thicket multi-year rotation forestry as a proportion of the overall forestry footprint at the SPA level.

In order to gauge the evenness of the relevant age-classes of the forest estate at the SPA network or the site level, one needs an estimate of the typical age of forest stands that are clear-felled. The harvest age of a particular stand of forest depends upon a multitude of factors, including tree type, soil type and environment, and commercial considerations. There is likely wide variation in harvest ages of forest coups across the SPA network. To help guide targets for this attribute, *i.e.* achieving this consistent matrix of age-classes for the SPA network and individual SPAs, using data from Moran & Wilson-Parr (2015), the limits of the age of harvest was estimated at 30–42 years, based respectively upon Farrelly (2020) and NPWS (2015a). If these harvest ages are representative, then the cumulative ages of the forest coups at the SPA level holding a more even or balanced aged forest estate are estimated to lie broadly within the dashed lines as illustrated in Figure 4-4. To aid interpretation of Figure 4-4, if an SPA's forest estate is achieving even age-group demographics, *i.e.* is meeting the target to achieve an even and consistent distribution of age-classes, then the values for pre-thicket would lie somewhere between approximately 30–40% of the overall forest estate, and the older age-classes at between 60–70%, depending on age of harvesting. As stated earlier, this crude analysis, based on a snapshot of 2013 forest demographics data presented in Moran & Wilson-Parr (2015), indicates that there is neither a consistent nor an even matrix of different forest age classes at the SPA network level, nor at the individual SPA level, with the possible exception of Slieve Beagh SPA. Definitive figures for each SPA cannot be produced at this time due to the lack of precision in the data analysis (NPWS (2015a); and as summarised in Appendix 5. In time, more precise data on the age-classes may become available, but further research would be needed to refine this target any further and it may not produce conclusive results.

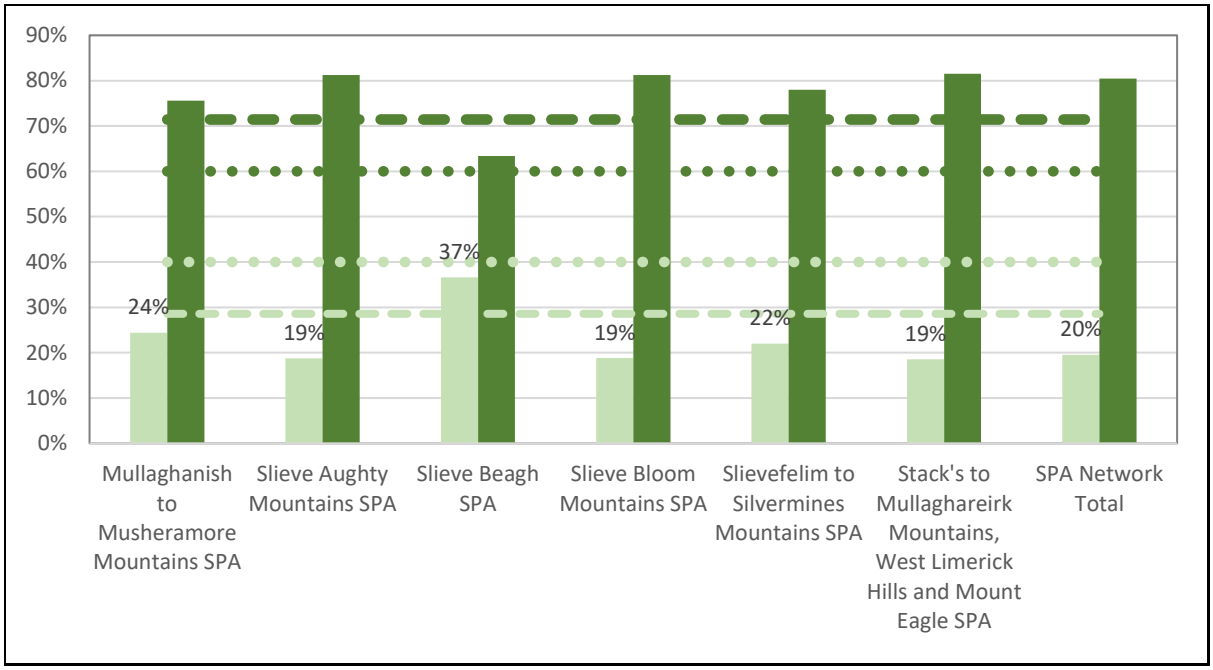

Figure 4-4. Estimated proportion of forestry age-classes per SPA and at the network level in 2013, grouped into those forest age-classes 12 years and younger, *i.e.* pre-thicket and 13 years and older, *i.e.* post-thicket. Forest age-class data from Moran & Wilson-Parr (2015).

Strategic or landscape-level management is required to help achieve greater evenness of forestry coup ages. The SPA network target for the attribute 'age structure of the forest estate' is to achieve an even and consistent distribution of age-classes across the forest estate. However, it should be noted that such analyses is at a scale greater than the individual hen harrier territory level. Parts of an SPA may be dominated by post-thicket 'closed-canopy' mature forestry that may displace nesting harriers from portions of the SPA. This conservation challenge is framed, to some degree, by way of the aforementioned attribute 'spatial distribution of breeding pairs' (see Section 2.3 above). Overall, the information set out in Figure 4-4 is a coarse assessment at the SPA level of the approximate proportion of pre-thicket to older age-classes of forestry, as set out in Moran & Wilson-Parr (2015) and the projected high-level targets to re-balance those proportions based on estimated ages of harvesting (*i.e.* 30–42 years).

As outlined earlier in Section 3 in relation to 'open habitat coherence', *i.e.* continuity of supporting open habitats, consideration is also to be given to the spatial configuration of the forest footprint itself. That is, even if percentage forest cover is similar across sites, and these forests are balanced in terms of age demographics, the arrangement of these forests across the landscape will likely affect the magnitude of impact on local breeding hen harrier populations, *i.e.* higher edge to area ratio of forests to open habitats is likely to be less favourable. As stated previously, such effects, if significant, will drive changes over time to the size and productivity of the SPA's breeding population and its spatial utilisation of the site.

*The SPA network **Target** for the attribute 'age structure of the forest estate' is to achieve an even and consistent distribution of age-classes across the forest estate.*

Targets for the attribute 'age structure of the forest estate' are set out in Table 4-1 below for each SPA. As highlighted in Figure 4-4, with the possible exception of Slieve Beagh SPA, the SPAs do not currently meet the requirements for favourable conservation condition for this attribute. Furthermore, as highlighted above, strategic level management across the network is required to achieve a more consistent and even matrix of age-classes across the forest estate.

Table 4-1. SPA targets for the attribute 'age structure of the forest estate' that are informed by the current known extents of forest age-classes in each SPA, as set out in Moran & Wilson-Parr (2015).

Site Code	Site Name	Target
004167	Slieve Beagh SPA	Maintain an even and consistent distribution of age-classes across the forest estate
004160	Slieve Bloom Mountains SPA	Achieve an even and consistent distribution of age-classes across the forest estate
004168	Slieve Aughty Mountains SPA	Achieve an even and consistent distribution of age-classes across the forest estate
004165	Slievefelim to Silvermines Mountains SPA	Achieve an even and consistent distribution of age-classes across the forest estate
004161	Stack's to Mullaghareirk Mountains, West Limerick Hills and Mount Eagle SPA	Achieve an even and consistent distribution of age-classes across the forest estate
004162	Mullaghanish to Musheramore Mountains SPA	Achieve an even and consistent distribution of age-classes across the forest estate

5 Disturbance to the breeding site attribute

The 2015 national survey set out to improve understanding of the pressures to hen harrier recorded within the vicinity of territories and/or suitable breeding habitat; a regional[15] breakdown was also presented (Ruddock *et al*., 2016). Observers were asked to record details, using pressure codes and descriptions utilised in Article 12 reporting under the Birds Directive, within 500m and 2km of the survey area. This information was used to derive a summary assessment of those pressures considered by the field observers to be influencing the species. The pressure indices derived using the observer data showed variability between 10km survey squares and across the regions in the occurrence and magnitude of disturbance activities. Full details are provided in Ruddock *et al*. (2016). Caravaggi *et al*. (2019b) revisited these 2015 national survey data to further explore the anthropogenic pressures acting on hen harrier within its breeding range in Ireland. Modelling by Caravaggi *et al*. (2019b) indicated a strong influence of activities relating to agriculture, forestry, and recreation as well as predator activity on surveys of areas that held territories.

Those pressures and disturbance activities of most significance to breeding hen harrier (forestry, agriculture and wind energy development) have been explored further elsewhere, (*i.e.* NPWS 2015a, NPWS 2015b, and NPWS, in prep). In addition, other potential disturbance activities include related disturbance from human recreation, persecution, wildfires and turf-cutting.

Disturbance to birds associated with human activity may take a variety of forms including noise, light, sound, vibration, trampling, and presence of people, animals and structures (Natural England, 2019a; 2019b). Gill (2007) set out the approaches to measuring the effects of human disturbance on birds. The primary manner in which human presence can impact birds is by altering their ability to exploit important resources, either through directly restricting access to resources such as food supplies, nesting sites or roosting sites, or by altering the actual or perceived quality of these sites. The nature, scale, timing and duration of some human activities can result in the disturbance of birds at a level that may substantially affect their behaviour, and consequently affect the long-term viability of the population (Natural England, 2019a; 2019b). Disturbance may undermine successful nesting, rearing, feeding and/or roosting, and/or may reduce the availability of suitable habitat as birds are displaced and their distribution within a site contracts.

Risks of such human-related disturbance include nest mortality and abandonment (Etheridge *et al*., 1997; Ruddock & Whitfield, 2007). Depending on the temporal and spatial nature of the

[15] Regional areas (as listed in Ruddock *et al*., 2016) include the following: Ballyhouras; Blue Stack Mountains, Pettigo Plateau, South Donegal; Boggeragh, Derrynasaggart Mountains; Castlecomer, Blackstairs, Kilkenny; Curlew Mountains; Devilsbit, Slievefelim, Silvermines, King Hill; East Cork, Waterford; Galtys Inishowen; Kildare; Knockmealdown, Kilworth, Comeraghs; Leitrim, Slieve Rushen; Longford; Nagles; North & West Clare; North-west; Ox Mountains; Roscommon; Slieve Aughty Mountains; Slieve Beagh; Slieve Bernagh-Keeper Hill; Slieve Blooms; South of Roscrea; Stack's, Glanaruddery, Knockanefune, Mullaghareirk Mountains; West Cork; West Kerry; Wexford; Wicklow Mountains.

disturbance, human activities within foraging ranges of breeding hen harrier can cause patch avoidance/or stress-related responses in foraging birds which may as a result stay away from their nests for longer periods, thereby increasing chick vulnerability (Caravaggi *et al*., 2020). Site-specific monitoring *e.g.* Slieve Bloom Mountains SPA (NPWS unpublished reports 2012-2016, J. Monaghan, NPWS) suggested the pressure from inadvertent disturbance by recreational users on breeding hen harrier in the SPAs could not be ruled out but more detailed supporting evidence linking recreational use to lower nest success or productivity in the SPA network is not currently available.

In Whitfield *et al*. (2008), based on expert opinion, the collective disturbance distances for hen harrier incubating and/or feeding young (and based on 'alert distance', static disturbance distance' and 'flight initiation distance' or 'active disturbance distance') is between 500–750m.

The effects of disturbance can be cross-cutting across the attributes described in Section 2 and Section 3. Chronic localised disturbance in an SPA can, for example, negatively impact population size, productivity, and spatial utilisation of breeding pairs and can also cause significant changes to the overall condition of supporting habitats. Some examples include:

- wildfires on heath and bog habitats;
- recreational pressures/footprints across open heath and bog habitats (*e.g.* Slieve Bloom Mountains SPA, unpublished NPWS reports (2010–2017) by J. Monaghan)
- reduced prey availability and/or productivity near wind turbines and displacement and/or collision impacts (NPWS, in prep.) and/or avoidance behaviour (Schaub *et al*., 2020)
- human-related disturbance to nesting pairs, including those pairs nesting proximate to or in forestry, increases risks of predation and reduced productivity (NPWS, 2015a).

The SPA network target for the attribute 'disturbance to breeding sites' is set out below with the targets for each SPA detailed in Table 5-1.

*The **Target** for the SPA network is that disturbance occurs at levels that do not significantly impact upon breeding hen harrier.*

Table 5-1. SPA targets for the attribute 'disturbance to breeding sites'.

Site Code	Site Name	Target
004167	Slieve Beagh SPA	Disturbance occurs at levels that do not significantly impact upon breeding hen harrier
004160	Slieve Bloom Mountains SPA	Disturbance occurs at levels that do not significantly impact upon breeding hen harrier
004168	Slieve Aughty Mountains SPA	Disturbance occurs at levels that do not significantly impact upon breeding hen harrier
004165	Slievefelim to Silvermines Mountains SPA	Disturbance occurs at levels that do not significantly impact upon breeding hen harrier
004161	Stack's to Mullaghareirk Mountains, West Limerick Hills and Mount Eagle SPA	Disturbance occurs at levels that do not significantly impact upon breeding hen harrier
004162	Mullaghanish to Musheramore Mountains SPA	Disturbance occurs at levels that do not significantly impact upon breeding hen harrier

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Appendix 1 Changes in national hen harrier population (and survey effort) from the 2000 to 2015 national surveys

Figure 1-A Reproduced from Ruddock *et al.* (2016) and highlights the increased survey effort (measured as hours) from the 2000 to the 2015 national surveys.

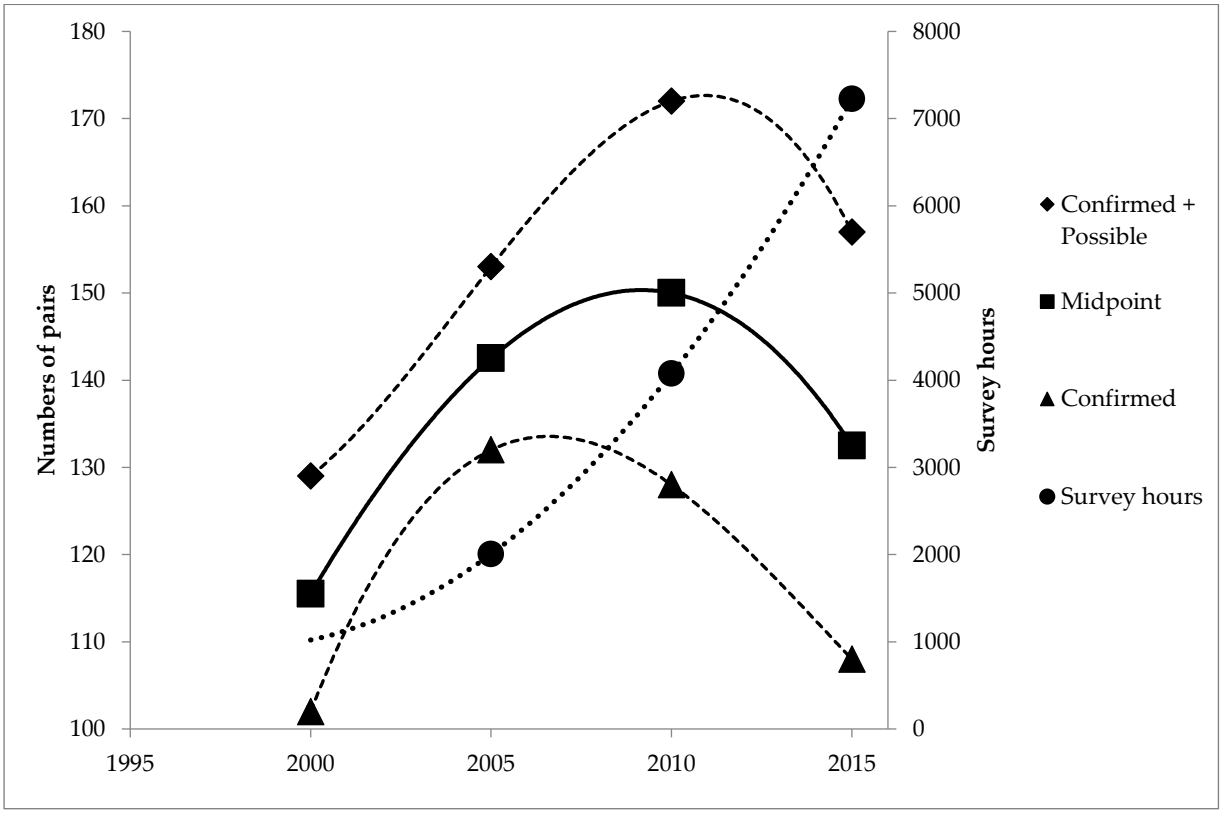

Figure 1. Graph showing the recorded population range and mid-point estimates, trendlines and survey effort (over the national Hen Harrier surveys).

Footnote: No value for survey hours was available for the 1998 – 2000 dataset and thus only the hindcasted trend predicted value is shown above.

Appendix 2 Classification of breeding status of hen harrier

Table 2-A Classification of breeding status of hen harrier (reproduced from Ruddock et al., 2016).

Breeding status	**Behaviours, evidence and/or activities observed**
Confirmed breeding	Food pass observed
	Adult carrying prey
	Recently fledged young
	Agitated behaviour or calls given by adults
	Direct evidence of a nest (eggs or chicks seen, chicks heard, used nest or eggshells found)
	Courtship or display behaviour involving both a male & female noted on two visits separated by at least a week
	A pair seen visiting a probable nest site on two visits separated by at least a week
	Nest building or carrying nest material
Possible breeding	Courtship or display behaviour involving both a male & female noted on only 1 visit, or only
	Only one bird is ever seen (*e.g.* displaying male seen twice but no female seen)
	A pair seen visiting a probable nest site on only one visit
	Pair or female seen in possible nesting habitat between mid-May & end of June
Seen	Single male, female or pair (outside mid-May & June) observed with no evidence of breeding behaviour
Not seen	Area of suitable breeding habitat with no observations of hen harriers

Appendix 3 Summary productivity data (2010 – 2016) for Slieve Bloom Mountains SPA

Table 3-A Summary productivity data *i.e.* numbers of fledged young per confirmed breeding pair, extracted from *Slieve Bloom Hen Harrier Breeding Season Reports* (Annual reports for the breeding seasons 2010-2016 prepared by Jason Monaghan, NPWS). Mean ± standard deviation (SDP) also provided.

Year	**Number of fledged young per confirmed pair**
2010	2.14
2011	0.6
2012	0.36
2013	1.5
2014	1.75
2015	1.17
2016	0.6
Mean ± SD	**1.16 ± 0.62**

Appendix 4 Breakdown of broad habitat categories set out in the *Hen Harrier Special Protection Area (SPA) Habitat Mapping Project 2014*

Table 4-A. The percentage (%) breakdown of broad habitat categories present in the Special Protection Areas (SPAs) as set out in the *Hen Harrier Special Protection Area (SPA) Habitat Mapping Project 2014* (please refer to Moran & Wilson-Parr, 2015 for further details).

SPA & Site Code **Habitat Category**	**Slieve Beagh 004167**	**Mullaghanish to Musheramore Mountains 004162**	**Slieve Bloom Mountains 004160**	**Slievefelim to Silvermines Mountains 004165**	**Slieve Aughty Mountains 004165**	**Stack's to Mullaghareirk Mountains, West Limerick Hills and Mount Eagle 004161**	**Total proportions within hen harrier SPA network.**
Low-intensity managed grassland	3.34	12.81	5.14	17.2	9.4	16.6	12.2
Scrub (& riparian woodland)	1.71	4.19	1.31	1.24	2.38	1.09	1.7
Broad-leaved woodland	0	0.18	1.6	0.53	1.2	0.12	0.75
Open peatlands	39.73	19	23.38	14.44	22.47	17.8	20.25
Medium to intensively managed grasslands	8.12	27.44	4.61	10.64	8.13	9.57	9.05
Non-habitat/Built Lands etc.	2.2	3.14	2.46	2.71	3.16	3.71	3.34
Land managed for Conifer plantation	44.98	33.14	61.15	53.03	52.23	50.9	52.31

Appendix 5 Breakdown of forest cover extent across the SPAs as set out in *Hen Harrier Special Protection Area (SPA) Habitat Mapping Project 2014*

Table 5-A Reproduced from NPWS (2015a).

Table 5-A The estimated extent of forest within the SPA network that is potentially useable as hen harrier **nesting habitat** for the period 2000 - 2045

	2000		2012		2025		2035		2045	
Special Protection Area / Site Code	Area (ha)	% of forest	Area (ha)	% of forest	Area (ha)	% of forest	Area (ha)	% of forest	Area (ha)	% of forest
Mullaghanish to Musheramore Mountains 004162 (4,975.6 ha)	648	**52**	371	**22**	116	**7**	298	**17**	670	**39**
Slieve Aughty Mountains 004168 (59,435.65 ha)	12773	**51**	5743	**18**	3751	**12**	4098	**13**	11663	**36**
Slieve Beagh 004167 (3,455 ha)	602	**62**	660	**41**	116	**7**	158	**10**	456	**28**
Slieve Bloom Mountains 004160 (21,761.25 ha)	4476	**44**	3430	**25**	1276	**9**	2016	**15**	4174	**30**
Slievefelim to Silvermines Mountains 004165 (20,909 ha)	5026	**59**	2609	**23**	1211	**11**	1579	**14**	4944	**44**
Stack's to Mullaghareirk Mountains, West Limerick Hills and Mount Eagle 004161 (56,627.2 ha)	11940	**54**	4950	**17**	3745	**13**	5016	**17**	10666	**4950**
Total	35465	**52**	17763	**20**	10216	**11**	13164	**15**	32573	**37**

Table 5-B Reproduced from NPWS (2015a).

Table 5-B The estimated extent of forest within the SPA network that is potentially useable as hen harrier **foraging habitat** for the period 2000 - 2045

	2000		2012		2025		2035		2045	
Special Protection Area / Site Code	Area (ha)	% of forest	Area (ha)	% of forest	Area (ha)	% of forest	Area (ha)	% of forest	Area (ha)	% of forest
Mullaghanish to Musheramore Mountains 004162 (4,975.6 ha)	783	63.11	510	30	295	17	568	33	878	51
Slieve Aughty Mountains 004168 (59,435.65 ha)	14197	56.15	7945	25	5710	18	7147	22	15804	49
Slieve Beagh 004167 (3,455 ha)	648	66.62	815	51	145	9	226	14	720	45
Slieve Bloom Mountains 004160 (21,761.25 ha)	5107	50.08	4045	29	2363	17	3414	25	6287	46
Slievefelim to Silvermines Mountains 004165 (20,909 ha)	5566	65.60	3119	28	1740	16	3483	31	5840	52
Stack's to Mullaghareirk Mountains, West Limerick Hills and Mount Eagle 004161 (56,627.2 ha)	13270	59.92	7261	25	5549	19	8499	30	13857	48
Total	39572	**57.9**	23695	**27**	15082	**18**	23337	**26**	43387	**49**