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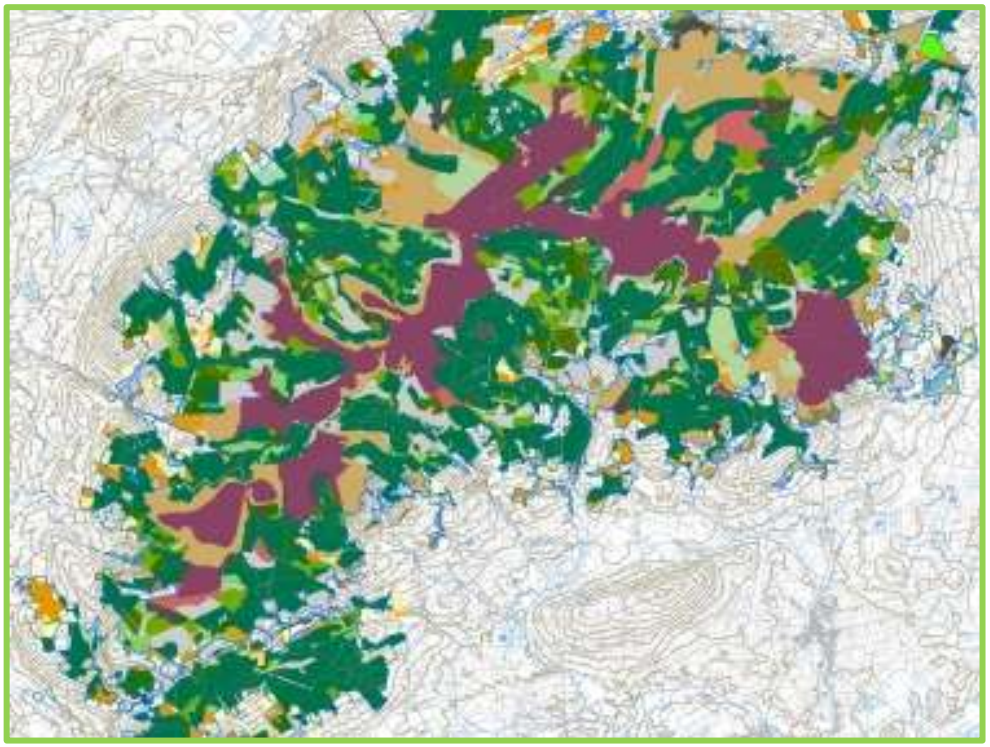
Hen Harrier Special Protection Area (SPA) Habitat Mapping Project 2014



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Hen Harrier Special Protection Area (SPA) Habitat Mapping Project 2014

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Executive Summary

Under Article 4 of the Birds Directive (Directive 2009/ 147/EC) six Special Protection Areas (SPAs), covering a total land area of *c*.1,671km², has been classified for the conservation of the Hen Harrier *Circus cyaneus* in Ireland. A survey of breeding Hen Harrier reported that 128 to 172 breeding pairs were recorded in 2010 which was broadly similar to the totals recorded in the previous survey in 2005. However notable declines were recorded in some traditional strongholds of this species' breeding range (Ruddock *et al.,* 2012).

In 2014 a Hen Harrier Habitat Mapping Project focusing on these SPAs and based on remote sensing techniques was undertaken. This produced a contemporary geospatially digitised habitat map for the six SPAs. Habitat categories that broadly correspond to the Fossitt Classification system (Smith *et al*., 2011) distinguish habitats of ecological relevance to Hen Harrier and a mapping resolution corresponding to the Ordnance Survey Ireland 1:5000 base-map allow land use within discreet enclosed land parcels to be readily identifiable.

Digital Globe Satellite Imagery 2013 was utilised for aerial interpretation of habitats. Several existing geospatially referenced datasets (National forest inventory datasets, National Parks & Wildlife Service habitat datasets) provided habitat data coverage equivalent to *c*.55% of the SPA land area. A digital geodatabase created within ArcGIS 10.2 integrated, categorised and quantified a total, *c*.169,152ha (1,691km²) of habitat within and overlapping the SPA boundaries.

The habitat map showed that strictly within the SPA network for breeding Hen Harrier, land managed for conifer plantation forest was the predominate habitat type, comprising *c*.52.3% of the total SPA area. Open peatland habitats formed *c*.20.2%; low intensity managed grasslands *c*.12.2%; medium to intensively managed grassland *c*.9%; non-habitat (built surfaces etc.) *c*.3.3%; scrub *c*.1.7%; broadleaved woodland and other natural and semi-natural open habitats comprised the remaining c.1%.

The mapping output covers an extensive area to a high thematic resolution (broadly Fossitt Habitat Level 3), and as such will serve as an important tool for spatial planning in SPAs, including environmental impact assessments (EIAs) and assessments required under Article 6 of the Habitats Directive to protect the Natura 2000 network.

This Irish Wildlife Manual provides detailed information on the methods employed in the production of this digital geodatabase. This will inform any future analyses of the recorded data as well as providing a template for the production of updated habitat maps of these important Hen Harrier areas.

Acknowledgements

We would like to express our sincere appreciation and gratitude to all FERS Ltd staff for their contribution to the Hen Harrier Habitat Mapping Project: Dr Kevin Black, Dr Ruth Carden, Kate Mc Knutt, Michelle O'Neill, Dr Sarah Ryan and Dr Emma Reeves. Thanks to Gareth John, Brian Carroll, Terence O'Rourke, Charles Stefanazzi and Mel Conway of the NPWS GIS Unit that provided technical support and access to spatial vector and raster datasets for use in the project. Thanks also to Robert Ovington of the Department of Environment, Community & Local Government for advice on outlining methodology options and data sources and to Margaret Guerin and Aoife Shinners of Ordnance Survey Ireland for assistance in accessing digital imagery. We would like to express our gratitude to Frank Barrett of the Forest Service, Department of Agriculture, Food & the Marine; and, Sharon Fitzpatrick and Marie Roche of Coillte for providing access to the Forest Inventory databases.

Introduction

The EU Birds Directive (Council Directive 2009/147/EC on the Conservation of Wild Birds) provides for the classification of Special Protection Areas (SPAs) across all member states to protect birds at their breeding, moulting and wintering areas as well as staging posts along their migration routes. The Directive instructs Member States to classify the most suitable sites as SPAs for regularly occurring migratory species and for those species listed on Annex I to the Directive.

The Hen Harrier *Circus cyaneus* is listed on Annex 1 and is also Amber listed on the Birds of Conservation Concern in Ireland (Colhoun & Simmons, 2013). Six SPAs covering a total land area of *c*.167,117ha (1,671km^2) have been classified for the conservation of this breeding species. A survey of breeding Hen Harrier reported that 128 to 172 breeding pairs were recorded in 2010 which was broadly similar to the totals recorded in the previous survey in 2005. However notable declines were recorded in some traditional strongholds of this species' breeding range (Ruddock *et al.*, 2012).

Detailed knowledge of the extent and nature of the various habitats contained within these large SPAs can provide valuable insights into the conservation condition of the breeding Hen Harrier populations. Importantly the conservation management of these areas can be significantly improved when it is based on such high resolution data.

Traditional methods of habitat mapping, involving field surveys of the entire area of the SPAs would be prohibitively expensive and time-consuming. As such, remote sensing techniques are more suited to the task of habitat-mapping such an extensive area (approximately 1700 km^2).

To this end, the National Parks and Wildlife Service (NPWS) though a public procurement process awarded a contract entitled "Provision of habitat data for six Hen Harrier Special Protection Areas using remote techniques" to Forest Environmental Research and Services Ltd.

The output of this project consists of polygon and linear shape-file habitat features for each of the six SPAs. The purpose of this brief report is to provide the information to allow a 3rd party to optimally interrogate the habitat data and to provide the methodology utilised in order to allow for a repeat of the mapping work to be done as a part of future monitoring such that any future maps produced will be directly comparable.

Methodology

Selected Sites

Ireland has designated six sites as SPAs for breeding Hen Harrier (see Table 1 and Figure 1).

Table 1: Special Protection Areas designated for breeding Hen Harrier

Site Code	Site Name	Land Area (hectares)*
IE0004160	Slieve Bloom Mountains SPA	21,771
IE0004161	Stacks to Mullaghareirk Mountains, West Limerick Hills and Mount Eagle SPA	56,610
IE0004162	Mullaghanish to Musheramore Mountains SPA	4,961
IE0004165	Slievefelim to Silvermines Mountains SPA	20,917
IE0004167	Slieve Beagh SPA	3,449
IE0004168	Slieve Aughty Mountains SPA	59,407

* Areas from NPWS SPA Shapefile ITM Positional Accuracy Improved (PAI) Version 3.

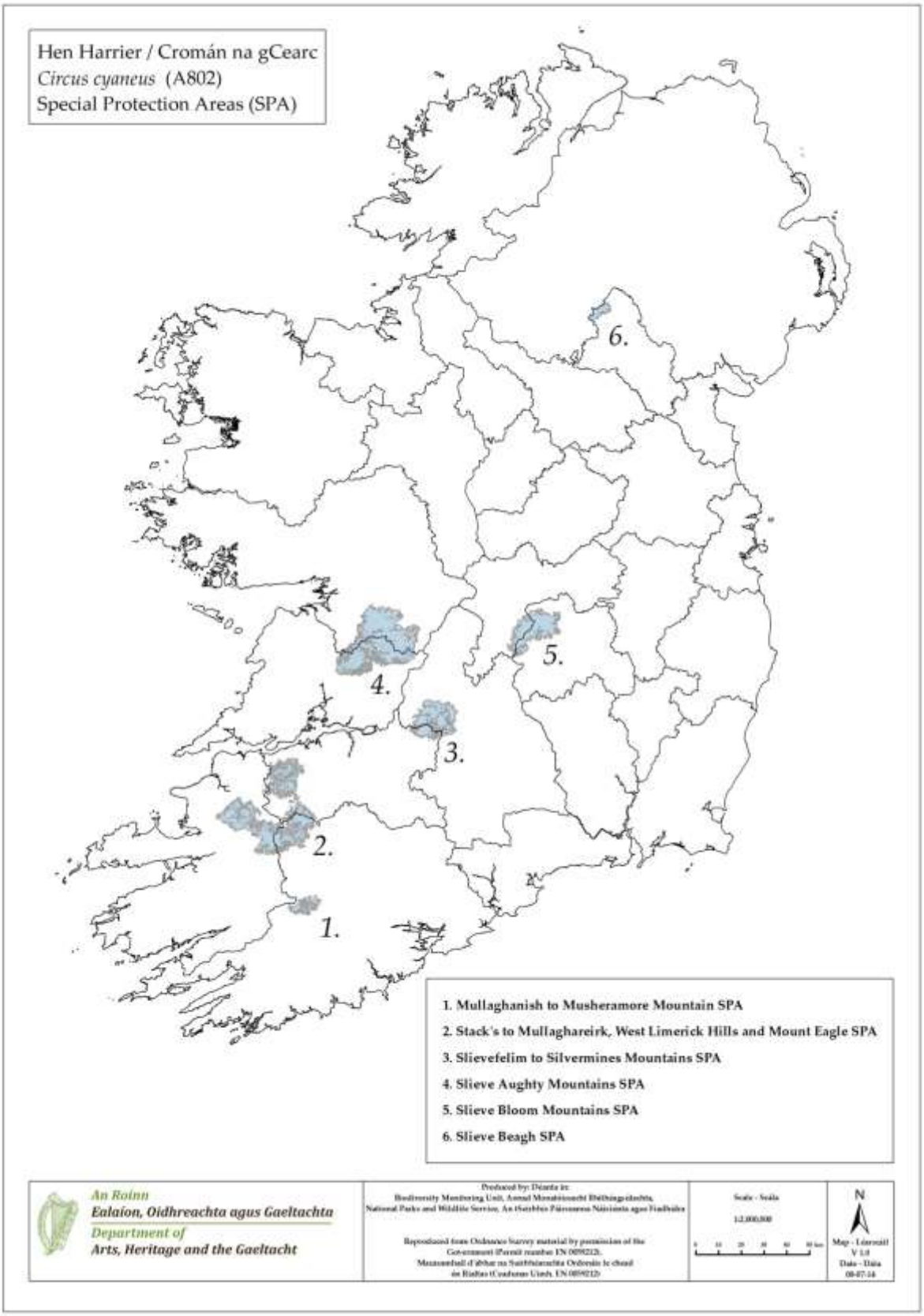
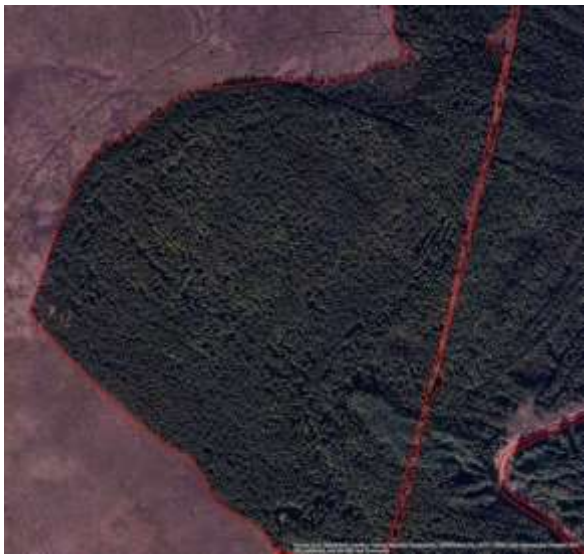


Figure 1: Locations of selected SPAs for Habitat Mapping Project.

Definition of Habitat Categories

Habitat categories are for the most part based on those as set out in "A Guide to Habitats in Ireland" (Fossitt, 2000). It must be noted, however, that this mapping project is approached from the point of view of habitat suitability for Hen Harrier rather than floristic composition, and as such, a number of modifications to the Fossitt system were required. In addition, owing to the large area concerned, habitats were limited to those defined here. All habitat categories utilised during this project are defined in Table 2.

Table 2: Habitat definitions and relevant habitat code utilised in geodatabase.

Site Code	Site Name	Land Area (hectares)*
FOR>15YR	Conifer plantation older than 15 years of age	
F0R13_14YR	Conifer plantation between 13 and 14 years of age.	

FOR9_12YR	Conifer plantation between 9 and 12 years of age.	
FOR4_8YR	Conifer plantation between 4 and 8 years of age.	
FOR<3YR	Conifer plantation of up to and including 3 years of age.	
FOR_UNK	Conifer plantation of unknown planting date.	Image not applicable

CL	Clear-fell conifer plantation.	
UNPRO	Unproductive sparse conifer plantation. Stands of conifer plantation at a high elevation on blanket peat typically above 400m above sea level (asl) or at the upward unenclosed margins of forest parcels.	
GA1	Improved agricultural grassland. Fields of high intensity managed grassland with <30% Juncus cover typified by a homogenous colour and obvious indications of management.	

MG_C3	Mosaic grassland. Fields of moderate to low intensity managed grassland with clustered Juncus cover ranging from 30 – 39%. Additional habitat categories may be present and relevant attribute fields must be allocated values.	
MG_C4	Mosaic grassland. Fields of moderate to low intensity managed grassland with clustered Juncus cover ranging from 40 – 49%. Additional habitat categories may be present and relevant attribute fields must be allocated values.	
MG_D3	Mosaic grassland. Fields of moderate to low intensity managed grassland with dispersed Juncus cover ranging from 30 – 39%. Additional habitat categories may be present and relevant attribute fields must be allocated values.	

MG_D4	Mosaic grassland. Fields of moderate to low intensity managed grassland with dispersed Juncus cover ranging from 40 – 49%. Additional habitat categories may be present and relevant attribute fields must be allocated values.	
RG	Rough grassland. Fields of low intensity or evidently unmanaged grassland with Juncus cover >50%. Additional habitat categories may be present and relevant attribute fields must be allocated values. This category was originally set at >70%, however there were concerns over mismatches between subjectivity and interpretation of orthophotography and field validation. Fields with >50% Juncus had only slight grazing/management and structurally were representative of vegetation of >1m in height and with several years growth. It is considered that this >50% also retains the relevance of this habitat category to the Hen Harrier. This revised category is more efficient for ortho-processing and offers greater consistency with field validation.	

GS1	Dry calcareous grassland and neutral grassland. Unimproved or semi-improved dry grassland that may be either calcareous or neutral, but not acid. Associated with low intensity agriculture and typically occurs on free-draining mineral soils.	
GS3	Dry-humid acid grassland. Unimproved or low to medium intensity managed grassland that occurs on free-draining soils that may be dry, humid, but not waterlogged. This type of grassland mainly occurs on mineral rich or peaty podzols in upland areas. Floristically, this habitat category can occur in medium to intensively managed agricultural fields, however emphasis should always be on structural condition relevant to the Hen Harrier and any indication of medium to intensive management in acid grassland should be categorised as GA1.	
GM1	Marsh. Marsh is found on level ground near riverbanks, lakeshores and in other places where mineral or shallow peaty soils are waterlogged, and where the water table is close to ground level for most of the year.	

HH	Heath. Combined categorisation for dry siliceous heath and wet heath. Heath includes areas where the vegetation is open and there is at least 25% cover of dwarf ericaceous shrubs, or where mosses dominate in the case of some montane areas. Additional habitat categories may be present and relevant attribute fields must be allocated values.	
HD1	Bracken. Areas of open vegetation that are dominated by Bracken (*Pteridium aquilinum*). Cover of the fern may be patchy or continuous, but should exceed 50% cover overall.	
PB2	Upland Blanket Bog. Upland blanket bog occurs on flat or gently sloping ground above 150m asl and is widespread on hills and mountains through the Republic of Ireland. The 150m asl limit serves to distinguish upland from lowland blanket peat but is loosely applied.	

PB3	Lowland Blanket Bog. Lowland Blanket Bog is largely confined to wetter regions along the western seaboard where the annual rainfall exceeds 1250mm, occurring on flat or gently sloping ground below 150m.	
PB4	Cutover Bog. This category should be used in situations where part of the original mass of peat has been removed through turf cutting or other forms of peat extraction.	
WD1	Mixed Broadleaved Woodland. This general category includes woodland areas with 75 – 100% cover of trees, and 0 – 25% cover of conifers. Trees may include native and non-native species.	

WS1	Scrub. This broad category includes areas that are dominated by at least 50% cover of shrubs, stunted trees or bramble. The canopy height is generally less than 5m, or 4m in the case of wetland areas. Scrub can be either open, or dense and impenetrable.	
WN5	Riparian Woodland. Riparian Woodland is dominated by stands of Willows that may include native (*Salix cinerea, S. pupurea, S. triandra*) and non-native (*S. fragilis, S. alba, S. viminalis*) species. Alder (*Alnus glutinosa*) is occasional. Fossitt defines this habitat as wet woodland of river margins (gallery scrub) and low islands that are subject to frequent flooding or where water levels fluctuate as a result of tidal movement (in lower reaches of river systems) however for the purposes of this mapping project, *Salix* is an important habitat for prey species of the Hen Harrier in cases where it colonises wet hollows and disturbed peat and acid grasslands, along upland stream catchments and where it encroaches onto open habitats at the edges of unmanaged track ways, fire breaks and between parcels of conifer plantation.	
WL1_A	Hedgerow with an intact and dense structure. Hedgerows over 20m in length and between 3 to 4m width.	
WL1_B	Hedgerow with a boxed or moderate structure. Hedgerows over 20m in length and between 1 to 3m width.	
WL1_C	Hedgerow with sparse, in some cases a fragmented structure.	

	Hedgerow over 20m length less than 1m in width.	
WL1_D	Hedgerow unmanaged and overgrown over 20m length and over 5m width.	
WL2	Treeline. A treeline is a narrow row of trees that is greater than 5m in height and typically occurs along field or property boundaries. Most treelines are planted and are often regularly spaced.	

Preparation of Digital Habitat Maps

Mapping to boundaries (attribute "LAND_PARCE")

The OSI 1:5000 boundary line was chosen as the base-layer upon which all habitat mapping was based. The SPA boundary data to be used for all habitat mapping was version 3 (Positioning Accuracy Improved (PAI) SPA boundaries in ITM). Previous versions of the SPA boundary were mapped on six inch maps and there are a number of discrepancies in SPA boundaries fitting neatly onto field boundaries in OSI 1:5000. If there were fields traversing the SPA boundary whole field, as it exists in the OSI 1:5000 base layer, was mapped. For this reason, a 500m buffer round the SPA boundary was established prior to mapping to ensure that any overlap was afforded full coverage in the habitat map. All habitats mapped by discrete polygons/lines were assigned an attribute "LAND_PARCE" within the relevant shape-file. "Select by location", was utilised to select if the discrete polygon/line feature was within the SPA boundary. Features contained within the SPA boundary have a value of "IN" for this attribute. Features traversing the SPA boundary, or outside of the boundary but considered of importance with regards to providing an ecological corridor (such as a hedgerow bounding a field that has been excluded from the SPA) have a value of "OUT" for this attribute.

Correction of existing datasets (attribute "BOUND_COR")

All habitats mapped by discrete polygons were assigned an attribute "BOUND_COR" within the relevant shape-file. This attribute notes whether an existing shape-file (FORESTRY12 or NPWS shape-file) has been extended or corrected to fit the Digital Globe Imagery 2013 or OSI 1:5000 boundary lines.

There were three potential categories:

1) Shape-file polygon belonging to an external dataset used in the mapping process has undergone correction to fit to the OSI 1:5000 anchor layer (having a value of 1 in the "BOUND_COR" attribute).

2) Shape-file polygon belonging to an external dataset used in the mapping process has undergone correction to fit to the actual habitats as represented on the Digital Globe Orthophotography (having a value of 2 in the "BOUND_COR" attribute).

3) Shape-file polygon belonging to an external dataset used in the mapping process has undergone correction to fit to both the OSI 1:5000 anchor layer and the actual habitats as represented on the Digital Globe Orthophotography (having a value of 3 in the "BOUND_COR" attribute).

Where the mapping of a discrete habitat polygon was not based on a pre-existing resource, the value assigned to the "BOUND_COR" attribute is 0.

Mapping of Habitat

Habitat (with an attribute "HABITAT_CO" indicating the habitat code of the mapped habitat) was mapped according to the habitat definitions as set out in Table 2. Habitat occurring in enclosed land parcels (fields) was mapped on a polygon basis (utilising the autocomplete polygon create feature and trace). There were several habitats in which additional habitat classes were recorded – (MG_C3, MG_C4, MG_D3, MG_D4, RG, HH and WS1). It was required that additional habitat classes be categorised and a subjective assessment of its cover with the land parcel noted (see below).

Outside of fields, habitat mapping was carried out on the basis of discrete polygons of habitat >25m² where possible. Again, there were several habitats in which additional habitat classes were recorded – (MG_C3, MG_C4, MG_D3, MG_D4, RG, HH and WS1). It was required that additional habitat classes be categorised and a subjective assessment of its cover with the land parcel noted

Hedgerows and treelines were mapped (utilising the create feature and trace) as linear features and fit OSI 1:5000 as relevant.

The attributes associated with additional habitats are described below:

- "ADD_HAB" – denotes an additional habitat category occurring within a discrete polygon.
- "ADD_HAB2" – denotes a second additional habitat category occurring within a discrete polygon.

Associated with the attributes "ADD_HAB" and "ADD_HAB2" were fields quantifying the proportion of additional habitat occurring ("ADD_HAB_CO" and "ADD_HAB2_C" respectively).

For "ADD_HAB_CO", the following values were assigned:

0 0 – 9% Additional habitat cover in total within polygon.

1 10 – 19% Additional habitat cover in total within polygon.

2 20 – 29% Additional habitat cover in total within polygon.

3 30 – 39% Additional habitat cover in total within polygon.

4 40 – 49% Additional habitat cover in total within polygon.

For "ADD_HAB2_C", the following values were assigned:

0 0 – 9% Additional habitat cover in total within polygon.

1 10 – 19% Additional habitat cover in total within polygon.

2 20 – 29% Additional habitat cover in total within polygon.

Associated with each mapped polygon/line feature are a number of other attributes:

AREA_HA (polygon habitats only)

This attribute denotes the area of the polygon feature in hectares. This value is determined by utilising the "Calculate Geometry" function.

SHAPE_LENG (linear habitats only)

This attribute denotes the length of the linear feature in metres. This value is determined by utilising the "Calculate Geometry" function.

SITE_NAME

This attribute denotes the name of the SPA within which the polygon/linear feature occurs.

SITE_NUMBE

This attribute denotes the site number of the SPA within which the polygon/linear feature occurs.

SURVEY_TYP

This attribute denotes the data-type on which discrete polygon/linear features were mapped, and is based on the guidelines outlined in "Best Practice Guidance for Habitat Survey and Mapping" (Smith *et al* 2011). The value assigned to this attribute for each polygon/line feature is according to the following convention:

S Habitat classification verified by ground truthing.

DC Habitat classification is derived from desktop interpretation of Digital Globe Satellite imagery supplemented by additional data sources of good quality (FORESTRY12, existing NPWS datasets).

DD Habitat classification is derived from desktop interpretation of Digital Globe Satellite imagery only.

PRIMARY_SE

The rotation of pre-thicket forestry (for the purposes of this project forestry belonging to the following categories FOR9_12YR, FOR4-8YR, FOR<3YR and FOR_UNK), i.e. primary or secondary rotation, was considered of utmost importance owing to the importance of this habitat for Hen Harrier. It was initially hoped to categorise this based on OSI orthophotography from 2000. If forestry was not present within the forest parcel identified from the Digital Globe Satellite imagery in the 2000 ortho, the forestry parcel would be considered primary rotation. This method, however, proved to be unsuccessful. Following consultation with Coillte, a database outlining the rotation status of **a** proportion of the forestry within the appropriate age class at each site was provided, and in combination with the FORESTRY12 data provided information on a proportion of the forestry at each site. One of the primary functions of ground truthing parcels of forestry of unknown planting date was to determine if the forestry was primary or secondary rotation. The default value of this attribute is 0, indicating unknown rotation. A value of 1 denotes primary rotation and a value of 2 denotes secondary rotation.

Sources of Data

It should be noted that although numerous sources of data were made available for the purposes of the project, the degree to which data could be used was limited, and the primary sources of data utilised were:

1) OSI vector mapping 1:5000 (boundary line).
2) Digital Globe Satellite Imagery (most up to date version available 2013 imagery)
3) FORESTRY12 dataset as updated by Frank Barrett of the Forest Service until 27/01/14.
4) Data regarding planting rotation within the SPAs as provided by Sharon Fitzpatrick of Coillte.
5) NPWS Blanket Bog NHA polygon data set.

OSI Vector Mapping 1:5000

OSI vector mapping (1:5000) was provided, and from this data, the "boundary line" OSI data was utilised as the anchor for habitat mapping. Where possible (for the most part individual fields), discrete polygons were mapped to the OSI 1:5000 boundary line.

Digital Globe Satellite Imagery

While the Digital Globe Satellite Imagery (from orthophotography collected and sourced predominantly from the summer of 2013) is available online, NPWS also provided a hard copy of the relevant tiles. In order to speed up the habitat classification process, the off-line hard-copy of the imagery was utilised. The relevant tiles for each site were merged using the "mosaic to new raster" function within ArcGIS. Non-forestry habitat classification was based almost entirely on this dataset.

FORESTRY12 dataset

NPWS was provided with the FORESTRY12 dataset updated by Frank Barrett (until 27/01/14). Utilising this dataset, the attribute "pyear" was utilised to categorise forestry according to the age classes required by habitat definitions. Where the attribute "pyear" was blank, the forestry was assigned to the category FOR_UNK (plantation of unknown planting date). It should be noted that this dataset was not anchored on the OSI 1:5000 base map and although the dataset provided information as to the age of forestry parcels, all forestry parcels required digitisation.

Data regarding planting rotation within the SPAs (Coillte)

The FORESTRY12 dataset provides no information as to rotation. Having consulted with Frank Barrett of the Forestry Service, Coillte were consulted and Sharon Fitzpatrick, Resource GIS Analyst with Coillte, provided a dataset with limited information regarding rotation. This allowed the assigning of primary or secondary rotation to a proportion of the forestry parcels of the appropriate age cohort.

NPWS Blanket Bog NHA polygon dataset

While NPWS provided numerous datasets, such as those generated by the semi-natural grasslands survey, the upland survey, the semi-native woodland survey, etc., the only dataset that yielded meaningful data on the scale required was the NPWS Blanket Bog NHA polygon data set. This data set was consulted, in conjunction with Digital Globe Satellite imagery when assigning habitats to habitat categories PB2, PB3 and PB4.

Ground Truthing

Limited ground truthing was carried out at each of the six SPA sites. Although the initial tender proposed a maximum of 15 days to be spent on ground truthing, in reality, 41 person-days were spent ground truthing, with 29 person-days spent in the field, and a further 12 days in the choosing of sites, preparation of site packs, etc. Parcels of forestry of unknown planting date were chosen as the primary habitat type to visit, with adjacent habitats also being ground truthed.

Forestry parcels of the type FOR_UNK were exported as a shape-file. Each parcel was assigned a unique ID number and then sites were chosen at random to allow for a representative sample of sites from within the SPA boundary to be visited. It must be noted, however, that for the most part, forestry of unknown planting date is located on private lands. In order to avoid conflict with potentially hostile landowners therefore, sites at which access/viewing from public roads was possible were given priority. Having chosen field sites, each site was designated a unique FID, and a site pack (approximately 15 sites per day), consisting of paper copies of the OSI base-map and the Digital Globe Imagery of each ground truth site were prepared. Using a 64GB IPAD with both wireless and cellular connectivity, all sites were located using Google Maps and bookmarked with the unique FID. When in the field Google Maps on the IPAD was utilised to navigate between sites, and to verify that the correct location was visited during ground truthing.

Having identified the forest parcel and adjudged whether the parcel was primary or secondary rotation, a selection of surrounding habitat parcels (and in particular mosaic grassland and rough

grassland habitats) were ground truthed by marking the habitat type present on the print-out of the Digital Globe Imagery for each site. Having completed ground truthing at each site, the marked aerial images were utilised to update the habitat map in ArcGIS. Ecologists involved in site pack preparation and ground truthing were: Dr Patrick Moran; Dr Ruth Carden; Kate Mc Knutt; Michelle O'Neill; Dr Sarah Ryan and Dr Emma Reeves.

Limitations

The single largest limitation the project encountered concerned the lack of existing datasets mapped to the OSI 1:5000 basemap. None of the datasets provided (including the SPA boundary) were mapped to the OSI 1:5000 basemap. This, critically, more than doubled the amount of work required to fulfil the requirements of the tender. The primary data-source utilised for identifying non-forestry habitats was the Digital Globe Satellite Imagery. The categorisation of habitats based on the interpretation of aerial images has an inherent limitation in that it is dependent on the ecologist interpreting the image. The categorisation of many of the habitat types is subjective, and different ecologists may assign different habitat categories.

The existing NPWS datasets, such as the Semi-Natural Grasslands and Semi-native Woodland datasets were based on the Fossitt categorisation of habitats. The mapping carried out for this project was, for the most part, only loosely based on the Fossitt categorisation of habitats, and focussed on structural and management aspects, rather than species composition. As a result, the data present in these data-sets (which was very limited given the huge scale of the mapping project) was of no significant use. The exception was the NPWS blanket bog NHA polygon dataset, which was of sufficient scale to be utilised for the purposes of this project.

As part of the tendering process the ground truthing part of the work was predicted to constitute approximately 15 days of the overall work. This was a significant underestimation of the actual days required to successfully undertake a robust ground truthing approach. A minimum of 60 days, and preferably 90 days should be allowed for ground truthing in any future monitoring survey of this scale.

An inherent bias exists in the sites chosen for ground truthing. This bias is present owing to the fact that much of the land surveyed was in private ownership, and access/viewing from a public road was considered a priority in site choice. This bias is unavoidable owing to the potentially hostile nature of land-owners as regards surveys of this kind.

Ground truthing indicated that the designation of grassland as Rough Grassland or Mosaic Grassland is best carried out using interpretation of aerial images rather than site visits, unless a lengthy walk-

through survey of the field is undertaken. An ecologist's view on the ground (and especially from the side of the road if the land in question is private) is very limited relative to aerial imagery.

Ground truthing indicated the rapidity with which Rough Grassland and Mosaic Grassland can be rendered into Improved Agricultural Grassland through very basic management. Ground truthing indicated that the habitat GS3 is regularly underestimated as it is often a large component of areas of heath and some areas of rough grassland.

Quality Control

Several processes were involved in the quality control of each dataset:

- Several ecologists were involved in the mapping of each site. This exercise was carried out in order to negate some of the inter-ecologist differences in aerial interpretation of habitats.
- Following the initial completion of each site, habitat mapping was independently reviewed by Ryan Wilson-Parr. This was an iterative process, with the feedback regarding habitat categorisation in sites feeding into the mapping of subsequent sites. The most common comment concerned the difference between a botanists interpretation of semi-natural grassland types (based on floristic composition) and the importance of different types of grassland from a Hen Harrier point of view (largely structural and therefore management as opposed to floristic composition)
- Having taken into account the independent reviews, and the ground truthing, polygon and linear habitat shape-files were prepared for each site, and GIS quality controls carried out on these shape-files.

GIS quality controls consisted of -

Multi-part polygon check –

This check was to ensure that no multi-part polygons were present within the dataset. The dataset table was converted to an excel spreadsheet, and a check for any duplicate FID values was carried out within excel using conditional formatting.

Geometry Check –

Having carried out the multi-part polygon check, the check geometry tool (which generates a report of any geometry problems within a feature class dataset) within ArcGIS was utilised to ensure that polygon and linear data sets were free of geometry errors.

Intersection

Utilising the intersect feature of the Geoprocessing tools within ArcGIS, any overlaps, etc. were identified. Through a combination of manual checking and automated checking using ETGeowizards (clean polygon, clean polyline, etc.), any overlaps, slivers, etc. were repaired to ensure the dataset was free from topological errors.

Outputs

The output of this project is the provision of habitat geodatabase (based primarily on remote techniques) for six Hen Harrier Special Protection Areas. The output consists of 12 shape-files (a polygon habitat shape-file and a linear habitat shape-file for each of the six Hen Harrier Special Protection Areas) and this report, which describes the methodology utilised to generate the shape-files. In total, *c*.169,152ha (1,691km²) of habitat was digitised, with approximately 53% of the area mapped based on data provided by FORESTRY12, and the remainder based largely on the interpretation by ecologists of Digital Globe Satellite Imagery of the six sites. A summary of habitat categories and areas within each of the six Hen Harrier SPAs is provided in Table 2 below.

Table 2: Summary of habitat cover in six SPAs from 2013 Digital Globe Satellite Imagery.

Habitat Code	Slieve Beagh 004167		Mullaghanish to Musheramore Mountain 004162		Slieve Bloom Mountains 004160		Slievefelim to Silvermines Mountains 004165		Slieve Aughty Mountains 004168		Stack's to Mullaghareirk Mountains, West Limerick Hills and Mount Eagle 004161		Total Proportions within Hen Harrier SPA network.	
	Area (ha)	% Cover	Area (ha)	% Cover	Area (ha)	% Cover	Area (ha)	% Cover	Area (ha)	% Cover	Area (ha)	% Cover	Area (ha)	% Cover
FOR_UNK	91.08	2.64	73.74	1.49	1855.06	8.52	647.61	3.10	2384.42	4.01	3088.90	5.46	8140.81	4.87
FOR_UNPRO	88.32	2.56	155.48	3.13	568.99	2.61	588.97	2.82	519.48	0.87	688.14	1.22	2609.38	1.56
FOR<3YR	35.59	1.03	86.98	1.75	631.40	2.90	119.27	0.57	824.52	1.39	613.09	1.08	2310.85	1.38
FOR>15YR	718.15	20.82	930.39	18.75	8226.01	37.78	7189.68	34.37	20706.54	34.86	18262.42	32.26	56033.19	33.53
FOR13_14	145.84	4.23	139.63	2.81	572.74	2.63	485.71	2.32	2097.41	3.53	2043.56	3.61	5484.89	3.28
FOR4_8	155.75	4.51	164.20	3.31	985.75	4.53	728.90	3.48	2070.00	3.48	1459.26	2.58	5563.86	3.33
FOR_CL	6.42	0.19	0.00	0.00	54.99	0.25	14.00	0.07	53.55	0.09	111.28	0.20	240.24	0.14

Habitat Code	Slieve Beagh 004167		Mullaghanish to Musheramore Mountain 004162		Slieve Bloom Mountains 004160		Slievefelim to Silvermines Mountains 004165		Slieve Aughty Mountains 004168		Stack's to Mullaghareirk Mountains, West Limerick Hills and Mount Eagle 004161		Total Proportions within Hen Harrier SPA network.	
	Area (ha)	% Cover	Area (ha)	% Cover	Area (ha)	% Cover	Area (ha)	% Cover	Area (ha)	% Cover	Area (ha)	% Cover	Area (ha)	% Cover
FOR9_12	308.10	8.93	94.02	1.90	419.52	1.93	1316.92	6.30	2375.48	4.00	2539.31	4.49	7053.35	4.22
GA1	155.56	4.51	602.81	12.15	424.09	1.95	1083.15	5.18	3501.76	5.89	3414.28	6.03	9181.65	5.49
GS1	0.00	0.00	0.00	0.00	12.71	0.06	14.58	0.07	239.29	0.40	636.45	1.12	903.03	0.54
GS3	12.38	0.36	712.39	14.36	291.84	1.34	337.86	1.62	313.95	0.53	379.75	0.67	2048.17	1.23
GM1	0.00	0.00	0.00	0.00	40.94	0.19	35.64	0.17	254.99	0.43	73.04	0.13	404.61	0.24
HD1	0.00	0.00	4.13	0.08	33.79	0.16	16.89	0.08	70.62	0.12	50.56	0.09	175.99	0.11
HH	235.80	6.84	872.32	17.58	2092.10	9.61	2177.24	10.41	5174.76	8.71	3746.64	6.62	14298.86	8.56
MG3	111.99	3.25	46.17	0.93	274.01	1.26	789.03	3.77	776.50	1.31	992.52	1.75	2990.22	1.79

Habitat Code	Slieve Beagh 004167		Mullaghanish to Musheramore Mountain 004162		Slieve Bloom Mountains 004160		Slievefelim to Silvermines Mountains 004165		Slieve Aughty Mountains 004168		Stack's to Mullaghareirk Mountains, West Limerick Hills and Mount Eagle 004161		Total Proportions within Hen Harrier SPA network.	
	Area (ha)	% Cover	Area (ha)	% Cover	Area (ha)	% Cover	Area (ha)	% Cover	Area (ha)	% Cover	Area (ha)	% Cover	Area (ha)	% Cover
MG4	48.49	1.41	64.75	1.31	121.95	0.56	614.78	2.94	615.12	1.04	585.10	1.03	2050.19	1.23
PB2	714.51	20.71	32.87	0.66	2716.41	12.48	335.83	1.61	2540.00	4.28	847.95	1.50	7187.57	4.30
PB3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	921.19	1.55	0.00	0.00	921.19	0.55
PB4	420.21	12.18	37.58	0.76	281.49	1.29	507.12	2.42	4712.68	7.93	5479.34	9.68	11438.42	6.84
RG	66.65	1.93	570.57	11.50	997.01	4.58	2977.34	14.23	4986.76	8.39	8816.51	15.57	18414.84	11.02
WD1	0.09	0.00	8.98	0.18	348.60	1.60	110.82	0.53	712.68	1.20	67.42	0.12	1248.59	0.75
WN5	48.08	1.39	82.55	1.66	155.37	0.71	158.52	0.76	776.20	1.31	299.48	0.53	1520.20	0.91
WS1	10.92	0.32	125.72	2.53	131.25	0.60	99.95	0.48	637.46	1.07	315.75	0.56	1321.05	0.79

Habitat Code	Slieve Beagh 004167		Mullaghanish to Musheramore Mountain 004162		Slieve Bloom Mountains 004160		Slievefelim to Silvermines Mountains 004165		Slieve Aughty Mountains 004168		Stack's to Mullaghareirk Mountains, West Limerick Hills and Mount Eagle 004161		Total Proportions within Hen Harrier SPA network.	
	Area (ha)	% Cover	Area (ha)	% Cover	Area (ha)	% Cover	Area (ha)	% Cover	Area (ha)	% Cover	Area (ha)	% Cover	Area (ha)	% Cover
BL3 / GA2	75.93	2.20	155.86	3.14	535.36	2.46	567.66	2.71	2141.82	3.61	2099.78	3.71	5576.41	3.34
Total SPA Boundary	3449.86		4961.14		21771.38		20917.47		59407.18		56610.53		167117.56	

Bibliography & Relevant Literature

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