The development of methodologies to assess the conservation status of limestone pavement and associated habitats in Ireland

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EXECUTIVE SUMMARY

The objective of this pilot survey was to develop methodologies to assess the conservation status of EU Annex I Habitat Limestone Pavement (8240) and associated habitats in Ireland. Thirty six survey plots within six survey units were surveyed during July and August 2008. These survey plots were sampled across the natural range of limestone pavement and mapped according to EU Annex I and Fossitt (2000) Habitats. Ninety relevés were recorded within four main habitat types; 40 limestone pavement relevés, 25 heath relevés, 18 grassland relevés and 6 scrub relevés. Mosaic relevés were recorded according to the dominant habitat present. In addition, one fen relevé was recorded.

The vegetation data analysis methods employed proved useful in separating the four main habitats surveyed; heath, pavement, grassland and scrub. The utilisation of hierarchical cluster analysis on the relevé data revealed four main habitat groups, with two of these groups (limestone pavement and grassland) further dividing into two sub-habitat groups (vegetation types). Each of the four main habitats is grouped fairly broadly and is likely to be relevant at a national scale. If the survey is extended, the addition of more relevé data may refine the description of habitats and vegetation communities further.

Targets were set to assess the conservation status of the EU Annex I Habitat Limestone pavement (8240) and associated habitats (i.e. exposed limestone pavement (8240), Festuco-Brometalia grassland (6210/6211) and European Dry Heath (4030)). Quarrying and removal of pavement were identified as the most threatening activity affecting exposed limestone pavement (8240). An overall favourable assessment was given to the EU Annex I Habitat 4030. Unfavourable assessment results for habitat 6210/6211 were the main reason for an overall unfavourable assessment for habitat 8240 when the assessments of the associated habitats were combined. Assessment criteria used in this pilot survey were based on existing methodologies, and may be subject to revision.

A National Limestone Pavement habitat distribution map was produced based on a revision of the map generated as part of the limestone pavement habitat (8240) Conservation Status Assessment report commissioned by NPWS in 2007. The revised map indicates that the overall extent of this habitat is 31,000 ha, rather than 36,000 ha as was reported in 2007. The final map contains 403 new limestone pavement areas, which account for 952ha. The addition of these new areas to the original 2007 map and the elimination of areas wrongly classified as limestone pavement in 2007 resulted in the modification of the habitat range map produced in 2007.

ACKNOWLEDGEMENTS

INTRODUCTION

Limestone pavement in Ireland

Limestone pavements are areas of calcareous rock that were exposed by the scouring action of ice sheets as they moved across the landscape during the last glaciation (Williams 1966). The habitat is found mainly in the west of Ireland (Figure 1a) with counties Clare, Galway and Mayo containing the largest extent. Smaller areas are found in Sligo, Leitrim, Donegal, Offaly, Kerry, Cavan, Limerick, Longford, Tipperary, Roscommon and Westmeath, as reported by the revised National Limestone Pavement habitat distribution map (Figure 1b). Ireland has the largest area of limestone pavement in the EU, over 31,000 ha, compared to less than 3,000 ha in the UK. The most extensive limestone pavement occurs in the Burren/East Galway area (Williams 1966).

Definition of Limestone Pavement

Limestone pavements are both geologically and biologically important resources. The structure of limestone pavement consists typically of blocks of rock, known as clints, separated by fissures, or grykes. There is considerable variation with some areas of massive blocks of smooth, relatively un-weathered pavement with well developed grykes, to areas where the grykes are very narrow and shallow. Finely fractured pavements or shattered pavements where grykes are almost absent can also occur. The rock surface is almost devoid of overlying soils (considerably less than 50% cover) except for some patches of shallow skeletal soils, although more extensive areas of deeper soil occasionally occur (Anon. 2007). This morphology offers a variety of microclimates allowing the establishment of complex vegetation consisting of a mosaic of different communities. The vegetation in grykes is unusual as it is composed of woodland and shade species along with plants of rocky habitats (Osborne *et al*. 2003; Ward & Evans 1976).

Many definitions exist for limestone pavement; however, there does not appear to be any standardised definition. The UKBAP Limestone Pavement Steering Group have classified limestone pavement in Britain into two subtypes; "Wooded" limestone pavements where a canopy of scrub and trees have covered the pavement, and "Open" pavements where there is no canopy. Ward (2007) defines the following two categories of limestone pavement; "Classic Limestone Pavement" where the exposed rock is equal or greater than 75%, and "Limestone Pavement Mosaic", where the patterns of clints and grykes can be discerned but is overlain by vegetation comprising 25% or more of the area.

Four different pavement types have been described as part of this pilot survey based on their morphology:

- Blocky: this type is characterised by a well defined structure of clints and grykes, which can vary greatly in depth and width.

- Sharp: sharp clints with grykes variable in depth and width, but generally narrow and shallow.

- Shattered: areas of loose rubble, which do not generally have a well defined structure of clints and grykes.

- Sheet: large slabs of pavement with a low occurrence of clints and grykes. If present the grykes are generally shallow and occasionally in-filled. The pavement can vary from smooth to rough surfaced.

Habitats and Species associated with limestone pavement in Ireland

The majority of research on limestone pavement habitats in Ireland has centred on the Burren region. Numerous studies have documented the unusual nature of upland and montane species growing at sea level, as well as woodland or shade species occurring in exposed areas (Osborne *et al.* 2003; Webb 1962). The mosaic of calcareous grassland, heath and limestone pavement supports arctic-alpine plants such as Mountain Avens (*Dryas octopetala*) and Spring Gentian (*Gentiana verna*) and Mediterranean species such as the Maidenhair Fern (*Adiantum capillus-veneris*) and the Dense Flowered Orchid (*Neotinea maculata*). These species do not usually occur in the same location. Calcicole and calcifuge species are also found growing side by side. Other species associated with this habitat include Bloody Crane's-bill (*Geranium sanguineum*), Wild Thyme (*Thymus polytrichus*), Carline Thistle (*Carlina vulgaris*), and Blue Moor-grass (*Sesleria caerulea*). Limestone pavement can also occur in a mosaic with areas of scrub/woodland, with extensive areas dominated by Hazel (*Corylus avellana*) and Hawthorn (*Crataegus monogyna*). Buckthorn (*Rhamnus catharticus*), Alder Buckthorn (*Frangula alnus*), Spindle (*Euonymus europaeus*) and Ash (*Fraxinus excelsior*) can also occur, as well as Juniper (*Juniperus communis*).

Limestone pavement and associated habitat classification

Limestone pavement is currently described under two categories in the Irish context; the Annex I habitats of the EU Habitats Directive (92/43/EEC), and those described by Fossitt (2000), (Table 1 and 2). Several EU Habitats Directive Annex I habitats associated with limestone pavement have been identified in Ireland and are listed below.

Table 1: EU Habitats Directive Annex I habitats associated with Limestone pavement

EU Habitats Directive Code	EU Habitats Directive Habitat
4030	European dry heath
4060	Alpine and sub-Alpine heath
5130	*Juniperus communis* formations on heaths or calcareous grasslands
6210	Semi-natural dry grasslands and scrub facies on calcareous substrates (Festuco-Brometalia) (Priority for important orchid sites (6211))
8240	Limestone pavement*
91J0	*Taxus baccata* woods*

* - priority habitats

The EU Habitats Directive Interpretation Manual (Anon. 2007) includes two corresponding categories in the UK for the Limestone Pavement Habitat (8240); "W8 *Fraxinus excelsior-Acer campestre-Mercurialis perennis* woodland" and "W9 *Fraxinus excelsior-Sorbus aucuparia-Mercurialis perennis* woodland". There are no corresponding vegetation categories for Ireland. According to the EU Habitats Directive Interpretation Manual (Anon. 2007) the definition of limestone pavement includes not only exposed rock, but areas of associated heath, scrub and grassland. Therefore, these areas also come under the definition of Limestone Pavement Habitat (8240) in Ireland. Fossitt (2000) defines six habitat categories which are relevant to this pilot survey.

Table 2: Fossitt (2000) habitats that are potentially associated with Limestone pavement

Fossitt Code	Fossitt Habitat
ER2	Exposed calcareous rock
GS1	Dry calcareous and neutral grassland
HH2	Dry calcareous heath
WS1	Scrub
WN2	Oak-ash-hazel woodland
WN3	Yew woodland

According to Fossitt (2000), Exposed calcareous rock (ER2) can also be associated with areas of grassland, heath and scrub. Other vegetation classifications of limestone pavement and associated habitats in Ireland, mainly focussing on the Burren, have been developed by Ivimey-Cook & Proctor (1966), Jeffrey (2003) and Parr *et al.* (2009).

Conservation of limestone pavement

The *Assessment, Monitoring and Reporting Under Article 17 of the Habitats Directive* report (Anon. 2006) provides the basic guidelines to report the conservation status of habitats listed in Annex I of the Habitats Directive. In addition, the Joint Nature Conservation Council (JNCC) has establishment *Common Standards Monitoring Guidelines* for a selection of habitats based on the UK 'NVC' vegetation types. Both sources have been the main reference for the establishment of previous conservation status

methodologies for Annex I EU habitats in Ireland such as raised bog habitats (Fernandez *et al.* 2006, grassland habitats (Dwyer *et al.* 2007, Martin *et al.* 2007), dune systems (Ryle *et al.* 2009) and salt marshes (McCorry 2007).

EU Habitats Directive (92/43/EEC) specifies that habitats protected by the Directive must be maintained in Favourable Conservation Status[1] within their range in the member states. The conservation status of a natural habitat will be taken as favourable when:

- its natural range and the area it covers within that range are stable or increasing, and

- the specific structure and functions which are necessary for its long-term maintenance exist and are likely to continue to exist for the foreseeable future, and

- the conservation status of its typical species is favourable.

Three parameters are scored in order to assess a habitat's overall conservation status. These are: **area**, **structure and functions**, and **future prospects**. A habitat conservation status assessment is based on the worst scenario, i.e. when any of the previous attributes is deemed unfavourable the overall habitat conservation status is also unfavourable (Table 3 below).

Table 3: Summary matrix of the parameters and conditions required to assess the conservation status of habitats (Anon. 2006).

	Favourable	Unfavourable - Inadequate	Unfavourable - Bad
Area	Stable	>0% <1% decline/year	> 1% decline/year
Structure & Functions	Green Pass Structures & functions (including typical species) in good condition and no significant deteriorations / pressures.	Yellow Fail Any other combination 1 – 25% decline/failure (e.g. 1-25% of monitoring stops fail)	Red Fail > 25% of the area is unfavourable as regards its specific structures and functions (including typical species)
Future Prospects	Good - The habitats prospects for its future are excellent / good, no significant impact from threats expected; long-term viability assured.	Poor - Any other combination	Bad - The habitats prospects are bad, severe impact from threats expected; long-term viability not assured.
Overall	All green	Combination of green and amber	One or more red

According to the Limestone pavement habitat baseline Conservation Status Assessment Report (NPWS 2007) the structure and functions, as well as the future prospects, of limestone pavement and its associated habitats in Ireland was assessed as unfavourable inadequate. This is due to a number of reasons such as abandonment of 'traditional' pastoral systems, including over- and under-grazing, quarrying (including removal of surface rocks) and trampling (overuse). The Northern Ireland Biodiversity Action Plan states that as the vegetation occurring on limestone pavement is quite varied, the assessment of favourable condition is based on the continued presence of the geological features found on the limestone pavement and the historic and desired vegetation for an individual site. For open pavement, the cover of bare rock and presence/cover of indicator plants such as Blue Moor-grass (*Sesleria caerulea*), Wild Thyme (*Thymus* sp.) and characteristic mosses should be maintained. The spread of plants such as Rye-grass (*Lolium perenne*), Bracken (*Pteridium aquilinum*) and shrubs is

undesirable. For scrubby pavement, the height and extent of the canopy cover and the presence/cover of woodland plants should be maintained. The spread of invasive species such as sycamore and excessive grazing damage to trees or ground flora should be prevented.

Scope of the report

This report summarises the findings of the pilot survey for the development of methodologies to assess the conservation status of limestone pavement and associated habitats in Ireland. The purpose of the survey was to fulfil the following criteria:

1) To update the existing map of the range and extent of limestone pavement in Ireland.

2) To propose methods to assess structure and functions and future prospects of limestone pavement in the field.

3) To test proposed methods in six areas: West-Burren, Mid-Burren & East-Burren, Lough Corrib, Lough Mask and Bricklieve Mountains.

4) To design a National Survey and a monitoring programme to assess the conservation status of limestone pavement in Ireland.

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[1] The concept of 'favourable conservation status' (FCS) constitutes the overall objective to be reached for all habitat types and species of community interest. In simple terms it can be described as a situation where a habitat type or species is prospering (in both quality and extent/population) and with good prospects to do so in future as well. The fact that a habitat or species is not threatened (i.e. not faced by any direct extinction risk) does not mean that it is in favourable conservation status (Anon. 2006).
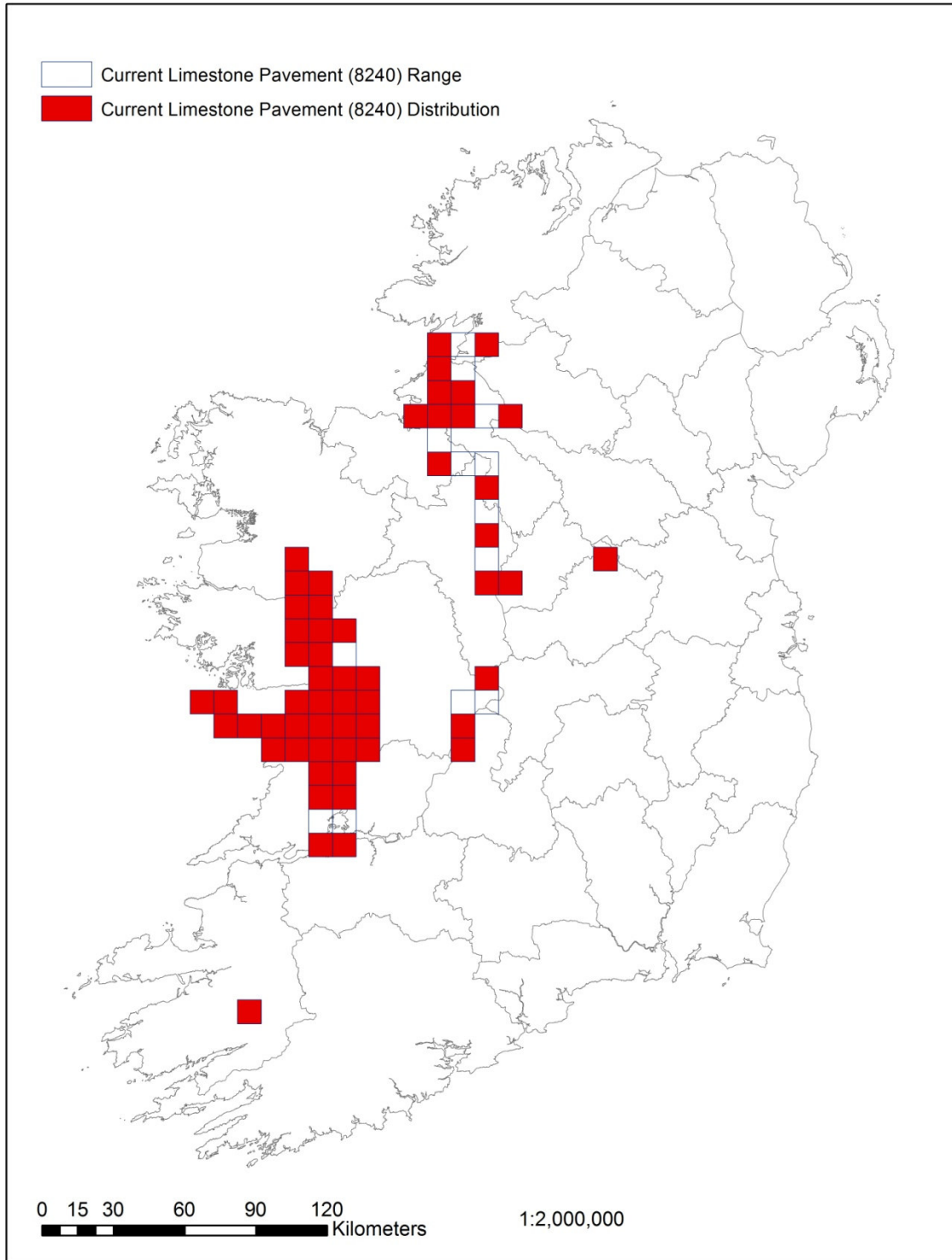
Figure 1: Current distribution and range of Limestone pavement in Ireland, from the revised National Limestone Pavement habitat distribution map (2008; see Figure 3).

METHODS

Site selection

The aim of this project was to survey Limestone Pavement and a number of associated habitats in six pre-selected areas. The following areas were proposed by NPWS for survey. They were chosen to cover the range and variability of limestone pavement and associated habitats in Ireland (Figure 2):

- West-Burren, Mid-Burren & East-Burren, Co. Clare and Co. Galway.

- Lough Corrib, Co. Galway.

- Lough Mask/Lough Carra, Co. Mayo.

- Bricklieve Mountains, Co. Sligo.

Within each area proposed by NPWS, a Survey Unit was selected, and within each Survey Unit a number of Survey Plots were chosen.

All but one of the survey areas contain Dinantian Pure Bedded limestone bedrock, the exception being the surveyed plots in Lough Mask which correspond to Dinantian Lower Impure limestone, according to the Geological Survey of Ireland (GSI) digital bedrock map.

The soils within the surveyed areas mostly correspond with shallow well-drained mineral soils, derived from mainly calcareous parent materials (BimSW). To a lesser degree shallow, lithosolic-podzolic type soils, predominantly shallow soils derived from calcareous rock or gravels with/without peaty surface horizon (BminSRPT) were also found (Fealy *et al*. 2006).
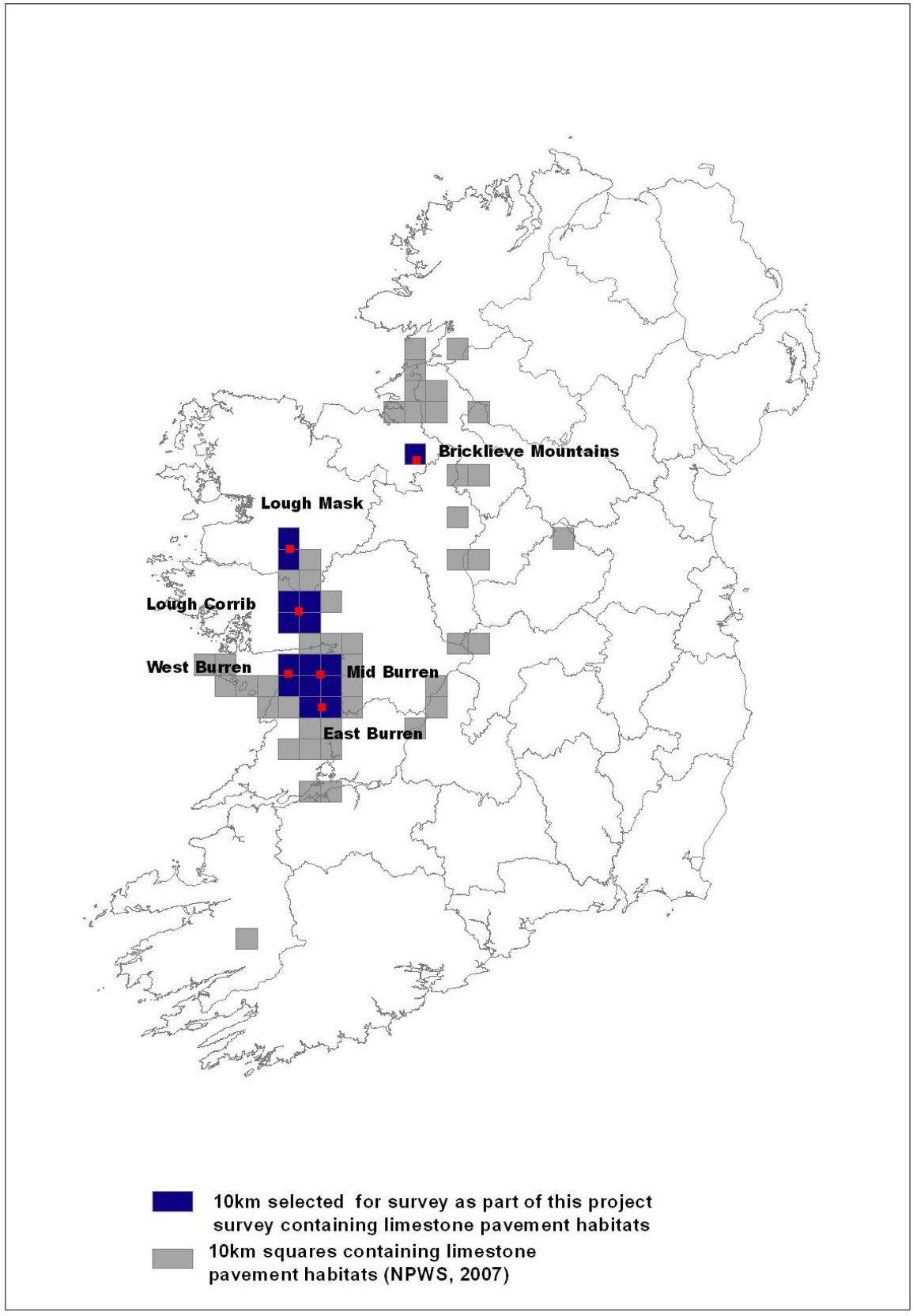
Figure 2: Location of survey sites

Site survey

Pre-survey

Pre-survey work involved the preparation of site packs for all six areas selected for field survey. Each site pack included general site information, a blank six inch map, an aerial photograph of the site at a six inch scale, and copies of any previous survey notes. Standardised field cards were designed prior to the field survey, 5 field cards were developed which are as follows:

- Plot description field card

- Plot species list field card

- Limestone Pavement relevé field card

- Grassland/Heath relevé field card

- Scrub/Woodland relevé field card

These field cards were designed for use in Microsoft Excel, not in hard copy format. The spreadsheets were subject to on-going refinement throughout the survey. Species nomenclature followed Stace (1997) for vascular plants, Smith & Smith (2004) for mosses and Smith (1991) for liverworts (see Appendix 2 for copies of field cards).

Preparation and testing of ruggedized mobile GPS computers (Trimble GeoXT) was carried out prior to the field survey. Custom data dictionaries were produced using TerraSync software, to record certain types of information in the field (e.g., time, date, habitat boundary, relevé type, location of invasive species, and location of rare species).

Plot selection

A 100 m grid based on the Irish national grid was overlaid upon the survey areas in order to select target sites. This grid was produced by splitting the larger scale (i.e. 10km) grid. Considering that this was a limestone pavement and associated habitats survey, one of the main selection criteria was that at least 25% bare rock was to be present in the plots. Both Annex I Habitat and Fossitt (2000) classification systems define limestone pavement habitat as containing at least 50% bare rock. Other factors that affected selection were:

- Distance from the sea in the case of coastal sites

- Altitude

- Exposure

- Homogeneous management units – the aim was to select plots within homogeneous management units, which are generally defined by stonewalls.

The large extent of Burren sites suggested the need to select smaller survey areas or Survey Units within each of the three Burren regions (see Appendix 1). Survey Units varied in extent and distinct boundaries separating the units from adjacent areas were not always clear. However, the general aim was to select survey units based on the presence of some physical boundaries (e.g. stone walls,

improved fields, flushes, woodland, dense scrub, etc.). A total of eight plots were selected within each Survey Unit aiming to cover variation within the Survey Unit (see Appendix 1).

The following areas were selected within the Burren region (the extent of the Survey Unit is given in brackets):

- West-Burren - Black Head (435ha)

- Mid-Burren - Abbey Hill (242ha)

- East Burren - Gortlecka (294ha)

Whereas the Burren region survey areas in counties Clare and Galway consists of large expanses of limestone pavement, the other three survey areas contained more isolated areas of pavement. Areas surveyed outside the Burren were:

- Gortnandarragh (Lough Corrib), Co. Galway (123ha).

- Lough Mask/Lough Carra, Co. Mayo (11.4ha).

- Bricklieve Mountains, Co. Sligo (5ha).

Lough Corrib SAC mostly contains areas of isolated limestone pavement, and difficulties were encountered with access to limestone areas in the SAC. Some areas were also flooded at the time of the field survey. The eastern section of Gortnandarragh (SAC 1271) was therefore selected as a substitute Survey Unit as it lies adjacent to Lough Corrib SAC.

The survey was only conducted in designated sites as site access and site management information were more readily available from NPWS regional staff than from non-designated areas. Due to the time constraints of the pilot survey, the gathering of information and surveying of non-designated sites would have been unfeasible. However, a National Survey of limestone pavement and associated habitats should also cover non-designated areas, as a representative sample of the national resource should be monitored.

Survey Methods

A *100m x 100m (1ha)* Plot size was considered the most appropriate, for the following reasons:

- The plots could be compared throughout the range of the habitat

- It was considered a manageable plot size.

- This method would cover higher variability than if surveying only a few large, homogeneous areas.

- The 100 x 100m could be easily used as a monitoring unit, whereas anything much larger would be impractical.

The 100m x 100m (1ha) plots were not selected randomly. One of the aims of the pilot survey was to cover a wide range of habitats within the selected Survey Units, considering factors such as altitude, orientation, exposure, management units, and the presence of habitat diversity. A purely randomised approach could well have omitted some areas of interest.

General data recorded

The following data were recorded for each plot:

Habitat boundary points: These were used in the production of the 2008 Survey Limestone Pavement habitat distribution map (see section 2.6). Each plot was mapped using both Fossitt (2000) and the EU Habitats Directive Annex I habitats associated with Limestone pavement. The map illustrates the extent and proportion of habitat types within each plot. The minimum mapping size was approximately 4m x 4m.

Plot Species List: Within each plot an exploratory walk was undertaken and the presence of vascular plant species, and the major bryophyte species, was recorded. Nomenclature followed Stace (1997) for vascular plants, Smith (2004) for mosses, and Smith (1991) for liverworts (see Appendix 2 for field cards).

Topographical features: The topographical position (e.g., upper slope, mid slope, lower slope) of the plot was also noted.

Site Management: Rangers were contacted to ascertain current management (within the last 12 months) and past management. Some of the most common activities affecting the habitat, including grazing and rock removal, were recorded. All relevant management practices were recorded and their intensity and impact assessed.

Grazing level: Grazing was recorded on a three point scale where possible; light, moderate or heavy.

Fauna: The presence of domestic animals (e.g. cattle, sheep, and horses) and other relatively common animal species (e.g. goats, hares, fallow deer) were recorded on the field card. Herbivore species recorded may contribute to the overall grazing level. The observed presence of other species of fauna (e.g. birds, butterflies, moths, etc) was also reported.

Damaging operations: Several damaging operations and possible threats were listed on the field card: rock removal, rock displacement, dumping, gryke filling, trampling, scrub removal, bracken and scrub encroachment and invasive species.

Geological features: Mean gryke depth, pavement shape and pavement type, were recorded. These features may affect the floristic diversity of limestone pavement. These variables were recorded in all limestone pavement relevés.

Additional features: Other features which were considered important, and were therefore recorded include: Site exposure, Direction of grykes (e.g., N/S, E/W), whether grykes are vegetated and what % of this vegetation is emergent vegetation. The latter three features were only recorded in limestone pavement relevés.

Photographs: A photographic record of each plot (overview) and relevé (detail and overview) were taken. The grid reference of each photograph was fixed with GPS, and the aspect of each taken with a compass.

All plot data recorded in the field were transferred to a Microsoft Access database (National Limestone Pavement database).

Recording of relevés

A minimum of one limestone pavement relevé was recorded in each plot. Multiple relevés were recorded where there was significant variation in the associated habitat. Different field cards were developed for grassland/heath, pavement, and scrub/woodland habitats. This was considered necessary as many environmental variables relevant to one habitat type were not relevant to another, (e.g. gryke depth, direction of grykes). Field cards for each of the habitat types can be found in Appendix 2. The size of the relevé used was dependant on habitat type:

- 1m x 1m relevés for grassland and heath habitats.

- 5m x 5m square relevés for limestone pavement and scrub habitats.

The decision on whether the habitat being recorded in the field was grassland or heath was based on dwarf shrub cover. Relevés with more than 25% dwarf shrub cover were considered heath habitat according to Fossitt (2000) classification. Due to the heterogeneous (mosaic) nature of habitats associated with limestone pavement, 1m x 1m relevés were recorded in grassland and heath habitats. This size was chosen to avoid recording a relevé in a mosaic of two different habitats, which could easily occur if using a 2m x 2m relevé. A 5m x 5m relevé was chosen for limestone pavement and scrub on pavement habitats. A 10mx10m was tested but it was considered inappropriate to record cover data from the pavements and grykes in a 100m^2.

Cover in vertical projection for all vascular and bryophyte species was recorded in percent cover as were other parameters such as bare soil, litter and bare rock. For each relevé a 12-figure grid reference (i.e. 6 digit easting and 6 digit northing) was obtained using a GPS. Topography, altitude, slope and aspect were also recorded. Photographic records of the relevé were taken: detail and overview for grassland and heath and overview for limestone pavement and scrub. Appendix 2 includes copies of relevés field cards.

All plot data recorded in the field was transferred to a Microsoft Access database (National Limestone Pavement database) and TurboVeg.

Data collection

A GeoExplorer handheld GPS minicomputer (Trimble GeoXT) was used in the field to record relevés, habitat boundaries, photographs, rare plants, invasive plants and other points of interest, into a custom data dictionary. The GPS positions of these features were logged and stored on Terrasync software (Trimble). Additional comments on features were also stored as text fields in the device. Post processing of data was carried out to improve accuracy based on the Active GPS Network from Ordnance Survey Ireland to obtain sub-metre accuracy of data.

Habitat mapping

National Limestone Pavement habitat distribution map

The National Limestone Pavement habitat distribution map was produced based on a revision of the limestone pavement habitat distribution map. The original map was generated as part of the limestone pavement habitat (8240) Conservation Status Assessment report commissioned by NPWS

(2007). The updated habitat distribution map was produced in polygon shapefile format in ArcGIS 9.3 using the Irish National Grid as the coordinate reference system.

Original habitat boundaries have been refined, new areas indicated by additional sources have been digitised, and areas misclassified as limestone pavement habitat in the original map have been deleted from the final map.

The refinement of the original map has included the production of a comprehensive attribute table where the sources indicating the occurrence of limestone pavement are recorded. The map not only contains areas of exposed limestone pavement but also limestone pavement areas covered by other associated habitats such as grassland, scrub, heath and woodland. The 2007 map poorly reported the reason for the selection of pavement areas, therefore particular emphasis has been given to assure that these sources are documented (Appendix 3).

The following data sources, which were used for the production of the 2007 limestone pavement habitat map, have been re-assessed in order to improve the accuracy of the final limestone pavement map. These sources are described in more detail in Appendix 4.

- Corine 2000 Land cover – EPA (2000)

- National Soils and Parent Material Map – Teagasc (2006)

- Bedrock Data - Geological Survey of Ireland (2006)

- Karst Heritage sites - Geological Survey of Ireland (2001)

- Designated sites records and digital maps - NPWS

- Landsat Thematic mapper satellite imagery

- 2005 Aerial ortho-photography - Ordnance Survey of Ireland (2005)

- Burren habitat mapping - Parr *et al*. (2006)

2008 Survey Limestone Pavement Habitat Distribution Map

Habitats reported during the 2008 Survey within the Survey Plots were digitised in ArcGIS 9.3 based on the 2005 ortho-photography and habitat boundary points recorded on the ground using the Irish National Grid as the co-ordinate reference system. Habitats were mapped at two different vegetation classification levels: Fossitt (2000) and EU Habitats Directive Habitat classification.

Vegetation data analysis

Data preparation

Ninety relevés and a total of 180 species were recorded during the survey. Outlier analysis was conducted in PCORD (MjM Software, Oregon) as outliers can profoundly influence multivariate analysis (McCune & Grace 2002). Using three standard deviations from the grand mean as a cut off resulted in no relevés being removed. Species occurring in fewer than three relevés were excluded from the analysis because species with only a few occurrences provide little reliability in assigning them to groups (McCune & Grace 2002). This yielded a matrix of 90 relevés and 108 species. Taxa

recorded to genus level were included in the analysis where there were no other taxa from the same genus identified to species level. Each "species" is considered different, so overlaps would confuse the similarity measure basis of the analyses.

Analysis techniques

A number of techniques were employed to analyse the data. All analysis was carried out using PCORD 5.

<u>Non-metric Multidimensional scaling (NMS)</u>

Non-metric Multidimensional scaling is the most generally effective ordination method for ecological community data (McCune & Grace 2002). Ordination techniques are used to simplify a complex multivariate data set into a small number of dimensions that explain most of the variation. The major objective is to achieve an effective data reduction, expressing many-dimensional relationships in a small number of dimensions. Objects close in the ordination space are generally more similar than objects distant in the ordination space. It is a useful tool for comparing relevés and to show relationships between relevés and different environmental data.

NMS is an ordination method that is well suited to data that are non-normal or are on arbitrary, discontinuous, or otherwise questionable scales. One of its main advantages is that it avoids the assumption of linear relationships among variables (McCune & Grace 2002). It is an iterative search for a ranking and placement of n entities on k dimensions (axes) that minimizes the stress of the k-dimensional configuration. The calculations are based on an $n \times n$ distance matrix calculated from the $n \times p$-dimensional main matrix, where n is the number of rows and p is the number of columns in the main matrix. "Stress" is a measure of departure from monotonicity in the relationship between the dissimilarity (distance) in the original p-dimensional space and distance in the reduced k-dimensional ordination space (McCune & Grace 2002).

The Sørenson (Bray-Curtis) distance measure was used in this analysis. To test the robustness of the data a Monte Carlo (randomisation) test of 100 runs was employed. Each run consists of a separate randomisation or permutation of the data. A large number of runs is generally desirable, but is dependent upon computer power, data set size, and the desired precision of the resulting p-value. Note that the p-value for a randomization test can be no smaller than 1/N where N is the total number of runs (McCune & Grace 2002).

With a matrix of 90 relevés and 108 species a preliminary 'slow and thorough' autopilot run was conducted. Following this, it was decided that a 2 dimensional solution with varimax rotation gave the lowest stress levels for the data set. Pearson correlation was used with the following environmental variables: aspect, altitude, slope, gryke depth, % bare earth, % rock, % litter, % low woody, % shrub, % bracken, grass height, herb height, presence of summer grazing, presence of winter grazing, distance from the sea, and species diversity. The correlation coefficient provides a way of comparing positions of the sample units on the ordination axes with environmental variables. If a variable has any linear relationship with an ordination axis, it is expressed in the correlation coefficient. These correlations should primarily be used for descriptive purposes (McCune & Grace 2002).

Hierarchical, agglomerative cluster analysis

Agglomerative cluster analysis is a useful tool if groups are sought from multivariate ecological data (McCune & Grace 2002). This was the primary method used to identify habitat types and to sort the data into group.

From a data matrix of 90 relevés and 108 species a distance matrix was calculated using Sørensen (Bray-Curtis) as a distance measure. Sørensen (Bray-Curtis) was used as a distance measure as it has repeatedly been shown to be one of the most effective measures of sample or species similarity (McCune & Grace 2002). Flexible Beta (-0.25) was used as a linkage method. This is an omnibus method that spans the range between nearest flexible neighbour (complete linkage) and farthest neighbour clustering, depending on what you set the beta parameter at. B = 1 gives a nearest neighbour clustering, with lots of chaining, and B = -1 gives farthest neighbour, with very little chaining where most relevés join pair-wise before forming larger clusters. Group membership was written at each step to a second matrix. The resulting nine new variables were added to a second matrix ranging from the 10 group level to the 2 group level. The results of the cluster analysis are displayed as a dendrogram.

Indicator Species Analysis (ISA)

This method combines information on the concentration of species abundance in a particular group and the faithfulness of occurrence of a species in a particular group (McCune & Grace 2002). Indicator values are tested for statistical significance using a randomisation (Monte Carlo) technique. This is a test of significance of observed maximum indicator value (IV) for each species, based on 1000 randomisations. The means and standard deviations of the IV from the randomisations are given along with p-values for the hypothesis of no difference between groups. The p-value is based on the proportion of randomised trials with indicator value equal to or exceeding the observed indicator value (McCune & Grace 2002).

Singleton and infrequent species have no possibility of being a statistically significant indicator species because the result of all its occurrences falling in one group is quite likely.

There are two main criteria for a species to be an indicator:

1. Significant Monte Carlo p-value

2. An indicator value (IV) of at least 25 (when 2 groups are being analysed) so that at least half the samples in the group have the species present. (i.e. [1/no.of groups]x0.5)

Indicator species can also be used as a stopping point in Cluster analysis (Dufrene & Legendre 1997). This works on the premise that if groups are too finely divided or if groups are too large that the Indicator Values will be low. Dufrene & Legendre (1997) found that the indicator values peak at some intermediate level of clustering and the position of the peak will vary with species. Taken collectively, the method can be used to decide on an appropriate level of clustering for species data. When there are more than two groups, the IVs for a species in a particular group depends on the set of sample units belonging to the other groups. Species with only 1 or 2 occurrences never yield an IV stronger than expected by chance, i.e. won't have a significant p-value. If groups are too finely divided then

indicator values will be low. If the groups are too large, then their internal heterogeneity will reduce the indicator values (McCune & Grace 2002).

ISA was run on the output of hierarchical cluster analysis, at the 2-10 cluster levels. The number of species, with significant indicator values ($p \leq 0.05$), and the sum of significant indicator values at each stage of grouping was compared. The average p-value across all species at each stage of clustering was also compared in order to choose the optimum number of groups in the data.

<u>Multi-response Permutation Procedures (MRPP)</u>

MRPP is a nonparametric procedure for testing the hypothesis of no difference between two or more groups or entities. MRPP has the advantage over discriminant analysis of not requiring assumptions (such as multivariate normality and homogeneity of variances) that are seldom met with ecological community data (McCune & Grace 2002). It was used to test for significant differences between the groups which resulted from Indicator Species Analysis and Cluster Analysis. In addition to a p-value, MRPP gives another test statistic, A, that describes within group homogeneity, compared to the random expectation. When, all items are identical within groups then $A = 1$. If heterogeneity within groups equals that expected by chance then $A = 0$, and if within group heterogeneity is less than expected by chance then $A < 0$ (McCune & Grace 2002). Sørenson distance was used on a rank transformed matrix of environmental variables.

Assessment of EU Annex I habitats conservation status

Area

A quantitative assessment of the variation in Annex I habitat extent should be carried out under this section. However, due to the lack of baseline data, this was not possible. A comparison based on changes in extent seen from ortho-photography was not considered reliable. In addition, changes in extent of habitat from the survey plots could not be ascertained due to the small scale mapping of the survey (i.e. survey plot size is only 1ha and minimum mapping unit 4x4m). In the case of exposed limestone pavement (EU Annex I Habitat 8240), evidence of recent damage or removal of pavement may be obvious from the ortho-photographs or from visual inspection on the ground. Visual assessment of pavement for signs of recent damage (e.g. broken, white, lichen-free rock, rubble, displaced clints & in-filled grykes) will help to ascertain changes in habitat extent.

Structure and functions

Article 1(e) of the Habitats Directive specifies that for the conservation status of a habitat to be favourable, "the specific structure and functions which are necessary for its long-term maintenance exist and are likely to continue to exist for the foreseeable future" Anon. (2006). The assessment of the habitats structure and functions is based on the selection of a series of measurable attributes (e.g. positive[2] and negative indicators) that should describe the condition of the habitat. Each attribute has a specific target, or a range of targets, against which the sample point can be scored to pass or fail.

Previous assessments in the Irish context such as Ryle *et al.* (2009), Martin *et al.* (2007) and McCorry (2007) based the assessment on the establishment of a series of monitoring stops in the field, where the selected attributes were assessed. Monitoring stops were evenly spaced and covered any expected

variation within the habitat. Seriously disturbed areas or areas suffering from encroachment were excluded. Monitoring stops were recorded in multiples of 4 (i.e. 4, 8, or 12) in order to simplify assessing whether more than 25% of monitoring stops had failed.

Four or multiple numbers of four monitoring stops could not be established at the plot level (100x100m) in this pilot survey due to the small extent of the habitats mapped within each plot (minimum mapping unit size approximately 16m² (4x4m)). However, multiple monitoring stops were established for a Survey Unit where a series of Survey Plots were surveyed. All relevés recorded within the 2008 survey, selected as representative of the overall condition of a habitat within a plot, were treated as monitoring stops here.

Previous assessment methodologies applied in Ireland required that all attributes must pass the stated targets at a monitoring stop in order for the monitoring stop to pass. This criterion is thought to be quite extreme: for example, when assessing the structure and functions within a Survey Unit with several monitoring stops it only requires one attribute to fail within just one monitoring stop for the entire Survey Unit to fail.

A new assessment based on a matrix is proposed where structure and functions are assessed at two different levels within a Survey Unit:

<u>Level 1 - Monitoring Stop level (row):</u>

Two fails within a monitoring stop result in an overall Yellow Fail for the Monitoring stop and three fails are deemed to correspond to a Red Fail (see Table 3). Subsequently at Survey Unit level 1-25% failure of monitoring stops results in an Unfavourable Inadequate assessment for the Survey Unit and more than 25% Unfavourable Bad (see Appendix 5).

_____

[2] Positive indicator species show high fidelity to a habitat type. In addition, they have reasonably stable populations given suitable ecological conditions, and are visible in the sward for much of the growing season (JNCC 2008). No one habitat supports all of the positive indicators listed. Ideally, the assessment should focus on the variation in positive species indicators previously recorded in a baseline survey.

<u>Level 2 - Attribute level (column):</u>

When between 25 and 50% of the monitoring stops fail for a particular attribute then the attribute is assessed as Yellow Fail whereas if more than 50% of the monitoring stops fail for a particular attribute the overall assessment for this attribute is Red Fail. An overall Yellow fail within an attribute automatically results in an overall Unfavourable Inadequate Assessment for the Survey Unit, while an overall Red fail will result in an Unfavourable Bad assessment for the Survey Unit structure and functions (see Appendix 5).

The proposed method is considered to be a better illustration of the condition of a habitat. Although this system may appear less critical than previous methods based on just one fail, the addition of a second level of assessment provides an accumulative level of assessment at attribute level. Four or multiples of four monitoring stops are deemed the most appropriate number for a standardised assessment. However, when only a small number of monitoring stops (i.e. 1 to 3) were recorded best expert judgment was used in the assessment. Best expert judgment was also used in the case of mosaic relevés (e.g. exposed limestone pavement and calcareous grassland or exposed limestone pavement and scrub). In this situation a combination of both habitat targets should be taken into consideration for the assessment.

Limestone pavement (exposed) (8240)

Monitoring methodologies have been established for this Annex I habitat by JNCC (2008). Positive indicator species were selected for Ireland based on the list of typical indicator species given by NPWS (2007). The plants listed as characteristic for this habitat in the EU Habitats Directive Interpretation Manual and positive indicators according to JNCC (2008) guidelines in Ireland (see Appendix 5) were also included. Only exposed areas of limestone pavement, with vegetation cover less than 25%, were assessed under this section. A list of negative indicators based on JNCC (2008) guidelines is also given, which includes bracken and non-native species. The habitats structure condition is assessed based on the presence of scrub and woody cover.

JNCC (2008) also proposes the assessment of the habitat structure based on grazing and browsing pressure, which is estimated based on the percentage of emergent vegetation (more than 25% of herbaceous vegetation cover should be made up of emergent and clint-top plants, flower heads and fern fronds). Thom (2004) suggests that emergent vegetation must be present on at least 25% of the pavement area for the site to be in favourable condition. It must be noted that these criteria are based on optimum conditions of limestone pavement in the British context and are not necessarily suitable for Ireland. This attribute was considered during the early stages of establishing methodologies. However it was not deemed relevant in the Irish context as certain areas of pavement, which are exposed to harsh weather conditions for example, naturally have low emergent vegetation, and would fail an assessment as a result. Therefore it was decided not to use this attribute as part of the assessment.

Semi-natural dry grasslands and scrubland facies on calcareous substrates (Festuco-Brometalia) (important orchid sites) (6210/6211)

Conservation status assessment methodologies were established for this habitat by Dwyer *et al.* (2007) and Martin *et al.* (2007). No differentiation was made between habitats 6210 and 6211; the main reason for not distinguishing orchid-rich sites is the ephemeral nature of orchids, with large orchid populations present one year and absent the next. Additional species (including bryophytes) were added to the list of positive indicators based on the 2008 limestone pavement survey. Some constant species listed by Parr *et al.* (2009) and species listed by Dwyer *et al.* (2007) as Burren and Western species were also included.

European dry heaths (4030)

Monitoring methodologies have been established for European dry heaths by JNCC (2004b) and are the basis for the methodologies provided in Appendix 5 for this Annex I habitat. A list of positive indicator species was produced based on the typical species given by NPWS (2007). Additional species (including bryophytes) were added to the list of positive indicators based on the 2008 limestone pavement survey and constant species list by Parr *et al.* (2009). A selection of negative indicators is also provided based on JNCC (2004b), and revised for Ireland. The vegetation structure assessment is based on the presence of trees and scrub cover, dwarf shrub species cover and *Ulex europaeus* cover. Additional attributes were also added based on JNCC (2004b) (Appendix 5).

Limestone pavement and associated habitats (8240)

The Habitats Directive Interpretation Manual describes this Annex I priority habitat as comprising of a mosaic of vegetation communities including the above mentioned habitats (i.e. exposed limestone pavement (8240), 6210/6211 and 4030). Therefore, an overall limestone pavement structure and functions assessment, which will lead finally to a conservation status assessment of 8240 and associated habitats, is needed. The assessment is based on each individual Annex I habitat structure and functions assessment result weighted by its extent within each area assessed (i.e. Survey Unit). The assessment criteria illustrated in Table 3 is then applied; when the overall extent of Annex I habitats failing within a Survey Unit is between 1 and 25%, habitat 8240 is given an overall Unfavourable Inadequate assessment, whereas when more than 25% of Annex I habitats fail, habitat 8240 is given an overall Unfavourable Bad assessment.

Future prospects

Future prospects for a habitat are deemed to be in favourable condition when no significant threats from activities affecting the habitat compromise the habitats viability. Previous assessments in Ireland (Ryle *et al.* 2009; Martin *et al.* 2007; Perrin *et al.* 2008) based the habitat's future prospects assessment on the following three parameters:

1. Indicators of negative trends and threats to the site

2. Indicators of local distinctiveness, such as notable plant species.

3. Designation status of the habitat

Negative activities categories represent a threat to a site while positive categories include factors that represent protection to the habitat such as designated status or the maintenance of certain notable features. Notable species were deemed to be those listed on the Flora (Protection) Order, 1999, or in the Irish Red Data Book (Curtis & McGough 1988).

The importance of each category is given a score ranging from 0 to -3 (for negative categories) and 0 to 3 (for positive categories). These values correspond to the impact levels of none, low, medium and high (active and immediate) proposed in the Natura 2000 Standard Data Form explanatory notes. Where possible, the percentage of surface area of the Annex I habitat affected by each category should also be estimated.

An assessment of future prospects for each Annex I habitat was undertaken at each Survey Unit. Appendix 6 includes a summary of the categories and the scoring method applied to assess future prospects for each Annex I habitat associated with limestone pavement. Some of the threatening activities only apply to specific habitats (e.g. afforestation to grasslands or heath). An overall assessment for Limestone pavement (8240) and associated habitats is then given based on the sum of the most negative values for each activity category that is recorded over all habitats (i.e. 8240, 6210/6211, 4030). Impacting activities outside surveyed plots but within the Survey Unit are also taken into account.

RESULTS

General site survey

A total of 36 plots and 90 relevés were recorded during the survey. The altitudinal range of the surveyed areas spanned from 10m (West-Burren) to above 220m in the Bricklieve Mountains. The overall extent of limestone pavement and associated habitats surveyed was 47 ha. The survey units are shown in Appendix 1 and an example of habitat maps at the plot level (Gortnandarragh) are given in Appendix 7. Four main habitats types were surveyed and recorded according to Fossitt (2000) and EU Annex I Habitat classification; Limestone pavement (40 relevés) Grassland (18 relevés), Heath (25 relevés), and Scrub (6 relevés). One fen relevé was also recorded. Relevés that were recorded as mosaic in the field were later classified according to their dominant habitat type. Table 4 below gives a summary of the survey results.

Table 4: Summary of survey site results

Site Name	Designated Site	Survey Unit Name	County	No of plots	Survey area (ha)	Number of relevés
West-Burren	SAC 20 - Black Head-Poulsallagh Complex	Black Head	Clare	8	8	18
Mid-Burren	SAC 1926 – East Burren Complex	Abbey Hill	Clare	8	8	18
East - Burren	SAC 1926 – East Burren Complex	Gortlecka	Clare	8	8	21
Lough Corrib	SAC1271 – Gortnandarragh	Gortnandarragh	Galway	8	8	19
Lough Mask	SAC 1774 - Lough Carra/Mask Complex	Lough Mask: Aghinish, Carrowaneeragh, Kilfaul	Mayo	3	11	11
Bricklieve Mountains	SAC 1656 - Bricklieve Mountains and Keishcorran	Bricklieve Mountains: Carrowkeel	Sligo	1	4	3

Habitat mapping

National Limestone Pavement habitat distribution map

The National Limestone Pavement habitat distribution map (Figure 3) was produced in a vector format and contains a comprehensively populated attribute table that lists all the sources indicating the occurrence of limestone pavement in Ireland. Appendix 3 contains a descriptive list of attributes for each limestone pavement habitat area mapped.
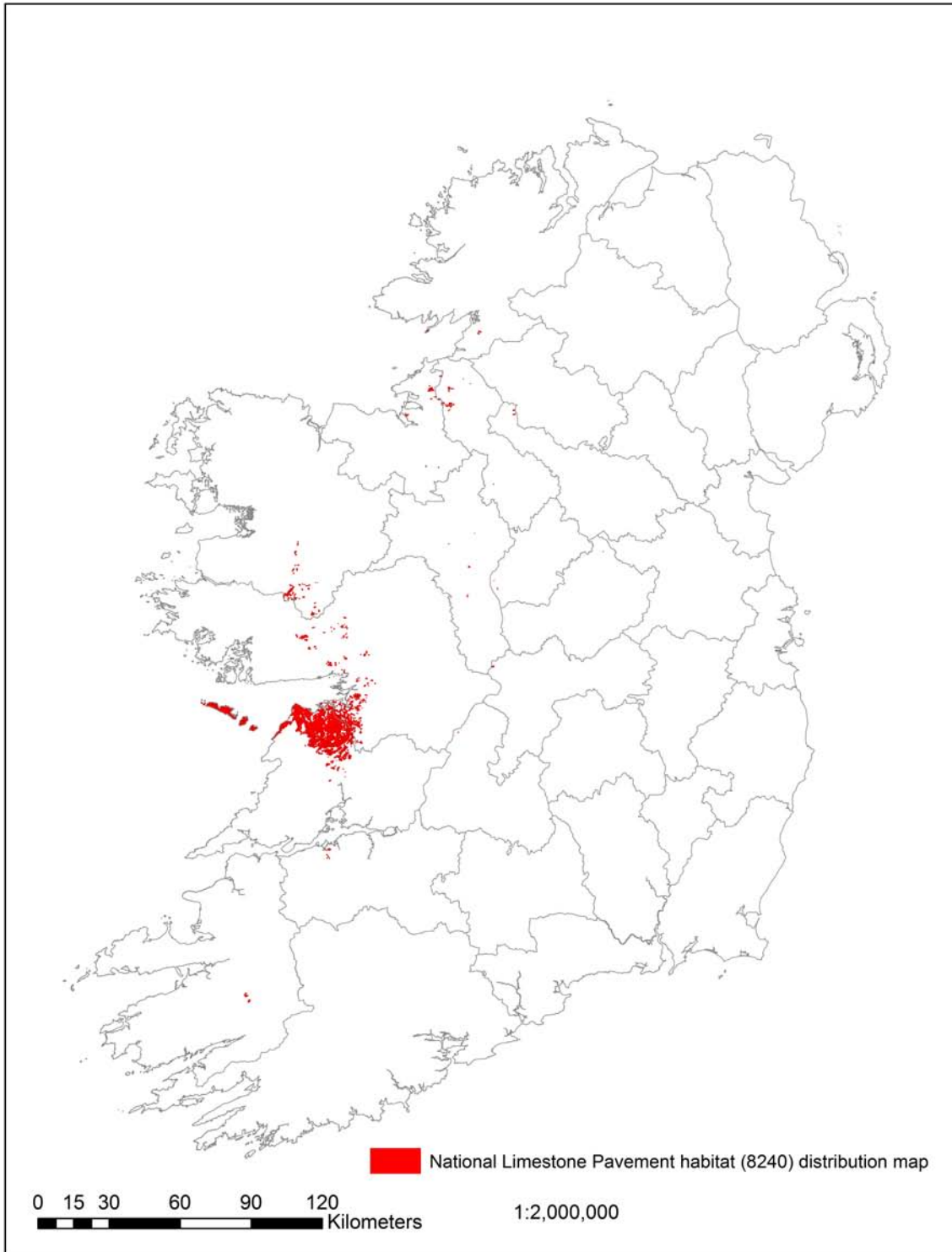
Figure 3: The National Limestone Pavement habitat distribution map (2008).

The map indicates that the total extent of limestone pavement in Ireland is 31,100 ha (see Table 5 below). This figure is smaller than the previously estimated in 2007 (36,000 ha). The reduction in the extent is the result of more accurate mapping of the habitat, rather than any actual loss. The final map

contains a total of 403 pavement areas that were not reported in the original 2007 map; these areas account for a total of 952 ha. The map also indicates that 26,200 ha (84.24%) of the limestone national resource are within a designated site, with the majority being under SAC designation (only 127ha of this resource is designated as pNHA).

The 2008 limestone habitat 10km distribution and range map has been revised as part of this survey.

Quarrying and pavement removal have been visually indentified as part of the process of map production and these activities are reported in the limestone pavement habitat map attribute table. Quarrying has been recorded to be affecting 43 pavement areas, 37 of which are outside a designated site. The remaining 6 areas are partially within a designated site. Pavement removal has been reported to be taking place in 104 locations, 81 of which are found outside a designated site. The figures provided are based on an approximate visual assessment of areas where removal and quarrying of limestone pavement has taken place prior to 2005 (using 2005 ortho-photographs). The actual current figures are likely to be larger. The figures also illustrate higher pressure from these activities outside designated sites.

Table 5: Extent of limestone pavement per county based on the National Limestone Pavement distribution map

County	Extent (ha)
Cavan	39.71
Clare	23,431.65
Donegal	120.07
Galway	6,032.57
Kerry	131.17
Leitrim	184.65
Limerick	70.26
Longford	3.17
Mayo	725.56
Offaly	39.65
Roscommon	19.07
Sligo	216.69
Tipperary	4.51
Westmeath	0.45
Total	31,019

2008 Survey Limestone Pavement habitat distribution map

The 2008 Survey Limestone Pavement habitat distribution mapcontains detailed habitat maps for a total of 36 Survey Plots within 6 Survey Units. Habitats were mapped according to Fossitt (2000) and, when applicable, Annex I EU categories (Anon. 2007). Table 6 below illustrates the extent of these habitats within each Survey Unit.

Table 6: Fossitt and EU Annex I habitats extent within each Survey Unit

Survey Unit	Fossitt Habitat	Extent (m²)	EU Habitat	Extent (m²)
Abbey Hill	ER2	52,136	8240	52,136
	ER2/GS1	4,323	8240	4,323
	ER2/HH2	2,449	8240	2,449
	GS1	3,159	6210	3,159
	HH2	16,632	4030	16,632
	WS1	1,301	No major correspondence	NA
BlackHead	ER2	65,486	8240	65,486
	ER2/GS1	6,257	8240	6,257
	ER2/HH2	725	8240	725
	GS1	2,830	6210	2,830
	HH2	4,500	4030	4,500
	LR	118	No major correspondence	NA
	PF1	85	No major correspondence	NA
Bricklieve Mountains	ER2/GS1	29,075	8240	29,075
	GS1	18,654	No major correspondence	NA
	WS1	1,391	8240 *	1,391
Gortlecka	ER2	63,373	8240	63,373
	ER2/GS1	817	8240	817
	GS1	4,325	6210	4,325
	HH2	4,813	4030	4,813
	WS1	6,672	No major correspondence	NA
Gortnandarragh (Lough Corrib)	ER2	52,181	8240	52,181
	ER2/GS1	6,173	8240	6,173
	ER2/HH2	3,741	8240	3,741
	GS1	1,150	6210	1,150
	HH2	13,392	4030	13,392
	WS1	3,363	No major correspondence	NA
Lough Mask/Lough Carra	ER2	40,319	8240	40,319
	ER2/GS1	1,094	8240	1,094
	ER2/WS1	16,763	8240	16,763
	GS1	12,671	6210	12,671
	HH2	675	4030	675
	PF1	19,358	Unknown	NA
	WS1	18,249	8240	5,056

* Conservation status assessments have not been carried out for Scrub on pavement, which can be, in certain situations, considered Annex I habitat 8240 associated habitat. Further work on the development of conservation status assessment methodologies for this habitat is required.

Vegetation data analysis

Cluster analysis and Indicator species analysis

Indicator species analysis (ISA) was used as a means of choosing an optimum number of groups from the cluster analysis results. According to the ISA results, the 7-cluster level was the most informative level of clustering according to the criterion of sum of significant indicator values (Figure 4). Table 7 summarises the cluster analysis and Indicator Species Analysis results.
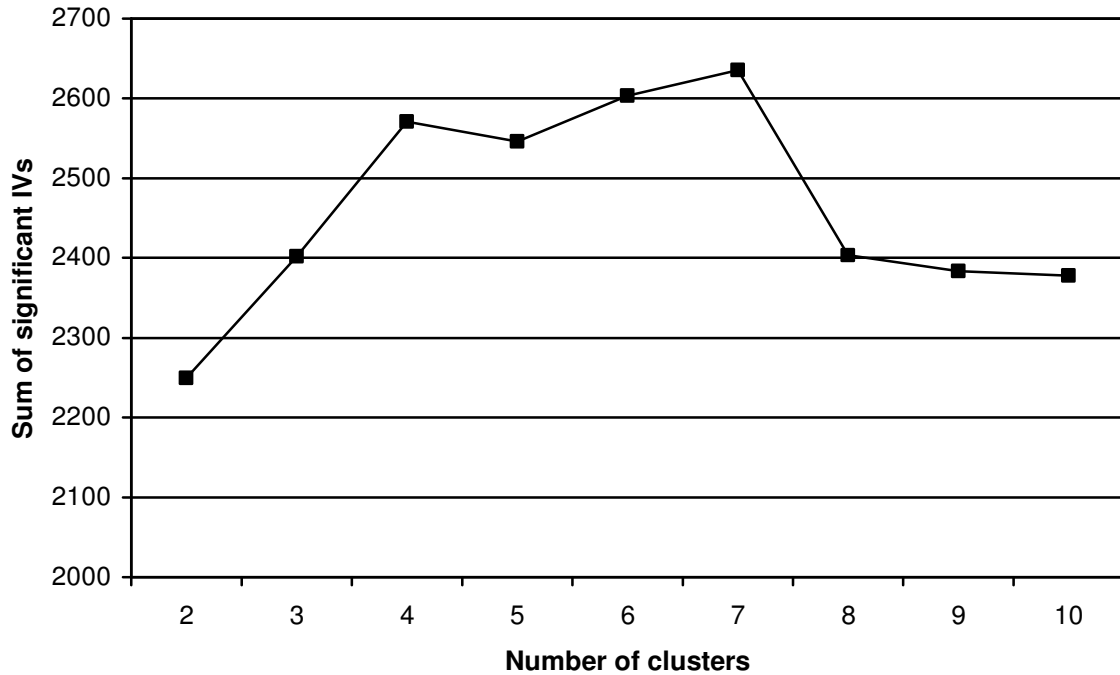
Figure 4: Changes in sum of significant indicator values (IVs) as determined by Indicator Species Analysis for each step of clustering.

Table 7: Habitat type and the number of relevés in each group determined by Indicator Species Analysis (ISA). The codes are those given to the groups in the cluster analysis output.

Habitat	ISA Group Number	Number of relevés
Heath	1	24
Pavement 1	2	23
Grassland 1	5	5
Grassland 2	8	10
Pavement 2	19	11
Mosaic	38	13
Scrub	39	4

Four main habitat types were revealed by the cluster analysis; heath, pavement, grassland, and scrub. Within these habitats there were two pavement subgroups and two grassland subgroups. The remaining group (Group 38) was a group made up of mostly "mosaic" habitats, i.e. relevés that were a mixture of two or more different habitat types. Multi-response permutation procedure on a Sørensen distance matrix showed significant differences among groups at the 7-cluster level (A = 0.337, *p* < 0.001). The test statistic (A) is similar to those reported in other surveys of Irish Habitats (Martin *et al.* 2007; Perrin *et al.* 2008).

Non-metric Multidimensional scaling

The non-metric multi-dimensional scaling (NMS) ordination found a 2-dimensional solution; the scatter plot is shown in (Figure 5). The groups which were identified in non multidimensional scaling were in agreement with the 7-level cluster results of the indicator species analysis. Stress on this

solution was 17.6 and the final instability criterion was 0.00013. Axis 1 (r^2=0.525) and Axis 2 (r^2=0.212) together cover 83% of the variance in the distance matrix.

From the 2-dimensional NMS ordination plot (Figure 5) it can be seen that relevés mainly fell into groups according to habitat types, which is in agreement with the cluster analysis solution. Group 1, which represents the majority of field determined heath relevés, groups together rather tightly in the ordination space. The limestone pavement relevés (Group 2 and 19) also group together in the ordination space. There appears to be a slight differentiation between limestone pavement relevés containing shattered pavement (Group 2) and those relevés containing blocky pavement (Group 19). The scattered distribution of the grassland groups (Group 5 and 8) in the ordination space reflects the variety of grassland types associated with limestone pavement. Further sampling is needed before these relationships can be teased out. One group (Group 38) is rather scattered. This is not surprising as this group is made up of mostly "mosaic" relevés (i.e. relevés with more than one habitat present). This reflects the mosaic nature of limestone pavement and its associated habitats. The scrub relevés (Group 39) are not closely grouped in the ordination space; this may be due to the small sample size.

Axis 1 seems to primarily represent bare rock cover with limestone pavement relevés positioned at the higher end of axis 1 and all other habitats found at the lower end of axis 1. Axis 2 seems to primarily represent shrub cover with all habitats except pavement at the higher end of the axis and pavement at the lower end of the axis. Pearson and Kendall correlation coefficients express the linear and rank relationships between the ordination scores and the individual variables used to construct the ordination (McCune & Grace 2002). Pearson and Kendall correlation found that NMS axes were significantly correlated with various environmental variables; these variables are shown in the ordination plot. Axis 1 was most significantly positively correlated with % Bare Rock, Gryke Depth, Blocky Pavement, Wide and Deep Grykes and Shattered Pavement. Axis 1 was most significantly negatively correlated with grass height, litter cover, herb height, low woody cover, and species diversity. Axis 2 was most significantly positively correlated with grass height, herb height, shrub cover and litter cover. Axis 2 was most significantly negatively correlated with % Bare Rock and Gryke Depth.
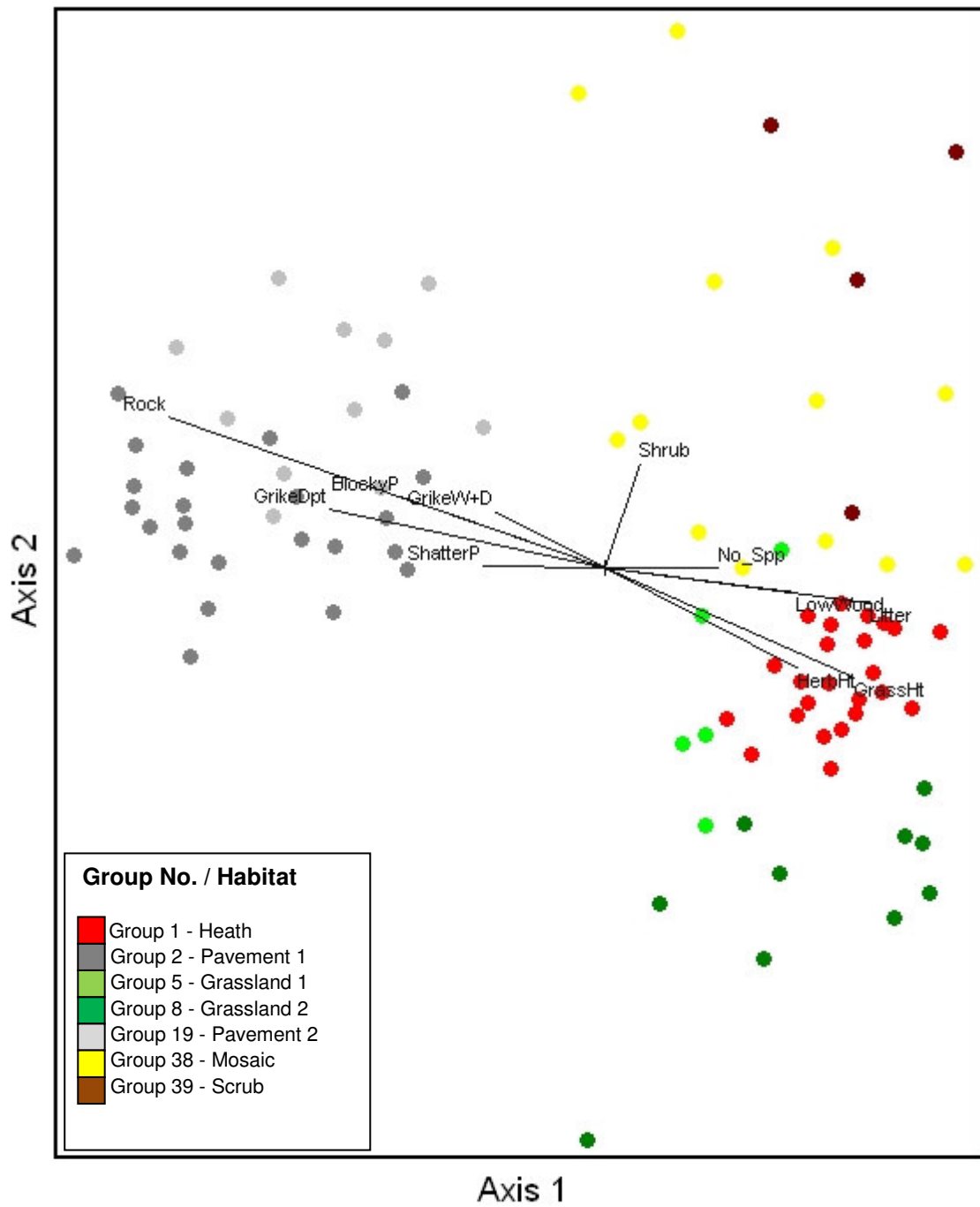
Figure 5: Non-metric multidimensional scaling ordination plot of 90 relevés. Direction of lines from origin shows Pearson correlation of environmental variables with axes. Length indicates strength of correlation. Shrub = Shrub cover, No_Spp = Species Diversity, Low Woody = Low Woody cover, Litter = Litter cover, GrassHt = Grass Height, HerbHt = Herb Height, ShatterP = Shattered Pavement, BlockyP = Blocky Pavement, GrykeW+D = Wide and deep grykes, Grike_Dpth = Gryke Depth, and Rock = % Bare rock.

Habitat Classification

Due to the variety of habitats sampled and the small sample size for some of the habitats surveyed, a comprehensive vegetation classification of each habitat was beyond the scope of this project. However, a preliminary classification is presented for the habitat types that were sampled during this survey. These habitats are listed and detailed in the order that they have been grouped by cluster and indicator species analysis. For each habitat group the significant indicator species is listed and a brief description of the habitat is given, as well as the topographical occurrence and geographical distribution where possible. These indicator species have been used to supplement the 'Conservation Status Assessment' indicator species lists for EU habitats in Ireland. Confusion tables (Table 8 and 9) are used to compare the habitat groups resulting from Indicator Species Analysis with previously described classifications, such as EU Annex I Habitats, and Fossitt (2000) Habitats. The results are discussed in four major groups; Heath, Pavement, Grassland, and Scrub.

Table 8: Relevés assigned to habitat types using hierarchical clustering with *a priori* assignment of relevés to Annex I habitat types. Figures are number of relevés. Mosaic relevés are listed by the dominant habitat. Figures in italics are row and column totals.

Habitat	Non EU Habitats	8240	4030	6210	*Total*
Heath			24		*24*
Pavement 1		23			*23*
Grassland 1				5	*5*
Grassland 2	1			9	*10*
Pavement 2		11			*11*
Mosaic	4	5	1	3	*13*
Scrub	4				*4*
Total	*9*	*39*	*25*	*17*	*90*

Table 9: Relevés assigned to habitat types using hierarchical clustering with *a priori* assignment of relevés to Fossitt (2000) habitat types. Figures are number of relevés. Mosaic relevés are listed by the dominant habitat. Figures in italics are row and column totals.

Habitat	ER2	GS1	HH2	WS1	PF1	Total
Heath			24			*24*
Pavement 1	23					*23*
Grassland 1		5				*5*
Grassland 2		10				*10*
Pavement 2	11					*11*
Mosaic	6	3	1	2	1	*13*
Scrub				4		*4*
Total	*40*	*18*	*25*	*6*	*1*	*90*

A synoptic table for each habitat group or subgroup is presented below. Frequency (over 5%) and percentage abundance data are given for the occurrence of each species in each habitat type, or sub-habitat type. Frequency is indicated by Roman numerals, where I = 0.1 – 20.0%, II = 20.1 – 40.0%, III = 40.1 – 60.0%, IV = 60.1 – 80.0% and V = 80.1 – 100%. Species with highest frequencies in the group (constant species with frequency greater than 60%) are listed first, and are in bold. Significant

indicators species for each group are denoted by asterisks, with the indicator value score being indicated by the number of asterisks, such that: * = 0.1 – 20.0%, ** = 20.1 – 40.0%, *** = 40.1 – 60.0%, **** = 60.1 – 80.0% and ***** = 80.1 – 100%. Species with only one asterisk are poor indicators. These indicator values may be a result of small sample size and should not be considered reliable indicators. The remaining species in the list are those that have occurred in the habitat type but that don't have any significant affinities with the habitat type; they generally occur in the habitat at low frequencies. These companion species are divided into the following groups; grasses/rushes/sedges, herbs, other vascular plants, and bryophytes, and are ordered by frequency within these groups.

Heath Description (Group 1; 24 relevés)

Indicator Species (Indicator Value %): *Calluna vulgaris (70%), Erica cinerea (54%), Potentilla erecta (48%), Dryas octopetala (42%), Hypericum pulchrum (36%), Succisa pratensis (35%), Lotus corniculatus (33%), Festuca ovina (30%), Carex flacca (29%).*

Description: Constant herbaceous species in the group include *Potentilla erecta, Lotus corniculatus, Festuca ovina, Sesleria caerulea, Carex flacca, Succisa pratensis* and the moss *Pseudoscleropodium purum.* Woody species associated with this habitat include *Calluna vulgaris, Erica cinerea* and *Dryas octopetala.* It is associated with limestone pavement in areas where soil has accumulated; these areas are well drained and leaching of the soils results in the proliferation of plants that are usually associated with acidic soils. This habitat was found in almost all of the plots in Abbey Hill and Lough Corrib (7 of 8 plots), in six plots in Black Head and in four plots in Gortlecka. This habitat has affinities with the Annex I Habitat 4030 – European Dry Heath; other affinities are listed below in Table 10. A full list of species for the habitat is given in Table 11 (synoptic).

Table 10: Relevant vegetation community affinities for the Heath group determined by ISA.

	Relevant Affinities
EU Annex I:	4030 – European dry heath
Fossitt:	HH2 – Dry calcareous heath
NVC:	H7 – *Calluna vulgaris-Scilla verna* heath community
	H10 – *Calluna vulgaris-Erica cinerea* heath community
Parr *et al.* (2009):	*Calluna vulgaris* community
	Dryas octopetala community

Table 11: Synoptic Table for the Heath habitat group.

Heath Indicator Species			
Calluna vulgaris	V	76	****
Potentilla erecta	V	48	***
Succisa pratensis	V	42	**
Lotus corniculatus	V	33	**
Carex flacca	V	31	**
Festuca ovina	V	30	**
Sesleria caerulea	V	18	*
Hypericum pulchrum	IV	55	**
Pteridium aquilinum	IV	30	**
Viola sp.	IV	23	*
Pseudoscleropodium purum	IV	20	*
Plantago lanceolata	IV	16	*
Thymus polytrichus	IV	15	*
Dryas octopetala	III	100	***
Erica cinerea	III	100	***
Dicranum scoparium	III	7	*
Solidago virgaurea	II	60	*
Geranium sanguineum	II	49	*
Breutelia chrysocoma	II	46	*
Carex pulicaris	II	37	*
Thuidium tamariscinum	II	33	*
Carex panicea	II	28	*
Juniperus communis	II	26	*
Briza media	II	23	*
Rhinanthus minor	II	22	*
Hylocomium splendens	II	21	*
Agrostis stolonifera	II	20	*
Agrostis capillaris	II	18	*
Hypochaeris radicata	II	17	*
Danthonia decumbens	II	16	*
Neckera crispa	II	14	*
Campanula rotundifolia	II	14	*
Teucrium scorodonia	II	9	*
Euphrasia sp.	II	8	*
Molinia caerulea	II	7	*
Linum catharticum	II	7	*
Ctenidium molluscum	II	3	*
Achillea millefolium	II	3	*
Rosa pimpinellifolia	II	3	*
Lathyrus linifolius	I	50	*

Heath Indicator Species			
Asperula cynanchica	I	34	*
Blackstonia perfoliata	I	26	*
Geranium robertianum	I	23	*
Polystichum setiferum	I	13	*
Vicia cracca	I	13	*
Rhytidiadelphus squarrosus	I	12	*
Rhytidiadelphus triquetrus	I	9	*
Pilosella officinarum	I	7	*
Carlina vulgaris	I	6	*
Galium verum	I	4	*
Other Grasses/Rushes/Sedges			
Anthoxanthum odoratum	II	2	
Koeleria macrantha	I	4	
Agrostis canina	I	1	
Dactylis glomerata	I		
Festuca rubra	I		
Other Herbs			
Antennaria dioica	I	4	
Taraxacum officinale agg.	I	2	
Leontodon hispidus	I	2	
Senecio jacobaea	I	1	
Centaurea nigra	I	1	
Leucanthemum vulgare	I	1	
Plantago maritima	I	1	
Trifolium pratense	I	1	
Trifolium repens	I		
Other vascular plants			
Prunus spinosa	I	10	
Gymnadenia conopsea	I	9	
Potentilla sterilis	I	1	
Hedera helix	I		
Corylus avellana	I		
Other Bryophytes			
Fissidens sp.	I	4	

Limestone Pavement Description

Type 1: Shattered Pavement Type (Group 2; 23 relevés)

Indicator Species; *Mycelis muralis (75%), Teucrium scorodonia (57%), Asplenium ruta-muraria (55%), Ceterach officinarum (55%), Senecio jacobaea (42%), Fissidens sp. (34%), Asplenium trichomanes (30%), Phyllitis scolopendrium (28%).*

Description: Constant species found in this group include *Mycelis muralis, Asplenium ruta-muraria, Sesleria caerulea, Teucrium scorodonia, Geranium robertianum,* and *Fissidens sp.* This habitat is characterised by pavement with very few well defined clints and grykes. If grykes are present they are generally narrow and shallow. There can be a significant amount of vegetation growing on the clint surface. Small pockets of calcareous grassland and heath can occur where there is sufficient soil present. This habitat type was found in all plots in Abbey Hill and Gortlecka, as well as in four plots in Lough Corrib. It was only surveyed once in Black Head and Lough Mask. This habitat has affinities with the Annex I Habitat 8240 – Limestone pavement; other affinities are listed below (Table 12). A full list of species for the habitat is given in Table 13 (synoptic).

Type 2: Blocky Pavement Type: (Group 19; 11 relevés)

Indicator Species: *Thalictrum minus* (45%), *Adiantum capillus-veneris* (27%), *Eupatorium cannabinum* (27%), *Conocephalum conicum* (24%).

Description: Constant species found in this group include *Sesleria caerulea, Teucrium scorodonia, Geranium robertianum, Phyllitis scolopendrium* and the mosses *Neckera crispa* and *Tortella tortuosa.* This habitat is characterised by pavement with well defined clints and grykes. Grykes are generally wide and deep. There is little vegetation growing on the clint surface. Where there isn't sufficient soil cover present, plants are restricted to the grykes. Typical species in these fissures include *Thalictrum minus, Geranium robertianum, Phyllitis scolopendrium* and *Eupatorium cannabinum.* This habitat type was found mostly in Black Head (7 of 8 plots), in three plots at Lough Corrib and once at Gortlecka. This habitat has affinities with the Annex I Habitat 8240 – Limestone pavement; other affinities are listed below in Table 12. A full list of species for the habitat is given in Table 13 (synoptic).

Table 12: Relevant vegetation community affinities for the Limestone pavement groups determined by ISA.

	Relevant Affinities
EU Annex I:	8240 – Limestone Pavement
Fossitt:	ER2 – Exposed calcareous rock
NVC:	OV38 – *Gymnocarpium robertianum – Arrhenatherum elatius* community
	OV39 – *Asplenium trichomanes – A.ruta-muraria* community
	OV40 – *Asplenium viride – Cystopteris fragilis* community
Parr *et al.* (2009):	Not applicable

Table 13: Synoptic Table for the Limestone Pavement habitat group.

Pavement Indicator Species	Shattered Pavement			Blocky Pavement		
Constant species						
Teucrium scorodonia	V	63	***	V	20	*
Geranium robertianum	V	15	*	V	14	*
Sesleria caerulea	V	4	*	V	3	*
Senecio jacobaea	IV	65	***	IV	26	*
Phyllitis scolopendrium	IV	45	**	IV	28	*
Neckera crispa	IV	33	**	IV	8	*
Tortella tortuosa	IV	13	*	IV	11	*
Shattered Pavement						
Mycelis muralis	V	78	****	III	22	*
Ceterach officinarum	IV	70	***	II	30	*
Asplenium ruta-muraria	V	57	***	III	25	*
Asplenium trichomanes	IV	46	**	II	18	*
Fissidens spp.	V	41	**	III	26	*
Hypochaeris radicata	III	43	*	I	8	*
Ctenidium molluscum	III	2	*	III	1	*
Taraxacum officinale agg.	II	24	*	II	27	*
Carlina vulgaris	II	20	*	I	7	*
Rosa pimpinellifolia	II	13	*	I	1	
Prunus spinosa	II	2		III	25	*
Lonicera periclymenum	I	59	*	I	41	*
Sonchus oleraceus	I	59	*	I	41	*
Plagiochila spp.	I	56	*			
Gymnadenia conopsea	I	47	*			
Cystopteris fragilis	I	42	*	I	58	*
Scapania sp.	I	26	*			
Pilosella officinarum	I	13	*	I	7	*
Polystichum setiferum	I	13	*			
Dryopteris filix-mas	I	12	*			
Crataegus monogyna	I	11	*	I	11	*
Viola sp.	I	8	*	II	3	*
Linum catharticum	I	4	*	III	6	*
Polygala vulgaris	I	4		I	78	*
Solidago virgaurea	I	2		I	10	*
Hypericum pulchrum	I	1		II	7	*
Molinia caerulea	I	1		I	4	*
Lotus corniculatus	I			III	3	*
Geranium sanguineum	I			III	5	*
Blocky Pavement						
Hedera helix	II	2		V	10	*
Thymus polytrichus	III	5	*	V	5	*
Carex flacca	II	1		IV	3	*

Pavement Indicator Species	Shattered Pavement		Blocky Pavement		
Thalictrum minus			III	100	***
Adiantum capillus-veneris			II	100	**
Eupatorium cannabinum			II	100	**
Conecephalum conicum	I	11	II	89	**
Rubia peregrina			I	70	*
Rubus fruticosus agg.			I	13	*
Plagiomnium undulatum			I	11	*
Campanula rotundifolia			I	9	*
Asperula cynanchica			I	7	*
Schoenus nigricans			I	7	*
Brachypodium sylvaticum			II	3	*
Other Grasses/Rushes/Sedges					
Festuca ovina	II		III		
Carex panicea	I	1	I	1	
Dactylis glomerata	I				
Agrostis stolonifera			I	1	
Carex pulicaris			I	5	
Other Herbs					
Oxalis acetosella	I	4			
Antennaria dioica	I	2			
Succisa pratensis	I		II	1	
Potentilla erecta	I		II	1	
Plantago lanceolata			II	1	
Plantago maritima			I	2	
Euphrasia sp.			I	1	
Lathyrus linifolius			I	4	
Leontodon autumnalis			I	1	
Other vascular plants					
Corylus avellana	II	2			
Pteridium aquilinum	I	5	I	1	
Juniperus communis	I				
Dryas octopetala			I		
Calluna vulgaris			I		
Other Bryophytes					
Rhytidiadelphus loreus	I	2			
Breutelia chrysocoma	I	1			
Hylocomium splendens	I	1	I		
Pseudoscleropodium purum	I				
Dicranum scoparium			I		
Rhytidiadelphus triquetrus			I	2	
Thuidium tamariscinum			I		

Grassland Description

Grassland Type 1: (Group 5; 5 relevés)

Indicator Species: *Euphrasia sp. (71%), Dicranum scordium (71%), Sesleria caerulea (63%), Thymus polytrichus* (50%), *Succisa pratensis (46%), Antennaria dioica (32%), Juniperus communis (28%).*

Description: Constant species found in this group include *Sesleria caerulea, Euphrasia sp., Thymus polytrichus*, *Succisa pratensis, Festuca ovina,* and the mosses *Dicranum scoparium,* and *Ctenidium molluscum*. This grassland habitat type was associated with areas of bare rock, and although it wasn't recorded in the field it can be inferred that it is found in areas with shallow soil cover. This habitat was only found in a small number of relevés (five); one in both Black Head and Abbey Hill and three in Lough Corrib. This habitat has affinities with the Annex I Habitat 6210 – Semi-natural dry grasslands and scrubland facies on calcareous substrates (Festuco-Brometalia), other affinities are listed below in Table 14.

Grassland Type 2: (Group 8; 10 relevés)

Indicator Species: *Trifolium repens (90%), Cynosurus cristatus (80%), Achillea millefolium (68%), Plantago lanceolata (52%), Trifolium pratensis (51%), Ranunculus bulbosus (51%), Centaurea nigra (44%), Anthoxanthum odoratum (42%), Leucanthemum vulgare (41%), Calliergonella cuspidata (39%), Festuca ovina (32%).*

Description: Constant species found in this group include *Trifolium repens, Cynosurus cristatus, Galium verum, Plantago lanceolata, Festuca ovina, Achillea millefolium, Lotus corniculatus, Dactylis glomerata, Trifolium pratensis* and *Pseudoscleropodium purum.* This habitat is characterised by less bare rock than grassland type 1. Although soil depth wasn't recorded in the field, it can be inferred that this type of grassland is found on deeper, more nutrient rich soils than Grassland type 1. This habitat was found in three plots in both Black Head and Gortlecka, two plots in Abbey Hill, and one plot in both Lough Mask and the Bricklieve Mountains. This habitat has affinities with the Annex I Habitat 6210 – Semi-natural dry grasslands and scrubland facies on calcareous substrates (Festuco-Brometalia), other affinities are listed below in Table 14. A full list of species is given in Table 15.

Table 14: Relevant vegetation community affinities for the Grassland groups determined by ISA.

	Relevant Affinities
EU Annex I:	6210 – Semi-natural dry grasslands and scrubland facies on calcareous substrates (Festuco-Brometalia)
Fossitt:	GS1 – Dry calcareous and neutral grassland
NVC:	CG9 – *Sesleria caerulea-Galium sterneri* grassland community
	CG10 – *Festuca ovina - Agrostis capillaris - Thymus praecox* grassland community
	CG13 – *Dryas octopetala-Carex flacca* heath community
Parr *et al.* (2009):	*Sesleria caerulea - Breutelia chrysocoma* community
	Dryas octopetala community

Table 15: Synoptic Table for the Grassland habitat groups.

Grassland Indicator Species	Grassland Type 1			Grassland Type 2		
Constant Species						
Festuca ovina	V	12	*	V	42	**
Grassland Type 1						
Euphrasia sp.	V	71	****	III	10	*
Sesleria caerulea	V	63	****	III	3	*
Thymus polytrichus	V	50	***	I	2	
Succisa pratensis	V	46	***	I	5	*
Dicranum scoparium	IV	89	****			
Ctenidium molluscum	IV	14	*	I		
Juniperus communis	III	46	**			
Linum catharticum	III	41	**	II	15	*
Carex panicea	III	35	**	II	7	*
Carex flacca	III	27	*	III	18	*
Potentilla erecta	III	7	*	III	9	*
Antennaria dioica	II	81	**			
Pilosella officinarum	II	36	*			
Briza media	II	20	*	II	8	*
Teucrium scorodonia	II	1	*			
Plantago maritima	I	75	*			
Blackstonia perfoliata	I	49	*	I	25	*
Campanula rotundifolia	I	51	*			
Gymnadenia conopsea	I	44	*			
Asperula cynanchica	I	33	*			
Solidago virgaurea	I	23	*			
Hypochaeris radicata	I	18	*			
Prunella vulgaris	I	13	*	III	56	**
Rhinanthus minor	I	14	*	I	63	*
Tortella tortuosa	I	13	*			
Koeleria macrantha	I	12	*	I	30	*
Danthonia decumbens	I	9	*			
Fissidens sp.	I	10	*			
Leontodon hispidus	I	4	*	I	19	*
Prunus spinosa	I	7	*	I		
Grassland Type 2						
Trifolium repens				V	90	*****
Cynosurus cristatus				V	88	****
Plantago lanceolata	III	7	*	V	58	***
Achillea millefolium				IV	97	****
Trifolium pratense	I	1		IV	73	***

Grassland Indicator Species	Grassland Type 1			Grassland Type 2		
Galium verum				IV	47	**
Dactylis glomerata				IV	45	**
Pseudoscleropodium purum	I	16	*	IV	19	*
Lotus corniculatus	III	30	*	IV	14	*
Centaurea nigra				III	89	***
Ranunculus bulbosus				III	85	***
Leucanthemum vulgare	I	2		III	82	***
Anthoxanthum odoratum				III	70	***
Cerastium fontanum				III	63	**
Agrostis capillaris				III	52	**
Viola sp.				III	14	*
Luzula campestris				II	100	**
Calliergonella cuspidata				II	98	**
Leontodon autumnalis				II	89	**
Veronica chamaedrys				II	73	**
Plagiomnium undulatum				II	50	*
Rhytidiadelphus squarrosus				II	50	*
Agrostis stolonifera	I	2		II	44	*
Rosa pimpinellifolia				II	34	*
Pteridium aquilinum				II	27	*
Vicia cracca				I	76	*
Festuca rubra				I	60	*
Daucus carota				I	54	*
Rhytidiadelphus triquetrus				I	46	*
Cirsium vulgare				I	18	*
Hylocomium splendens				I	17	*
Polystichum setiferum				I	12	*
Taraxacum officinale agg.				I	10	*
Agrostis canina	I	2		I	8	*
Potentilla sterilis				I	8	*
Geranium sanguineum				I	6	*
Molinia caerulea				I	3	*
Other vascular plants						
Calluna vulgaris	II	1				
Hypericum pulchrum				I	3	
Crataegus monogyna				I		
Other Bryophytes						
Rhytidiadelphus loreus				I	4	
Breutelia chrysocoma	I	2				

<u>Scrub Description (Group 39; 4 relevés)</u>

Indicator Species: *Corylus avellana (89%), Brachythecium sylvaticum (71%), Hedera helix (61%), Rubus fruticosus agg. (55%), Dactylis glomerata (52%), Prunus spinosa (43%), Agrostis canina (37%), Ctenidium molluscum (37%), Thuidium tamariscinum (33%), Crataegus monogyna (32%).*

Description: Constant species found in this group include *Corylus avellana, Dactylis glomerata, Brachythecium sylvaticum, Rubus fruticosus agg., Hedera helix, Rosa pimpinellifolia, Viola sp.* and the mosses *Breutelia chrysocoma, Pseudoscleropodium purum* and *Ctenidium molluscum.* This habitat is characterised by at least 50% shrub and bryophyte cover. Grykes may or may not be present. This habitat can also occur in shattered pavement areas where soil has accumulated. This habitat was found in two plots in Gortlecka, one plot in Lough Mask and in the Bricklieve Mountains. This habitat has no Annex I Habitat affinities, other affinities are listed below in Table 16. A full list of species for the habitat is given in Table 17 (synoptic).

Table 16: Relevant vegetation community affinities for the Scrub group determined by ISA.

	Relevant Affinities
EU Annex I:	8240 – Limestone Pavement
Fossitt:	WN2 – Oak-ash-hazel woodland
	WS1 – Scrub
NVC:	W9a – *Fraxinus excelsior – Sorbus aucuparia – Mercurialis perennis* woodland typical sub-community
Kelly (2005):	Corylo-Fraxinetum coryletosum / veronicestosum
Perrin *et al.* (2008):	*Corylus avellana – Oxalis acetosella* vegetation type
Parr *et al.* (2009):	No major correspondence

Table 17: Synoptic Table for the Scrub habitat group.

Scrub Indicator Species			
Corylus avellana	**V**	**89**	*****
Dactylis glomerata	**V**	**52**	***
Viola sp.	**V**	**40**	**
Brachypodium sylvaticum	**IV**	**94**	****
Hedera helix	**IV**	**82**	***
Rubus fruticosus agg.	**IV**	**74**	***
Prunus spinosa	**IV**	**57**	***
Ctenidium molluscum	**IV**	**49**	**
Pseudoscleropodium purum	**IV**	**39**	**
Breutelia chrysocoma	**IV**	**25**	*
Rosa pimpinellifolia	**IV**	**10**	*
Carex flacca	**IV**	**7**	*
Agrostis canina	III	74	**
Thuidium tamariscinum	III	67	**
Crataegus monogyna	III	64	**
Hylocomium splendens	III	42	**
Potentilla sterilis	III	40	*
Lathyrus linifolius	III	38	*
Neckera crispa	III	34	*
Geranium robertianum	III	33	*
Tortella tortuosa	III	23	*
Asplenium trichomanes	III	21	*
Anthoxanthum odoratum	III	20	*
Pteridium aquilinum	III	16	*
Geranium sanguineum	III	12	*
Potentilla erecta	III	10	*
Festuca ovina	III	8	*
Teucrium scorodonia	III	4	*
Centaurea nigra	III	3	*
Sesleria caerulea	III	1	*
Rhytidiadelphus loreus	II	95	**
Oxalis acetosella	II	83	**
Scapania sp.	II	74	*
Leontodon hispidus	II	71	*
Dryopteris filix-mas	II	67	*
Danthonia decumbens	II	57	*
Cirsium vulgare	II	46	*
Daucus carota	II	45	*
Rhytidiadelphus triquetrus	II	43	*
Carlina vulgaris	II	38	*
Rhytidiadelphus squarrosus	II	37	*
Carex pulicaris	II	34	*
Plagiochila spp.	II	34	*
Polystichum setiferum	II	30	*
Agrostis capillaris	II	27	*
Cerastium fontanum	II	29	*
Briza media	II	20	*
Hypericum pulchrum	II	21	*
Veronica chamaedrys	II	20	*
Polygala vulgaris	II	14	*
Prunella vulgaris	II	16	*
Antennaria dioica	II	13	*
Cynosurus cristatus	II	10	*
Festuca rubra	II	12	*
Fissidens sp.	II	12	*
Leucanthemum vulgare	II	12	*
Linum catharticum	II	13	*
Ranunculus bulbosus	II	14	*
Thymus polytrichus	II	11	*
Asplenium ruta-muraria	II	7	*
Calluna vulgaris	II	6	*
Leontodon autumnalis	II	9	*
Phyllitis scolopendrium	II	9	*
Pilosella officinarum	II	9	*
Plantago lanceolata	II	8	*
Trifolium pratense	II	7	*
Agrostis stolonifera	II	2	*
Dicranum scoparium	II	2	*
Galium verum	II	5	*
Lotus corniculatus	II	3	*
Trifolium repens	II	4	*

Other Grasses/Rushes/Sedges		
Molinia caerulea	25	

Other Herbs		
Plantago maritima	25	2
Succisa pratensis	25	1

Assessment of EU Annex I habitats conservation status

Area assessment

As previously discussed in the methods section, it was not possible to calculate the variation in habitat extent. Any estimation based on ortho–photography would have been inaccurate particularly at the level of mapping undertaken. Data on habitat extent generated as part of this survey should be taken as baseline information to ascertain future changes in this attribute. Subsequently, an Unknown assessment is given to this attribute.

Structure and functions assessment

<u>Limestone pavement (exposed) (8240)</u>

Structure and functions were assessed at a total of 39 monitoring stops containing exposed limestone pavement or pavement in a mosaic with another habitat (e.g. grassland), within the six Survey Units. This habitat failed at one Survey Unit (Table 18); a Red Fail assessment was given to Lough Mask/Lough Carra, as 40% of the monitoring stops failed (Appendix 8). An inadequate number of positive indicators and high cover of non-native species (*Cotoneaster microphyllus*) were the reasons for this failed assessment.

<u>Semi-natural dry grasslands and scrubland facies on calcareous substrates (Festuco-Brometalia) (important orchid sites) (6210/6211)</u>

Structure and functions were assessed at a total of 17 monitoring stops containing Annex I habitat 6210/6211 (Appendix 8) within five of the six Survey Units surveyed. This habitat failed at four of the Survey Units (Table 18).

Litter cover is used as an indicator of grazing conditions, and although the percentage of litter cover (< 25% required) was assessed, this attribute was not taken into account in the overall habitat structure and functions. The litter cover was very high in almost all of the monitoring stops ranging from 0.5 to 90% (average 44%), and thus most of the plots would have failed on this attribute. The majority of the plots surveyed are winterage sites, which were surveyed at the end of the growing season prior to the grazing period. According to JNCC (2004a) methodologies, litter cover is considered a secondary attribute and should be used to provide substantiating evidence for an assessment but should not be used as a primary indicator of conditions. Therefore it was considered justifiable to exclude this attribute from the assessment, although the importance of this target may need to be re-assessed in the future.

A Red Fail assessment was given to the following Survey Units: Abbey Hill, Black Head, Gortnandarragh (Lough Corrib) and Lough Mask/Lough Carra. All these Survey Units fail as a result of a low Grass:Forbs ratio. In addition Lough Mask/Lough Carra also failed due to low number of positive indicators and Scrub/Bracken/Heath encroachment. This Survey Unit failed at two levels in the matrix, monitoring stop level and attribute level (Appendix 8).

<u>European dry heaths (4030)</u>

Structure and functions were assessed at a total of 25 monitoring stops containing Annex I habitat 4030 within four of the six Survey Units. This habitat passed at all the Survey Units (Table 18). Although positive indicators and bracken cover attributes fail at some of the monitoring stops, this was not deemed enough to justify a negative assessment on the whole (Appendix 8).

Table 18: Structure and functions assessment results per habitat and Survey Unit

EU Habitat	Survey Unit	Survey Unit Structure & functions
8240 (exposed) + mosaic	Abbey Hill	Pass
	Black Head	Pass
	Bricklieve Mountains	Pass
	Gortlecka	Pass
	Gortnandarragh (Lough Corrib)	Pass
	Lough Mask/Lough Carra	Fail
6210/6211	Abbey Hill	Fail
	Black Head	Fail
	Gortlecka	Pass
	Gortnandarragh (Lough Corrib)	Fail
	Lough Mask/Lough Carra	Fail
4030	Abbey Hill	Pass
	Black Head	Pass
	Gortlecka	Pass
	Gortnandarragh (Lough Corrib)	Pass

<u>Limestone pavement and associated habitats (8240)</u>

An overall assessment of the structure and functions of the priority habitat 8240 taking into consideration the assessment given to its associated habitats was carried out (Table 19). Structure and functions were considered Favourable at two Survey Units; Unfavourable Inadequate at three Survey Units and Unfavourable Bad at the one remaining Survey Unit. An unfavourable assessment for the calcareous grassland component was the reason for the Unfavourable Inadequate assessment results at Abbey Hill, Black Head and Gortnandarragh (Lough Corrib). A combination of an unfavourable assessment for both exposed limestone pavement and calcareous grassland was the reason for the Unfavourable Bad assessment at Lough Mask/Lough Carra.

Table 19: Limestone pavement and associated habitats structure & functions assessment results per Survey Unit.

Survey Unit	EU Habitat	Individual habitat structure and functions result	Habitat extent (m²)	% Pass	% Fail	Overall Limestone pavement & associated habitats (8240) structure & functions
Abbey Hill	8240 (exposed) + mosaic *	Pass	58,908	96	4	Unfavourable Inadequate
	6210/6211	Fail	3,159			
	4030	Pass	16,632			
Black Head	8240 (exposed) + mosaic	Pass	72,460	96.5	3.5	Unfavourable Inadequate
	6210/6211	Fail	2,830			
	4030	Pass	4,500			
Bricklieve Mountains	8240 (mosaic)	Pass	29,075	100	0	Favourable
Gortlecka	8240 (exposed) + mosaic	Pass	64,190	100	0	Favourable
	6210/6211	Pass	4325			
	4030	Pass	4813			
Gortnandarragh (Lough Corrib)	8240 (exposed) + mosaic	Pass	62,095	98.5	1.5	Unfavourable Inadequate
	6210/6211	Fail	1,150			
	4030	Pass	13,392			
Lough Mask/Lough Carra	8240 (exposed) + mosaic	Fail	58,176	1	99	Unfavourable Bad
	6210/6211	Fail	12,671			
	4030	Pass	675			

* A small number of monitoring stops consisting of a mosaic (e.g. exposed limestone pavement and calcareous grassland or exposed limestone pavement and scrub) were also included here. Best expert judgement was employed to assess their structure and functions in Bricklieve Mountains Survey Unit.

Future prospects assessment

<u>Limestone pavement (exposed) (8240)</u>

Future prospects were assessed for exposed limestone pavement in all of the six Survey Units. Table 20 illustrates the results of the assessment; a further description of the assessment results is given in Appendix 9.

Future prospects were considered Unfavourable Inadequate in three out of six Survey Units. Invasive species (*Cotoneaster microphyllus)* were reported at Abbey Hill, Gortnandarragh (Lough Corrib) and Lough Mask/Lough Carra. In addition quarrying was reported as a negative impacting activity in Gortnandarragh (Lough Corrib).

<u>Semi-natural dry grasslands and scrubland facies on calcareous substrates (Festuco-Brometalia) (important orchid sites) (6210/6211)</u>

Future prospects were assessed for habitat 6210/6211 in five of the six Survey Units (Table 20); a further description of the assessment results is given in Appendix 9.

Future prospects were considered Unfavourable Inadequate at two of the five Survey Units. Invasive species were reported at Gortnandarragh (Lough Corrib) and Lough Mask/Lough Carra. In addition, quarrying was reported in Gortnandarragh (Lough Corrib). These were the main reasons for an unfavourable assessment at these Survey Units.

<u>European dry heaths (4030)</u>

Future prospects were assessed for habitat 4030 in four of the six Survey Units (Table 20); a further description of the assessment results is given in Appendix 9.

An Unfavourable Inadequate Future prospects assessment was given at Gortnandarragh (Lough Corrib) Survey Unit. Quarrying and invasive species were the negative impacting activities reported at this Unit. A Favourable assessment was given to the remaining Survey Units.

<u>Limestone pavement and associated habitats (8240)</u>

Table 20 illustrates that future prospects have been assessed Unfavourable Inadequate at half (three out of six) of the Survey Units.

An Unfavourable assessment of at least one of the limestone pavement associated habitats has resulted in an overall assessment for future prospects of EU Annex I Habitat 8240 as Unfavourable.

Table 20: Future prospects assessment results for Annex I habitat and Survey Unit

Survey Unit	EU Annex I habitat	Overall Future prospects	Survey Unit Overall Future prospects
Abbey Hill	4030	Favourable	Unfavourable Inadequate
	6210/6211	Favourable	
	8240 (exposed) + mosaic	Unfavourable Inadequate	
	Overall		
Black Head	4030	Favourable	Favourable
	6210/6211	Favourable	
	8240 (exposed) + mosaic	Favourable	
	Overall		
Bricklieve Mountains	8240 (mosaic)	Favourable	Favourable
	Overall		
Gortlecka	4030	Favourable	Favourable
	6210/6211	Favourable	
	8240 (exposed) + mosaic	Favourable	
	Overall		
Gortnandarragh Lough Corrib)	4030	Unfavourable Inadequate	Unfavourable Inadequate
	6210/6211	Unfavourable Inadequate	
	8240 (exposed) + mosaic	Unfavourable Inadequate	
	Overall		
Lough Mask	6210/6211	Unfavourable Inadequate	Unfavourable Inadequate
	8240 (exposed) + mosaic	Unfavourable Inadequate	
	Overall		

Overall Assessment

The overall assessment of the conservation status of limestone pavement has been carried out at two different levels:

1. Each Annex I habitat associated with limestone pavement (i.e. exposed limestone pavement (8240), 6210/6211 and 4030), (Table 21).

2. Overall limestone pavement and associated habitats (8240) (Table 22).

Limestone pavement (exposed) (8240)

The overall conservation status for exposed limestone pavement was assessed as Favourable (Table 21) at three out of six Survey Units, Unfavourable Inadequate at two Survey Units and Unfavourable Bad at one Survey Unit. The presence of negative indicator species and invasive species (*Cotoneaster microphyllus*), were the main reasons for an Unfavourable assessment at Abbey Hill and Lough Mask. Quarrying was the main reason for an Unfavourable assessment in Gortnandarragh (Lough Corrib).

Semi-natural dry grasslands and scrubland facies on calcareous substrates (Festuco-Brometalia) (important orchid sites) (6210/6211)

The overall conservation status was considered to be Unfavourable for habitat 6210/6210 at all Survey Units containing the Annex I habitat except for Gortlecka (Table 21). Four Survey Units were given an Unfavourable Bad assessment. A high Forbs ratio requirement was identified as the main reason for an overall negative assessment for the habitat structure and functions. Quarrying and invasive species (*Cotoneaster microphyllus*) were also threatening this Annex I habitat in Gortnandarragh (Lough Corrib). Gortlecka was the only Survey Unit that passed the conservation status assessment.

European dry heaths (4030)

The overall conservation status for habitat 4030 was assessed as Favourable (Table 21) at three out of the four Survey Units containing the Annex I habitat. Gortnandarragh (Lough Corrib) was given an Unfavourable Inadequate assessment, as a result of quarrying and the presence of invasive species (*Cotoneaster microphyllus*).

Limestone pavement and associated habitats (8240)

The conservation status of limestone pavement and associated habitats has been assessed as Favourable at two of the six Survey Units (Bricklieve Mountains and Gortlecka); Unfavourable Inadequate at Abbey Hill, Black Head and Gortnandarragh (Lough Corrib) and Unfavourable Bad at Lough Mask/Lough Carra (Table 22). The assessment of the overall habitat 8240 is based on the assessment results given in tables 19 and 20.

Table 21: Individual Annex I habitat Conservation Status Assessment

EU Habitat	Survey Unit	Area	Structure and functions	Future prospects	Overall Conservation Status Assessment
8240 (exposed)	Abbey Hill	Unknown	Pass	Unfavourable Inadequate	Unfavourable Inadequate
	Black Head	Unknown	Pass	Favourable	Favourable
	Bricklieve Mountains	Unknown	Pass	Favourable	Favourable
	Gortlecka	Unknown	Pass	Favourable	Favourable
	Gortnandarragh (Lough Corrib)	Unknown	Pass	Unfavourable Inadequate	Unfavourable Inadequate
	Lough Mask/ Lough Carra	Unknown	Fail	Unfavourable Inadequate	Unfavourable Bad
6210 / 6211	Abbey Hill	Unknown	Fail	Favourable	Unfavourable Bad
	Black Head	Unknown	Fail	Favourable	Unfavourable Bad
	Gortlecka	Unknown	Pass	Favourable	Favourable
	Gortnandarragh (Lough Corrib)	Unknown	Fail	Unfavourable Inadequate	Unfavourable Bad
	Lough Mask/ Lough Carra	Unknown	Fail	Unfavourable Inadequate	Unfavourable Bad
4030	Abbey Hill	Unknown	Pass	Favourable	Favourable
	Black Head	Unknown	Pass	Favourable	Favourable
	Gortlecka	Unknown	Pass	Favourable	Favourable
	Gortnandarragh (Lough Corrib)	Unknown	Pass	Unfavourable Inadequate	Unfavourable Inadequate

Table 22: Overall Limestone pavement and associated habitats (8240) Conservation Status Assessment

Survey Unit	Area	Overall Structure and functions	Overall Future Prospects	Overall Conservation Status Assessment
Abbey Hill	Unknown	Unfavourable Inadequate	Unfavourable Inadequate	Unfavourable Inadequate
Black Head	Unknown	Unfavourable Inadequate	Favourable	Unfavourable Inadequate
Bricklieve Mountains	Unknown	Favourable	Favourable	Favourable
Gortlecka	Unknown	Favourable	Favourable	Favourable
Gortnandarragh (Lough Corrib)	Unknown	Unfavourable Inadequate	Unfavourable Inadequate	Unfavourable Inadequate
Lough Mask/Lough Carra	Unknown	Unfavourable Bad	Unfavourable Inadequate	Unfavourable Bad

Proposed National Survey and monitoring programme

The purpose of a National Survey and Monitoring Programme for limestone pavement will be to assess the conservation status of limestone pavement and associated habitats across its geographical range in Ireland.

Data collected during the National Survey will also allow the further development of a comprehensive vegetation classification of limestone pavement and associated habitats in Ireland, which has already been initiated as part of the 2008 Pilot Survey.

Conservations status assessment methodologies established during the 2008 Pilot Survey should be tested and refined where required. Further monitoring guidelines should be established for associated habitats not encountered in the 2008 Survey.

Quality Standards should be followed and complied during the course of all survey stages, including consistency in data collection, habitat mapping, monitoring methodologies implementation, data analysis, etc.

Three stages in the survey are recognised: Pre-survey; Field Survey and Post-survey.

Pre-survey

This section relates to all work to be carried out prior to the commencement of field surveys. It includes the collation of information on sites to be surveyed and preparation of materials necessary to carry out the survey.

Field Survey

Field Survey should be carried out based on survey methodologies and conservation status assessment guidelines devised as part of the 2008 Pilot Survey. Surveys should be undertaken within specific 100 x 100 m Plots selected within Survey Units. A detailed vegetation survey should be undertaken within each plot.

The following data should be recorded within Survey Units:

- Habitat boundary points
- Vascular and bryophyte species
- A number of relevés that will be use as monitoring stops
- Pressure and threats
- Photographic records
- Other features related to site management, damaging operations, fauna, etc

Habitats within each plot should be mapped using both Fossitt (2000) and the EU Habitats Directive Annex I habitats classification. Survey Plots should be representative of the ecological and geographical variability and management type within the Survey Unit.

Standard safety procedures will be followed. Team members should be familiar with the NPWS Health & Safety Statement and Safe Operational Procedures for Field Work in the National Parks & Wildlife Service.

Post-survey

This section includes the processing of survey data in order to establish a vegetation classification of limestone pavement and associated habitats and assess the conservation status of identified Annex I habitats at national level. Data gathered during field-work should be inputted into the National Limestone Pavement Survey Database.

Sites selection

The selection of Survey Units should be based on the National Limestone Pavement habitat distribution map. However consultation with the following agents should take place:

- National experts and NPWS staff.

- Local Authorities including Heritage and Biodiversity Officers, NPWS regional staff and BSBI county recorders.

- National Biodiversity Data Centre.

Survey Units selection should take into account the ecological and geographical variation within limestone pavement in Ireland.

Number and location of sites

A total of 40 Survey Units are considered appropriate to cover the geographical and ecological range of the habitat in Ireland. Approximately half of the Survey Units should be located in counties Galway and Clare; the remaining Units should be located in other counties such as Longford, Meath, Limerick, Kerry, Roscommon and Donegal where isolated limestone pavement sites occur.

Timing of surveys

Surveys should be carried out between May and September, preferably over a two year period. This will allow the re-assessment of methods established within the 2008 Pilot Survey and the development of new methods required for those Annex I habitats not encountered in the 2008 Survey.

Data management

Standardisation and consistency in data collection and analysis is essential. Appropriate training should take place before the survey starts; this will ensure standards are met during the field survey. Quality control of survey standards and data recording is also essential throughout the duration of the survey, to ensure on-going standards are achieved.

Data collected during the National Survey and Monitoring Programme should be entered in the National Limestone Pavement Survey Database already established as part of the 2008 Pilot Survey.

This will allow future analysis and improve efficiency in data use. GIS data and photographs may be stored in separate digital files.

Data analysis

Data gathered from the National Survey and Monitoring Program should be used to assess the conservation status of limestone pavement and associated habitats in Ireland as well as establishing a national vegetation classification. The refinement and completion of Common Standards for Monitoring Limestone Pavement and associated habitats in Ireland should also be carried out.

Data analysis should include:

- Phytosociological analysis in order to establish a national limestone pavement and associated habitats vegetation classification. This should include a multivariate analysis of species and environmental data.

- Assessment of Habitats Directive Annex I habitats conservation status at different levels; Survey Unit and other appropriate geographical levels: county or national level. This will be based on the habitat's natural range; specific habitat structure and functions; conservation status of its typical species as well as identification of negative indicators and current and future impacts and threats.

DISCUSSION

Habitat Mapping

The Limestone Pavement habitat map depicts the distribution and extent of limestone pavement and associated habitats (e.g. grassland, heath, scrub and woodland) at national level. Due to the scale of the mapping exercise, small areas of pavement may have been omitted. A more accurate mapping would require further work, and in some cases ground surveying, which is beyond the scope of this project. However, it should be mentioned that areas as small as 500 m² have been mapped.

The final limestone pavement habitat map indicates that the overall extent of this habitat is 31,000 ha. Although this figure is 5,000 ha smaller than the figure reported in 2007, this reduction in habitat extent is the result of a much higher level of mapping accuracy rather than any actual habitat loss. The final map contains 403 new limestone pavement areas, which account for 952ha. The addition of these new areas to the original 2007 map and the elimination of areas wrongly classified as limestone pavement in 2007 resulted in the modification of the habitat range map produced in 2007.

Ortho-photography was found to be of limited use in identifying pavement areas completely covered with scrub or woodland. The presence of open pavements adjacent to wooded ones have helped in targeting areas where scrub or wooded pavements may be present. However, isolated areas of pavement covered by scrub of woodland where there is no obvious exposed pavement may have been omitted. Further field-work is required in order to improve habitat boundaries and/or to identify new areas (especially areas covered in scrub), particularly in counties Clare and Galway.

Areas have been identified, using the 2005 ortho-photographs, where removal of pavement or quarrying has taken place. The occurrence of these activities within a pavement site has been reported in the Limestone Pavement distribution map attribute table. The identification of these damaged sites using 2005 ortho-photographs is limited, as activities that took place prior to 2005 may have been overlooked while areas damaged subsequently will obviously have been omitted. The exercise did indicate however that the removal of pavement and quarrying is particularly frequent in counties Galway, Clare and Mayo.

Data Analysis and Habitat classification

The data analysis methods proved useful in separating the four main habitats surveyed; heath, pavement, grassland and scrub. Analysis methods also distinguished two sub-habitat groups (vegetation communities) for limestone pavement and grassland, which appear to be associated with pavement type and soil depth respectively. Each of the four main habitat groups forms a fairly broad grouping and are likely to be relevant at a national scale. If the survey is extended to a national level, the addition of more relevé data will refine the description of habitats and vegetation communities further.

The remaining group classified by the suite of data analysis techniques was a "mosaic" group. It mainly consisted of relevés that contained a mixture of one or more habitat types. Fossitt (2000) defines a mosaic as a complex pattern or patchwork of habitats or species occurring in intimate associations. Fossitt (2000) does not attempt to classify these mosaics but rather states that the

identification and differentiation of habitats is often difficult in practice. Habitats frequently merge or grade from one to another, or form complex mosaics, with the result that a continuum of variation often exists within and between different habitat types. Therefore it is not clear as yet where to assign these mosaic relevés. This grouping should be investigated further if a National Survey of limestone pavement and associated habitats is proposed.

Due to the relatively small number of relevés recorded during this pilot survey it was not possible to produce a complete vegetation classification of vegetation communities within all of the four habitats. However, certain vegetation types (e.g. grassland type 1 and 2) show similarities to those described by Parr *et al.* (2009) and Martin *et al.* (2007). The subjective sampling of relevés within pre-selected survey sites may be another reason for the number of vegetation types detected. Again, the addition of more relevé data will allow the further classification of these vegetation types.

Of the 90 relevés surveyed, 40 were recorded as pavement or pavement mosaic relevés, 25 as heath, all of which were considered Fossitt Habitat ER2 and HH2 respectively. Of the 18 grassland relevés recorded, all were assigned to the Fossitt category GS1; the six scrub relevés were assigned to WS1. The data analysis presented in this report divides the calcareous grassland (GS1) and the exposed rock (ER2) of Fossitt (2000) into two groups for each habitat rather than one. This should prove useful in the future classification and mapping of limestone pavement and associated habitats.

EU Annex I habitats assessment

Conservation status assessments were carried out (post-survey) for the following Annex I EU habitats: Limestone pavement (exposed) (8240); Semi-natural dry grasslands and scrubland facies on calcareous substrates (Festuco-Brometalia) (important orchid sites) (6210/6211) and European dry heaths (4030). Other habitats potentially found associated with limestone pavement were not reported as part of the 2008 Survey and thus methodologies to assess their conservation status were not established for this project. Elements of the EU Annex I Habitat Alpine and sub-Alpine Heath (4060) were found in the grassland and heath communities associated with limestone pavement. However, pure stands of this habitat were not recorded during this survey and therefore no assessment could be undertaken.

The methods used were based on existing methodologies that may need to be revised in future. Following discussions with NPWS experts, certain situations where scrub occurs on limestone pavement were also considered as an associated habitat of limestone pavement (Annex I habitat 8240). This situation was only reported on two occasions as part of this Survey. The data that were gathered were not considered sufficient to establish conservation status assessment methodologies and further work in this area is needed. Overall, the results provided by this assessment should be taken as an indication of current status of these habitats rather than an assessment of changes within a reporting period. They can be used as a baseline for further monitoring of these habitats.

The overall conservation status of limestone pavement and associated habitats (8240) was determined, based on each of the individual associated habitat conservation status assessment results. Unfavourable assessment results for habitat 6210/6211 were the main reason for an overall unfavourable assessment for habitat 8240. Future prospects and structure and functions assessment targets proposed in this project were based on existing methodologies. These criteria may require further revision, particularly in relation to positive (e.g. positive indicator species) and negative

indicators (e.g. litter cover, Grass/Forbs ratio, scrub/bracken encroachment). These amendments are likely to result in changes in the conservation status assessments for both limestone pavement habitat as a whole (8240) and those EU Habitats associated with limestone pavement (6210/6211, 4030).

Quarrying and removal of pavement were identified as the most threatening activity affecting exposed limestone pavement (8240). Invasive species (*Cotoneaster microphyllus*) and other negative indicators (e.g. negative indicator species, bracken encroachment) were also reported as threats to the habitat. A list of positive indicator species has been proposed as part of the assessment; this list may be subject to further revision.

Assessment methodologies proposed by Dwyer *et al*. (2007) and Martin *et al*. (2007) for habitat 6210/6211 were slightly modified during this survey: new species were added to the list of positive indicators, including bryophytes. The results of the assessment indicate a rather unfavourable conservation status for this habitat. A high Forbs ratio requirement based on the methods established by Dwyer *et al*. (2007) and Martin *et al*. (2007) was the main reason for a negative assessment. Further surveys will result in a better understanding of this habitat and are likely to bring about changes in this attribute target requirements. Although invasive species (*Cotoneaster microphyllus*) were reported as negative indicators in some of the Survey Units, quarrying was the most seriously threatening activity to this Annex I habitat.

Conservation status assessment methodologies were also devised for habitat 4030. The proposed list of positive and negative indicators may require further revision once better understanding of this habitat is achieved. An overall favourable assessment was given to habitat 4030. Only Gortnandarragh (Lough Corrib) Survey Unit has been given an unfavourable assessment for this habitat's conservation status as a result of the presence of quarrying threatening this habitat and the presence of (*Cotoneaster microphyllus*).

A new method for assessing structure and functions of EU habitats was devised during this project. This method is based on the analysis of a matrix where structure and functions are assessed at monitoring stop level and attribute level. The proposed method is considered to be a fairer representation of the condition of a habitat. The addition of a second level of assessment provides an accumulative level of assessment at attribute level (i.e. if the same attributes fail at several monitoring stops within a survey unit it is taken into consideration in the assessment).

The categorisation of structure and functions criteria attributes into primary and secondary attributes as proposed by JNCC (2004a) for grassland habitats should be explored in further assessment reviews for any of the Annex I habitats. This categorisation is based on the grounds that some attributes should be mandatory to assess structure and functions whereas other attributes should be taken only as early warning signals. The secondary attributes should therefore be used to indicate a potential deterioration in the quality of the habitat or should only be looked at when conditions allow and/or are deemed appropriate. The addition of other structure and functions criteria to the assessment, such as an indication of scrub encroachment and scrub removal, should also be explored in the future.

Change in habitat extent was not assessed as part of this survey. The use of ortho-photography for evaluating changes in habitat extent was not deemed appropriate. The size of the Survey Plots (1ha) and minimum mapping unit size (4m x 4m) made it impossible to ascertain area changes at this level

of fine scale mapping. However, data on habitat extent gathered as part of this survey will be useful as baseline data for future assessments.

All Survey Units for which assessments were carried out are included within designated sites (i.e. SAC and/or NHA). A National Survey should also include areas outside designated sites in order to give a more realistic view of the conservation status of limestone pavement and associate habitats on a national scale. Negatively impacting activities are more likely to be threatening areas that are not protected by any form of designation. The refinement of the national limestone pavement distribution map has indicated that the removal of pavement is particularly prevalent in areas of non-designated land.

CONCLUDING REMARKS

This pilot study has allowed the development of methodologies to assess the conservation status of limestone pavement and associated habitats in Ireland. These methods have been used to examine the range of variation within these habitats on a regional and national scale. Accurate habitat maps have been produced at the monitoring plot level, and all data recorded in the field has been stored accordingly in either GIS format or in a MS Access database. A National Limestone Pavement habitat distribution map has also been produced based on the map generated as part of the limestone pavement habitat (8240) Conservation Status Assessment report commissioned by NPWS in 2007.

The methods have been tested in six areas: West-Burren, Mid-Burren & East-Burren, Lough Corrib, Lough Mask and Bricklieve Mountains. The utilisation of hierarchical cluster analysis on the data recorded has proved useful in separating the four main habitats surveyed; heath, pavement, grassland and scrub. Two of these groups (limestone pavement and grassland) have been further dividing into two sub-habitat groups (vegetation types). These findings should add valuable information to current classifications and may prove useful in the future classification and mapping of limestone pavement and associated habitats.

Methods were proposed to assess the conservation status (i.e. structure and functions and future prospects) of limestone pavement and associated habitats at two different levels: a) each individual Annex I habitat associated with limestone pavement (i.e. exposed limestone pavement (8240), Festuco-Brometalia grassland (6210/6211) and European Dry Heath (4030) and b) overall limestone pavement and associated habitats (8240). Quarrying and removal of pavement have been identified as the most threatening activity affecting limestone pavement and its associated habitats. The assessment has highlighted the vulnerability of limestone pavement and associated habitats, particularly in those areas which are not protected by designation.

The commissioning of this pilot survey has allowed the study of a valuable national resource and highlights the need for further research into the conservation of EU Annex I Habitats in Ireland. This survey has hopefully brought a better understanding of the status of limestone pavement and associated habitats in an Irish context. It is of utmost importance that baseline data has been established, so that the future monitoring of limestone pavement and those habitats associated with it is ensured.

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APPENDIX 1: DETAIL VIEW OF SURVEY UNITS AND PLOTS

Brieklieve Mountains Survey Unit

Gortlecka Survey Unit

Lough Mask Survey Unit (map 2 of 2)
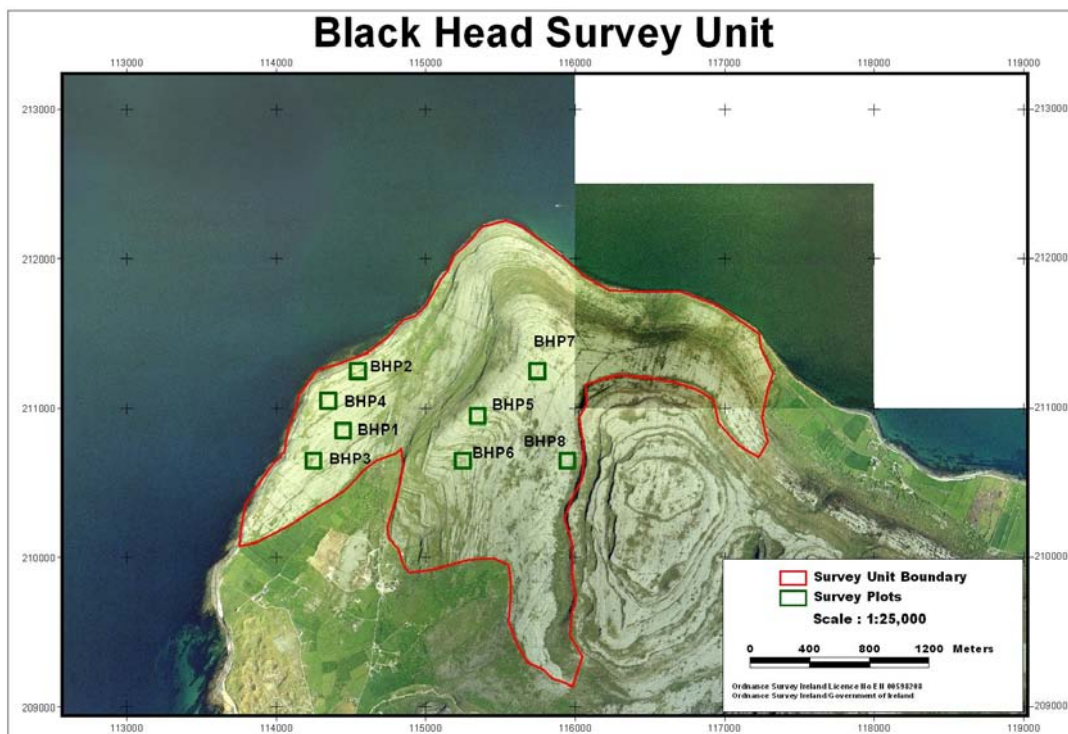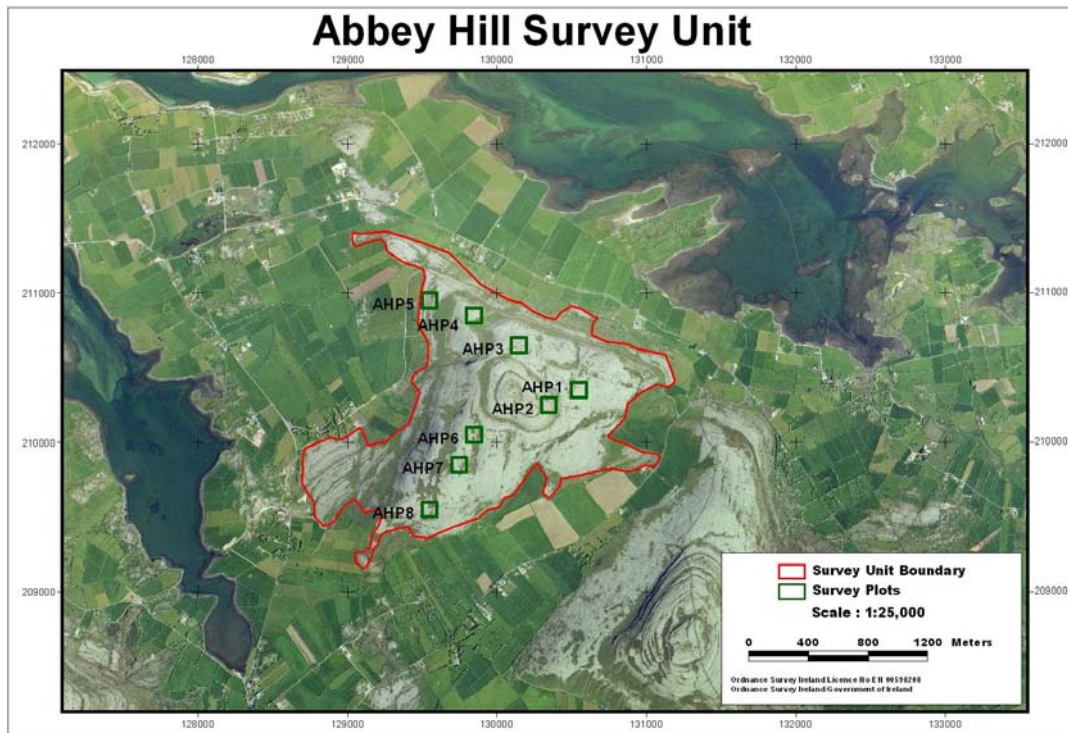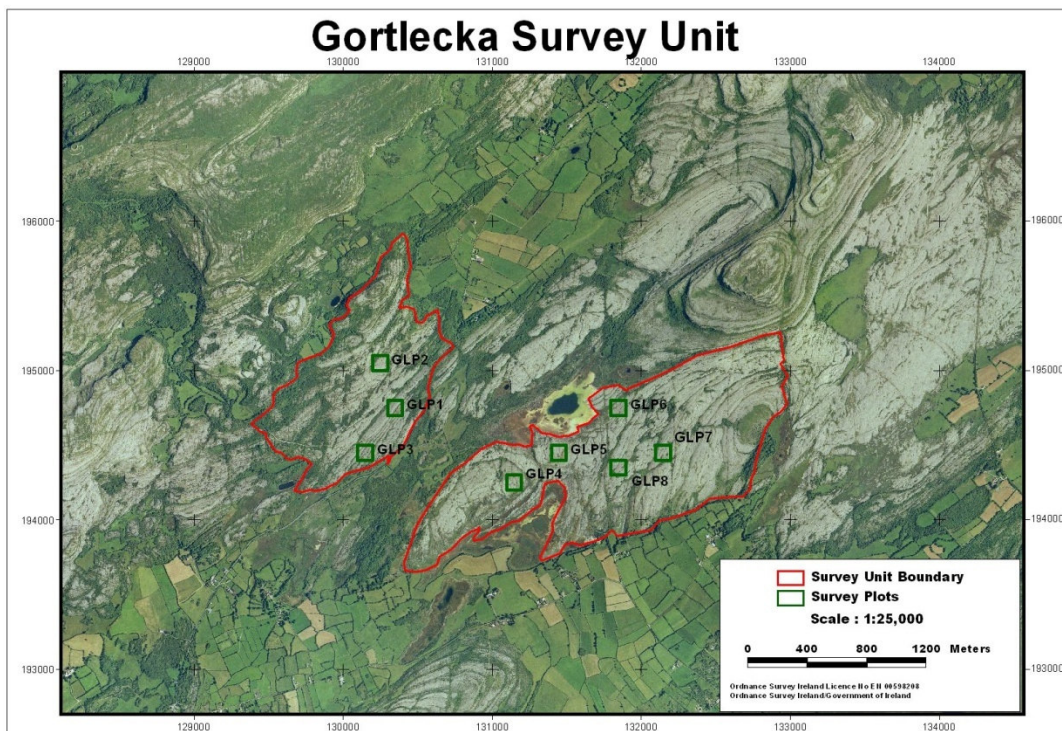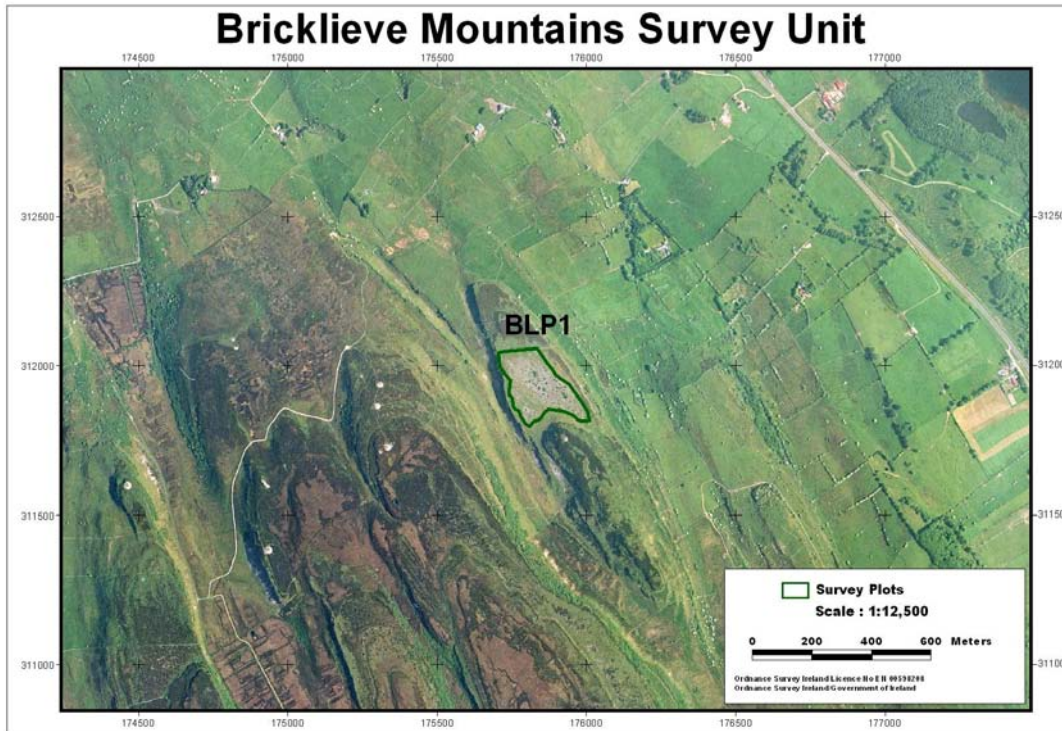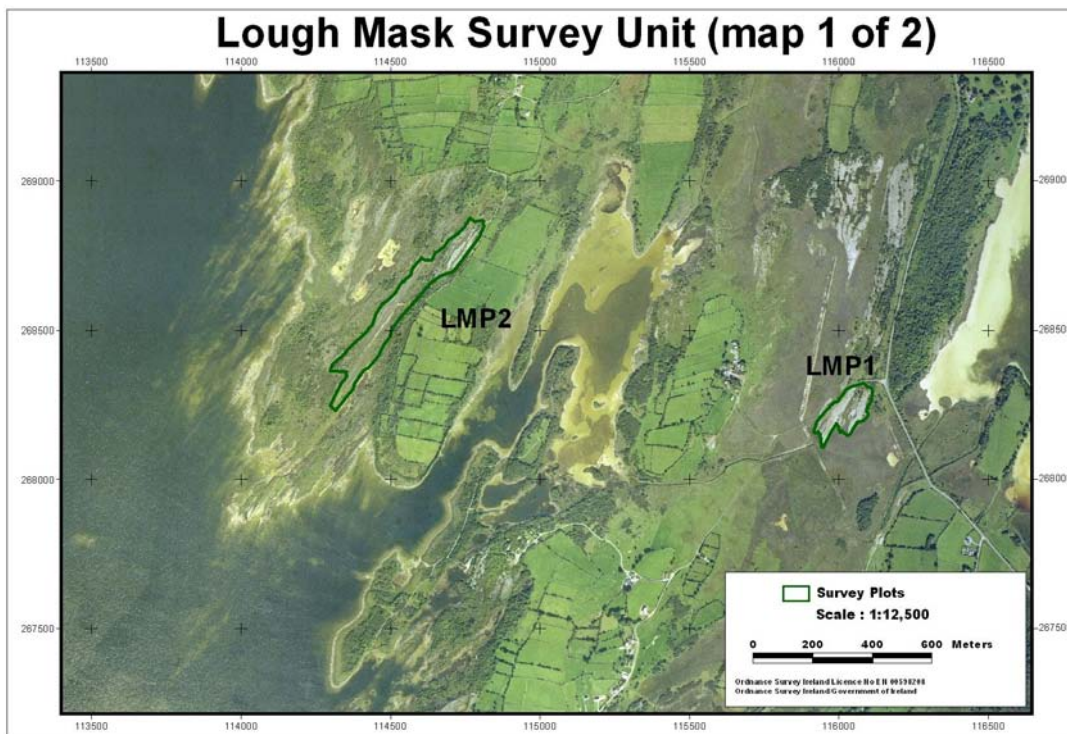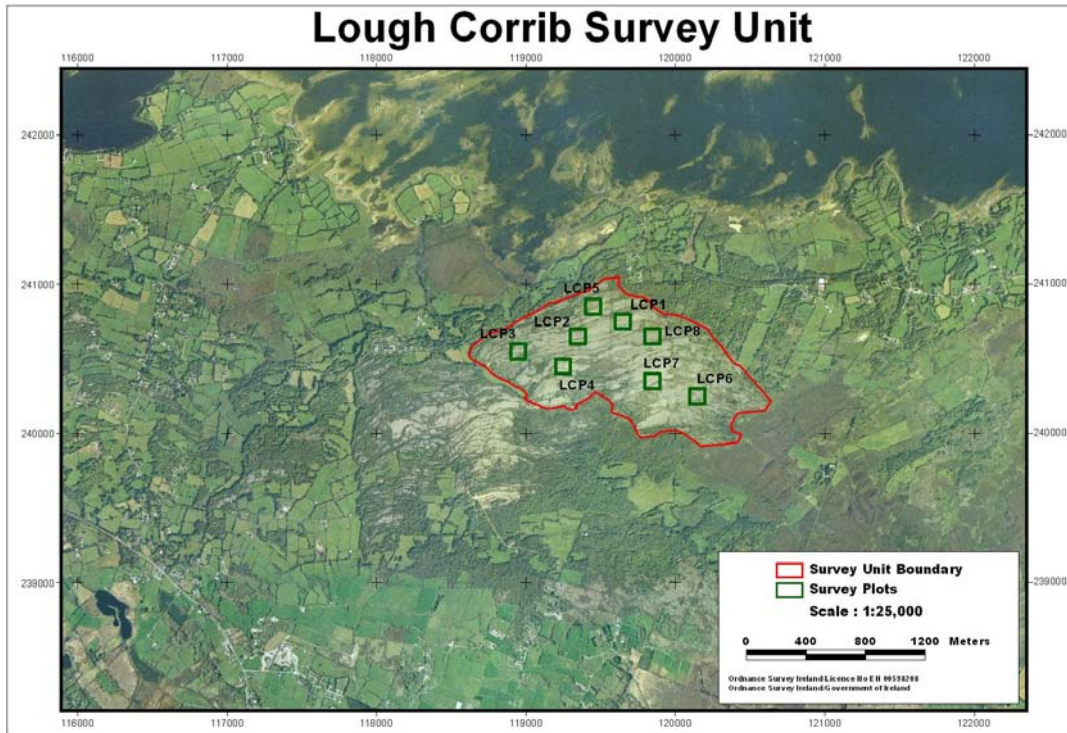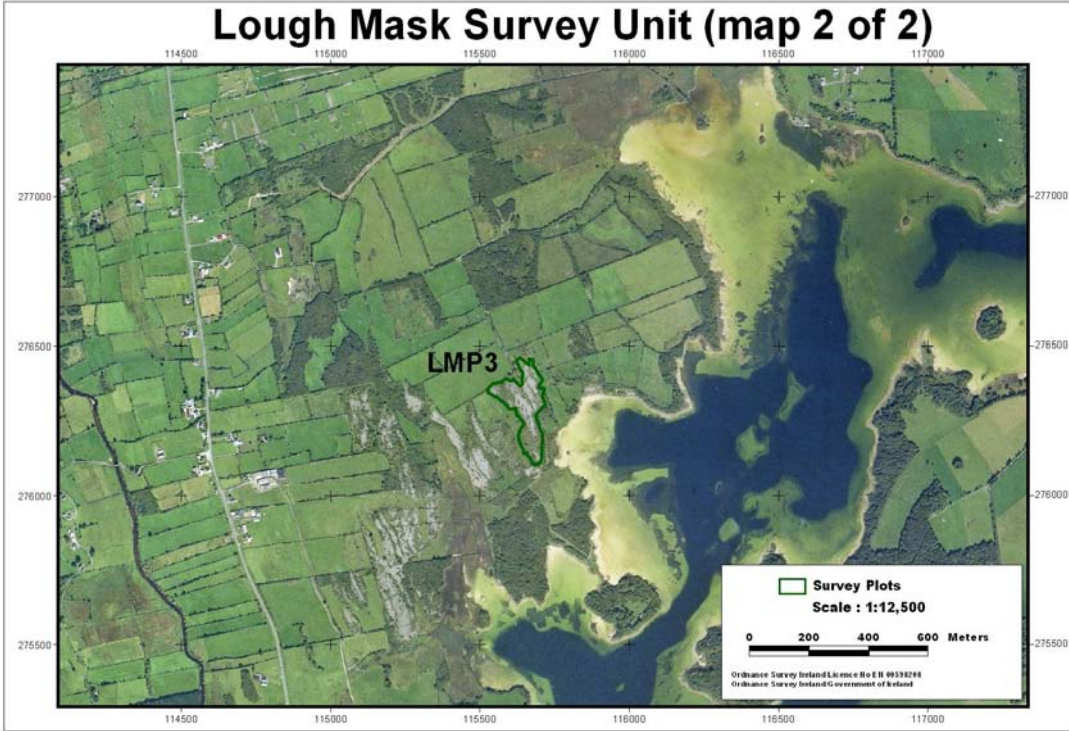
APPENDIX 2: FIELD CARDS

Plot description field card

Plot species list field card

Limestone Pavement relevé field card

Grassland/Heath relevé field card

Scrub/Woodland relevé field card

Limestone pavement survey methodology – Plot description field card

						Relevé No:	Description
Site Name		6210 Orchid-rich grassland		Heath		Relevé No:	Description
Plot ID		91J0 Taxus baccata woods		Scrub			
Date		7210 Calcareous Fens		Mosaic			
Altitude range (m)		7220 Petrifying Springs		None			
Slope		7230 Alkaline Fen		**Invasive Present (L-M-H)**			
Slight		8210 Calcareous rocky slopes		**Species:**			
Moderate		8240 Limestone pavement		Pavement			
Steep		Other		Grassland			
Flat		None		Heath			
Depression		**Fossitt Habitats**		Scrub			
Not Applicable		GS1 Dry calcareous/ neutral grassland		Mosaic			
Aspect		HH2 Dry calcareous heath		None			
Exposure		WS1 Scrub		**Fauna**			
Exposed		ER2 Exposed calcareous rock		Rabbits			
Partially exposed		WN2 Oak-ash-hazel woodland		Hares			
Sheltered		WN3 Yew Woodland		Frogs			**General Plot Notes**
Topographical situation		BL1 Stone walls		Ant hills			
Summit		HD1 Dense Bracken		Other			
Upper slope		Other		None			
Mid-slope		**Site Management**					
Lower slope		Cattle					
Depression		Goats					
Ridges		Horses					
Flat		Sheep					
Other		Other					
Pavement shape		Spring grazing May-Jun					
Extensive		Summer grazing:Jul-aug					
Isolated		Autumn graing:Sep-Nov					
Discontinuous		Winter grazing: Dec-Apr					
Stepped		Supplementary feeding					
Dominant pavement type		Scrub removal					
Blocky		**Damaging operations**					
Sharp		Stone removal					
Shattered		Dumping					
Other		Displacement					
Other pavement type		Gryke filling					
Blocky		Trampling					
Sharp		Other					
Shattered		None					
Other		**Grazing level**					
None		None					
EU Annex I Habitats		Light					
1150 Coastal Lagoons		Moderate					
3180 Turloughs		Heavy					
4030 Dry Heath		**Bracken Present (L-M-H)**					
4060 Alpine and sub-alpine heath		Pavement					
5130 Juniperus communis form		Grassland					

Limestone pavement survey methodology – Plot species list field card

Site ID	*Festuca rubra*	*Galium sterneri*	*Ranunculus ficaria*	*Dicranum scoparium*	*Dryas octopetala*
Plot ID	*Helictotrichon pubescens*	*Galium verum*	*Ranunculus repens*	*Didymodon fallax*	*Empetrum nigrum*
Relevé ID	*Holcus lanatus*	*Gentiana verna*	*Rhinanthus minor*	*Ditrichum flexicaule*	*Erica cinerea*
Date	*Juncus acutiflorus*	*Gentianella amarella*	*Rubia peregrina*	*Entodon concinnus*	*Hedera helix*
Aspect	*Juncus conglomeratus*	*Geranium molle*	*Rumex acetosa*	*Eucladium verticillatum*	*Helianthemum oelandicum*
Easting	*Juncus inflexus*	*Geranium robertianum*	*Sagina nodosa*	*Fissidens adianthoides*	*Lonicera periclymenum*
Northing	*Kobresia simpliciuscula*	*Geranium sanguineum*	*Samolus valerandi*	*Fissidens dubius*	*Rosa pimpinellifolia*
Altitude (m)	*Koeleria macrantha*	*Geum rivale*	*Sanguisorba minor*	*Fissidens incurvus*	*Rubus fruticosus agg.*
	Lolium perenne	*Gymnadenia conopsea*	*Sanicula europaea*	*Fissidens taxifolius var. taxifolius*	*Thymus praecox*
Ferns	*Luzula campestris*	*Hieracium anglicum agg.*	*Saxifraga hypnoides*	*Gymnostomum calcareum*	**Woody**
Adiantum capillus-veneris	*Molinia caerulea*	*Hyacinthoides non-scripta*	*Saxifraga rosacea*	*Homalothecium lutescens*	*Corylus avellana*
Asplenium adiantum-nigrum	*Poa annua*	*Hypericum androsaemum*	*Saxifraga tridactylites*	*Homalothecium sericeum*	*Crataegus monogyna*
Asplenium marinum	*Poa pratensis*	*Hypericum calycinum*	*Sedum acre*	*Hylocomium splendens*	*Euonymus europaeus*
Asplenium ruta-muraria	*Schoenus nigricans*	*Hypericum maculatum*	*Sedum sp.*	*Hypnum cupressiforme*	*Frangula alnus*
Asplenium trichomanes	*Sesleria caerulea*	*Hypericum pulchrum*	*Senecio jacobaea*	*Leucobryum glauca*	*Fraxinus excelsior*
Botrychium lunaria	*Trichophorum caespitosum*	*Hypochaeris radicata*	*Solidago virgaurea*	*Loeskeobryum brevirostre*	*Ilex aquifolium*
Ceterach officinarum	*Trisetum flavescens*	*Knautia arvensis*	*Sonchus oleraceus*	*Neckera crispa*	*Juniperus communis*
Cystopteris fragilis	**Herbs**	*Lathyrus linifolius*	*Stellaria graminea*	*Palustriella commutata*	*Potentilla fruticosa*
Dryopteris filix-mas	*Achillea millefolium*	*Lathyrus pratensis*	*Succisa pratensis*	*Plagiomnium undulatum*	*Prunus spinosa*
Ophioglossum vulgatum	*Alchemilla filicaulis*	*Leontodon autumnalis*	*Taraxacum sect. ruderalia*	*Pleurozium schreberi*	*Rhamnus catharticus*
Phyllitis scolopendrium	*Alchemilla xanthochlora*	*Leontodon hispidus*	*Teucrium scorodonia*	*Pseudoscleropodium purum*	*Rubus saxatilis*
Polypodium interjectum	*Anemone nemorosa*	*Leontodon saxatilis*	*Thalictrum minus*	*Racomitrium lanuginosum*	*Salix repens*
Polystichum aculeatum	*Antennaria dioica*	*Leontodon taraxacoides*	*Trifolium pratense*	*Rhytidiadelphus squarrosus*	*Salix sp.*
Polystichum setiferum	*Anthyllis vulneraria*	*Leucanthemum vulgare*	*Trifolium repens*	*Rhytidiadelphus triquetrus*	*Sorbus aucuparia*
Pteridium aquilinum	*Arabidopsis thaliana*	*Linum catharticum*	*Valeriana officinalis*	*Syntrichia ruralis*	*Taxus baccata*
Grasses/Sedges/Rushes	*Armeria maritima*	*Lotus corniculatus*	*Veronica chamaedrys*	*Thuidium delicatulum*	**Other spp.**
Agrostis canina	*Asperula cynanchica*	*Medicago lupulina*	*Veronica montana*	*Thuidium tamariscinum*	
Agrostis capillaris	*Aster tripolium*	*Minuartia verna*	*Veronica officianalis*	*Tortella flavovirens*	
Agrostis stolonifera	*Bellis perennis*	*Mycelis muralis*	*Veronica serpyllifolia*	*Tortella tortuosa*	
Anthoxanthum odoratum	*Blackstonia perfoliata*	*Orobanche alba*	*Vicia cracca*	*Trichostomun brachydontium*	
Arrhenatherum elatius	*Campanula rotundifolia*	*Parietaria judaica*	*Vicia sepium*	**Orchids**	
Brachypodium sylvaticum	*Carlina vulgaris*	*Parnassia palustris*	*Viola sp.*	*Anacamptis pyramidalis*	
Briza media	*Centaurea nigra*	*Pedicularis palustris*	*Viola canina*	*Coeloglossum viride*	
Bromus hordeaceus	*Centaurium erythraea*	*Pedicularis sylvatica*	*Viola riviniana*	*Dactylorhiza fuchsii*	
Carex binervis	*Cerastium arvense*	*Pilosella officinarum*	**Liverworts**	*Dactylorhiza incarnata*	
Carex caryophyllea	*Cerastium fontanum*	*Pimpinella saxifraga*	*Colura calyptrifolia*	*Dactylorhiza maculata*	
Carex distans	*Cirsium dissectum*	*Plantago lanceolata*	*Conocephalum conicum*	*Epipactis atrorubens*	
Carex flacca	*Cochlearia anglica*	*Plantago maritima*	*Frullania tamarisci*	*Epipactis helleborine*	
Carex flava	*Cochlearia officinalis*	*Polygala serpyllifolia*	*Lejeunea patens*	*Epipactis palustris*	
Carex hostiana	*Conopodium majus*	*Polygala vulgaris*	*Lophocolea bidentata*	*Gymnadenia conopsea*	
Carex nigra	*Crepis capillaris*	*Potentilla anserina*	*Scapania aspera*	*Listera ovata*	
Carex panicea	*Daucus carota*	*Potentilla erecta*	**Mosses**	*Neotinia intacta*	
Carex pulicaris	*Erophila verna*	*Potentilla sterilis*	*Breutelia chrysocoma*	*Odontites verna*	
Catapodium marinum	*Eupatorium cannabinum*	*Primula veris*	*Bryum sp.*	*Orchis mascula*	
Catapodium rigidum	*Euphrasia sp.*	*Primula vulgaris*	*Calliergonella cuspidata*	*Platanthera bifolia*	
Cynosurus cristatus	*Filipendula ulmaria*	*Prunella vulgaris*	*Campyliadelphus chrysophyllus*	*Spiranthes spiralis*	
Dactylis glomerata	*Filipendula vulgaris*	*Pyrola media*	*Campylopus introflexus*	**Low Woody**	
Danthonia decumbens	*Fragaria vesca*	*Ranunculus acris*	*Climacium dendroides*	*Arctostaphylos uva-ursi*	
Festuca ovina	*Galium saxatile*	*Ranunculus bulbosus*	*Ctenidium molluscum*	*Calluna vulgaris*	

		Ferns					Woody	
Site ID		**Ferns**	Luzula campestris	Hieracium anglicum agg.	Saxifraga hypnoides	Gymnostomum calcareum	**Woody**	
Plot ID		Adiantum capillus-veneris	Molinia caerulea	Hyacinthoides non-scripta	Saxifraga rosacea	Homalothecium lutescens	Corylus avellana	
Relevé ID		Asplenium adiantum-nigrum	Poa annua	Hypericum androsaemum	Saxifraga tridactylites	Homalothecium sericeum	Crataegus monogyna	
Date		Asplenium marinum	Poa pratensis	Hypericum calycinum	Sedum acre	Hylocomium splendens	Euonymus europaeus	
Aspect		Asplenium ruta-muraria	Schoenus nigricans	Hypericum maculatum	Sedum sp.	Hypnum cupressiforme	Frangula alnus	
Easting		Asplenium trichomanes	Sesleria caerulea	Hypericum pulchrum	Senecio jacobaea	Leucobryum glaucum	Fraxinus excelcior	
Northing		Botrychium lunaria	Trichophorum caespitosum	Hypochaeris radicata	Solidago virgaurea	Loeskeobryum brevirostre	Ilex aquifolium	
Altitude (m)		Ceterach officinarum	Trisetum flavescens	Knautia arvensis	Sonchus oleraceus	Neckera crispa	Juniperus communis	
Slope		Cystopteris fragilis	**Herbs**	Lathyrus linifolius	Stellaria graminea	Palustriella commutata	Potentilla fruticosa	
Slight		Dryopteris filix-mas	Achillea millefolium	Lathyrus pratensis	Succisa pratensis	Plagiomnium undulatum	Prunus spinosa	
Moderate		Ophioglossum vulgatum	Alchemilla filicaulis	Leontodon autumnalis	Taraxacum sect. ruderalia	Pleurozium schreberi	Rhamnus catharticus	
Steep		Phyllitis scolopendrium	Alchemilla xanthochlora	Leontodon hispidus	Teucrium scorodonia	Pseudoscleropodium purum	Rubus saxatilis	
Flat		Polypodium interjectum	Anemone nemorosa	Leontodon saxatilis	Thalictrum minus	Racomitrium lanuginosum	Salix repens	
Depression		Polystichum aculeatum	Antennaria dioica	Leontodon taraxacoides	Trifolium pratense	Rhytidiadelphus squarrosus	Salix sp.	
		Polystichum setiferum	Anthyllis vulneraria	Leucanthemum vulgare	Trifolium repens	Rhytidiadelphus triquetrus	Sorbus aucuparia	
% Cover		Pteridium aquilinum	Arabidopsis thaliana	Linum catharticum	Valeriana officinalis	Syntrichia ruralis	Taxus baccata	
Bare rock		**Grasses/Sedges/Rushes**	Armeria maritima	Lotus corniculatus	Veronica chamaedrys	Thuidium delicatulum	**Other spp.**	
Gryke		Agrostis canina	Asperula cynanchica	Medicago lupulina	Veronica montana	Thuidium tamariscinum		
% veg in grykes		Agrostis capillaris	Aster tripolium	Minuartia verna	Veronica officinalis	Tortella flavovirens		
% emergent veg		Agrostis stolonifera	Bellis perennis	Mycelis muralis	Veronica serpyllifolia	Tortella tortuosa		
Bare Earth		Anthoxanthum odoratum	Blackstonia perfoliata	Orobanche alba	Vicia cracca	Trichostomun brachydontium		
Litter		Arrhenatherum elatius	Campanula rotundifolia	Parietaria judaica	Vicia sepium	**Orchids**		
Field Layer		Brachypodium sylvaticum	Carlina vulgaris	Parnassia palustris	Viola sp.	Anacamptis pyramidalis		
Grass		Briza media	Centaurea nigra	Pediculars palustris	Viola canina	Coeloglossum viride		
Sedge		Bromus hordeaceus	Centaurium erythraea	Pedicularis sylvatica	Viola riviniana	Dactylorhiza fuchsii		
Broad Leaves		Carex binervis	Cerastium arvense	Pilosella officinarum	**Liverworts**	Dactylorhiza incarnata		
Bryos		Carex caryophyllea	Cerastium fontanum	Pimpinella saxifraga	Colura calyptrifolia	Dactylorhiza maculata		
Low Woody		Carex distans	Cirsium dissectum	Plantago lanceolata	Conocephalum conicum	Epipactis atrorubens		
Shrub		Carex flacca	Cochlearia anglica	Plantago maritima	Frullania tamarisci	Epipactis helleborine		
		Carex flava	Cochlearia officinalis	Polygala serpyllifolia	Lejeunea patens	Epipactis palustris		
Direction of grykes		Carex hostiana	Conopodium majus	Polygala vulgaris	Lophocolea bidentata	Gymnadenia conopsea		
Grykes type		Carex nigra	Crepis capillaris	Potentilla anserina	Scapania aspera	Listera ovata		
Narrow + shallow (<10<30)		Carex panicea	Daucus carota	Potentilla erecta	**Mosses**	Neotinia intacta		
Narrow + deep		Carex pulicaris	Erophila verna	Potentilla sterilis	Breutelia chrysocoma	Odontites verna		
Wide + shallow grykes		Catapodium marinum	Eupatorium cannabinum	Primula veris	Bryum sp.	Orchis mascula		
Wide + deep		Catapodium rigidum	Euphrasia sp.	Primula vulgaris	Calliergonella cuspidata	Platanthera bifolia		
Soil on clint surface		Cynosurus cristatus	Filipendula ulmaria	Prunella vulgaris	Campyliadelphus chrysophyllus	Spiranthes spiralis		
Solution features		Dactylis glomerata	Filipendula vulgaris	Pyrola media	Campylopus introflexus	**Low Woody**		
Solution cups		Danthonia decumbens	Fragaria vesca	Ranunculus acris	Climacium dendroides	Arctostaphylos uva-ursi		
Solution holes		Festuca ovina	Galium saxatile	Ranunculus bulbosus	Ctenidium molluscum	Calluna vulgaris		
Deepest grykes (m)		Festuca rubra	Galium sterneri	Ranunculus ficaria	Dicranum scoparium	Dryas octopetala		
		Helictotrichon pubescens	Galium verum	Ranunculus repens	Didymodon fallax	Empetrum nigrum		
Pavement Type %		Holcus lanatus	Gentiana verna	Rhinanthus minor	Ditrichum flexicaule	Erica cinerea		
Blocky		Juncus acutiflorus	Gentianella amarella	Rubia peregrina	Entodon concinnus	Hedera helix		
Sharp		Juncus conglomeratus	Geranium molle	Rumex acetosa	Eucladium verticillatum	Helianthemum oelandicum		
Shattered		Juncus inflexus	Geranium robertianum	Sagina nodosa	Fissidens adianthoides	Lonicera periclymenum		
Sheet		Kobresia simpliciuscula	Geranium sanguineum	Samolus valerandi	Fissidens dubius	Rosa pimpinellifolia		
Boulders		Koeleria macrantha	Geum rivale	Sanguisorba minor	Fissidens incurvus	Rubus fruticosus agg.		
		Lolium perenne	Gymnadenia conopsea	Sanicula europaea	Fissidens taxifolius var. taxifolius	Thymus praecox		

Site ID	Agrostis stolonifera	Bellis perennis	Mycelis muralis	Veronica serpyllifolia	Tortella tortuosa
Plot ID	Anthoxanthum odoratum	Blackstonia perfoliata	Orobanche alba	Vicia cracca	Trichostomun brachydontium
Relevé ID	Arrhenatherum elatius	Campanula rotundifolia	Parietaria judaica	Vicia sepium	**Orchids**
Date	Brachypodium sylvaticum	Carlina vulgaris	Parnassia palustris	Viola sp.	Anacamptis pyramidalis
Aspect	Briza media	Centaurea nigra	Pedicularis palustris	Viola canina	Coeloglossum viride
Easting	Bromus hordeaceus	Centaurium erythraea	Pedicularis sylvatica	Viola riviniana	Dactylorhiza fuchsii
Northing	Carex binervis	Cerastium arvense	Pilosella officinarum	**Liverworts**	Dactylorhiza incarnata
Altitude (m)	Carex caryophyllea	Cerastium fontanum	Pimpinella saxifraga	Colura calyptrifolia	Dactylorhiza maculata
Slope	Carex distans	Cirsium dissectum	Plantago lanceolata	Conocephalum conicum	Epipactis atrorubens
Slight	Carex flacca	Cochlearia anglica	Plantago maritima	Frullania tamarisci	Epipactis helleborine
Moderate	Carex flava	Cochlearia officinalis	Polygala serpyllifolia	Lejeunea patens	Epipactis palustris
Steep	Carex hostiana	Conopodium majus	Polygala vulgaris	Lophocolea bidentata	Gymnadenia conopsea
Flat	Carex nigra	Crepis capillaris	Potentilla anserina	Scapania aspera	Listera ovata
Depression	Carex panicea	Daucus carota	Potentilla erecta	**Mosses**	Neotinia intacta
% Cover	Carex pulicaris	Erophila verna	Potentilla sterilis	Breutelia chrysocoma	Odontites verna
Bare rock	Catapodium marinum	Eupatorium cannabinum	Primula veris	Bryum sp.	Orchis mascula
Bare Earth	Catapodium rigidum	Euphrasia sp.	Primula vulgaris	Calliergonella cuspidata	Platanthera bifolia
Litter	Cynosurus cristatus	Filipendula ulmaria	Prunella vulgaris	Campyliadelphus chrysophyllus	Spiranthes spiralis
Field Layer	Dactylis glomerata	Filipendula vulgaris	Pyrola media	Campylopus introflexus	**Low Woody**
Grass	Danthonia decumbens	Fragaria vesca	Ranunculus acris	Climacium dendroides	Arctostaphylos uva-ursi
Sedge	Festuca ovina	Galium saxatile	Ranunculus bulbosus	Ctenidium molluscum	Calluna vulgaris
Broad Leaves	Festuca rubra	Galium sterneri	Ranunculus ficaria	Dicranum scoparium	Dryas octopetala
Bryos	Helictotrichon pubescens	Galium verum	Ranunculus repens	Didymodon fallax	Empetrum nigrum
Low Woody	Holcus lanatus	Gentiana verna	Rhinanthus minor	Ditrichum flexicaule	Erica cinerea
Shrub	Juncus acutiflorus	Gentianella amarella	Rubia peregrina	Entodon concinnus	Hedera helix
Median grass hgt (cm)	Juncus conglomeratus	Geranium molle	Rumex acetosa	Eucladium verticillatum	Helianthemum oelandicum
Median herb hgt (cm)	Juncus inflexus	Geranium robertianum	Sagina nodosa	Fissidens adianthoides	Lonicera periclymenum
Heather Max Height (cm)	Kobresia simpliciuscula	Geranium sanguineum	Samolus valerandi	Fissidens dubius	Rosa pimpinellifolia
Shrub Height (cm)	Koeleria macrantha	Geum rivale	Sanguisorba minor	Fissidens incurvus	Rubus fruticosus agg.
	Lolium perenne	Gymnadenia conopsea	Sanicula europaea	Fissidens taxifolius var. taxifolius	Thymus praecox
Ferns	Luzula campestris	Hieracium anglicum agg.	Saxifraga hypnoides	Gymnostomum calcareum	**Woody**
Adiantum capillus-veneris	Molinia caerulea	Hyacinthoides non-scripta	Saxifraga rosacea	Homalothecium lutescens	Corylus avellana
Asplenium adiantum-nigrum	Poa annua	Hypericum androsaemum	Saxifraga tridactylites	Homalothecium sericeum	Crataegus monogyna
Asplenium marinum	Poa pratensis	Hypericum calycinum	Sedum acre	Hylocomium splendens	Euonymus europaeus
Asplenium ruta-muraria	Schoenus nigricans	Hypericum maculatum	Sedum sp.	Hypnum cupressiforme	Frangula alnus
Asplenium trichomanes	Sesleria caerulea	Hypericum pulchrum	Senecio jacobaea	Leucobryum glauca	Fraxinus excelcior
Botrychium lunaria	Trichophorum caespitosum	Hypochaeris radicata	Solidago virgaurea	Loeskeobryum brevirostre	Ilex aquifolium
Ceterach officinarum	Trisetum flavescens	Knautia arvensis	Sonchus oleraceus	Neckera crispa	Juniperus communis
Cystopteris fragilis	**Herbs**	Lathyrus linifolius	Stellaria graminea	Palustriella commutata	Potentilla fruticosa
Dryopteris filix-mas	Achillea millefolium	Lathyrus pratensis	Succisa pratensis	Plagiomnium undulatum	Prunus spinosa
Ophioglossum vulgatum	Alchemilla filicaulis	Leontodon autumnalis	Taraxacum sect. ruderalia	Pleurozium schreberi	Rhamnus catharticus
Phyllitis scolopendrium	Alchemilla xanthochlora	Leontodon hispidus	Teucrium scorodonia	Pseudoscleropodium purum	Rubus saxatilis
Polypodium interjectum	Anemone nemorosa	Leontodon saxatilis	Thalictrum minus	Racomitrium lanuginosum	Salix repens
Polystichum aculeatum	Antennaria dioica	Leontodon taraxacoides	Trifolium pratense	Rhytidiadelphus squarrosus	Salix sp.
Polystichum setiferum	Anthyllis vulneraria	Leucanthemum vulgare	Trifolium repens	Rhytidiadelphus triquetrus	Sorbus aucuparia
Pteridium aquilinum	Arabidopsis thaliana	Linum catharticum	Valeriana officinalis	Syntrichia ruralis	Taxus baccata
Grasses/Sedges/Rushes	Armeria maritima	Lotus corniculatus	Veronica chamaedrys	Thuidium delicatulum	**Other spp.**
Agrostis canina	Asperula cynanchica	Medicago lupulina	Veronica montana	Thuidium tamariscinum	
Agrostis capillaris	Aster tripolium	Minuartia verna	Veronica officianalis	Tortella flavovirens	

Limestone pavement survey methodology – Scrub/Woodland releve field card

Site ID	Anthoxanthum odoratum	Blackstonia perfoliata	Orobanche alba	Vicia cracca	Trichostomun brachydontium
Site ID	Anthoxanthum odoratum	Blackstonia perfoliata	Orobanche alba	Vicia cracca	Trichostomun brachydontium
Plot ID	Arrhenatherum elatius	Campanula rotundifolia	Parietaria judaica	Vicia sepium	**Orchids**
Relevé ID	Brachypodium sylvaticum	Carlina vulgaris	Parnassia palustris	Viola sp.	Anacamptis pyramidalis
Date	Briza media	Centaurea nigra	Pedicularis palustris	Viola canina	Coeloglossum viride
Aspect	Bromus hordeaceus	Centaurium erythraea	Pedicularis sylvatica	Viola riviniana	Dactylorhiza fuchsii
Easting	Carex binervis	Cerastium arvense	Pilosella officinarum	**Liverworts**	Dactylorhiza incarnata
Northing	Carex caryophyllea	Cerastium fontanum	Pimpinella saxifraga	Colura calyptrifolia	Dactylorhiza maculata
Altitude (m)	Carex distans	Cirsium dissectum	Plantago lanceolata	Conocephalum conicum	Epipactis atrorubens
Slope	Carex flacca	Cochlearia anglica	Plantago maritima	Frullania tamarisci	Epipactis helleborine
Slight	Carex flava	Cochlearia officinalis	Polygala serpyllifolia	Lejeunea patens	Epipactis palustris
Moderate	Carex hostiana	Conopodium majus	Polygala vulgaris	Lophocolea bidentata	Gymnadenia conopsea
Steep	Carex nigra	Crepis capillaris	Potentilla anserina	Scapania aspera	Listera ovata
Flat	Carex panicea	Daucus carota	Potentilla erecta	**Mosses**	Neotinia intacta
Depression	Carex pulicaris	Erophila verna	Potentilla sterilis	Breutelia chrysocoma	Odontites verna
% Cover	Catapodium marinum	Eupatorium cannabinum	Primula veris	Bryum sp.	Orchis mascula
Bare rock	Catapodium rigidum	Euphrasia sp.	Primula vulgaris	Calliergonella cuspidata	Platanthera bifolia
Bare Earth	Cynosurus cristatus	Filipendula ulmaria	Prunella vulgaris	Campyliadelphus chrysophyllus	Spiranthes spiralis
Litter	Dactylis glomerata	Filipendula vulgaris	Pyrola media	Campylopus introflexus	**Low Woody**
Dead Wood	Danthonia decumbens	Fragaria vesca	Ranunculus acris	Climacium dendroides	Arctostaphylos uva-ursi
Field Layer	Festuca ovina	Galium saxatile	Ranunculus bulbosus	Ctenidium molluscum	Calluna vulgaris
Grass	Festuca rubra	Galium sterneri	Ranunculus ficaria	Dicranum scoparium	Dryas octopetala
Sedge	Helictotrichon pubescens	Galium verum	Ranunculus repens	Didymodon fallax	Empetrum nigrum
Broad Leaves	Holcus lanatus	Gentiana verna	Rhinanthus minor	Ditrichum flexicaule	Erica cinerea
Bryos	Juncus acutiflorus	Gentianella amarella	Rubia peregrina	Entodon concinnus	Hedera helix
Low Woody	Juncus conglomeratus	Geranium molle	Rumex acetosa	Eucladium verticillatum	Helianthemum oelandicum
Shrub	Juncus inflexus	Geranium robertianum	Sagina nodosa	Fissidens adianthoides	Lonicera periclymenum
Median shrub hgt (cm)	Kobresia simpliciuscula	Geranium sanguineum	Samolus valerandi	Fissidens dubius	Rosa pimpinellifolia
Regeneration %	Koeleria macrantha	Geum rivale	Sanguisorba minor	Fissidens incurvus	Rubus fruticosus agg.
	Lolium perenne	Gymnadenia conopsea	Sanicula europaea	Fissidens taxifolius var. taxifolius	Thymus praecox
Ferns	Luzula campestris	Hieracium anglicum agg.	Saxifraga hypnoides	Gymnostomum calcareum	**Woody**
Adiantum capillus-veneris	Molinia caerulea	Hyacinthoides non-scripta	Saxifraga rosacea	Homalothecium lutescens	Corylus avellana
Asplenium adiantum-nigrum	Poa annua	Hypericum androsaemum	Saxifraga tridactylites	Homalothecium sericeum	Crataegus monogyna
Asplenium marinum	Poa pratensis	Hypericum calycinum	Sedum acre	Hylocomium splendens	Euonymus europaeus
Asplenium ruta-muraria	Schoenus nigricans	Hypericum maculatum	Sedum sp.	Hypnum cupressiforme	Frangula alnus
Asplenium trichomanes	Sesleria caerulea	Hypericum pulchrum	Senecio jacobaea	Leucobryum glauca	Fraxinus excelsior
Botrychium lunaria	Trichophorum caespitosum	Hypochaeris radicata	Solidago virgaurea	Loeskeobryum brevirostre	Ilex aquifolium
Ceterach officinarum	Trisetum flavescens	Knautia arvensis	Sonchus oleraceus	Neckera crispa	Juniperus communis
Cystopteris fragilis	**Herbs**	Lathyrus linifolius	Stellaria graminea	Palustriella commutata	Potentilla fruticosa
Dryopteris filix-mas	Achillea millefolium	Lathyrus pratensis	Succisa pratensis	Plagiomnium undulatum	Prunus spinosa
Ophioglossum vulgatum	Alchemilla filicaulis	Leontodon autumnalis	Taraxacum sect. ruderalia	Pleurozium schreberi	Rhamnus catharticus
Phyllitis scolopendrium	Alchemilla xanthochlora	Leontodon hispidus	Teucrium scorodonia	Pseudoscleropodium purum	Rubus saxatilis
Polypodium interjectum	Anemone nemorosa	Leontodon saxatilis	Thalictrum minus	Racomitrium lanuginosum	Salix repens
Polystichum aculeatum	Antennaria dioica	Leontodon taraxacoides	Trifolium pratense	Rhytidiadelphus squarrosus	Salix sp.
Polystichum setiferum	Anthyllis vulneraria	Leucanthemum vulgare	Trifolium repens	Rhytidiadelphus triquetrus	Sorbus aucuparia
Pteridium aquilinum	Arabidopsis thaliana	Linum catharticum	Valeriana officinalis	Syntrichia ruralis	Taxus baccata
Grasses/Sedges/Rushes	Armeria maritima	Lotus corniculatus	Veronica chamaedrys	Thuidium delicatulum	**Other spp.**
Agrostis canina	Asperula cynanchica	Medicago lupulina	Veronica montana	Thuidium tamariscinum	
Agrostis capillaris	Aster tripolium	Minuartia verna	Veronica officianalis	Tortella flavovirens	
Agrostis stolonifera	Bellis perennis	Mycelis muralis	Veronica serpyllifolia	Tortella tortuosa	

APPENDIX 3: NATIONAL LIMESTONE PAVEMENT DISTRIBUTION MAP ATTRIBUTE TABLE DESCRIPTION

Attribute Name	Description	Source	Values
DESIG	This logical field describes the location of the area mapped in relation to a designated site: within SAC/NHA or outside.	The Habitats Assignment Project (2007) NPWS Designated sites boundaries	▪ SAC ▪ NHA ▪ No
CSA_07	This logical field describes whether the area mapped was reported within the original 2007 limestone pavement habitat distribution map or not.	NPWS - EU 8240 Limestone pavements habitat Conservation Status Assessment (2007)	▪ Yes ▪ No
CORINE	This logical field describes whether the area mapped intersects an area mapped as bare rock in Corine Land Cover map 2000 or not.	EPA - Corine National Land Cover data (2000)	▪ Yes ▪ No
COMM	This logical field describes whether the area mapped intersects an area mapped as Limestone Pavement / Grassland (XIII) as part of the Commonage Framework Plan Surveys.	Department of Agriculture & Food and the & NPWS - Commonage Framework Plans	▪ Yes ▪ No
KARST	This logical field describes whether the area mapped intersects any Karst features record.	Geological Survey of Ireland - The Karst Heritage of the Republic of Ireland (2001)	▪ Yes ▪ No
ROCK	This logical field describes the dominant underlying rock unit type according to the Geological Survey of Ireland bedrock unit map.	Geological Survey of Ireland - The Bedrock Data (2006)	▪ Aillwee member ▪ Balliny Member ▪ Black Head Member Bricklieve Limestone Formation ▪ etc
PARR06	This logical field describes the dominant underlying parent material type according to The National Soils and Parent Material Map.	Teagasc - The National Soils and Parent Material Map (2006)	▪ RcKCa ▪ RcKNCa ▪ TLs ▪ etc
IFC_SOIL	This logical field describes the dominant soil type according to The National Soils and Parent Material Map.	Teagasc - The National Soils and Parent Material Map (2006)	▪ BminSW ▪ BminSRPT ▪ BimDW ▪ etc
PARTMAT	This logical field describes whether the area mapped intersects any limestone pavement area (vegetated or bare) mapped by Parr *et al.* (2006).	Parr *et al.* (2006) - The Burren Habitat Mapping project	▪ Yes ▪ No ▪ Not applicable (area mapped is outside Parr *et al.* (2006) survey area.
COUNTY	This logical field provides the county where the area mapped is located.	Ordnance Survey of Ireland counties map.	County Name
SOURCE	This logical field describes additional sources of information for the location of new areas of limestone pavement habitats.	The Habitats Assignment Project (2007) (NPWS) John Cross (pers. comm.) (NPWS) NPWS - Offaly-Roscommon Grassland Survey (2007) OSI 2005 Ortho photographs Department of Agriculture & Food and NPWS - Commonage Framework Plans	As per sources reported

Attribute Name	Description	Source	Values
POTENLP *	This logical field describes the potential associated habitats dominating the area mapped; only based on a visual identification on the 2005 Ortho-photographs.	Ordnance Survey of Ireland - 2005 Ortho-photographs	▪ LP/Grassland ▪ LP/Grassland/Heath ▪ LP/Grassland/Heath/Scrub ▪ LP/Grassland/Scrub/Woodland/Heath ▪ LP/Grassland/Heath/Molinia Peat ▪ etc
WATER_DIST	This logical field describes the geographical location of the limestone pavement area mapped in relation to a wetland or distance from the sea.	Ordnance Survey of Ireland - 2005 Ortho-photographs	▪ Adj Wetland ▪ Intersects Turlough record ▪ Within <100m of Turlough record (NPWS 2008) ▪ Distances from the sea (e.g. <10m to <2500m) ▪ Not applicable (> 2500m from sea)
ALTITUDE	This logical field gives an approximate altitude value for the area mapped.	Ordnance Survey of Ireland - contours	
THREAT	This logical field gives threatening activities to mapped limestone pavement areas. This is based on visual identification of the 2005 Ortho-photographs and is uncompleted. Further work is required.	Ordnance Survey of Ireland - 2005 Ortho-photographs	• Threatened by removal • Threatened by adjacent Quarry
AREA_M2	This logical field provides the extent of limestone pavement habitat for each polygon digitised.		• Area in m^2
AREA_DESIG	This logical field provides the extent of limestone pavement habitat within a designated site (SAC or NHA)		• Area in m^2
%_DESIGN	This logical field provides the percentage of limestone pavement within a designated site.		• Percentage (%)
NOTES	This logical field provides additional information for each area mapped, particularly when field visit is required to confirm the occurrence of limestone pavement.		

* This field also includes areas where the ocurrence of limestone pavament is uncertainand and other habitats may be present and so it is specified within this field (e.g. LP (or Exposed Rock)/Grassland/Scrub/Heath; LP or Wetland)). The potential habitats listed under this field are only based on a approximate visual identification and thus this data should not be used for statistical purposes.

APPENDIX 4: NATIONAL LIMESTONE PAVEMENT HABITAT DISTRIBUTION MAP SOURCES

Corine 2000 Land cover Map

The Corine National Land Cover map was produced by the Environmental Protection Agency (EPA) in 2000. Only bare rock was used to select pavement areas. The minimum mapping unit for Corine 2000 was 25ha and therefore smaller rock outcrop areas were not recorded.

National Soils and Parent Material Map

The National Soils and Parent Material map was produced by Teagasc under the Irish Forest Soils Project in 2006. The map included two datasets: soils and sub-soils. The sub-soils have a class of calcareous rock and this was used to select areas of potential limestone pavement. However, the calcareous rocks sub-soils class appears to include limestone pavement and thin soils over limestone bedrock. Thus the class is not a definitive guide to limestone pavements.

Bedrock Data - Geological Survey of Ireland

The Bedrock Data (i.e. solid geology) map was produced by Geological Survey of Ireland in 2006. This dataset was looked at to select areas of pure carboniferous limestone as these were thought to comprise most of the limestone pavements. Much of the Irish midlands are underlain by these rocks and whilst the class is not very useful in finding limestone pavements, it does provide a check against any areas of bare rock mapped from 2005 ortho-photography.

Karst Heritage sites - Geological Survey of Ireland

The Karst Heritage of the Republic of Ireland was produced by Geological Survey of Ireland in 2001. This dataset contains Karst features listed in the karst database. These were used to map limestone pavement, but they were not found to be of much use. All sites mapped were inspected using the 2005 ortho-photographs. Most of the features in the karst database are sinks, resurgences, cave entrances, dolins or turloughs.

Designated sites records and digital maps - NPWS

The main NPWS sources consulted to obtain information on limestone pavement records were:

- **The Habitats Assignment Project** - This main aim of this desktop project was to identify and report habitats listed in the Annex I of the Habitats Directive (92/43/EEC) from a series of sources. These sources included NHA site files, MPSU Plans, Natura 2000 Forms, NPWS surveys, Aerial photographs, NGO proposals, etc.

- **NPWS designated sites boundaries** - NHA and SAC sites maps for those sites listed in the Habitats Assignment Project as containing limestone pavement were looked at in order to ascertain the location of limestone pavement.

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Landsat Thematic mapper satellite imagery

Landsat Thematic mapper satellite imagery was employed to map the distribution of limestone pavement during the production of the 2007 map. Cloud-free Landsat TM imagery is available for Ireland from 2000/2001. A supervised classification was performed on the imagery based upon visual interpretation of training areas from both imagery and ortho-photographs. Two classes of limestone pavements were recognized in the Burren area: bare limestone and sparsely vegetated limestone. There was no accuracy assessment of the classification as it was used purely to guide the subsequent visual interpretation of the ortho-photography.

2005 Aerial ortho - photography - Ordnance Survey of Ireland

2005 ortho-photography have been an essential source of information to identify new areas of limestone pavement and confirm the occurrence of areas reported by other sources. The digitisation of limestone pavement areas would not have been possible without these dataset.

Burren habitat mapping

The Burren Habitat mapping project produced a broad habitat map of the Burren using satellite imagery. The final map contains polygons of bare and vegetated limestone pavement for the Burren identified by Parr *et al.* (2006) from Landsat satellite imagery.

APPENDIX 5: STRUCTURE AND FUNCTIONS ASSESSMENT CRITERIA FOR ANNEX I EU HABITATS

Limestone pavement (exposed) (8240)

Positive indicator species	Negative indicators
Ferns	**Negative indicator species**
Adiantum capillus-veneris	*Arrhenatherum elatius*
Asplenium trichomanes	*Cirsium arvense*
A ruta-muraria	*Cirsium vulgare*
Ceterach officinarum	*Cynosurus cristatus*
Cystopteris fragilis	Large docks (*Rumex* spp.)
Dryopteris filix-mas	*Lolium perenne*
D. affinis	*Senecio jacobaea*
Phyllitis scolopendrium	*Rubus fruticosus*
	Urtica dioica
Herbs and woody	Pass = Collective cover ≤1%
Aphanes arvensis	
Antennaria dioica	Bracken cover
Arabis hirsuta	Pass = Collective cover ≤10%
Asperula cynanchica	
Briza media	Non-native species (*Cotoneaster* spp, *Centranthus ruber*, *Fagus sylvatica* and *Acer* spp.)
Calluna vulgaris	Pass ≤ 1% of vegetation cover
Coryllus avellana	
Crataegus monogyna	**Vegetation structure**
Dryas octopetala	
Eupatorium cannabinum	
Gentiana verna	Scrubby and woody cover *
Geranium sanguineum	Pass ≤ 25% of the pavement feature
G. robertianum	
Gymnocarpium robertianum	*Prunus spinosa* cover
Hedera helix	Pass≤ 10% (Thom *et al.* 2004)
Helianthemum canum	
Juniperus communis	**Indicators of local distinctiveness**
Mycelis muralis	Red Data species (e.g. *Calamagrostis epigejos*, *Frangula alnus* and *Viola hirta*)
Prunus spinosa	
Rhamnus cathartica	
Rosa pimpinellifolia	
Rubia peregrina	
Saxifraga hypnoides	
Sesleria caerulea	
Taxus baccata	
Teucrium scorodonia	
Thalictrum minus	
Thymus polytrichus	
Viola reichenbachiana	
Mosses & liverworts	
Breutelia chrysocoma	
Conecephalum conicum	
Fissidens dubius	
Neckera crispa	
Orchids	
Epipactis atrorubens	*Corylus avellana, Crataegus monogyna, Euonymus europaeus, excelcior, Ilex aquifolium, Juniperus communis, Prunus spinosa, catharticus, Rubus saxatilis, Rubus fruticosus agg., Rosa micran pimpinellifolia, Salix sp., Sorbus aria, Sorbus aucuparia, Taxus Viburnum opulus*
Pass = >=7 of listed species present	

Semi-natural dry grasslands and scrubland facies on calcareous substrates (Festuco - Brometalia) (important orchid sites) (6210/6211) (as per Martin *et al.* (2007))

Positive indicator species	
Herbs	**Bryophytes**
Antennaria dioica	*Calliergonella cuspidate*
Anthyllis vulneraria	*Ctenidium molluscum*
Asperula cynanchica *	*Dicranum scoparium***
Blackstonia perfoliata	*Hylocomium splendens*
Briza media	*Plagiomnium undulatum*
Bromus erectus	*Pseudoscleropodium purum*
Campanula rotundifolia	*Rhytideadelphus squarrosus*
Carex caryophyllea	
Carex flacca	Pass = >=7 of listed species present
Carlina vulgaris	*Species listed as Burren and Western species Dwyer *et al.*(2007)
Centaurea scabiosa	** Additional species added to the list based on 2008 survey and *Sesleria*
Conopodium majus	*caerulea –Breutelia chrysocoma* grassland group species from Parr *et al.*
Daucus carota	(2009), Some are strong calcareous indicators.
Euphrasia spp. **	
Filipendula vulgaris *	**Negative indicator species**
Galium verum	
Gentianella campestris	**Agriculture weeds**
Geranium sanguineum *	*Rumex crispus*
Gentiana verna *	*Rumex obtusifolius*
Helictotrichon pubescens	*Urtica dioica*
Homalothecium lutescens	Pass = Collective cover ≤ 5%
Knautia arvensis	
Koeleria macrantha	**Rank grasses**
Leontodon hispidus	*Dactylis glomerata*
Linum catharticum	*Arrhenatherum elatius*
Lotus corniculatus	Pass = Collective cover ≤ 10%
Origanum vulgare	
Pilosella officinarum	**Agriculturally favoured species**
Primula veris	*Lolium perenne*
Ranunculus bulbosus	*Trifolium repens*
Sanguisorba minor	Pass = Collective cover ≤ 20% and individual cover ≤ 10%
Sesleria albicans *	
Thymus polytrichus **	**Neophyte species**
Trisetum flavescens	Pass = Collective cover ≤ 5%
Orchid species	**Vegetation structure**
Anacamptis pyramidalis	Grass/sedge: Forb ratio
Dactylorhiza fuchsii	Pass = Forb component 40-90%
Dactylorhiza maculate	
Gymnadenia conopsea	Scrub/Bracken/Heath encroachment
Listera ovata	Pass= Cover of woody species (except *Juniperus communis*) plus
Neotinea maculate*	*Pteridium* ≤ 5% cover.
Ophyrs apifera	
Orchis masculata	Sward height
Orchis morio	Pass = 30-70% of the sward 2-50cm high
Platanthera bifoliata	
Platanthera chlorantha	Litter cover
Spiranthes spiralis	Pass = Total extent is ≤ 25% cover
	Bare ground
	Pass = Total extent is ≤ 10% cover
	Grazing and disturbance
	Pass= No more than 20m^2 in vicinity of monitoring stops showing signs of serious disturbance
	Indicators of local distinctiveness
	Red data species

Note: Bryophytes species recorded during this project were added to the list of positive indicators. Most frequent species for *Sesleria caerulea - Breutelia chrysocoma* community (Parr *et al.* (2009)) and most frequent species for *Succisa pratensis* and *Dactylis glomerata* grassland types (*Cynosurus cristatus – Plantago lanceolata* grassland group) from Martin *et al.* (2007) were also added.

European dry heaths (4030)

Positive indicator species	Negative indicator species

Woody & herbs
Agrostis spp
Antennaria dioica
Anthyllis vulneraria
Arctostaphylos uva-ursi
Armeria maritima
Calluna vulgaris
Campanula rotundifolia *
Carex binervis
Carex flacca *
Carex pulicaris *
Carlina vulgaris
Daboecia cantabrica
Deschampsia flexuosa
Dryas octopetala*
Empetrum nigrum
Erica cinerea
Festuca spp.
Galium saxatile
Galium verum
Helianthemum spp.
Hypericum pulchrum *
Jasione montana
Juniperus communis*
Lotus corniculatus *
Molinia caerulea *
Nardus stricta
Plantago maritima
Potentilla erecta
Rumex acetosella
Sanguisorba minor
Scilla verna
Thymus polytrichus
Ulex gallii
Vaccinium myrtillus
Vaccinium vitis-idaea
 	
Mosses & liverworts
Pseudoscleropodium purum**
Breutelia chrysocoma**
 	
Pass = >= 7of listed species present
*Added from this project 2008 survey and constant species according to Parr *et al.* (2009)
	Herbaceous spp
	  Cirsium arvense
	  Cirsium vulgare
	  Digitalis purpurea
	  Epilobium spp. (excluding. E. palustre)
	  Juncus effuses
	  J. squarrosus
	  Ranunculus spp.
	  Senecio spp.
	  Rumex obtusifolius
	  Urtica dioica
	  Coarse grasses (*Holcus lanatus* and *Dactylis glomerata*)
	Pass = Collective cover ≤1%
	
	Bracken cover
	Pass ≤ 10% (dense canopy)
	
	Non native species
	  Rhododendron ponticum
	  Fallopia japonica
	Pass ≤ 1% of vegetation cover

Vegetation structure
Trees & scrub cover   *Betula* spp., *Prunus spinosa*, *Pinus* spp., *Rubus* spp., *Sarothamnus scoparius*, *Quercus* spp., *Hippophae rhamnoides* Pass ≤15% of vegetation cover **Dwarf * species cover** Pass = 25-90% cover **Total *Ulex europaeus* cover** Pass ≤25% cover

Other assessment criteria
Habitat eroded cover [1] Pass ≤1% habitat heavily eroded **Bare ground** (rocks or stones NOT included) Pass = Total extent is ≤ 10% cover **Indicators of local distinctiveness** Notable species * Dwarf-shrubs include: *Arctostaphylos uva-ursi, Calluna vulgaris, Empetrum nigrum, Erica ciliaris, E. cinerea, E. tetralix, E. vagans, , Ulex gallii, U. minor, Vaccinium myrtillus, V. vitis-idaea*

[1] The effects of too frequent or intense fires and over-grazing will hopefully be reflected in other attributes, such as the extent of bare ground and the relative proportions of heather growth phases, but may usefully be recorded on the field forms to inform management. Overgrazing may create difficulty for the assessment of the heather growth phases. Signs of overgrazing can include areas of dead heather and very low mature heather, shoots grazed to the previous season's growth, up-rooted or broken shoots, the reduction of heather cover to almost invisible miniature shoots and the development of distinct heather growth forms. However, occasional heather plants may exhibit these growth forms even when grazing is not heavy. If in doubt, it is therefore important to check for browsed shoots. It is also important to note that some heather plants naturally have a more spreading or prostrate habit (JNCC 2004b).

APPENDIX 6: FUTURE PROSPECTS ASSESSMENT FOR ANNEX I EU HABITATS

Negative impacts and activities categories

Agricultural improvement (Code 103) This includes ploughing, fertiliser application, topping and liming.

Level	Description	Score	% of area
0	None recorded		
-1	Recorded in Survey Unit but not in close proximity to Annex I habitat		
-2	Recorded in close proximity to Annex I habitat		
-3	Recorded within Annex I habitat		

Removal of limestone pavement (e.g. stone removal or displacement) (Code 104) (only applicable to Limestone pavement (exposed) (8240))

Level	Description	Score	% of area
0	None recorded		
-1	Small to medium sized area of limestone pavement removed or displaced, used sporadically by landowners for infill or maintenance, recorded adjacent to Survey Unit		
-2	Large sized area of limestone pavement actively removed or displaced adjacent to Survey Unit		
-3	Area of any size of limestone pavement removed or displaced within the Survey Unit within the last 10 years		

Evidence of undergrazing (Code 140)

Level	Description	Score	% of area
0	None recorded		
-1	Undergrazing recorded in Survey Unit but not in monitoring stops		
-2	Undergrazing recorded from one monitoring stop		
-3	Undergrazing recorded from more than one monitoring stop and rank sward noted		

Evidence of overgrazing (Code 140)

Level	Description	Score	% of area
0	None recorded		
-1	Overgrazing recorded in Survey Unit but not in monitoring stops		
-2	Overgrazing recorded from one monitoring stop		
-3	Overgrazing recorded from more than one monitoring stop		

Afforestation (Code 161) (only applicable to grassland (6210/6211) and heath (4030))

Level	Description	Score	% of area
0	None recorded.		
-1	Afforestation recorded within Survey Unit but not near Annex I habitat		
-2	Afforestation recorded adjacent to Annex I habitat		
-3	Afforestation recorded adjacent to Annex I habitat and plans for future forestry on the site		

Supplementary feeders (Code 171)

Level	Description	Score	% of area
0	None recorded		
-1	Recorded in Survey Unit but not in close proximity to Annex I habitat		
-2	Recorded in close proximity to Annex I habitat		
-3	Recorded within Annex I habitat		

Burning (Code 180)

Level	Description	Score	% of area
0	None recorded		
-1	Minor scorch marks (e.g. from campfire)		
-2	Localised fires which have scorched surrounding vegetation		
-3	Widespread fires which have burnt large areas of vegetation within Annex I habitat		

Active quarries (Code 301)

Level	Description	Score	% of area
0	None recorded		
-1	Small-medium sized quarry used sporadically by landowners for infill or maintenance, recorded adjacent to Survey Unit		
-2	Large quarry actively used for commercial purposes recorded adjacent to Survey Unit		
-3	Quarry of any size recorded within Survey Unit, or a quarry that has infringed on a Survey Unit within the last 10 years		

Dumping (Code 750)

Level	Description	Score	% of area
0	None recorded		
-1	Dumping recorded within Survey Unit but not near Annex I habitat		
-2	Dumping recorded adjacent to Annex I habitat		
-3	Dumping within Annex I habitat		

Landfill, land reclamation and drying out, general (e.g. Gryke filling) (Code 800) (only applicable to Limestone pavement *(exposed) (8240))*

Level	Description	Score	% of area
0	None recorded		
-1	Recorded adjacent to Annex I		
-2	Recorded within the Annex I habitat but little or no impact		
-3	Recorded within the Annex I habitat and noted to be impacting on it		

Drainage (Code 810) (only applicable to grassland (6110/6111) and heath (4030))

Level	Description	Score	% of area
0	None recorded		
-1	Recorded as occurring in the Survey Unit but not in the vicinity of the Annex I habitat		
-2	Recorded in the vicinity of the Annex I habitat		
-3	Recorded adjacent or within the Annex I habitat and noted to be impacting on it		

Non-native invasive species (Code 954)

Level	Description	Score	% of area
0	None recorded		
-1	Non-native species are rare or occasional within other habitat in the Survey Unit		
-2	Non-native species are frequent or abundant within other habitat in the Survey Unit		
-3	Non-native species recorded within targeted Annex I habitat within Survey Unit		

Other

Level	Description	Score	% of area
0	None recorded		
-1	Evidence of negative past management where the vegetation has recovered from the activities and semi-natural communities are re-established / Occurrence of other low intensity negative or destructive management activities		
-2	Landowner considering change of land management to a negative management practice / Occurrence of other medium intensity negative or destructive management activities		
-3	Landowner has actively carried out some activity not previously listed that is or will in the near future cause the functioning of the limestone pavement to be seriously impaired or cease		

Positive conservation categories

Notable species

Level	Description	Score
0	None recorded.	
1	Species listed in Red Data Book recorded on Survey Unit	
2	Species listed under Flora Protection Order recorded on Survey Unit	
3	Both Red Data Book and Flora Protection Order species recorded on the Survey Unit	

Designated site status

Level	Description	Score
0	None recorded.	
1	Annex habitat within NHA boundary	
2	Annex habitat within SAC boundary	
3	Annex habitat within National Park or NPWS managed Nature Reserve	

Overall score = > 0: status is Favourable

Overall score = –1 to –9: status is Unfavourable Inadequate

Overall score = ≤ -10: status is Unfavourable Bad

APPENDIX 7: AN EXAMPLE OF HABITAT MAPPING AT PLOT LEVEL (GORTNANDARRAGH)
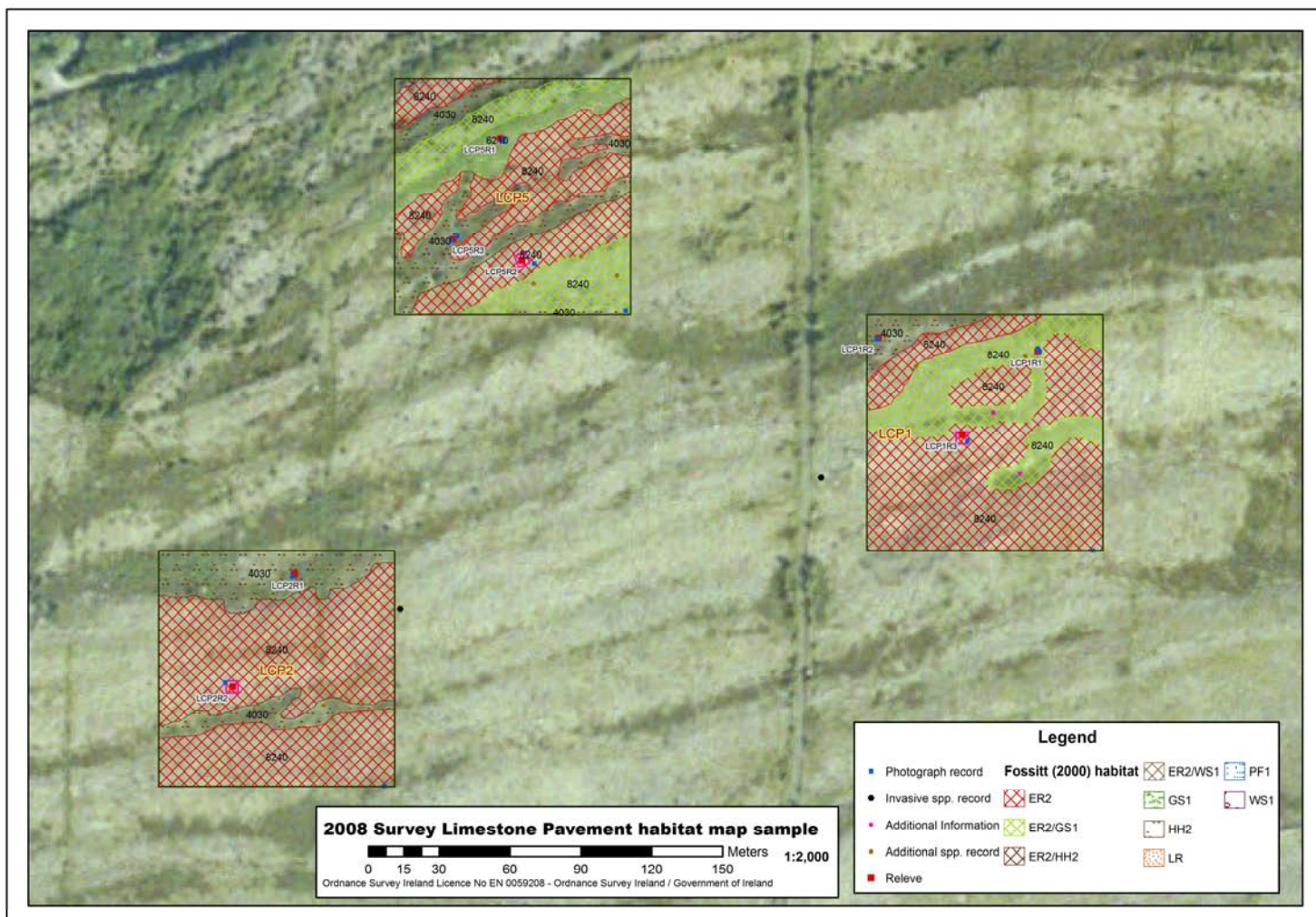
APPENDIX 8: EU HABITAT STRUCTURE AND FUNCTIONS ASSESSMENT RESULTS PER SURVEY UNIT

Limestone Pavement (exposed) (8240)									
Survey Unit	Monitoring Stop	Positive indicators	Negative indicators (≤1%)	Bracken cover (≤10%)	Non native species (≤1%)	Scrubby and woody cover (≤25%)	*Prunus spinosa* cover (≤10%)	Indicators of local distinctiveness	Overall Structure and functions	Survey Unit Structure and functions
Abbey Hill	AHP1R2	Pass	Pass	Pass	Pass	Pass	Pass	None	Pass	
	AHP2R1	Pass	Pass	Pass	Pass	Pass	Pass	None	Pass	
	AHP3R1	Pass	Pass	Pass	Pass	Pass	Pass	None	Pass	
	AHP4R2	Pass	Pass	Pass	Pass	Pass	Pass	None	Pass	Pass
	AHP5R2	Pass	Pass	Pass	Pass	Pass	Pass	None	Pass	
	AHP6R3	Pass	Pass	Pass	Pass	Pass	Pass	None	Pass	
	AHP7R2	Pass	Pass	Pass	Pass	Pass	Pass	None	Pass	
	AHP8R2	Pass	Pass	Pass	Pass	Pass	Pass	None	Pass	
		Pass	Pass	Pass	Pass	Pass	Pass	None	Pass	
Black Head	BHP1R1	Pass	Pass	Pass	Pass	Pass	Pass	None	Pass	
	BHP2R2	Pass	Pass	Pass	Pass	Pass	Pass	None	Pass	
	BHP3R1	Pass	Fail	Pass	Pass	Pass	Pass	None	Pass	
	BHP4R1	Pass	Pass	Pass	Pass	Pass	Pass	None	Pass	Pass
	BHP5R2	Pass	Pass	Pass	Pass	Pass	Pass	None	Pass	
	BHP6R1	Pass	Pass	Pass	Pass	Pass	Pass	None	Pass	
	BHP7R1	Pass	Pass	Pass	Pass	Pass	Pass	None	Pass	
	BHP8R2	Pass	Pass	Pass	Pass	Pass	Pass	None	Pass	
		Pass	Pass	Pass	Pass	Pass	Pass		Pass	
Bricklieve Mnts	BLP1R2	Pass	Pass	Pass	Pass	Pass	Pass	None	Pass	Pass *
		Pass	Pass	Pass	Pass	Pass	Pass		Pass	
Gortlecka	GLP1R1	Pass	Pass	Pass	Pass	Fail	Pass	None	Pass	
	GLP1R3	Pass	Pass	Pass	Pass	Pass	Pass	None	Pass	
	GLP2R2	Pass	Pass	Pass	Pass	Pass	Pass	None	Pass	
	GLP3R2	Pass	Pass	Pass	Pass	Pass	Pass	None	Pass	
	GLP4R2	Pass	Pass	Pass	Pass	Pass	Pass	None	Pass	Pass
	GLP5R2	Pass	Pass	Pass	Pass	Pass	Pass	None	Pass	
	GLP6R2	Pass	Pass	Pass	Pass	Pass	Pass	None	Pass	
	GLP7R1	Pass	Pass	Pass	Pass	Pass	Pass	None	Pass	
	GLP8R3	Pass	Pass	Pass	Pass	Pass	Pass	None	Pass	
		Pass	Pass	Pass	Pass	Pass	Pass	None	Pass	
Gortnandarragh	LCP1R3	Pass	Pass	Pass	Pass	Pass	Pass	None	Pass	
	LCP2R2	Pass	Pass	Pass	Pass	Pass	Fail	None	Pass	
	LCP3R2	Pass	Pass	Pass	Pass	Pass	Pass	None	Pass	
	LCP4R2	Pass	Pass	Pass	Pass	Pass	Pass	None	Pass	
	LCP5R2	Pass	Pass	Pass	Pass	Pass	Pass	None	Pass	Pass
	LCP6R2	Pass	Pass	Pass	Pass	Pass	Pass	None	Pass	
	LCP7R2	Pass	Pass	Pass	Pass	Pass	Pass	None	Pass	
	LCP8R1	Pass	Pass	Pass	Pass	Pass	Pass	None	Pass	
		Pass	Pass	Pass	Pass	Pass	Pass	None	Pass	
Lough Mask	LMP1R2	Fail	Pass	Pass	Fail	Pass	Pass	None	Fail	
	LMP2R1	NA	NA	NA	NA	NA	NA	NA	NA	
	LMP2R2	Fail	Fail	Pass	Pass	Pass	Pass	None	Fail	
	LMP2R4	Pass	Pass	Pass	Fail	Pass	Pass	None	Pass	Fail
	LMP3R2	Pass	Pass	Pass	Pass	Pass	Pass	None	Pass	
	LMP3R3	Pass	Pass	Pass	Pass	Fail	Pass	None	Pass	
		Fail	Pass	Pass	Fail	Pass	Pass	None	Fail	

* According to methods described in Appendix 5, this 8240 habitat monitoring stop should have failed because the collective cover of negative indicators species (*Cynosurus cristatus, Cirsium vulgare, Arrhenatherum elatius*) was greater than 1%. However, best expert judgement has been used in the case; the monitoring stop corresponds to a mosaic relevé (i.e. limestone pavement (exposed) and calcareous grassland) and this was taken into account for the assessment. *Cirsium vulgare* and *Cynosurus cristatus* are deemed negative indicators for exposed limestone pavement, but not for grassland. This coupled with the fact that the cover threshold of the one common negative indicator (*Arrhenatherum elatius*) is much higher in grassland led to the passing of this monitoring stop.

Limestone Pavement (exposed) (8240) individual monitoring stop summary table

EU Habitat	Assessment Criteria		Monitoring stops Pass	Monitoring stops Fail	Monitoring stops passed
8240	**Positive indicator species**		37	2	95 %
	Negative indicators	Negative indicator species (≤1%)	37	2	95 %
		Bracken cover (≤10%)	39	0	100 %
		Non Native species (≤1%)	37	2	95 %
	Vegetation structure	Scrubby and woody cover (≤25%)	37	2	95 %
		Prunus spinosa (≤10%)	38	1	97 %
		Indicators of local distinctiveness	None	None	Not Applicable
	Overall		**37**	**2**	**95 %**

Survey Unit	Monitoring Stop	Positive indicator species	Agriculture weeds (≤ 5%)	Rank grasses (≤ 10%)	Agriculturally favoured species (≤10%)	Neophyte species (≤ 5%)	Grass/sedge: Forb ratio (Forb component 40-90)	Scrub/Bracken/Heath encroachment (≤ 5%)	Sward height (2-50cm high)	Litter cover (≤25%)	Bare ground (≤10%)	Overall Structure and functions	Survey Unit Structure and functions
Abbey Hill	AHP2R3	Pass	Pass	Pass	Pass	Pass	Fail	Pass	Pass	Fail	Pass	Pass	**Fail**
	AHP4R1	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Fail	Pass	Pass	
	AHP6R1	Pass	Pass	Pass	Pass	Pass	Fail	Pass	Pass	Fail	Pass	Pass	
		Pass	Pass	Pass	Pass	Pass	Fail	Pass	Pass	Fail	Pass	Fail	
Black Head	BHP2R1	Pass	Pass	Pass	Fail	Pass	Pass	Pass	Pass	Pass	Pass	Pass	**Fail**
	BHP3R3	Pass	Pass	Pass	Pass	Pass	Fail	Pass	Pass	Pass	Pass	Pass	
	BHP4R3	Pass	Pass	Pass	Pass	Pass	Fail	Pass	Pass	Pass	Pass	Pass	
	BHP6R2	Pass	Pass	Pass	Pass	Pass	Fail	Pass	Pass	Pass	Pass	Pass	
		Pass	Pass	Pass	Pass	Pass	Fail	Pass	Pass	Pass	Pass	Fail	
Gortlecka	GLP2R1	Pass	Pass	Fail	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	**Pass**
	GLP3R1	Pass	Pass	Pass	Pass	Pass	Pass	Fail	Pass	Fail	Pass	Pass	
	GLP4R1	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	
	GLP7R3	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Fail	Pass	Pass	
	GLP8R2	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Fail	Pass	Pass	
		Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Fail	Pass	Pass	
Gortnan-darragh	LCP1R1	Pass	Pass	Pass	Pass	Pass	Fail	Pass	Pass	Fail	Pass	Pass	**Fail**
	LCP5R1	Pass	Pass	Pass	Pass	Pass	Fail	Pass	Pass	Fail	Pass	Pass	
	LCP8R2	Pass	Pass	Pass	Pass	Pass	Fail	Pass	Pass	Fail	Pass	Pass	
		Pass	Pass	Pass	Pass	Fail	Pass	Pass	Fail	Pass	Fail		
Lough Mask	LMP1R1	Fail	Pass	Pass	Pass	Pass	Fail	Fail	Pass	Fail	Pass	Fail	**Fail**
	LMP3R1	Fail	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Fail	Pass	Pass	
		Fail	Pass	Pass	Pass	Pass	Fail	Fail	Pass	Fail	Pass	Fail	

Semi-natural dry grasslands and scrubland facies on calcareous substrates (Festuco - Brometalia) (important orchid sites) (6210/6211) individual monitoring stop summary table

EU Habitat	Assessment Criteria		Monitoring stops Pass	Monitoring stops Fail	Monitoring stops passed
6210	**Positive indicator species**		15	2	88 %
	Negative indicator species	Agriculture weeds (≤ 5%)	17	0	100 %
		Rank grasses (≤ 10%)	16	1	94 %
		Agriculturally favoured species (≤10%)	16	1	94 %
		Neophyte species (≤ 5%)	17	0	100 %
	Other criteria	Grass/sedge: Forb ratio (Forbs 40-90)	8	9	47 %
		Scrub/Bracken/Heath encroachment (≤ 5%)	15	2	88 %
		Sward height (2-50cm)	17	0	100 %
		Litter cover (≤25%)	6	11	35 %
		Bare ground (≤10%)	17	0	100 %
		Grazing and disturbance	None	None	Not Applicable
	Overall		**16**	**1**	**94 %**

Survey Unit	Monitoring Stop	Positive indicator species	Herbaceous Negative indicators	Bracken cover (≤10%)	Non Native species (≤1%)	Trees & scrub cover (≤15%)	Dwarf species cover (25-90% cover)	Total Ulex europaeus cover(≤25%)	Habitat eroded cover	Bare ground (≤10%)	Indicators of local distinctiveness	Overall Structure and functions	Survey Unit Structure and functions
		European dry heaths (4030)											
Abbey Hill	AHP1R1	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	None	Pass	**Pass**
	AHP2R2	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	None	Pass	
	AHP3R2	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	None	Pass	
	AHP5R1	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	None	Pass	
	AHP6R2	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	None	Pass	
	AHP7R1	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	None	Pass	
	AHP8R1	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	None	Pass	
		Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	None	Pass	
Black Head	BHP3R2	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	None	Pass	**Pass**
	BHP4R2	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	None	Pass	
	BHP5R1	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	None	Pass	
	BHP6R3	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	None	Pass	
	BHP7R2	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	None	Pass	
	BHP8R1	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	None	Pass	
		Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	None	Pass	
Gortlecka	GLP5R1	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	None	Pass	**Pass**
	GLP6R1	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	None	Pass	
	GLP6R3	Fail	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	None	Pass	
	GLP7R2	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	None	Pass	
	GLP8R1	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	None	Pass	
		Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	None	Pass	
Gortnandarragh (Lough Corrib)	LCP1R2	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	None	Pass	**Pass**
	LCP2R1	Fail	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	None	Pass	
	LCP4R1	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	None	Pass	
	LCP5R3	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	None	Pass	
	LCP6R1	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	None	Pass	
	LCP7R1	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	None	Pass	
	LCP8R3	Pass	Pass	Fail	Pass	Pass	Pass	Pass	Pass	Pass	None	Pass	
		Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	None	Pass	

European dry heaths (4030) individual monitoring stop summary table

EU Habitat	Assessment Criteria		Monitoring stops Pass	Monitoring stops Fail	Monitoring stops passed
4030	**Positive indicator species**		23	2	92 %
	Negative indicator species	Herbaceous Negative indicators	25	0	100 %
		Bracken cover (≤10%)	24	1	96 %
		Non Native species (≤1%)	25	0	100 %
	Vegetation structure	Trees & scrub cover (≤15%)	25	0	100 %
		Dwarf species cover (25-90% cover)	25	0	100 %
		Total *Ulex europaeus* cover(≤25%)	25	0	100 %
	Other criteria	Habitat eroded cover	25	0	100 %
		Bare ground (≤10%)	25	0	100 %
		Indicators of local distinctiveness	None	None	N/A
	Overall		**25**	**0**	**100 %**

APPENDIX 9: EU HABITAT FUTURE PROSPECTS ASSESSMENT RESULTS PER SURVEY UNIT

Survey Unit	EU Annex I habitat	Agricultural improvement (Code 103)	Removal of pavement(Code 104)	Evidence of undergrazing (Code 140)	Evidence of overgrazing (Code 140)	Afforestation (Code 161)	Supplementary feeders (Code 171)	Burning (Code 180)	Active quarries (Code 301)	Dumping (Code 750)	Gryke filling) (Code 800)	Drainage (Code 810)	Non-native Invasive species (Code 954)	Other	Notable species	Designated site status	Total	Overall Future Prospects	Survey Unit Overall Future Prospects
Abbey Hill	4030	0	NA	0	0	0	0	0	0	0	NA	0	-1	0	0	2	1	Fav.	
	6210	0	NA	0	0	0	0	0	0	0	NA	0	-1	0	0	2	1	Fav.	
	8240 (exposed)	0	0	0	0	NA	0	0	0	0	0	NA	-3	-1	0	2	-2	Unfav Inadeq.	
	Overall	0	0	0	0	0	0	0	0	0	0	0	-3	-1	0	2	-2		Unfav Inadeq.
Black Head	4030	0	NA	0	0	0	0	0	0	0	NA	0	0	0	0	2	2	Fav.	
	6210	0	NA	0	0	0	0	0	0	0	NA	0	0	0	0	2	2	Fav.	
	8240 (exposed)	0	0	0	0	NA	0	0	0	0	0	NA	0	-1	0	2	1	Fav.	
	Overall	0	0	0	0	0	0	0	0	0	0	0	0	-1	0	2	1		Fav.
Gortlecka	4030	0	NA	0	0	0	-1	0	0	0	NA	0	0	0	0	2	1	Fav.	
	6210	0	NA	0	0	0	-1	0	0	0	NA	0	0	0	0	2	1	Fav.	
	8240 (exposed)	0	0	0	0	NA	-1	0	0	0	0	NA	0	-1	0	2	0	Fav.	
	Overall	0	0	0	0	0	-1	0	0	0	0	0	0	-1	0	2	0		Fav.
Bricklieve Mnts	8240 (exposed)	0	0	0	0	NA	0	0	0	0	0	NA	0	0	0	2	2	Fav.	
	Overall	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2		Fav.
Gortnandarragh Lough (Corrib)	4030	0	NA	0	0	0	0	0	-2	0	NA	0	-1	0	0	2	-1	Unfav Inadeq.	
	6210	0	NA	0	0	0	0	0	-2	0	NA	0	-1	0	0	2	-1	Unfav Inadeq.	
	8240 (exposed)	0	0	0	0	NA	0	0	-2	0	0	NA	-1	0	0	2	-1	Unfav Inadeq.	
	Overall	0	0	0	0	0	0	0	-2	0	0	0	-1	0	0	2	-1		Unfav Inadeq.
Lough Mask	6210	0	NA	0	0	0	0	0	0	0	NA	0	-3	0	0	2	-1	Unfav Inadeq.	
	8240 (exposed)	0	0	0	0	NA	0	0	0	0	0	NA	-3	0	0	2	-1	Unfav Inadeq.	
	Overall	0	0	0	0	0	0	0	0	0	0	0	-3	0	0	2	-1		Unfav Inadeq.