Irish Semi-natural Grasslands Survey

Annual Report No. 5:

Leinster

(except Offaly, Longford, Dublin & Kildare)

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November 2013

An Roinn
Ealaíon, Oidhreachta agus Gaeltachta
Department of
Arts, Heritage and the Gaeltacht

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Acknowledgements

We are grateful to everyone who contributed to the planning and completion of this project.

The work has been funded by the National Parks and Wildlife Service (Department of Arts, Heritage and the Gaeltacht).

A number of people provided guidance throughout the earlier years of this project, notably the late Marie Dromey. We also thank Deirdre Lynn for her project support and for helpful comments on earlier drafts of this report. We acknowledge the assistance of NPWS field staff, local authority personnel and BSBI recorders who suggested sites for survey. The assistance of Nick Hodgetts and Rory Hodd for identification of problematic bryophyte samples is also gratefully acknowledged.

We are grateful to John Brophy, Dolores Byrne, Deborah Darcy, Aoife Delaney, Jo Denyer, Kristi Leyden, Maria Long, Michelle O'Neill, Jenni Roche and Caroline Sullivan for their hard work in the field.

Finally, we thank the farmers and landowners of Leinster for giving us permission to survey their land and for the background information they provided.

Cover: Dry calcareous grassland (EU Annex I habitat 6210), Coolnacrutta, Co. Kilkenny. (Photo © Jim Martin, BEC Consultants)

Executive Summary

Between 2011 and 2012, 71 sites and 237 relevés in the eight Leinster counties Carlow, Kilkenny, Laois, Louth, Meath, Westmeath, Wexford, and Wicklow were surveyed as part of the Irish Semi-natural Grasslands Survey (ISGS). 57.7% of these sites were associated with an NPWS conservation site (SAC, NHA, pNHA or SPA). Wet grassland was the most frequent semi-natural grassland habitat, recorded at 67.6% of sites and covering 43.9% of the total area of grassland surveyed. Freshwater marsh was the least frequent grassland habitat and represented less than 1% of the grassland area surveyed across these counties. The EU Habitats Directive Annex I grassland habitat with the highest frequency of occurrence was dry calcareous grassland Festuco-Brometalia (6210 and *6210), recorded at 13 sites, followed by Hydrophilous tall herb communities (6430) recorded at four sites, Lowland hay meadows (6510) recorded at three sites, and *Molinia* meadows (6410) recorded at two sites. No Species-rich *Nardus* grassland (6230) was recorded in the eight Leinster counties surveyed in 2011-2012. In terms of area, 6210 covered the largest area, 13.0 ha. This was followed by 6430 (4.7 ha), 6510 (3.5 ha) and 6410 (1.8 ha).

The median area of the semi-natural grassland sites in Carlow, Kilkenny, Laois, Louth, Meath, Westmeath, Wexford, and Wicklow was 7.0 ha and the county medians ranged from 3.4 ha in Wicklow to 16.2 ha in Laois, with individual sites ranging in size from 0.3 ha to 39.5 ha. Conservation scores, based on factors such as habitat diversity and quality, species richness, site size and presence of plant species of conservation interest within a site, were calculated for all 71 sites. Of the 22 sites that scored highest (a score of 25% or over) in the conservation evaluation, 17 were associated with an NPWS conservation site. Threat scores were based on factors such as damaging activities, agricultural improvement, negative adjacent habitats and presence of negative species within a site. Nine of the 10 sites that received a high threat evaluation (a score of over 45%) were associated with an NPWS conservation site.

The main category of habitat adjacent to surveyed sites was woodland, including hedges and treelines, scrub, and semi-natural woodland, adjacent to 95.8% of sites (with hedgerows and treelines adjacent to 71.8% of sites and scrub adjacent to 70.4% of sites). Improved grassland and cultivated land together were the next most frequent category, adjacent to 87.3% of sites.

Primary areas of Annex I grassland have been identified which represent the best examples of Annex I grassland habitat surveyed during the ISGS; these provide a focus for semi-natural grassland conservation and monitoring in Ireland. Of the 71 Leinster sites surveyed between 2011 and 2012, six primary areas of Annex I grassland habitat were identified.

The main negative impacts recorded for Annex I grassland habitats surveyed in the eight Leinster counties in 2011 and 2012 were species composition change (succession) and problematic native species (e.g. bracken). Only seven of the 22 areas of Annex I grassland surveyed received an overall assessment of *Favourable* (i.e., having favourable conservation assessments for area, structure and functions and future prospects), emphasising their vulnerability and the urgency with which they need to be studied and monitored. However, in most cases the implementation of appropriate management would improve the condition of the Annex I habitat, and assessment scores of *Favourable* could be attainable in the medium term.

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1: INTRODUCTION

1.1 General background

Grassland habitats are reported to cover approximately 60% (Byrne 1996, CSO 2012) of the land area of Ireland, but the overwhelming majority of this is improved agricultural grassland, with semi-natural grassland habitats contributing only a small percentage of the total. The term 'semi-natural', when applied to grassland, implies that it has been altered by human agricultural or pastoral activity, generally grazing or mowing, but without the input of fertilisers (Calaciura and Spinelli 2008) or reseeding with high-yielding species such as *Lolium perenne* and *Trifolium repens*. The current dominance of grassland habitats in Ireland is the result of millennia of human activity altering the predominantly wooded landscape that existed 5,000 years ago (Hall and Pilcher 1995). The low-intensity agricultural practices that once allowed the development of species-rich semi-natural grassland have now all but ceased, threatening the existence of this habitat type within Ireland. Any semi-natural grasslands that remain are threatened either by the abandonment of all management, which for most grassland areas results in reversion to scrub and ultimately woodland, or by the intensification of management, resulting in the replacement of a diverse array of species with a small number of high-yielding ones.

During the last fifty years, agriculture in Ireland has changed completely with increases in mechanisation, the implementation of arterial drainage schemes and the application of fertilisers. Ireland's entry into the European Economic Community (EEC) in 1973 resulted in financial incentives to improve agricultural productivity (Feehan 2003), and as a result the nature of Ireland's grasslands has been radically altered. From 1990 to 2000, arable land (including land used for silage production) and permanent crops increased in area by 35%, followed closely by artificial surfaces, which increased by 31%. These changes were largely at the expense of pasture and mixed farmland (EPA 2006). The majority of the remaining areas of semi-natural grassland within Ireland owe their continued existence to either a continuation of traditional extensive farming practices by some landowners, conservation measures, or edaphic and topographical conditions that make them unsuitable for fertiliser application, reseeding or drainage.

1.2 Vegetation studies of Irish grasslands

Since Braun-Blanquet and Tüxen (1952) made the initial attempts at classifying the grasslands of Ireland, the number of vegetation studies of this habitat has been disproportionately small considering the large area of Ireland that grasslands occupy. One reason for this is that the overwhelming majority of Irish grassland vegetation is low-diversity agricultural grassland. The most notable research on Irish grasslands was conducted by O'Sullivan (1965, 1968, 1976, 1982), who collected field data from a broad range of grassland habitats. In addition to this research contributing to the most comprehensive classification of Irish grasslands to date (O'Sullivan 1982), the data from the thousands of individual relevés collected provide researchers with a well-documented and archived

dataset (Bourke *et al.* 2007). The majority of the other grassland vegetation studies carried out in Ireland have been more specific in their aims. Research has either focused on a particular region of Ireland, such as the Burren (Ivimey-Cook and Proctor 1966, O'Donovan 1987, Keane and Sheehy-Skeffington 1995, Parr *et al*. 2009; Long 2011), Leinster (Byrne 1996), Galway (Sullivan *et al.* 2010), Sligo (O'Donovan 2007) or Fermanagh (Eakin 1995), or on a particular grassland vegetation type, such as callows grassland (Heery 1991, Tolkamp 2001, Maher 2013), esker grasslands (Bleasdale 1998, Tubridy 2006), grassland associated with limestone pavement (Wilson and Fernández 2013), hay meadows (Martin 1991) or Calaminarian grasslands (Holyoak 2008). However, some of the most recent studies have been broader in their remit. O'Donovan and Byrne (2004) carried out research in Sligo and Westmeath with the aim of developing a method for mapping semi-natural grassland across Ireland, and Dwyer *et al.* (2007) carried out a countrywide study of priority Annex I grassland habitats within Special Areas of Conservation (SACs). More recently in 2007, the semi-natural grasslands in both Roscommon and Offaly were surveyed (Martin *et al.* 2007), serving as a pilot study for the current project. In 2008, the current project commenced with a comprehensive survey of the semi-natural grasslands of Cork and Waterford (Martin *et al*. 2008). It continued in 2009 with a detailed survey of grasslands in Cavan, Leitrim, Longford and Monaghan (O'Neill *et al.* 2009), and in 2010 with a survey of Donegal, Dublin, Kildare and Sligo grasslands (O'Neill *et al.* 2010). The study culminated in 2011/12 with this reported study of eight Leinster counties; Carlow, Kilkenny, Laois, Louth, Meath, Westmeath, Wexford and Wicklow, plus a study of six Munster and Connacht counties; Clare, Galway, Kerry, Limerick, Mayo and Tipperary (Devaney *et al.* 2013).

1.3 Classification of Irish grasslands

Braun-Blanquet and Tüxen (1952) were the first to systematically classify Irish grasslands based on the Zurich-Montpellier phytosociological approach, but it was not until 1982 that the first comprehensive classification was published (O'Sullivan 1982). Using the same phytosociological approach, O'Sullivan divided all non-coastal Irish grassland into three classes: the Molinio-Arrhenatheretea, the Calluno-Ulicetea (Nardetea) and the Festuco-Brometea. The Molinio-Arrhenatheretea, which includes lowland meadows and pastures on neutral soils, was the most frequent group, based on over 2,500 relevés and estimated to cover 65% of the land area of Ireland. The Molinio-Arrhenatheretea is divided into the Arrhenatheretalia and Molinietalia orders. The Arrhenatheretalia generally includes drier meadows and pastures, including improved agricultural fields dominated by *Lolium perenne* and *Trifolium repens*. The Molinietalia represents wet meadows and pasture communities on clay, loam and humus-rich gley soils that are generally not fertilised. The Calluno-Ulicetea (Nardetea) includes acid grassland communities and was estimated to cover 4.4% of the land area of Ireland. The Festuco-Brometea, represented in Ireland by the sole order Brometalia erecti, includes dry limestone grasslands on base-rich soils, and was estimated to be the least frequent of the three major classes of grassland, covering only 0.3% of the Irish land area. White and Doyle (1982) in their catalogue of Irish vegetation types drew heavily on the work of O'Sullivan (1982), reapplying his classification of Irish grasslands and adding some rarer associations, such as the Violetea calaminariae class, which includes the grassland vegetation of

areas rich in heavy metals, and the Carici rupestris-Kobresietea bellardii class of arctic-alpine grass heaths, of which one association, the Breutelio-Seslerietum, has been described in Ireland from Ben Bulben in Co. Sligo.

Fossitt (2000) is the most widely utilised grassland classification in Ireland. Unlike O'Sullivan (1982), which is a vegetation classification, Fossitt (2000) is a habitat classification which utilises soils, geology and landscape features, in addition to plant communities, to define each habitat. Fossitt (2000) presents a simplified and standardised way to classify habitats in Ireland; however, it is based on the results of previous phytosociological studies rather than being based objectively on empirical data. The five Fossitt habitat categories directly relevant to this survey of semi-natural grassland are as follows:

- **Fossitt Code GS1 - Dry calcareous and neutral grassland.** This encompasses all unimproved and semi-improved dry grasslands on both calcareous and neutral soil. It is associated with free-draining mineral soils and low-intensity agriculture.
- **Fossitt Code GS2 - Dry meadows and grassy verges.** This habitat is found on free-draining mineral soils. The management is different from that in GS1 in that the grassland has little or no grazing but instead is managed primarily by mowing.
- **Fossitt Code GS3 - Dry-humid acid grassland.** This grassland is found on free-draining acid soils that are not waterlogged. It is found mainly on mineral-rich or peaty podzols in uplands, but is also found on siliceous sandy soils in the lowlands.
- **Fossitt Code GS4 - Wet grassland.** This habitat type is found on poorly drained mineral and organic soils and includes grassland that is seasonally or periodically flooded. It encompasses a range of wet grassland types, from wet rushy pasture to callows.
- **Fossitt Code GM1 - Freshwater marsh.** This habitat is found on waterlogged mineral and shallow peat soils near lake and river edges and other wetland habitats, where the watertable is close to the surface for most of the year. It is characteristically rich in broadleaf herbs, and grasses and sedges should not exceed 50% of the ground cover.

The grasslands section of the National Vegetation Classification (NVC) used to classify British plant communities (Rodwell 1991, 1992, 1995, 2000) does not utilise Irish data, but it does provide an indication of the range of plant communities likely to exist in Ireland. It also provides this in a system that does not follow the subjective methods inherent in the central European phytosociological approach of Braun-Blanquet and Tüxen (1952). Perrin *et al.* (2008a, b) produced an NVC-style classification of Irish woodland vegetation employing a range of more objective techniques. These techniques have also been applied in the analysis of the Irish semi-natural grasslands data. Previous ISGS reports (Martin *et al.* 2007, 2008; O'Neill *et al.* 2009, 2010) have outlined interim classifications produced as the survey progressed. As data are now available from all 26 counties, the final vegetation classification of semi-natural grasslands in the Republic of Ireland has been produced and is detailed in a separate national synthesis ISGS report (O'Neill *et al.* 2013). With a total of 19

individual grassland vegetation types distributed among four groups, this new vegetation classification proposed by O'Neill *et al.* (2013) highlights the limitations of Fossitt (2000), which only classifies semi-natural grassland into four groups and marsh into one group that is rigidly defined by the proportions of forbs (broadleaf herbs) and graminoids (grasses, sedges and rushes) present; it should prove a useful tool for describing the complexity of Irish semi-natural grasslands.

1.4 Conservation of Irish grasslands

Semi-natural grasslands act as an important refuge for many invertebrate, bird and mammal species, and also provide a suitable habitat for rare and protected plant species (Flora Protection Order species). Semi-natural grasslands are an extremely vulnerable habitat in Ireland. Areas of semi-natural grassland that are accessible to machinery are particularly susceptible to agricultural improvement. Keane and Sheehy-Skeffington (1995) showed that the addition of fertiliser to semi-natural grasslands resulted in a change of sward composition and a loss of plant species diversity. The vulnerability of semi-natural grasslands to agricultural improvement, afforestation and scrub encroachment was demonstrated by Byrne (1996), who found that 38% of the sites documented by O'Sullivan during the 1970s no longer supported semi-natural grassland communities by 1994. Similar trends have also been demonstrated in England and Wales, where a review of available data showed that only between one and two percent of remaining lowland grasslands comprise semi-natural communities (Blackstock *et al.*1999). Stevens *et al.* (2010) recently completed a comprehensive study of lowland grasslands in Wales which recognised lowland grassland as a priority for detailed survey and assessment because of the rapid losses and damage that had been taking place to the habitat over a number of decades.

Grasslands of conservation interest are protected in Ireland through conservation designations that vary in the level of protection they provide to the species and habitats found within them. For example, the Flora (Protection) Order 1999 affords protection to the 89 individual plant species listed in the Order, and the protection extends to their habitats. The Wildlife Act, 1976 and the subsequent Wildlife (Amendment) Act, 2000 are the two main articles of legislation that provide protection to wild flora, fauna and semi-natural habitats, including grasslands. Additional statutory protection is available under the recent Environmental Impact Assessment Agriculture Regulations (Statutory Instrument 456 of 2011), which offer protection to semi-natural grasslands in the event of their intended conversion for intensive agriculture, requiring screening to take place if the area to be affected exceeds a certain size. Semi-natural grassland habitats are also afforded legal protection by the Environmental Liability Directive, which prevents and remedies environmental damage to natural habitats and protected species.

Grasslands located within National Parks and Nature Reserves can have the highest level of protection, as they are State-owned and managed for conservation. Special Areas of Conservation (SACs) and Special Protection Areas for birds (SPAs) designated as a result of EU directives provide the next highest level of protection, while Natural Heritage Areas (NHAs) designated under domestic

legislature provide the third tier of protection. As not all NHAs have been designated, proposed NHA (pNHA) is used to distinguish non-designated sites. Throughout this report when referring collectively to SACs, NHAs/pNHAs and SPAs, the term 'NPWS conservation sites' is often used. As there has been no comprehensive survey of semi-natural grassland for almost 30 years, the application of conservation designations to protect areas of semi-natural grassland has taken place in the absence of an accurate record of the extent of each habitat on the ground.

The EU Habitats Directive has contributed to the conservation of semi-natural grassland in Ireland by listing and defining 31 types of Annex I grassland habitat of conservation importance in Europe (Anon. 2007). Under this directive, Ireland has a responsibility to designate SACs to protect any of these habitats that occur within the State and to maintain them at a favourable conservation status. SACs are the most important wildlife conservation areas in the country and are strictly protected under the EU Habitats Directive. Any plans, projects or activities which are proposed and may significantly impact on an SAC must undergo special scrutiny in the form of an appropriate assessment. Also, certain activities which occur within an SAC that might be damaging (Notifiable Actions) can only be carried out with the permission of the Minister. Six Annex I grassland habitats of conservation importance have been recorded within Ireland by the National Parks and Wildlife Service (NPWS):

- Semi-natural dry grasslands and scrubland facies on calcareous substrates (Festuco-Brometalia) ([*]6210).[1]
- Species-rich *Nardus* grasslands on siliceous substrates in mountain areas (and sub-mountain areas, in Continental Europe) (*6230).
- *Molinia* meadows on calcareous, peaty or clayey-silt-laden soils (Molinion caeruleae) (6410).
- Hydrophilous tall herb fringe communities of plains and of the montane to alpine levels (6430).
- Lowland hay meadows (*Alopecurus pratensis*, *Sanguisorba officinalis*) (6510).
- Calaminarian grasslands of the Violetalia calaminariae (6130).

Only two grassland habitats in Ireland, the orchid-rich variant of 6210 (*6210) and *6230, are accorded priority status (i.e. habitats in danger of disappearance and whose natural range falls within the territory of the European Union). Priority Annex I habitats are conventionally listed with the habitat code preceded by an asterisk '*'. Throughout this report, [*]6210 is used to denote both 6210 and the priority orchid-rich variant together.

Three distinct communities can be considered for the 6430 habitat in Ireland. The first is a lowland community of watercourses, particularly of unmanaged edges of slow-moving rivers and lake margins. The second occurs in the uplands on ungrazed or lightly grazed cliff ledges, typically occurring as

[1] Festuco-Brometalia is an old synonym for the order Brometalia-erecti. It is *not* synonymous with the class Festuco-Brometea as indicated in Fossitt (2000)

small individual patches less than one metre across. The third variant is another lowland community that possibly occurs as a nitrophilous tall-herb community of woodland edges, referred to as a 'saum' community. However, this community has been little studied in Ireland (see Wilmanns and Brun-Hool 1982) and further investigation and discussion is required to determine if Ireland supports any examples worthy of Annex I status. The first two community types were assessed for the recent National Conservation Assessments (NPWS 2013); however, only the first lowland community was surveyed during the ISGS, and then only if it occurred in association with grassland.

As semi-natural grasslands in Ireland almost always exist within farming systems, agri-environment schemes such as the Rural Environmental Protection Scheme (REPS), the Agri-Environment Options Scheme (AEOS) and the NPWS Farm Plan Scheme are expected to contribute to the conservation of semi-natural grassland. Regional conservation projects are also impacting positively on the status of semi-natural grasslands. Wilson and Fernández (2013) report on initiatives in improved land use management by the BurrenLIFE Project and Burren Farming for Conservation Project (Anon. 2013) that aim to reduce current pressures and future threats, such as inappropriate grazing regimes and scrub encroachment within the Burren area.

1.5 Assessment and monitoring of Irish grasslands

The monitoring and assessment of the Annex I grassland habitats located within the State started with 33 orchid-rich calcareous grassland sites (*6210) and nine species-rich *Nardus* grasslands (*6230) being surveyed during 2006 (Dwyer *et al.* 2007). The methodology employed for the monitoring and assessment adapted those published by the EU (Anon. 2006), the Joint Nature Conservancy Council (JNCC) in Britain (JNCC 2004) and the methodology already utilised for dune systems in Ireland (Ryle *et al.* 2009). Following on from Dwyer *et al.* (2007), Annex I grassland monitoring was an integral part of the Irish Semi-natural Grasslands Survey, with the monitoring results published in Martin *et al.* (2007, 2008) and O'Neill *et al.* (2009, 2010). Additional studies of Annex I grassland habitats within Ireland include studies of the Shannon Callows (Heery 1991, Heery and Keane 1999) and Calaminarian grasslands (Holyoak 2008), the latter study having a particular emphasis on bryophytes. The National Parks and Wildlife Service published *The Status of EU Protected Habitats and Species in Ireland* (NPWS 2013) and this lists the overall conservation status of each of the Annex I grassland habitats as *Bad*.

1.6 Scope of this report

This document reports on a survey of semi-natural grassland and marsh communities in counties Meath and Westmeath, conducted in summer 2011, and counties Carlow, Kilkenny, Laois, Louth, Wexford and Wicklow carried out in summer 2012, which represent the fourth and fifth years (the final two years) of the *Irish Semi-natural Grasslands Survey* (ISGS). It follows on from the surveys of Donegal, Dublin, Kildare and Sligo grasslands in 2010 (O'Neill *et al.* 2010), Cavan, Leitrim, Longford and Monaghan grasslands in 2009 (O'Neill *et al.* 2009) and Cork and Waterford grasslands in 2008

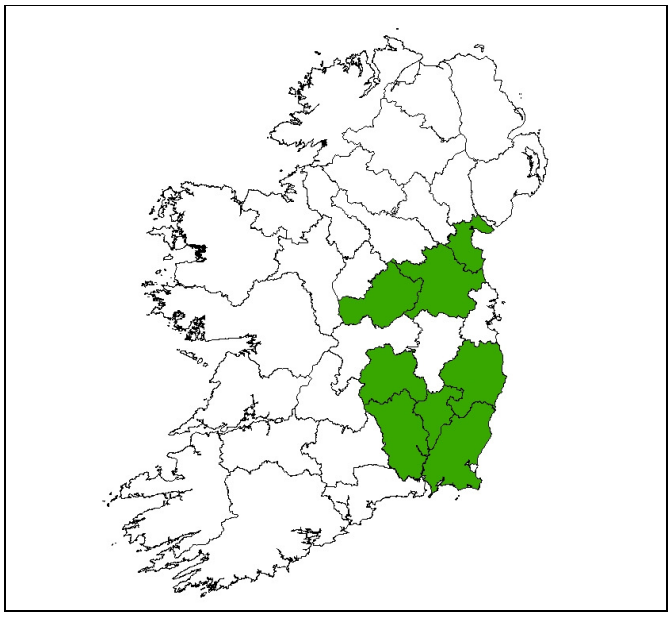
(Martin *et al.* 2008). A pilot survey was also carried out in 2007 to examine Offaly and Roscommon grasslands (Martin *et al.* 2007). The remit of the project in the final two years was to survey 400 sites across the remaining 14 counties, recording relevés in each of the semi-natural grassland types which occur, and to map all habitat types found at each site using GIS. A further aim was to conduct a conservation assessment of any Annex I grassland habitats found. In addition, a scheme to assess the conservation value of each site as a whole was used to highlight important sites. The eight Leinster counties listed above – Carlow, Kilkenny, Laois, Louth, Meath, Westmeath, Wexford and Wicklow – are reported on here; the five western seaboard counties, Clare, Galway, Kerry, Limerick and Mayo, plus Tipperary are covered by a separate report (Devaney *et al.* 2013). Data from the survey were to be combined across all 26 counties to evaluate existing classification systems and to create an objective classification that described the diversity of vegetation types found. As noted above, this final vegetation classification encompassing all semi-natural grassland sites surveyed between 2007 and 2012 during the ISGS are detailed in a separate document (O'Neill *et al.* 2013). This report will primarily focus on results from the 2011-2012 field season as carried out in the eight Leinster counties listed above.

1.7 Study area

The eight counties within the survey area are located in the eastern half of Ireland (Fig. 1.1), ranging from the smallest (821 km^2) and most northerly county of the eight surveyed, Louth, to the largest (2,353 km^2) and most southerly, Wexford. The remaining counties in order of decreasing area are Meath (2,343 km^2), Kilkenny (2,062 km^2), Wicklow (2,024 km^2), Westmeath (1,839 km^2), Laois (1,719 km^2) and Carlow (896 km^2) (OSI 2013a). Agriculturally, the counties are distributed across four regions: the Central Statistics Office lists Louth within the Border agricultural region, Laois and Westmeath within the Midland region, Meath and Wicklow in the Mid-East region and Carlow, Kilkenny and Wexford within the South-East region (CSO 2007). The survey region is split into two halves (Fig. 1.1), due to Dublin and Kildare being surveyed in 2010 and reported on separately in O'Neill *et al.* (2010), and Offaly surveyed in 2007 and reported on in Martin *et al.* (2007).

The Midland (Laois and Westmeath) and Border (Louth) counties are agriculturally less well developed than the other five counties in the Mid-East (Meath and Wicklow) and South-East (Carlow, Kilkenny, and Wexford). This is evidenced by generally smaller farm sizes in the Midland and Border regions: 36 ha to 37 ha, compared to 39 ha to 44 ha in the Mid-East and South-East regions (CSO 2012). The four regions also differ slightly in terms of the main farm types recorded there, with a higher proportion of specialist tillage farms and dairy farms in the South-East, particularly Wexford and Kilkenny respectively. In the other six counties specialist beef production is the most common farming type, with these farms particularly common in Meath, Westmeath and Laois (CSO 2012).

Figure 1.1 Map of Ireland showing the survey area of counties Carlow, Kilkenny, Laois, Louth, Meath, Westmeath, Wexford and Wicklow (Ordnance Survey Ireland Licence No EN 0059208 © Ordnance Survey Ireland / Government of Ireland).



All eight of the surveyed counties are in the province of Leinster. Of these eight counties, Laois, Westmeath, Carlow and Kilkenny are landlocked, the four others having varying lengths of coastline along the Irish Sea. The Wexford coastline is the longest in the study area at 264 km, followed in size by the coastlines of Louth (90 km), Wicklow (61 km) and Meath (21 km) (Anon. 1996).

Overall, regional differences in climate are small and, as is to be expected, with all eight counties for this report being relatively close to each other, there are no significant differences between them climatically. The southeast is slightly dryer than the midlands, with average annual rainfall (30-year average between 1981 and 2010) ranging from 857 mm at the weather station in Kilkenny to 941 mm at the weather station in Mullingar, Co. Westmeath (Met Éireann 2013). In terms of temperatures, the summer climate is similar across the counties surveyed, with a July mean temperature ranging from 15.2°C in Westmeath to 15.8°C in Kilkenny. However, the winters in the coastal southeast are milder, with a January mean of 6.5°C in Wexford, compared to 4.5°C in Mullingar and 4.9°C in Kilkenny.

In terms of relief, Ireland can be described as being saucer-shaped due to its relatively low, flat midlands being surrounded by a ring of coastal mountains. The major mountain ranges that are found in the eastern section of the survey area are the Wicklow Mountains, Carlingford Mountains and the Blackstairs, formed during the Caledonian fold movement (Freeman 1950). The Wicklow Mountains include Lugnaquilla (940 m) the highest peak outside Kerry (OSI 2013b). The other significant upland area is the Slieve Blooms in the west of the survey area in Co. Laois.

A review of the principal soil and sub-soil types, using the digital soil maps of Fealy *et al.* (2006), shows that eskers and moraines extend westwards from Dublin to Galway, with prominent esker systems found in Westmeath. The upland areas of the Slieve Blooms and Wicklow Mountains have the highest proportion of blanket peats, with cutaway peat (basin peat originally) commonest in the Midland counties of Laois and Westmeath. The most common parent material for the soils in the survey area are tills of different origins. In sections of Meath, Westmeath, Kilkenny and Laois limestone tills are the most frequent, while in Carlow, Wexford, Wicklow, and Louth more acid soils derived from sandstone, shale and granite tills are commoner.

Large lakes and rivers are not a major feature in many of the eight counties within the survey area, Kilkenny, Laois, Carlow and Louth having the lowest proportion of water habitats of all the counties within the State (OSI 2013b). However, there are a number of significant lakes within Westmeath, including Lough Ree, and this county has a much larger proportion of water features and aquatic habitats than any of the other eight counties surveyed. Important river systems are located within the study area, with the River Barrow and River Nore in Laois, Kilkenny and Carlow, the River Slaney in Wicklow, Carlow and Wexford, and the River Boyne in Meath and Westmeath.

2: METHODS

2.1 Site selection

The target for this project in 2011-2012 was to visit and record at least one relevé in 400 sites across 14 counties: Carlow, Clare, Galway, Kerry, Kilkenny, Laois, Limerick, Louth, Mayo, Meath, Tipperary, Westmeath, Wexford and Wicklow. Clare, Mayo, Meath and Westmeath were surveyed in 2011, and the remaining ten counties were surveyed in 2012. This report gives the findings for the eight Leinster counties surveyed between 2011 and 2012: Carlow, Kilkenny, Laois, Louth, Meath, Westmeath, Wexford and Wicklow. The findings for the five western counties and Tipperary are given in a separate report (Devaney *et al.* 2013). The target number of sites for the eight Leinster counties was 74. The number of sites selected in each county was calculated based on a combination of the size of the county and the amount of agricultural intensification within each county (Lafferty *et al.* 1999). A further downward adjustment of potential survey area was made by excluding all upland SACs from this survey to prevent overlap with the National Survey of Upland Habitats (Roche *et al.* 2010). Based on these criteria, the eight Leinster counties were expected to contain relatively small amounts of semi-natural grassland, and most were assigned a low target number of sites (fewer than 10): only Meath and Westmeath had targets exceeding 10 (16 and 21 respectively).

Sites were primarily selected by interpretation of aerial orthographical photographs (2005 Ordnance Survey of Ireland series) and six-inch maps. Every effort was made to select an even geographic spread of sites. However, the method used in the early years of this project (2008-2009) of selecting 3-5 sites per 10 km square was found to be unworkable due to the uneven distribution of potential grassland sites, due mainly to the occurrence of extensive areas of bog and improved agricultural land within the survey area. Therefore, there were occurrences of 10 km squares that contained very little potential grassland sites for survey. Despite the unevenness of grassland habitat distribution, however, the number of sites to be surveyed in each county was maintained as per the calculations made above. As in previous years, additional sites were selected to allow for those that would not be surveyed due to problems such as a lack of semi-natural grassland habitats or denial of access by landowners.

In addition to this stratified sampling of the survey area, the criteria listed below were considered during site prioritisation to ensure that a broad range of semi-natural grassland sites was included in the survey:

- National Parks & Wildlife Service (NPWS) conservation sites[1], particularly SACs that had an Annex I grassland habitat listed as a qualifying interest within the site.
- Large areas of semi-natural grassland for which few or no data are currently available.
- Sites which occur on different soil and sub-soil types, as indicated by the digital soils map of Fealy *et al.* (2006).

[1] Note that, throughout this report, the term 'NPWS conservation sites' is used to refer collectively to NHAs, proposed NHAs (pNHAs), SACs and SPAs

- Sites that represent the geographical variation that exists in the study area, such as altitudinal range, with the exclusion noted above of upland SACs.
- Sites identified by the National Survey of Upland Habitats (Roche *et al.* 2010) as containing the Annex I grassland habitat Species-rich *Nardus* grassland (*6230), for which more data were desirable.
- Sites associated with important landscape features (e.g., eskers).
- Sites adjacent to river and lake systems, ensuring a representative sample of wet grasslands and marshes.
- Information from the Botanical Survey of the British Isles (BSBI) county recorders.
- Information from NPWS regional staff.

Each of the criteria listed above was used in conjunction with the 2005 set of aerial photographs, which were used either to identify or to confirm all sites.

A subjective approach to site selection was adopted for this survey, primarily due to the practical constraints on the project and the need to acquire a critical mass of data for several habitat types. For example, for rarer grassland habitats, such as marsh, it was desirable to include a minimum number of sites within the survey to ensure that a reasonable level of information about this habitat type was obtained. It was also desirable to survey NPWS conservation sites, such as SACs, that contained semi-natural grassland so that comparisons could be made with sites outside this network. Given that a limited number of sites could be surveyed within the financial and time limits of the project, a purely randomised approach could well have omitted some or all of these sites. A similar case can be made for most of the criteria listed above. Furthermore, difficulties with obtaining access permission and accurately identifying semi-natural grassland habitats from aerial photographs and GIS datasets made a randomisation approach to site selection unworkable.

For the location and summary data of all sites see Appendices 1 and 2.

2.2 General site survey

For all sites selected for field survey, a site pack was compiled. Each site pack included a cover sheet that detailed general site information for the field surveyors (e.g. townlands, geology, soil types, grid reference), a six-inch map, an aerial photograph of the site at a scale appropriate for mapping, and copies of any previous survey notes. Electronic handheld Personal Digitial Assistants (PDAs) loaded with TurbovegCE version 1.5 for recording site and relevé data were carried by each team of two. Paper data sheets (Appendix 3) were also carried for recording general site data, Annex I grassland habitat assessment data and Annex I grassland habitat impacts, as well as for recording site and relevé species in the event of PDA battery failure. Copies of the Annex I grassland habitat assessment criteria (Appendix 5) and impact criteria (Appendix 7) were also carried by individual surveyors.

For each selected site, a decision was made upon arrival in the field on the validity of surveying it, based on the presence of semi-natural grassland habitats and the area they covered: sites with semi-

natural grassland covering less than the minimum site size of 0.5 ha were rejected (with some exceptions; see below). Similarly, sites deemed to be comprised primarily of improved grassland or non-grassland habitat (e.g., heath, scrub) were rejected. Permission was sought from the owner or owners of a site before entering, and whenever possible the management of the site was discussed with the landowner. Sites for which access was denied were rejected. In some cases landowners were contacted by telephone before leaving for a site by using the Land Direct on-line service (www.landdirect.ie) provided by the Land Registry Office. For a small fee the name and address of the registered landowner for a particular site could be obtained. Eircom's on-line telephone directory (www.eircomphonebook.ie) was then utilised to find telephone numbers.

Sites at which recent habitat loss had reduced the area of suitable habitat to less than 0.5 ha were rejected. Areas of non-grassland habitat (such as woodland) more than 400 m^2 in area and linear habitats (such as rivers) more than 4 m wide were excluded from the site. Species-poor *Molinia*-dominated vegetation on deeper (more than 0.5 m deep), often degraded peats were deemed to be peatland, or degraded wet heath if in the uplands, and excluded from the site. Areas of improved grassland (GA under Fossitt (2000)) that had recently been ploughed, re-seeded with *Lolium perenne* and *Trifolium repens*, drained and/or fertilised were also excluded. Areas with significant cover of *Sphagnum* species were also not surveyed, generally being categorised as fen, flush or bog.

The EU Annex I habitat 6430 Hydrophilous tall-herb swamp communities was within the remit of the survey, although swamp habitats in general were not. For the 2011 and 2012 field seasons, at the discretion of the surveyors, areas of tall herb swamp, even though they may not have corresponded to the Annex I habitat, could be included within a site where they existed with other semi-natural grassland habitats.

Some intermediate, semi-improved grassland types were retained within sites, especially if it was considered that such areas were of potential conservation importance if negative practices such as overgrazing or fertiliser application were to be removed. When semi-improved grassland habitats were recorded, an 'i' was inserted into the Fossitt category of the habitat type deemed to have been present prior to improvement. Thus, for example, GSi4 denotes semi-improved wet grassland of potential conservation value.

The following details were recorded for each site surveyed. Unless otherwise indicated, these details were recorded on the general site data sheet:

Internal habitats: All habitats that were observed within the boundaries of a site were noted. The internal grassland habitats recorded within each site were categorised as Annex I grassland habitats (Anon. 2007), non-Annex I semi-natural grassland habitats (Fossitt 2000) or semi-improved grassland. Non-grassland habitats, as defined by Fossitt (2000), that were below the minimum mapping area (<400 m^2) or mapping width (<4 m) were also listed and retained within the site.

Following Dwyer *et al.* (2007), no differentiation was made in the field between the Annex I habitat Semi-natural dry grassland and scrubland facies on calcareous substrates (6210) and the priority Annex I habitat Semi-natural dry grassland and scrubland facies on calcareous substrates – important orchid sites (*6210). The main reason for Dwyer *et al*. (2007) not distinguishing orchid-rich sites is the ephemeral nature of orchids, with large orchid populations present one year and absent the next. Therefore all areas referred to as [*]6210 in this report may potentially include areas of the priority habitat.

Adjacent habitats: Adjacent habitats observed during the field survey, including boundary habitats such as hedgerows or walls, were recorded for each site using the categories defined by Fossitt (2000). Areas of non-grassland habitat greater than the minimum mapping area, which were mapped out of the site, were also listed as adjacent habitats.

Site geography: Any geographical feature associated with the site, such as a hill, valley, drumlin or lake, was recorded. In addition, it was noted if seasonal flooding was observed or thought to occur on the site. Topography (e.g., upper slope, lower slope) was not recorded at site level in 2011-2012, unlike years 2007-2009 of the project, as this was found to be too broad a level to provide useful information. Topography of relevés, however, was recorded (see section 2.3 below).

Site management: Semi-natural grasslands are habitats that require some human management, in most cases grazing or mowing. Land managers were consulted, wherever possible, to ascertain current management practices. Variables recorded include frequency and timing of grazing/mowing, type of livestock, fertiliser application and burning.

Fauna: In addition to domestic animals such as cattle, sheep and horses using grassland for pasture, there are also several relatively common wild animals that utilise semi-natural grassland habitats; some may contribute to the overall maintenance of the habitat, for example, by grazing (e.g., deer), while others simply use the habitats for foraging (e.g., badger). The presence of such species was recorded. Anthills were also recorded within the fauna section, as there is evidence that they can indicate the presence of old semi-natural grassland (Breen and O'Brien 1995). Observations of Annex II species of animals (EU Habitats Directive), such as marsh fritillary, or Annex I species of birds (EU Birds Directive), such as chough, were also recorded.

Damaging operations: Three damaging operations were listed on the general site data sheet: drainage, dumping and recent afforestation in the vicinity. The occurrence of dumping at a site can be associated with illegal activities, whereas drainage and afforestation represent changes in management practice which are typically detrimental to semi-natural grassland habitats. Burning is included under site management. Camp fires were recorded separately as a damaging operation under 'Other'. Grazing levels (overgrazing, undergrazing and appropriate grazing) and encroachment (scrub, heath and bracken) were not recorded at a site level in 2011-2012, unlike years 2007-2009 of the project, as these data were found to be recorded at too coarse a resolution to be entirely useful;

all three grazing levels were frequently recorded at sites, and a small amount of encroachment was accorded the same weighting on a small site as a large site, despite being proportionately more damaging in the smaller site. Scrub, heath and bracken were still recorded as adjacent habitats where they were large enough to be mapped out, or as internal habitats if they were smaller than the minimum mapping area. Grazing and encroachment were, however, recorded separately if they impacted on Annex I grassland habitats (see section 2.4).

Archaeological features: Any archaeological feature (e.g., lazy beds, ring forts) present on a site was recorded.

Habitat mapping: A habitat map of the site was drawn in the field using the colour aerial photograph in the site pack as a base map. A handheld GPS (Garmin GPS 76 with MapSource) was used in the field to accurately map site boundaries, areas of Annex I grassland habitats (Anon. 2007), non-Annex I semi-natural grasslands (Fossitt 2000) and semi-improved grassland habitats, particularly where these were not visible on the photograph. The minimum mapping unit for habitats was 400 m^2, with a minimum habitat width of 4 m. An accurate habitat map of each site was produced using these data within ArcMap 9.3.

Site area: Site area in hectares was derived from the ArcMap habitat maps as accurately as is possible in the absence of a Digital Terrain Model (DTM). In the absence of a DTM, areas of habitat on steep slopes are likely to be underestimated due to the fact that only a vertical projection has been used to calculate area.

Site summary: In addition to the specific site data gathered and recorded on the general site data field sheet, a general description of each site was also written. A specific format was adhered to when writing descriptions of the sites. Included within these descriptions were:

- A summary of the location and geography of the site
- A description of the habitats and vegetation types present at the site
- A summary of management at the site and any damaging activities
- Rare/protected or notable species recorded at the site
- Archaeological features recorded on site
- Any relevant information given by the landowner / locals.

General site survey results are in section 3.1.
Summary information on the grassland habitats recorded at each site is in Appendix 4.

Site species list: For the semi-natural grassland habitats present at each site, a comprehensive list of vascular plant species and the major components of the bryophyte flora found were input into a Turboveg database (TurbovegCE 1.5) on the PDA; these data were subsequently downloaded to a Microsoft® Access relational database. The site bryophyte list was supplemented, particularly in the

case of smaller and less obvious taxa, by the intensive sampling conducted within each relevé; macro-lichens were also recorded from relevés and added to the site list. Identification of bryophytes and lichens in the laboratory was conducted as required and problematic species were referred to an expert. Species names used throughout the survey for vascular plants, bryophytes and macro-lichens are according to the current Irish National Biodiversity Data Centre (NBDC) species checklist; at the time of writing, this is Ireland2008v2.

As noted above, the site species list was input into the Turboveg database. The remainder of the site data, with the exception of the habitat maps, were input into the Access database. When there was ownership information available for a site, this was also added to the Access database. Digital photographs were taken at all of the surveyed sites, and all of these images were submitted on CD with the GIS project.

2.3 Relevé survey

A minimum of one 2 m x 2 m relevé was recorded from within each semi-natural grassland habitat area mapped in each site. Multiple relevés were recorded where there was significant variation in the sward composition within a habitat type, for example, in transitional areas, or where Annex I grassland habitat assessments were conducted. For each relevé, a 12-figure grid reference was obtained using a GPS unit, and topography, altitude (from the OSi Discovery Series of maps or GPS unit), slope and aspect were recorded.

Cover in vertical projection for each vascular and bryophyte species was recorded on the Domin scale (Kent and Coker 1992), as were other general parameters: bare soil, bare rock, leaf litter, surface water, total field layer and total bryophyte cover. The Domin scale is superior to the Braun-Blanquet scale as the greater number of recording subdivisions permits more variation in vegetation composition to be detected in subsequent analysis. It also provides for a more sensitive means of monitoring changes in sward composition over time.

For each relevé, additional data were also recorded to define the structure of the grassland within the 2 m x 2 m plot. These were:

- Overall cover of forbs (broadleaf herbs, omitting ferns and horsetails), measured on the Domin scale;
- Ratio of % forb cover to % graminoid (grass / sedge / rush) cover, expressed as (%forb/(%forb+%graminoid))x100;
- An estimate of the median graminoid height (omitting flowering heads of grasses unless significant in area, and omitting small clumps of taller species);
- An estimate of the median forb height;
- A digital photograph of the relevé.

Five soil sub-samples were taken from each relevé (one from the centre and one from each corner) with an aluminium corer to a depth of 20 cm, and combined for analysis. Soil pH of field-fresh

material was recorded using a glass electrode and a 1:1 soil / water paste. Soil samples were air-dried and retained for subsequent laboratory analyses of total organic carbon and total phosphorus. During 2012, soil samples were collected from most relevés but only a sub-set of samples, mainly from Annex I relevés, was analysed as above: the majority were not analysed but instead dried and sent to a storage facility in the Agriculture and Food Science Centre in University College Dublin. A soil profile was examined to a minimum depth of 20 cm, and the soil type was defined according to a simplified version of the Great Soil Groups of Gardiner and Radford (1980) with the aid of the soil identification key in Trudgill (1989). The simplified categories are as follows:

- Well-drained mineral: includes brown earths, grey/brown podzolics and brown podzolics
- Gleys: includes gleys and peaty gleys
- Podzols
- Basin peat
- Lowland blanket bog peat
- Upland peat
- Other: includes rendzinas, regosols, lithosols, skeletal soils, alluvial soils and some coastal soils such as shallow peat over sand.

All of the above relevé data, with the exception of digital photographs, were added directly to the Turboveg database (one database was used to hold both site and relevé data) and subsequently downloaded to the Access database. All digital images were submitted on DVD with the ArcMap project.

2.4 Assessment of Annex I grassland

The conservation status of all mapped areas of Annex I grassland habitat within the eight Leinster counties surveyed in 2011-2012 was assessed. The methodology used was similar to that used by the NPWS for their survey of dune systems (Ryle *et al*. 2009) and grassland (Dwyer *et al.* 2007), with subsequent adjustments to criteria made over the course of the ISGS in previous years (Martin *et al.* 2007, 2008; O'Neill *et al*. 2009, 2010). *JNCC Common Standards Monitoring Guidelines* (JNCC 2004) were used as a guide to help evaluate the conservation status of the habitats in conjunction with the *Interpretation manual of European Union habitats* (Anon. 2007) and explanatory notes and guidelines for Article 17 assessment given by Evans & Arvela (2011). All relevés recorded during the entire course of the ISGS (2007 to 2012) were re-checked for correspondence to Annex I habitats, and all Annex I relevés identified were assessed using a unified set of assessment criteria that were finalised for the National Conservation Assessments (NCAs) of grassland Annex I habitats. These NCAs were completed in 2013 as part of Ireland's reporting commitments under Article 17 of the EU Habitats Directive. The assessment criteria used are described below for each of the Annex I grassland habitats recorded during the ISGS in 2011-2012.

For each habitat assessment, three parameters were scored: area, structure and functions, and future prospects. For a habitat at a site to receive an overall assessment of *Favourable*, the habitat had to

be assessed as *Favourable* within each of the three assessment parameters (Table 2.1). Any deviation from stability, as indicated by a negative change in area, structure and functions (determined by defined criteria assessed at monitoring stops; see Appendices 5 and 6) or future prospects (determined by defined criteria assessed at the Annex I habitat level; see Appendices 7 and 8), implies a negative impact, and the assessment is affected accordingly.

Table 2.1 Summary matrix of the parameters and conditions required to assess the conservation status of habitats (modified from Ryle *et al.* (2009)).

	Favourable	Unfavourable - Inadequate	Unfavourable - Bad
Area	Stable	>0% - <1% decline/year	≥1% decline/year
Structure & Functions	Stable	1 – 25% monitoring stops decline/failure	>25% monitoring stops decline/failure
Future Prospects	Good (≥0)	Poor (<0 to -3)	Bad (<-3)
Overall	All green	Combination of green and / or amber	One or more red

Results of Annex I grassland assessments are in section 3.2 as follows: Area assessment: p. 42; Structure and functions: p. 43 and Appendix 6; Future prospects: Appendix 8; Overall condition assessment: Appendix 9

Area assessment

Loss of extent was assessed by comparing the area of the Annex I grassland habitat mapped during the 2011-2012 surveys with the estimated extent of the habitat apparent in 2000 following interpretation of aerial photographs from 2000. This comparison was made using the GIS. While small changes in area were difficult to detect, this was nonetheless regarded as the best approach for the baseline assessment in the absence of an established monitoring scheme. On a technical note, the 2005 aerial photographs have been utilised when producing base maps, with the 2011 and 2012 boundaries superimposed over them. There was therefore an unavoidable bias towards the 2005 extent, with small habitat changes (such as scrub encroachment of less than 400 m^2) that occurred between 2005 and 2011 or 2012 not being mapped. However, changes in extent greater than 400 m^2 were mapped and these changes were reflected in the overall final percentage area change (see results in section 3.2 below).

Structure and functions assessment

The information required for the structure and functions assessment was recorded at monitoring stops, as described in Ryle *et al.* (2009). Areas of Annex I grassland habitat measuring less than 400 m^2 were usually not assessed, unless the habitat was particularly rare and deficient in data either nationally or regionally, such as the Annex I habitat Hydrophilous tall herb fringe communities (6430). In cases where the area was only slightly larger than 400 m^2, only one or two monitoring stops were recorded to avoid stops being positioned adjacent to each other. Where the habitat area was large enough, a minimum of four monitoring stops were recorded, with an increasing number of stops recorded with increasing area. Table 2.2 shows the scale used to determine the number of monitoring stops to record; this table was proposed in O'Neill *et al.* (2009) to ensure adequate

coverage of the Annex I grassland habitat. At each monitoring stop a full relevé was also recorded, with the exception of soil data, which were generally only recorded from the first stop in each Annex I grassland habitat. Each series of monitoring stops was positioned to encompass the variation that existed within the habitat, but did not usually include seriously disturbed areas or areas with very high levels of encroachment. Structure and functions were assessed at each monitoring stop using a number of factors, namely: forb to graminoid ratio, high quality species, positive indicator species, negative indicator species, scrub and bracken encroachment, sward height, litter cover, extent of bare ground, and grazing and disturbance levels. Threshold values for each of these criteria differ for each of the Annex I grassland habitats assessed (Appendix 5). For the Annex I habitat to receive a *Favourable* assessment for structure and functions, a pass was generally required for all criteria within all monitoring stops; however, high quality sites which narrowly failed on only one or two criteria were re-examined and, using expert judgement, a decision was made on whether a *Favourable* assessment for structure and functions was warranted. Components of structure and functions that were found to vary seasonally, such as sward height, litter, bare ground or disturbance levels, were all considered in the context of the date that the area was surveyed.

Table 2.2 Monitoring stop scale for Annex I grassland habitats

Area (ha)	Number of monitoring stops
<0.04	0
0.04 - 0.25	2
>0.25 – 4	4
>4 – 8	6
>8 – 16	8
>16 – 32	10
>32 – 64	12
>64	14+

For each of the Annex I grassland habitats found within Ireland, the general approaches taken by Dwyer *et al.* (2007) and JNCC (2004) were adopted when compiling the structure and functions criteria. The *Interpretation Manual of European Union Habitats* (Anon. 2007) and White and Doyle (1982) were also consulted to produce working lists of positive indicator species for each Annex I grassland habitat. As the ISGS progressed from 2007 to 2012, the structure and functions criteria were revised based on the data collected in the field. Only native Irish plant species were considered for inclusion as positive indicator species. No woody species, such as *Calluna vulgaris* or *Dryas octopetala*, were considered as positive indicator species for the grassland Annex I habitats, as woody species are often indicative of a lack of management or of communities where succession is occurring. To assist surveyors in identifying each of the Annex I habitats, key species or habitat management were sometimes highlighted. For example, Lowland hay meadows (6510) will almost always be managed as a traditional hay meadow, at least in the recent past, and *Molinia* meadows (6410) will usually contain some *Molinia caerulea*. High quality indicator species that are indicative either of a particular Annex I habitat or of habitat quality were also chosen to assist in the identification and assessment of Annex I grassland habitats. For the Annex I habitats [*]6210 , 6410 and 6510, all

orchid species were considered to indicate good habitat quality and were included as high quality indicator species.

The final structure and functions criteria for each Annex I habitat (Appendix 5) were applied *post hoc* to all assessment relevés recorded between 2007 and 2012. A summary of the process applied to produce the list of positive indicator species for each of the Annex I habitats is given below.

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

The list of positive indicator species (Table 2.3) includes the 10 species listed in Anon. (2007) that are native to Ireland; the orchid species listed in Anon. (2007) are not specifically listed in Table 2.3 as the presence of any orchid species within the Annex I habitat is a positive indicator. In addition, all the indicator species listed for [*]6210 by Dwyer *et al.* (2007) were considered for inclusion within the final list of positive indicator species. After comparing the list of positive indicator species proposed by Dwyer *et al.* (2007) with the ISGS 2007-2012 dataset, it was decided to remove *Conopodium majus* from the indicator species list due to its occurrence in calcareous, neutral and acidic habitats. *Thymus polytrichus* and *Ctenidium molluscum* were added to the list, as both are calcicole species that are frequently recorded in the [*]6210 habitat. Frequent forb species that are associated with agriculturally improved grassland, such as *Trifolium repens,* or slightly more mesotrophic grasslands, such as *Trifolium pratense* or *Plantago lanceolata,* were not considered for inclusion within the list of positive indicator species. With the exception of *Briza media*, none of the graminoid species that were frequently recorded within the [*]6210 dataset, such as *Anthoxanthum odoratum* and *Festuca rubra*, were considered to be particularly indicative either of the [*]6210 habitat or of good structure and functions within this Annex I habitat. Finally, species that frequently occur within the [*]6210 habitat but are more characteristic of damper conditions, such as *Succisa pratensis*, or acidic conditions, such as *Potentilla erecta*, were also not included within the list of positive indicator species for this Annex I habitat.

The character species listed for the Festuco-Brometea class and Mesobromion alliance (White and Doyle 1982) were considered for addition to the list of positive indicator species and it was decided that the species listed in Table 2.3 already included the most suitable candidates listed in White and Doyle (1982).

Table 2.3 Positive indicator species used to assess the structure and functions of the Annex I habitat [*]6210. The three sources for the indicator species are listed; high quality indicators are denoted by an asterisk. Note that all orchid species recorded within this habitat are considered to be high quality indicator species. *Leontodon saxatilis* is only included as a positive indicator species when *Leontodon hispidus* is not present in the community.

Anon. (2007)	**Dwyer *et al.* (2007)**	**ISGS data (2007-12)**
*Anthyllis vulneraria**	*Antennaria dioica**	*Ctenidium molluscum*
Arabis hirsute	*Asperula cynanchica**	*Thymus polytrichus*
Brachypodium pinnatum	*Blackstonia perfoliata**	
Bromopsis erecta	*Briza media**	
*Carex caryophyllea**	*Campanula rotundifolia**	
*Carlina vulgaris**	*Carex flacca*	
*Centaurea scabiosa**	*Daucus carota*	
Leontodon hispidus/saxatilis	*Filipendula vulgaris**	
*Primula veris**	*Galium verum*	
*Sanguisorba minor**	*Gentiana verna**	
	*Gentianella campestris/amarella**	
	*Geranium sanguineum**	
	Helictotrichon pubescens	
	Homalothecium lutescens	
	*Knautia arvensis**	
	*Koeleria macrantha**	
	*Linum catharticum**	
	Lotus corniculatus	
	Origanum vulgare	
	Pilosella officinarum	
	Ranunculus bulbosus	
	Sesleria albicans	
	Trisetum flavescens	

*species that are considered as high quality indicators

If the [*]6210 grassland has a population of any orchid species other than the relatively common *Dactylorhiza fuchsii* and *Dactylorhiza maculata* it should be considered for the orchid-rich priority habitat *6210 . The following uncommon orchid species have been recorded in this Annex I habitat during the ISGS, *Anacamptis pyramidalis, Coeloglossum viride, Dactylorhiza fuchsii v. okellyi, Epipactis palustris, Gymnadenia conopsea, Ophrys apifera, Ophrys insectifera, Orchis mascula, Orchis morio, Listera ovate, Neotinea maculata, Platanthera bifolia, Platanthera chlorantha.*

- Species-rich *Nardus* grasslands, on siliceous substrates in mountain areas (*6230)

The list of positive indicator species (Table 2.4) includes the nine species listed in Anon. (2007) that are native to Ireland and that are associated with the *6230 Annex I habitat in Ireland. The native Irish species *Carex pallescens, C. panicea, Hypericum maculatum, Pedicularis sylvatica, Platanthera bifolia* and *Polygala vulgaris*, which are also listed for the *6230 habitat in Anon. (2007), are either not strongly associated with the *6230 habitat in Ireland, or in the case of *Carex panicea* and *Pedicularis sylvatica* are often associated with damper habitats or wetter flushes.

The most frequent plant species recorded in *6230 relevés during the National Survey of Upland Habitats (NSUH) (2009-2011), plus species from this dataset that are considered to be characteristic of the Annex I habitat, were also added to the list of positive indicator species (see Table 2.4). Mineral flushing is usually required to create a habitat that supports a more species-rich *6230 community that conforms to the Annex I habitat as described in the interpretation manual of EU habitats (Anon. 2007). Both a calcareous (calcareous flushing) and a non-calcareous sub-community of *6230 have been identified in Ireland and indicative species for both of these communities were identified from the NSUH (2009-2012) dataset. Any frequent species that were associated with agriculturally improved grassland, such as *Trifolium repens,* were not considered for inclusion within the list of positive indicator species. It was decided to use the NSUH dataset to define the *6230 Annex I habitat, as most of the ISGS data were collected on the periphery of the range of the *6230 habitat.

Table 2.4 Positive indicator species used to assess the structure and functions of the Annex I habitat *6230. The two sources for the indicator species are listed; high quality indicators are denoted by the relevant superscript. *Luzula campestris* is only included as a positive indicator species when *Luzula multiflora* is not present in the community.

Anon. (2007)	**NSUH data (2009-2012)**
*Antennaria dioica**	*Alchemilla glabra**
Festuca ovina	*Agrostis capillaris*
Galium saxatile	*Anthoxanthum odoratum*
Lathyrus linifolius[1]	*Breutelia chrysocoma*[1]
Nardus stricta	*Campanula rotundifolia**
Pseudorchis albida[1]	*Carex binervis*
Potentilla erecta	*Carex caryophyllea*[1]
Veronica officinalis	*Carex pilulifera*[1]
Viola canina[1]	*Conopodium majus**
	*Ctenidium molluscum**
	Danthonia decumbens[1]
	Hylocomium splendens
	*Linum catharticum**
	*Lotus corniculatus**
	Luzula multiflora / L. campestris
	*Lysmachia nemorum**
	Polygala serpyllifolia
	*Primula vulgaris**
	*Prunella vulgaris**
	Rhytidiadelphus loreus
	Rhytidiadelphus squarrosus
	*Thymus polytrichus**
	Viola riviniana[1]

* species that are considered as high quality indicators for the calcareous sub-community

[1] species that are considered as high quality indicators for the non-calcareous sub-community

The character species listed for the Calluno-Ulicetea (Nardetea) class and the Nardo-Galion saxatilis alliance (White and Doyle 1982) were considered for addition to the list of positive indicator species

and it was decided that the species listed in Table 2.4 already included the most suitable candidates listed in White and Doyle (1982).

- *Molinia* meadows on calcareous, peaty or clayey-silt-laden soils (Molinion caeruleae) (6410)

For this habitat, the positive indicator species used in the assessment (Table 2.5) include the 12 species listed in Anon. (2007) that are native to Ireland for which fen meadows are one of their main habitats. *Colchicum autumnale* and *Inula salicina* are both listed for the Annex I habitat 6410 in Anon. (2007); however, neither was added to the list of positive indicator species for Ireland as both species are extremely rare within the State and have been observed at all of their current sites, none of which corresponds to the Annex I habitat 6410. *Sanguisorba officinalis* is also listed for the Annex I habitat in Anon. (2007), but during the ISGS survey it was found to have a greater affinity with 6510 than 6410 and was therefore not included in the list of positive indicator species for 6410. *Carex pallescens*, although native in Ireland, has very little affinity with the 6410 habitat in Ireland.

In addition, 14 of the most frequent forb, sedge and rush species recorded in 6410 relevés during the ISGS (2007-2012) were included in the list of positive indicator species (see Table 2.5). Any frequent forb species that were associated with agriculturally improved grassland, such as *Trifolium repens,* or slightly more mesotrophic grasslands, such as *Ranunculus acris*, or drier grasslands, such as *Plantago lanceolata*, were not considered for the list of positive indicator species. With the exception of *Molinia caerulea*, none of the individual graminoid species recorded frequently within the *Molinia* meadows dataset, such as *Anthoxanthum odoratum* and *Holcus lanatus*, were considered to be particularly indicative either of *Molinia* meadows or of good structure and functions within this Annex I habitat. Two rare forb species – *Carum verticillatum* and *Lathyrus palustris* – listed in Curtis and McGough (1988) were added to the list of high quality indicator species for the habitat. These two species were rarely recorded in the 6410 Annex I habitat but are indicative of good structure and functions. It should be noted that these species are indicative of an Annex I habitat with high conservation value but they are not particularly characteristic of *Molinia* meadows.

The character species listed for the alliances Junco conglomerati – Molinion and Juncion acutiflora (White and Doyle 1982) were considered for addition to the list of positive indicator species but it was decided that the species listed in Table 2.5 already included the most suitable candidates listed in White and Doyle (1982).

Table 2.5 Positive indicator species used to assess the structure and functions of the Annex I habitat 6410. The three sources for the indicator species are listed; high quality indicators are denoted by an asterisk. Note that all orchid species recorded within this habitat are considered to be high quality indicator species.

Anon. (2007)	ISGS data (2007-12)	Curtis and McGough (1988)
*Cirsium dissectum**	*Achillea ptarmica*	*Carum verticillatum**
*Crepis paludosa**	*Carex echinata*	*Lathyrus palustris**
*Galium uliginosum**	*Carex flacca*	
*Juncus conglomeratus**	*Carex nigra*	
Lotus pedunculatus	*Carex panicea*	
Luzula multiflora	*Carex pulicaris**	
Molinia caerulea	*Carex viridula*	
*Ophioglossum vulgatum**	*Equisetum palustre*	
Potentilla anglica	*Filipendula ulmaria*	
Potentilla erecta	*Galium palustre*	
Viola palustris	*Juncus acutiflorus / J. articulatus*	
*Viola persicifolia**	*Mentha aquatica*	
	Ranunculus flammula	
	Succisa pratensis	

*species that are considered as high quality indicators

- Hydrophilous tall herb fringe communities of plains and of the montane to alpine levels (6430)

Only the plant communities within this Annex I habitat that form tall herb edge communities along water courses, particularly unmanaged edges of slow-moving rivers and the margins of lakes, were recorded as part of this survey, and the typical species presented in Table 2.6 reflect this. The hydrophilous tall herb fringe community of montane to alpine levels has been surveyed and defined as part of the NSUH (Perrin *et al.* 2011, 2012). In the lowlands, this Annex I habitat also occurs as a nitrophilous tall herb community of woodland borders, sometimes referred to as a saum community. This saum community would fall within the Glechoma hederaceae order which is listed under this habitat in the Interpretation Manual (Anon 2007). No data were collected from this saum community as part of the ISGS.

As the Annex I habitat 6430 is a tall herb community, only forbs were used as positive indicator species. For this habitat, the diagnostic species from Convolvuletalia sepium and diagnostic and differential species from Filipendulion listed in White and Doyle (1982) were included. *Phalaris arundinacea*, a graminoid, was omitted from the list of indicators. The uncommon Irish species *Crepis paludosa*, which is listed for this habitat in Anon. (2007) was also included as a positive indicator species for this habitat, as was *Filipendula ulmaria* which is listed in Anon (2007) and was also the most frequent forb species recorded in 6430 relevés during the ISGS (2007-2012). *Trollius europaeus* is listed in Anon (2007) in the context of tall herb communities of montane to alpine levels, as *T. europaeus* sites in Ireland are often on the flooded margins of lakes it was retained in the list of indicator species presented in Table 2.6. *Epilobium hirsutum* and *Lythrum salicaria* are listed under Anon. (2007), but could also have been listed under White and Doyle (1982) in addition to being frequent forb species recorded in 6430 relevés. Sixteen common or indicative forb species recorded

in 6430 relevés, or in a few cases tall herb communities that had an affinity with the Annex I habitat, during the ISGS were also included in the list of positive indicator species (see Table 2.6).

Table 2.6 Positive indicator species used to assess the structure and functions of the Annex I habitat 6430. The three sources for the indicator species are listed.

Anon. (2007)	ISGS data (2007-12)	White and Doyle (1982)
Crepis paludosa	*Alisma lanceolatum*	*Calystegia sepium*
Epilobium hirsutum	*Alisma plantago-aquatica*	*Epilobium parviflorum*
Filipendula ulmaria	*Angelica sylvestris*	*Eupatorium cannabinum*
Lythrum salicaria	*Cicuta virosa*	*Hypericum tetrapterum*
Trollius europaeus	*Epilobium palustre*	*Solanum dulcamara*
	Equisetum fluviatile	*Stachys palustris*
	Equisetum palustre	*Symphytum officinale*
	Galium palustre	
	Iris pseudacorus	
	Lysimachia vulgaris	
	Mentha aquatica	
	Myosotis scorpioides	
	Persicaria amphibia	
	Rumex hydrolapathum	
	Sium latifolium	
	Valeriana officinalis	

- Lowland hay meadows (*Alopecurus pratensis, Sanguisorba officinalis*) (6510)

For this habitat, the positive indicator species used in the assessment (Table 2.7) include the nine species listed in Anon. (2007) that are native to Ireland and for which meadows are one of their main habitats. Added to this were four additional species from the list of positive indicator species for the NVC lowland meadow community MG4 *Alopecurus pratensis-Sanguisorba officinalis* (Rodwell 1992), a community that has a very high affinity with the Annex I habitat 6510 (JNCC 2004). Only native species that had been recorded from a Lowland hay meadow during the ISGS survey (2007-2012) were considered, of these species, those that are more indicative of another Annex I habitat, such as *Galium verum*, which is more indicative of [*]6210, were discounted.

In addition, 10 of the most frequent forb species recorded in Annex I Lowland hay meadow relevés during the ISGS survey were included in the list of positive indicator species (see Table 2.7). Any frequent forb species that were associated with agriculturally improved grassland, such as *Trifolium repens* and *Cerastium fontanum*, were not considered for inclusion within the list of positive indicator species. None of the individual graminoid species recorded frequently within the Lowland hay meadows dataset, such as *Festuca rubra, Anthoxanthum odoratum* and *Holcus lanatus*, were considered to be particularly indicative either of Lowland hay meadows or of good structure and functions within this Annex I habitat. However, two rare meadow grass species that are listed in Curtis and McGough (1988) – *Hordeum secalinum* and *Bromus racemosus* – were added to the list of high quality indicator species for the habitat. Both of these species were rarely recorded in Lowland hay meadow (*Hordeum secalinum* from four relevés and *Bromus racemosus* from two relevés), but they are indicative of a Lowland hay meadow with enhanced conservation value.

Table 2.7 Positive indicator species used to assess the structure and functions of the Annex I habitat 6510. The four sources for the indicator species are listed; high quality indicators are denoted by an asterisk. Note that all orchid species recorded within this habitat are considered to be high quality indicator species.

Anon. (2007)	JNCC (2004)	ISGS data (2007-12)	Curtis and McGough (1988)
Alopecurus pratensis	*Centaurea nigra*	*Crepis capillaris*	*Bromus racemosus**
Daucus carota	*Filipendula ulmaria*	*Heracleum sphondylium*	*Hordeum secalinum**
*Knautia arvensis**	*Lotus corniculatus**	*Hypochaeris radicata*	
Leontodon hispidus	*Rhinanthus minor**	*Lathyrus pratensis*	
*Leucanthemum vulgare**		*Leontodon autumnalis*	
*Pimpinella major**		*Plantago lanceolata*	
*Sanguisorba officinalis**		*Prunella vulgaris*	
*Tragopogon pratensis**		*Ranunculus acris*	
Trisetum flavescens		*Trifolium pratense*	
		Vicia cracca	

*species that are considered as high quality indicators

The character and diagnostic species listed for Arrhenatherion elatioris (White and Doyle 1982) were considered for addition to the list of positive indicator species but it was decided that the species listed in Table 2.7 already included the most suitable candidates listed in White and Doyle (1982). Grass species such as *Arrhenatherum elatius* and *Dactylis glomerata* were not considered as suitable candidates as they are both negative indicators for lowland meadows when their cover is high (JNCC 2004).

Future prospects assessment

The future prospects assessment relates to the likely development and maintenance of the Annex I grassland habitat in favourable condition for the foreseeable future. In order to assess this likelihood, pressures, threats and activities (including management) were recorded for each area of Annex I grassland habitat surveyed using the EU-devised list of impact codes (Ssymank, 2010; Appendix 7). Following Ssymank (2010) and recommendations made in Ellmauer (2010), the intensity of each impact at each site was assessed and given a score ranging from 0.5 to 1.5 (Table 2.8), corresponding to the EU criteria of low, medium and high impact/importance. Negative pressures were assigned a negative value, positive impacts/management were assigned a positive value and a score of zero indicated a neutral impact, balanced in terms of its positive and negative effects. The percentage of the Annex I habitat affected by the impact was also recorded, along with its source, i.e., whether it originated inside or outside the Annex I habitat. The percentage of the Annex I habitat affected was scored from 0.5 to 3 to correspond with the ranges <1% to 100% (Table 2.8). The source criterion was not scored (unlike in O'Neill *et al.* 2010) as this was not deemed to be a key issue when assessing the severity of the impact. As the data collected here are baseline data, trends of impact intensity could not be determined. When assessments are repeated in future years, it will be possible to record whether a particular impact is increasing, decreasing or stable in trend by comparing with assessment data from previous years.

By multiplying together the scores of intensity, area and source and then combining the result with the negative, positive or neutral effect of each (i.e., by multiplying the score by -1, +1 or 0 respectively), a final score for each impact was produced. (Thus a neutral impact would always receive a score of 0 by this scheme.) For an Annex I habitat that was subject to multiple impacts on a site, the final scores were summed to gain an overall future prospect score for the habitat. Areas of Annex I grassland habitat that scored ≥0 were determined to have *Favourable* future prospects, while those scoring between <0 and -3 were *Unfavourable – Inadequate* and <-3 *Unfavourable – Bad*, as shown in Table 2.1. Furthering this quantitative analysis of future prospects, each site containing an Annex I grassland habitat was examined by a surveyor who took part in the field assessment to determine whether these scores were a true reflection of the future prospects of the habitat.

Table 2.8 Scoring system used to calculate Future prospects scores for Annex I grassland habitats assessed in Leinster in 2011-2012

Impact	Value	Score
% Area of Annex I habitat impacted	<1%	0.5
	1-25%	1
	26-50%	1.5
	51-75%	2
	76-99%	2.5
	100%	3
Intensity of impact	High	1.5
	Medium	1
	Low	0.5

All results for the assessment of Annex I grassland habitats (under the parameters area, structure and functions, future prospects) are in section 3.2. All assessment data were input into the Access database.

Structure and functions results for individual monitoring stops are in Appendix 6
Future prospects results for each assessed area of Annex I grassland are in Appendix 8
Condition assessment results for each assessed area of Annex I grassland are in Appendix 9

Primary areas of Annex I habitat

It was proposed in Martin *et al.* (2008) that a list of premium quality sites containing Annex I grassland habitats above a minimum size and of adequate structure and functions (according to field assessments) should be produced. Hereafter referred to as ***primary areas*** of Annex I grassland, these represent the best examples of Annex I grassland habitat so far recorded during the ISGS and are judged to be of primary importance due to a combination of the area they cover and their structure and functions. They should provide a focus for monitoring and conservation efforts in the future. A list of primary areas of Annex I grassland habitat surveyed in Leinster in 2011-2012 was compiled. Criteria for primary areas of Annex I grassland habitat include: an extent of at least 1 ha; structure and functions should generally be *Favourable*; however, assessed areas with stops which failed but were considered to be near misses (e.g., only one positive indicator species off a pass, or within 10% of the required forb:graminoid ratio) were sometimes included if the condition of the habitat was otherwise

good. Future prospects and past changes in extent were not taken into account when compiling this list of sites.

2.5 Ranking of sites using conservation and threat evaluations

Conservation of habitats is often best achieved on a site-by-site basis, with specific management plans based on the individual characteristics of a given habitat at a particular site (e.g., management, history, rarity). However, it is also useful to be able to evaluate sites in the context of others, and to make general comparisons regarding status. A broad range of sites was surveyed in the ISGS, with varying degrees of naturalness. As part of the survey methodology, data were collected which allowed the general condition of the site to be evaluated, with regard in particular to its conservation value and the presence of threats to the grassland. Factors which contribute to the conservation value of a site include its size, habitat diversity and quality, species richness and the presence of plant species of conservation interest, and factors such as these have been used when evaluating sites for conservation in the UK (Usher 1989). By assigning a conservation score to each site, the sites can be compared and those which are of particularly high conservation value can be identified. This allows management efforts to focus on sites which are most valuable from a conservation point of view, and also provides a basis for monitoring individual sites into the future. Human activities such as agriculture, recreation and development can pose threats to semi-natural grassland habitats, as can the abandonment of traditionally managed land.

Conservation status was scored on the basis of seven criteria (Table 2.9). Semi-natural grassland habitats were scored on the basis of mapped surveyed areas in the site. Primary and secondary Annex I grassland habitats were identified as outlined above in section 2.4. Adjacent and internal semi-natural habitats evaluate the site in terms of its landscape context; because internal semi-natural grassland and marsh habitats were already scored under the semi-natural grassland habitats criterion, these were only scored here if they were recorded as present but not mapped (i.e., below the minimum mapping area). A modified figure for species density was derived, to remove the bias towards larger sites, by dividing the number of non-woody species present by the $\log_{10}(\text{area}+1)$, with area measured in hectares. Notable species include those listed on the Flora (Protection) Order 1999 (FPO) and in the vascular plant species Red Data Book of Curtis and McGough (1988), excluding those with an IUCN category of 'nt' (not threatened); species that occur in both lists were only scored once, as an FPO species. For the purposes of the conservation score calculation, high quality indicator species included all indicator species – both high quality and non-high quality – listed for the four main Annex I grassland habitats ([*]6210, *6230, 6410 and 6510), as well as an additional four marsh species (*Caltha palustris, Hydrocotyle vulgaris, Lychnis flos-cuculi* and *Potentilla palustris*) and one dry grassland taxon (*Euphrasia* spp.) listed as indicators of species-rich grassland in QUB (2008) The final score for each site is given as a percentage of the total possible score of 47.5. The results for the 22 highest scoring sites surveyed in Leinster in 2011-2012 are given in section 3.3, and the full list of conservation scores for the 71 Leinster sites is given in Appendix 10.

Table 2.9 Criteria used in the calculation of the conservation score for each site.

Criterion	Scoring		Max. score
Semi-natural grassland habitats	1 for each semi-natural grassland habitat 0.5 for each semi-improved grassland habitat where the corresponding semi-natural grassland habitat is not present		5
Annex I grassland habitats	Annex I grassland habitats are divided into primary and secondary areas on the basis of quality (see section 2.4)		12
	2 One secondary Annex I grassland habitat	4 One primary Annex I grassland habitat	
	4 Two or more secondary Annex I grassland habitats	8 Two or more primary Annex I grassland habitats	
Adjacent and internal semi-natural habitats	0.5 for each of the following habitat groups recorded during the survey:		2.5
	F (Freshwater)	GS/GM (Semi-natural grassland, marsh)	
	H/P (Heath [excl. bracken], bog, fen)	WN/WS/WL (Woodland, scrub)	
	ER/EU/C/L/M (Exposed rock, coastal [excl. coastal constructions], littoral/marine habitats)		
Area	Sites are divided into eight groups on the basis of the percentile distribution. The range is greater in the larger site groups, and this is reflected by the steep increase in the scores for larger sites.		12
	0 0-<0.5ha	4 20-<40ha	
	1 0.5-<5ha	6 40-<80ha	
	2 5-<10ha	9 80-<160ha	
	3 10-<20ha	12 $\geq$ 160 ha	
Species density	Modified species density = number of non-woody species divided by $\log_{10}$ (area +1) of the site. The resulting figures were then divided according to percentiles as shown.		4
	0 < 25 spp./ha	2 57 – 71.9 spp./ha	
	1 25 – 56.9 spp./ha	3 72 – 96.9 spp./ha	
		4 $\geq$ 97 spp./ha	
Notable species	Notable species are those listed on the Flora (Protection) Order 1999 (FPO) and the Red Data Book (RDB) (Curtis and McGough 1988) of vascular plants.		8
	0 No notable species	2 One RDB species	
	4 One FPO species	4 Two RDB species	
	8 Two or more FPO species	6 Three or more RDB species	
High quality indicator species	High quality indicator species were identified as described in section 2.5. Sites were scored on the number of high quality (HQ) indicator species recorded as shown.		4
	0 1-10 HQ species	2 16-20 HQ species	
	1 11-15 HQ species	3 21-25 HQ species	
		4 >25 HQ species	
Maximum total score			**47.5**

The assessment of threats to each site was based on the criteria detailed in Table 2.10. Damaging activities consisted mainly of drainage, dumping, quarrying and recent afforestation in the vicinity of

grassland sites. Agricultural improvement primarily included fertiliser application, liming, topping and supplementary feeding. The negative adjacent habitats of improved grassland and cultivated land follow the definitions of Fossitt (2000). The presence of certain negative species indicating habitat disturbance or sward improvement were used as a further measure of the extent to which sites were under threat. Fourteen species were used for this assessment: *Brassica napus, B. rapa, Capsella bursa-pastoris, Chenopodium album, Cirsium arvense, Lolium perenne, Matricaria discoidea, Plantago major, Poa annua, Polygonum aviculare, Rumex crispus, Senecio jacobaea, Stellaria media* and *Trifolium repen*s.

Table 2.10 Criteria used in the calculation of the threat score for each site.

Criterion	Scoring						Max. score
Negative adjacent habitats	0	No negative adjacent habitats					2
	1	Improved grassland (GA) or cultivated land (BC) adjacent					
	2	Improved grassland (GA) and cultivated land (BC) adjacent					
Damaging activities*	0	No damaging activities	1	One damaging activity			3
	2	Two damaging activities	3	Three or more damaging activities			
Agricultural Improvement*	0	No improvements	1	One improvement type			3
	2	Two improvement types	3	Three or more improvement types			
Negative species**	1	1-3 species	2	4-6 species	3	7-9 species	5
	4	10-12 species	5	13-14 species			
Maximum total score							**13**

* See section 2.5 for description of criteria.
** See section 2.5 for list of species scored.

Conservation and threat scores were entered separately into the Access database and were not combined to produce one overall score. Combining scores can lead to misinterpretation when comparing sites, for example comparing a high quality site with many threats and a medium quality site with no threats. Therefore threats were scored separately from conservation value so that sites with a high conservation score which are threatened could be identified. The scores are written as percentages of the total possible score. This allows a simple comparison to be made between sites, even if data were not available in all of the categories shown in Tables 2.9 and 2.10.

Conservation and threat score results are summarised in section 3.3
Full details in Appendices 10 and 11.

2.6 Vegetation data analysis

Analysis to produce a working classification of grassland and marsh for Ireland is presented in a separate report, O'Neill *et al*. (2013), which combines relevés from all 26 counties surveyed during the entire course of the ISGS, from 2007 to 2012.

3: RESULTS

3.1 General site survey

During the Irish Survey of Semi-natural Grasslands (ISGS) from April 2011 to September 2012, 774.5 ha of grassland and marsh were surveyed: 47.1 ha in Carlow, 110.5 ha in Kilkenny, 138.5 ha in Laois, 41.4 ha in Louth, 137.0 ha in Meath, 215.2 ha in Westmeath, 60.8 ha in Wexford and 24.0 ha in Wicklow. An additional 5.7 ha of swamp vegetation (FS and FS2 in Fossitt (2000)) were also surveyed in Kilkenny, Meath and Wexford. This section of the results summarises the distribution of grassland and marsh habitats (GS and GM under Fossitt (2000)). The location of each site is shown in Appendix 1. In total, 71 sites were surveyed: 5 (7.0%) in Carlow, 8 (11.3%) in Kilkenny, 8 (11.3%) in Laois, 5 (7.0%) in Louth, 14 (19.7%) in Meath, 18 (25.4%) in Westmeath, 7 (9.9%) in Wexford and 6 (8.5%) in Wicklow. The median site area across the eight counties was 7.0 ha (the mean site area of 11.0 ha is skewed by a small number of larger sites), with sites ranging in size from 0.3 ha to 39.5 ha. The median site areas for the eight counties showed some variability, with Wicklow sites having the smallest median size (3.4 ha) and Laois the highest (16.2 ha).

An additional 20 sites were visited but rejected from the survey. This is equal to 22% of the 91 sites which were visited. The reasons for rejecting sites fell into four broad categories: difficulty in obtaining permission to access a site, strong evidence of improvement for agricultural or amenity use, dominance of non-grassland habitats, and forestry. Some sites were rejected for more than one reason. Table 3.1 indicates the number of sites which were rejected within each of the different categories.

Table 3.1 The number of sites that were rejected and the reasons for rejection. Twenty sites were rejected but there are 25 reasons for rejection as some sites were rejected for more than one reason.

Reason for rejection	Number of sites
Access difficulty	14
Agricultural improvement	7
Non-grassland habitat	3
Forestry	1
Number of sites rejected	*25*

The most frequently cited reasons for rejecting sites were access difficulty, agricultural improvement and dominance of non-grassland habitats. Difficulty in obtaining access to a site was generally due to the refusal of permission by the owner, or difficulty in making contact with the owner. For reasons of personal safety, land was not entered if certain livestock (e.g. a bull) were present, and a landowner would sometimes refuse permission due to potentially dangerous livestock. Agricultural improvement was often recorded as the reason for rejecting a site when improved grassland for agricultural or amenity use was common on a site. The non-grassland habitats encountered most frequently included heath, swamp, and fen.

Grassland habitats

A detailed habitat map has been produced for each site showing the Fossitt (2000) and Annex I grassland habitats, the position of all relevés and the location of pNHAs, NHAs, and SACs. Table 3.2 shows the area in hectares covered by the different grassland habitats surveyed within the eight counties (defined according to Fossitt (2000)), together with the percentage by area and percentage by frequency of the habitats within each of the counties surveyed.

Table 3.2 Summary habitat statistics of sites surveyed in Carlow, Kilkenny, Laois, Louth, Meath, Westmeath, Wexford, and Wicklow in 2011-2012. Percentage frequency only includes sites where there was a mapped area of the Fossitt habitat.

		GS1	**GS2**	**GS3**	**GS4**	**GM1**	**GA1**	***Overall***
Carlow	Area (ha)*	3.2	23.6	4.5	13.6	0.0	2.2	*47.1*
	% survey area	6.7	50.2	9.6	28.8	0.0	4.7	
	% freq	40.0	60.0	40.0	100.0	0.0	40.0	
	No. of sites	2	3	2	5	0	2	*5*
Kilkenny	Area (ha)*	55.4	14.5	0.0	35.4	0.0	5.2	*110.5*
	% survey area	50.1	13.1	0.0	32.0	0.0	4.7	
	% freq	50.0	25.0	0.0	62.5	0.0	37.5	
	No. of sites	4	2	0	5	0	3	*8*
Laois	Area (ha)*	35.2	1.3	1.6	87.7	0.0	12.6	*138.5*
	% survey area	25.4	1.0	1.2	63.3	0.0	9.1	
	% freq	37.5	25.0	12.5	75.0	0.0	37.5	
	No. of sites	3	2	1	6	0	3	*8*
Louth	Area (ha)*	4.7	5.0	27.0	4.7	0.0	0.0	*41.4*
	% survey area	11.3	12.1	65.2	11.5	0.0	0.0	
	% freq	20.0	20.0	60.0	60.0	0.0	0.0	
	No. of sites	1	1	3	3	0	0	*5*
Meath	Area (ha)*	11.6	30.3	1.0	81.4	0.0	12.8	*137.0*
	% survey area	8.5	22.1	0.7	59.4	0.0	9.3	
	% freq	42.9	21.4	7.1	78.6	0.0	42.9	
	No. of sites	6	3	1	11	0	6	*14*
Westmeath	Area (ha)*	43.7	31.1	1.0	96.4	0.8	42.0	*215.2*
	% survey area	20.3	14.5	0.5	44.8	0.4	19.5	
	% freq	66.7	61.1	5.6	66.7	11.1	50.0	
	No. of sites	12	11	1	12	2	9	*18*
Wexford	Area (ha)	19.7	2.3	4.0	9.4	0.0	25.3	*60.8*
	% survey area	32.5	3.8	6.6	15.5	0.0	41.6	
	% freq	28.6	42.9	14.3	57.1	0.0	28.6	
	No. of sites	2	3	1	4	0	2	*7*
Wicklow	Area (ha)*	5.2	6.1	0.0	11.1	0.0	1.7	*24.0*
	% survey area	21.5	25.3	0.0	46.1	0.0	7.0	
	% freq	16.7	50.0	0.0	33.3	0.0	50.0	
	No. of sites	1	3	0	2	0	3	*6*
Overall	*Area (ha)**	*178.8*	*114.3*	*39.2*	*339.7*	*0.8*	*101.8*	*774.5*
	% survey area	*23.1*	*14.8*	*5.1*	*43.9*	*0.1*	*13.1*	
	% freq	*43.7*	*39.4*	*12.7*	*67.6*	*2.8*	*39.4*	
	No. of sites	*31*	*28*	*9*	*48*	*2*	*28*	*71*

* Components may not sum to totals because of rounding

GS4 (wet grassland) was the most extensive of the semi-natural grassland habitats recorded in the survey, accounting for 43.9% of the total grassland area surveyed across the eight counties in 2011

and 2012. This was followed in order of decreasing extent by GS1 (dry calcareous and neutral grassland) at 23.1%, GS2 (dry meadows and grassy verges) at 14.8%, GS3 (dry-humid acid grassland) at 5.1%, and GM1 (marsh) at less than 1%.

GS4 covered a large proportion of the surveyed area and was highest, as a percentage of the area surveyed in Laois at 63.3% and lowest at 11.5% in Louth. GM1 was only recorded at two sites within the eight counties and both of these sites were in Westmeath. Although GM1 was not recorded from seven of the counties: Carlow, Kilkenny, Laois, Louth, Meath, Wicklow and Wexford it would be expected that areas of this habitat do exist within these counties in locations that were not surveyed for the ISGS. GS1 as a percentage of the survey area was highest in Kilkenny at 50.1% and was most frequent in Westmeath, found in 66.7% of sites. Carlow had the lowest percentage area recorded as GS1 at 6.7%, but the frequency of occurrence within sites was much higher at 40.0%. No areas of GS3 grassland were recorded in Kilkenny and Wicklow, the absence of GS3 in Wicklow is due to the survey being restricted to lowland areas, the upland areas of GS3 within the Wicklow Mountains SAC (002122) will be surveyed as part of the National Survey of Upland Habitats. Generally GS3 was uncommon within the eight counties surveyed with the exception being in Louth where the habitat represented 65.2% of the area surveyed due to one relatively large site in the Carlingford Mountains. GS2 was most common in Carlow, with the habitat recorded in 50.2% of the surveyed area and 60% of sites; in terms of percentage of the surveyed area it was least common in Laois at 1%.

Areas of GA1 (improved agricultural grassland) which had a sufficient quantity of semi-natural grassland species to be of interest to the survey were included within the GSi (semi-improved grassland) category used throughout this survey but mapped within sites as GA1. Of the area of grassland surveyed in each county, Wexford had the greatest proportion of semi-improved grassland (GA1) with 41.6%; Louth had the lowest with no semi-improved grassland recorded within the five sites surveyed.

For details of grassland habitats for individual sites, see Appendix 4

NPWS conservation sites

A total of 41 sites were found to overlap with a NPWS conservation site. For Table 3.3 all surveyed areas of GS, GM, FS2 (plus FS), and Annex I grassland (including some small areas of fen) that intersected with a NPWS conservation site were investigated. Following a similar methodology to that applied in 2010, any grassland site with an overlap of less than the minimum mapping area (400 m^2) was removed from the analysis. An exception to this was site 2000 in Westmeath, the overlap was below the minimum mapping area as calculated based on vertical projection but the area was retained as in the field the steeply sloping area was estimated to be above the minimum mapping area. The remaining overlaps that were less than 0.2 ha were visually inspected to determine if the overlap was genuine or an anomaly due to differences in the base map used for the NPWS conservation sites and ISGS sites. The visual inspection was carried out for overlaps with SACs,

SPAs, and NHAs, but not with pNHAs as these only have proposed boundaries and the mapping appears outdated in places. All overlaps above the minimum mapping area were reported. The 41 ISGS sites that overlap with a NPWS conservation site represent 57.7% of the sites surveyed across the eight counties. It should be noted that many of the 41 sites overlap with more than one type of NPWS conservation site.

Table 3.3 Occurrence of NPWS conservation sites (pNHA/NHA, SAC and SPA) within the survey. Areas presented below are based on the total surveyed area (GS, GM, and FS) within each county.

		NHA/pNHA	SAC	SPA
Carlow	No. of sites	1	1	0
	% of sites	20.0	20.0	0.0
	Area (ha)	1.8	4.2	0.0
	% survey area	3.9	9.0	0.0
Kilkenny	No. of sites	4	5	1
	% of sites	50.0	62.5	12.5
	Area (ha)	53.2	54.9	0.1
	% survey area	48.1	49.6	0.1
Laois	No. of sites	3	3	2
	% of sites	37.5	37.5	25.0
	Area (ha)	33.6	23.8	0.7
	% survey area	24.3	17.2	0.5
Louth	No. of sites	3	3	0
	% of sites	60.0	60.0	0.0
	Area (ha)	26.8	26.8	0.0
	% survey area	64.7	64.7	0.0
Meath	No. of sites	8	7	2
	% of sites	57.1	50	14.3
	Area (ha)	58.3	27.6	0.2
	% survey area	41.0	19.4	0.1
Westmeath	No. of sites	10	7	7
	% of sites	55.6	38.9	38.9
	Area (ha)	63.1	44.2	49.6
	% survey area	29.3	20.5	23.1
Wexford	No. of sites	3	3	2
	% of sites	42.9	42.9	28.6
	Area (ha)	35.9	13.6	24.8
	% survey area	58.9	22.3	40.7
Wicklow	No. of sites	1	1	0
	% of sites	16.7	16.7	0.0
	Area (ha)	0.7	0.8	0.0
	% survey area	3.1	3.2	0.0
Overall	*No. of sites*	33	30	14
	% of sites	46.5	42.3	19.7
	*Area (ha)**	273.4	195.9	75.4
	% survey area	35.0	25.1	9.7

* Components may not sum to overall total because of rounding

Table 3.3 shows that 30 sites (42.3% of sites surveyed) overlap with an SAC, representing 25.1% of the total surveyed area in the eight counties. As would be expected the figures are lower for SPAs, at 14 sites and 9.7% of the surveyed area, as these are designated for bird species rather than habitats.

Of the eight counties Louth had the greatest proportion of surveyed grassland within SACs and pNHAs, at 64.7% in both, but the joint lowest at 0% in SPAs along with Carlow and Wicklow. Wicklow also had the lowest proportion of surveyed grassland in both SACs and NHAs at 3.2% and 3.1% respectively. Wexford had the highest proportion of surveyed grassland within SPAs at 40.7%.

Table 3.4 Area in hectares of different grassland habitats surveyed within NPWS conservation sites.

County	Designation	GS1	GS2	GS3	GS4	GM1	GA1
Carlow	NHA/pNHA	1.8	0.0	0.0	0.0	0.0	0.0
	SAC	0.0	0.3	3.8	0.2	0.0	0.0
	SPA	0.0	0.0	0.0	0.0	0.0	0.0
Kilkenny	NHA/pNHA	48.4	0.0	0.0	2.5	0.0	2.3
	SAC	48.7	0.8	0.0	2.9	0.0	2.3
	SPA	0.0	0.0	0.0	0.0	0.0	0.0
Laois	NHA/pNHA	13.5	1.2	1.6	17.4	0.0	0.0
	SAC	2.9	0.0	0.0	20.7	0.0	0.3
	SPA	0.0	0.0	0.0	0.1	0.0	0.6
Louth	NHA/pNHA	2.5	0.0	24.2	0.1	0.0	0.0
	SAC	2.4	0.0	24.2	0.1	0.0	0.0
	SPA	0.0	0.0	0.0	0.0	0.0	0.0
Meath	NHA/pNHA	7.4	3.0	1.0	32.7	0.0	10.0
	SAC	0.1	3.1	1.0	10.8	0.0	7.4
	SPA	0.0	0.0	0.0	0.1	0.0	0.1
Westmeath	NHA/pNHA	7.9	8.4	1.4	42.3	0.7	2.8
	SAC	7.8	0.1	0.0	32.8	0.7	2.8
	SPA	3.9	0.3	0.0	41.8	0.7	3.0
Wexford	NHA/pNHA	9.6	1.1	0.0	0.5	0.0	25.3
	SAC	9.8	0.0	0.0	2.1	0.0	1.5
	SPA	0.0	1.0	0.0	0.1	0.0	23.7
Wicklow	NHA/pNHA	0.0	0.7	0.0	0.0	0.0	0.0
	SAC	0.0	0.8	0.0	0.0	0.0	0.0
	SPA	0.0	0.0	0.0	0.0	0.0	0.0
*Total**	*NHA/pNHA*	*91.1*	*14.5*	*28.3*	*95.3*	*0.7*	*40.4*
	SAC	*71.7*	*5.1*	*29.0*	*69.5*	*0.7*	*14.2*
	SPA	*3.9*	*1.3*	*0.0*	*42.1*	*0.7*	*27.4*

* Components may not sum to totals because of rounding

The occurrence of semi-natural grassland habitats within SACs, SPAs, and NHA/pNHAs followed slightly different patterns with GS4, the most common grassland habitat within the survey area, having the largest area within SPAs and NHA/pNHAs, but GS1, the second most common grassland habitat within the survey area, having the largest area within SACs. It should be noted that GS1 and GS3 were more common within SACs, 40.1% and 74.0% respectively, than GS4, at 20.5%, relative to the total area surveyed for each of the habitats across the six counties. This pattern is repeated within NHA/pNHAs. GA1 is proportionately more common in SPAs, with 27.4 ha recorded within this designation type, with only GS4, at 42.1 ha, having a higher area surveyed within SPAs. GM1, although an uncommon habitat within the surveyed area, was almost always found within a NPWS conservation site and 87.5% of the total area of this habitat surveyed within the eight counties was found within SACs. GS2 was poorly represented within SACs and NHA/pNHAs with only 4.5% and

12.7% of the total area of this habitat within the eight counties found within these NPWS conservation sites.

Among the eight counties, the areas of the different grassland habitats within NPWS conservation sites (Table 3.4) tended to follow similar trends to those discussed above for Table 3.2. Kilkenny had a large area of GS1 within SACs and NHA/pNHAs and Louth had a large area of GS3 within SACs and NHAs/pNHAs. Westmeath contained the largest total surveyed areas of GS2 and GS4 within the eight counties and the county also contained the largest areas of GS2 within NHA/pNHAs and the largest areas of GS4 across all types of NPWS conservation site.

Annex I grassland habitats

The area of land covered by Annex I grassland habitats in Carlow, Kilkenny, Laois, Meath, and Westmeath is shown in Table 3.5, together with the number of areas recorded. Of the eight counties surveyed no Annex I grassland habitat, with an area at least equal to the minimum mapping area of 400 m^2, was recorded in Louth, Wicklow, or Wexford. For Louth and Wicklow the fact that the survey was restricted to lowland areas meant that the vast majority of the Carlingford and Wicklow Mountains and potential areas of Annex I grassland habitat within these were not surveyed. The Annex I habitat *Nardus* grassland (*6230) was not recorded within the eight Leinster counties surveyed. In total, 23.0 ha of Annex I grassland habitat were recorded from 22 areas during the survey, which equates to 2.9% of the 780.2 ha (including FS/FS2) surveyed within the eight counties. The greatest amount of this occurred in Kilkenny, where 8.0 ha were mapped as Annex I grassland habitat, representing 7.2% of the total area of grassland surveyed in that county.

Table 3.5 Area in hectares (number of areas) of Annex I grassland habitats recorded in Carlow, Kilkenny, Laois, Meath, and Westmeath. No Annex I habitat was found in Louth, Wicklow or Wexford and *Nardus* grassland (*6230) was not recorded within the eight counties.

County	Festuco-Brometalia [*]6210	*Molinia* meadows 6410	Hydrophilous tall herb communities 6430	Lowland hay meadows 6510	Total area (no. of areas)	No. of sites*
Carlow	1.1 (1)	0.0 (0)	0.0 (0)	0.0 (0)	1.1 (1)	1
Kilkenny	7.8 (3)	0.0 (0)	0.2 (1)	0.0 (0)	8.0 (4)	4
Laois	0.0 (0)	0.8 (1)	0.0 (0)	0.0 (0)	0.8 (1)	1
Meath	0.2 (3)	0.0 (0)	4.4 (2)	0.6 (1)	5.2 (6)	5
Westmeath	3.8 (6)	1.0 (1)	0.1 (1)	2.9 (2)	7.8 (10)	7
Total	13.0 (13)	1.8 (2)	4.7 (4)	3.5 (3)	23.0 (22)	18

* Two or more Annex I grassland habitats found in three sites

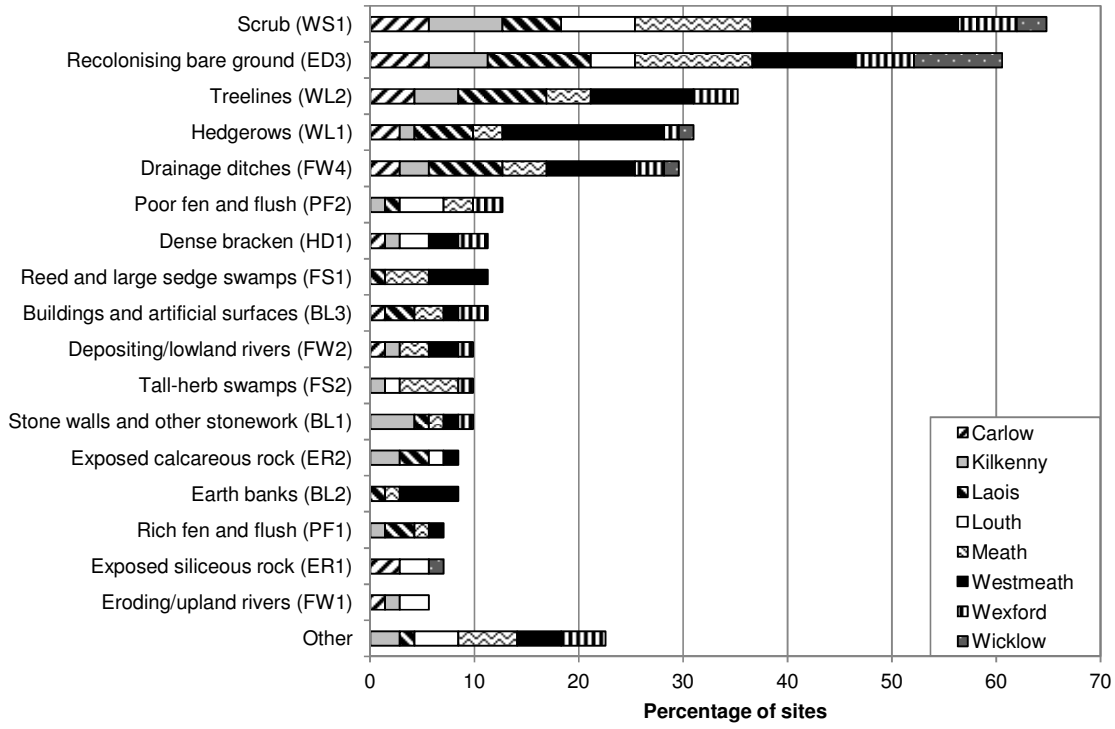
The Annex I grassland habitat with the greatest cover and frequency across the eight counties was Festuco Brometalia ([*]6210), with 13 ha in total across 13 sites. The assessed areas of Annex I grassland habitat occurred at 18 sites, or 25.4% of all sites surveyed. Of these, seven were in Westmeath (38.9% of Westmeath sites), five sites were in Meath (35.7% of sites in Meath), four were in Kilkenny (50% of Kilkenny sites) and one each in Carlow and Laois. Hydrophilous tall herb

communites (6430) were the second most abundant Annex I grassland habitat, recorded at four sites over 4.7 ha, with the majority of this area associated with the River Boyne floodplain in Co. Meath.

Internal habitats

Non-grassland internal habitats recorded during the 2011-2012 survey of Carlow, Kilkenny, Laois, Louth, Meath, Westmeath, Wexford and Wicklow are shown in Fig. 3.1. Scrub was present at 64.8% of sites and was the most frequently occurring non-grassland internal habitat at sites across Kilkenny, Louth and Westmeath. Recolonising bare ground was the most frequently occurring non-grassland internal habitat at sites across Laois and Wicklow, while recolonising bare ground and scrub were equally the most frequent across sites in Carlow, Meath and Wexford. Overall, recolonising bare ground was the next most frequent internal habitat and occurred at 60.6% of sites, followed by treelines (35.2% of sites), hedgerows (31.0%) and drainage ditches (29.6%). The "Other" category includes habitats which occurred at less than 5% of sites in the survey, including calcareous scree and loose rock, wet heath and dry heath (siliceous and calcareous), exposed sand, gravel or till, lagoons and saline lakes, swamp, improved grassland and oak-ash-hazel woodland.

Figure 3.1 Frequency of non-grassland Fossitt (2000) habitats within all surveyed sites, differentiated by county.

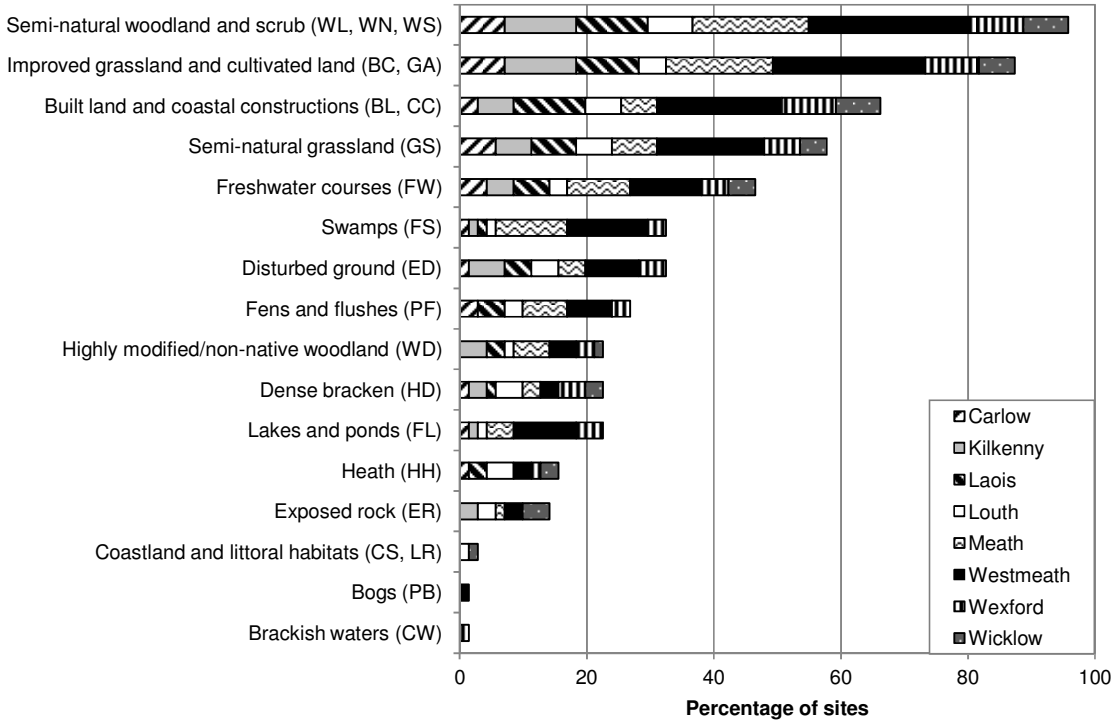


Adjacent habitats

Frequency of habitats which occurred adjacent to sites is shown in Fig. 3.2. Semi-natural woodland and scrub together formed the main land use adjacent to sites in the survey, and were recorded from 95.8% of sites. This category includes linear features and scrub, but excludes highly modified woodland. The bulk of this figure can be attributed to hedgerows and treelines, adjacent to 71.8% of

sites, with the highest proportion in Laois (100% of sites in the county); and scrub, adjacent to 70.4% of sites, the highest proportion of this recorded in Louth (100% of sites in the county). Improved grassland and cultivated land together were the next most frequent category, being recorded adjacent to 87.3% of sites. Most of this figure can be attributed to improved grassland, which was recorded adjacent to 85.9% of sites, ranging from 60% of sites in Louth to 100% of sites in Carlow and Kilkenny. Cultivated land was rarer (adjacent to 22.5% of sites, none in Louth or Wicklow), although proportionally higher in Carlow (60.0% of sites in the county). Other habitats frequently recorded adjacent to sites included built land and coastal constructions, adjacent to 66.2% of sites, with Laois having the highest proportion (100% of sites in the county); semi-natural grassland, adjacent to 57.7% of sites; and freshwater courses, adjacent to 46.5% of sites. Louth and Carlow had the highest proportion of sites with semi-natural grassland as an adjacent habitat (80% for both counties), while Meath had the lowest proportion of sites with semi-natural grassland as an adjacent habitat (35.7% of Meath sites). Swamp habitats are notably more frequent as adjacent habitats in Westmeath and Meath, recorded at 50.0% and 57.1% of sites respectively. Multiple adjacent habitats were recorded at all sites, with a median of six habitats occurring at sites across the eight counties.

Figure 3.2 Frequency of habitats occurring adjacent to surveyed sites, differentiated by county.

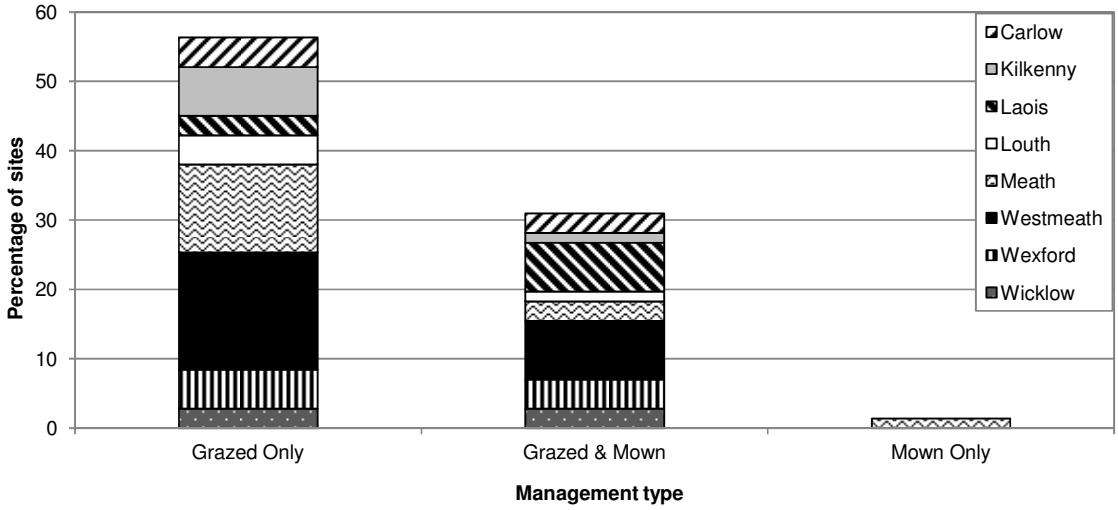


Management

The majority of sites within the eight Leinster counties surveyed during 2011-2012 were just grazed (56.3% of sites) while 1.4% were just mown (Fig. 3.3). A total of 31.0% of sites were managed through a combination of both grazing and mowing, while 11.3% of the sites had no evidence of mowing or grazing recorded. Laois and Wicklow had the lowest proportion of "Grazed only" sites (25.0% and 33.3% of sites within these counties respectively); all other counties had over 50% of their

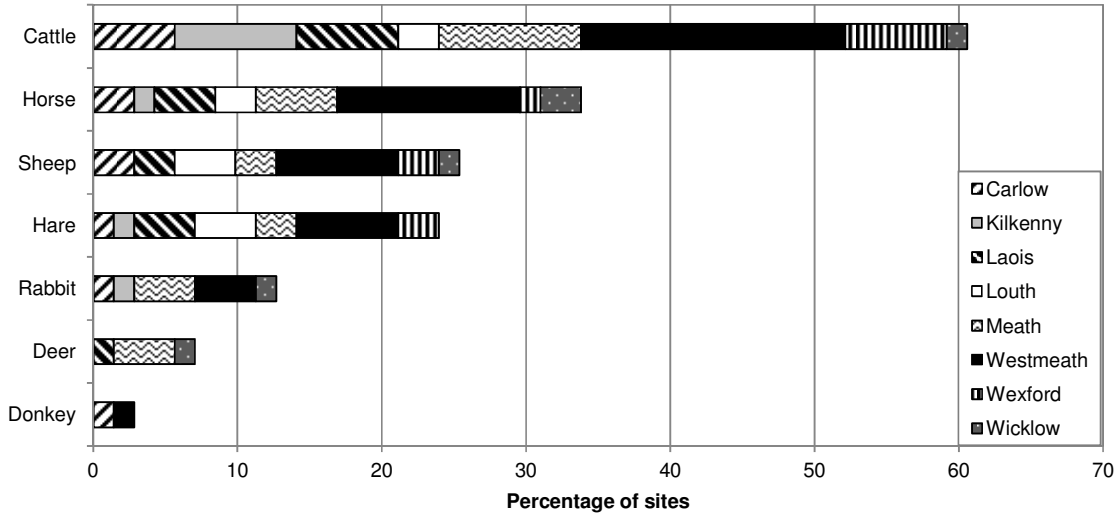
sites managed solely by grazing, with Westmeath having the highest proportion (66.7% of sites in the county). Meath was the only county which had "Mown only" sites. For all other counties, where mowing occurred, grazing was also recorded. Laois had the highest proportion of sites with a mixed regime of mowing and grazing (62.5% of Laois sites), followed by Wexford and Carlow (42.9% and 40.0% of sites in these counties respectively). Carlow, Westmeath and Wexford were the only counties that had grazing, mowing or a combination of the two at all sites surveyed. The other five counties had some sites which had no grazing or mowing recorded at all, with Wicklow having the highest proportion (33.3% of sites in the county).

Figure 3.3 Frequency of different management regimes at sites, differentiated by county.



More than one grazing type was frequently encountered on a site. Cattle were the most frequently occurring grazing animal, recorded on 60.6% of sites (Fig. 3.4). Horses and sheep were encountered at 33.8% and 25.4% of sites respectively. Kilkenny was the only county where sheep were not recorded as grazers. The only other domestic grazer recorded was donkeys, which were found grazing in both Carlow and Westmeath. Wild and feral grazers were also recorded, and these included deer, goats, rabbits and hares. Most common of these were hares, recorded at 23.9% of sites.

Figure 3.4 Frequency of grazing animals at sites, differentiated by county.



The most frequently recorded damaging activity was drainage (19.7% of sites), followed by adjacent afforestation (14.1% of sites), other (9.9% of sites) and dumping (8.5% of sites; Fig. 3.5). A total of 53.5% of sites had no damaging activities recorded at all, with the highest proportion occurring in Meath (71.4% of sites in this county had no damaging activities recorded). Damaging activities that occurred at less than 3% of sites included abandonment, campfires, disturbance, herbicide application and man-made developments. These were grouped under "Other" damaging activities.

Figure 3.5 Frequency of occurrence of different types of damaging activity at sites, differentiated by county.

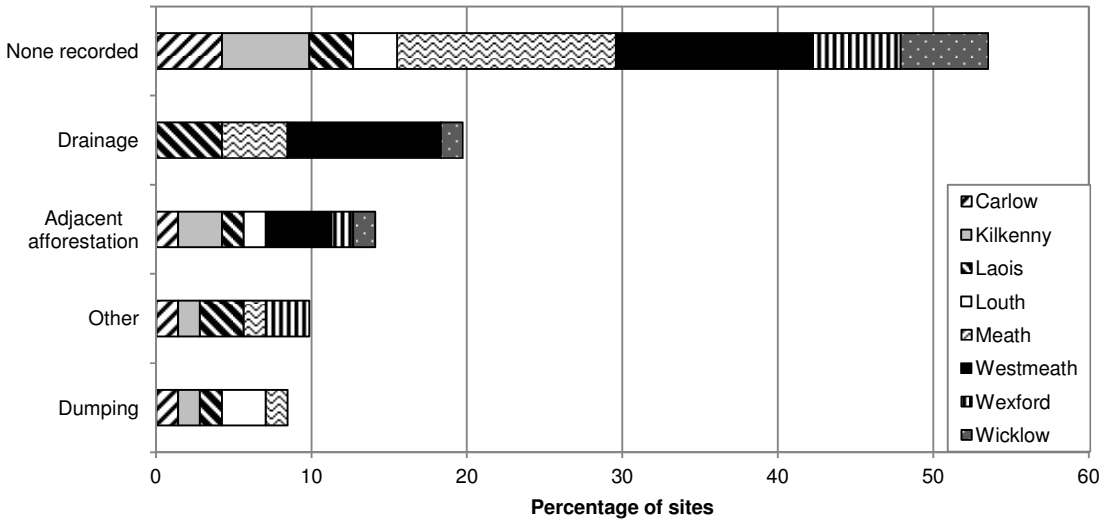
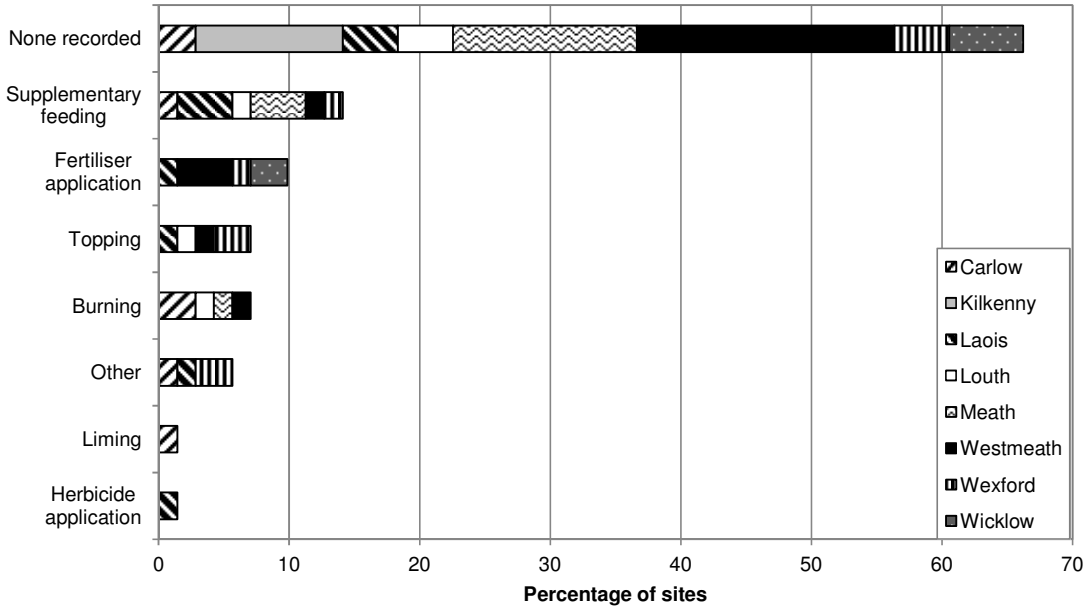


Fig. 3.6 indicates the frequency of agricultural activities in Carlow, Kilkenny, Laois, Louth, Meath, Westmeath, Wexford and Wicklow. The most frequent method of improvement observed was the provision of supplementary feeding (14.1% of sites), with the highest proportion recorded within Laois (37.5% of Laois sites). Kilkenny and Wicklow sites had no records for supplementary feeding.

Fertiliser application (recorded in 9.9% of all sites), topping (7.0% of all sites) and burning (7.0% of all sites) were the next most frequent agricultural activities recorded. Fertiliser application was highest in Wicklow (33.3% of Wicklow sites), while topping was highest in Wexford (28.6% of Wexford sites) and burning highest in Carlow (40% of Carlow sites). All counties had some sites in which none of these more intensive agricultural activities were recorded (66.2% of all sites); with Kilkenny having the highest proportion (100%). Other activities such as scrub clearance, shooting (species unspecified), educational uses, liming and herbicide application were recorded in much fewer semi-natural grassland sites (5% or less of all sites).

Figure 3.6 Frequency of agricultural activities recorded, differentiated by county.

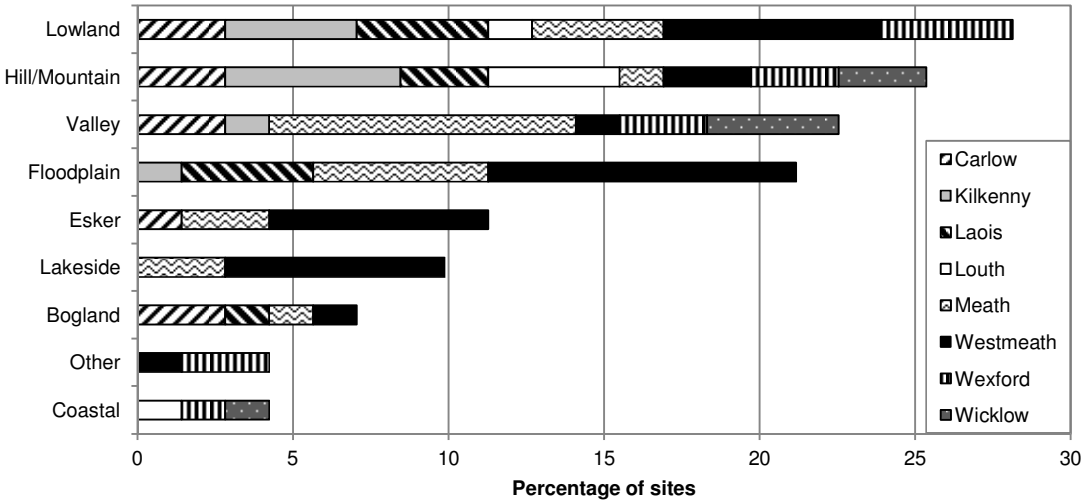


Landscape features

Fig. 3.7 indicates the landscape features associated with sites included in the survey. The landscape feature most frequently recorded in association with sites was lowland plains, with this landscape feature associated with 28.2% of sites. Wexford and Carlow were the counties with the highest proportion of sites on lowland plains (42.9% and 40.0% of sites in each county respectively). Wicklow had no sites recorded in association with lowland plains. Louth had the lowest incidence of sites associated with lowland plains (20.0% of Louth sites), but the highest proportion of hills or mountains (60.0% of sites in the county). Hills and mountains were the next most frequent landscape features recorded, and were noted at 25.4% of all surveyed sites, highest within Louth (60.0% of Louth sites) followed by Kilkenny (50.0% of sites in the county). Meath had the lowest proportion of sites associated with hills or mountains (7.1% of sites in the county), but the highest proportion of sites associated with valleys, the third most frequent landscape feature recorded. Both Meath and Wicklow had half of their sites associated with valleys, while Laois and Louth had none. The only other features of significance were floodplains and eskers which were present in 21.1% and 11.3% of sites respectively. Westmeath had the highest proportion of sites associated with floodplains (38.9% of

sites in the county) and eskers (27.8% of sites in the county). Eskers were also recorded in association with sites in Meath and Carlow (14.3% and 20.0% of sites in each county respectively). Over 60% of sites associated with eskers also supported Annex I quality habitats. Landscape features such as polderland, turloughs and kettle holes were classified as "Other", with only one record of each recorded.

Figure 3.7 Frequency of different geographical features associated with sites, differentiated by county.



3.2 Assessment of Annex I grassland

A total of 18 of the sites surveyed in the eight counties Carlow, Kilkenny, Laois, Louth, Meath, Westmeath, Wexford, and Wicklow during 2011 and 2012 contained an area of Annex I grassland habitat greater than the minimum mapping area of 400 m^2. Of these, the majority were in counties Westmeath (7 sites), Meath (5 sites), and Kilkenny (4 sites; Table 3.6). Half of the Annex I grassland areas are outside SACs, with 11 of the 22 Annex I areas overlapping with an SAC. The data presented below summarise the extent, structure and functions, and future prospects for the 22 areas of Annex I grassland habitat recorded within the 71 sites.

Table 3.6 The 22 areas surveyed in Carlow, Kilkenny, Laois, Meath and Westmeath containing areas assessed as Annex I grassland habitat.

Site no.	Annex I habitat	County	SAC*
1903	[*]6210	Meath	
1908	[*]6210	Meath	002299
1908	6510	Meath	002299
1909	[*]6210	Meath	
1915	6430	Meath	002299
1916	6430	Meath	002299
2000	[*]6210	Westmeath	001831
2000	6510	Westmeath	
2001	[*]6210	Westmeath	001831
2003	[*]6210	Westmeath	
2012	[*]6210	Westmeath	000440
2012	6410	Westmeath	000440
2012	6430	Westmeath	
2014	[*]6210	Westmeath	
2015	[*]6210	Westmeath	
2025	6510	Westmeath	
2113	[*]6210	Carlow	
2500	[*]6210	Kilkenny	000831
2501	[*]6210	Kilkenny	000849
2502	[*]6210	Kilkenny	
2526	6430	Kilkenny	002162
2607	6410	Laois	

* SAC code only shown if Annex I grassland habitat occurs within the SAC

Area assessment

Of the 22 areas of Annex I grassland habitat assessed across the eight Leinster counties, one had increased in extent, two had decreased in extent and the remaining 19 were unchanged (Table 3.7), based on an area comparison between aerial photographs of 2000 and areas mapped during the either the 2011 or 2012 survey. Therefore all Annex I grassland areas were scored as *Favourable* for area assessment except site 2500, which was assessed as *Unfavourable – Inadequate*, and 2113 that was scored as *Unfavourable – Bad.*

Table 3.7 Annual percentage change in area between the years 2000 and 2012 of Annex I grassland habitats surveyed in Carlow, Kilkenny, Laois, Meath and Westmeath in 2012. Only sites where a change in area was recorded are presented. Individual components may not sum to totals because of rounding

Site no.	Annex I habitat	Area in 2000 (ha)	Area in 2012 (ha)	% change per yr
2113	[*]6210	2.16	1.11	-4.07
2500	[*]6210	6.63	6.59	-0.05
2502	[*]6210	0.46	0.49	0.52

Structure and functions assessment

Of the ten individual criteria assessed, forb component was the criterion with the lowest pass rate in *Molinia* meadows (6410), positive indicator species had the lowest pass rate in Festuco-Brometalia ([*]6210) and negative indicator species had the lowest pass rate in Lowland hay meadows (6510). Grazing and disturbance, along with forb component, had the lowest pass rates in Hydrophilous tall herb communities (6430). The pass rate for the monitoring stops was lower across each of the Annex I habitats than for the individual criteria because a failure in any one of the criteria resulted in a failure for the monitoring stop overall. The highest percentage of passes at individual monitoring stops was achieved by Festuco-Brometalia ([*]6210) and Hydrophilous tall herb communities (6430) with a pass rate of 70% and 75% respectively, the lowest was 6410 with a pass rate of 50%.

Table 3.8 Percentage pass rate for individual criteria used to assess structure and functions for each Annex I grassland habitat surveyed across the eight Leinster counties in 2011-2012. Note: A monitoring stop fails even if only one criterion fails.

	Festuco-Brometalia ([*]6210)	***Molinia* meadows (6410)**	**Hydrophilous tall herb communities (6430)**	**Lowland hay meadows (6510)**
Positive indicator species (HQ**)	93	88	NA	89
Positive indicator species (HQ & Non-HQ)	91	100	100	78
Non-native species	100	100	100	100
Negative indicator species	98	100	100	67
Encroachment	100	88	100	100
Sward height	89	88	100	89
Litter cover	100	75	NA	100
Bare ground cover	100	100	100	100
Grazing & disturbance	100	100	75	100
Forb component	93	63	75	89
Pass rate for monitoring stops before expert judgement applied	70	50	75	56
Pass rate for monitoring stops after expert judgement applied	91	50	75	67

* Annex I grassland habitat Nardus grassland (*6230) was not presented in this table as no monitoring stops were recorded
** HQ = High Quality positive indicator species (see section 2.4).

For results of individual structure and functions criteria within monitoring stops, see Appendix 6

As stated in section 2.4 for an Annex I habitat to receive a *Favourable* assessment for structure and functions, a pass was generally required for all criteria within all monitoring stops; however, high quality sites which narrowly failed on only one or two criteria were re-examined and, using expert judgement, a decision was made on whether a *Favourable* assessment for structure and functions was warranted. This approach resulted in the number of individual stops that passed for structure and functions across the four Annex I grassland habitats increasing from 44 to 55. The effect of this re-assessment was most noticeable for [*]6210, where the overall pass rate for monitoring stops increased from 70% to 91%.

Future prospects assessment

Assessment of the future prospects parameter for each of the Annex I grassland areas identified was carried out according to the scoring system outlined in Tables 2.1 and 2.8, with a score of 0 or greater assessed as *Favourable*, -1 to -3 as *Unfavourable – Inadequate* and less than -3 as *Unfavourable – Bad*. In total, 17 out of 22 (77.3%) Annex I grassland habitat areas assessed were scored as *Favourable* (i.e. with the effects of positive and negative impacts balanced in favour of the positive). Within the eight counties surveyed the Annex I habitats with the best overall future prospects were 6410 and 6510, with two and three areas respectively that were all assessed as having *Favourable* future prospects. The next most favourably rated was 6430, with 75.0% of its assessed areas (3 out of 4 areas) receiving a *Favourable* score. [*]6210 had the least favourable future prospects with 69.2% (9 out of 13 areas) receiving a *Favourable* score.

In terms of the impacts recorded, seven negative impacts were recorded on Annex I grassland habitats, with six positive and four neutral impacts also noted (Table 3.9). The most frequent negative impact recorded was species composition change (succession), which occurred at 15 of the 22 areas. It should be noted that the top four negative impacts often related to current insufficient management or agricultural abandonment. Species composition change (succession) was often recorded in the absence of abandonment and in the presence of non-intensive grazing that was judged to be having an overall positive impact. The top five positive impacts were all related to the management of grasslands through either grazing or mowing. Collectively, grazing was identified as the most frequent positive impact, with cattle and horses the most frequent grazing animal, each recorded in seven areas of Annex I habitat. Mowing was a positive feature at four areas, including all three of the 6510 areas. Note that grazing was identified in some sites as a positive effect and at others as a neutral impact (neither positive nor negative). Grazing was generally recorded as having a negative impact in areas where it was insufficient to prevent a rank sward from developing, or where negative impacts due to trampling or enrichment outweighed any other positive effect that grazing might achieve; but cattle grazing was recorded as having a positive effect where it successfully controlled sward rankness and more than cancelled out any of the negative effects of grazing. An assessment of neutral impact was made when the positive and negative impacts cancelled each other out when an assessment was made across the total area of Annex I habitat within a site. This was a highly context-sensitive assessment, requiring a weighing up of all of the individual impacts seen at a site.

For future prospects results of assessed Annex I grassland habitat areas, see Appendix 8

Table 3.9 Impacts recorded for each of the Annex I grassland habitats assessed in counties Carlow, Kilkenny, Laois, Meath and Westmeath, showing the number of areas each impact occurred at for each Annex I habitat.

(a) Negative impacts

Impact code	Description	Annex I grassland habitat [*]6210	6410	6430	6510	Total
K02.01	Species composition change (succession)	10	2	2	1	15
I02	Problematic native species	5	-	-	-	5
A03.03	Abandonment / lack of mowing	1	-	-	1	2
A04.03	Abandonment of pastoral systems, lack of grazing	1	1	-	-	2
A08	Fertilisation	1	-	-	-	1
G05	Other human intrusions and disturbances	-	-	-	1	1
I01	Invasive non-native species	1	-	-	-	1

(b) Positive impacts

Impact code	Description	Annex I grassland habitat [*]6210	6410	6430	6510	Total
A04.02.01	Non intensive cattle grazing	5	-	2	-	7
A04.02.03	Non intensive horse grazing	5	1	-	1	7
A03.02	Non intensive mowing	1	-	-	3	4
A04.02.02	Non intensive sheep grazing	3	-	-	1	4
A04.02.05	Non intensive mixed animal grazing	-	1	-	-	1
J02.04.01	Flooding	-	-	1	-	1

(c) Neutral impacts

Impact code	Description	Annex I grassland habitat [*]6210	6410	6430	6510	Total
A04.02.01	Non-intensive cattle grazing	3	-	-	-	3
C01.01.01	Sand and gravel quarries	1	-	-	-	1
G01.02	Walking, horse-riding and non-motorised vehicles	-	-	1	-	1
K01.01	Erosion	1	-	-	-	1

Overall condition assessment

The condition assessment scores for the 22 areas of Annex I grassland habitat assessed across the eight counties were derived as outlined in section 2.4. Examining each of the assessment parameters separately (area, structure and functions, future prospects), the highest number of *Favourable* assessments were within area assessment with 20 of the 22 areas assessed as *Favourable* (Table 3.7; see also Appendix 9), and the lowest were within structure and functions, with 14 of the 22 areas assessed as *Favourable*, even after all monitoring stops had been re-examined for near misses.

In terms of the overall condition assessment (i.e., combining all three assessment parameters with reference to the matrix presented in Table 2.1) for each of the 22 areas of Annex I grassland habitat, seven areas received an overall assessment of *Favourable.*

For overall condition assessments of assessed Annex I grassland habitat areas, see Appendix 9

Primary areas of Annex I grassland habitat

During 2011-2012, 22 areas of Annex I grassland habitat greater than the minimum mapping area located at 18 sites (three sites contained more than one Annex I grassland habitat) were surveyed. Many of these areas of Annex I grassland habitat are either small (less than 1 ha) or have unfavourable structure and functions. Following the proposal in Martin *et al.* (2008) that a list of premium quality sites containing Annex I grassland habitats above a minimum size and of adequate structure and functions be produced, Table 3.10 shows the list of such sites compiled from the Annex I grassland habitats assessed within the eight counties; only four of these counties contained at least one primary area of Annex I habitat. The six areas of Annex I grassland listed are hereafter referred to as ***primary areas*** of Annex I grassland and represent the best examples of Annex I grassland habitat recorded across the eight counties. They are judged to be of primary importance due to a combination of the area they cover (at least 1 ha) and their structure and functions, and should provide a focus for monitoring and conservation efforts in the future. Three of the 14 areas that received a *Favourable* structure and functions assessment were included in the list of primary areas, the other eleven being too small. Three of the six primary areas were recorded in Westmeath, with the remainder located within Carlow, Kilkenny, and Meath. No areas of primary Annex I grassland habitat were recorded in Laois, Louth, Wexford, or Wicklow.

Five of the six areas of primary Annex I habitat were located within NPWS conservation sites; for four of these, between 90% and 100% of the Annex I habitat was located within an SAC.

Table 3.10 List of the six primary areas of Annex I grassland habitat surveyed within Carlow, Kilkenny, Meath, and Westmeath. The sites are ordered by Annex I habitat type and then site number within each type. The % within NPWS site refers to the % of the Annex I habitat located in an SAC or pNHA. % Pass for Structure and Functions is after expert judgement applied.

Site No.	County	Annex habitat	Area (ha)	Structure and functions	% in NPWS site	NPWS site no.
2001	Westmeath	[*]6210	1.2	80% Pass = Unfavourable-Inadequate	39	SAC 001831
2113	Carlow	[*]6210	1.1	100% Pass = Favourable	99	pNHA 000797
2500	Kilkenny	[*]6210	6.6	100% Pass = Favourable	100	SAC 000831
2012	Westmeath	6410	1.0	50% Pass = Unfavourable-Bad	100	SAC 000440
1915	Meath	6430	1.1	100% Pass = Favourable	100	SAC 002299
2000	Westmeath	6510	2.1	75% Pass = Unfavourable-Inadequate	0	-

3.3 Ranking of sites using conservation and threat evaluations

Conservation and threat scores were calculated as described in section 2.5. The full list of conservation and threat scores for Leinster sites surveyed in 2011-2012 is given in Appendices 10 and 11.

Conservation scores

The 22 sites of highest conservation value are presented in Table 3.11, all of these sites had a conservation score greater than 25%. Ten of the top 22 sites are in Westmeath, five are in Kilkenny, three are in Meath, and Carlow and Laois contain two each. All but three of these top sites occur at least partly within an NPWS conservation site. One of the three that does not occur within an NPWS conservation site contains an Annex I grassland habitat. Thirteen of the top sites received the maximum score for species density, with seven of these thirteen also receiving the maximum score for high quality indicator species. Fifteen of the 22 sites contain at least one Annex I habitat, with the highest scoring site – Creaghduff, Westmeath (2012) – containing two primary Annex I areas.

Table 3.11 The 22 highest ranked grassland sites according to their conservation score surveyed in Leinster in 2011-2012. Rankings shared by two or more sites are indicated by "=".

Site No.	Site Name	County	NHA/pNHA	SAC	% score	Rank
2012	Creaghduff	Westmeath	000440	000440	54.7	1
1908	Sranaboll	Meath	000556	002299	42.1	2
2000	Toorlisnamore	Westmeath	001831	001831	40.0	3
2015	Derrya	Westmeath	000684	-	38.9	=4
2113	Ballymoon Esker	Carlow	000797	-	38.9	=4
2001	Ballymachugh	Westmeath	001831	001831	33.7	=6
2005	Dysart	Westmeath	000685	000685	33.7	=6
2500	Coolnacrutta	Kilkenny	000831	000831	33.7	=6
1911	Duleek Commons	Meath	001578	-	31.6	=9
2023	Lough Derravaragh	Westmeath	000684	-	31.6	=9
2102	Coolmanagh Lower	Carlow	-	000781	30.5	=11
2611	Great Heath	Laois	000881	-	30.5	=11
1903	Julianstown	Meath	000554	-	29.5	=13
2502	Clomantagh (Mountgarret)	Kilkenny	000849	000849	29.5	=13
2607	Derrycarrow	Laois	-	-	29.5	=13
2014	Mace	Westmeath	-	-	28.4	16
2003	Toorfelim	Westmeath	001713	-	27.4	=17
2020	Portloman	Westmeath	-	-	27.4	=17
2525	Baun	Kilkenny	-	-	27.4	=17
2025	Clonava	Westmeath	-	-	26.3	20
2501	Ballyspellan	Kilkenny	000849	000849	25.3	=21
2526	Jerpoint Abbey	Kilkenny	000410	002162	25.3	=21

Threat scores

The 10 most threatened sites are presented in Table 3.12, representing all sites that scored over 40% in the threat evaluation. Three of the sites occur in Westmeath and one in Meath, with two each in Carlow, Laois and Wexford. Five of these sites – Ballymoon Esker, Carlow (2113), Creaghduff, Westmeath (2012), Clonava, Westmeath (2025), Dysart, Westmeath (2005) and Coolmanagh Lower, Carlow (2102) – also appear on the list of the sites of greatest conservation value, highlighting the vulnerable nature of these grassland sites. All but one of these sites occur at least partly within NPWS conservation sites.

Table 3.12 The 10 highest ranked grassland sites according to their threat score surveyed in Leinster in 2011-2012. Rankings shared by two or more sites are indicated by "=".

Site No.	Site Name	County	NHA/pNHA	SAC	% score	Rank
2113	Ballymoon Esker	Carlow	000797	-	61.5	=1
2600	Ballyprior	Laois	-	002256	61.5	=1
2012	Creaghduff	Westmeath	000440	000440	53.8	=3
2025	Clonava	Westmeath	-	-	53.8	=3
1910	Ballyhoe Lough	Meath	001594	-	46.2	=5
2005	Dysart	Westmeath	000685	000685	46.2	=5
2102	Coolmanagh Lower	Carlow	-	000781	46.2	=5
2608	Vicarstown (Dodd)	Laois	-	002162	46.2	=5
3003	Screen Hills	Wexford	000708	000708	46.2	=5
3006	Wexford Wildfowl Reserve	Wexford	000712	-	46.2	=5

4: DISCUSSION

4.1 Summary data and the ranking of all surveyed sites

In this discussion the data collected in counties Carlow, Kilkenny, Laois, Louth, Meath, Westmeath, Wexford and Wicklow during ISGS 2011-2012 will be compared with the data collected in counties Clare, Galway, Kerry, Limerick, Mayo and Tipperary in 2011-2012 and the other 12 counties surveyed from 2007 to 2010. The discussion will focus on the eight Leinster counties surveyed in 2011 and 2012, with the remaining four Leinster counties surveyed between 2007 and 2010 included where relevant. A detailed discussion of all counties surveyed during the lifespan of the ISGS can be found in O'Neill *et al.* (2013).

Table 4.1 Summary of sites surveyed by the ISGS 2007-2012. The counties are ordered by median site area.

County	Year	Hectares surveyed	No. of sites	Median site area (ha)	No. of relevés	Sites in SAC	Sites in NHA/pNHA	Annex I grassland sites
Leitrim	2009	3925.2	77	40.6	390	18	29	30
Sligo	2010	1527.4	52	24.8	312	20	26	31
Longford	2009	1290.7	49	23.1	187	12	14	5
Limerick	2012	398.0	15	21.6	86	6	4	6
Roscommon	2007	1381.1	51	20.0	178	10	19	19
Cavan	2009	1841.7	66	17.6	273	17	18	17
Laois	2012	138.5	8	16.2	29	3	3	1
Monaghan	2009	893.6	47	14.0	189	1	12	5
Kildare	2010	823.3	22	13.6	107	1	5	7
Kerry	2012	577.3	32	13.5	136	21	16	6
Clare	2011	1074.2	63	13.5	248	36	39	32
Dublin	2010	749.6	26	12.7	97	6	12	6
Offaly	2007	1365.0	41	12.1	139	10	21	15
Westmeath	2011	215.2	18	11.5	84	7	10	7
Carlow	2012	47.1	5	9.8	20	1	1	1
Mayo	2011	1456.2	115	9.7	465	58	52	33
Donegal	2010	1438.1	103	8.8	382	40	41	32
Tipperary	2012	264.0	21	7.7	71	7	7	10
Cork	2008	1859.5	192	7.2	589	40	42	14
Waterford	2008	706.0	58	7.1	176	15	17	4
Kilkenny	2012	110.7	8	6.9	27	5	4	4
Meath	2011	142.3	14	6.5	37	7	8	5
Galway	2012	837.0	91	5.9	282	42	39	34
Wexford	2012	61.0	7	4.0	15	3	3	0
Louth	2012	41.4	5	4.0	12	3	3	0
Wicklow	2012	24.0	6	3.4	13	1	1	0
Total		*23188.1*	*1192*	*11.6*	*4544*	*390*	*446*	*324*

Table 4.1 gives a summary of the 26 counties surveyed over the six years of the ISGS 2007-2012. The eight Leinster counties surveyed in 2011 and 2012 are mostly in the bottom half of the table with

the smaller median site areas, only Laois with a median site size of 16.2 ha is in the top half of Table 4.1. Laois had the second highest median site size of all 12 Leinster counties, with only Longford (surveyed during 2009) higher at 23.1 ha. Wexford, Louth, and Wicklow had the smallest median site sizes of the eight Leinster counties surveyed in 2011 and 2012 and they were also the smallest nationally, with all three counties having a median site size of less than 5 ha.

The median site area for counties provides some indication of the overall status of the grassland present, with a greater proportion of smaller sites within a county evidence for more fragmented areas of semi-natural grassland. Agricultural improvement is probably the cause of habitat fragmentation within Wexford, with 100% of semi-natural grassland sites within the county having agriculturally improved habitats adjacent to them. Although it should be noted that in Carlow and Kilkenny 100% of all surveyed semi-natural grassland sites also had agriculturally improved habitats adjacent to them. Louth and Wicklow had the lowest proportion of sites with agriculturally improved habitats, represented by the Fossitt codes GA and BC, adjacent to them so it is unlikely that agricultural improvement is significantly contributing to the smaller areas of semi-natural grassland surveyed in these two counties. The lack of semi-natural grassland habitats, represented by Fossitt codes GS and GM, adjacent to a site can also indicate fragmented semi-natural grassland habitats, either due to natural processes or agricultural improvement. Meath had the lowest proportion of sites with adjacent semi-natural grassland habitats, at 35.7% of sites, while Wicklow had the joint second lowest at 50.0% and Louth had the joint highest proportion at 80%. Apart from their small site size there is little evidence in the ISGS data as to why the semi-natural grassland sites in Louth, Wicklow are any more fragmented than the other six Leinster counties surveyed in 2011/12. One possible reason is the geographical and land-use composition of the two counties, both of which have relatively large upland, coastal and urban areas where semi-natural grassland habitats would be expected to be a minor component. There is some support for this in the landscape data collected during this survey with Louth and Wicklow having the lowest incidence of sites within lowland plains, the landscape feature most commonly associated with semi-natural grassland throughout the survey.

The occurrence of the four GS habitats and GM1 across all eight Leinster counties surveyed in 2011 and 2012 followed the expected trends with GS4, at 43.9% of the survey area, the most common habitat followed by GS1, at 23.1% of the survey area. Generally GS3 was uncommon within the eight counties surveyed with the exception being in Louth where the habitat represented 65.2% of the area surveyed, due to one relatively large site in the Carlingford Mountains. In addition, to the highest occurrence of GS3, as a percentage of the surveyed grassland area within a Leinster county this was also the highest figure nationally. No areas of GS3 grassland were recorded in Kilkenny and Wicklow, the absence of GS3 in Wicklow is due to the survey being generally restricted to lowland areas, the upland areas of GS3 within the Wicklow Mountains SAC (002122) will be surveyed as part of the National Survey of Upland Habitats (NSUH). Of the other eight counties surveyed Carlow had a large proportion of the survey area that was GS2 (50.2%), with three of the five sites surveyed within the county having significant meadow areas. Wexford had a high proportion of semi-improved

(GSi) habitats, at 41.6% of the area of surveyed grassland within the county, which was the highest percentage recorded nationally. Kilkenny had the highest proportion of the survey area that was GS1 (50.1% of the grassland surveyed within the county) which was also the highest percentage recorded nationally. Although these habitats were common in these counties the fact that Louth, Kilkenny, and Wexford have proportionately such large areas of GS3, GS1, and GSi is partly a consequence of the small number of sites and the small areas of semi-natural grassland surveyed within each of these counties. As Table 4.1 shows the total hectares surveyed within each of the eight Leinster counties visited in 2011 and 2012 was lower than for any other counties within the survey. This was partly due to other counties in less intensively farmed regions of the country being prioritised and also because of changes in the structure of the project that resulted in the survey intensity being reduced in 2011 and 2012.

Eskers are one of the habitats most closely associated with high nature value calcareous grassland (GS1) and the Annex I habitat Festuco-Brometalia (6210) in particular. Eskers were recorded within eight sites in Westmeath, Carlow and Meath, accounting for 27.8%, 20% and 14.3%of the sites within these counties respectively. The three counties also account for the majority of the 6210 habitat within the eight Leinster counties.

Of the eight Leinster counties surveyed in 2011 and 2012 Meath had the highest proportion of sites with adjacent swamp communities, at 57.1% of sites surveyed in the county, with many of the semi-natural grassland sites within this county located within the flood plain of the River Boyne. Westmeath also had a high incidence of sites with adjacent swamp communities, at 50.0% of sites surveyed in the county, a consequence of Westmeath having a larger proportion of lakes (e.g. Lough Ree) and aquatic habitats than any of the other eight Leinster counties surveyed (OSI 2013b). Unsurprisingly, within the eight Leinster counties three of the four sites containing Hydrophilous tall herb communities (6430), were located in these two counties.

Conservation scores were calculated on the same basis as in 2010. Table 4.2 shows the top 21 sites by conservation score over the six years of the ISGS 2007-2012. All of the sites in the table have a conservation score of over 50% and scored highly on all of the parameters tested. The top ranked site in the Leinster region is Moystown Demesne and Bullock Island (ISGS site 109) an Offaly site located along the Shannon Callows (SAC 000216). It is interesting to note that, although Dublin suffers from the disadvantages of urbanisation, the second highest ranking site from the Leinster region is Glenasmole Valley (ISGS site 1300 and SAC 001209), surveyed in Dublin in 2010. Only one site from the eight Leinster counties surveyed in 2011 and 2012 is included in the list, Creaghduff (ISGS site 2012) a Westmeath site surveyed in 2011. This site is located on the shores of Coosan Lough (Lough Ree SAC 000440) and contains three different Annex I grassland habitats. Creaghduff is only one of three sites from the Leinster region that are listed in the top 21 sites in the country.
Threat scores were also calculated for all the Leinster sites surveyed in 2011 and 2012. Threat scores are of maximum benefit when viewed in conjunction with conservation scores, particularly for

sites that have a high conservation score. A number of sites with high conservation scores received high threat scores also. The three most notable of these are Ballymoon Esker, Carlow (ISGS site 2113), Ballyprior, Laois (ISGS site 2600), and Creaghdff, Westmeath (ISGS site 2012). Two of these sites Ballyprior and Creaghduff are within SACs, Ballyprior Grassland (SAC 002256) and Lough Ree (SAC 000440) respectively. Highlighting the fact that designation does not necessarily decrease the threats to a site. Most of the threats scored are associated with activities relating to agricultural improvements. Buffer zones around areas of special conservation value might help to mitigate unwanted effects from agriculture such as weedy species and damaging activities such as drainage and fertiliser application.

Table 4.2 Top 21 sites ranked by conservation score, surveyed during ISGS 2007-2012.
For Conservation score criteria see Table 2.4.

Site ID	Site Name	County	Area (ha)	SAC	NHA/pNA	Annex I grassland habitat	Conserv Score (%)
2704	Aughinish	Limerick	31.8	002165	000435	6210, 6510	70.5
109	Moystown Demesne and Bullock Island	Offaly	235.2	000216	000216, 002104	6410, 6510	65.3
818	Lugnafaughery	Leitrim	95.7	000623	002435	6210, 6410	65.3
811	Larganavaddoge	Leitrim	76.3	000623	000623	6210	62.1
1300	Glenasmole Valley	Dublin	45.0	001209	001209	6210, 6410, 6510	58.9
850	Letterfine	Leitrim	121.1	-	-	6210, 6510	57.9
2701	Barrigone	Limerick	20.1	000432	000432	6210, 6510	57.9
825	Ballynaboll	Leitrim	178.8	-	-	6210	56.8
1248	Rossnowlagh Lower	Donegal	45.2	000138	000138	6410, 6510	56.8
808	Keeloges	Leitrim	115.8	001403	001403	6210	55.8
1067	Manragh Upper	Cavan	87.9	-	-	6210	54.7
2012	Creaghduff	Westmeath	20.4	000440	000440	6210, 6410, 6430	54.7
712	Coolberrin	Monaghan	95.9	-	-	6410, 6430	53.7
1250	St. John's Point	Donegal	70.1	000191	000191	6210, 6410	52.6
1502	Edenbaum	Sligo	40.6	-	002435	6210	52.6
1541	Cloonmacduff	Sligo	74.8	001898	001898	6210, 6410	52.6
807	Aghadunvane	Leitrim	130.9	001403	001403	6210	51.6
813	Aghalateeve	Leitrim	69.8	000623, 001919	000623, 001919	-	51.6
1004	Moneen	Cavan	208.0	002032	-	6410	50.5
1249	Drumhome	Donegal	13.6	000138	000138	6230, 6410	50.5
2329	Killure More	Galway	22.0	-	000254	6210, 6410	50.5

4.2 Condition assessment of Annex I grassland

The number of sites in the eight Leinster counties of Carlow, Kilkenny, Laois, Louth, Meath, Westmeath, Wexford, and Wicklow recorded as having Annex I grassland was lower than the number recorded in the western counties Clare, Galway, Kerry, Limerick, Mayo and Tipperary over the same period (2011 to 2012). In the six western counties 9.1% of the survey area and 36.2% of sites contained Annex I grassland habitats, while in the eight Leinster counties these habitats were only recorded within 2.9% of the survey area and 25.4% of sites.

A total of 22 areas of Annex I grassland were assessed in terms of their change in extent since 2000, structure and functions and future prospects. Of the 22 Annex I grassland areas seven (32% of areas assessed) received an overall assessment of *Favourable*. It should be noted that the Annex I habitat *Nardus* grassland (*6230) was not recorded within any of the eight Leinster counties surveyed in 2011 and 2012 and was not recorded in Leinster during the ISGS 2007-2012. The *6230 habitat has been recorded previously within Leinster in the Wicklow Mountains (O'Donovan 2007) and the Carlingford Mountains (Roche *et al.* 2010), but only the lower slopes of these mountain regions, outside the boundaries of the upland SACs, were within the remit of this survey. Due to the fact that the upland regions of Louth and Wicklow were not surveyed no Annex I grassland habitats were recorded in either of these counties. Wexford was the only other county within Ireland where no Annex I grassland habitats were recorded during this survey. This is most probably due to the high level of agricultural intensification within the county, but the fact that the survey methodology that was applied (section 2.1) resulted in the county being less intensely surveyed is also a factor.

Area assessment

Change in area (extent) was noted in the methodology in section 2 as being slightly biased towards the area boundaries visible on the 2005 aerial photographs. This fact is being mentioned specifically in this report as the series of aerial photographs used as base mapping for the digitisation of sites in 2011 and 2012, including Annex I grassland areas, is seven years old and is therefore likely to be less representative of the site boundary than in previous years of this survey due to the greater time elapsed since the photographs were taken in 2005. While GPS points were used to map grassland habitat boundaries that were not visible on the photograph (such as a transition from Annex I grassland to non-Annex I grassland), existing features on the aerial photograph, such as hedgerows or patches of scrub, were used where present on the ground in 2011 and 2012. Slight differences in features such as thickness of hedges or extent of scrub encroachment may not have been seen on the ground to be significantly different from the photograph, and may therefore not have been mapped in the field. Many such changes are likely to have been smaller than the minimum mapping area; there may, however, have been some area changes that were above the minimum mapping area but not identified when mapping in the field. This may potentially have impacted slightly on the results for area assessment, most of the Annex I areas having been recorded as having undergone no decrease in area. Two sites within the eight Leinster counties recorded a measureable loss of area, while one site underwent a slight increase due to recolonisation of bare ground in an old quarry site. Loss of

area can be attributed to quarrying and succession to scrub. The accurate assessment of area change will be much improved when a new series of aerial photographs becomes available, and also when the surveys switch from baseline to monitoring.

Structure and functions assessment

The National Conservation Assessments (NCAs) of Annex I grassland habitats were completed in 2013 (NPWS 2013) as part of Ireland's reporting commitments under Article 17 of the EU Habitats Directive. The structure and functions criteria previously used during the ISGS were reviewed and amendments were made as part of the NCA process. Notably, new criteria were added for the *Nardus* grassland (*6230) structure and functions assessment to ensure that only species-rich examples of this vegetation type were assessed and that the calcareous sub-community of this Annex I habitat was recognised. Also, some negative indicators for *Molinia* meadows (6410) were removed as they characterise the fen-meadow variant of this habitat, rather than suggesting negative structure and functions. All relevés recorded during the entire course of the ISGS (2007-2012) were re-checked for correspondence to Annex I habitats, and all Annex I relevés identified were assessed using this new criteria (refer to Appendix 5 for a breakdown of the structure and functions criteria and threshold levels).

For the majority of criteria for each of the five Annex I grassland habitats assessed there was a pass rate of 80% or greater. The structure and functions criteria with the lowest pass rates included forb component (63%), grazing and disturbance (75%), and litter cover (75%) for *Molinia* meadows (6410), and negative indicator species (67%) and positive indicator species (78%) for Lowland hay meadows (6510). Specific criteria failing or passing is often dependent on the degree to which the habitat is managed. Inadequate grazing or mowing regimes may result in a build-up of litter and the development of a rank, tussocky sward or succession to scrub, while the application of fertiliser or reseeding may increase the incidence of negative indicator species such as *Lolium perenne*.

The pass rate for the monitoring stops was lower across each of the Annex I habitats than for the individual criteria because a failure in any one criterion resulted in a failure for the monitoring stop overall. *Molinia* meadows (6410) had the lowest pass rate (50%), Festuco-Brometalia ([*]6210) had the highest pass rate (91%), while the Annex I habitats Hydrophilous tall herb (6430) and Lowland hay meadows (6510) had pass rates of 75% and 67% respectively. In order for an area to acquire a Favourable status, all monitoring stops within the area must have passed the structure and functions criteria. The importance of appropriate management is of vital importance to the structure and functions of Annex I grassland habitats. With the correct management, the pass rate for all Annex I grassland habitats could be higher. To that end, agri-environment schemes In Ireland should assist farmers in the recognition of these important habitats and in implementing appropriate management practices.

Future prospects assessment

The assessment of this parameter utilised the list of impacts given by Ssymank (2010). This attempts to list all the potential negative, positive and neutral practices that impact on Annex I habitats. In 2010, the first year in which this list of impact criteria was used for a full field season, it was found that some negative criteria, such as scrub, bracken or heath encroachment, were not explicitly listed among the impacts and could no longer be scored individually, or could potentially be scored in a number of ways, such as "Problematic native species" or by inference from another category; for example, encroachment could be scored through the negative impact "Abandonment / lack of mowing", if the field was formerly mown, or "Abandonment of pastoral systems, lack of grazing" if formerly grazed. Following a review of the impact criteria after the field season in 2010, the recording of encroachment by scrub or heath by using the code "Species composition change (succession)" and use of "Problematic native species" being reserved for the recording of bracken encroachment was utilised for the 2011-2012 field seasons.

The top four negative impacts within the Annex I grassland habitats recorded in the eight Leinster counties relate to a lack of management and agricultural abandonment, with species composition change listed as the top ranking negative impact. Species composition change, which often meant succession from grassland to scrub, was a particular problem for Festuco-Brometalia ([*]6210) with the impact noted at 10 (76.9%) of the 13 sites where the [*]6210 habitat was recorded. These impacts highlight the vulnerability of both non-Annex and Annex I grassland habitats to a lack of appropriate management. Without the correct grazing or mowing regime in place, grassland habitats can often develop a rank sward dominated by a few species and eventually succeed to scrub, heath and woodland habitats. A lack of management can also allow bracken to establish within a grassland.

The most commonly recorded positive impacts for the Annex I habitats were non-intensive grazing and mowing. All three of the Lowland hay meadow (6510) sites surveyed within the eight Leinster counties were managed by non-intensive mowing. *Molinia* meadows (6410) were managed by non-intensive grazing, and non-intensive grazing, particularly cattle and horses, were recorded as positive impacts for 11 of the 13 Festuco-Brometalia ([*]6210) sites.

Primary areas of Annex I grassland habitat 2012

Martin *et al*. (2008) proposed the compilation of a list of Annex I grassland areas that were of exceptionally good quality in terms of their structure and functions and overall area. Such a list would act as a focus for grassland conservation efforts in the future. Based on the data collected between 2007 and 2012 there is now a national list of 135 primary areas of Annex I habitat, 19 of which are within the Leinster region and six of these were surveyed this year (Table 3.10).

Of the eight Leinster counties surveyed in 2011 and 2012, Westmeath has the highest number of sites included in the primary areas list, with a total of three sites, covering three different Annex I grassland habitats (6210, 6410, and 6510), listed as being of sufficient area and having good

structure and functions. Of all 12 Leinster counties only Offaly with 10 primary areas of Annex I habitat, covering three different Annex I habitats (6210, 6410, and 6510) has a greater number of sites in the region. Meath has one primary area of Hydrophilous tall herb community (6430) and this is one of only five recorded nationally during the ISGS and the only primary area of 6430 recorded within Leinster. However, it is expected that this Annex I habitat is probably more common than the ISGS data suggest, being more commonly associated with areas of swamp than with semi-natural grassland, the focus of this survey.

One of the Westmeath primary areas is not within an NPWS conservation site, and another one only has a small proportion (39%) within an NPWS conservation site. These sites are prime candidates for inclusion within a designated area through the extension of an existing conservation site boundary, or they could be examined with a view to designating them for the Annex I grassland habitats they support. The other four primary areas of Annex I habitat recorded within Leinster in 2011 and 2012 were either 99% or 100% within an SAC.

Three of the six primary areas of Annex I habitats surveyed within the eight Leinster counties during 2011 and 2012 received an assessment of Favourable for structure and functions, while two were Unfavourable-Inadequate and one was Unfavourable–Bad. Any future monitoring of Annex I habitats should focus on these primary areas.

4.3 Vegetation classification

Please refer to the National Synthesis Report (O'Neill *et al.* 2013) for the vegetation classification of all semi-natural and semi-improved grassland habitats using the ISGS full dataset (2007-2012).

4.4 Concluding remarks

This survey of 71 semi-natural grassland sites in the eight Leinster counties of Carlow, Kilkenny, Laois, Louth, Meath, Westmeath, Wexford, and Wicklow representing years four and five and the third phase of the Irish Semi-natural Grasslands Survey, has helped define the methodologies used to study the range of different semi-natural grassland habitats within the region, to identify and assess Annex I grassland habitats, and to accurately map and store survey data within datasets using a combination of GIS, a Turboveg database and an Access database.

The data showed that semi-natural grassland sites in the eight Leinster counties tended overall to be somewhat smaller than those found in most other counties. One Westmeath site was ranked as having a high conservation value and was listed in the 21 most highly-ranked sites in the country. Westmeath also included three of the six sites that contained primary areas of Annex I habitat.

A detailed habitat map has been produced for each site, showing the Fossitt (2000) and Annex I grassland habitats, the position of all relevés and the location of any associated NPWS conservation

sites (NHAs/pNHAs and SACs). These habitat maps are available as a digitised GIS layer which can be overlaid onto the aerial photographs and viewed or printed at any scale.

This report on the ISGS data collected within Leinster in 2011 and 2012, together with the report on the data collected in counties Clare, Galway, Kerry, Limerick, Mayo and Tipperary (Devaney *et al.* 2013) over the same time period represent the final phase of the project. In addition to these final two regional reports a national report (O'Neill *et al*. 2013) has also been written that summaries the data collected across the whole country and presents a classification of semi-natural grassland.

5: REFERENCES

Anon. (1996). *Environmentally friendly coastal protection (ECOPRO) – Code of practice.* The Stationery Office, Dublin.

Anon. (2006). *Assessment, monitoring and reporting under Article 17 of the Habitats Directive: Explanatory notes & guidelines, Draft 2*. European Commission, DG Environment.

Anon. (2007). *Interpretation manual of European Union habitats*. EUR 27. European Commission, DG Environment.

Anon. (2008). *The Status of EU Protected Habitats and Species in Ireland*. National Parks and Wildlife Service, Dublin.

Anon. (2013). *Burren Farming for Conservation Programme: Programme Report No. 3 (May 1st 2012 to April 30th 2013).* Report submitted by the BFCP team to the National Parks and Wildlife Service of the Department of Arts, Heritage and the Gaeltacht. Dublin.

Blackstock, Rimes, Stevens, Jefferson, Robertson, Mackintosh & Hopkins (1999). The extent of semi-natural grassland communities in lowland England and Wales: A review of conservation surveys 1978-96. *Grass and Forage Science* **54**(1), 1-18.

Bleasdale, A. (1998). *A desk study of eskers in Ireland: Collation of information from the National Parks and Wildlife Service and the Geological Survey of Ireland*. Report submitted to the National Parks and Wildlife Service, Dublin.

Bourke, D., Hochstrasser, T., Nolan, S., Schulte, R. (2007). Historical Grassland Turboveg Database Project: 2067 Relevés Recorded by Austin O'Sullivan 1962-1982. Database reference Nos: 25604-28543. Report submitted to the National Parks and Wildlife Service, Dublin.

Braun-Blanquet, J. & Tüxen, R. (1952). Irische pflanzengesellschaften. In *Die pflanzenwelt Irlands.* (ed. W. Ludi). Hans Huber, Bern.

Breen, J. & O'Brien, A. (1995). Species richness in oldfield limestone grassland. In *Irish Grasslands – their biology and management.* (eds. D.W. Jeffrey, M.B. Jones & J.H. McAdam). Royal Irish Academy, Dublin. pp. 204-209.

Byrne, C. (1996). *Semi-natural grassland communities in eastern Ireland: Classification, conservation and management*. Ph.D. Thesis, University of Dublin, Trinity College.

Calaciura, B. and Spinelli, O. (2008). *Management of Natura 2000 habitats. 6210 Semi-natural dry grasslands and scrubland facies on calcareous substrates (Festuco-Brometalia) (*important orchid sites).* European Commission, DG Environment.

CSO (2007). http://www.cso.ie/en/media/csoie/releasespublications/documents/agriculture/2007/farmstructure_2007.pdf

CSO (2012). http://www.cso.ie/en/media/csoie/releasespublications/documents/agriculture/2010/full2010.pdf

Curtis, T. G. F. & McGough, H.N. (1988). *The Irish red data book: 1 Vascular plants.* Wildlife Service Ireland, Dublin.

Devaney, F.M., Martin, J.R., O'Neill, F.H. & Delaney, A. (2013). *Irish semi-natural grasslands survey Annual Report No. 4: Western Seaboard Counties (Clare, Galway, Kerry, Limerick, Mayo) & County Tipperary.* Report submitted to the National Parks and Wildlife Service, Dublin.

Dwyer, R., Crowley, W. & Wilson, F. (2007). *Grassland monitoring project 2006*. Report submitted to the National Parks and Wildlife Service, Dublin.

Eakin, M. (1995). A botanical survey of conserved grassland in County Fermanagh. In *Irish Grasslands, their biology and management*. D.W. Jeffrey, M.B. Jones & J.H. McAdam (eds). Royal Irish Academy, Dublin. pp. 227-235.

Ellmauer, T. (2010). Future prospects: Draft discussion paper for the expert group on reporting under the Nature Directives. http://circa.europa.eu/Public/irc/env/monnat/library?l=/expert_reporting/workpackage_revision/sub-group_papers/future_prospects/prospects_june2010pdf/_EN_1.0_&a=d

EPA (2006). *Environment in Focus. Environmental Indicators for Ireland*. Environmental Protection Agency, Wexford.

Evans, D. & Arvela, M. (2011). Assessment and reporting under Article 17 of the Habitats Directive. Explanatory notes & guidelines for the period 2007-2012. European Topic Centre on Biological Diversity. Paris, France. https://circabc.europa.eu/sd/d/2c12cea2-f827-4bdb-bb56-3731c9fd8b40/Art17%20-%20Guidelines-final.pdf

Fealy, R., Loftus, M. & Meehan, R. (2006). *Soils and sub-soils mapping project*. Teagasc, Dublin.

Feehan, J. (2003). *Farming in Ireland – history, heritage and environment,* University College. Dublin.

Fossitt, J.A. (2000). *A Guide to habitats in Ireland.* The Heritage Council, Kilkenny.

Freeman, T.W. (1950). *Ireland: its physical, historical, social and economic geography*. Methuen, London.

Gardiner, M.J. & Radford, T. (1980). *Soil associations of Ireland and their land use potential*. Soil Survey Bulletin **36**, An Foras Talúntais, Dublin.

Hall, V.A. & Pilcher, R.P. (1995). Irish grassland history. In *Irish grasslands: their biology and management*. D.W. Jeffrey, M.B. Jones & J.H. McAdam (eds). Royal Irish Academy, Dublin. pp. 188-193.

Heery, S. (1991). The plant communities of the grazed and mown grasslands of the River Shannon callows. *Proceedings of the Royal Irish Academy* **91B**, 199-217.

Heery, S. & Keane, S. (1999). Shannon Callows Management Plan. MPSU. National Parks and Wildlife Service, Department of Environment, Heritage and Local Government, Dublin, Ireland.

Holyoak, D. (2008). *Bryophytes and metallophyte vegetation on metalliferous mine-waste in Ireland*. Report submitted to the National Parks and Wildlife Service, Dublin.

Ivimey-Cook, R.B. & Proctor, M.C.F. (1966). The plant communities of the Burren Co. Clare. *Proceedings of the Royal Irish Academy* **64B**, 211-301.

JNCC (2004). *UK guidance on conservation objectives for monitoring designated sites*. Joint Nature Conservation Committee Report, Peterborough.

Keane, S. & Sheehy-Skeffington, M. (1995). Vegetation in east Burren uplands in relation to land use and conservation. In *Irish grasslands, their biology and management.* D.W. Jeffrey, M.B. Jones & J.H. McAdam (eds). Royal Irish Academy, Dublin. pp. 253-266.

Kent, M. & Coker, P. (1992). *Vegetation description and analysis: a practical approach.* Belhaven Press, London.

Lafferty, S., Commins, P. & Walsh, J.A. (1999). *Irish agriculture in transition: a census atlas of agriculture in the Republic of Ireland*. Teagasc. Dublin

Long, M.P. (2011). Plant and snail communities in three habitat types in a limestone landscape in the west of Ireland, and the effects of exclusion of large grazing animals. Ph.D Thesis, University of Dublin, Trinity College.

Maher, C. (2013). An examination of how flooding patterns and farming practices effect plant and marsh fly communities on unregulated floodplain meadows in Ireland. Ph.D Thesis, National University of Ireland, Galway.

Martin, J.M., Perrin, P.M., Delaney, A.M., O'Neill, F.H. & McNutt, K.E. (2008). *Irish semi-natural grasslands survey Annual Report No. 1: Counties Cork and Waterford*. Report submitted to the National Parks and Wildlife Service, Dublin.

Martin, J.R., Gabbett, M., Perrin, P.M & Delaney, A. (2007). *Semi-natural grassland survey of Counties Roscommon and Offaly.* Report submitted to the National Parks and Wildlife Service, Dublin.

Martin, W.L. (1991). Survey of hay meadows in the area of west Corrib, Co. Galway. *Irish Naturalists' Journal* **23**(9), 365-371.

Met Éireann (2013). http://www.met.ie/climate-ireland/30year-averages.asp. Accessed 26/03/2013

NPWS (2013). *The Status of EU Protected Habitats and Species in Ireland. Habitat Assessments Volume 2.* Version 1.0, National Parks and Wildlife Service, Department of Arts, Heritage and the Gaeltacht, Dublin, Ireland.

O'Donovan, G. (1987). Ecosystem dynamics of Burren limestone grassland. Ph.D. Thesis, University of Dublin, Trinity College.

O'Donovan, G. & Byrne, C. (2004). *A scoping study for the classification of lowland grassland in Ireland*. The Heritage Council, Kilkenny.

O'Donovan, G. (2007). *Lowland grassland survey of Sligo*. Report submitted to Sligo County Council.

O'Neill, F.H., Martin, J.R., Perrin, P.M., Delaney, A, McNutt, K.E. & Devaney, F.M. (2009). *Irish semi-natural grasslands survey Annual Report No. 2: Counties Cavan, Leitrim, Longford and Monaghan.* Report submitted to the National Parks and Wildlife Service, Dublin.

O'Neill, F.H., Martin, J.R, Devaney, F.M., McNutt, K.E., Perrin, P.M. & Delaney, A. (2010). *Irish semi-natural grasslands survey Annual Report No. 3: Counties Donegal, Dublin, Kildare and Sligo.* Report submitted to the National Parks and Wildlife Service, Dublin.

O'Neill, F.H., Martin, J.R., Devaney, F.M., Delaney, A. & Perrin, P.M. (2013) *The Irish Semi-natural Grasslands Survey 2007-2012*. Report submitted to the National Parks and Wildlife Service, Dublin.

OSI (2013a).
http://www.osi.ie/Education/Secondary-Schools/Teacher-Resources/Area-and-Land-Mass.aspx.
Accessed 26/03/2013.

OSI (2013b).
http://www.osi.ie/Education/Primary-Schools/Seniors/Mountains,-Rivers-Lakes-(1).aspx.
Accessed 15/05/2013.

O'Sullivan, A.M. (1965). A phytosociological survey of Irish lowland meadows and pastures. Ph.D. Thesis, University College Dublin.

O'Sullivan, A.M. (1968). *The lowland grasslands of Co. Limerick (Irish Vegetation Studies No. 2.* An Foras Talúntais, Dublin.

O'Sullivan, A.M. (1976). The phytosociology of the Irish wet grasslands belonging to the order Molinietalia. *Coll. Phytosoc*. **5,** 259-267.

O'Sullivan, A.M. (1982). The lowland grasslands of Ireland. *Journal of Life Sciences, Royal Dublin Society* **3**, 131-142.

Perrin, P.M, Martin, J.R., Barron, S.J., O'Neill, F.H., McNutt, K.E. & Delaney, A.M. (2008a). *National Survey of Native Woodlands 2003-2008: Volume I: Main report.* Report submitted to the National Parks and Wildlife Service, Dublin.

Perrin, P.M, Martin, J.R., Barron, S.J., O'Neill, F.H., McNutt, K.E. & Delaney, A.M. (2008b). *National Survey of Native Woodlands 2003-2008: Volume II: Woodland classification.* Report submitted to the National Parks and Wildlife Service, Dublin.

Perrin, P.M., Roche, J.R. & Barron, S.J. (2011). *National Survey of Upland Habitats, Site Report No 1: Mweelrea, Sheeffry, Erriff Complex cSAC (001932) Co. Mayo*. Report submitted to the National Parks and Wildlife Service, Dublin.

Perrin, P.M., Roche, J.R., Barron, S.J. & Daly, O.H. (2012). *National Survey of Upland Habitats (Phase II, 2011-2012), Site Report No. 7: Mount Brandon cSAC (000375), Co. Kerry*. Report submitted to the National Parks and Wildlife Service, Dublin.

Queen's University Belfast (QUB) (2008*). Biological Monitoring of the Countryside Management Scheme in Northern Ireland 2002/03 - 2006/07*. Report to Department of Agriculture and Rural Development, Northern Ireland.

Roche, J.R., Perrin, P.M. & Barron, S.J. (2010). *National Survey of Upland Habitats (Pilot Survey Phase, 2009-2010), Site Report No. 4: Carlingford Mountain cSAC (0004453) Co. Louth*. Report submitted to the National Parks and Wildlife Service, Dublin.

Rodwell, J.S. (ed.) (1991). *British plant communities Volume 2: Mires and heaths*. Cambridge Community Press, Cambridge.

Rodwell, J.S. (ed.) (1992). *British plant communities Volume 3: Grasslands and montane communities*. Cambridge Community Press, Cambridge.

Rodwell, J.S. (ed.) (1995). *British plant communities Volume 4: Aquatic communities, swamps and tall-herb fens.* Cambridge Community Press, Cambridge.

Rodwell, J.S. (ed.) (2000). *British plant communities Volume 5: Maritime communities and vegetation of open habitats*. Cambridge Community Press, Cambridge.

Rodwell, J.S., Morgan, V., Jefferson, R.G. & Moss, D. (2007). *The European context of British lowland grasslands*. Joint Nature Conservation Committee Report No. 394, Peterborough.

Ryle, T., Murray, A., Connolly, C. & Swann, M. (2009). *Coastal Monitoring Project 2004-2006*. Report submitted to the National Parks and Wildlife Service, Dublin.

Ssymank, A. (2010). Reference list Threats, Pressures and Activities (final version). http://bd.eionet.europa.eu/activities/Natura_2000/Folder_Reference_Portal/Ref_threats_pressures_FINAL_20110330.xls. Accessed 19/7/2013.

Stevens, D.P., Smith, S.L.N., Blackstock, T.H., Bosanquet, S.D.S., Jones, P.S. (2010). *Grasslands of Wales: A survey of lowland species-rich grasslands, 1987 – 2004.* University of Wales Press, UK.

Sullivan, C.A., Sheehy Skeffington, M. Gormally, M. J and Finn, A.J. (2010). The ecological status of grasslands on lowland farmlands in western Ireland and implications for grassland classification and nature value assessment. *Biological Conservation* 143, 1529-1539.

Tolkamp, W. (2001). *Gradients in floristic composition of callow grasslands, County Longford Ireland*. Undergraduate thesis, Wageningen University.

Trudgill, S. (1989). Soil types: a field identification guide. *Field Studies* **7**, 337-363.

Tubridy, M. (2006). *County Offaly esker survey 2006*. Report submitted to Offaly County Council.

Usher, M.B. (1989). Scientific aspects of nature conservation in the United Kingdom. *Journal of Applied Ecology* **26**, 813-824.

Wilson, S. & Fernández, F. (2013). National Survey of Limestone Pavement and Associated Habitats in Ireland. *Irish Wildlife Manuals*, No. **73**. National Parks & Wildlife Service, Department of Arts, Heritage and the Gaeltacht, Dublin, Ireland.

White, J. & Doyle, G. (1982). The vegetation of Ireland: a catalogue raisonné. *Journal of Life Sciences*, *Royal Dublin Society* **3,** 289-368.