# EirGrid Evidence Based Environmental Studies Study 4: Habitats

Literature review and evidence based field study on the effects of high voltage transmission lines on natural and semi -natural habitats in Ireland

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*The evidence contained in this study has been provided by RPS Group.*



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# SUMMARY

Habitats are the basic units of the environment for plants and animals. Natural habitats can be defined by the species that live together and by the physical components of the environment. In Ireland, agricultrural practices influence over half the landcover. Peatland and wetland habitats are the second most widespread landcover types. Natural and semi-natural habitats support native plants and animals. Protection of these habitats is important to conserve the ecology and biodiversity of Ireland.

This report is an independent, evidence-based study undertaken by experts in ecology. The research examines the actual effects of the construction and presence of high voltage transmission lines on Ireland's habitats.

The purpose of this study is:

- To determine if high voltage transmission infrastructure affects habitats in Ireland.
- To provide a factual basis for future Evidence-Based Environmental Design Guidelines for transmission projects in Ireland.

The routing of transmission projects is a complex process. It requires a balance between a number of issues, including EirGrid's obligations to ensure a safe and secure transmission grid, land use constraints, engineering, cost and other technical requirements. Impacts on the environment must also be considered. Transmission projects have the potential to impact the environment which includes the habitats that make up part of the Irish landscape.

Habitats of particular conservation importance include those that are protected as Annex I habitats under European law (Habitats Directive). These habitats include active peatlands, hay meadows and even caves. They need special management to help protect their features. The construction and maintenance of electricity transmission infrastructure can potentially damage habitats. The main potential impacts can include habitat loss habitat damage. By following certain measures during route planning, construction and in the sequence of works, these impacts can be avoided or reduced.

A literature review and a field survey were carried out to examine if transmission infrastructure does affect natural and semi-natural habitats. Published information from other linear construction projects (road and rail) was also examined. It was found that construction can affect habitats in several ways including habitat loss, habitat change, fragmentation and hydrological change. Peatlands were found to be the most sensitive to construction work of any kind. Grassland habitats were found to recover rapidly after construction activity.

The field survey was planned to examine if predictions of impacts on habitats as reported in Environmental Impact Statements (EISs) for transmission projects were accurate.

The survey was designed around the following four questions:

1. Does the composition of plant species vary between the location of the powerline structures and the wider habitat
2. Do fewer plant species occur at the base of powerline structures
3. Does the length of time since construction affect plants found (number and type) at structures?
4. Is there a difference between the effects of various types of transmission infrastructure (wooden poles and steel towers) on plant communities?

In 2012, 17 peatland sites[1] and 5 grassland sites with powerlines present were surveyed during the summer months. All these sites had Annex I habitats present. The powerlines were in place for 10 to 20 years. Botanical surveys were undertaken at the base of structures (wooden poles or steel towers) and at control sites located 50 metres (m) away.

Analysis of the peatland sites showed a significant difference in plant community structure and species richness between all sites surveyed. Some differences were found which related to distance from the transmission infrastructure. Peatland species including mosses like *Sphagnum spp.*, cottongrass, deergrass and lichen

[1] Results from blanket bog, raised bog and wet heath were grouped together under peatlands.

showed a decreased abundance close to the structures. An increase in other species was found including some sedges, purple moor-grass and rush species.

Analysis of the grassland sites, showed significant differences between number and type of plants between all sites examined. However, no statistically significant difference was found related to the distance from the transmission infrastructure.

This study showed that plant composition and richess can vary between transmission infrastructure and control sites for peatland habitats in particular. Changes in overall habitat classification were not detected.

The field-based element of this study has provided a factual basis for a future review and update of EirGrids Ecology Guidelines for electricity transmission projects. It will assist in the development of habitat specific guidelines for transmission projects in Ireland and ensure a consistent approach to habitat impact assessment at all stages of the development and on-going management of transmission projects.

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# 1 INTRODUCTION

## 1.1 THE SCOPE OF THIS PROJECT

In April 2012, EirGrid published the *Grid25 Implementation Programme 2011-2016*, and it's associated Strategic Environmental Assessment (SEA).

The SEA identified a number of Environmental Mitigation Measures. These were developed to prevent, reduce and, offset any significant adverse impacts on the environment that may result from the Implementation Programme.

Environmental Mitigation Measure (EMM) 3 concerns *Preparation of Evidence-Based Environmental Guidelines*. These are intended to comprise a series of authoritative studies examining the actual effects of the construction and operation of transmission infrastructure in Ireland. The studies would thereby provide benchmarks to facilitate the robust designof projects with an evidence-based understanding of likely environmental impact.

Three types of studies are envisaged under EMM3:-

- **Environmental benchmarking studies**: to determine the actual effect, in respect of a number of environmental topics, of the construction and operation of transmission projects across a representative range of Irish environmental conditions – typical, non-standard, and worst-case. The studies, while authoritative, are conceived as an ongoing body of work that can be continuously updated to take account of new information and/or developments in understanding arising from practice and research;

- **Evidence-based environmental design guidelines:** deriving from the factual basis and evidence contained in the initial Benchmarking Studies, these will provide practical guidance to practitioners and consultants in the planning and design of transmission infrastructure from the perspective of a particular environmental topic. These might comprise new guidelines, or the updating of existing guidelines;

- **Guidelines on EIA for transmission projects in Ireland:** accompanying, or incorporated into the Design Guidelines, these are intended to provide an agreed and authoritative format for the preparation of EIA for transmission projects in Ireland, again in respect of particular environmental topics.

This Study is one of the environmental benchmarking studies – to determine the actual effect of the construction and existence of transmission infrastructure in Ireland on its receiving environment.

## 1.2 THE AIM OF THIS PROJECT

The aim of this Evidence-based environmental study is to investigate the impacts of the construction and presence of high voltage transmission infrastructure on natural and semi-natural habitats in Ireland. To do this both a literature review and habitat survey have been conducted.

For the literature review, existing information was examined in relation to the impacts of electricity infrastructure on natural habitats. Linear construction projects for road and rail were also referred to. A study methodology was developed appropriate to natural habitats in Ireland, with the aim of quantifying the impacts of existing electricity infrastructure on a range of habitats including bog, heath and grassland. These habitats represent the most and least sensitive habitat respectively. The range of potential conditions found during the construction and maintenance phases could then be assessed.

Through univariate and multivariate statistical analysis of collected data, four study questions were examined. These were:

1. Does the vegetation community vary between relevés at structures and relevés at a distance from structures?
2. Is species richness reduced close to overhead line structures?
3. Does the length of time since overhead line structure construction affect vegetation community or species richness?
4. Is there a difference between the effect of wooden polesets and towers (angle masts) on either vegetation community or species richness?

The study investigated if any statistically significant changes in vegetation community structure were caused by the presence of high voltage support structures and tested whether these changes varied with time elapsed since construction.

Recommendations from the findings of this evidence-based environmental study will be integrated to the existing EirGrid ecology guidelines for transmission projects.

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## 1.3 THE TRANSMISSION NETWORK AND HABITATS

Electricity supply is an essential service in Ireland's economy. The transmission system is a meshed network of 400kV, 220kV and 110kV high voltage lines and cables and plays a vital role in the supply of electricity[2].

The development of the transmission network is the responsibility of EirGrid, the Transmission System Operator (TSO), under statutory instrument 445/2000[3]. EirGrid is committed to delivering quality connection, transmission and market services to its customers and to developing the transmission grid infrastructure required to support the development of Ireland's economy.

Grid development requires a careful balance between meeting the technical requirement for a project, the costs of that project, and the environmental impact of that project.

The Electricity Supply Board (ESB) as the Transmission Asset Owner (TAO) is charged with constructing the transmission assets as specified by the TSO. ESB also has the role of Distribution System Operator (DSO) with which the TSO coordinates planning and development requirements.

An overview of the primary types of transmission infrastructure, including an outline of construction methodology is set out in **Appendix A** of this study.

EirGrid is committed to the preservation of the natural environment and ensuring that transmission infrastructure development is undertaken in an environmentally sensitive manner that conserves it. EirGrid already comply with Ecology guidelines[4] during the planning and construction of projects. The findings of this Evidence-based environmental study will inform these existing ecology guidelines and help improve measures to protect habitats.

Some habitats are more sensitive to disturbance and therefore the potential impacts of the construction and maintenance of transmission infrastructure. Impacts may include habitat degradation, fragmentation, loss and/or the introduction of invasive species. As referred to in EirGrid's ecology guidelines, wetland and peatland habitats depend on specific hydrological conditions and are particularly vulnerable to disturbance. For example, peat soils can be locally destabilised during pole and tower construction, conductor stringing and line maintenance work. Vehicular movements, storage of materials and trampling by people can cause physical damage to specialised plants and disruption to the upper surface soil layers through compaction and erosion. In addition, sensitive habitat types

[2] Transmission Development Plan 2008-2012 EirGrid

[3] S.I. No. 445/2000 - European Communities (Internal Market in Electricity) Regulations, 2000

[4] Flynn, M. & Nairn, R. (2012): Ecology Guidelines for Electricity Transmission Projects - A Standard Approach *to Ecological* Impact Assessment *of* High Voltage Transmision Projects. EirGrid, Dublin

including bogs, heaths and wetlands, tend to be of a higher nature conservation value. They are referred to as priority habitats and are often protected under European and national legislation.

In transmission infrastructure development, every effort is made to cause the least disturbance to landowners and local residents during construction. Where feasible, routes are planned to cross habitat types of a lower sensitivity and conservation status. This avoids negative environmental impacts and associated complex planning and legal issues. Good ground conditions are also preferred for construction. When these principles are considered alongside the fact that Ireland is dominated by dry grassland habitats[5], impacts on habitats with a higher nature conservation value should not occur.

Any conflict between grid infrastructure and high value habitat types is usually in upland or wetland areas. Uplands are typically bog/heath/acid grassland type habitats. Due to the increased sensitivity of these habitats to disturbance this evidence-based environmental study investigates both the normal and worst case construction/maintenance conditions on dry grasslands and peatlands.

The significance of any adverse effects on terrestrial habitats depends on the location and scale of the proposed infrastructure and potential for screening and mitigation measures.

This is why transmission infrastructure development should be reviewed by a suitably qualified ecologist as the design of a scheme progresses.

## 1.4 THE STUDY LAYOUT

This evidence-based environmental study sets out the background, context and objectives of the study. It describes Irish habitats and construction techniques for transmission infrastructure in Ireland. The case study conducted as part of the Evidence-Based study is also presented. Recommendations are included in the conclusion.

Chapter 2 presents a review of terrestrial habitats in Ireland, including wetlands, peatlands and grasslands. European and national legislation governing protection of these habitats is detailed, which provides context to habitats deemed of a higher conservation value than others. Habitats listed on Annex I of the Habitats Directive are protected from direct and indirect damage under this legislation.

Chapter 3 outlines EirGrid's construction techniques and sequence of works for transmission infrastructure projects. This helps to indicate the potential impacts of construction on habitats. The main impacts are summarised as habitat loss and/or damage to habitat quality.

Chapter 4 contains a literature review. It was found that there was limited peer reviewed scientific literature on the effects of powerline construction on habitats. Literature on the effects on habitats of

[5] Fealy & Green (2009)

linear constructions, such as road and rail, was therefore used. The general effects of construction on specific habitats (wetlands, peatlands, and grasslands) were examined and the specific effects of powerlines on those habitats.

Chapter 5 details the categorisation of environmental impacts. Using references and published guidance the different approaches used by consultants in Environmental Impact Statements (EISs) to predict impacts is presented.

Chapter 6 details the case study used to investigate the impacts of powerline construction on habitats in Ireland. Peatland and grassland habitats were used as they are either the most sensitive to development, or the most likely to be crossed by transmission infrastructure in Ireland.

Chapter 7 provides an overview of the results of the case study for both peatland and grassland sites, with a review of the statistical/data analysis also provided.

Chapter 8 discusses the key findings from the case study but also refers to untested factors that may influence plant communities. The findings from the case study and literature review support the impact predictions of powerline constructions published in EISs that impacts are rarely significant.

Chapter 9 concludes with a discussion on how the evidence-based environmental study can inform future evidence based design guidelines. Recommendations focused on future monitoring to detect changes over time/distance from source of impact are included.

# 2 TERRESTRIAL AND WETLAND HABITATS IN IRELAND

Ireland's land cover is predominantly influenced by agricultural management practices (figure 2.1). The main land cover in Ireland is agricultural land, which accounts for two thirds of the national land mass. Most of this is permanent grassland pasture (Lehane & O'Leary, 2012). Peatlands and wetlands are the second most widespread land cover type, covering almost one-fifth of the country, while forested areas cover less than one-tenth of the country (Fealy *et al.*, 2009). The National Teagasc Habitat Indicator Map for 1995 (THIM95) shown below in Figure 2.1 illustrates the range of these habitats. Table 2.1 summarises habitat coverage by type, and derives from Fealy *et al.* (2009).

**Table 2.1: Habitat coverage by type across Ireland, taken from THIM95 (Fealy *et al.* 2009).**

| Habitat Class | % coverage of national land area |
|---|---|
| Dry Grassland | 58.8 |
| Fen and Raised Bog | 14.6 |
| Woodland, Forest and Scrub | 6.7 |
| Upland Blanket Bog | 5.9 |
| Wet Grassland | 5.7 |
| Heath | 4.1 |
| Lowland Blanket Bog | 3.7 |
| Water | 1.9 |
| Urban | 1.2 |
| Other wetland | 0.5 |
| Bare Peat & Soil | 0.2 |
| Karst, bare rock and rocky complexes | 0.1 |
| Saltmarsh, sand and coastal complexes | 0.1 |

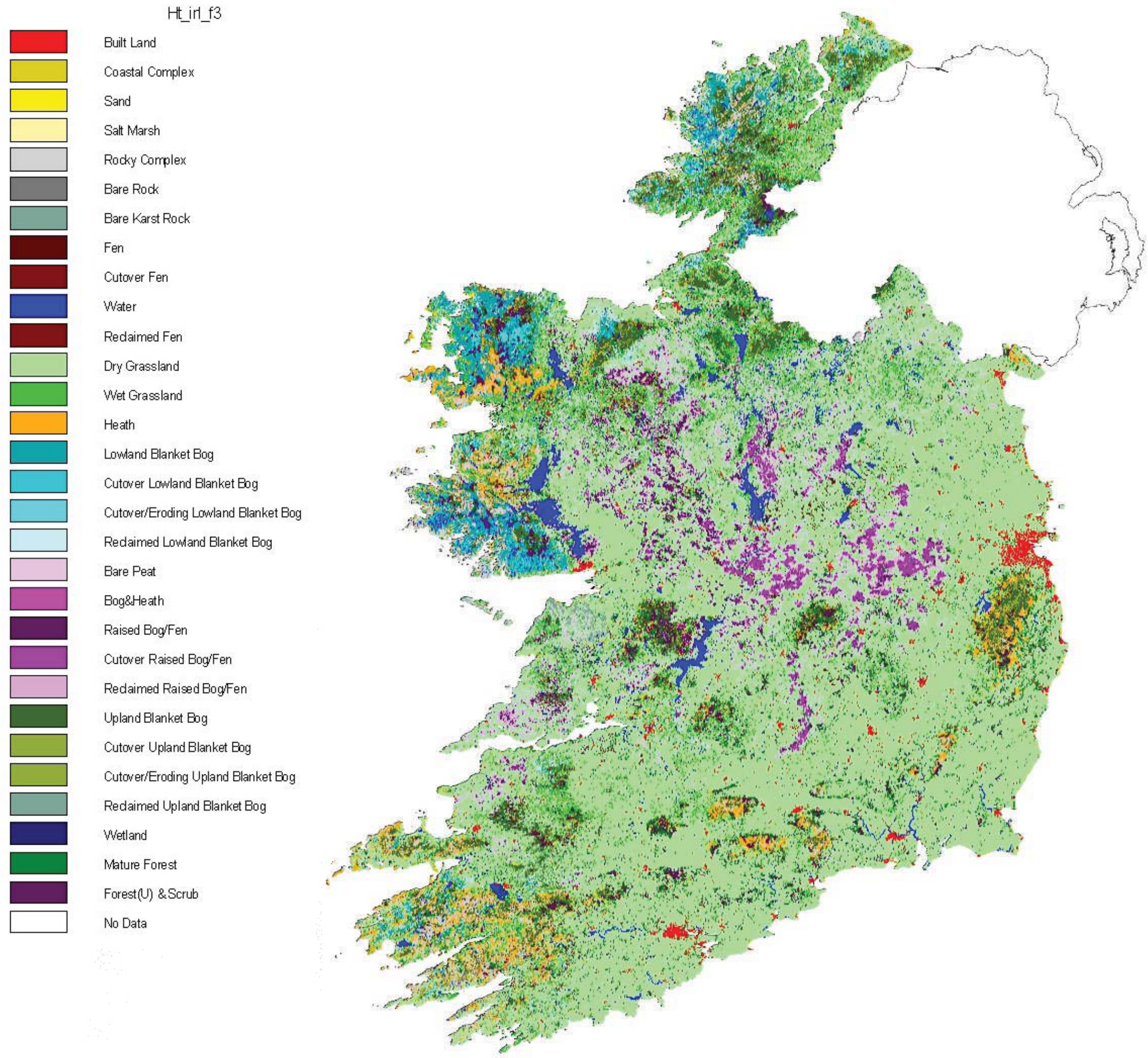


**Figure 2.1: National Teagasc Habitat Indicator Map (courtesy of Fealy *et al.* 2009).**

Figure 2.2 illustrates the extent of the transmission grid across Ireland. Northern Ireland's infrastructure is also shown to provide a complete all-Island picture.

This Section of the report describes the major terrestrial habitat types present in Ireland. The environmental legislation used in the planning system to protect natural and semi-natural habitats of nature conservation value is also referenced. As noted in Section 1.3, new build projects are planned taking habitat value and sensitivity into account. However, it is not always feasible to completely avoid higher value habitats. This is particularly true when collecting onshore renewable energy for transmission across the grid, which tends to be generated in upland habitats.


**Figure 2.2: All-Island map showing built transmission infrastructure across the Country.**

## 2.1 WETLANDS

For the purposes of this report, descriptions of ‘palustrine’ (marshy) wetland habitats will be used wetlands, that is, swamps, peatlands, wet grassland and marshes. These habitats will be described in more detail in their relevant classification under Level 1 of the broad habitat groups as used in the Guide to Habitats in Ireland (Fossitt, 2000). Swamp is considered under the ‘freshwater’ habitat group; wet grassland is described under ‘grassland and marsh’; fens and bogs are described under the general habitat type ‘peatlands’; and wet woodlands are under ‘woodlands’.

Wetland is a collective term for ecosystems whose formation has been dominated by water and whose processes and characteristics are largely controlled by water (Keddy, 2010). A wetland is a place that has been wet enough for a long enough time to develop specially adapted vegetation and other organisms (Maltby, 1986, in Foss *et al.* [2011]).

Wetlands will form where enough water is put into the system to counteract evapotranspiration and maintain a water level at or just below the soil surface. In Ireland, On average, more water falls as precipitation than is lost through evapotranspiration. Therefore, Ireland is particularly rich in wetlands.

In Ireland, the following types of wetland can be found (Otte, 2003):

- coastal and estuarine salt marshes, dune slacks and saline wet meadows
- lagoons
- fens and bogs
- canals, river and lake edges and reed swamps
- callows, floodplains and freshwater wet meadows
- turloughs, and
- wet woodlands.

### 2.1.1 Swamp

Swamps are stands of emergent herbaceous vegetation growing in the transitional areafrom open water to terrestrial habitats, and are commonly found along the margins of slow flowing rivers, lakes, canals, lagoons and estuaries. There are two types; the first is **Reed and large sedge swamp**, which is dominated by reeds and other large grasses or large tussock-forming sedges and is typically species poor. The other type is **Tall-herb swamp**, which is comparatively species rich, and occurs in areas where the water table is above the ground surface for most of the year, or where water levels fluctuate regularly. This habitat is dominated by broadleaved herbs, rather than reeds (Fossitt, 2000).

### 2.1.2 Peatland

Peatlands are wetland ecosystems characterised by the accumulation of organic matter which derives from dead and decaying plant material under high water saturation conditions. Peat accumulates where the production of plant material exceeds decay. Water is the most important factor limiting decay. Most peatlands that exist today were formed at the beginning of the Holocene period and have developed under climatic conditions whereby precipitation exceeded evapotranspiration, or in areas of impeded drainage. The interconnection and interdependencies between water, plants and peat are critical to the survival of the peatlands and therefore make them vulnerable to a wide range of disturbances.

Hammond (1981) recorded that peatlands covered a total area of 1.17 million hectares(ha), or 17% of the area of Ireland. Much of this original area has been modified by human activity. Peat has been used in Ireland since prehistoric times but since the advent of industrial peat extraction, the process has accelerated. Virtually all Irish peatlands have been affected by peat cutting, (over)grazing, drainage,fire, afforestation and/or improvement to one extent or another. Malone and O'Connell (2009) estimated that only 10% of the original raised bog and 28% of the original blanket peatland resource are suitable for conservation. The Environmental Protection Agency(EPA) (2011) split Irish peatlands into four general categories:

- fen
- raised bog
- Atlantic/lowland blanket bog, and
- mountain/ upland blanket bog.

This categorisation is not exact or precise, but serves a general purpose for habitat classification at the scale intended by Fossitt (2000). Wheeler and Proctor (2000) summarise a range of ecological, hydrochemical and floristic gradients across which mire communities can be found in northwest Europe. This degree of subdivision is unnecessary for the purpose of describing generalities of Irish peatlands.

Fens are peatlands that formed from vegetation receiving a constant influx of base-rich groundwater and therefore can be described as minerotrophic (fed by groundwater). Fen peats in Ireland usually have a relatively high pH (alkaline) but some remain acidic, with a pH ranging from 4.5 to 8.0 (Doyle and Ó Críodáin, 2003). The vegetation is generally species rich and largely dominated by tall herbs, rushes and grasses, with brown mosses a feature of the ground layer. There is a notable absence of *Sphagnum* species.

Raised bogs formed over shallow lakes across much of central Ireland. These lakes received nutrient-rich groundwater derived from calcareous glacialtill. Reeds and sedges encroached around the lake edges, their remains only partly decomposing under the water, over time forming a thick layer of reed peat. The continuous process elevated the surface above the level of the surrounding groundwater and peat-moss species, solely fed by rain, took over and continued to grow upward. The result was a dome-shaped peat mass. Raised bogs were originally fens that became buried under ombrotrophic peat mosses (*Sphagnum* species). Other plant species found on raised bogs are heather *Calluna vulgaris*, cotton-grasses *Eriophorum angustifolium*/*Eriophorum vaginatum* and several species of sundew *Drosera* and orchids. Raised bogs are found mainly in the midlands under moderate rainfall.

Blanket bogs are distinctive landscape features of the western seaboard and mountainous areas of Ireland. They developed about 4,000 years ago but some are currently being initiated (EPA, 2011). Like raised bogs, blanket bogs are ombrotrophic or rain fed. The peat sits over an underlying acidic mineral soil. The vegetation of blanket bogs in Ireland is typically dominated by graminoids, mainly *Molinia caerulea* and *Schoenus nigricans*, while the bryophyte cover is low compared to raised bogs (Hammond, 1981; Doyle, 1990; Sheehy Skeffington and O'Connell, 1998). The surface of blanket bogs generally forms a mosaic of vegetation communities organized in undulating microforms; hummocks, lawns and hollows (Lindsay, 1995; Tallis, 1998) that are supported by differences in water table height (Belyea and Clymo, 1998). The formation of a hummock-hollow pattern is triggered by different rates of peat accumulation (Tallis, 1998). These species also occur in raised bogs, but generally only around the edges, where ecological conditions resemble those typical of blanket bogs (Feehan *et al.,* 2008). The peat in a blanket bog is generally very dense and highly decomposed throughout the peat profile, resulting in a very slow downward movement of water through the peat. There are two types of blanket bogs in Ireland:

- **Atlantic blanket bogs:** found in low-lying coastal plains and valleys in mountainous areas of Western Counties, below 200 m OD. They are particularly well developed in Counties Donegal, Mayo, Galway, Kerry, Clare and Sligo. Their vegetation is clearly distinct from raised bog and mountain blanket bogs (White and Doyle, 1982).

- **Mountain blanket bogs: found** on relatively flat terrain (across mountain plateaux and gentle slopes) in the higher Irish mountains, above 200 m OD. They are distributed more widely than Atlantic blanket bog.

## 2.2 GRASSLAND AND MARSH

The current dominance of grassland in the Irish landscape is the result of human activity, mainly agriculture, that altered the predominantly wooded landscape that existed in Ireland 5000 years ago (Pilcher & Hall, 2001). Up until the mid-1950s, the extent of undeveloped land and basic agricultural land use practices promoted species-rich, semi-natural grasslands. However, changes in land use practices on agricultural land have been identified as the most significant factor in the decline in Ireland's semi-natural grasslands (Dolan *et al*, 2009).

During the last 50 years, increases in mechanisation along with arterial drainage schemes and the application of fertilisers have resulted in a radical alteration of Ireland's grasslands (Feehan, 2003). Recent studies have found that, since 1990, there has been a decrease in semi-natural grassland, heathland, wetland and mixed farmland, while arable and permanent pasture have increased by over 30% (Sullivan *et al*, 2011). The majority of the remaining areas of semi-natural grasslands owe their presence to edaphic and topographical conditions that make them unsuitable for fertiliser application, reseeding or drainage (O' Sullivan, 1982, O'Neill *et al*, 2010).

Grasslands are grouped under the Irish Habitat Classification system into three groups: improved grassland, semi-natural grassland and freshwater marsh (Fossitt, 2000). These three groups are then sub-divided to level three of the classification which is the individual habitat. These are detailed below with some brief information on distribution (CBD, 2010[6]):

- **Improved grassland** is intensively managed or highly modified agricultural grassland that has been reseeded and may be regularly fertilised and is either heavily grazed or used for silage.
- **Amenity grassland** is improved grassland that is managed for purposes of amenity rather than agriculture. These improved grasslands have low species diversity, and consequently are of little conservation interest.
- **Dry calcareous or neutral grassland** is unimproved or semi-improved dry grassland undergoing low intensity grazing. Species rich grassland of conservation value such as those on eskers are found in parts of the midlands.
- **Dry meadows and grassy verges** are distinguished from the previous category by the lack of grazing and fertilisation as management treatments but may be cut once or twice a year. Hay meadows are now rare in Ireland but dry grassland such as road verges and cemeteries would fall in to this category. Remaining traditional hay meadows are found mainly in the west and the north of the country.

[6] Convention on Biological Diverstiy Secretariat 2010

- **Dry-humid acid grassland** is unimproved or semi-improved grassland on acid but free-draining, soil. This type of grassland is mainly found in upland areas but can also be found on siliceous sandy soils in the lowlands. The best examples are found in association with calcareous bands through the mainly acidic bedrock, for example those in The Cuilcagh Mountains of Cavan and Leitrim.

- **Wet grassland** occurs in upland and lowland areas on wet or waterlogged soils that are waterlogged or periodically flooded. Lowland wet grasslands exist throughout the country, with the best examples occurring along the banks of large rivers, such as in the Shannon, Munster Blackwater, Moy and Suir catchments.

- **Marsh** is found on level ground near river banks, lakeshores or soils that are waterlogged and the water table is close to ground level for most of the year. Marsh differs from swamp in that the vegetation is usually more species rich and not dominated by reeds and other tall, bulky grasses or sedges. It can intergrade with wet grassland but wetland herbs should be prominent, with a general absence of drier ground, and less than 50% cover of grasses and sedges.

## 2.3 HEATH

### 2.3.1 Wet heath

Wet heath is a wetland habitat that includes vegetation of at least 25% cover of dwarf shrubs (such as Ling) on peaty soils that are typically 15-50cm deep. Wet heath can occur in upland and lowland areas and is widespread on the lower slopes of hills and mountains that are either too dry or too steep for peat accumulation. Wet heath can grade into, or form intimate mosaics with, blanket bog or dry heath with minor changes in slope and topography.

Wet heath is typically dominated by Cross-leaved Heath (*Erica tetralix*) and Ling (*Calluna vulgaris*) and, but can also be dominated by Purple Moor-grass (*Molinia caerulea*) and/or sedges (Fossitt, 2000).

Reclamation, afforestation and burning have resulted in extensive loss of wet heath. Overstocking with sheep has also degraded large areas of habitat through trampling and overgrazing.

### 2.3.2 Dry Heath

Dry heath is found on flat to steeply-sloping ground in upland and lowland areas. Dry siliceous heath occurs on dry or free-draining soils that are acid and poor in nutrients. Typical components of the vegetation include shrubs such as Ling *Calluna vulgaris*, Bell Heather *Erica cinerea* and Bilberry *Vaccinium myrtillus*, and it can contain elements of, and grade into dry-humid acid grassland. Dry calcareous heath occurs mainly in limestone areas on rocky ground or shallow soils that are well-drained and base rich. It is different to siliceous heath in that it is usually more species rich and contains a number of calcicolous broadleaved herbs, grasses and mosses (Fossitt, 2000). The main threats to dry heath are afforestation, over-burning, over-grazing, under-grazing and bracken invasion (CBD, 2010).

## 2.4 WOODLANDS

Forestry accounts for 11% of the land cover in Ireland, which is low in comparison to the European average of 35%. Much of the forest in Ireland is young, with 40% having been planted since 1990, and 75% of the forest estate is predominantly conifer (Lehane & O'Leary, 2012).

Ancient woodland is rare in Ireland and, according to the National Woodland Survey, the total area of native woodland was estimated to be 132,990 hectares in 2004-2006 (Perrin *et al*, 2008).

Woodlands are placed into four groups in Level 2 of the Irish Habitat Classification System (Fossitt, 2000). These are semi-natural woodland, highly modified/non-native woodland, scrub/transitional woodland and linear woodland/scrub. Seven types of semi-natural woodland are recognised:

- **oak-birch-holly woodland** is native, semi-natural broadleaved woodland that occurs on acid or base-poor soils that may be either dry or humid, but not waterlogged
- **oak-ash-hazel woodland** is native, semi-natural woodland that occurs on base-rich or calcareous soils that are generally dry or well drained, or on rocky limestone terrain
- **yew woodland** is stands of native, semi-natural woodland that are dominated by Yew
- **wet pedunculate oak-ash woodland** is associated with areas that are flooded or waterlogged in winter, but which dry out in summer
- **riparian woodland** is wet woodland of river margins and low islands that are subject to frequent flooding, or where water levels fluctuate as a result of tidal movement
- **wet willow-alder-ash woodland** includes woodlands of permanently waterlogged sites, and
- **bog woodland** includes woodlands of intact ombrotrophic bogs, bog margins and cutover bog, typically on deep acid peat.

The largest single area of native woodland is in Killarney National Park, while smaller amounts are conserved in Glenveagh and Wicklow Mountains National Parks. In addition, sizeable areas are in private ownership and protected in Special Areas of Conservation (SACs) (CBD 2010).

Highly modified/non-native woodland includes the habitats mixed broadleaved woodland, mixed broadleaved/ conifer woodland, mixed conifer woodland, conifer plantation and scattered trees and parkland. The scrub and transitional woodland category includes areas that are dominated by at least 50% cover of shrubs, stunted trees and brambles. Scrub often develops as a precursor to woodland and is often found in inaccessible places and marginal farmland.

### 2.4.1 Hedgerows

Hedgerows and treelines are a prominent feature of the Irish landscape, and act as linear strips of woodland. Cabot (1999) estimated that if added together, hedgerows may hold up to 5% of the total broadleaved stock of Ireland. Hedges provide niches for a number of woodland plants and animals, and act as corridors between habitat patches. Hedgerows have undergone significant losses, largely due to removal for agricultural purposes (Lucey & Doris, 2001). A number of countywide hedgerow surveys have been carried out in Ireland to increase knowledge into the ecology, floristics and condition of hedges throughout Ireland[7].

## 2.5 EU HABITATS AND EIA REGULATIONS

The Environmental Impact Assessment Directive (EIA) 85/337/EEC was codified[8] by Directive 2011/92/EU and amended by Directive 2014/52/EU. The EIA Directive requires applicants for development consents to prepare an EIS and requires national competent authorities to conduct and EIA. An Ecological Impact Assessment (EcIA) addresses the potential impacts of development projects on the natural environment and flora and fauna, and can form a chapter of an EIS. In Ireland the EIA Directive is implemented through the Planning and Development Acts 2000 to 2010 as amended and associated Regulations 2001-2011.

EIA is mandatory for projects as specified in Annex I of the EIA Directive. For developments involving the transmission of electricity, the EIA Directive requires an EIA for electrical powerlines with a voltage of 220kV or more and a length of more than 15km. An EIA may also be required for development involving transmission of electricity by overhead cables at a lesser voltage/distance where significant impacts on the environment are likely (DOEHLG, 2003).

[7] www.hedgelaying.ie

[8] Codified due to previous amendments by Directives 97/11/EC, 2003/35/EC and 2009/31/EC

The prevention and remedying of environmental damage is addressed by the Environmental Liability Directive. The European Communities (Environmental Liability) Regulations 2008 (S.I. 547 of 2008) transposes EU Directive 2004/35/EC on environmental liability. This Directive establishes a framework for environmental liability based on the 'polluter pays' principle with a view to prevention and remedy of environmental damage. One of the definitions of damage in the Directive is direct or indirect damage to species and natural habitats protected by Article 4 (2) of the Birds Directive (2009/147/EC) or listed in Annex I to that Directive. Another example is direct or indirect damage to species protected by inclusion on Annexes II and IV to the Habitats Directive (92/43/EEC) and the natural habitats included in Annex I to that Directive.

A landscape-based perspective to the protection of European Sites (Special Areas of Conservation and Special Protection Areas), is implemented through Article 10 of the EU Habitats Directive, which states –

> *"Member States shall endeavour, where they consider it necessary, in their land-use planning and development policies and, in particular, with a view to improving the ecological coherence of the Natura 2000 network, to encourage the management of features of the landscape which are of major importance for wild fauna and flora.*
>
> *Such features are those which, by virtue of their linear and continuous structure (such as rivers with their banks or the traditional systems for marking field boundaries) or their function as stepping stones (such as ponds or small woods), are essential for the migration, dispersal and genetic exchange of wild species."*

Under the Planning and Development Acts (2000-2010), Development Plans should include objectives for the encouragement of linear features, or 'stepping stones', such as small woodlands, hedgerows and rivers. These connecting areas add to the coherence of the Natura 2000 network. This Article of the Directive is of relevance to electricity infrastructure developments due to their linear nature. Aspects of both the ecological impacts, and the potential benefits, of linear developments are investigated in the Literature Review.

As detailed previously, habitats in Ireland are generally classified in accordance with the Heritage Councils *Guide to Habitats in Ireland* (Fossitt, 2000). This guide sets out a standard scheme for identifying, describing and classifying habitats. Habitats in Ireland are evaluated in a hierarchical way with habitats listed in Annex I of the Habitats Directive 92/43/EEC and in particular *Priority habitats*, at the upper end of the scale; and highly modified habitats which have been subject to significant anthropogenic influence with little or very low wildlife interest at the lower end of the scale.

Ireland supports 59 Annex I habitats (Table 2.2). These are habitat types whose conservation requires the designation of Special Areas of Conservation. Of these, 16 are priority habitats (Table 2.2). Priority habitats are those which the EU considers require particular protection because their global distribution largely falls within the EU and they are in danger of disappearance (NPWS, 2008).

**Table 2.2: EU Directive Annex I habitats in Ireland (v EUR 27).** Asterisks indicate priority habitats.

| Code | Description |
|---|---|
| 1110 | Sandbanks which are slightly covered by sea water all the time |
| 1130 | Estuaries |
| 1140 | Mudflats and sandflats not covered by sea water at low tide |
| 1150 | *Coastal lagoons |
| 1160 | Large shallow inlets and bays |
| 1170 | Reefs |
| 1210 | Annual vegetation of drift lines |
| 1220 | Perennial vegetation of stony banks |
| 1230 | Vegetated sea cliffs of the Atlantic and Baltic coasts |
| 1310 | *Salicornia* and other annuals colonising mud and sand |
| 1320 | *Spartina* swards (*Spartinion maritimae*) |
| 1330 | Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*) |
| 1410 | Mediterranean salt meadows (*Juncetalia maritimi*) |
| 1420 | Mediterranean and thermo-Atlantic halophilous scrubs (*Sarcocornetea fructicosi*) |
| 2110 | Embryonic shifting dunes |
| 2120 | Shifting dunes along the shoreline with *Ammophila arenaria* (white dunes) |
| 2130 | *Fixed coastal dunes with herbaceous vegetation (‘grey dunes) |
| 2140 | fixed dunes with *Empetrum nigrum* |
| 2150 | *Atlantic decalcifled fixed dunes (*Calluno-Ulicetea*) |
| 2160 | Dunes with *Hippophae rhamnoides* |
| 2170 | Dunes with *Salix repens* ssp. *argentea* (*Salicion arenariae*) |
| 2190 | Humid dune slacks |
| 21A0 | Machairs (*in Ireland) |
| 3110 | Oligotrophic waters containing very few minerals of sandy plains (*Littorelletalia uniflorarae*) |
| 3130 | Oligotrophic to mesotrophic standing waters with vegetation of the *Littorelletea uniflorarae* and/or *Isoeto-Nanojuncetea* |
| 3140 | Hard oligo-mesotrophic waters with benthic vegetation of *Chara* spp. |

| Code | Description |
|---|---|
| 3150 | Natural eutrophic lakes with *Magnopotamion* or *Hydrocharition*-type vegetation |
| 3160 | Natural dystrophic lakes and ponds |
| 3180 | *Turloughs |
| 3260 | Watercourses of plain to montane levels with the *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation |
| 3270 | Rivers with muddy banks with *Chenopodion rubri* pp. and *Bidention* pp. vegetation |
| 4010 | Northern Atlantic wet heaths with *Erica tetralix* |
| 4030 | European dry heaths |
| 4060 | Alpine and Boreal heaths |
| 5130 | Juniperus communis formations on heaths or calcareous grasslands |
| 6130 | Cataminarian grasslands of the *Violetalia calaminariae* |
| 6210 | Semi-natural dry grasslands and scrubland fades on calcareous substrates (*Festuco-Brometea*) (*important orchid sites) |
| 6230 | *Species rich *Nardus* grasslands on siliceous substrates in mountain areas (and submountain areas in continental Europe) |
| 6410 | Molinia meadows on calcareous, peaty or clayey-silt-laden soils (*Molinion caeruleae*) |
| 6430 | Hydrophilous tall herb fringe communities of plains and of the montane to alpine levels |
| 6510 | Lowland hay meadows (*Alopecurus pratensis, Sanguisorba officinalis*) |
| 7110 | *Active raised bogs |
| 7120 | Degraded raised bogs still capable of natural regeneration |
| 7130 | Blanket bog (*if active bog) |
| 7140 | Transition mires and quaking bogs |
| 7150 | Depressions on peat substrates of the *Rhynchosporion* |
| 7210 | *Calcareous fens with *Cladium mariscus* and species of the *Caricion davallianae* |
| 7220 | *Petrifying springs with tufa formation (*Cratoneurion*) |
| 7230 | Alkaline fens |
| 8110 | Siliceous scree of the montane to snow levels (*Androsacetalia alpinae* and *Galeopsietalia ladani*) |
| 8120 | Calcareous and caleshist screes of the montane to alpine levels (*Thlaspietea rotundifolii*) |

| Code | Description |
|---|---|
| 8210 | Calcareous rocky slopes with chasmophytic vegetation |
| 8220 | Siliceous rocky slopes with chasmophytic vegetation |
| 8240 | * Limestone pavements |
| 8310 | Caves not open to the public |
| 8330 | Submerged or partially submerged sea caves |
| 91A0 | Old sessile oak woods with *Ilex* and *Blechnum* in the British Isles |
| 91D0 | *Bog woodland |
| 91E0 | *Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (*Alno-padion*, *Alnion incanae, Salicion albae*) |
| 91J0 | **Taxus baccata* woods of the British Isles |

**Table 2.3: Heritage Council (Fossitt, 2000) non-marine habitat classifications, with standard alphanumeric habitat codes.**

| Code | Habitat |
|---|---|
| F | Freshwater |
| FL | Lakes and ponds |
| FL1 | Dystrophic lakes |
| FL2 | Acid oligotrophic lakes |
| FL3 | Limestone/marl lakes |
| FL4 | Mesotrophic lakes |
| FL5 | Eutrophic lakes |
| FL6 | Turloughs |
| FL7 | Reservoirs |
| FL8 | Other artificial lakes and ponds |
| FW | Watercourses |
| FW1 | Eroding/upland rivers |
| FW2 | Depositing/lowland rivers |
| FW3 | Canals |

| Code | Habitat |
|---|---|
| FW4 | Drainage ditches |
| FP | Springs |
| FP1 | Calcareous springs |
| FP2 | Non-calcareous springs |
| FS | Swamps |
| FS1 | Reed and large sedge swamps |
| FS2 | Tall-herb swamps |
| G | Grassland and marsh |
| GA | Improved grassland (highly modified) |
| GA1 | Improved agricultural grassland |
| GA2 | Amenity grassland (improved) |
| GS | Semi-natural grassland |
| GS1 | Dry calcareous and neutral |

| Code | Habitat |
|---|---|
| | grassland |
| GS2 | Dry meadows and grassy verges |
| GS3 | Dry-humid acid grassland |
| GS4 | Wet grassland |
| GM | Freshwater marsh |
| GM1 | Marsh |
| H | Heath and dense bracken |
| HH | Heath |
| HH1 | Dry siliceous heath |
| HH2 | Dry calcareous heath |
| HH3 | Wet heath |
| HH4 | Montane heath |
| HD | Dense bracken |
| HD1 | Dense bracken |
| P | Bogs |
| PB1 | Raised bog |
| PB2 | Upland blanket bog |
| PB3 | Lowland blanket bog |
| PB4 | Cutover bog |
| PB5 | Eroding blanket bog |
| PF | Fens and flushes |
| PF1 | Rich fen and flush |
| PF2 | Poor fen and flush |
| PF3 | Transition mire and quaking bog |
| W | Woodland and scrub |
| WN | Semi-natural woodland |
| WN1 | Oak-birch-holly woodland |

| Code | Habitat |
|---|---|
| WN2 | Oak-ash-hazel woodland |
| WN3 | Yew woodland |
| WN4 | Wet pedunculate oak-ash woodland |
| WN5 | Riparian woodland |
| WN6 | Wet willow-alder-ash woodland |
| WN7 | Bog woodland |
| WD | Highly modified/non-native woodland |
| WD1 | (Mixed) broadleaved woodland |
| WD2 | Mixed broadleaved/conifer woodland |
| WD3 | (Mixed) conifer woodland |
| WD4 | Conifer plantation |
| WD5 | Scattered trees and parkland |
| WS | Scrub/transitional woodland |
| WS1 | Scrub |
| WS2 | Immature woodland |
| WS3 | Ornamental/non-native shrub |
| WS4 | Short rotation coppice |
| WS5 | Recently-felled woodland |
| WL | Linear woodland and scrub |
| WL1 | Hedgerows |
| WL2 | Treelines |
| E | Exposed rock/disturbed ground |
| ER | Exposed rock |
| ER1 | Exposed siliceous rock |
| ER2 | Exposed calcareous rock |
| ER3 | Siliceous scree and loose rock |

| Code | Habitat |
|---|---|
| ER4 | Calcareous scree and loose rock |
| EU | Underground rock and caves |
| EU1 | Non-marine caves |
| EU2 | Artificial underground habitats |
| ED | Disturbed ground |

| Code | Habitat |
|---|---|
| ED1 | Exposed sand, gravel or till |
| ED2 | Spoil and bare ground |
| ED3 | Recolonising bare ground |
| ED4 | Active quarries and mines |
| ED5 | Refuse and other waste |

# 3 CONSTRUCTION TECHNIQUES FOR TRANSMISSION PROJECTS

## 3.1 GENERAL

In order to assess the impacts of transmission lines on habitats, it is necessary to investigate typical construction techniques used for high voltage lines in Ireland. The main impacts of transmission lines on habitats occur during construction (Soderman, 2006; EcoFys, 2008). This Chapter provides an outline of typical types of structures used for the three different high voltage lines and the techniques used in their installation. Much of the information detailed in this study is derived from ESBI construction methodology statements (ESBI 2012a, b, and c). Appendix A provides a summary of all transmission infrastructure and construction methods. During the operational phase there is potential for impacts on habitats during the lifetime of the transmission line when lines are being refurbished or uprated and structures require replacement.

## 3.2 TYPES OF STRUCTURE

### 3.2.1 110kV lines

**Wooden polesets**

In Ireland, single circuit 110kV transmission lines are typically supported by wooden polesets consisting of two wooden poles, 5 metres apart and connected near the top with a rolled steel channel. The wooden poles are typically between 16 and 23 metres in height, depending on topography. A minimum of 2.3m of pole is buried underground as illustrated in Figure 3.1. The average span between polesets is approximately 250m, but this varies according to local topography. Wooden polesets on a 110kV line (study site 49) are illustrated in Figure 3.2.

**Braced polesets**

Braced polesets are used for 110kV transmission lines where the line angle is less than 20 degrees. Braced polesets appear similar to the wooden polesets illustrated above, but the poleset is braced for extra strength along its centre and on the earthwire section using steel channels, as illustrated in Figure 3.3.

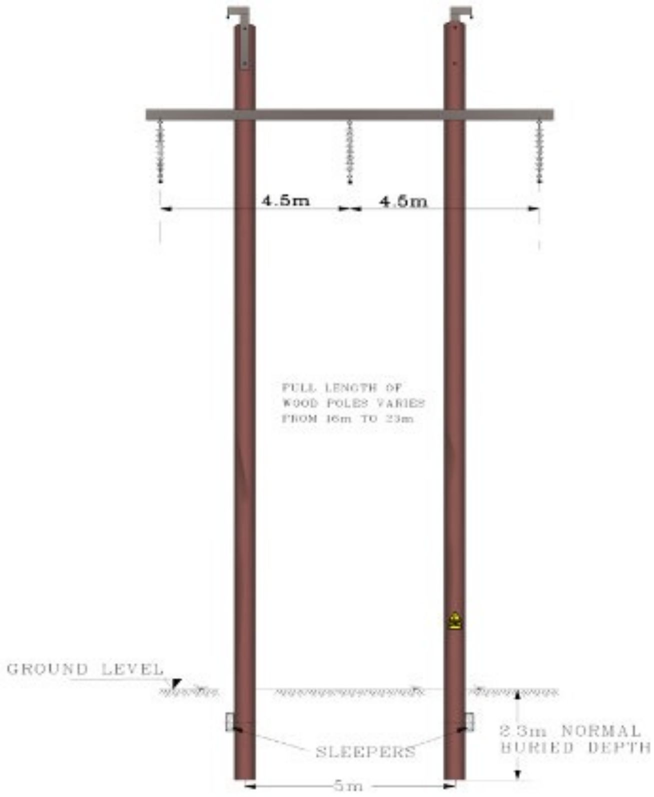


**Figure 3.1: Typical wooden poleset (ESBI 2012a).**

**Figure 3.2: Example of a 110kV transmission line showing wooden polesets**

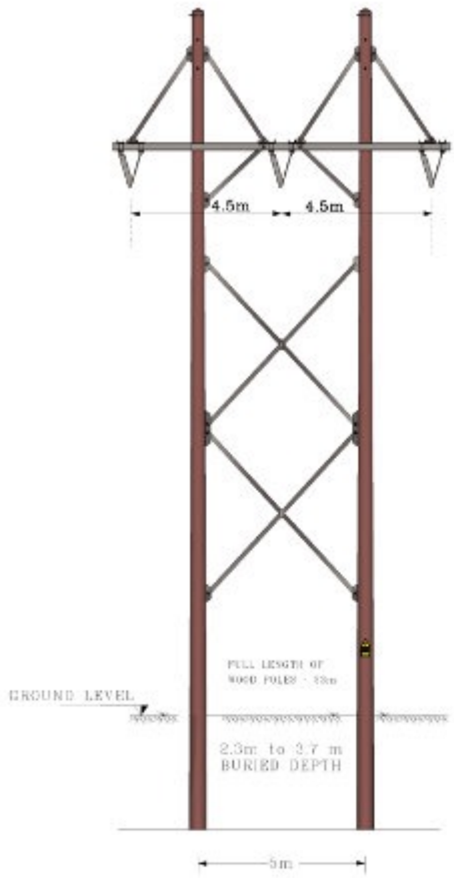


**Figure 3.3: Typical braced wooden pole set (ESBI 2012a).**

The typical excavation required for each pole is 1.5-2m x 3m x 2.3m deep, and the average working area for construction of an 110kV poleset will extend 10m all around the footprint of the base of the poleset (ESBI 2012c). A sleeper is installed attached to the base of the poles for added stability.

**Steel Angle Towers**

Steel angle towers are galvanised lattice structures that are used where a 110kV transmission line changes direction. They range in height from 18 to 24.5 metres depending on topography. Figure 3.4 illustrates a typical earthwire steel angle structure, with a typical steel angle line shown in situ in Figure 3.5.

Concrete foundations are required for all steel towers, and pile foundations may be required in unstable ground. The average foundation size for each tower leg used in the 110kV towers is 4m x 4m x 3m (ESBI 2012c).

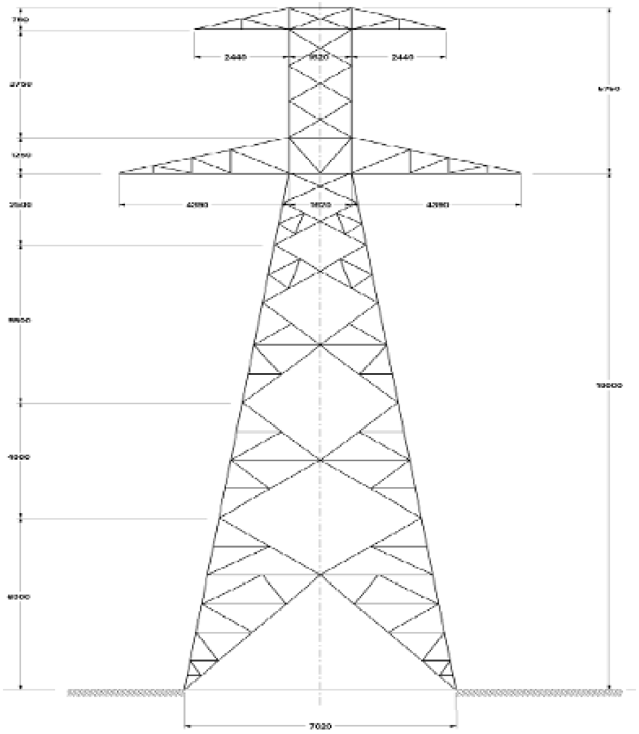

**Figure 3.4: Typical 110kV steel angle tower with earth wire (ESBI 2012a).**

**Figure 3.5: Typical 110kV angle tower in situ (ESBI 2012c).**

### 3.2.2 220kV lines

220kV conductors are supported exclusively on steel lattice towers. The steel bases are concreted into the ground. Four foundation blocks are excavated, ranging in width from 1.4m to 3.9m depending on the tower design (single or double circuit, angle tower or double circuit intermediate tower). The average span on a 220kV line is 320m, depending on local topography. A typical design of 220kV tower is illustrated in Figure 3.6, and the typical excavation required for the tower foundations is illustrated in Figure 3.7.

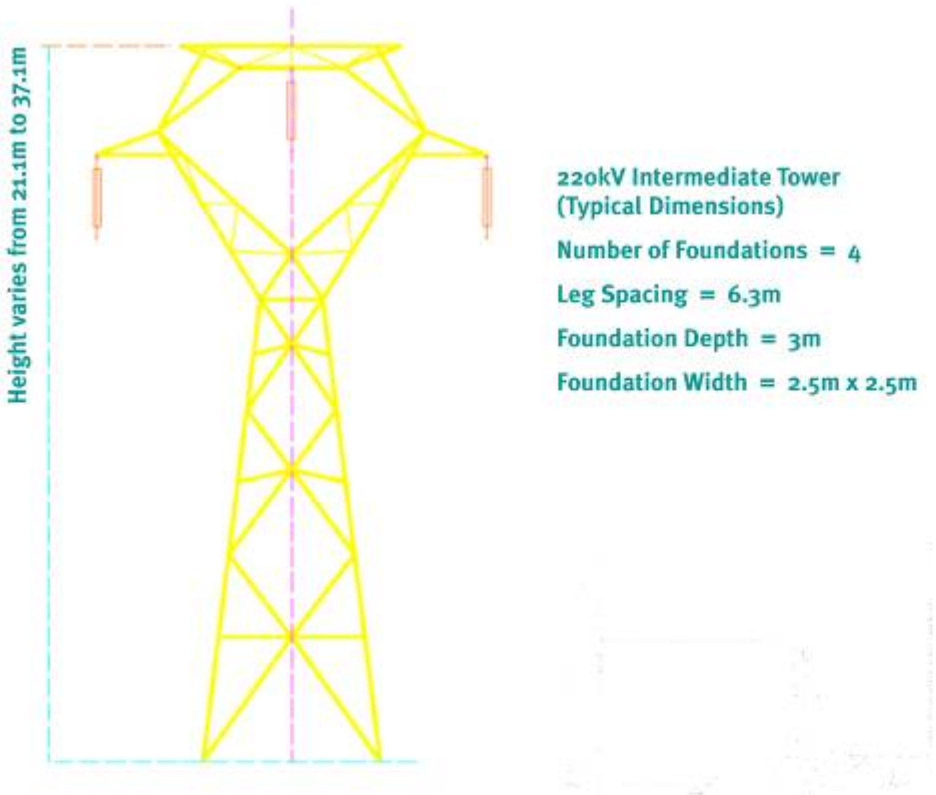


**Figure 3.6: Typical 220kV Intermediate Tower (from Flynn & Nairn, 2012).**

**Figure 3.7: Photograph of typical tower base with excavations (ESBI 2012b).**

### 3.2.3 400kV lines

400kV conductors are supported exclusively on lattice steel structures. The steel bases are concreted into the ground. Four foundation blocks are excavated, each block ranging in diameter from 2.8m-5.3m depending on the tower design (single or double circuit angle tower or double circuit intermediate tower). The average span of a 400kV line is 250-330m depending on local topography. Figure 3.8 illustrates a typical 400kV intermediate tower as currently used in Ireland; Figure 3.9 illustrates a tower base being prepared for concreting, and shows the footprint of vegetation clearance; while Figure 3.10 shows 400kV tower structures in use on the grid.

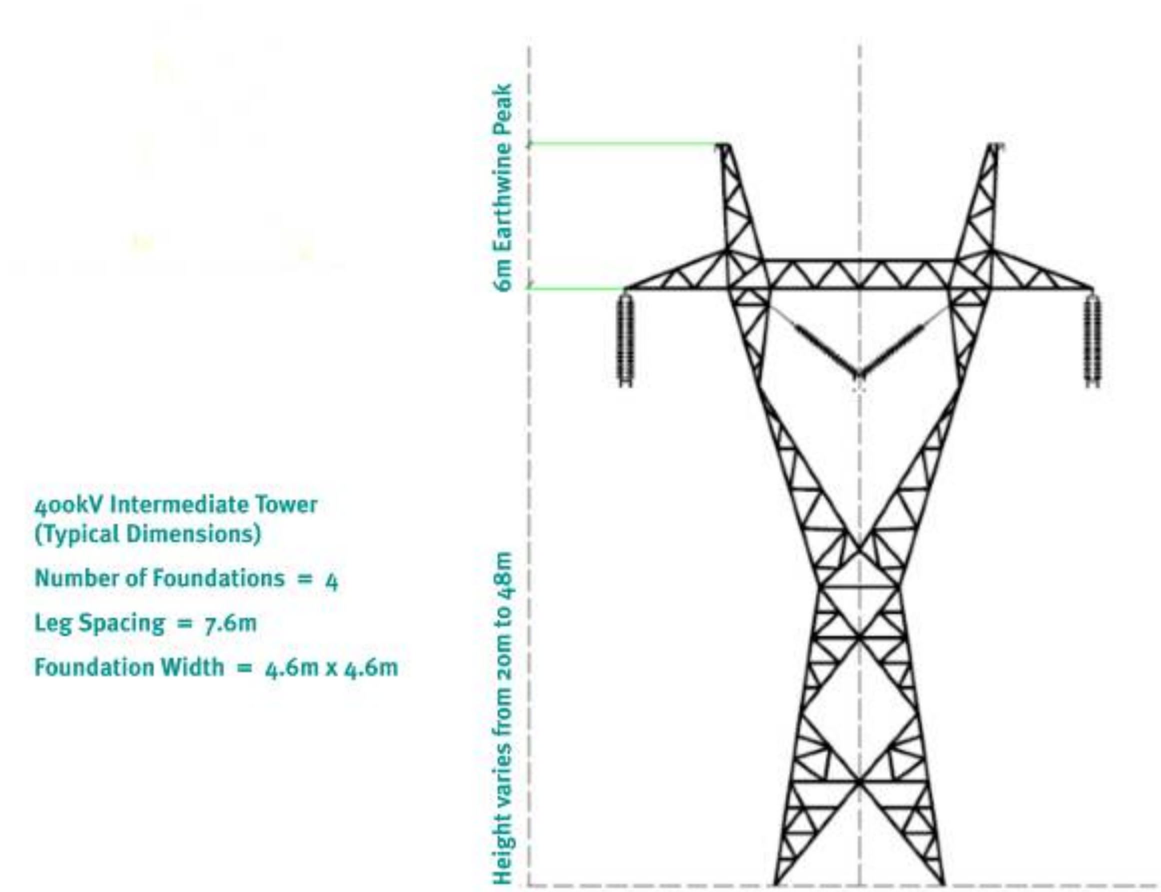


**Figure 3.8: 400 kV Intermediate tower (from Flynn & Nairn, 2012)**

**Figure 3.9: 400kV tower foundations being prepared for concreting (ESBI 2012c)**

**Figure 3.10: Moneypoint to Oldstreet 400kV transmission line showing an example of a 400kV angle tower.**

## 3.3 CONSTRUCTION SEQUENCE OF WORKS

The construction works required to construct a High Voltage Transmission Line typically follow the sequence of events as given below:

- Preliminary procedures including verification that planning conditions have been satisfied; pre-construction site investigations including an access review and assessment of ground conditions; delineation of on-site working area.
- Setting out of tower/ pole foundations
- Installation of tower foundations
- Erection of towers and pole sets
- Stringing of conductors and commissioning
- Reinstate land
- Remove temporary access

Table 3.1 below outlines the typical construction equipment required for the erection of different structure types.

**Table 3.1: Typical plant required for transmission structure types.**

| Structure Type | Typical Plant Required |
|---|---|
| Double wooden pole set | Transit van<br>Excavator<br>Winch tractor/pole erector<br>Chains and other small tools |
| Tower | Transit van<br>4x4 vehicle<br>Winch tractor/pole erector<br>Tractor and trailer<br>Crane<br>Teleporter<br>Chains and other small tools<br>Concrete vibrator<br>Water pump |

| Structure Type | Typical Plant Required |
|---|---|
| | Wheeled/ track dumper<br>Excavator<br>Concrete trucks |

### 3.3.1 Stringing of conductors

Once the towers or pole sets have been erected, the phase conductors and shieldwires are installed. Typical construction equipment required for stringing conductors:

- 4 x 4 vehicle
- Puller-tensioner x2
- Teleporter x2
- Drum stands x2
- Drum carrier x2
- Stringing wheels
- Conductor drums
- Compressor and head
- Transit vans chains and other small tools

## 3.4 ACCESS

In order to access individual structure sites, the contractors use the local public road network in the vicinity of the line, and then access the actual site on private land using existing private tracks or roads wherever possible. Existing farm entrances and also farm tracks or roads are used as much as possible, and access to structure locations is carefully selected to avoid impact to the surrounding area. Access routes are fenced off, or a barrier erected, to keep disturbance to a minimum.

Machinery and vehicle access for overhead line construction is assessed prior to entry. Where peat areas are encountered, access is achieved by using wide tracked low ground pressure vehicles to minimise damage to ground, and in sensitive areas may be combined with bog mats. Where very poor soft or boggy ground is encountered, a temporary access road or track may need to be constructed. Occasionally on particularly sensitive habitats or where access is challenging, materials can be air lifted using a helicopter. Generally, temporary roads are constructed using stone; however in certain sensitive situations aluminium road panels can be used. Stone road construction involves the excavation of the topsoil and storage of this to one side of the track. Geotextile reinforcement is placed on the subsoil surface and approximately 200mm of stone placed on top and compacted to form the track. Alternatively, in soft bog, a stone or panel road as described above may not be appropriate and in this case timber sleepers can be used. The plant required for construction of access roads is typically as follows:

- 4x4 vehicle
- Wheeled dumper or Track dumper
- 360˚ tracked excavator
- Teleporter or other mobile aerial platform and lifting equipment.
- All terrain crane (depending on site)
- Transit van
- Chains and other small tools
- Road material delivered by supplier to closest convenient point

## 3.5 REFURBISHMENT AND UPRATING OF OVERHEAD POWERLINES

Lines are often refurbished including structure replacement at certain locations. Lines can also be uprated to increase capacity or strengthen electrical resilience in the system. There is currently a programme of works where many lines are being uprated or refurbished across Ireland. The types of impact associated with this work are similar to new build work, albeit not generally as extensive, or of equal duration or impact magnitude as primary new build work.

Upon completion of construction or refurbishment / uprate, access is generally only necessary for standard maintenance plant and personnel. These generally do not require the installation of temporary access routes. However, in bad ground conditions and bog habitats temporary bog mats or access roads may be necessary. Existing access roads are used whenever possible.

## 3.6 CONCLUSION

The main potential impacts of the construction techniques detailed in this Chapterinclude:

- habitat loss at the footprint of the structures;
- removal of vegetation and topsoil at base of poles and towers,
- damage to vegetation by trampling and crushing and the associated impacts of construction on soil quality, which in turn has potential impacts on habitat quality.

# 4 LITERATURE REVIEW

## 4.1 OBJECTIVES OF LITERATURE REVIEW

The overall aim of the literature review is to examine the ways in which natural habitats are impacted by electricity infrastructure. While conducting this review, it was found that there is a lack of peer-reviewed scientific literature available on the effects of electricity transmission infrastructure on habitats, particularly in a European context. Due to the lack of published literature, it was necessary to expand the review to include literature available detailing the impacts of other construction projects on habitats.

The literature review focussed on the key issues associated with the development of electricity transmission infrastructure and habitats, as identified by Flynn & Nairn (2009), namely habitat loss, habitat damage, habitat fragmentation and a change in the hydrology of wetland habitats.

The objectives of the literature review were as follows:

- To review published literature on the general effects of linear construction projects on habitats and relate these impacts to transmission projects where appropriate.
- To examine the effects of construction projects more specifically on various habitat types and relate these impacts to transmission projects where appropriate.
- To review the published literature on the effects of transmission infrastructure on habitats, and examine the results of this review, in combination with the review of construction project literature, in order to establish which habitats emerge as most sensitive, and to establish the nature of the impacts upon these habitats.
- To review the predictions for duration of impact as given in a selection of EISs submitted for electricity infrastructure projects in Ireland.

## 4.2 METHODOLOGY

A focus was made on peer reviewed journals, and conference abstracts were also used to collate evidence. Grey literature was searched, including sources such as Irish Government Agency publications and guidelines, UK statutory agency research papers and International sources such as the European Environment Agency publications. InternationalTransmission System Operator and Industry-wide collective organisation websites were searched for relevant literature too, including Red Eléctrica de España, Réseau de transport d'électricité (RTE) of France, SwissGrid, TenneT of the Netherlands and Germany; TransNet BW of Germany; CIGRÉ (Conseil international des grands réseaux électriques or International Council on Large Electric Systems in English) and ENTSOE (European Network of Transmission System Operators for Electricity)..

## 4.3 GENERAL EFFECTS OF CONSTRUCTION ON HABITATS

### 4.3.1 Disturbance/ degradation

Habitat degradation can be defined as the process by which habitat quality declines (Hunter & Gibbs, 2007). There are many causes of disturbance or degradation of habitats, and the following provides a brief overview of habitat damage in relation to construction.  Operational effects are occasionally covered within literature under long term monitoring project papers, e.g Andrews (1990); Laurance & Yensen (1991); and Lathrop & Bunnell (2009).

Habitat damage such as vegetation trampling or removal, and soil compaction or erosion may be particularly associated with the construction phase of developments, and is not necessarily temporary or reversible, particularly in long-established semi-natural habitats. Chronic and progressive habitat damage can also result from increased human activity that development may generate. Habitat damage may also involve damage to microhabitats, which can result in indirect effects within a wider hydrological system. (Morris & Therivel, 2009).

Pollution such as release of sediment or hydrocarbons can also be generated by construction, and can be carried via air or water, and can also bioaccumilate in food webs. Soil can be contaminated by a wide range of contaminants, through either point source (for example spills and leakages) or diffuse contamination (for example agriculture) (Lehane & O'Leary, 2012).

### 4.3.2 Habitat loss and fragmentation

The process by which a natural landscape is broken up into small parcels of natural ecosystems, isolated from one another in a matrix of land dominated by human activity, is termed fragmentation (Hunter & Gibbs, 2007). Fragmentation almost always involves both the loss and isolation of habitats, and is most evident in urbanised or otherwise intensively used regions, where fragmentation is the result of the linkage of built up areas via linear infrastructure such as roads and railways (Jaeger *et al*, 2011).

The effects of fragmentation have been well studied (Harrison & Bruna, 1999). Ecological impacts can be divided into three major components: habitat reduction, edge effects and barrier effects. Reduction in habitat area generally results in a reduction of species richness (Spellerberg & Gaywood, 1993). The main reasons why large fragments will have more species than small fragments are firstly that a large fragment will almost always have greater habitat diversity than small fragments, and so more niches for different species. Secondly, a large fragment is more likely to have both common species and rare species, and thirdly small populations are more vulnerable to local extinction (Hunter & Gibbs, 2007). In addition, increased distances among remaining habitat fragments is an inherent part of a reduction in habitat area (Laurance and Yensen, 1991), and this leads to isolation of populations in smaller areas, or islands or patches (Fahrig, 2003).

Reduction in areas of a habitat creates new edges and causes changes in physical factors such as temperature, humidity and light on the newly created edge. The new conditions will be favourable for some species, and unfavourable for others, particularly those that inhabit the inner regions of the community. The habitat patches are also more vulnerable to external impacts such as pollution and disturbance, and also to invasion by non-native species (Spellerberg & Gaywood, 1993).

As landscapes become more fragmented, the mobility of species becomes more restricted. The removal of the interconnecting habitats or construction of physical barriers such as roads can create barriers to species dispersal. The barrier can either be physical, so that a species cannot cross it, behavioural, that is, species may be unwilling to cross it, or hazardous, so that high mortality can result on crossing (Morris & Therivel, 2009).

Linear developments such as roads and utility corridors have been identified as key drivers of habitat fragmentation (Andrews, 1990). Where transmission lines are constructed through woodland, habitat fragmentation occurs. The ecological effects of road development are well studied (s Spellerberg & Morrison, 1998 & Spellerberg, 1998), with ecological impacts identified including, but not limited to (Jaeger *et al*, 2011).

- loss of habitat;
- soil compaction;
- loss of or damage to vegetation;
- road mortality;
- higher levels of disturbance or stress to fauna;
- modification of food availability and composition;
- barrier effect;
- disruption to migration pathways;
- reduction and isolation of habitats;
- loss of species and reduction in biodiversity;

- increase in invasive species; and
- disruption to metapopulation dynamics

It is important to note that overhead power lines do not generate the same quantum of direct habitat loss as a road or other utility corridor with a constant ground footprint. For overhead lines, impacts on the ground are confined to tower or pole bases and access required for same, the latter being temporary. The principal exception to this is when lines need to cross woodland. In that case, a clearway is required (potentially up to 70m depending on the line specification, voltage and other safety considerations.

### 4.3.3 Invasive species

Invasive species can have a major negative impact on biodiversity (Stokes *et al*, 2006; EEA, 2010). When non-native species become invasive, they can transform ecosystems and threaten native and endangered species (DAISIE, 2009). The most prominent negative effect of invasive species, in terms of ecology, is competition with native biota and alteration of habitats (Stokes *et al*, 2006). Habitat removal, in particular for a road or utility corridor, can encourage the spread of invasive species by the creation of edge effects, and the direct introduction of non-native plant species by transfer of vector material on construction vehicles or equipment. In a study of non-native species along transport corridors, Hansen & Clevanger (2005) found that transport corridors can encourage the invasion of non-native species by removing barriers in several ways.

First, transport corridors alter disturbance regimes of neighbouring vegetation both directly by creating gaps and altering vegetation composition, and indirectly by altering conditions such as light and soil moisture. Secondly, vehicles aid in the dispersal of non-native species into the surrounding habitat by causing air turbulence and by acting as vectors for spread of seeds and vegetative plant parts.

Invasive species can occur in many habitats in Ireland including hedgerows, scrub, woodland, wetlands and watercourses. The disturbance or removal of any of these habitats can increase the spread of invasive species within a site and also between sites, as a result of machinery. Additionally, where a clearway is required through a woodland habitat the level of risk of spread of invasive species along a corridor into the woodland increases for an electricity transmission project.

## 4.4 EFFECTS OF CONSTRUCTION ON PARTICULAR HABITAT TYPES

### 4.4.1 Wetlands

#### 4.4.1.1 Hydrological impacts

The water quantity features of hydrological systems can be affected by a range of impacts from a variety of different sources; the main concerns in relation to wetland ecosystems are changes in water level and water flow regimes. Changes in water level can affect many of the wetland habitats discussed in this review, and are often critical for habitats such as peatland, fen and marsh. These types of impact are most frequently associated with construction requiring significant earthmoving or alteration of the natural bedrock overburden.

The main types of human disturbances of freshwaters include: organic matter, thermal pollution, acidification, eutrophication, increased sediment loading and contamination with metals, harmful chemicals and oil (Morris & Therivel, 2009). As part of the evidence based suite of environmental studies, two other studies, namely Soil and Water, and Aquatic Ecology focus on the degree to which construction and maintenance operations of transmission infrastructure affects soil release and any direct impact on water quality and aquatic ecology. A literature review of soil, sediment and water quality related impacts are available for each of these studies.

#### 4.4.1.2 Peatland

The interconnections and interdependencies between water, plants and peat are critical to the survival of peatlands and make them vulnerable to a wide range of disturbances. Disturbances that substantially lower or raise water levels in peatlands will negatively affect peat hydrological properties and associated functions. The hydrological properties of the peatland will, in turn, affect the vegetation growing on the surface of the peatland, which in turn will affect the peat type occurring on the surface and its hydrology. This natural feedback means that any removal of vegetation will affect the sustainability of the peatland (Renou-Wilson *et al*, 2011). For a detailed study of peatland hydrology, see Holden (2005) and Lindsay & Freeman (2008).

Wind-farm developments and other infrastructure developments including roads, electricity pylons and gas pipelines have been identified as potentially damaging to peatlands. The main impacts arise from the construction of associated road networks across the peatlands, service structures, drainage, soil conduits for power cables, turbine foundations and electricity pylons (NPWS, 2008; Malone & O'Connell, 2009; Lindsay & Freeman (2008) for EcIA). The potential impacts of transmission infrastructure on peatlands are discussed further in Section 4.5.2.

### 4.4.2 Grassland

As discussed in Chapter 2, changes in land use practices on agricultural land have been identified as the most significant factor in the decline in Ireland's semi-natural grasslands. Construction and development of new urban and rural fabric has also affected grassland and heathland, and surviving areas of semi-natural grassland and heathland have become fragmented and have declined in quality.

Causes of degradation and loss in relation to development include pollution, introduction of alien species, and soil erosion and compaction (Price, 2003).

#### 4.4.2.1 Habitat loss and fragmentation

Semi-natural grasslands have declined in area and become increasingly fragmented across Ireland. Of the six Annex I grassland habitats identified as being present in Ireland, semi-natural dry grasslands and scrubland facies on calcareous substrates, species rich acid grasslands, *Molinia* meadows and lowland hay meadows have all been identified as having reduced in extent, and have been judged to be of bad conservation status (NPWS 2008). Additional impacts on Annex I grassland habitats include the spread of invasive species, which threatens hydrophilous tall herb communities, and also reclamation, which threatens Calaminarian grassland.

Other non-agricultural related negative impacts identified during the Irish semi-natural grassland survey (O'Neill *et al*, 2010) include paths and trackways, trampling and over-use, grassland removal, and roads, paths and railroads. In this study, which comprised 203 sites and 912 relevé samples, electricity and phone lines and military constructions were listed as neutral impacts on grasslands surveyed in Counties Donegal, Dublin, Kildare and Sligo. This is an important point drawn from the literature as it comes from a scientific and published study undertaken to (1) map grasslands; (2) conduct a conservation assessment of any Annex I grassland habitats found and (3) evaluate existing classification systems and to create an objective classification that described the diversity of grassland vegetation types found.

Whilst assessment of effects of construction upon grassland habitats was not a primary aim of that study, as part of the conservation assessment, it was reported that power lines resulted in a neutral effect upon the following Annex I grassland types –

- 6210: Semi-natural dry grasslands and scrubland fades on calcareous substrates;
- 6230: Species rich Nardus grasslands on siliceous substrates in mountain areas;
- 6410: Molinia meadows on calcareous, peaty or clayey-silt-laden soils; and
- 6510: Lowland hay meadows.

Earlier associated studies in Counties Cork and Waterford (Martin *et al.,* 2008) and Cavan, Leitrim, Longford and Monaghan (O'Neill *et al.*, 2009) did not characterise threats in the same way and no distinction can be drawn for power lines. The 2010 report followed revised EU threat codes published in 2010 to include the category D02.01 (Electricity and phone lines).

Agricultural and construction vehicles and machinery can lead to the compaction of both pasture and silage fields, causing compaction of both surface and sub-surface soils. A review of evidence on the impacts of soil compaction by DEFRA (2007) found that, within species rich grassland, there is substantial variation among species in their ability to grow on compacted soil. This modifies plant community composition, with compacted soils tending to support less diverse assemblages than those on better structured soil profiles. The study goes on to acknowledge that there has been little research carried out in the UK, with studies concentrating on amenity paths and military ground rather than semi-natural grassland.

The revegetation of calcareous and neutral grassland exposed to disturbance on a military training area was studied by Hirst *et al* (2005). The study focussed on grassland that had been disturbed over a 50 year period, and found that the sampled calcareous grasslands were less resilient following disturbance than neutral grassland, with slower colonisation of bare ground and target species re-assembly. Neutral grassland typically took 30-40 years to re-establish, whereas calcareous grassland took at least 50 years. Even after such long time periods there remained subtle but significant differences in vegetation composition between disturbed and undisturbed soils. An earlier study by Hirst *et al* (2003) also found that small scale but acute disturbance events by vehicles can have significant effects on plant community composition in chalk grassland. This finding is from a series of grassland sites with a range of floral abundance between 30-40 species per $m^2$ and where repeated tank movements had occurred. It demonstrates that in species rich grasslands, resilience of the floristic community to repeated disturbance is reduced.

### 4.4.3 Woodland

The National Survey of Native Woodlands in Ireland (Perrin *et al*, 2008) found that native woodland is limited in extent and is also highly fragmented. The vast majority of contiguous units of broadleaf or mixed broadleaf/conifer woodland are less than 5ha in size and only a very small proportion are greater than 50ha. Fragmented woodland can only support smaller numbers of species, which are then more vulnerable to extinction. Smaller woodland will also have proportionately more edge habitat and less core area (Larsson, 2001; Perrin *et al*, 2008).

The main external threat to woodland in Ireland is felling. Woodland may be cleared as a result of developments such as road building or housing development, agricultural improvement, or replacement with commercial plantation. Wet woodland is also threatened by drainage schemes. The internal structure of woodland can also be degraded by inappropriate grazing, and also by invasive species (Perrin *et al*, 2008).

Hedgerows and treelines provide habitat for a range of woodland flora and fauna (Cabot, 1999) and also provide seed source areas, stock barriers, nutrient sinks, shelter, aesthetic landscape value, carbon sequestration, flood prevention, protection from soil erosion and aquatic siltation (Murray, 2003). The main effect of development on hedgerows is via habitat loss and temporary disturbance.

## 4.5 THE EFFECTS OF ELECTRICITY TRANSMISSION INFRASTRUCTURE ON HABITATS

Anthropogenic disturbances can have many effects on plant communities and associated habitats. Utility corridors for roads, gas pipelines, railway lines, canals and powerlines are a ubiquitous part of the global landscape and can cover vast stretches of land (Andrews, 1990; Rubino and Williams, 2002; Clarke and White, 2008). In the United States the land area covered by powerline corridors exceeds almost all national parks, including Yellowstone (Russell *et al*. 2005). In this context the risk to habitats from overhead powerlines particularly during the construction phase (with the clearing of vegetation for access routes and pylon bases) is considerable (EcoFys, 2008). Maintenance of powerline rights-of-way can also lead to a critical source of habitat damage where vegetation management activities are carried out (Smallridge *et al*., 1996). Having said this, section 4.3.2 notes how overhead power lines do not generate the same quantum of direct habitat loss as a road or other utility corridor with a constant ground footprint (unless crossing woodland requiring a clearway).

In Ireland, landowners continue to own and manage land along the route of the powerline. The infrastructure is constructed along a wayleave. Here, impact on the ground is confined to tower or pole bases and access required for same, the latter being temporary. The principal exception to this is when lines need to cross woodland. In that case, a clearway is required (potentially up to 70m depending on the line specification, voltage and other safety considerations. Where an overhead line crosses farmland landscapes, routine pollarding/ lopping of trees on hedgerows occurs on a rotational basis.

Where they do occur elsewhere, and notably in North America, the impacts of powerline corridors on habitats are site specific and can vary extensively depending on land use. From an ecological perspective, construction of an overhead powerline may not always be associated with habitat degradation. Intensively managed agricultural land makes up a large amount of the total land area in the United States (grassland pasture and range land, 25.9%; cropland, 19.5%; Lubowski *et al*., 2006) and construction of an overhead powerline in these situations may lead to no change in floristic diversity. In some woodland scenarios where a Right Of Way (ROW) is maintained under a power line, management of this ROW improves biodiversity (Section 4.5.4).

The main effects of transmission infrastructure such as support towers on habitats occur during construction, and to a lesser extent maintenance, and may include: vegetation clearance and habitat loss, erosion and sedimentation, construction of access roads and dirt tracks and habitat fragmentation (Soderman, 2006).

The following provides a summary of scientific literature published on the effects of powerlines on different habitats. It should be noted that the majority of literature sourced for this Section of the study addressed the impacts of overhead power lines and their support structures on the habitats they traverse, but differentiation between structure types and line voltage was generally not made in the papers.

### 4.5.1 Wetlands

Disturbance to soils and vegetation during the construction of powerlines can lead to erosion and siltation, affecting wetland and aquatic habitats, particularly from the construction of access roads and tree-felling (Morgan and Rickson, 1995; Morgan, 2005; and Alsharif, 2010). Wetland soils are especially vulnerable to compaction from heavy construction equipment, which can also damage water channels and permanently change hydraulic regimes (United Nations, 2006; EcoFys, 2008; Public Service Wisconsin, 2011).

Wetlands are often used to site powerlines in the USA as they are free from major obstructions, away from public view and low in cost (Thibodeau and Nickerson, 1986). Nickerson (1989) carried out a 10 year study of the revegetation of a wooded swamp called Cattail Marsh, , and a shrub/bog woodland. The study found that both the Cattail Marsh and wooded swamp recovered within a few years, but that the shrub/bogland habitat had not recovered as well as the other types. A further review of Nickerson's (1989) study by Reed (1996) emphasised that the response of wetland habitats will vary according to the resilience of the species present. Reed (1996) also concluded that the depressed recovery of the shrub/bog habitat indicated that wetlands should be considered carefully when assessing the impacts of developments and disturbance events.

### 4.5.2 Peatlands

Lindsay and Freeman (2008) offer an in-depth narrative on the ecological effects of constructing a windfarm on the Lewis Peatlands SPA in Scotland. In consideration of the effects of construction of overhead powerline across blanket bog, the authors focus on (i) habitat loss due to the permanent infrastructure; and (ii) effects of the creation of temporary access to facilitate the construction stage. They note that the quantifiable footprint of pylon bases can easily be underestimated and that permanent footprint (or habitat loss) due to overhead line construction can be overlooked if the impact assessor is not overly familiar with actual line construction.

In relation to to temporary access tracks/road-ways, including those consisting of wooden boards placed over vegetation, the study also notes that peatland habitats are easily damaged. Wet mire in particular has a very low load-bearing capacity and eroded or gullied ground that needs to be crossed may need to be evened out, which the authors argue is very difficult to restore post construction.

In the EirGrid guidance for EcIA for transmission projects (Flynn and Nairn, 2012) the vulnerability of bogs to damage from the construction of overhead powerlines is highlighted. Brooks and Stoneman (1997) note that significant impacts can result from heavy construction traffic on *Sphagnum* dominated areas of peatland which can damage and destabilise the peat. Holden (2005) suggests that impacts of disturbance to peat can be irreversible once the hydrology has been altered beyond a point which has implications for the perceived success and understanding of peatland restoration strategies.

There is a body of literature on the failure of floating road construction on peatlands, synthesised in MacCulloch (2006), but this relates mostly to peat slippage or movement and slumping of the road surface from a geotechnical perspective. Lindsay (2010) acknowledges that little research has been undertaken into the long term eco-hydrological impacts of floating roads.

Farrell (2007) summarises the impacts of constructing a 110kV overhead line upon Atlantic blanket bog in County Mayo under two headings:

<u>Short-term</u>

- loss of vegetation at base of pole-sets;
- loss of vegetation along access routes of machinery for installation; and
- disturbance and exposure of vulnerable peat soils leading to erosion.

<u>Long-term</u>

- localised increase of rushes and purple moor grass at base of pole-sets; and
- localised drainage impacts confined to actual footprint of the disturbance.

Magnusson and Stewart (1986) described the effects of disturbance along hydroelectrical transmission corridors through peatlands in Manitoba, finding that affected plant communities in the right-of-way had lower abundance of *Sphagnum* and *Ericoid* vegetation and more exposed peat surfaces.

Dubé *et al.* (2011) investigated the spread of invasive plant species along overhead powerline corridors and into adjacent bog and fen habitats in Québec. They found that powerline corridors are efficient dispersal vectors of native non-peatland and invasive plant species into fen habitats and less so for bog habitats.

### 4.5.3 Grassland and heathland

Notably, O'Neill *et al*, (2010) found that electricity lines resulted in neutral impacts on four Annex I grassland types surveyed in Counties Donegal, Dublin, Kildare and Sligo as part of an overall conservation assessment study of Irish grasslands. Beyond this research, there is very little published information on the effects of powerlines on grassland and dry heathland. In a case study undertaken in Mayo, Ireland, Farrell (2007) found that there were short term, localised effects on grassland, with loss of vegetation at the base of pole-sets, but the vegetation recovers relatively quickly. Some longer term effects could be seen by a localised increase in rushes around the pole-sets, but there was no impact observed in dry grassland communities. In dry heathland, Farrell (2007) found that there was an impact on the footprint of the development (base of pole-sets and access roads) with loss of vegetation, and a slow recovery of the vegetation thereafter. The exposed peat soils were also prone to erosion, with an associated wider impact on adjacent freshwater habitats. Longer term impacts observed included a localised increase in rushes at the base of the pole-sets, and a change in species composition to include an increase in acid grassland species and a reduction in cover of dwarf shrubs such as Ling (*Calluna vulgaris*).

EcoFys (2008) found that flora was affected by the clearance of vegetation for the right of way or easement , but that most flora will likely recover in 18-24 months on lowland pasture and agricultural grassland. However, flora is often much more sensitive in other habitats such as wetlands and heathlands and may fail to fully recover. This is in keeping with work undertaken by Farrell (2007), who concluded that grassland communities, particularly improved grassland communities, are the least vulnerable in terms of impacts and show good recovery in a relatively short time period.

### 4.5.4 Woodlands

Vegetation along ROWs is usually maintained at early successional stage by cutting, mowing or spraying herbicides (Andrews, 1990). International research on the effect of clearance of woodland for overhead powerlines includes the impacts of fragmentation, edge effects and barrier effects, mostly in relation to effects on local fauna (Andrews, 1990; Goosem & Turton, 2000; Strevens, 2007). Goosem & Turton (2000) also provide an evaluation of the effects of powerline easements on wet tropics in Queensland, Australia. In the wet tropic habitat, the edge effect of the open canopy of the easement altered the microclimate along the line and past the forest edge zone. The soil temperature along the easement was elevated, and species composition of the easement vegetation had altered, exhibiting higher species richness than surrounding deep forest, largely due to an increase in weed and pioneer species.

The general consensus appears to be that linear habitat fragmentation has a negative ecological effect (IEEM, 2006 and NRA, 2009). However, some studies carried out in the USA have found positive impacts associated with powerline ROW. A 30-year study on a ROW clearance in Pennsylvania, by Bramble and Byrnes (1983), found that a stable community comprising a mixture of forest plants and open area plants developed. This community provided increased food for wildlife in comparison to the control, and provided valuable shrubby edges (shrubland habitat is encouraged by conservation strategies in the USA, Buffum *et al*, 2011).

Schmidt & Barnwell (2002) carried out a floral study of the Rockhill Blackjacks preserve, South Carolina. The preserve was comprised mainly of glade, shrub habitats and woodland, but also contained three linear habitats created by utility ROW. The study found that where the utility corridors had been subject to regular disturbance in the form of cutting or herbicide application, a prairie-like vegetation community had developed. The authors concluded that the prairie-like vegetation had developed due to the survival of a seed bank in the soil, and the regular disturbance created by ROW maintenance. The plant species observed in the corridors were diverse, and included '*at least 20 plants listed by the South Carolina Heritage Trust as requiring attention at the State level*'.

Bodin (2012) provides a description of 'Integrated Vegetation Management' of powerline corridors in the USA, which includes the use of herbicides, hand cutting and mowing. This management technique has resulted in the presence of a threatened species of Sunflower under a line in Vermont, and a population of endangered New England Cottontail under a line in New Hampshire. Bodin also noted that the removal of trees has resulted in a prairie-like ecosystem developing under a powerline in Vermont, and that in parts of New York and New Hampshire, the normally fire dependant sandplain ecosystem has reverted to forest in many areas, but the removal of trees for powerlines has allowed the sandplain habitat to regenerate.

The management of powerline ROW receives further attention in Lathrop & Bunnell (2009), who provide a detailed management plan for the New Jersey Pinelands. The aim of the management plan was to provide a ROW vegetation management plan to create and maintain relatively stable and sustainable habitats that represent characteristic Pineland habitats. The study also makes reference to the presence of a number of rare and threatened species under the powerline spans, and takes account of these species within the management plan. Lathrop and Bunnell (2009) also make reference to the work of Yahner and Hutnik (2004) and Bramble and Byrnes (1983) in their study. These three studies show that by actively managing vegetation in a woodland ROW, by a variety of means including chemical spray, mechanical and hand cutting methods, a species rich 'proclimax' vegetation community not dominated by trees can persist, proclimax being a community maintained by repeated disturbance. Clarke & White (2008) recommend a long rotation between cutting in order to retain a stable shrub community and prevent degradation and invasion by non-native species in Australian ROW.

There is a lack of published scientific research on the effects of transmission powerlines on habitats in Europe. Studies that have been carried out point out that placing powerlines or underground cables through woodland would involve permanent felling, with no tree regrowth possible over underground cables, and restriction of tree height regrowth under overhead powerlines (Jacobs Babtie, 2005; EcoFys, 2008). In addition, Farrell (2007) points out that clear-felling of conifers on peat soil has been linked with severe degradation of water quality and salmonid streams in the west of Ireland, and there will also be a change of habitat from woodland to scrub underneath the powerlines. It should be noted as well that During the construction of either underground cables or overhead powerlines, field boundaries may change or undergo temporary removal to accommodate access or trench digging (EcoFys, 2008).

The ELIA Life project (http://www.life-elia.eu) is a European project concerning the ecology of overhead powerlines. The project, which is being undertaken in France and Belgium and was set up in recognition that the construction and maintenance of overhead powerlines can sometimes have a negative effect on biodiversity but if managed correctly, there is scope for positive biodiversity enhancement. The project website states that management techniques used to keep the powerline corridor clear of vegetation often involve the use of heavy machinery which can compact the soil, damaging the soils upper layers, upsetting soil microfauna and damaging vegetation. The project has developed management prescriptions to reduce these impacts and improve the biodiversity of areas underneath powerlines, which is in many ways the approach espoused by Bramble and Byrnes (1983), Yahner and Hutnik (2004) and Lathrop and Bunnell (2009) as above.

These prescriptions include reducing the area that needs cutting or mowing by the creation of shrubby or grassy edges in the corridors, along with the planting of orchards, establishment of meadows, creation of a network of ponds and the restoration of peatlands and moors crossed by the powerlines. Management of the corridors includes extensive grazing, mowing regimes and timing of cutting to avoid the periods when the soil is most sensitive to damage.

## 4.6 CONCLUSION

The literature review has highlighted the following issues in terms of the types of impacts that construction developments, including electricity transmission development, potentially have upon habitats in Ireland:

- **Habitat loss** has been particularly prevalent in semi-natural grassland and broad-leaved woodland habitats, and has also impacted the network of hedgerows across Ireland.
- **Habitat change** can be wide ranging, including vegetation trampling or removal, the introduction of invasive species, compaction of soil and associated change in species composition of vegetation, and change of vegetation community type, for example from woodland to a scrub habitat underneath areas cleared for overhead powerlines.
- **Fragmentation**, which is characterised by habitat reduction, edge effects and barrier effects. Linear developments have been identified as key drivers of fragmentation, although this is more relevant to road construction than overhead powerlines..
- **Hydrological change**, including change in water level and water flow regimes. Changes in water level are particularly critical for habitats such as peatland, fen and marsh.

The key points regarding the effects of overhead powerline construction on habitat types that have emerged from the literature review are:

- **Woodland** is vulnerable to fragmentation and associated edge and barrier effects. However, impacts are not always negative, and management that is sympathetic to the aims of nature conservation can create ‘target’ habitats underneath overhead powerlines, for example the sub-shrub communities in the USA.

- The literature relating to **grasslands** is limited, but suggests that dry grassland is robust, and recovers quickly from disturbance. Habitats that are either wet or very dry (for example chalk grassland) take longer to recover, and some may fail to recover fully. Notably, Irish grasslands subjected to the National Survey of Native Grasslands in 2010 were found to have a neutral effect attributed to their conservation assessment by the presence of electricity lines.

- **Peatlands** are particularly sensitive to development and are vulnerable to a wide range of disturbances. Construction efforts can impact upon bog vegetation through habitat loss, peat compression, vegetation degradation, nutrient enrichment and ecohydrological regime change. Impacts can be of a long duration and literature suggests that vegetation may fail to fully recover from development.

The literature review has identified that peatland habitat types represent the most sensitive habitat types and will therefore comprise the main focus of the casestudy. Dry grasslands comprise almost 60% of Ireland's landscape, and will therefore be the habitat type which projects brought forward under Grid25 will probably cross most often. They are also investigated further.

# 5 CATEGORISING IMPACTS FOR ENVIRONMENTAL IMPACT ASSESSMENT

## 5.1 GUIDELINES FOR ECOLOGICAL ASSESSMENT

In Ireland, the criteria to be used for assessing the significance of ecological impacts is based on guidance supplied by the EPA (2002), the Institute of Ecology and Environmental Management (IEEM, 2006) and the National Roads Authority (NRA, 2009).

Impact assessment is a subjective discipline, and relies on *ex-ante* predictions made by professionals and experts capable of speculating *ex-post* effects of events that have not yet occurred with a reasonable degree of accuracy. The magnitude or significance of any given impact can usually be argued further up or further down a scale of intensity.

One area where debate occurs as to the accuracy of impact prediction is in the duration of impacts. EPA (2002) defines the duration of impacts as set out in Table 5.1. EirGrid has adopted these definitions in their ecology guidelines for electricity transmission projects (Figure 5.1).

**Table 5.1: Duration of impacts as defined by EPA (2002)**

| Definition | Duration |
|---|---|
| Temporary Impact | Impact lasting for one year or less. |
| Short-term Impact | Impact lasting one to seven years. |
| Medium-term Impact | Impact lasting seven to fifteen years. |
| Long-term Impact | Impact lasting fifteen to sixty years. |
| Permanent Impact | Impact lasting over sixty years. |

## 5.2 SELECTED REVIEW OF EXISTING PROJECTS

A review of some recent EISs for proposed overhead electricity transmission projects in Ireland (including Northern Ireland) demonstrates the different ways in which a specialist can describe duration of the impact of construction, as outlined in Table 5.2. Whilst this is explained to some degree by the variation in projects being assessed and also resilience of habitat types subjected to the impacts of construction, it suggests that professionals and expert ecologists may not always agree as how to best describe impacts upon habitats subjected to construction of transmission line infrastructure, or indeed the degree or magnitude of residual permanent impacts.

One of the stated objectives for this study is to identify any impacts to habitat quality caused by the construction of high voltage support structures, and to identify the duration of any impacts on habitat quality resulting from construction. This will aid the prediction of duration of impact of construction on habitats.

**Figure 5.1: Criteria used in ecological impact assessment (EcIA) in Ireland**

**CRITERIA THAT SHOULD BE USED IN ECOLOGICAL IMPACT ASSESSMENT**

**(EPA 2002, IEEM 2006)**

**Positive or Negative:**
Is the impact likely to be positive or negative? International and national policy now push for projects to deliver positive outcomes for biodiversity

**Context (Magnitude and extent):**
A scheme may affect only a small part of a site but the area of habitat affected in that location (in hectares) should be given in the context of the total area of such habitat available (e.g. 1ha of a woodland which measures 30ha in total).

**Character:**
The type of habitat (e.g. natural or highly modified woodland; mature or recently established, wet or dry) is important, as is the quality of the site (e.g. undamaged active blanket bog).

**Significance:**
State whether a site has a designation, such as SAC or NHA, or contains a listed (Annex I) habitat. The ecological value of a site can be assigned a rating using an evaluation scheme, such as that described in Chapter 2 (e.g. undesignated areas of semi-natural broadleaved woodland are normally rated as high value, locally important).

**Sensitivity:**
Indicate changes that would significantly alter the character of an aspect of the environment (e.g. changes in hydrology of a wetland due to construction of access road).

**Duration:**
Indicate the time for which the impact is expected to last prior to recovery or reinstatement of impacted habitats and /or species.

The duration of an activity may differ from the duration of the resulting impact caused by the activity (e.g. short-term construction activities may cause disturbance to birds during the breeding season, however, there may be longer-term impacts due to a failure to reproduce in the disturbed area during that season).

**Reversibility:**
Identify whether an ecological impact is permanent (non-reversible) or temporary (reversible - with or without mitigation).

**Timing and Frequency:**
Some changes may only cause an impact if they happen to coincide with critical life-stages or seasons (for example, the bird nesting season). This may be avoided by careful scheduling of the relevant activities.

Taken from p63 of Flynn and Nairn (2012).

**Table 5.2: Duration of impacts upon habitats as predicted in eight EIS documents (Predicted impact highlighted in bold text)**

| Project | Selected text quotations | Impact summary |
|---|---|---|
| **EirGrid / ESB Networks Donegal 110kV Project** | "*With application of a sensitive access strategy and appropriate mitigation measures, the impact to **blanket bog** will result in a **medium-term impact**. As blanket bog is an Annex I habitat (and priority where pristine), it is categorised as being of very high conservation value, even where undesignated. The magnitude of impact predicted is minor negative and the overall impact appraisal for this habitat type is a slight adverse impact.*" | Minor, slight, medium term |
| **EirGrid Connemara 110kV Project** | "*There will be a **low magnitude permanent** impact on the habitats within the immediate proximity of the power line and masts, particularly peatland habitats such as bog and heath. Given the actual footprint of works required this be a very **low magnitude impact** overall. Permanent effects on vegetation will be **localised** at the bases of supporting structures. Potential permanent impacts on birds and animals along the route will be of **slight negative** impact as the route does not interrupt established flight paths. Recovery of bog vegetation following installation of supporting structures and power lines can occur within 5 years as long as the area of disturbance is minimised and best practice is employed (Farrell 2007b). It is strongly advised that the main mitigation measures should be reduction of traffic and minimising the actual footprint required during access for construction and maintenance*". | Low, slight, 5 years |
| **EirGrid Woodland to Moyhill 400 kV Project** | "*There will be a **low negative impact** on most habitats within the proposed development area. For more species rich mature linear woodland this impact is assessed as a **moderate negative impact** during the construction phase. Post construction vegetation will be allowed to re-grow depending on the decisions of the landowner and this impact will likely be a slight negative permanent impact.*" | Low, slight, temporary |
| **EirGrid Moyhill to Border (Lemgare) 400 kV Project** | *"Predicted impact significance: **Imperceptible negative**. Given the nature of the development, and the mitigation measures proposed, the overall impact on the sites of high local value will be imperceptible negative."* | Imperceptible |
| **EirGrid Clashavoon to** | "*The footprint of the development will cause a direct loss of habitat where the angle mast foundations are to be placed, however based on the design of the angle masts habitat loss is likely to be minimal and following the construction phase habitat re-instatement and natural regeneration will result in only **short term habitat loss**. In the case of forested areas,* | Minimal, neutral, short-term |

| Project | Selected text quotations | Impact summary |
| --- | --- | --- |
| **Dunmanway 110kV Project** | *long term habitat loss will occur as maintenance and safety requirements will necessitate felling of trees in these areas.*"<br>"*Direct **short term habitat loss** will occur in those areas where angle masts are to be constructed. Stockpiling of material within the site has the potential to cause additional short term habitat loss should it be placed in a manner that would smother vegetation.*"<br>*"The construction will require temporary drainage at angle mast sites to facilitate construction. This may cause a secondary impact on adjacent habitats by causing drying out of the surface. The absence of sensitive wetland habitats at and adjacent to angle mast locations means that this secondary impact will be a **neutral impact**.*" | |
| **NIE**<br>**Tyrone – Cavan**<br>**400kV Interconnector Project** | "*The proposed erection of new towers will require permanent land take, which will inevitably lead to **direct habitat loss**, although each tower site will occupy a footprint that is small in relation to the extensive habitats along the line route.*"<br>"*The proposed overhead line route is marginal to areas of wet grassland, fen and swamp, and the proposed development will largely avoid these habitats. Where direct impacts occur, these will mainly be restricted to disturbance of habitats during stringing of the lines. Where tower locations are in damp ground, de watering of excavations may be necessary, and this will most likely require a discharge consent from the Water Management Unit of NIEA. Magnitude of impact on these habitats is considered to be **negligible**.*" | Negligible |
| **NIE**<br>**Omagh – Magherakeel**<br>**110kV Project** | "*Access to pole and tower sites may require the construction of temporary tracks across adjacent habitats, which will result in the **temporary disruption** of those habitats, but generally vehicular access to the site is unlikely to be more damaging than the current use of farm machinery."* | Temporary |
| **NIE**<br>**Tamnamore to Omagh**<br>**110kV Project** | "*Some access tracks and haul roads will be constructed across heathland habitats. The impact of this construction footprint has been considered. Measures to reduce the scale of these impacts have been included. Access will be made across lower value habitats prior to final approach to the structure in order to minimise the compression footprint upon these habitats. Overall, these habitats are of high value but are all degraded to some extent. The construction impact upon heathland habitats is considered intermediate in the absence of mitigation, and **minor with mitigation**. The corresponding significance of impact is **minor adverse**."* | Minor |

# 6 CASE STUDY

## 6.1 INTRODUCTION

As outlined in Section 1, the objective of this study is to investigate the impacts of the construction of high voltage transmission infrastructure on natural terrestrial habitats in Ireland. Peatland and grassland habitats are to be studied. As the study is seeking to consider the duration of impacts on habitats as measured by floristics as a proxy for vegetation recovery, it is necessary to know how long it has been since the last major construction event at any given part of the grid. Time groups were established and samples taken within two groups. All overhead transmission voltage types were sampled.

## 6.2 SITE SELECTION AND METHODOLOGY

A review of GIS data layers and information on the transmission network system in Ireland was undertaken to determine what tools could be used to select sites. A GIS database was constructed comprising –

(i) EirGrid's national transmission network;
(ii) NPWS dataset of Annex I habitats (assumed to be an incomplete but best available dataset);
(iii) the CORINE 2000 Landcover dataset (complete dataset); and
(iv) Department of Agriculture's Forestry07 dataset (complete dataset).

The transmission network database was converted into Google Earth file format to enable review of Google sourced aerial imagery.

High value (i.e. Annex I) habitats were selected principally for three reasons:

(i) They are available as a spatial dataset upon which sites to study can be derived;
(ii) Higher magnitudes of impact are predicted in EIA for Annex I habitats due to their sensitivity, often restricted range and greater protection afforded by the EU Habitats Directive and therefore, they are more often the focus of debate as to the accuracy of impact prediction; and
(iii) EirGrid has published guidelines (Flynn and Nairn, 2012) to ensure a standard approach to EcIA of high voltage transmission projects, where the objectives are *inter alia*, to provide best practice guidance and a systematic approach for EcIA of high voltage overhead power line infrastructure projects and to provide best practice guidance on ecological topics of particular relevance to high voltage overhead power lines including "*impacts of electricity transmission projects on sensitive habitats, particularly wetlands, peatlands and watercourses*".

Study sites were split into three categories as follows:

### 6.2.1 Worst case condition

Peatlands have been identified as sensitive habitats for transmission line development in the EirGrid Ecology guidelines. The literature review carried out to inform this study also identified peatlands as the habitat types most sensitive to development. This study has therefore selected peatland habitats as the principal subject area of study as a worst case scenario.

### 6.2.2 Standard condition

The literature review suggests that grassland resilience to disturbance is greater than that of peatlands, particularly in agricultural and dry grasslands. Unlike the low level management regime of peatlands, grasslands are most often under high level management and input regimes. This will influence a vegetation community considerably and the consequent variability is difficult to account for.

Management may affect grassland vegetation much more than a construction event from a given point in the past. In consideration of the level of influence of management on grassland vegetation communities, the increased resilience of grasslands to disturbance, and their lower level of predicted impact magnitude (from a nature conservation perspective) in EIA, it has been decided that grassland sites were selected to represent the standard condition. Grasslands cover much of Ireland and a great deal of future infrastructure coming forward under Grid25 will cross grassland habitats.

### 6.2.3 Non-standard condition

At the commencement of this study, a non-standard condition category was investigated that would include an assessment of forestry or woodland. As stated in Section 2.4, woodland/forestry accounts for around10% of land cover in Ireland, and 75% of this is of conifer plantation. Taking this into consideration, combined with the distribution of the transmission network, the study team were unable to select sufficient overhead line (OHL) crossings of broadleaf woodland (or clearfell zones within them) to study this condition. Wayleave corridors within coniferous plantation are more common, principally because lines are planned and designed to avoid broadleaf woodland. Within these wayleaves, ground flora commonly reverts to heathland or scrub vegetation types on the peat soils (authors, *pers. obs*).

An empirical study of conifer clearfell would confirm that the habitat types pre- and post-construction are different, and would describe and record the surface vegetation in the wayleave corridor. It is possible to qualitatively describe, for example, the ground flora of a coniferous woodland and compare that to the vegetation of a clearfell zone, but this approach is not consistent with the study objective which seeks to measure the change in vegetation cover and assess the degree of recovery as measured by time elapsed since construction. A depauperate conifer plantation ground flora will not 'recover' after the trees have been felled. The vegetation will undergo succession instead.

For these reasons (lack of study sites, and inconsistency with the study objective), the non-standard condition or woodland habitat has been excluded from the case study element of this research project.

### 6.2.4 Establishing time groupings

As the study is seeking to consider the duration of impacts on habitats as measured by vegetation recovery, it is necessary to know how long it has been since the last major construction event at any given part of the grid. ESB Networks staff assisted EirGrid in outlining this information to the study team. Based on the EPA temporal impact categories, the study team set about categorising 37 sections of high voltage overhead powerlines on the Irish transmission network that crossed Annex I peatland habitats, and 9 sections that crossed Annex I grassland habitats, into one of two groups. These were 10yrs or less and 20yrs or more since construction, in order to provide a comparison between the two groups based on time. These time groupings were arrived at once time elapsed had been acquired from ESB Networks. It is simply a matter of fact that major construction works on Ireland's transmission infrastructure has occurred in waves over the last four decades, and not continually along a 40 year spectrum. There was no example of a time group in between.

Worst-case and standard sites, constructed ≤10yrs and ≥20yrs were determined as the sites to be assessed in order to investigate the impacts of the construction of high voltage overhead powerlines on natural habitats in Ireland.

This exercise resulted in identification of 31 peatland sites and 9 grassland sites, categorised below:

- 11 sections of overhead transmission line were identified which cross sizeable amounts of peatland habitat and which have not been subject to a major construction effort in 20 years or more. This includes different locations along the same line in some instances.
- 20 sections of overhead transmission line were identified which cross sizeable amounts of peatland habitat and which have been subject to a major construction effort within the last 10 years.
- 6 sections of overhead line were rejected because they did not in fact cross peatland when high resolution aerial photography was inspected; they were not in fact transmission lines; or it was not possible to determine how much time had elapsed since the last major construction effort.
- 9 sections of overhead transmission line were identified which cross grassland habitats identified in the NPWS dataset for Annexed grassland habitats, or NPWS Grassland Monitoring Project 2006 plot coverage for Annexed habitats. At this stage, it was not yet possible to determine how much time had elapsed since the last major construction effort.

### 6.2.5 Line Voltage

The voltage of the overhead transmission lines were then examined using EirGrid's national transmission network dataset, and the 31 peatland sites, and 9 grassland sites to be progressed were then further sub-divided according to the voltage of line crossing it.

The initial site lists, including details of voltage and time elapsed since major construction (where known), are shown in Table 6.1 (peatlands), and Table 6.2 (grasslands).

The spread of sites around the country are illustrated in Figure 6.1.

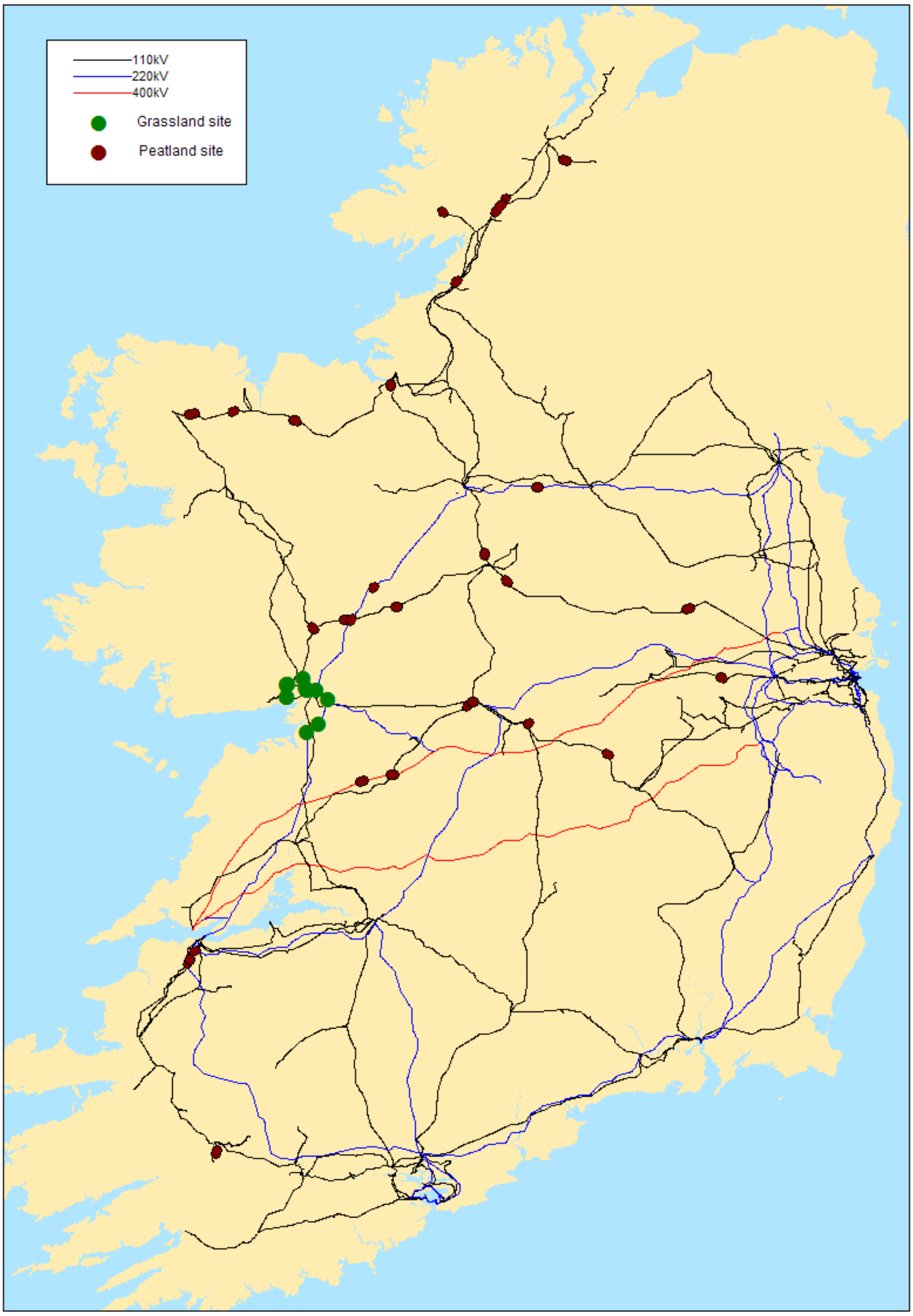


**Figure 6.1: Map showing position of sites selected as part of the case study**

**Table 6.1: Initial peatland study site list**

| Site number | Line | Voltage kV | Annex I Code | Habitat | Years elapsed since major construction |
|---|---|---|---|---|---|
| 53 | Letterkenny-Strabane | 110 | 7140 | Transition Mire | 20+ |
| 3 | Tarbert-Tralee | 110 | 7110 | Raised Bog | 20+ |
| 4 | Tarbert-Tralee | 110 | 7110 | Raised Bog | 20+ |
| 28 | Derryiron-Maynooth | 110 | 7110 | Raised Bog | 20+ |
| 40 | Corduff-Mullingar | 110 | 7110 | Raised Bog | 20+ |
| 57 | Binbane-CathaleenF | 110 | 7130 | Blanket Bog | 9 |
| 52 | CathaleenF-Drumkeen | 110 | 7140 | Transition Mire | 8 |
| 51 | CathaleenF-Letterkenny | 110 | 7130 | Blanket Bog | 9 |
| 50 | CathaleenF-Drumkeen | 110 | 7130 | Blanket Bog | 9 |
| 49 | Binbane-CathaleenF | 110 | 4010 | Wet Heath | 9 |
| 49 | CathaleenF - L'kenny (1) | 110 | 4010 | Wet Heath | 9 |
| 49 | CathaleenF - L'kenny (2) via Drumkeen | 110 | 4010 | Wet Heath | 8 |
| 47 | Cunghill-Moy | 110 | 7130 | Blanket Bog | 7 |
| 46 | Bellacorick-Moy | 110 | 7110? | Raised Bog? | 10 |
| 45 | Bellacorick-Moy | 110 | 7130 | Blanket Bog | 10 |
| 2 | Clonkeen-Coolmaghearlahy | 110 | 7130 | Blanket Bog | 6 |
| 20 | Agannygal-Shannonbridge | 110 | 7110 | Raised Bog | 9 |
| 21 | Cashla-Shannonbridge | 110 | 7110 | Raised Bog | 9 |
| 23 | Shannonbridge-Thurles | 110 | 7110 | Raised Bog | 10 |
| 25 | Portlaoise-Shannonbridge | 110 | 4010 | Wet Heath | 10 |
| 31 | Castlebar-Cloon | 110 | 7130 | Blanket Bog | 9 |

| Site number | Line | Voltage kV | Annex I Code | Habitat | Years elapsed since major construction |
|---|---|---|---|---|---|
| 32 | Cloon-Lanesboro | 110 | 7110 | Raised Bog | 8 |
| 33 | Cloon-Lanesboro | 110 | 7110 | Raised Bog | 8 |
| 36 | Flagford-Lanesboro | 110 | 7110 | Raised Bog | 3 |
| 37 | Lanesboro-Mullingar | 110 | 7110 | Raised Bog | 9 |
| 5 | Clashavoon-Tarbert | 220 | 7110 | Raised Bog | 20+ |
| 34 | Cashla-Flagford | 220 | 7110 | Raised Bog | 20+ |
| 35 | Cashla-Flagford | 220 | 7110 | Raised Bog | 20+ |
| 41 | Flagford-Louth | 220 | 7110 | Raised Bog | 20+ |
| 18 | Moneypoint-Oldstreet | 400 | 7130 | Blanket Bog | 20+ |
| 19 | Moneypoint-Oldstreet | 400 | 7130 | Blanket Bog | 20+ |

**Table 6.2: Initial grassland study site list**

| Site number | Line | Voltage kV | Annex I code | Habitat | Years elapsed since major construction |
|---|---|---|---|---|---|
| G1 | Cashla - Flagford | 220 | - | Improved agricultural grassland | 20+ |
| G2 | Cashla - Tynagh | 220 | - | Improved agricultural grassland | unknown |
| G3 | Cashla - Prospect | 220 | 6210 | Semi-natural dry grassland | unknown |
| G4 | Cashla-Prospect | 220 | 6210 | Semi-natural dry grassland | 20+ |
| G5 | Cashla - Galway | 110 | - | Improved agricultural | 20+ |

| Site number | Line | Voltage kV | Annex I code | Habitat | Years elapsed since major construction |
|---|---|---|---|---|---|
| | | | | grassland | |
| G6 | Cashla - Galway | 110 | - | Improved agricultural grassland | 20+ |
| G7 | Cashla - Cloon | 110 | - | Improved agricultural grassland | unknown |
| G8 | Dalton - Galway | 110 | - | Improved agricultural grassland | 12 |
| G9 | Cashla - Galway | 110 | - | Improved agricultural grassland | 20+ |

### 6.2.6 Site list revision

The initial list of study sites underwent revision following site visits. Issues encountered on site included: agricultural improvement, including reseeding of the sward; overhead lines crossing peatland habitats but the structures standing on a different habitat type; and peatland habitat being intensively managed, for example for industrial peat extraction. Table 6.3 details the final peatland sites selected for the study.

**Table 6.3: Final selection of peatland study sites.**

| Site number | Line | Voltage kV | Annex I Code | Habitat | Time elapsed since major construction |
|---|---|---|---|---|---|
| 3 | Tarbert-Tralee | 110 | 7110 | Raised Bog | 20 |
| 28 | Derryiron-Maynooth | 110 | 7110 | Raised Bog | 20 |
| 57 | Binbane-CathaleenF | 110 | 7130 | Blanket Bog | 9 |
| 49 | Binbane-CathaleenF | 110 | 4010 | Wet Heath | 9 |

| Site number | Line | Voltage kV | Annex I Code | Habitat | Time elapsed since major construction |
|---|---|---|---|---|---|
| 49 | CathaleenF - L'kenny (1) | 110 | 4010 | Wet Heath | 9 |
| 49 | CathaleenF - L'kenny (2) via Drumkeen | 110 | 4010 | Wet Heath | 8 |
| 47 | Cunghill-Moy | 110 | 7130 | Blanket Bog | 7 |
| 46 | Bellacorick-Moy | 110 | 7110 | Raised Bog | 10 |
| 45 | Bellacorick-Moy | 110 | 7130 | Blanket Bog | 10 |
| 23 | Shannonbridge-Thurles | 110 | 7110 | Raised Bog | 10 |
| 25 | Portlaoise-Shannonbridge | 110 | 4010 | Wet Heath | 10 |
| 31 | Castlebar-Cloon | 110 | 7130 | Blanket Bog | 9 |
| 32 | Cloon-Lanesboro | 110 | 7110 | Raised Bog | 8 |
| 33 | Cloon-Lanesboro | 110 | 7110 | Raised Bog | 8 |
| 37 | Lanesboro-Mullingar | 110 | 7110 | Raised Bog | 9 |
| 35 | Cashla-Flagford | 220 | 7110 | Raised Bog | 20 |
| 18 | Moneypoint-Oldstreet | 400 | 7130 | Blanket Bog | 20 |

Agricultural improvement was particularly common amongst the grassland sites initially selected for survey, to the extent that only one of the grassland sites was found to qualify as an Annex I habitat during the site visit. Sites that were very species poor were excluded from the study, leaving 5 study sites to be taken forward for the final selection, as shown in Table 6.4.

**Table 6.4: Final selection of grassland study sites**

| Site number | Line | Voltage kV | Annex I Code | Habitat | Time elapsed since major construction |
|---|---|---|---|---|---|
| G1 | Cashla - Flagford | 220 | - | Dry calcareous and neutral grassland | 20+ |
| G4 | Cashla-Prospect | 220 | 6210 | Semi-natural dry grasslands | 20+ |
| G5 | Cashla - Galway | 110 | - | Dry meadows and grassy verges | 20+ |
| G8 | Dalton - Galway | 110 | - | Improved agricultural grassland | 12 |
| G9 | Cashla - Galway | 110 | - | Improved agricultural grassland & Dry calcareous and neutral grassland | 20+ |

## 6.3 SITE SURVEY

### 6.3.1 General approach of site survey

In order to identify the potential impacts to habitat quality caused by the construction of high voltage lines and their support structures, survey of the vegetation present at the base of the support structure was carried out by an experienced botanist, using the methodology set out below. In order to provide a comparison to the vegetation present at the structures, a survey was also done in a pre-construction condition, or control, at a distance of 50m from the structure in identical habitat.

### 6.3.2 Survey methodology

Field survey work was undertaken between June and August 2012, during the optimum period for vegetation survey. A 2m x 2m relevé was placed at the base of a structure, either a double wooden poleset or a steel tower, along a section of overhead line. Vascular plants, bryophytes and lichens present in the relevé were recorded using the DOMIN scale of cover/abundance by visual estimation (see Table 6.5). A second relevé was then placed at a distance approximately 50m from the structure, and all plant species recorded. The second relevé was placed so as to ensure as best as possible that it was still located within the same habitat type, and in an area subject to the same slope, aspect, drainage and other topographical parameters as the relevé at the structure.

The aim was to record six relevés per site - three consecutive structures in the construction zone and three ‘controls’. However, during field survey, it was found that it was not always possible to record at three consecutive sets of poles, or pylons, without encountering a complete change in habitat type at one of the structures. The grassland sites were particularly difficult to survey at three consecutive structures due mainly to habitat change among structures, with agricultural improvement of the sward (mainly in the form of re-seeding or very heavy grazing) having occurred at several sites. In these instances, only the structures situated in the relevant habitat type were surveyed, plus their ‘controls’. This resulted in a limitation applied to any analysis of the grassland samples, which is discussed further in Section 9.2.1.

When using the DOMIN scale, small differences among small cover values are of greater significance than similar differences between high cover values, but a balance must be made between the sampling strategy (such as measuring abundance, density or cover) and the requirement to sample many sites with efficiency of resources.

**Table 6.5: The Domin scale (Rodwell, 2006).**

| Cover | Domin |
|---|---|
| 91-100% | 10 |
| 76-90% | 9 |
| 51-75% | 8 |
| 34-50% | 7 |
| 26-33% | 6 |
| 11-25% | 5 |
| 4-10% | 4 |
| <4 (many individuals) | 3 |
| <4% (several individuals) | 2 |
| <4% (few individuals) | 1 |

## 6.4 DATA ANALYSIS

### 6.4.1 General approach to analysis

Vegetation survey data collected from relevés close to and at a distance from overhead line structures located on grasslands and peatland habitats were examined. Vegetation was quantified on a scale of relative dominance, ranging from zero to ten as outlined in Section 6.3.2.

The following four questions were tested separately for grassland and peatland habitats:

1. Does the vegetation community vary between relevés at structures and relevés at a distance from structures?
2. Is species richness reduced close to overhead line structures?
3. Does the length of time since overhead line structure construction affect vegetation community or species richness?
4. Is there a difference between the effect of wooden polesets and towers (angle masts) on either vegetation community or species richness?

### 6.4.2 Data analyses

All analyses of data from peatlands comprised five independent variables; *Site* and *Structure number* were random factors, with *Structure number* nested within *Site* and *Site* nested within both *Years since construction* and *Structure type*. *Structure type* (two levels; wooden polesets and angle masts), *Years since construction* (two levels; ≤ 10 years and ≤ 20 years) and *Distance from Structure* (two levels; adjacent and at a distance) were incorporated as fixed factors in each analysis, as summarised in Table 6.6.

**Table 6.6: Summary of treatment of variables in analysis**

| Random | Nested | Fixed |
|---|---|---|
| **Site** | **Structure number *(within site)*** | **Structure type**<br>**Years since construction**<br>**Distance from Structure** |
| **Structure number** | **Site *(within Years since construction and Structure type*)** | |

Given the smaller dataset collected from grassland sites there was no variation in *Years since construction* or *Structure type*. These variables were therefore omitted from analyses of grassland vegetation data.

Questions regarding vegetation community were examined by permutational multivariate analysis of variance (PERMANOVA; Anderson 2001a; McArdle & Anderson 2001; Anderson *et al.* 2008) with PRIMER (Version 6.1.13; Primer-E Ltd., Plymouth, UK). These analyses were done with 9999 permutations of the residuals under a reduced model based on Bray-Curtis similarity matrices (Bray & Curtis 1957) calculated from untransformed relative dominance vegetation data. Similarity percentages species contributions (SIMPER) analysis was then used to identify the plant taxa that contributed most strongly to differences between sites located at different distances from pylons.

Questions regarding plant species richness were examined with permutational analysis of variance (Anderson 2001b). These analyses were done with 9999 permutations of the residuals under a reduced model based on Euclidian distance matrices calculated from untransformed plant species richness data.

All analyses were based on Type III sums of squares. Tests for data heteroscedasticity were performed *a priori* with permutational analysis of multivariate dispersions (PERMDISP; Anderson 2006; for multivariate analyses) and Cochran's test (for univariate analyses).

Heteroscedasticity means that variables are random and uncorrelated. This is important in analysis of variance, because the presence of heteroscedasticity can invalidate statistical tests of significance that assume that the modelling errors are uncorrelated and normally distributed and that their variances do not vary with the effects being modelled.

# 7 RESULTS OF CASE STUDY

## 7.1 OVERVIEW OF RESULTS

A full list of all vegetation data collected at the sites is tabulated in Appendix B for peatland sites and in Appendix C for grassland sites. Table 7.1 summarises the survey effort across habitat type, overhead line and structure type and time groupings.

Results of quantitative data analyses are firstly presented, followed by qualitative summaries of peatland and grassland sample results. Photographs of typical swards encountered at sampling sites are also presented. Changes in species richness as recorded in relevés placed adjacent to an overhead line structure when compared with the control site at distance (refer to Section 6.3.2) are described.

**Table 7.1: Summary table of relevé sampling across habitats, line and structure types and time groups.**

| **Sample Summary** | | |
|---|---|---|
| **Variable** | | **Number of samples** |
| **Total** | | **102** |
| **Structure Type** | Tower | 37 |
| | Poleset | 65 |
| **Voltage** | 110kV | 82 |
| | 220kV | 8 |
| | 400kV | 12 |
| **Broad Habitat Category** | Peatland | 84 |
| | Grassland | 18 |
| **Habitat type (Refer Table 2.3)** | GA1 Improved agricultural grassland | 7 |
| | GS1 Dry calcareous and neutral grassland | 8 |
| | GS2 Dry meadows and grassy verges | 3 |
| | HH3-GS3 Mosaic of wet heath and Dry-humid acid grassland | 4 |

| Sample Summary | | |
|---|---|---|
| **Variable** | | **Number of samples** |
| | PB3-GS4 Mosaic of Lowland blanket bog and Wet grassland | 2 |
| | HH1 Dry siliceous heath | 4 |
| | HH3 Wet heath | 25 |
| | HH3-PB4 Mosaic of Wet heath and Cutover bog | 3 |
| | PB1 Raised bog | 27 |
| | PB1-PB4 Mosaic of Raised bog and Cutover bog | 13 |
| | PB3 Lowland blanket bog | 6 |
| **Annex 1 habitat type (refer Table 2.2)** | 4010 Northern Atlantic wet heaths with *Erica tetralix* | 32 |
| | 6210 Semi-natural dry grasslands and scrubland fades on calcareous substrates | 3 |
| | 6510 Lowland hay meadows | 2 |
| | 7110 Active raised bogs | 40 |
| | 7130 Blanket bog | 8 |
| | Non-Annex | 17 |
| **Time group** | 10yrs or less | 60 |
| | 20 yrs + | 24 |
| | Unknown time group | 18 |

## 7.2 RESULTS OF STATISTICAL ANALYSIS

Statistical analysis was undertaken as outlined in Section 6.4. Data were retabulated and restructured to facilitate permutational multivariate analysis (PERMANOVA), permutational analysis of variance (ANOVA) and Similarity percentages species contributions (SIMPER) analyses to test separately the following four questions for grassland and peatland habitats. Peatland data was pooled for blanket bog, raised bog and heathland relevé data:

1. Does the vegetation community vary between relevés at structures and relevés at a distance from structures?

2. Is species richness reduced close to overhead line structures?

3. Does the length of time since overhead line structure construction affect vegetation community or species richness?

4. Is there a difference between the effect of wooden polesets and towers (angle masts) on either vegetation community or species richness?

Analysis showed that there was a significant interaction between site, and distance from overhead line structure on both the community structure ($F_{14,24}$ = 1.71, $P$ = 0.0001) and taxon richness ($F_{14,24}$ = 2.99, $P$ = 0.009) of plants on peatlands (Table 7.2). In other words, the samples at a control point at distance from a structure varied between sites to a statistically significant degree on peatland plant communities. Plant communities sampled adjacent to an overhead line structure tended to have reduced relative cover of the Bryophyte layer, and notably *Sphagnum capillifolium* and *Sphagnum denticulatum*; and increased cover of *Carex panicea* and *Molinia caerulea* when compared with the control site (Table 7.3).

In relation to questions 3 and 4, neither the number of years since construction nor the type of structure had a detectable effect on overall plant community structure ($F_{1,18}$ = 1.03 and 1.36, $P$ = 0.39 and 0.21, respectively) or plant taxon richness ($F_{1,18}$ = 2.16 and 0.24, $P$ = 0.16 and 0.62, respectively) on peatlands (Table 7.2).

Both the community structure ($F_{4,8}$ = 6.3, $P \leq 0.0001$) and taxon richness ($F_{4,8}$ = 5.31, $P$ = 0.032) of plants on grasslands varied significantly between sites. There was, however, no statistically significant effect of distance from overhead line structure on community structure and taxon richness (Table 7.4).

**Table 7.2: Results of (a) PERMANOVA and (b) permutational ANOVA testing for an effect of distance from overhead line structures on, the community structure and taxon richness of peatland plants.** Significant (P < 0.05) values are highlighted in bold.

| Community structure | | | | | |
|---|---|---|---|---|---|
| | **Source** | **df**[9] | **MS**[10] | **Pseudo-F**[11] | **P**[12] |
| | Distance from structure, D | 1 | 2635.6 | 3.61 | **0.007** |
| | Years since construction, Y | 1 | 2056.4 | 1.03 | 0.39 |
| | Structure type, T | 1 | 2694.6 | 1.36 | 0.21 |
| | Site, S(Y*T) | 14 | 2355.4 | 3.07 | **≤0.0001** |
| | Y*D | 1 | 385.81 | 0.5 | 0.83 |
| **(a)** | Y*T | 1 | 1855.3 | 0.93 | 0.47 |
| | D*T | 1 | 650.85 | 0.89 | 0.51 |
| | Y*D*T | 1 | 760.13 | 1.04 | 0.4 |
| | Structure number, P(S(Y*T)) | 24 | 766.81 | 1.62 | **0.0006** |
| | S(Y*T)*D | 14 | 808.06 | 1.71 | **0.0001** |
| | Residual | 24 | 494.3 | | |
| taxon richness | | | | | |
| | **Source** | **df** | **MS** | **Pseudo-F** | **P** |
| | Distance from structure, D | 1 | 0.19 | 0.02 | 0.89 |
| | Years since construction, Y | 1 | 48.07 | 2.16 | 0.16 |
| | Structure type, T | 1 | 5.37 | 0.24 | 0.62 |
| | Site, S(Y*T) | 14 | 25.09 | 1.96 | 0.065 |
| **(b)** | Y*D | 1 | 1.12 | 0.12 | 0.74 |
| | Y*T | 1 | 1.06 | 0.04 | 0.83 |
| | D*T | 1 | 3.93 | 0.41 | 0.53 |
| | Y*D*T | 1 | 30.44 | 3.16 | 0.098 |
| | Structure number, P(S(Y*T)) | 24 | 12.8 | 3.37 | **0.003** |

[9] df is degrees of freedom is the number of values in the final calculation of a statistic that are free to vary.
[10] MS is the Mean Square Between groups.
[11] Pseudo-F is the ratio of constrained and unconstrained total Inertia (variances), each divided by their respective ranks.
[12] *p*-value is the probability of obtaining a test statistic at least as extreme as the one that was actually observed, assuming that the null hypothesis is true

| Community structure | | | | |
|---|---|---|---|---|
| Source | df[9] | MS[10] | Pseudo-F[11] | P[12] |
| S(Y*T)*D | 14 | 11.38 | 2.99 | **0.009** |
| Residual | 24 | 4.2 | | |

**Table 7.3: Results of SIMPER analysis; identifying the eight plant taxa that contributed most strongly to differences between peatland vegetation communities located at and at distance from overhead line structure.**

| Taxon | Mean rank cover (at pylons) | Mean rank cover (at distant structure ) | Contribution to dissimilarity (%) | Cumulative contribution (%) |
|---|---|---|---|---|
| *Sphagnum capillifolium* | 2.4 | 4.8 | 5.8 | 5.8 |
| *Sphagnum denticulatum* | 2.7 | 3.5 | 4.3 | 10.2 |
| *Carex panicea* | 2.6 | 2 | 4.3 | 14.4 |
| Other Bryophytes | 6.1 | 7.8 | 4.2 | 18.6 |
| *Eriophorum angustifolium* | 2.1 | 3.2 | 4 | 22.6 |
| *Molinia caerulea* | 5.3 | 4.8 | 3.7 | 26.3 |
| *Scleropodium purum* | 2.1 | 2.3 | 3.3 | 29.6 |
| *Cladonia portentosa* | 1.3 | 2.5 | 3.1 | 32.7 |

**Table 7.4: Results of (a) PERMANOVA and (b) permutational ANOVA testing for an effect of distance from overhead line structure on the community structure and taxon richness of grassland plants.** Significant ($P < 0.05$) values are highlighted in bold.

| | Source | df | MS | Pseudo-F | P |
|---|---|---|---|---|---|
| (a) | Site, S | 4 | 3953.7 | 6.33 | **≤0.0001** |
| | Distance from structure, D | 1 | 704.5 | 0.9 | 0.49 |
| | D*S | 4 | 794.9 | 1.27 | 0.21 |
| | Residual | 8 | 624.3 | | |
| | **Source** | **df** | **MS** | **Pseudo-F** | **P** |

| | | | | | |
|---|---|---|---|---|---|
| | Site, S | 4 | 76.2 | 5.31 | **0.032** |
| | Distance from structure, D | 1 | 1.8 | 0.33 | 0.61 |
| **(b)** | D*S | 4 | 5 | 0.35 | 0.81 |
| | Residual | 8 | 14.4 | | |

## 7.3 QUALITATIVE PEATLAND RESULTS

Vegetation sampled at peatland sites was across three habitat types; blanket bog, raised bog and wet heath. Plates 7.1 to 7.8 show the vegetation typically encountered at relevé locations in peatland sites.

### 7.3.1 Change in species frequency

#### 7.3.1.1 Blanket Bog

The relevés placed adjacent to the structures on Blanket Bog showed a reduced frequency of White Beak-sedge (*Rhynchospora alba*), Deergrass (*Trichophorum cespitosum*), the bryophytes *Pleurozia purpurea, Sphagnum capillifolium* and *S. subnitens*, and also the lichen *Cladonia portentosa* when compared to the relevés at distance.

There was an increase in the frequency of graminoids such as Velvet Bent (*Agrostis canina*), Purple Moor-grass (*Molinia caerulea*) and Carnation Sedge (*Carex panicea*); and also an increase in Tormentil (*Potentilla erecta*) and Round-leaved Sundew (*Drosera rotundifolia*) at the relevés placed adjacent to the structures. The frequencies of species are shown in Table 7.5, and illustrated in the bar chart in Figure 7.9 where frequencies are converted to a 1-10 numeral scale for the bar chart.

**Plate 7.1: Bare peat around wooden poles in Raised Bog vegetation**
(Site 23 –Tables B5-6, Appendix B for species)

Plate 7.2: Sward at control relevé in Raised Bog vegetation
(Site 23 –Tables B5-6, Appendix B for species)

Plate 7.3: Standing water with *Rhynchospora alba* in Raised Bog vegetation
(Site 28 –Tables B11-16, Appendix B for species)

**Plate 7.4: Sward at control relevé in Raised Bog vegetation**
(Site 28 –Tables B5-6, Appendix B for species)

**Plate 7.5: Sward under tower in Blanket Bog vegetation**

(Site 18 –Tables B73-78, Appendix B for species)

**Plate 7.6: Sward at control relevé in Blanket Bog vegetation**

(Site 18 –Tables B73-78, Appendix B for species)

**Plate 7.7: Vegetation adjacent to wooden poles in Wet Heath vegetation**
(Site 49 –Tables B57-64, Appendix B for species)

**Plate 7.8: Sward at control relevé, with increased cover of bryophytes in comparison to vegetation at structure in Wet Heath vegetation**
(Site 49 –Tables B57-64, Appendix B for species)

Table 7.5: The frequency of occurrence of plant species in relevés placed in Blanket Bog, adjacent to the structure and at the control.

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| **Species** | **Frequency of occurrence at structure** | **Frequency of occurrence at control** |
|---|---|---|
| *Species with a **decreased** frequency of occurrence adjacent to structure* | | |
| *Eriophorum vaginatum* | absent | I |
| *Rhynchospora alba* | II | III |
| *Trichophorum cespitosum* | III | IV |
| *Hypnum jutlandicum* | absent | I |
| *Pleurozia purpurea* | absent | II |
| *Racomitrium lanuginosum* | absent | I |
| *Scleropodium purum* | IV | V |
| *Sphagnum capillifolium* | III | V |
| *Sphagnum denticulatum* | III | IV |
| *Sphagnum subnitens* | + | III |
| *Cladonia portentosa* | II | III |
| *Species with an **increased** frequency of occurrence adjacent to structure* | | |
| *Agrostis canina* | I | absent |
| *Carex panicea* | IV | III |
| *Drosera rotundifolia* | IV | III |
| *Molinia caerulea* | IV | III |
| *Myrica gale* | I | absent |
| *Pedicularis sylvatica* | I | absent |
| *Potentilla erecta* | III | II |
| *Schoenus nigricans* | I | + |
| *Succisa pratensis* | I | absent |
| *Ulex europaeus* | I | absent |
| *Aulacomnium palustre* | I | + |

| Species | Frequency of occurrence at structure | Frequency of occurrence at control |
|---|---|---|
| *Calliergonella cuspidata* | + | absent |
| *Polytrichum commune* | + | absent |
| *Sphagnum compactum* | I | + |
| *Sphagnum cuspidatum* | I | + |
| *Cladonia uncialis* | I | + |

The symbols denote the frequency of species as follows: V = Occurrence of in 81- 100% of quadrats; IV = Occurrence in 61 – 80% of quadrats; III = Occurrence in 41 – 60% of quadrats; II = Occurrence in 21 – 40% of quadrats; I = Occurrence in 11 – 20% of quadrats; + = Occurrence in 6 –10% of quadrats. Species recorded from < 5% of quadrats are omitted from this table.

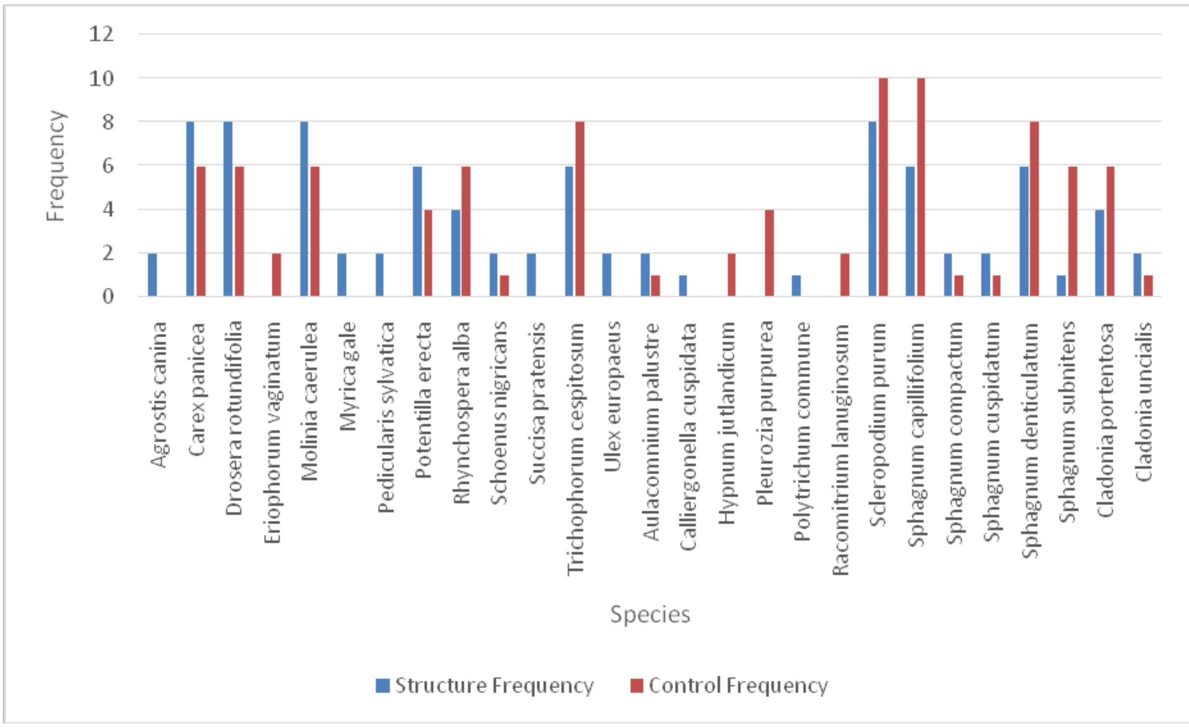



**Figure 7.9: Bar chart showing the frequency of occurrence of species recorded in all relevés adjacent to structures and at the controls (i.e at distance) placed 50m from the structure in Blanket Bog habitat.**

#### 7.3.1.2 Raised bog

Common Cottongrass (*Eriophorum angustifolium*) and Deergrass (*Trichophorum cespitosum*) were reduced in frequency adjacent to the structures in raised bog when compared with control samples; as were *Sphagnum capillifolium, S. denticulatum, S. papillosum, S. subnitens, S. tenellum* and *Cladonia portentosa.*

Graminoids increased in frequency adjacent to the structure when compared with control samples, with more Sweet Vernal-grass (*Anthoxanthum odoratum*), Carnation Sedge *(Carex panacea)*, Purple Moor-grass *(Molinia caerulea)*; and also the forb Tormentil *(Potentilla erecta)* recorded.

The frequencies of species are shown in Table 7.6, and illustrated in the bar chart in Figure 7.10 where frequencies are converted to a 1-10 numeral scale for the bar chart.

**Table 7.6: The frequency of occurrence of plant species in relevés placed in Raised Bog, adjacent to the structure and at the control.**

| Species | Frequency of occurrence at structure | Frequency of occurrence at control |
|---|---|---|
| *Species with a **decreased** frequency of occurrence adjacent to structure* | | |
| *Eriophorum angustifolium* | IV | V |
| *Eriophorum vaginatum* | absent | + |
| *Succisa pratensis* | I | III |
| *Trichophorum cespitosum* | I | III |
| *Hypnum jutlandicum* | absent | + |
| *Polytrichum commune* | + | I |
| *Scleropodium purum* | IV | V |
| *Sphagnum capillifolium* | III | V |
| *Sphagnum cuspidatum* | absent | + |
| *Sphagnum denticulatum* | III | IV |
| *Sphagnum papillosum* | I | II |
| *Sphagnum subnitens* | + | III |
| *Sphagnum tenellum* | I | II |
| *Cladonia portentosa* | II | III |

| Species | Frequency of occurrence at structure | Frequency of occurrence at control |
|---|---|---|
| *Species with an* ***increased*** *frequency of occurrence adjacent to structure* | | |
| *Anthoxanthum odoratum* | I | absent |
| *Carex panicea* | IV | III |
| *Molinia caerulea* | IV | III |
| *Polygala serpyllifolia* | II | I |
| *Potentilla erecta* | III | II |
| *Ulex europaeus* | I | absent |
| *Calliergonella cuspidata* | I | absent |
| *Sphagnum compactum* | I | absent |

The symbols denote the frequency of species as follows: V = Occurrence of in 81- 100% of quadrats; IV = Occurrence in 61 – 80% of quadrats; III = Occurrence in 41 – 60% of quadrats; II = Occurrence in 21 – 40% of quadrats; I = Occurrence in 11 – 20% of quadrats; + = Occurrence in 6 –10% of quadrats. Species recorded from < 5% of quadrats are omitted from this table.

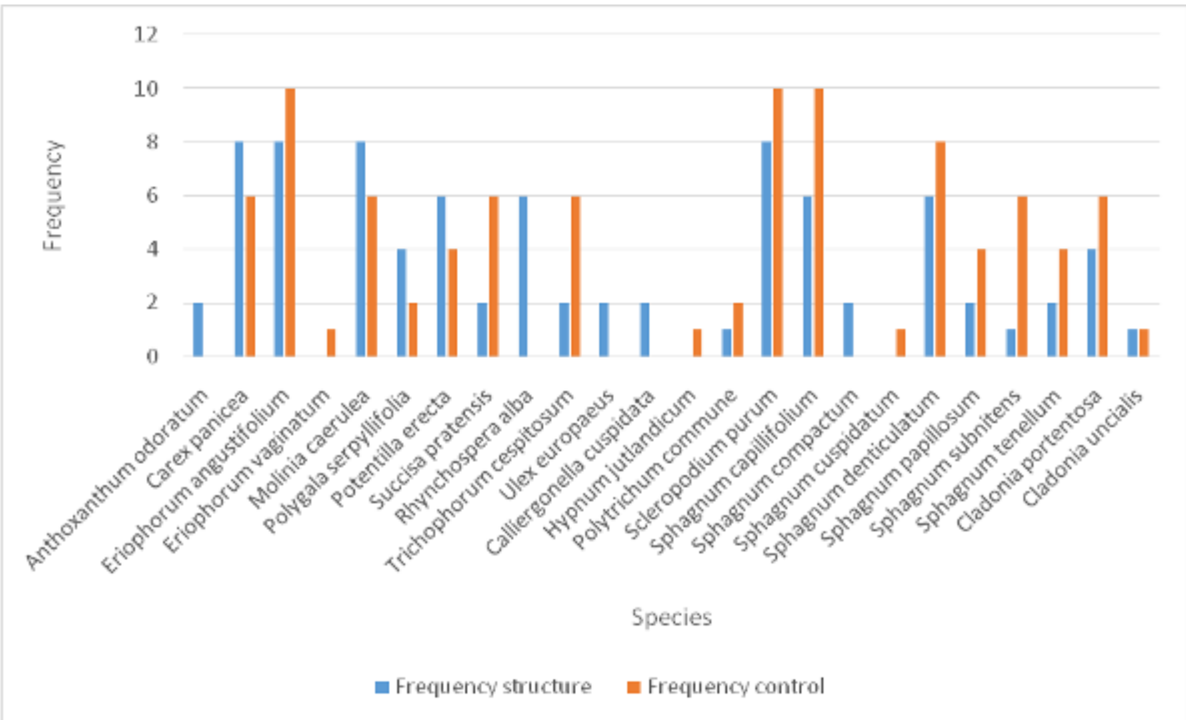



**Figure 7.10: Bar chart showing the frequency of occurrence of species recorded in all relevés adjacent to structures and at the controls (i.e at distance) placed 50m from the structure in Raised Bog habitat.**

#### 7.3.1.3 Wet Heath

The relevés adjacent to the structures in Wet Heath showed a reduced frequency in Common Cottongrass (*Eriophorum angustifolium*) and Deergrass (*Trichophorum cespitosum*) when compared with control samples; and also less Tormentil *(Potentilla erecta)* and Heath Milkwort (*Polygala serpyllifolia*). Bryophytes *Aulocomnium palustre, Scleropodium purum, Sphagnum capillifolium, S. papillosum, S. subnitens* and *S.tenellum* were reduced in frequency, as was *Cladonia portentosa.*

There was a marked increase in Graminoids adjacent to the structures in Wet Heath, with increases recorded in Velvet Bent *(Agrostis canina)*, Common Bent (*Agrostis capillaris*), Sweet Vernal-grass *(Anthoxanthum odoratum)*, Sheep's Fescue (*Festuca ovina*), Mat-grass (*Nardus stricta*) and Common Yellow-sedge (*Carex viridula* subsp. *oedocarpa*). There was an increase in rushes, particularly Jointed Rush (*Juncus articulatus*) and Soft Rush (*J. effusus*) and also Lousewort (*Pedicularis sylvatica*) and the bryophyte *Polytrichum commune.*

The frequencies of species are shown in Table 7.7 below, and illustrated in bar charts presented as Figure 7.11 for vascular plants and Figure 7.12 for Bryophyte and Lichen species where frequencies are converted to a 1-10 numeral scale for the bar chart.

**Table 7.7: The frequency of occurrence of plant species in relevés placed in Wet Heath, adjacent to the structure and at the control.**

| Species | Frequency of occurrence at structure | Frequency of occurrence at control |
|---|---|---|
| *Species with a **decreased** frequency of occurrence adjacent to structure* | | |
| *Eriophorum angustifolium* | II | III |
| *Eriophorum vaginatum* | + | I |
| *Myrica gale* | absent | + |
| *Polygala serpyllifolia* | I | II |
| *Potentilla erecta* | IV | V |
| *Succisa pratensis* | + | I |
| *Trichophorum cespitosum* | III | IV |
| *Aulacomnium palustre* | I | II |
| *Breutelia chrysocoma* | absent | I |
| *Diplophyllum albicans* | absent | I |

| **Species** | **Frequency of occurrence at structure** | **Frequency of occurrence at control** |
|---|---|---|
| *Hypnum jutlandicum* | absent | + |
| *Pleurozia purpurea* | + | I |
| *Scleropodium purum* | II | III |
| *Sphagnum capillifolium* | II | V |
| *Sphagnum cuspidatum* | + | I |
| *Sphagnum papillosum* | I | II |
| *Sphagnum subnitens* | I | II |
| *Sphagnum tenellum* | absent | III |
| *Cladonia portentosa* | II | IV |
| *Cladonia uncialis* | + | II |
| *Species with an* ***increased*** *frequency of occurrence adjacent to structure* | | |
| *Agrostis canina* | III | absent |
| *Agrostis capillaris* | II | absent |
| *Anthoxanthum odoratum* | III | absent |
| *Carex echinata* | I | + |
| *Carex nigra* | + | absent |
| *Carex pulicaris* | I | absent |
| *Carex viridula ssp oedocarpa* | II | absent |
| *Cirsium palustre* | + | absent |
| *Cynosurus cristatus* | + | absent |
| *Danthonia decumbens* | I | absent |
| *Erica cinerea* | II | I |
| *Festuca ovina* | II | + |
| *Festuca rubra* | I | absent |
| *Galium saxatile* | I | absent |
| *Juncus acutiflorus* | + | absent |
| *Juncus articulatus* | I | absent |

| **Species** | **Frequency of occurrence at structure** | **Frequency of occurrence at control** |
|---|---|---|
| *Juncus bufonius* | + | absent |
| *Juncus bulbosus* | I | + |
| *Juncus effusus* | II | absent |
| *Leontodon autumnalis* | + | absent |
| *Luzula sp* | + | absent |
| *Nardus stricta* | II | + |
| *Pedicularis sylvatica* | III | II |
| *Rhynchospora alba* | I | + |
| *Taraxacum agg* | + | absent |
| *Ulex europaeus* | + | absent |
| *Vaccinium myrtillus* | I | absent |
| *Calliergonella cuspidata* | + | absent |
| *Campylopus flexuosus* | I | absent |
| *Fissidens osmundoides* | + | absent |
| *Hylocomnium splendens* | I | absent |
| *Polytrichum commune* | II | absent |
| *Rhytidiadelphus loreus* | I | + |

The symbols denote the frequency of species as follows: V = Occurrence of in 81- 100% of quadrats; IV = Occurrence in 61 – 80% of quadrats; III = Occurrence in 41 – 60% of quadrats; II = Occurrence in 21 – 40% of quadrats; I = Occurrence in 11 – 20% of quadrats; + = Occurrence in 6 –10% of quadrats. Species recorded from < 5% of quadrats are omitted from this table.

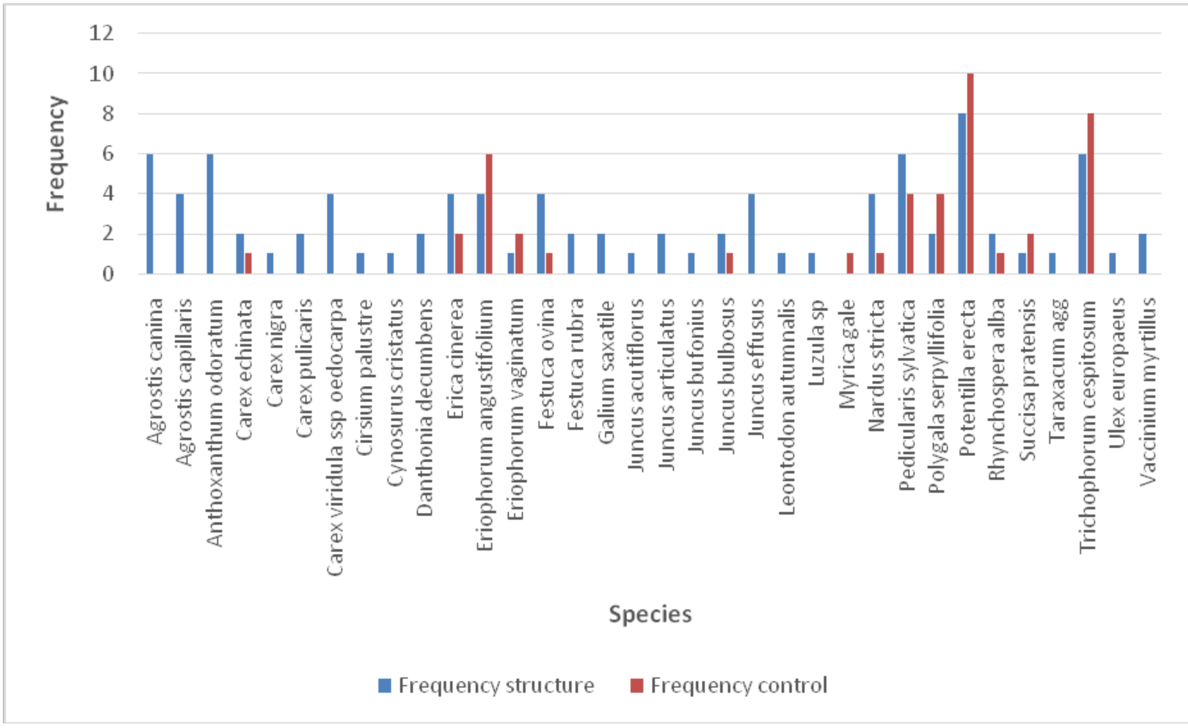



**Figure 7.11: Bar chart showing the frequency of occurrence of species recorded in all relevés adjacent to structures and at the controls (i.e at distance) placed 50m from the structure in Wet Heath habitat.**

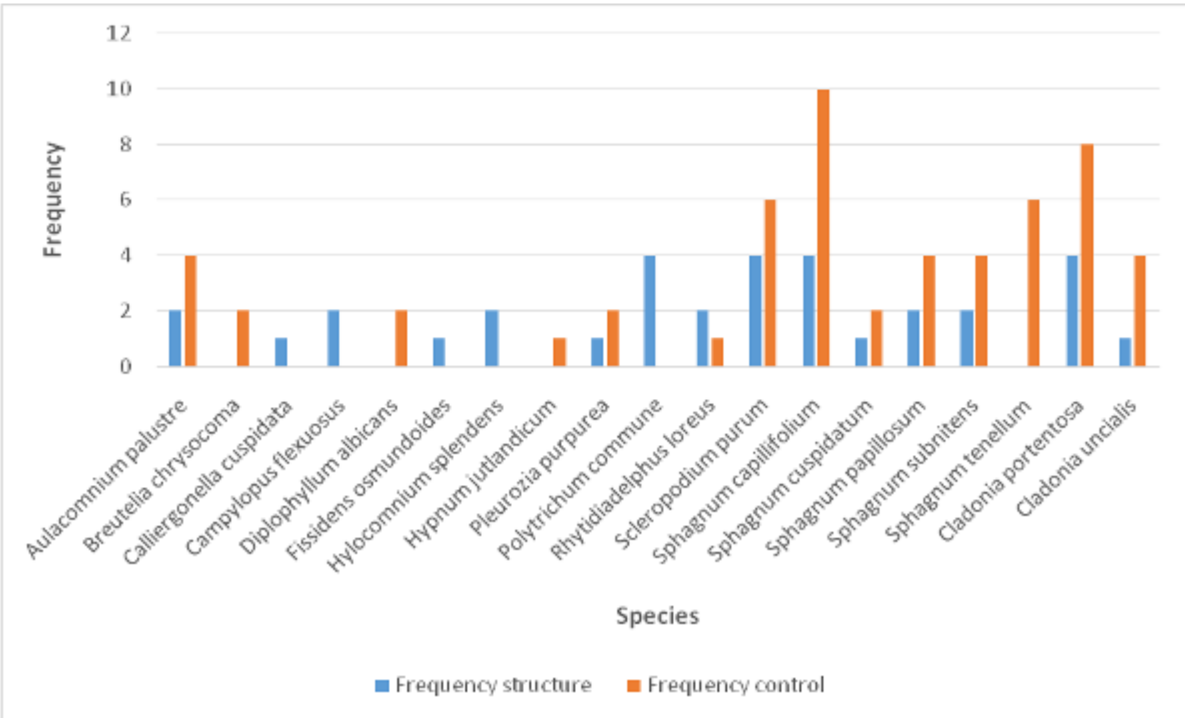



**Figure 7.12: Bar chart showing the frequency of occurrence of bryophyte and lichen species recorded in all relevés adjacent to structures and at the controls (i.e at distance) placed 50m from the structure in Wet Heath habitat.**

The main differences in frequency of species recorded at the structures in wet peat habitats when compared to the control relevés, were a reduction in species such as Common Cottongrass and Deergrass at the structure; and a reduction of sphagnum, particularly *Sphagnum capillifolium* and *S. subnitens*.

There was an increase in graminoids at the structures compared to the control, in particular, Bent grasses (*Agrostis spp*), Purple Moor-grass *(Molinia caerulea)* and Carnation Sedge *(Carex panicea)*. There was also an increase in bare peat and standing water adjacent to the structures, and White-beak Sedge *(Rhyncospora alba)* and Round-leaved Sundew *(Drosera rotundifolia)* have colonised some of these areas.

#### 7.3.1.4 General trend for peatland sites

There are differences in species frequencies across the habitats, but with a common pattern of increasing frequency of Graminoids (including Velvet Bent, Purple Moor-grass and Carnation Sedge) adjacent to the structures when compared to the control relevés. For wet heath in particular, there was a marked increase in Graminoid frequency and also an increase in frequncy of Rush (*Juncus*) species. Conversely, a trend of decreasing frequency was observed at peatland sample sites for Cottongrass *(Eriphorum spp.)*, Deergrass *(Tricophorum cespitosum)* and certain *Sphagnum* mosses and *Cladonia* lichen species. Tormentil *(Potentilla erecta)* frequency increased at structures in bog habitats, but decreased at structures in heath habitat. This correlates with Table 7.3 in Section 7.2 describing results of Similarity percentages species contributions (SIMPER) analysis identifying the eight plant taxa that contributed most strongly to differences between peatland vegetation communities located at and at distance from overhead line structure.

## 7.4 QUALITATIVE GRASSLAND RESULTS

Vegetation was surveyed at grassland sites comprising four habitat types; Dry calcareous and neutral grassland, Semi-natural dry grassland, Dry meadows and grassy verges, and improved agricultural grassland. Only the latter habitat occurred at more than one site. Plates 7.13 to 7.16 show the vegetation typically encountered at relevé locations in grassland sites.

### 7.4.1 Change in species frequency

Relevés placed adjacent to the structure on grassland showed a reduced frequency of Sweet Vernal-grass *(Anthoxanthum odoratum)*, Cock's-foot (*Dactylis glomerata*), Red Clover (*Trifolium pratense*) and Eyebright (*Euphrasia agg.*) when compared to the control.

There was an observed increase in frequency of scrub adjacent to the structures, with species including Hawthorn (*Crataegus monogyna*), Blackthorn (*Prunus spinosa*) and Juniper (*Juniperus communis*).

Other species that showed an increased frequency adjacent to the structure include grasses such as False Oat-grass (*Arrhenatherum elatius*), Perennial Rye-grass (*Lolium perenne*), Red Fescue (*Festuca rubra*) and Sheep's Fescue *(Festuca ovina)*; and forbs including Greater Plantain (*Plantago major*), Selfheal (*Prunella vulgaris*), Meadow Buttercup (*Ranunculus acris*), Autumn Hawkbit (*Leontodon autumnalis*), Common Mouse-ear (*Cerastium fontanum*) and Common Bird's-foot-trefoil (*Lotus corniculatus*).

The frequencies of species are shown in Table 7.8, and illustrated in the bar chart in Figure 7.17 where frequencies are converted to a 1-10 numeral scale for the bar chart.

**Plate 7.13: Scrub growth under structure in Semi-natural dry grasslands [6210]**
(Site G4 – refer Tables C4-C6, Appendix C for species)

**Plate 7.14: Sward at control relevé in Semi-natural dry grasslands [6210]**
(Site G4 – refer Tables C4-C6, Appendix C for species)

**Plate 7.15: Long sward adjacent to fenced off structure in Improved Agricultural Grassland**
(Site G9 – refer Tables C13-C18, Appendix C for species)

**Plate 7.16: Heavily grazed sward at control relevé in Improved Agricultural Grassland**
(Site G9 – refer Tables C13-C18, Appendix C for species)

Table 7.8: The frequency of occurrence of plant species in relevés placed in grassland, adjacent to the structure and at the control**.**

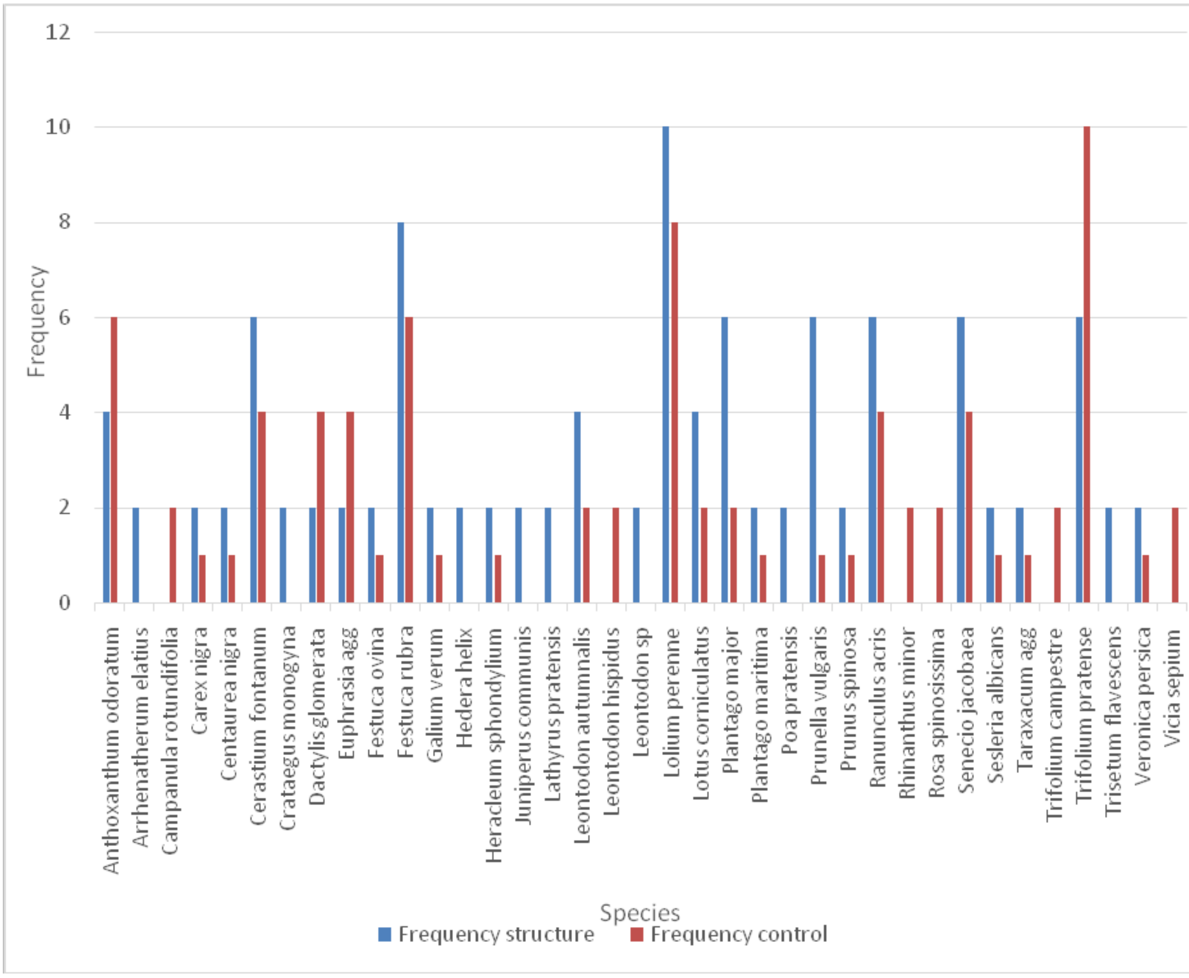
| **Species** | **Frequency of occurrence at structure** | **Frequency of occurrence at control** |
|---|---|---|
| *Species with a **decreased** frequency of occurrence adjacent to the structure* | | |
| *Anthoxanthum odoratum* | II | III |
| *Campanula rotundifolia* | absent | I |
| *Carlina vulgaris* | absent | + |
| *Dactylis glomerata* | I | II |
| *Euphrasia agg* | I | II |
| *Galium aparine* | absent | + |
| *Leontodon hispidus* | absent | I |
| *Orchid sp* | absent | + |
| *Poa sp* | absent | + |
| *Potentilla erecta* | absent | + |

| Species | Frequency of occurrence at structure | Frequency of occurrence at control |
|---|---|---|
| *Rhinanthus minor* | absent | I |
| *Rosa spinosissima* | absent | I |
| *Rumex crispus* | absent | + |
| *Rumex obtusifolia* | absent | + |
| *Trifolium campestre* | absent | I |
| *Trifolium pratense* | III | V |
| *Vicia sepium* | absent | I |
| *Species with an* ***<u>increased</u>*** *frequency of occurrence adjacent to the structure* | | |
| *Arrhenatherum elatius* | I | absent |
| *Carex nigra* | I | + |
| *Centaurea nigra* | I | + |
| *Cerastium fontanum* | III | II |
| *Crataegus monogyna* | I | absent |
| *Festuca ovina* | I | + |
| *Festuca rubra* | IV | III |
| *Galium verum* | I | + |
| *Hedera helix* | I | absent |
| *Heracleum sphondylium* | I | + |
| *Juniperus communis* | I | absent |
| *Lathyrus pratensis* | I | absent |
| *Leontodon autumnalis* | II | I |
| *Leontodon sp* | I | absent |
| *Lolium perenne* | V | IV |
| *Lotus corniculatus* | II | I |
| *Plantago major* | III | I |
| *Plantago maritima* | I | + |
| *Poa pratensis* | I | absent |

| Species | Frequency of occurrence at structure | Frequency of occurrence at control |
|---|---|---|
| *Prunella vulgaris* | III | + |
| *Prunus spinosa* | I | + |
| *Ranunculus acris* | III | II |
| *Senecio jacobaea* | III | II |
| *Sesleria albicans* | I | + |
| *Taraxacum agg* | I | + |
| *Trisetum flavescens* | I | absent |
| *Veronica persica* | I | + |

The symbols denote the frequency of species as follows: V = Occurrence of in 81- 100% of quadrats; IV = Occurrence in 61 – 80% of quadrats; III = Occurrence in 41 – 60% of quadrats; II = Occurrence in 21 – 40% of quadrats; I = Occurrence in 11 – 20% of quadrats; + = Occurrence in 6 –10% of quadrats. Species recorded from < 5% of quadrats are omitted from this table.

**Figure 7.17: Bar chart showing the frequency of Vascular plant species recorded in relevés adjacent to structures and at the controls placed 50m from the structure in grassland habitats.**



# 8 DISCUSSION OF RESULTS

## 8.1 OVERVIEW

As outlined in Section 1.2 of this report, the objective of this habitat study was to '*investigate the impacts of the construction and presence of high voltage transmission infrastructure on natural and semi-natural habitats in Ireland'* by conducting a thorough literature review, developing a field survey methodology using standard botanical methodology to collect data and subjecting the data collected to analysis to test four questions regarding possible changes in vegetation community structure (1) caused by the presence of high voltage support structures and (2) time elapsed since construction.

This Chapter firstly discusses results specifically in relation to the questions posed. It then looks at the applicability of the results in relation to EcIA as part of EIA, a procedural step in the consenting regime for new transmission infrastructure.

## 8.2 QUESTIONS POSED

The stated study questions were –

1. Does the vegetation community vary between relevés at structures and relevés at a distance from structures?
2. Is species richness reduced close to overhead line structures?
3. Does the length of time since overhead line structure construction affect vegetation community or species richness?
4. Is there a difference between the effect of wooden polesets and towers (angle masts) on either vegetation community or species richness?

### 8.2.1 Questions 1 and 2

**Does the vegetation community vary between relevés at structures and relevés at a distance from structures and is plant taxon richness reduced close to overhead line structures?**

In relation to Question 1, analysis of peatland data showed that there was a significant interaction between sample location and distance from overhead line structure on the community structure.

In relation to Question 2, analysis of peatland data showed that there was a significant interaction between site and distance from overhead line structure on the species richness of plants.

In relation to Question 1, analysis of grassland data showed that there was no significant interaction between site and distance from overhead line structure on the community structure.

In relation to Question 2, analysis of grassland data showed that there was no significant interaction between site and distance from overhead line structure on the species richness of plants.

Changes in community structure and taxon richness which were detected do not indicate a change in habitat type categorised by Fossitt (2000). Instead changes are more subtle, perhaps indicating a shift along the NW European mire community floristic gradient described by Wheeler and Proctor (2000), or within the mire and heath sub-communities of the British National Vegetation Classification (NVC) (Rodwell, 1991).

Changes in species frequency and SIMPER analysis as described in Chapter 6 generally indicate an increase in Graminoids and a decrease in certain *Sphagnum* mosses and *Cladonia* lichens, and the Bryophyte layer generally at an overhead line structure when compared with control sites. This is likely a result of ground disturbance and compaction for structure placement altering the hydrological and possibly nutrient regime at that location, but there are other factors at play which may also influence vegetation. (Section 8.3.2 for more detail).

### 8.2.2 Questions 3 and 4

**Does the length of time since overhead line construction, or a difference in structure type affect vegetation community structure or diversity on peatlands?**

Analysis of peatland data showed that neither the number of years since construction nor the type of structure had a statistically significant effect on overall plant community structure or plant taxon richness.

Section 6.2 'Site Selection' outlines how the study team arrived at the sampling sites for survey. All grassland vegetation was surveyed at towers (or control sites). Therefore no wooden poleset data was gathered. Information on the time of the last significant construction event was not available for all grassland sites until after site selection had been undertaken as detailed in Tables 6.2 and subsequently surveyed as detailed in Table 6.4. As the tables show, most sites sampled were within a 20+ year construction grouping. Consequently, *Structure* and *Years since construction* were omitted from analyses of grassland vegetation data.

The authors had no prior expectation in answer to this question. This was in part due to the sample number and its associated power of detection through analysis, and in part due to the crudity of 'time elapsed' groupings. The implications of this are discussed below.

## 8.3 RELEVENCE OF FINDINGS TO ECOLOGICAL IMPACT ASSESSMENT

Chapter 5 outlines the framework against which new transmission projects are assessed under the EIA Directive (Section 2.5). EirGrid have published sectoral specific guidelines to standardise EcIA in relation to transmission projects (Flynn and Nairn, 2012).

Some key findings arise from this original case study which can be applied to EcIA for transmission projects.

### 8.3.1 Literature Review

Published research on the direct effects of constructing overhead powerlines is scarce. A small body of literature exists on how powerline ROW or easements are utilised by faunal groups and ruderal, opportunistic plant species to disperse and colonise new habitats created by the transmission corridor, but this is not directly applicable to the Irish Grid, as ROWs are not used here. There is very little published research which has measured the response of habitats to the construction of powerlines and described how their vegetation communities have changed.

The sample of EIS documents reviewed (Table 5.2) suggests that residual impacts as predicted on a number of new build transmission projects are chiefly minor negative, and temporary in scale. Whilst this is clearly a body of literature documenting *ex-ante* predictions made by professionals and experts in the field, it is worth noting that published EIS documents relating to overhead line projects concluding significant adverse effects upon habitats were not found.

The literature review component of this study reaffirms the notion that impact assessment in relation to the effect of powerlines on habitats remains a subjective discipline, reliant on a wider body of literature describing impacts of various construction activities on a range of habitat types, supplemented with personal experience and observation on construction sites. Lindsay and Freeman (2008) note that the quantifiable footprint of pylon bases can easily be underestimated and that permanent footprint (or habitat loss) due to overhead line construction can be overlooked if the impact assessor is not overly familiar with actual line construction.

The field based element of this study has however, provided some primary research to supplement the knowledge base in this field.

### 8.3.2 Differences in vegetation community structure

Some local changes in vegetation community structure and floristic richness were detected in response to transmission infrastructure being constructed, when compared with sites at distance.

These changes were statistically significant for peatland sites only. It is important to note that many factors influence plant community floristics, notably soil type, topography, climate, nutrient input, grazing and land management. One might wonder to what degree a particular historic event (such as construction and erection of an overhead line structure ) has influenced the vegetation community as it is today when considered as part of a wider dynamic of influencing factors. Whilst these other untested and unmeasured factors need to be taken into account in the interpretation of the case study results, visual clues in the field are important. If on the one hand it appears the habitat is only degraded at the base of a structure when compared to the surrounding habitat, this can be taken as a good indication that the contruction event was responsible for that vegetation change. On the other hand, an absence of visual clues in relation to differences in habitat degradation may suggest that the land management is influencing vegetation to a greater degree (e.g. if erosion from sheep grazing is evident throughout the site).

Some of the visual clues discussed above were observed in both the larger dataset collected from peatland sites and the smaller dataset collected from grassland sites. Plant communities sampled adjacent to an overhead line structure tended to have increased cover of some Graminoid species including *Carex panicea, Molinia caerulea* and *Eriophorum angustifolium,* and reduced relative cover of the Bryophyte layer; notably some *Sphagnum* species. These findings align with those of Farrell (2007) where *Molinia* increased at the construction site, but with the caveat that other factors may also be influencing vegetation response.

Regarding increased cover of *C. panicea, M. caerulea* and *E. angustifolium*, the former two are widely distributed species occurring in a broad range of habitats. Similarly, *E. angustifolium* has the widest distribution of all *Eriophorum* species, characterising its ability to colonise a greater variety of habitat types and hydrological regimes. The increased relative richness of these species at the site of former construction likely indicates them being opportunistic species which have a more rapid growth rate and thereby recolonise faster than species more typically indicative of these habitats, and also their greater tolerance to disturbance and ability to persist in a micro-environment subject to significant disruption of the hydrological regime as would be expected after a construction event to erect transmission infrastructure.

Regarding decreased cover of a number of bryophytes including *Sphagnum* and *Scleropodium* species, and the lichen *Cladonia portentosa*, this likely indicates the greater dependency of these species on more stable and specific hydrological regimes, and allied to this is their reduced tolerance to disturbance and ability to persist in a micro-environment subject to significant disruption of the hydrological regime as would be expected after a construction event to erect transmission infrastructure (Renou-Wilson *et al*. 2011).

Table 7.6 lists 8 species of bryophyte which decreased adjacent to a structure in raised bog and Table 7.7 lists 9 species of bryophyte which decreased adjacent to a structure in wet heath habitat. This highlights the increased vulnerability and susceptibility of peatland habitats in particular to changes in hydrological regime and concurs with the findings of Magnusson and Stewart (1986).

The case study finding that scrub species and generalist graminoid species increased adjacent to a structure in the grassland sites (Table 7.8) again suggests that species more tolerant to disturbance and with less specific requirements are more likely to persist in a micro-environment subject to significant disruption.

It is important to note that changes in community structure and taxon richness detected by survey and subsequent analysis do not indicate a shift in habitat type categorised by Fossitt (2000). The change is more subtle, as outlined in Section 8.2.1 above, and this is discussed further in Chapter 9.

### 8.3.3 Differences in transmission system structure type

No difference in vegetation community structure could be attributed to erection of wooden polesets as opposed to steel towers with any degree of confidence based on data collected at the sites surveyed for this study. This too is an important point. Whilst the preparatory works for erecting a steel tower foundation and a wooden poleset differ, the residual effect upon vegetation community structure adjacent to the working footprint remains the same (whilst acknowledging that the quantum of habitat loss differs between these structure types due to the difference in scale of the structure bases).

### 8.3.4 Differences in time groups

This study has not revealed any statistically significant difference between vegetation data gathered from sites where construction occurred 10 years ago or less and those sites where construction occurred more than 20 years ago . Simple comparative observation of the relevé sheets between the time groups does suggest a small degree of increased taxon richness at sites where construction has occurred within the last 10 years as opposed to structures where construction has not occurred for at least 20 years. This broadly supports the discussion in Section 8.3.2 on differences in vegetation community structure, whereby opportunistic and more generalist species will readily colonise an area after construction but will gradually be outcompeted over time[13].

### 8.3.5 *Ex-ante* impact prediction

On balance, the results of this study, both literature review and case study, suggest a broad alignment with the range of impact predictions as detailed in Table 5.2 in that residual effects were mainly predicted to be minor and the case study showed that the broad habitat type does not change after construction. In Table 5.2, professional ecologists mostly predicted impacts of a minor or slight

[13] Generally not applicable to invasive species that dominate and outcompete typically, native species.

magnitude, although the temporal scale of the stated effect is not always apparent. Where stated, temporal scale of effect is mostly temporary or short-term, which aligns well with Farrell (2007) and EcoFys (2008).

The available evidence outlined earlier in this report shows that powerline construction within the habitats noted in those examples in general rarely produces significant effects. Inevitably, some projects will result in significant adverse effects, such as those not identified for blanket bog in the Lewis Wind Power EIA reports as suggested by Lindsay and Freeman (2008).

The evidence based research supports the common consensus of impact predictions according to the EIS reports listed in Table 5.2. In general, impacts to these sensitive habitats as a result of powerline construction are rarely significant.

This study has been unable to add scientific certainty to the temporal scale of effect on habitats, and this is discussed further in Chapter 9. This in itself may also support the temporal scale of *ex-ante* predictions being short term or temporary as cited in this report.

# 9 CONCLUSIONS AND RECOMMENDATIONS

This Chapter provides a closing discussion on how this study is of relevance to the expansion of the Irish transmission network under Grid25, and how it can inform any future Evidence Based Design and Ecological Impact Assessment (EcIA) Guidelines. It recommends potential improvements to the sampling strategy employed.

## 9.1 RELEVENCE OF FINDINGS TO GRID25

This study and other Evidence-Based Studies that have been commissioned in response to the Strategic Environmental Assessment of EirGrid's Grid25 Implementation Programme, aim to inform the knowledge base for EIA for transmission projects in Ireland. New information to reduce potential negative environmental effects at both a plan and project level will be used in Design Guidelines and be applied to individual transmission projects.

### 9.1.1 Evidence Based Design Guidelines

Chapter 3 presents a summary of current practice for overhead transmission line construction in Ireland, distilled from decades of experience by ESB staff and contractors in the field. Any new overhead line construction project will result in an assortment of ecological effects, unique to that project. During the planning phases along an EirGrid Project Development Roadmap, Stage 1 '*Information Gathering'* is the optimum stage to avoid high value habitat types which are often associated with difficult ground conditions (e.g. blanket bog or fen).

National datasets of designated Natura 2000 sites, NHAs (and pNHAs) are considered at this desktop constraint stage, and 'best available' national habitat dataset are acquired by EirGrid to facilitate avoidance of Annex I habitats, particularly outside of the Natura 2000 network, from the outset. This study relied heavily on the National Parks and Wildlife Service (NPWS) dataset, and concluded that it is an invaluable Geographic Information System (GIS) tool, albeit with gaps and limitations. NPWS update their database from time to time, and EirGrid's Grid25 PMO receive these updates to employ in Stage 1 on the Project Development Roadmap to facilitate a 'standardised approach' as required by their EcIA Guidelines.

Stage 3 of the Project Development Roadmap is where line design occurs, and structure types and spans are outlined in a preliminary design. Here, the emphasis should be on minimising footprint by employing novel methods of construction to reduce ground disturbance on sensitive habitats and compaction at structure locations. This already occurs as evidenced by Appendix 5 to EirGrid's EcIA

Guidelines. In conclusion, EirGrid already employ best available techniques to avoid or mitigate impacts on high value habitat types. No further commentary is required.

### 9.1.2 Ecological Impact Assessment Guidelines

#### 9.1.2.1 Classification criteria

As noted previously, changes in vegetation community structure and taxon richness were detected, but they did not indicate a change in broad habitat type categorised by Fossitt (2000). Changes were more subtle than this. It is recommended that on high value or Annex I habitats, survey should be planned to allow for vegetation classification based on a more sensitive system, such as the NVC, (Rodwell 1991), Wheeler & Proctor (2000), or the recent provisional vegetation classification system (Perrin & Hodd, 2013) as an output of the NPWS funded National Survey of Upland Habitats 2008-2013 (final report).

#### 9.1.2.2 Magnitude, Extent and Duration of Effect

This study has concluded that vegetation community structure is different between relevés adjacent to an overhead line structure and control relevés. Vegetation at any location is heavily dependent on a range of edaphic, climatic and land management factors (e.g. Goosem & Turton, 2000) and the degree to which it changes varies greatly depending on a wide range of site specific conditions, many of which were not quantified as part of this study (Section 9.2.1).

Statistically significant changes in vegetation community structure were recorded on peatland sites at the location of transmission structureswhen copared to control sites. The observed changes were subtle and habitat type did not change between experimental and control location. It must however be noted that other factors also influence vegetation cover, as discussed previously in this report.

This study was not specifically designed to test the extent of detectable vegetation change from the source outwards to the control. This could be undertaken as a follow up project by sampling relevés at points along a transect, as discussed in Section 9.2.2.

As previously noted, this study has been unable to add scientific certainty to the temporal scale of effect on habitats. This was in part due to the sample number and its associated power of detection through analysis, and in part due to the crudity of ‘time elapsed’ groupings.

#### 9.1.2.3 Monitoring

Ecological monitoring may occur at Stage 5 of a transmission project (as per Project Development Roadmap) if stipulated as part of mitigation in an EIS or as conditioned by the Planning Authority. This is dealt with briefly in EirGrid's Ecology guidelines for Transmission projects (Flynn and Nairn, 2012).

If a new build overhead line project were to be consented within a Special Area of Conservation it would be highly recommended that prior to construction, vegetation sampling along the project corridor would be undertaken and repeated after 5 years , As asset owner of the built infrastructure, ESB Networks should support such a monitoring programmewhich could potentially be allied to any proposed refinement or evolution of this study as discussed in Section 9.2.

## 9.2 REFINEMENT OF THE CASE STUDY

### 9.2.1 Limitations of the Study

As discussed in Section 6.1 on site selection, some difficulties were encountered in using desk-based GIS and web-based resources to determine where the transmission grid crossed desired habitats. Some habitat types were removed from further consideration as no transmission infrastructure could be found to occur on these habitats. These included [8240] limestone pavement; [7230] alkaline fen; or [91A0] old sessile oak woods with Ilex and Blechnum in the British Isles. At the next stage some sites were dropped from the study as they did not meet the criteria for site selection. One key limiting factor in selecting sites for study by desktop methods was the absence of a comprehensive and accurate national dataset of habitat classification. The Annex I database held by NPWS is an amalgam of various research project outputs over the past twenty years. EirGrid do not possess (and nor do ESB Networks) a dataset of habitat classification covering the full existing grid and indeed it is not within their core remit to do so.

It is important to note that many factors influence plant community floristics, notably soil type, topography, climate, nutrient input, grazing and land management. One might wonder to what degree a particular eventsuch as overhead power line construction 10 years ago has influenced the vegetation as it is today. It was beyond the scope of this study to quantitatively gather data on all the major influences contributing to vegetation at study sites. Therefore the study does not purport to fully explain the differences in plant community vegetation within habitats or between time or structure groups.

### 9.2.2 Refining a sampling strategy

If further study was to be considered, it is recommended that the transmission grid is catalogued into time groups in a GIS database to facilitate design of a study with a balanced blend of time groupings across a range such as 0-2yrs; 2-5yrs; 5-10yrs, 10-20yrs; and 20+yrs as originally envisaged by this study. Once it has been established which sites are to be studies and they have been divided into the groupings required (habitat type; structure type; time elapsed), a sample size should be chosen.

The minimum recommended sample size for the questions posed in this study is 2, and preferably 3 (or more) structure sampling points per site, which requires sampling both close to and at a standardised distance from structures. Further, the power of statistical analysis to detect effects of transmission construction as revealed by the analyses in this study suggests a minimum of ten separate sites per habitat or time group category.

In order to test the extent of detectable vegetation change from the source of construction outwards to a control point, a further iteration to the experiment / control sampling strategy would be to undertake relevé sampling at points along a transect, for example at 0m; 5m; 10m; 20m; 30m; and 50m from a structure. If sufficient data is collected from a range of site locations, it may be possible to determine the extent to which a construction effect can be measured by vegetation cover changes.

The scope of this case study primarily aimed to determine if changes in vegetation community structure caused by the presence of high voltage support structures could be attributed at a level of statistical significance and also to test whether these changes varied with time elapsed since construction. The method employed was not designed to test the spatial extent of detectable, statistically significant vegetation change.

A robust finding in this regard may be of greater benefit toward informing *ex-ante* predictions made by professional ecologists by providing a body of evidence on spatial extent of detectable vegetation change based on measured *ex-post* effects. This would go some way towards providing more certainty as to the extent of habitat effects, and particularly in sensitive peatlands, for consenting authorities as part of EIA and possibly also Appropriate Assessment (AA). Under Article 191 of the Lisbon Treaty (OJEU, 2007), European environmental policy including the EIA and Habitats & Species Directives, continue to be based on the precautionary principle (EC, 2000) which exists in order to protect the environment where any uncertainty remains as to the significance of potential impacts.

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# APPENDIX A

# OVERVIEW OF ELECTRICITY TRANSMISSION INFRASTRUCTURE, INCLUDING TYPICAL CONSTRUCTION METHODOLOGY

# A1 Description of Typical Electricity Transmission Project Designs

The transmission network in Ireland comprises structures and overhead lines, underground cables and substations. When the need for a new circuit is identified in Ireland, EirGrid will consider all available solutions for the new circuit. This will include overhead line and underground cable solutions, considering both High Voltage Alternating Current (HVAC) and High Voltage Direct Current (HVDC) technology, as appropriate.

Factors which will influence the solution decision include technical, economic and environmental considerations. It is important to note that each project is different and EirGrid will determine potential technology solutions on a project-by-project basis. EirGrid will continue to keep technology developments under review and will consider new technologies as appropriate.

## A1.1 Overhead Lines (OHL)

Transmission lines are generally supported on either wooden pole sets or steel lattice towers. Towers along a straight of the alignment are known as intermediate towers. Angle towers are used where a line changes direction and conductors are held under tension.

The type and height of structures required will vary according to the voltage of the overhead line, and the location and type of environment and terrain in which they are placed.

## A1.2 Structure Design

For all new electricity transmission projects, efficient, appropriately placed and optimally designed structures are carefully considered and proposed. The design employed depends on the local environment, topography and technologies involved, and will vary from 110 kV, 220 kV or 400 kV, depending on the specific transmission need identified.

The spacing between structures depends on technical limitations and on the topography, particularly to ensure that conductors maintain a specific minimum clearance above the ground at all times.

**Steel Lattice Tower Structures**
The weight of conductors and characteristics of 220 kV and 400 kV lines require that they be supported exclusively on lattice steel structures (this also applies to angle towers along a 110 kV line). The three phases (conductors) of a circuit are carried in a horizontal plane.

**Table A1: Key Design Features: Single Circuit 220 kV and 400 kV overhead line structures**

| Key Design Features | 220 kV Indicative Range | 400 kV Indicative Range |
|---|---|---|
| Height range | Depends on technical details of individual projects but generally between 20-40m | Depends on technical details of individual projects but generally between 20m -52m |
| Maximum range of width at ground level | 6m to 12m | 7m to 12m |
| Number of foundations per structure | 4 | 4 |
| Average span between towers | Approx. 320m (dependent on local topography) | Approx. 350 (dependent on local topography) |

**Example of a 400 kV intermediate tower design along the Dunstown-Moneypoint overhead line, Co Clare**

**Example of a 220 kV intermediate tower design along the Cashla – Flagford overhead line, Co Roscommon**

**Single Circuit 110 kV Overhead Lines**

A 110 kV single circuit overhead line requires that conductors (and earth wires[1]) are supported on a combination of steel lattice angle towers and double wood intermediate polesets.

The average span between polesets for a 110 kV single circuit alignment is approximately 180m; however, the actual span achievable depends on local topography. Again, the three phases of the circuit are carried in a horizontal plane.

**Table A2: Key Design Features of Single Circuit 110 kV overhead line support structures**

| Key Design Features | 110 kV Indicative Range |
|---|---|
| Height range (double wood polesets) | 16m to 23m (incl. buried depth normally 2.3m) |
| Pole centres | 5m |
| Number of foundations | 2 |
| Height range (steel angle towers) | 18m to 24m |
| Maximum width at ground level | 4m to 9.8m |
| Average span | 180m |

**Example of a typical 110kV single-circuit double wood polesets with earthwire (Co Sligo)**

On an alignment there may arise a very slight change in direction, and this may necessitate, in the case of a 110 kV single-circuit line, the use of a braced wood poleset, wherein the space between the polesets is reinforced with steel members.

[1] Lines running above the conductors which protect the conductors from lightning strike.

**Braced double wood poleset**

**Double Circuit Overhead Lines**

Overhead alignments can be configured as single circuit or double circuit (two separate circuits supported on a single structure). This generally only occurs where two single circuit lines are in close proximity (for example on approach to a substation), or where space is at a premium.

Double circuit alignments, including 110 kV overhead lines, always require to be supported by lattice steel towers. The average number of structures on a line is 3-4 per km depending on topography. In addition, the structures are higher, as each circuit must be carried in a vertical plane.

**Typical 110 kV double circuit structures**

## A1.3 Construction of Overhead Lines

Overhead line construction typically follows a standard sequence of events comprising:

- Prepare access;
- Install tower foundations/Excavation;
- Erect towers or wood poles;
- Stringing of conductors;
- Reinstate tower sites and remove temporary accesses.

**Prepare Access**

It is preferable to have vehicular access to every tower site for foundation excavation, concrete delivery and a crane to erect towers. With wood pole construction, (on 110 kV single circuits) a crane is not usually required, as these are normally erected with a digger using a lifting arm.

Access can take various forms and is dependent on ground conditions. In poorer conditions, more complex access works are required which can vary from the laying of bog mats, or laying temporary wooden matting, to installing crushed stone roads. Some of this work may entail removal of topsoil.

Access routes may require to be constructed for both the construction and maintenance of the transmission line, and may be temporary or permanent.

Every effort is made to cause least disturbance to landowners and local residents, and to cause the least potential environmental impact during construction. As a result, the most direct access route to a tower installation may not always be the most appropriate.


**Example of a newly built access route for a transmission project, Co. Donegal**

**Install Tower Foundations/Excavation**

Tower foundations are typically 2–4m deep with excavation carried out by mechanical excavator. Excavations are set out specifically for the type of tower and the type of foundation required for each specific site.

A larger footing may be required in the case of weak soils. Pile foundations may be required in the case of deep bog. In the case of rock being encountered at shallow depths, reduced footing size foundations may be required.

Prior to excavation, the foundations for each tower site will be securely fenced off to ensure the safety of members of the public and livestock. Tower stubs (the lower part of the tower leg) are concreted into the ground. Once the concrete has been poured and cured, the excavation is back-filled using the original material in layers. Surplus material is removed from site.

The excavation required for a wooden poleset is typically 1.5m-2m x 3m x 2.3m deep; no concrete foundations are required for polesets in normal ground conditions. Installation time is approximately two per day. The average foundation size for a braced poleset is 9.3m x 3.1m x 3.2m deep.

In addition to the excavation required for the poleset itself, where ground conditions dictate, stay lines may be required. This generally involves excavation of four trenches (approximately 2m x 2m x 1.8–2m deep) at a distance from the poleset. The installation of stay wires expands the area of disturbance associated with the erecting a poleset.

**Stay lines in place, Donegal 110 kV Project**

Concrete foundations are required for all steel towers. Foundation size and type is dependent on ground conditions and tower type, but is typically 4m x 4m x 3.1m for each foundation pad. The base installation time is approximately one week.

**110kV angle towers at Srananagh Station with exposed substructures**

For all transmission lines with earth wires, there is a requirement to install an earth ring or mat at the base of the structure to ground the structure for safety reasons. The ground around the base of structures is excavated after conductors and earthwires are in place and the earth ring is installed.

**Earth ring on Donegal 110kV Project**

**Erect Towers or Wood Poles**

Materials required for construction are transported around the site by general purpose cross country vehicles with a lifting device. Excavators are generally of the tracked type to reduce likely damage to and compaction of the ground. In addition a temporary hard standing may be required for machinery and this may require the removal of topsoil. Materials are delivered to site storage/assembly areas by conventional road transport and then transferred to sites.

Tower erection can generally commence two weeks after the foundations have been cast. Tower steelwork is usually delivered to site and assembled on site.

**Installation of tower using a derrick pole at the base**

**Construction of wooden poleset support structure for Donegal 110 kV Project (Binbane – Letterkenny)**

**Stringing of conductors**
Once angle towers are erected, conductor stringing can commence, installing conductors from angle tower to angle tower via the line intermediate structures. Conductor drums are set up at one end of the straight with special conductor stringing machinery, and pulled from one end to the other.


**Stringing Machine**

**Conductor stringing equipment**

**Reinstate tower sites and remove temporary accesses**
The disturbed ground around a tower or poleset location is made good, and all temporary access materials generally removed.

## A1.4 Line Uprating and Refurbishment

In general a transmission line requires little maintenance. It is periodically inspected to identify any unacceptable deterioration of components so that they can be replaced as necessary. A more detailed condition assessment on a line is usually carried out when it is approximately 35 years old.

The majority of the existing transmission grid was constructed after 1960; the majority of those lines constructed prior to 1960 have already been refurbished. There is an on-going programme of line refurbishment concentrating on older lines.

Refurbishment projects are condition based, and once a line has been identified for refurbishment, consideration is given to the potential opportunity to upgrade its carrying capacity or thermal rating. This might involve replacing existing conductors with modern conductors which, while having effectively the same diameter, can carry significantly greater amounts of electricity.

Often the additional weight of these replacement conductors means associated replacement of support structures with stronger structures. Where structures require replacement during a line upgrade or refurbishment, additional excavation may be required particularly where angle towers or structures require replacement. In general they are replaced within the footprint of the original structure.

Insulators and conductors are normally replaced after about 40 years, and towers are painted every 15-20 years or as necessary.

## A1.5 Underground Cabling (UGC)

High voltage (HV) circuits can only be laid underground using special HV cables designed specifically for underground use. The conductors in underground HV cables must be heavily insulated to avoid a short circuit between the conductor and the ground around the cable.

**Table A3: Key Design Features: Underground Cabling**

| Key Design Features | HV Cable (typical dimensions) |
|---|---|
| Cable Trenches | c.0.6m wide-1.25m deep for a 110 kV trench,<br>c. 1.1m wide x 1.25m deep for 220 kV and 400 kV for a single cable |
| Joint Bays | 6m long, 2.5m wide and 1.8m deep |
| Excavation trench for Joint Bay | 7m long, 3m wide and 2m deep |
| Average span between joint bays | 500m–700m |
| Directional Drill entry and exit pits | 1m x 1m x 2m |

The cable is installed directly into the ground in an excavated trench. The majority of high voltage cable routes are located along public roads and open spaces. It is very unusual for a cable route to cross private open ground but this may be the case on occasion. The civil contractor will scan the ground using a cable avoidance tool (CAT), carry out a visual inspection of existing services and compare the information with the utility service records which they will have obtained from the various service providers in advance. If any previously unidentified services are discovered the site engineer will adjust the cable route accordingly.

**Typical 110kV Trench Excavation (Ducts in Trefoil Formation)**

The overall installation of a cable route over a large distance is broken down into sections of cable that are connected using a cable joint. Cable joints are installed in joint bays which are typically concrete structures buried underground, occurring generally every 500–700m along an alignment, and ranging in size up to 6m long, 2.5m wide and 1.8m deep.

**Typical Joint Bay Construction Adjacent to Public Road**

If the cable was installed directly in the ground the entire trench from joint bay to joint bay must be fully excavated. The advantage with installing cable in pre-laid ducts is that only a short section of cable trench, up to 100m is open at any time. This helps to minimise the impact on the local residents and minimise traffic impact at any given time.

**Typical HV Cable Installation**

Once installed, the road surface is reinstated. Where a cable route is in an open area, it is returned to agricultural/grassland use. Where a cable passes through forested land the route is not replanted with trees to prevent any damage to the cable by tree root growth.

**Re-growth following underground cable construction on agricultural land**

## A1.6 Substations

Substations connect two or more transmission lines; they take the electricity from the transmission lines and transform high to low voltage, or vice versa. They contain various electrical equipment, including voltage switches, transformers, protection equipment, and associated lines and cabling.

The siting of a substation depends on topography; the ground must be suitable to meet technical standards. With regard to earthing requirements and soil stability, substations are usually constructed on reasonably level ground, in areas that are not liable to flooding or crossed by significant watercourses.

A substation site is normally future proofed with the capability to be extended if the need arises.

Substations can take two forms:

An Air Insulated Switchgear (AIS) substation is where the electrical equipment infrastructure is primarily installed outdoors, with the use of natural air as an insulation between circuits. This option requires a relatively large compound footprint.

**Srananagh 220kV/110kV substation, Co Sligo, example of a typical outdoor AIS substation**

A Gas Insulated Switchgear (GIS) substation, is where gas (Sulphur Hexafluoride – SF6) is used as the insulation between circuits. This requires the electrical equipment to be contained internally, in buildings of some 11–13m over ground. This allows for a significantly smaller substation footprint.

Both options require the associated provision of access roads off and onto the public road network and the provision of associated electrical equipment and infrastructure (including underground cables), as well as ancillary waste water treatment facilities and other site development and landscaping works. Both are therefore significant civil engineering projects.

**Example of a typical indoor GIS substation, Co Limerick**

# APPENDIX B

# SITE SURVEY RESULTS

# (PEATLANDS)

**Table B1: Site 3, Relevé 3.1 results**

| Species or feature | DOMIN Cover |
|---|---|
| Calluna vulgaris | 4 |
| Erica tetralix | 3 |
| Drosera rotundifolia | 2 |
| Polygala serpyllifolia | 3 |
| Potentilla erecta | 2 |
| Juncus bulbosus | 3 |
| Carex panicea | 4 |
| Eriophorum angustifolium | 1 |
| Molinia caerulea | 8 |
| Scleropodium purum | 3 |
| Bare soil | 6 |
| Bryophyte layer | 3 |
| Field layer[1] | 8 |
| Dwarf shrub layer[2] | 4 |

**Table B2: Site 3, Relevé 3.1.2 results**

| Species or feature | DOMIN Cover |
|---|---|
| Calluna vulgaris | 8 |
| Erica tetralix | 4 |
| Potentilla erecta | 3 |
| Eriophorum angustifolium | 4 |
| Trichophorum cespitosum | 4 |
| Molinia caerulea | 7 |
| Scleropodium purum | 2 |

[1] Field layer is the level of vegetation cover within a relevé that is comprised by low growing species.
[2] Shrub layer is the level of vegetation cover within a relevé that is comprised of taller species above the field layer.

| Species or feature | DOMIN Cover |
|---|---|
| Sphagnum capillifolium | 7 |
| Bare soil | 2 |
| Bryophyte layer | 7 |
| Field layer | 9 |
| Dwarf shrub layer | 8 |

**Table B3: Site 3, Relevé 3.2 results**

| Species or feature | DOMIN Cover |
|---|---|
| Calluna vulgaris | 4 |
| Erica tetralix | 5 |
| Polygala serpyllifolia | 3 |
| Luzula multiflora | 1 |
| Carex panicea | 4 |
| Eriophorum angustifolium | 3 |
| Agrostis capillaris | 2 |
| Anthoxanthum odoratum | 3 |
| Molinia caerulea | 8 |
| Calliergonella cuspidata | 5 |
| Scleropodium purum | 4 |
| Sphagnum compactum | 4 |
| Bryophyte layer | 6 |
| Field layer | 10 |
| Dwarf shrub layer | 5 |

**Table B4: Site 3, Relevé 3.2.2 results**

| Species or feature | DOMIN Cover |
|---|---|
| Calluna vulgaris | 4 |
| Erica tetralix | 6 |
| Polygala serpyllifolia | 3 |
| Potentilla erecta | 3 |
| Carex panicea | 5 |
| Eriophorum angustifolium | 6 |
| Anthoxanthum odoratum | 2 |
| Molinia caerulea | 7 |
| Aulacomnium palustre | 3 |
| Hypnum jutlandicum | 5 |
| Scleropodium purum | 5 |
| Sphagnum capillifolium | 4 |
| Sphagnum denticulatum | 6 |
| Sphagnum subnitens | 6 |
| Bryophyte layer | 9 |
| Field layer | 10 |
| Dwarf shrub layer | 6 |

**Table B5: Site 23, Relevé 23.1 results**

| Species or feature | DOMIN Cover |
|---|---|
| Andromeda polifolia | 2 |
| Calluna vulgaris | 4 |
| Erica tetralix | 4 |
| Ulex europaeus | 4 |
| Drosera rotundifolia | 2 |
| Narthecium ossifragum | 3 |

| Species or feature | DOMIN Cover |
|---|---|
| Potentilla erecta | 3 |
| Carex panicea | 2 |
| Eriophorum angustifolium | 3 |
| Rhynchospora alba | 3 |
| Molinia caerulea | 5 |
| Aulacomnium palustre | 3 |
| Campylopus flexuosus | 3 |
| Dicranum scoparium | 2 |
| Scleropodium purum | 3 |
| Sphagnum compactum | 2 |
| Sphagnum denticulatum | 3 |
| Sphagnum subnitens | 3 |
| Bare soil | 7 |
| Bryophyte layer | 4 |
| Field layer | 7 |
| Dwarf shrub layer | 5 |

**Table B6: Site 23, Relevé 23.1.2 results**

| Species or feature | DOMIN Cover |
|---|---|
| Calluna vulgaris | 6 |
| Erica tetralix | 5 |
| Narthecium ossifragum | 5 |
| Potentilla erecta | 3 |
| Carex panicea | 5 |
| Eriophorum angustifolium | 4 |
| Rhynchospora alba | 4 |
| Trichophorum cespitosum | 4 |

| Species or feature | DOMIN Cover |
|---|---|
| Dicranum scoparium | 3 |
| Scleropodium purum | 5 |
| Sphagnum capillifolium | 4 |
| Sphagnum cuspidatum | 4 |
| Sphagnum denticulatum | 7 |
| Sphagnum magellanicum | 3 |
| Sphagnum subnitens | 4 |
| Sphagnum tenellum | 5 |
| Calypogeia muelleriana | 3 |
| Diplophyllum albicans | 4 |
| Cladonia portentosa | 3 |
| Surface water | 4 |
| Bryophyte layer | 9 |
| Field layer | 8 |
| Dwarf shrub layer | 6 |

**Table B7: Site 25, Relevé 25.1 results**

| Species or feature | DOMIN Cover |
|---|---|
| Calluna vulgaris | 5 |
| Erica tetralix | 4 |
| Drosera rotundifolia | 2 |
| Narthecium ossifragum | 4 |
| Pedicularis sylvatica | 2 |
| Potentilla erecta | 3 |
| Juncus squarrosus | 4 |
| Carex panicea | 5 |
| Eriophorum angustifolium | 4 |

| Species or feature | DOMIN Cover |
|---|---|
| Trichophorum cespitosum | 5 |
| Agrostis canina | 4 |
| Molinia caerulea | 6 |
| Sphagnum capillifolium | 5 |
| Sphagnum cuspidatum | 4 |
| Sphagnum denticulatum | 5 |
| Sphagnum papillosum | 5 |
| Bare soil | 4 |
| Surface water | 3 |
| Bryophyte layer | 7 |
| Field layer | 8 |
| Dwarf shrub layer | 5 |

**Table B8: Site 25, Relevé 25.1.2 results**

| Species or feature | DOMIN Cover |
|---|---|
| Calluna vulgaris | 6 |
| Erica tetralix | 6 |
| Drosera rotundifolia | 2 |
| Narthecium ossifragum | 5 |
| Juncus squarrosus | 3 |
| Carex panicea | 4 |
| Eriophorum angustifolium | 4 |
| Eriophorum vaginatum | 3 |
| Trichophorum cespitosum | 4 |
| Molinia caerulea | 5 |
| Aulacomnium palustre | 3 |
| Campylopus introflexus | 6 |

| Species or feature | DOMIN Cover |
|---|---|
| Dicranum scoparium | 4 |
| Hypnum jutlandicum | 2 |
| Scleropodium purum | 4 |
| Sphagnum capillifolium | 4 |
| Sphagnum denticulatum | 4 |
| Sphagnum subnitens | 4 |
| Bryophyte layer | 8 |
| Field layer | 8 |
| Dwarf shrub layer | 7 |

**Table B9: Site 25, Relevé 25.2 results**

| Species or feature | DOMIN Cover |
|---|---|
| Erica tetralix | 3 |
| Pedicularis sylvatica | 3 |
| Potentilla erecta | 3 |
| Juncus articulatus | 5 |
| Juncus bufonius | 3 |
| Juncus squarrosus | 1 |
| Carex panicea | 5 |
| Trichophorum cespitosum | 4 |
| Agrostis canina | 4 |
| Anthoxanthum odoratum | 4 |
| Festuca ovina | 3 |
| Molinia caerulea | 8 |
| Bare soil | 5 |
| Field layer | 9 |
| Dwarf shrub layer | 5 |

**Table B10: Site 25, Relevé 25.2.2 results**

| Species or feature | DOMIN Cover |
|---|---|
| Calluna vulgaris | 4 |
| Erica tetralix | 4 |
| Juncus squarrosus | 5 |
| Trichophorum cespitosum | 5 |
| Molinia caerulea | 7 |
| Campylopus introflexus | 3 |
| Scleropodium purum | 4 |
| Sphagnum capillifolium | 5 |
| Sphagnum compactum | 4 |
| Sphagnum subnitens | 5 |
| Sphagnum tenellum | 4 |
| Bryophyte layer | 8 |
| Field layer | 9 |
| Dwarf shrub layer | 5 |

**Table B11: Site 28, Relevé 28.1 results**

| Species or feature | DOMIN Cover |
|---|---|
| Erica tetralix | 5 |
| Eriophorum angustifolium | 5 |
| Rhynchospora alba | 4 |
| Trichophorum cespitosum | 5 |
| Campylopus introflexus | 4 |
| Scleropodium purum | 7 |
| Sphagnum denticulatum | 4 |

| Species or feature | DOMIN Cover |
|---|---|
| Cladonia portentosa | 4 |
| Bare soil | 5 |
| Surface water | 4 |
| Bryophyte layer | 8 |
| Field layer | 7 |
| Dwarf shrub layer | 8 |

**Table B12: Site 28, Relevé 28.1.2 results**

| Species or feature | DOMIN Cover |
|---|---|
| Calluna vulgaris | 5 |
| Erica tetralix | 6 |
| Drosera rotundifolia | 2 |
| Eriophorum angustifolium | 2 |
| Rhynchospora alba | 4 |
| Trichophorum cespitosum | 3 |
| Campylopus introflexus | 3 |
| Scleropodium purum | 3 |
| Sphagnum capillifolium | 2 |
| Sphagnum denticulatum | 4 |
| Cladonia portentosa | 3 |
| Bare soil | 5 |
| Surface water | 4 |
| Bryophyte layer | 5 |
| Field layer | 6 |
| Dwarf shrub layer | 7 |

**Table B13: Site 28, Relevé 28.2 results**

| Species or feature | DOMIN Cover |
|---|---|
| Calluna vulgaris | 5 |
| Erica tetralix | 4 |
| Drosera rotundifolia | 2 |
| Eriophorum angustifolium | 5 |
| Eriophorum vaginatum | 5 |
| Rhynchospora alba | 2 |
| Campylopus introflexus | 3 |
| Hypnum jutlandicum | 4 |
| Scleropodium purum | 3 |
| Bare soil | 8 |
| Bryophyte layer | 5 |
| Field layer | 5 |
| Dwarf shrub layer | 5 |

**Table B14: Site 28, Relevé 28.2.2 results**

| Species or feature | DOMIN Cover |
|---|---|
| Calluna vulgaris | 5 |
| Erica tetralix | 6 |
| Narthecium ossifragum | 3 |
| Eriophorum angustifolium | 3 |
| Eriophorum vaginatum | 5 |
| Rhynchospora alba | 4 |
| Campylopus introflexus | 6 |
| Scleropodium purum | 4 |
| Sphagnum capillifolium | 5 |
| Sphagnum denticulatum | 4 |

| Species or feature | DOMIN Cover |
|---|---|
| Sphagnum subnitens | 5 |
| Sphagnum tenellum | 4 |
| Bare soil | 5 |
| Bryophyte layer | 9 |
| Field layer | 6 |
| Dwarf shrub layer | 8 |

**Table B15: Site 28, Relevé 28.3 results**

| Species or feature | DOMIN Cover |
|---|---|
| Andromeda polifolia | 1 |
| Calluna vulgaris | 4 |
| Erica tetralix | 5 |
| Drosera rotundifolia | 3 |
| Narthecium ossifragum | 2 |
| Eriophorum angustifolium | 4 |
| Rhynchospora alba | 6 |
| Campylopus introflexus | 4 |
| Sphagnum capillifolium | 4 |
| Sphagnum denticulatum | 4 |
| Bare soil | 6 |
| Surface water | 6 |
| Bryophyte layer | 6 |
| Field layer | 6 |
| Dwarf shrub layer | 5 |

**Table B16: Site 28, Relevé 28.3.2 results**

| Species or feature | DOMIN Cover |
|---|---|
| Andromeda polifolia | 1 |
| Calluna vulgaris | 5 |
| Erica tetralix | 5 |
| Drosera rotundifolia | 2 |
| Narthecium ossifragum | 5 |
| Eriophorum angustifolium | 3 |
| Eriophorum vaginatum | 6 |
| Campylopus introflexus | 5 |
| Scleropodium purum | 4 |
| Sphagnum capillifolium | 5 |
| Sphagnum denticulatum | 4 |
| Sphagnum subnitens | 5 |
| Sphagnum tenellum | 4 |
| Bare soil | 3 |
| Bryophyte layer | 9 |
| Field layer | 8 |
| Dwarf shrub layer | 7 |

**Table B17: Site 31, Relevé 31.1 results**

| Species or feature | DOMIN Cover |
|---|---|
| Calluna vulgaris | 6 |
| Erica tetralix | 4 |
| Narthecium ossifragum | 3 |
| Pinguicula vulgaris | 2 |
| Potentilla erecta | 4 |
| Carex panicea | 3 |

| Species or feature | DOMIN Cover |
|---|---|
| Carex viridula ssp oedocarpa | 2 |
| Molinia caerulea | 9 |
| Dactylorhiza maculata | 1 |
| Centaurea nigra | 2 |
| Scleropodium purum | 5 |
| Bryophyte layer | 3 |
| Field layer | 10 |
| Dwarf shrub layer | 6 |

**Table B18: Site 31, Relevé 31.1.2 results**

| Species or feature | DOMIN Cover |
|---|---|
| Calluna vulgaris | 6 |
| Erica tetralix | 5 |
| Polygala serpyllifolia | 1 |
| Carex panicea | 5 |
| Eriophorum angustifolium | 5 |
| Molinia caerulea | 6 |
| Scleropodium purum | 5 |
| Sphagnum capillifolium | 6 |
| Sphagnum tenellum | 8 |
| Bryophyte layer | 9 |
| Field layer | 10 |
| Dwarf shrub layer | 7 |

**Table B19: Site 31, Relevé 31.2 results**

| Species or feature | DOMIN Cover |
|---|---|
| Calluna vulgaris | 4 |
| Erica tetralix | 4 |
| Myrica gale | 4 |
| Ulex europaeus | 1 |
| Narthecium ossifragum | 3 |
| Polygala serpyllifolia | 3 |
| Potentilla erecta | 5 |
| Succisa pratensis | 4 |
| Carex panicea | 4 |
| Agrostis canina | 5 |
| Anthoxanthum odoratum | 3 |
| Festuca rubra | 2 |
| Molinia caerulea | 5 |
| Cirsium palustre | 2 |
| Bare soil | 6 |
| Field layer | 7 |
| Dwarf shrub layer | 5 |

**Table B20: Site 31, Relevé 31.2.2 results**

| Species or feature | DOMIN Cover |
|---|---|
| Calluna vulgaris | 5 |
| Erica tetralix | 4 |
| Myrica gale | 5 |
| Polygala serpyllifolia | 3 |
| Potentilla erecta | 4 |
| Succisa pratensis | 2 |

| Species or feature | DOMIN Cover |
|---|---|
| Molinia caerulea | 9 |
| Scleropodium purum | 9 |
| Bryophyte layer | 9 |
| Field layer | 10 |
| Dwarf shrub layer | 7 |

**Table B21: Site 31, Relevé 31.3 results**

| Species or feature | DOMIN Cover |
|---|---|
| Calluna vulgaris | 6 |
| Erica tetralix | 3 |
| Pedicularis sylvatica | 3 |
| Polygala serpyllifolia | 2 |
| Potentilla erecta | 6 |
| Succisa pratensis | 4 |
| Carex panicea | 2 |
| Trichophorum cespitosum | 3 |
| Anthoxanthum odoratum | 3 |
| Molinia caerulea | 8 |
| Pleurozium schreberi | 5 |
| Scleropodium purum | 5 |
| Sphagnum denticulatum | 4 |
| Sphagnum tenellum | 4 |
| Bryophyte layer | 7 |
| Field layer | 9 |
| Dwarf shrub layer | 6 |

**Table B22: Site 31, Relevé 31.3.2 results**

| Species or feature | DOMIN Cover |
|---|---|
| Calluna vulgaris | 7 |
| Erica tetralix | 6 |
| Potentilla erecta | 4 |
| Festuca rubra | 6 |
| Molinia caerulea | 7 |
| Scleropodium purum | 3 |
| Sphagnum capillifolium | 9 |
| Sphagnum denticulatum | 4 |
| Bryophyte layer | 10 |
| Field layer | 9 |
| Dwarf shrub layer | 7 |

**Table B23: Site 32, Relevé 32.1 results**

| Species or feature | DOMIN Cover |
|---|---|
| Calluna vulgaris | 5 |
| Erica tetralix | 4 |
| Polygala serpyllifolia | 3 |
| Potentilla erecta | 3 |
| Eriophorum angustifolium | 6 |
| Molinia caerulea | 8 |
| Scleropodium purum | 4 |
| Bryophyte layer | 4 |
| Field layer | 8 |
| Dwarf shrub layer | 5 |

**Table B24: Site 32, Relevé 32.1.2 results**

| Species or feature | DOMIN Cover |
|---|---|
| Calluna vulgaris | 7 |
| Erica tetralix | 4 |
| Carex panicea | 4 |
| Eriophorum angustifolium | 5 |
| Rhynchospora alba | 3 |
| Trichophorum cespitosum | 3 |
| Molinia caerulea | 5 |
| Hypnum jutlandicum | 5 |
| Sphagnum subnitens | 4 |
| Bryophyte layer | 5 |
| Field layer | 7 |
| Dwarf shrub layer | 7 |

**Table B25: Site 32, Relevé 32.2 results**

| Species or feature | DOMIN Cover |
|---|---|
| Calluna vulgaris | 5 |
| Erica tetralix | 4 |
| Drosera rotundifolia | 4 |
| Narthecium ossifragum | 3 |
| Polygala serpyllifolia | 2 |
| Carex panicea | 5 |
| Eriophorum angustifolium | 6 |
| Rhynchospora alba | 3 |
| Trichophorum cespitosum | 3 |
| Molinia caerulea | 5 |
| Scleropodium purum | 3 |

| Species or feature | DOMIN Cover |
|---|---|
| Sphagnum capillifolium | 5 |
| Sphagnum denticulatum | 4 |
| Sphagnum subnitens | 5 |
| Sphagnum tenellum | 4 |
| Cladonia portentosa | 5 |
| Bryophyte layer | 9 |
| Field layer | 8 |
| Dwarf shrub layer | 5 |

**Table B26: Site 32, Relevé 32.2.2 results**

| Species or feature | DOMIN Cover |
|---|---|
| Andromeda polifolia | 3 |
| Calluna vulgaris | 5 |
| Erica tetralix | 5 |
| Narthecium ossifragum | 6 |
| Carex panicea | 6 |
| Eriophorum angustifolium | 5 |
| Rhynchospora alba | 4 |
| Trichophorum cespitosum | 4 |
| Racomitrium lanuginosum | 3 |
| Scleropodium purum | 3 |
| Sphagnum capillifolium | 5 |
| Sphagnum denticulatum | 4 |
| Sphagnum subnitens | 5 |
| Sphagnum tenellum | 4 |
| Pleurozia purpurea | 3 |
| Cladonia portentosa | 5 |

| Species or feature | DOMIN Cover |
|---|---|
| Bryophyte layer | 8 |
| Field layer | 8 |
| Dwarf shrub layer | 5 |

**Table B27: Site 32, Relevé 32.3 results**

| Species or feature | DOMIN Cover |
|---|---|
| Calluna vulgaris | 5 |
| Erica tetralix | 5 |
| Ulex europaeus | 4 |
| Polygala serpyllifolia | 1 |
| Potentilla erecta | 4 |
| Carex panicea | 5 |
| Molinia caerulea | 8 |
| Hypochaeris radicata | 1 |
| Polytrichum commune | 3 |
| Scleropodium purum | 5 |
| Bryophyte layer | 5 |
| Field layer | 8 |
| Dwarf shrub layer | 5 |

**Table B28: Site 32, Relevé 32.3.2 results**

| Species or feature | DOMIN Cover |
|---|---|
| Andromeda polifolia | 1 |
| Calluna vulgaris | 4 |
| Erica tetralix | 4 |
| Drosera rotundifolia | 2 |
| Narthecium ossifragum | 4 |

| | |
|---|---|
| Polygala serpyllifolia | 1 |
| Eriophorum angustifolium | 6 |
| Rhynchospora alba | 4 |
| Trichophorum cespitosum | 3 |
| Molinia caerulea | 7 |
| Scleropodium purum | 4 |
| Sphagnum capillifolium | 5 |
| Sphagnum compactum | 3 |
| Sphagnum denticulatum | 4 |
| Sphagnum papillosum | 4 |
| Sphagnum subnitens | 5 |
| Bryophyte layer | 7 |
| Field layer | 9 |
| Dwarf shrub layer | 4 |

**Table B29: Site 33, Relevé 33.1 results**

| Species or feature | DOMIN Cover |
|---|---|
| Erica cinerea | 5 |
| Erica tetralix | 4 |
| Drosera rotundifolia | 2 |
| Rhyncospora alba | 2 |
| Tricophorum cespitosum | 8 |
| Scleropodium purum | 3 |
| Sphagnum capillifolium | 4 |
| Sphagnum denticulatum | 4 |
| Cladonia portentosa | 5 |
| Cladonia uncialis | 2 |
| Bare soil | 4 |

| Species or feature | DOMIN Cover |
|---|---|
| Surface water | 4 |
| Bryophyte layer | 5 |
| Field layer | 9 |
| Dwarf shrub layer | 5 |

**Table B30: Site 33, Relevé 33.1.2 results**

| Species or feature | DOMIN Cover |
|---|---|
| Calluna vulgaris | 5 |
| Erica tetralix | 5 |
| Narthecium ossifragum | 4 |
| Carex panicea | 4 |
| Eriophorum angustifolium | 5 |
| Rhyncospora alba | 7 |
| Tricophorum cespitosum | 6 |
| Racomitrium lanuginosum | 3 |
| Scleropodium purum | 3 |
| Sphagnum capillifolium | 7 |
| Sphagnum denticulatum | 5 |
| Pleurozia purpurea | 3 |
| Cladonia portentosa | 6 |
| Bryophyte layer | 8 |
| Field layer | 8 |
| Dwarf shrub layer | 5 |

**Table B31: Site 33, Relevé 33.2 results**

| Species or feature | DOMIN Cover |
|---|---|
| Calluna vulgaris | 5 |
| Erica tetralix | 4 |
| Drosera rotundifolia | 3 |
| Narthecium ossifragum | 3 |
| Carex panicea | 4 |
| Eriophorum angustifolium | 3 |
| Rhyncospora alba | 4 |
| Tricophorum cespitosum | 7 |
| Scleropodium purum | 3 |
| Sphagnum capillifolium | 7 |
| Sphagnum denticulatum | 6 |
| Sphagnum papillosum | 6 |
| Cladonia portentosa | 5 |
| Cladonia uncialis | 3 |
| Surface water | 4 |
| Bryophyte layer | 8 |
| Field layer | 8 |
| Dwarf shrub layer | 5 |

**Table B32: Site 33, Relevé 33.2.2 results**

| Species or feature | DOMIN Cover |
|---|---|
| Calluna vulgaris | 6 |
| Erica tetralix | 5 |
| Drosera rotundifolia | 4 |
| Narthecium ossifragum | 5 |
| Carex panicea | 4 |

| | |
|---|---|
| Eriophorum angustifolium | 5 |
| Tricophorum cespitosum | 6 |
| Scleropodium purum | 4 |
| Sphagnum capillifolium | 4 |
| Sphagnum denticulatum | 4 |
| Sphagnum papillosum | 5 |
| Sphagnum subnitens | 7 |
| Pleurozia purpurea | 3 |
| Cladonia portentosa | 5 |
| Cladonia uncialis | 3 |
| Bryophyte layer | 8 |
| Field layer | 8 |
| Dwarf shrub layer | 7 |

**Table B33: Site 33, Relevé 33.3 results**

| Species or feature | DOMIN Cover |
|---|---|
| Andromeda polifolia | 2 |
| Betula pubescens | 1 |
| Calluna vulgaris | 4 |
| Erica tetralix | 4 |
| Drosera rotundifolia | 3 |
| Menyanthes trifoliata | 1 |
| Narthecium ossifragum | 3 |
| Potentilla erecta | 3 |
| Tricophorum cespitosum | 6 |
| Molinia caerulea | 6 |
| Aulacomnium palustre | 7 |
| Calliergonella cuspidata | 7 |

| Species or feature | DOMIN Cover |
|---|---|
| Polytrichum commune | 6 |
| Sphagnum capillifolium | 6 |
| Sphagnum papillosum | 4 |
| Sphagnum tenellum | 4 |
| Bryophyte layer | 10 |
| Field layer | 8 |
| Dwarf shrub layer | 5 |

**Table B34: Site 33, Relevé 33.3.2 results**

| Species or feature | DOMIN Cover |
|---|---|
| Andromeda polifolia | 3 |
| Calluna vulgaris | 7 |
| Erica tetralix | 5 |
| Drosera rotundifolia | 3 |
| Narthecium ossifragum | 4 |
| Carex panicea | 5 |
| Tricophorum cespitosum | 5 |
| Scleropodium purum | 4 |
| Sphagnum capillifolium | 7 |
| Sphagnum denticulatum | 4 |
| Sphagnum papillosum | 4 |
| Sphagnum subnitens | 5 |
| Cladonia portentosa | 6 |
| Cladonia uncialis | 3 |
| Bryophyte layer | 9 |
| Field layer | 7 |
| Dwarf shrub layer | 7 |

**Table B35: Site 37, Relevé 37.1 results**

| Species or feature | DOMIN Cover |
|---|---|
| Calluna vulgaris | 7 |
| Erica tetralix | 3 |
| Drosera rotundifolia | 4 |
| Carex panicea | 2 |
| Eriophorum angustifolium | 5 |
| Molinia caerulea | 5 |
| Campylopus introflexus | 5 |
| Sphagnum capillifolium | 4 |
| Sphagnum palustre | 4 |
| Calypogeia muelleriana | 2 |
| Cladonia portentosa | 4 |
| Bryophyte layer | 6 |
| Field layer | 7 |
| Dwarf shrub layer | 7 |

**Table B36: Site 37, Relevé 37.1.2 results**

| Species or feature | DOMIN Cover |
|---|---|
| Calluna vulgaris | 5 |
| Erica tetralix | 4 |
| Drosera rotundifolia | 3 |
| Eriophorum angustifolium | 6 |
| Rhynchospora alba | 5 |
| Trichophorum cespitosum | 4 |
| Campylopus introflexus | 4 |
| Scleropodium purum | 3 |
| Sphagnum capillifolium | 4 |

| | |
|---|---|
| Sphagnum denticulatum | 5 |
| Sphagnum palustre | 4 |
| Cladonia portentosa | 1 |
| Bare soil | 4 |
| Surface water | 4 |
| Bryophyte layer | 6 |
| Field layer | 8 |
| Dwarf shrub layer | 5 |

**Table B37: Site 37, Relevé 37.2 results**

| Species or feature | DOMIN Cover |
|---|---|
| Calluna vulgaris | 5 |
| Erica tetralix | 3 |
| Ulex europaeus | 4 |
| Drosera rotundifolia | 3 |
| Potentilla erecta | 2 |
| Succisa pratensis | 2 |
| Carex panicea | 2 |
| Rhynchospora alba | 3 |
| Trichophorum cespitosum | 5 |
| Molinia caerulea | 7 |
| Campylopus introflexus | 4 |
| Sphagnum compactum | 3 |
| Cladonia portentosa | 4 |
| Bare soil | 5 |
| Surface water | 5 |
| Bryophyte layer | 4 |
| Field layer | 7 |

| Species or feature | DOMIN Cover |
|---|---|
| Dwarf shrub layer | 6 |

**Table B38: Site 37, Relevé 37.2.2 results**

| Species or feature | DOMIN Cover |
|---|---|
| Calluna vulgaris | 5 |
| Erica tetralix | 5 |
| Drosera rotundifolia | 3 |
| Carex panicea | 4 |
| Eriophorum angustifolium | 4 |
| Rhynchospora alba | 6 |
| Trichophorum cespitosum | 5 |
| Campylopus introflexus | 3 |
| Sphagnum capillifolium | 6 |
| Sphagnum cuspidatum | 3 |
| Sphagnum denticulatum | 4 |
| Cladonia portentosa | 6 |
| Bare soil | 4 |
| Surface water | 4 |
| Bryophyte layer | 7 |
| Field layer | 8 |
| Dwarf shrub layer | 5 |

**Table B39: Site 45, Relevé 45.1 results**

| Species or feature | DOMIN Cover |
|---|---|
| Calluna vulgaris | 5 |
| Erica tetralix | 5 |
| Myrica gale | 4 |

| Species or feature | DOMIN Cover |
|---|---|
| Drosera rotundifolia | 3 |
| Narthecium ossifragum | 3 |
| Carex panicea | 3 |
| Eriophorum angustifolium | 5 |
| Schoenus nigricans | 4 |
| Trichophorum cespitosum | 3 |
| Molinia caerulea | 6 |
| Campylopus introflexus | 3 |
| Scleropodium purum | 3 |
| Sphagnum capillifolium | 7 |
| Sphagnum cuspidatum | 4 |
| Sphagnum denticulatum | 4 |
| Sphagnum papillosum | 4 |
| Diplophyllum albicans | 2 |
| Cladonia portentosa | 5 |
| Cladonia uncialis | 2 |
| Bryophyte layer | 8 |
| Field layer | 8 |
| Dwarf shrub layer | 5 |

**Table B40: Site 45, Relevé 45.1.2 results**

| Species or feature | DOMIN Cover |
|---|---|
| Calluna vulgaris | 5 |
| Erica tetralix | 5 |
| Drosera rotundifolia | 3 |
| Narthecium ossifragum | 2 |
| Polygala serpyllifolia | 2 |

| Species or feature | DOMIN Cover |
|---|---|
| Potentilla erecta | 2 |
| Trichophorum cespitosum | 4 |
| Molinia caerulea | 7 |
| Racomitrium lanuginosum | 3 |
| Scleropodium purum | 3 |
| Sphagnum capillifolium | 4 |
| Sphagnum denticulatum | 3 |
| Sphagnum subnitens | 7 |
| Pleurozia purpurea | 3 |
| Cladonia portentosa | 7 |
| Bryophyte layer | 7 |
| Field layer | 9 |
| Dwarf shrub layer | 5 |

**Table B41: Site 45, Relevé 45.2 results**

| Species or feature | DOMIN Cover |
|---|---|
| Calluna vulgaris | 4 |
| Erica tetralix | 4 |
| Myrica gale | 5 |
| Drosera rotundifolia | 3 |
| Narthecium ossifragum | 2 |
| Eriophorum angustifolium | 4 |
| Schoenus nigricans | 4 |
| Trichophorum cespitosum | 4 |
| Molinia caerulea | 6 |
| Aulacomnium palustre | 2 |
| Campylopus introflexus | 2 |

| Species or feature | DOMIN Cover |
|---|---|
| Dicranum scoparium | 3 |
| Racomitrium lanuginosum | 2 |
| Rhytidiadelphus squarrosus | 1 |
| Scleropodium purum | 4 |
| Sphagnum capillifolium | 5 |
| Sphagnum denticulatum | 4 |
| Sphagnum fallax | 3 |
| Sphagnum papillosum | 6 |
| Sphagnum tenellum | 3 |
| Bare soil | 4 |
| Bryophyte layer | 9 |
| Field layer | 8 |
| Dwarf shrub layer | 5 |

**Table B42: Site 45, Relevé 45.2.2 results**

| Species or feature | DOMIN Cover |
|---|---|
| Calluna vulgaris | 5 |
| Erica tetralix | 4 |
| Drosera intermedia | 3 |
| Drosera rotundifolia | 3 |
| Narthecium ossifragum | 2 |
| Potentilla erecta | 1 |
| Rhynchospora alba | 5 |
| Schoenus nigricans | 4 |
| Trichophorum cespitosum | 5 |
| Molinia caerulea | 8 |
| Campylopus atrovirens | 3 |

| | |
|---|---|
| Sphagnum capillifolium | 5 |
| Sphagnum denticulatum | 4 |
| Sphagnum fallax | 3 |
| Sphagnum papillosum | 7 |
| Pleurozia purpurea | 4 |
| Cladonia portentosa | 5 |
| Bryophyte layer | 9 |
| Field layer | 9 |
| Dwarf shrub layer | 5 |

**Table B43: Site 45, Relevé 45.3 results**

| Species or feature | DOMIN Cover |
|---|---|
| Calluna vulgaris | 5 |
| Erica tetralix | 4 |
| Myrica gale | 4 |
| Drosera rotundifolia | 3 |
| Narthecium ossifragum | 3 |
| Carex panicea | 3 |
| Eriophorum angustifolium | 7 |
| Rhynchospora alba | 4 |
| Schoenus nigricans | 3 |
| Trichophorum cespitosum | 3 |
| Molinia caerulea | 6 |
| Scleropodium purum | 5 |
| Sphagnum capillifolium | 6 |
| Sphagnum cuspidatum | 4 |
| Sphagnum denticulatum | 7 |
| Sphagnum papillosum | 4 |

| Species or feature | DOMIN Cover |
|---|---|
| Sphagnum tenellum | 4 |
| Bare soil | 4 |
| Bryophyte layer | 9 |
| Field layer | 9 |
| Dwarf shrub layer | 5 |

**Table B44: Site 45, Relevé 45.3.2 results**

| Species or feature | DOMIN Cover |
|---|---|
| Calluna vulgaris | 6 |
| Erica tetralix | 4 |
| Drosera rotundifolia | 3 |
| Narthecium ossifragum | 4 |
| Eriophorum angustifolium | 4 |
| Rhynchospora alba | 3 |
| Schoenus nigricans | 5 |
| Trichophorum cespitosum | 5 |
| Racomitrium lanuginosum | 2 |
| Sphagnum capillifolium | 5 |
| Sphagnum denticulatum | 5 |
| Sphagnum papillosum | 5 |
| Sphagnum subnitens | 4 |
| Pleurozia purpurea | 3 |
| Cladonia portentosa | 5 |
| Bare soil | 4 |
| Bryophyte layer | 8 |
| Field layer | 8 |
| Dwarf shrub layer | 6 |

**Table B45: Site 46 Relevé 46.1 results**

| Species or feature | DOMIN Cover |
|---|---|
| Calluna vulgaris | 8 |
| Erica tetralix | 5 |
| Narthecium ossifragum | 2 |
| Carex panicea | 5 |
| Eriophorum angustifolium | 5 |
| Molinia caerulea | 5 |
| Scleropodium purum | 6 |
| Sphagnum capillifolium | 7 |
| Cladonia portentosa | 3 |
| Bryophyte layer | 8 |
| Field layer | 7 |
| Dwarf shrub layer | 8 |

**Table B46: Site 46 Relevé 46.1.2 results**

| Species or feature | DOMIN Cover |
|---|---|
| Calluna vulgaris | 5 |
| Erica tetralix | 4 |
| Drosera rotundifolia | 3 |
| Narthecium ossifragum | 5 |
| Carex panicea | 6 |
| Eriophorum angustifolium | 7 |
| Trichophorum cespitosum | 3 |
| Molinia caerulea | 4 |
| Sphagnum capillifolium | 6 |
| Sphagnum denticulatum | 7 |

| | |
|---|---|
| Sphagnum papillosum | 5 |
| Bryophyte layer | 10 |
| Field layer | 9 |
| Dwarf shrub layer | 5 |

**Table B47: Site 46 Relevé 46.2 results**

| Species or feature | DOMIN Cover |
|---|---|
| Calluna vulgaris | 5 |
| Erica tetralix | 3 |
| Drosera rotundifolia | 3 |
| Carex panicea | 4 |
| Eriophorum angustifolium | 8 |
| Rhynchospora alba | 2 |
| Calliergonella cuspidata | 2 |
| Scleropodium purum | 4 |
| Sphagnum capillifolium | 7 |
| Sphagnum denticulatum | 6 |
| Sphagnum papillosum | 6 |
| Sphagnum tenellum | 3 |
| Cladonia portentosa | 4 |
| Bare soil | 5 |
| Bryophyte layer | 9 |
| Field layer | 8 |
| Dwarf shrub layer | 5 |

**Table B48: Site 46 Relevé 46.2.2 results**

| Species or feature | DOMIN Cover |
|---|---|
| Calluna vulgaris | 6 |
| Erica tetralix | 5 |
| Drosera rotundifolia | 3 |
| Narthecium ossifragum | 1 |
| Eriophorum angustifolium | 8 |
| Scleropodium purum | 4 |
| Sphagnum capillifolium | 8 |
| Sphagnum papillosum | 5 |
| Sphagnum tenellum | 3 |
| Cladonia portentosa | 5 |
| Bryophyte layer | 8 |
| Field layer | 9 |
| Dwarf shrub layer | 6 |

**Table B49: Site 46 Relevé 46.3 results**

| Species or feature | DOMIN Cover |
|---|---|
| Calluna vulgaris | 5 |
| Erica tetralix | 4 |
| Drosera rotundifolia | 3 |
| Narthecium ossifragum | 2 |
| Potentilla erecta | 3 |
| Eriophorum angustifolium | 8 |
| Molinia caerulea | 7 |
| Calliergonella cuspidata | 2 |
| Sphagnum capillifolium | 6 |
| Sphagnum denticulatum | 8 |

| | |
|---|---|
| Bryophyte layer | 9 |
| Field layer | 9 |
| Dwarf shrub layer | 5 |

**Table B50: Site 46 Relevé 46.3.2 results**

| Species or feature | DOMIN Cover |
|---|---|
| Calluna vulgaris | 5 |
| Erica tetralix | 4 |
| Potentilla erecta | 2 |
| Eriophorum angustifolium | 7 |
| Molinia caerulea | 8 |
| Aulacomnium palustre | 3 |
| Polytrichum commune | 2 |
| Racomitrium lanuginosum | 3 |
| Scleropodium purum | 4 |
| Sphagnum capillifolium | 6 |
| Sphagnum denticulatum | 7 |
| Sphagnum papillosum | 6 |
| Sphagnum tenellum | 4 |
| Cladonia portentosa | 4 |
| Bryophyte layer | 9 |
| Field layer | 9 |
| Dwarf shrub layer | 5 |

**Table B51: Site 47 Relevé 47.1 results**

| Species or feature | DOMIN Cover |
|---|---|
| Calluna vulgaris | 7 |
| Erica tetralix | 3 |
| Galium saxatile | 2 |
| Pedicularis sylvatica | 2 |
| Polygala serpyllifolia | 3 |
| Juncus squarrosus | 3 |
| Luzula sp | 1 |
| Carex panicea | 3 |
| Eriophorum angustifolium | 4 |
| Agrostis canina | 4 |
| Anthoxanthum odoratum | 4 |
| Festuca rubra | 4 |
| Molinia caerulea | 8 |
| Nardus stricta | 4 |
| Hylocomnium splendens | 5 |
| Polytrichum commune | 3 |
| Rhytidiadelphus loreus | 4 |
| Sphagnum denticulatum | 5 |
| Bryophyte layer | 6 |
| Field layer | 9 |
| Dwarf shrub layer | 7 |

**Table B52: Site 47 Relevé 47.1.2 results**

| Species or feature | DOMIN Cover |
|---|---|
| Calluna vulgaris | 6 |
| Erica cinerea | 3 |
| Erica tetralix | 3 |
| Potentilla erecta | 4 |
| Molinia caerulea | 8 |
| Breutelia chrysocoma | 4 |
| Sphagnum tenellum | 4 |
| Bryophyte layer | 5 |
| Field layer | 9 |
| Dwarf shrub layer | 6 |

**Table B53: Site 47 Relevé 47.2 results**

| Species or feature | DOMIN Cover |
|---|---|
| Calluna vulgaris | 5 |
| Erica cinerea | 4 |
| Erica tetralix | 3 |
| Galium saxatile | 5 |
| Potentilla erecta | 4 |
| Juncus effusus | 3 |
| Juncus squarrosus | 4 |
| Anthoxanthum odoratum | 3 |
| Molinia caerulea | 3 |
| Nardus stricta | 4 |
| Hylocomnium splendens | 5 |
| Polytrichum commune | 3 |
| Rhytidiadelphus loreus | 4 |

| Species or feature | DOMIN Cover |
|---|---|
| Sphagnum denticulatum | 3 |
| Bryophyte layer | 7 |
| Field layer | 9 |
| Dwarf shrub layer | 6 |

**Table B54: Site 47 Relevé 47.2.2 results**

| Species or feature | DOMIN Cover |
|---|---|
| Calluna vulgaris | 7 |
| Erica cinerea | 4 |
| Erica tetralix | 4 |
| Potentilla erecta | 4 |
| Carex echinata | 2 |
| Eriophorum angustifolium | 4 |
| Molinia caerulea | 9 |
| Breutelia chrysocoma | 3 |
| Sphagnum capillifolium | 5 |
| Sphagnum papillosum | 5 |
| Bryophyte layer | 6 |
| Field layer | 10 |
| Dwarf shrub layer | 7 |

**Table B55: Site 47 Relevé 47.3 results**

| Species or feature | DOMIN Cover |
|---|---|
| Calluna vulgaris | 6 |
| Erica cinerea | 3 |
| Erica tetralix | 4 |
| Vaccinium myrtillus | 1 |

| Species or feature | DOMIN Cover |
|---|---|
| Potentilla erecta | 3 |
| Juncus effusus | 4 |
| Juncus squarrosus | 4 |
| Eriophorum angustifolium | 3 |
| Agrostis canina | 3 |
| Anthoxanthum odoratum | 3 |
| Festuca rubra | 4 |
| Molinia caerulea | 5 |
| Nardus stricta | 4 |
| Polytrichum commune | 6 |
| Rhytidiadelphus loreus | 3 |
| Sphagnum capillifolium | 7 |
| Sphagnum denticulatum | 6 |
| Sphagnum papillosum | 6 |
| Bryophyte layer | 9 |
| Field layer | 9 |
| Dwarf shrub layer | 6 |

**Table B56: Site 47 Relevé 47.3.2 results**

| Species or feature | DOMIN Cover |
|---|---|
| Calluna vulgaris | 6 |
| Erica tetralix | 5 |
| Polygala serpyllifolia | 2 |
| Potentilla erecta | 2 |
| Eriophorum angustifolium | 5 |
| Molinia caerulea | 8 |
| Sphagnum denticulatum | 8 |

| | |
|---|---|
| Sphagnum papillosum | 5 |
| Sphagnum subnitens | 2 |
| Sphagnum tenellum | 3 |
| Bryophyte layer | 8 |
| Field layer | 9 |
| Dwarf shrub layer | 6 |

**Table B57: Site 49 Relevé 49.1.1 results**

| Species or feature | DOMIN Cover |
|---|---|
| Calluna vulgaris | 7 |
| Erica tetralix | 4 |
| Drosera rotundifolia | 2 |
| Pedicularis sylvatica | 1 |
| Potentilla erecta | 1 |
| Succisa pratensis | 1 |
| Juncus bulbosus | 1 |
| Juncus squarrosus | 3 |
| Trichophorum cespitosum | 3 |
| Molinia caerulea | 7 |
| Pleurozium schreberi | 7 |
| Racomitrium lanuginosum | 4 |
| Scleropodium purum | 3 |
| Sphagnum capillifolium | 7 |
| Sphagnum denticulatum | 3 |
| Cladonia portentosa | 4 |
| Cladonia uncialis | 2 |
| Bare rock | 4 |
| Surface water | 4 |

| Species or feature | DOMIN Cover |
|---|---|
| Bryophyte layer | 10 |
| Field layer | 9 |
| Dwarf shrub layer | 7 |

**Table B58: Site 49 Relevé 49.1.1.2 results**

| Species or feature | DOMIN Cover |
|---|---|
| Calluna vulgaris | 3 |
| Erica cinerea | 3 |
| Erica tetralix | 5 |
| Drosera rotundifolia | 3 |
| Narthecium ossifragum | 4 |
| Pedicularis sylvatica | 3 |
| Potentilla erecta | 1 |
| Carex panicea | 2 |
| Trichophorum cespitosum | 4 |
| Molinia caerulea | 8 |
| Dicranum scoparium | 2 |
| Racometrium lanuginosum | 4 |
| Sphagnum denticulatum | 5 |
| Diplophyllum albicans | 3 |
| Pleurozia purpurea | 5 |
| Cladonia portentosa | 3 |
| Cladonia uncialis | 2 |
| Bare rock | 4 |
| Bryophyte layer | 7 |
| Field layer | 8 |
| Dwarf shrub layer | 5 |

**Table B59: Site 49 Relevé 49.1.2 results**

| Species or feature | DOMIN Cover |
|---|---|
| Calluna vulgaris | 6 |
| Erica cinerea | 6 |
| Erica tetralix | 4 |
| Potentilla erecta | 3 |
| Agrostis canina | 3 |
| Anthoxanthum odoratum | 3 |
| Molinia caerulea | 7 |
| Dicranum scoparium | 3 |
| Pleurozium schreberi | 7 |
| Scleropodium purum | 5 |
| Bryophyte layer | 9 |
| Field layer | 8 |
| Dwarf shrub layer | 8 |

**Table B60: Site 49 Relevé 49.1.2.2 results**

| Species or feature | DOMIN Cover |
|---|---|
| Calluna vulgaris | 6 |
| Erica tetralix | 4 |
| Pedicularis sylvatica | 3 |
| Potentilla erecta | 3 |
| Juncus squarrosus | 1 |
| Carex panicea | 5 |
| Trichophorum cespitosum | 6 |
| Festuca ovina | 2 |
| Molinia caerulea | 5 |
| Aulacomnium palustre | 3 |

| | |
|---|---|
| Dicranum scoparium | 4 |
| Sphagnum capillifolium | 5 |
| Sphagnum denticulatum | 7 |
| Sphagnum papillosum | 4 |
| Cladonia portentosa | 4 |
| Bryophyte layer | 9 |
| Field layer | 8 |
| Dwarf shrub layer | 6 |

**Table B61: Site 49 Relevé 49.2.1 results**

| Species or feature | DOMIN Cover |
|---|---|
| Calluna vulgaris | 5 |
| Erica tetralix | 4 |
| Potentilla erecta | 3 |
| Eriophorum angustifolium | 1 |
| Trichophorum cespitosum | 2 |
| Molinia caerulea | 8 |
| Aulacomnium palustre | 5 |
| Pleurozium schreberi | 7 |
| Polytrichum commune | 3 |
| Sphagnum capillifolium | 5 |
| Sphagnum denticulatum | 4 |
| Bare soil | 5 |
| Bryophyte layer | 7 |
| Field layer | 8 |
| Dwarf shrub layer | 5 |

**Table B62: Site 49 Relevé 49.2.1.2 results**

| Species or feature | DOMIN Cover |
|---|---|
| Calluna vulgaris | 5 |
| Erica tetralix | 5 |
| Pedicularis sylvatica | 3 |
| Polygala serpyllifolia | 1 |
| Potentilla erecta | 4 |
| Succisa pratensis | 1 |
| Carex panicea | 3 |
| Eriophorum angustifolium | 5 |
| Eriophorum vaginatum | 5 |
| Trichophorum cespitosum | 4 |
| Molinia caerulea | 7 |
| Aulacomnium palustre | 5 |
| Pleurozium schreberi | 6 |
| Scleropodium purum | 4 |
| Sphagnum capillifolium | 6 |
| Sphagnum denticulatum | 5 |
| Cladonia portentosa | 4 |
| Bryophyte layer | 8 |
| Field layer | 9 |
| Dwarf shrub layer | 6 |

**Table B63: Site 49 Relevé 49.2.2 results**

| Species or feature | DOMIN Cover |
|---|---|
| Calluna vulgaris | 5 |
| Erica cinerea | 4 |
| Erica tetralix | 5 |

| Species or feature | DOMIN Cover |
|---|---|
| Ulex europaeus | 1 |
| Drosera rotundifolia | 3 |
| Narthecium ossifragum | 6 |
| Pedicularis sylvatica | 3 |
| Carex panicea | 5 |
| Trichophorum cespitosum | 3 |
| Molinia caerulea | 7 |
| Campylopus flexuosus | 3 |
| Campylopus introflexus | 2 |
| Dicranum scoparium | 4 |
| Racometrium lanuginosum | 4 |
| Scleropodium purum | 4 |
| Sphagnum compactum | 5 |
| Sphagnum denticulatum | 5 |
| Pleurozia purpurea | 3 |
| Cladonia portentosa | 3 |
| Bare soil | 4 |
| Bare rock | 4 |
| Bryophyte layer | 8 |
| Field layer | 8 |
| Dwarf shrub layer | 6 |

**Table B64: Site 49 Relevé 49.2.2.2 results**

| Species or feature | DOMIN Cover |
|---|---|
| Calluna vulgaris | 5 |
| Erica tetralix | 5 |
| Drosera rotundifolia | 3 |

| Species or feature | DOMIN Cover |
|---|---|
| Narthecium ossifragum | 4 |
| Potentilla erecta | 2 |
| Succisa pratensis | 3 |
| Juncus squarrosus | 5 |
| Carex panicea | 5 |
| Trichophorum cespitosum | 4 |
| Molinia caerulea | 7 |
| Aulacomnium palustre | 4 |
| Sphagnum capillifolium | 7 |
| Sphagnum compactum | 4 |
| Sphagnum denticulatum | 4 |
| Pleurozia purpurea | 5 |
| Cladonia portentosa | 4 |
| Cladonia uncialis | 2 |
| Surface water | 4 |
| Bryophyte layer | 8 |
| Field layer | 10 |
| Dwarf shrub layer | 6 |

**Table B65: Site 57 Relevé 57.1 results**

| Species or feature | DOMIN Cover |
|---|---|
| Erica tetralix | 5 |
| Narthecium ossifragum | 4 |
| Potentilla erecta | 3 |
| Rhynchospora alba | 4 |
| Trichophorum cespitosum | 6 |
| Molinia caerulea | 8 |

| | |
|---|---|
| Aulacomnium palustre | 3 |
| Racometrium lanuginosum | 4 |
| Scleropodium purum | 3 |
| Sphagnum capillifolium | 7 |
| Sphagnum compactum | 3 |
| Sphagnum denticulatum | 4 |
| Sphagnum subnitens | 4 |
| Cladonia portentosa | 3 |
| Bryophyte layer | 9 |
| Field layer | 10 |
| Dwarf shrub layer | 5 |

**Table B66: Site 57 Relevé 57.1.2 results**

| Species or feature | DOMIN Cover |
|---|---|
| Erica tetralix | 5 |
| Myrica gale | 5 |
| Pedicularis sylvatica | 3 |
| Polygala serpyllifolia | 2 |
| Potentilla erecta | 3 |
| Trichophorum cespitosum | 7 |
| Molinia caerulea | 7 |
| Racometrium lanuginosum | 3 |
| Scleropodium purum | 4 |
| Sphagnum capillifolium | 6 |
| Sphagnum subnitens | 7 |
| Cladonia portentosa | 3 |
| Bryophyte layer | 9 |
| Field layer | 10 |

| | |
|---|---|
| Dwarf shrub layer | 5 |

**Table B67: Site 57 Relevé 57.2 results**

| Species or feature | DOMIN Cover |
|---|---|
| Calluna vulgaris | 3 |
| Erica tetralix | 4 |
| Pedicularis sylvatica | 2 |
| Polygala serpyllifolia | 3 |
| Potentilla erecta | 3 |
| Taraxacum agg | 1 |
| Juncus acutiflorus | 2 |
| Juncus squarrosus | 1 |
| Carex panicea | 5 |
| Carex pulicaris | 2 |
| Carex viridula ssp oedocarpa | 4 |
| Agrostis capillaris | 4 |
| Anthoxanthum odoratum | 3 |
| Danthonia decumbens | 2 |
| Molinia caerulea | 7 |
| Nardus stricta | 5 |
| Scleropodium purum | 3 |
| Cirsium palustre | 1 |
| Cynosurus cristatus | 3 |
| Bare rock | 3 |
| Bryophyte layer | 3 |
| Field layer | 9 |
| Dwarf shrub layer | 4 |

**Table B68: Site 57 Relevé 57.2.2 results**

| Species or feature | DOMIN Cover |
|---|---|
| Calluna vulgaris | 3 |
| Erica tetralix | 5 |
| Potentilla erecta | 3 |
| Eriophorum angustifolium | 6 |
| Rhynchospora alba | 1 |
| Trichophorum cespitosum | 5 |
| Molinia caerulea | 7 |
| Racometrium lanuginosum | 5 |
| Sphagnum capillifolium | 5 |
| Sphagnum denticulatum | 5 |
| Sphagnum tenellum | 3 |
| Pleurozia purpurea | 3 |
| Cladonia portentosa | 5 |
| Cladonia uncialis | 2 |
| Bryophyte layer | 7 |
| Field layer | 10 |
| Dwarf shrub layer | 5 |

**Table B69: Site 57 Relevé 57.3 results**

| Species or feature | DOMIN Cover |
|---|---|
| Calluna vulgaris | 4 |
| Erica tetralix | 4 |
| Vaccinium myrtillus | 3 |
| Polygala serpyllifolia | 2 |
| Carex panicea | 3 |
| Trichophorum cespitosum | 3 |

| | |
|---|---|
| Agrostis capillaris | 5 |
| Anthoxanthum odoratum | 3 |
| Danthonia decumbens | 2 |
| Molinia caerulea | 7 |
| Nardus stricta | 8 |
| Campylopus flexuosus | 3 |
| Bare soil | 5 |
| Bryophyte layer | 3 |
| Field layer | 9 |
| Dwarf shrub layer | 5 |

**Table B70: Site 57 Relevé 57.3.2 results**

| Species or feature | DOMIN Cover |
|---|---|
| Calluna vulgaris | 7 |
| Erica tetralix | 4 |
| Pedicularis sylvatica | 4 |
| Potentilla erecta | 3 |
| Juncus squarrosus | 3 |
| Carex panicea | 4 |
| Trichophorum cespitosum | 4 |
| Molinia caerulea | 7 |
| Nardus stricta | 3 |
| Pleurozium schreberi | 4 |
| Rhytidiadelphus loreus | 6 |
| Scleropodium purum | 4 |
| Sphagnum capillifolium | 5 |
| Sphagnum compactum | 6 |
| Diplophyllum albicans | 3 |

| | |
|---|---|
| Cladonia portentosa | 5 |
| Cladonia uncialis | 2 |
| Bryophyte layer | 8 |
| Field layer | 8 |
| Dwarf shrub layer | 7 |

**Table B71: Site 35 Relevé 35.1 results**

| Species or feature | DOMIN Cover |
|---|---|
| Calluna vulgaris | 4 |
| Ulex europaeus | 3 |
| Potentilla erecta | 5 |
| Succisa pratensis | 1 |
| Trifolium repens | 1 |
| Carex nigra | 2 |
| Carex panicea | 3 |
| Schoenus nigricans | 5 |
| Arrhenatherum elatius | 2 |
| Festuca rubra | 4 |
| Molinia caerulea | 8 |
| Poa sp | 3 |
| Pleurozium schreberi | 5 |
| Bryophyte layer | 5 |
| Field layer | 9 |
| Dwarf shrub layer | 4 |

**Table B72: Site 35 Relevé 35.1.2 results**

| Species or feature | DOMIN Cover |
|---|---|
| Calluna vulgaris | 5 |
| Erica tetralix | 3 |
| Potentilla erecta | 3 |
| Schoenus nigricans | 4 |
| Molinia caerulea | 9 |
| Listera ovata | 1 |
| Pleurozium schreberi | 5 |
| Surface water | 4 |
| Bryophyte layer | 5 |
| Field layer | 9 |
| Dwarf shrub layer | 5 |

**Table B73: Site 18 Relevé 18.1 results**

| Species or feature | DOMIN Cover |
|---|---|
| Calluna vulgaris | 5 |
| Erica tetralix | 4 |
| Potentilla erecta | 4 |
| Juncus articulatus | 4 |
| Juncus squarrosus | 3 |
| Carex echinata | 2 |
| Carex panicea | 7 |
| Carex pulicaris | 5 |
| Carex viridula ssp oedocarpa | 3 |
| Agrostis capillaris | 5 |
| Anthoxanthum odoratum | 4 |
| Festuca ovina | 6 |

| | |
|---|---|
| Calliergonella cuspidata | 3 |
| Campylopus flexuosus | 3 |
| Sphagnum denticulatum | 4 |
| Bare soil | 4 |
| Bryophyte layer | 4 |
| Field layer | 9 |
| Dwarf shrub layer | 5 |

**Table B74: Site 18 Relevé 18.1.2 results**

| Species or feature | DOMIN Cover |
|---|---|
| Calluna vulgaris | 5 |
| Erica tetralix | 4 |
| Drosera rotundifolia | 3 |
| Polygala serpyllifolia | 3 |
| Potentilla erecta | 3 |
| Carex panicea | 3 |
| Trichophorum cespitosum | 7 |
| Molinia caerulea | 8 |
| Sphagnum capillifolium | 6 |
| Sphagnum cuspidatum | 4 |
| Sphagnum denticulatum | 7 |
| Sphagnum papillosum | 8 |
| Cladonia portentosa | 4 |
| Bryophyte layer | 10 |
| Field layer | 9 |
| Dwarf shrub layer | 5 |

**Table B75: Site 18 Relevé 18.2 results**

| Species or feature | DOMIN Cover |
|---|---|
| Calluna vulgaris | 4 |
| Erica tetralix | 4 |
| Juncus articulatus | 3 |
| Juncus bulbosus | 3 |
| Juncus effusus | 4 |
| Carex echinata | 3 |
| Carex viridula ssp oedocarpa | 2 |
| Agrostis canina | 6 |
| Festuca ovina | 7 |
| Molinia caerulea | 5 |
| Sphagnum denticulatum | 6 |
| Surface water | 4 |
| Bryophyte layer | 6 |
| Field layer | 9 |
| Dwarf shrub layer | 5 |

**Table B76: Site 18 Relevé 18.2.2 results**

| Species or feature | DOMIN Cover |
|---|---|
| Calluna vulgaris | 7 |
| Erica tetralix | 4 |
| Potentilla erecta | 3 |
| Juncus squarrosus | 5 |
| Carex panicea | 5 |
| Eriophorum angustifolium | 5 |
| Molinia caerulea | 5 |
| Sphagnum capillifolium | 7 |

| | |
|---|---|
| Sphagnum tenellum | 4 |
| Bare soil | 3 |
| Bryophyte layer | 7 |
| Field layer | 8 |
| Dwarf shrub layer | 7 |

**Table B77: Site 18 Relevé 18.3 results**

| Species or feature | DOMIN Cover |
|---|---|
| Calluna vulgaris | 5 |
| Erica cinerea | 4 |
| Erica tetralix | 4 |
| Pedicularis sylvatica | 2 |
| Potentilla erecta | 5 |
| Juncus bulbosus | 3 |
| Juncus effusus | 3 |
| Juncus squarrosus | 4 |
| Carex echinata | 3 |
| Carex nigra | 3 |
| Carex panicea | 5 |
| Carex pulicaris | 2 |
| Carex viridula ssp oedocarpa | 2 |
| Agrostis capillaris | 4 |
| Anthoxanthum odoratum | 4 |
| Festuca ovina | 5 |
| Molinia caerulea | 5 |
| Nardus stricta | 7 |
| Leontodon autumnalis | 2 |
| Fissidens osmundoides | 3 |

| Species or feature | DOMIN Cover |
|---|---|
| Bryophyte layer | 3 |
| Field layer | 9 |
| Dwarf shrub layer | 5 |

**Table B78: Site 18 Relevé 18.3.2 results**

| Species or feature | DOMIN Cover |
|---|---|
| Calluna vulgaris | 5 |
| Erica tetralix | 4 |
| Potentilla erecta | 3 |
| Juncus bulbosus | 2 |
| Juncus squarrosus | 4 |
| Carex panicea | 5 |
| Eriophorum angustifolium | 7 |
| Molinia caerulea | 7 |
| Scleropodium purum | 3 |
| Sphagnum capillifolium | 4 |
| Sphagnum denticulatum | 7 |
| Sphagnum tenellum | 3 |
| Cladonia portentosa | 4 |
| Bryophyte layer | 7 |
| Field layer | 9 |
| Dwarf shrub layer | 5 |

**Table B79: Site 19 Relevé 19.1 results**

| Species or feature | DOMIN Cover |
|---|---|
| Calluna vulgaris | 6 |
| Erica tetralix | 4 |
| Drosera rotundifolia | 3 |
| Narthecium ossifragum | 4 |
| Juncus effusus | 2 |
| Carex panicea | 3 |
| Eriophorum vaginatum | 6 |
| Rhynchospora alba | 4 |
| Agrostis canina | 2 |
| Molinia caerulea | 4 |
| Campylopus introflexus | 2 |
| Sphagnum denticulatum | 7 |
| Sphagnum papillosum | 5 |
| Sphagnum subnitens | 4 |
| Cladonia portentosa | 4 |
| Surface water | 4 |
| Bryophyte layer | 8 |
| Field layer | 9 |
| Dwarf shrub layer | 6 |

**Table B80: Site 19 Relevé 19.1.2 results**

| Species or feature | DOMIN Cover |
|---|---|
| Calluna vulgaris | 5 |
| Erica tetralix | 4 |
| Drosera rotundifolia | 3 |
| Narthecium ossifragum | 4 |

| | |
|---|---|
| Eriophorum angustifolium | 7 |
| Eriophorum vaginatum | 6 |
| Scleropodium purum | 3 |
| Sphagnum capillifolium | 6 |
| Sphagnum cuspidatum | 4 |
| Sphagnum denticulatum | 6 |
| Sphagnum papillosum | 7 |
| Sphagnum subnitens | 3 |
| Sphagnum tenellum | 3 |
| Cladonia portentosa | 4 |
| Cladonia uncialis | 2 |
| Bryophyte layer | 8 |
| Field layer | 9 |
| Dwarf shrub layer | 5 |

**Table B81: Site 19 Relevé 19.2 results**

| Species or feature | DOMIN Cover |
|---|---|
| Calluna vulgaris | 8 |
| Pedicularis sylvatica | 3 |
| Potentilla erecta | 4 |
| Juncus effusus | 2 |
| Carex binervis | 3 |
| Carex panicea | 6 |
| Agrostis canina | 2 |
| Festuca ovina | 5 |
| Molinia caerulea | 4 |
| Nardus stricta | 4 |
| Pleurozium schreberi | 4 |

| | |
|---|---|
| Bryophyte layer | 4 |
| Field layer | 7 |
| Dwarf shrub layer | 8 |

**Table B82: Site 19 Relevé 19.2.2 results**

| Species or feature | DOMIN Cover |
|---|---|
| Calluna vulgaris | 8 |
| Eriophorum vaginatum | 6 |
| Molinia caerulea | 6 |
| Pleurozium schreberi | 5 |
| Rhytidiadelphus loreus | 4 |
| Sphagnum capillifolium | 7 |
| Sphagnum denticulatum | 5 |
| Bryophyte layer | 8 |
| Field layer | 8 |
| Dwarf shrub layer | 8 |

**Table B83: Site 19 Relevé 19.3 results**

| Species or feature | DOMIN Cover |
|---|---|
| Calluna vulgaris | 6 |
| Potentilla erecta | 3 |
| Carex panicea | 5 |
| Festuca ovina | 5 |
| Molinia caerulea | 4 |
| Pleurozium schreberi | 3 |
| Sphagnum denticulatum | 2 |
| Bare soil | 6 |
| Bryophyte layer | 3 |

| | |
|---|---|
| Field layer | 7 |
| Dwarf shrub layer | 6 |

**Table B84: Site 19 Relevé 19.3.2 results**

| Species or feature | DOMIN Cover |
|---|---|
| Calluna vulgaris | 6 |
| Eriophorum angustifolium | 4 |
| Trichophorum cespitosum | 4 |
| Molinia caerulea | 8 |
| Sphagnum capillifolium | 8 |
| Cladonia portentosa | 4 |
| Bryophyte layer | 8 |
| Field layer | 9 |
| Dwarf shrub layer | 6 |

# APPENDIX C

# SITE SURVEY RESULTS

# (GRASSLANDS)

**Table C1: Site G1, Relevé G1.1 results**

| Species or feature | DOMIN Cover |
|---|---|
| Lolium perenne | 7 |
| Festuca rubra | 4 |
| Cynosurus cristatus | 3 |
| Agrostis capillaris | 3 |
| Plantago major | 2 |
| Ranunculus repens | 4 |
| Trifolium pratense | 4 |
| Achillea millefolium | 3 |
| Leontodon autumnalis | 4 |
| Odontites vernus | 4 |
| Potentilla anserina | 1 |
| Taraxacum agg | 2 |
| Plantago lanceolata | 4 |
| Ranunculus acris | 3 |
| Rumex acetosa | 2 |
| Cerastium fontanum | 1 |
| Cirsium arvense | 1 |
| Field layer | 10 |

**Table C2: Site G1, Relevé G1.2 results**

| Species or feature | DOMIN Cover |
|---|---|
| Holcus lanatus | 6 |
| Lolium perenne | 3 |
| Poa sp | 2 |
| Ranunculus repens | 6 |
| Cirsium arvense | 6 |

| Species or feature | DOMIN Cover |
|---|---|
| Odontites vernus | 3 |
| Cerastium fontanum | 2 |
| Trifolium pratense | 3 |
| Rumex acetosa | 2 |
| Galium aparine | 1 |
| Ranunculus acris | 4 |
| Field layer | 10 |

**Table C3: Site G1, Relevé G1.3 results**

| Species or feature | DOMIN Cover |
|---|---|
| Lolium perenne | 7 |
| Leontodon autumnalis | 4 |
| Ranunculus repens | 4 |
| Trifolium pratense | 5 |
| Rumex acetosa | 3 |
| Odontites vernus | 1 |
| Potentilla anserina | 2 |
| Cirsium arvense | 2 |
| Agrostis capillaris | 3 |
| Cerastium fontanum | 2 |
| Plantago lanceolata | 4 |
| Plantago major | 4 |
| Holcus lanatus | 5 |
| Cynosurus cristatus | 2 |
| Field layer | 10 |

**Table C4: Site G4, Relevé G4.1 results**

| Species or feature | DOMIN Cover |
|---|---|
| Briza media | 7 |
| Sesleria albicans | 4 |
| Festuca rubra | 4 |
| Festuca ovina | 2 |
| Trisetum flavescens | 2 |
| Carex flacca | 4 |
| Thymus polytrichus | 3 |
| Pilosella officinarum | 3 |
| Euphrasia agg | 4 |
| Juniperus communis | 6 |
| Lotus corniculatus | 5 |
| Hedera helix | 2 |
| Teucrium scorodonia | 2 |
| Crataegus monogyna | 1 |
| Leontodon sp | 1 |
| Geranium columbinum | 2 |
| Senecio jacobaea | 1 |
| Succisa pratensis | 3 |
| Viola sp | 1 |
| Linum catharticum | 3 |
| Galium verum | 1 |
| Asperula cynanchica | 2 |
| Plantago lanceolata | 2 |
| Plantago maritima | 2 |
| Bare rock | 5 |
| Field layer | 9 |

**Table C5: Site G4, Relevé G4.2 results**

| Species or feature | DOMIN Cover |
|---|---|
| Briza media | 6 |
| Sesleria albicans | 4 |
| Festuca rubra | 5 |
| Carex flacca | 3 |
| Thymus polytrichus | 4 |
| Pilosella officinarum | 2 |
| Euphrasia agg | 4 |
| Lotus corniculatus | 4 |
| Teucrium scorodonia | 3 |
| Geranium columbinum | 2 |
| Succisa pratensis | 5 |
| Viola sp | 1 |
| Linum catharticum | 2 |
| Asperula cynanchica | 3 |
| Plantago lanceolata | 1 |
| Plantago maritima | 1 |
| Campanula rotundifolia | 2 |
| Carlina vulgaris | 1 |
| Anthoxanthum odoratum | 3 |
| Leontodon hispidus | 2 |
| Achillea millefolium | 1 |
| Veronica persica | 1 |
| Potentilla erecta | 1 |
| Rosa spinosissima | 1 |
| Trifolium repens | 1 |
| Dactylis glomerata | 2 |
| Bare rock | 4 |

| Species or feature | DOMIN Cover |
|---|---|
| Field layer | 10 |

**Table C6: Site G4, Relevé G4.3 results**

| Species or feature | DOMIN Cover |
|---|---|
| Briza media | 7 |
| Festuca rubra | 5 |
| Festuca ovina | 3 |
| Carex flacca | 3 |
| Thymus polytrichus | 4 |
| Pilosella officinarum | 2 |
| Euphrasia agg | 4 |
| Lotus corniculatus | 5 |
| Teucrium scorodonia | 1 |
| Geranium columbinum | 3 |
| Succisa pratensis | 5 |
| Viola sp | 2 |
| Linum catharticum | 3 |
| Asperula cynanchica | 2 |
| Plantago lanceolata | 1 |
| Campanula rotundifolia | 2 |
| Leontodon hispidus | 4 |
| Rosa spinosissima | 1 |
| Prunus spinosa | 4 |
| Trifolium pratense | 3 |
| Orchid sp | 1 |
| Bare rock | 4 |
| Field layer | 10 |

**Table C7: Site G5, Relevé G5.1 results**

| Species or feature | DOMIN Cover |
|---|---|
| Ranunculus repens | 7 |
| Holcus lanatus | 6 |
| Plantago lanceolata | 3 |
| Cerastium fontanum | 3 |
| Cynosurus cristatus | 5 |
| Cirsium arvense | 2 |
| Lolium perenne | 6 |
| Agrostis capillaris | 3 |
| Ranunculus acris | 2 |
| Prunella vulgaris | 2 |
| Field layer | 10 |

**Table C8: Site G5, Relevé G5.2 results**

| Species or feature | DOMIN Cover |
|---|---|
| Ranunculus repens | 4 |
| Holcus lanatus | 3 |
| Plantago lanceolata | 7 |
| Cynosurus cristatus | 6 |
| Agrostis capillaris | 3 |
| Rhinanthus minor | 6 |
| Vicia sepium | 4 |
| Dactylis glomerata | 2 |
| Anthoxanthum odoratum | 4 |
| Trifolium pratense | 3 |
| Heracleum sphondylium | 2 |
| Festuca rubra | 4 |

| Species or feature | DOMIN Cover |
|---|---|
| Trifolium campestre | 2 |
| Field layer | 10 |

**Table C9: Site G5, Relevé G5.3 results**

| Species or feature | DOMIN Cover |
|---|---|
| Ranunculus repens | 4 |
| Holcus lanatus | 4 |
| Plantago lanceolata | 4 |
| Cynosurus cristatus | 6 |
| Agrostis capillaris | 4 |
| Rhinanthus minor | 6 |
| Vicia sepium | 2 |
| Dactylis glomerata | 3 |
| Anthoxanthum odoratum | 4 |
| Trifolium pratense | 4 |
| Festuca rubra | 4 |
| Trifolium campestre | 3 |
| Leontodon autumnalis | 1 |
| Field layer | 10 |

**Table C10: Site G8, Relevé G8.1 results**

| Species or feature | DOMIN Cover |
|---|---|
| Holcus lanatus | 5 |
| Lolium perenne | 7 |
| Poa pratensis | 2 |
| Trifolium repens | 6 |
| Ranunculus repens | 5 |

| Species or feature | DOMIN Cover |
|---|---|
| Cerastium fontanum | 2 |
| Plantago major | 3 |
| Odontites vernus | 2 |
| Plantago lanceolata | 5 |
| Heracleum sphondylium | 1 |
| Leontodon autumnalis | 2 |
| Field layer | 10 |

**Table C11: Site G8, Relevé G8.2 results**

| Species or feature | DOMIN Cover |
|---|---|
| Lolium perenne | 6 |
| Trifolium repens | 5 |
| Ranunculus repens | 5 |
| Cerastium fontanum | 2 |
| Odontites vernus | 2 |
| Plantago lanceolata | 5 |
| Agrostis capillaris | 5 |
| Potentilla anserina | 2 |
| Taraxacum agg | 3 |
| Senecio jacobaea | 1 |
| Trifolium pratense | 5 |
| Bare soil | 4 |
| Field layer | 9 |

**Table C12: Site G8, Relevé G8.3 results**

| Species or feature | DOMIN Cover |
|---|---|
| Lolium perenne | 7 |
| Ranunculus repens | 5 |
| Plantago lanceolata | 6 |
| Agrostis capillaris | 4 |
| Trifolium pratense | 5 |
| Rumex crispus | 2 |
| Ranunculus acris | 3 |
| Anthoxanthum odoratum | 3 |
| Field layer | 10 |

**Table C13: Site G9, Relevé G9.1.1 results**

| Species or feature | DOMIN Cover |
|---|---|
| Centaurea nigra | 5 |
| Senecio jacobaea | 3 |
| Lathyrus pratensis | 3 |
| Odontites vernus | 4 |
| Festuca rubra | 5 |
| Holcus lanatus | 4 |
| Cerastium fontanum | 2 |
| Veronica persica | 2 |
| Ranunculus repens | 4 |
| Ranunculus acris | 3 |
| Lotus corniculatus | 3 |
| Prunella vulgaris | 2 |
| Cynosurus cristatus | 5 |
| Plantago lanceolata | 3 |

| Species or feature | DOMIN Cover |
|---|---|
| Cirsium arvense | 2 |
| Lolium perenne | 4 |
| Agrostis capillaris | 4 |
| Arrhenatherum elatius | 3 |
| Prunus spinosa | 1 |
| Anthoxanthum odoratum | 4 |
| Field layer | 10 |

**Table C14: Site G9, Relevé G9.1.2 results**

| Species or feature | DOMIN Cover |
|---|---|
| Centaurea nigra | 4 |
| Senecio jacobaea | 2 |
| Odontites vernus | 3 |
| Holcus lanatus | 3 |
| Ranunculus repens | 4 |
| Ranunculus acris | 3 |
| Cynosurus cristatus | 5 |
| Plantago lanceolata | 6 |
| Cirsium arvense | 4 |
| Lolium perenne | 7 |
| Anthoxanthum odoratum | 4 |
| Galium verum | 1 |
| Dactylis glomerata | 3 |
| Potentilla anserina | 4 |
| Achillea millefolium | 3 |
| Trifolium pratense | 6 |
| Field layer | 10 |

**Table C15: Site G9, Relevé G9.2.1 results**

| Species or feature | DOMIN Cover |
|---|---|
| Senecio jacobaea | 2 |
| Festuca rubra | 3 |
| Ranunculus repens | 6 |
| Prunella vulgaris | 3 |
| Cynosurus cristatus | 6 |
| Plantago lanceolata | 7 |
| Lolium perenne | 7 |
| Agrostis capillaris | 2 |
| Anthoxanthum odoratum | 4 |
| Dactylis glomerata | 3 |
| Potentilla anserina | 2 |
| Carex nigra | 2 |
| Plantago major | 3 |
| Trifolium pratense | 6 |
| Bare soil | 4 |
| Field layer | 9 |

**Table C16: Site G9, Relevé G9.2.2 results**

| Species or feature | DOMIN Cover |
|---|---|
| Senecio jacobaea | 2 |
| Ranunculus repens | 3 |
| Ranunculus acris | 3 |
| Cynosurus cristatus | 4 |
| Plantago lanceolata | 6 |
| Cirsium arvense | 2 |
| Lolium perenne | 8 |

| Species or feature | DOMIN Cover |
|---|---|
| Agrostis capillaris | 3 |
| Anthoxanthum odoratum | 4 |
| Carex nigra | 3 |
| Plantago major | 3 |
| Rumex obtusifolia | 1 |
| Bare soil | 5 |
| Field layer | 9 |

**Table C17: Site G9, Relevé G9.3.1 results**

| Species or feature | DOMIN Cover |
|---|---|
| Festuca rubra | 4 |
| Ranunculus repens | 4 |
| Plantago lanceolata | 6 |
| Lolium perenne | 8 |
| Agrostis capillaris | 4 |
| Plantago major | 2 |
| Trifolium pratense | 4 |
| Bare soil | 4 |
| Field layer | 9 |

**Table C18: Site G9, Relevé G9.3.2 results**

| Species or feature | DOMIN Cover |
|---|---|
| Senecio jacobaea | 3 |
| Odontites vernus | 2 |
| Festuca rubra | 4 |
| Holcus lanatus | 5 |
| Ranunculus repens | 5 |

| Species or feature | DOMIN Cover |
|---|---|
| Prunella vulgaris | 2 |
| Cynosurus cristatus | 7 |
| Plantago lanceolata | 5 |
| Cirsium arvense | 2 |
| Lolium perenne | 7 |
| Agrostis capillaris | 3 |
| Euphrasia agg | 4 |
| Trifolium pratense | 6 |
| Field layer | 10 |